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NBS GCR 78-130

An Annotated Compilation of the Sources of Information Related to the Usage of Electricity in Non-Industrial Applications

Sponsored by
Division of Energy, Building Technology and Standards
Office of Policy Development and Research
Department of Housing and Urban Development
Washington, D.C. 20410

Prepared for
Center for Building Technology
National Engineering Laboratory
National Bureau of Standards
Washington, D.C. 20234

hudmius
MODULAR INTEGRATED UTILITY SYSTEMS
improving community utility services by supplying electricity, heating, cooling, and water/ processing liquid and solid wastes/ conserving energy and natural resources/ minimizing environmental impact



MASTER

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

Issued July 1978

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NBS GCR 78-130

AN ANNOTATED COMPILATION OF THE SOURCES OF INFORMATION RELATED TO THE USAGE OF ELECTRICITY IN NON-INDUSTRIAL APPLICATIONS

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U.S. DEPARTMENT OF COMMERCE, Juanita M. Kreps, *Secretary*

Dr. Sidney Harman, *Under Secretary*

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NATIONAL BUREAU OF STANDARDS, Ernest Ambler, *Director*

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PREFACE

This Government Contractor's Report (GCR) has been prepared in fulfillment of NBS Purchase Order Number 61440 (Items 3 and 5) and NBS Purchase Order Number 716065. These purchase orders contracted with Mr. Ben Reznek to: prepare an annotated bibliography (by user category) of data sources related to patterns of electrical demand for non-industrial users; work with public utilities in obtaining their approval of abstracts from their literature; include a glossary of pertinent technical terms related to the field; package these abstracts with suitable introductory material for publication. Publication of this government contractor's report makes the sources of information related to the usage of electricity in non-industrial application available to the interested public. The government contractor bears all responsibility as to the technical content of this report and its presentation.

This government contractor's report is a NBS/HUD-MIUS team product for the HUD-MIUS program of the Division of Energy, Building Technology and Standards in the Department of Housing and Urban Development. Mr. Clinton W. Phillips is the NBS/HUD-MIUS program manager. Mr. Jerome H. Rothenberg is the HUD-MIUS program manager. Mr. Joseph Sherman is responsible for all HUD programs in the Division of Energy, Building Technology and Standards.

Mr. Reznek, the government contractor, developed this publication for the MIUS Implementation Technology Project of the NBS/HUD-MIUS program. In behalf of the MIUS Implementation Technology project, I would like to recognize the support provided to Mr. Reznek by the Association of Edison Illuminating Companies, the AEIC Load Research Committee and the past and current chairmen of the LRC/AEIC, Mr. J. A. Leo and Mr. Robert E. Ashburn. Thirty AEIC member companies permitted NBS to obtain and Mr. Reznek to summarize copies of pertinent LRC material on standardized reporting forms. Each company reviewed and granted NBS permission to publish the respective completed reporting forms which this report contains.

David J. Mitchell

David J. Mitchell, Project Leader
MIUS Implementation Technology
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ACKNOWLEDGEMENTS

The author/editor of this Compilation wishes to express his sincere thanks for the cooperation of the many individuals, organizations - both private and government - and electrical utilities who assisted him by supplying references and by granting the National Bureau of Standards permission to cite "privately-printed" material.

Special thanks are certainly due to Mrs. Norma Wood for cheerfully providing the expert secretarial support that was necessary in producing a document of the nature of this Compilation. Her skills have contributed markedly to the completion of this task, since the final format has been directly reproduced from her typed copy.

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** Abstracts for these Reports start immediately after the "Published" classification listings.

FOREWORD

HUD has been conducting the MIUS Program which is devoted to the development and demonstration of the technical, economic and institutional advantages of integrating the systems for providing all or most of the utility services for a community. [These services include electric power, heating/cooling, potable water, liquid waste treatment and solid waste management.] The MIUS concept is intended to provide the desired services with a reduced use of critical resources plus improved protection of the environment and lower costs. The program goal is to foster implementation of the IUS concept by any organization, private or public, which has been selected by a community to provide its utilities.

Under HUD direction, several agencies have been participating in the HUD-MIUS Program, including: the Department of Energy; Department of Defense; Environmental Protection Agency; Department of Health, Education and Welfare; National Aeronautics and Space Administration; National Bureau of Standards. [The National Academy of Engineering has provided an independent assessment of the Program.]

This report was sponsored by HUD as part of the MIUS Program, since a data base for estimating "start-up" and "future" electrical usage is a necessary and important requirement for developing a MIUS. MIUS-type demonstration projects are being investigated but the relative importance of this energy concept is still to be evaluated; therefore, it was decided to expand the scope of this Compilation's information search so as to include data with potential use for non-Industrial, non-MIUS applications. Material has also been introduced which deals with the general background of Load Research, past usage experience and the various techniques for predicting future trends in electricity consumption. Thus, this Compilation can be viewed as being somewhat more than a collection of abstracts since it provides a capsulized background plus data base sources for use in conventional, T.E., MIUS and other conceptual applications.

This Compilation of abstracted references includes certain material from the HUD-MIUS Program and (related) activities in the area of T.E. applications. The electrical data that is found in such references was not the primary concern of their author(s) but generally appeared, with varying specificity and emphasis, as part of the data base for various energy-related computer programs or for illustrative calculations.

EXECUTIVE SUMMARY

This document provides a list of abstracts of "published" (and "privately-printed") electricity usage information which is either directly, or in a significant secondary context, related to the non-industrial usage classifications. [The pertinent literature has been examined and abstracted for a period beginning about 1952 and extending thru 1977.]

Categorization of this Compilation's information sources was kept reasonably simple, as can be seen from the two Subject Classifications lists. However, a substantial percentage of the abstracts needed extensive cross-referencing even though their primary information content tends to center in the subject area identified by the first D.C.N. (Document Classification Number), as listed in their Document Classification space in the forms used for abstracting. A limited number of general interest areas were felt to merit some background discussion; such areas are covered by summarizing paragraphs in the INTRODUCTION.

The Load Research Committee of the Association of Edison Illuminating Companies' (LRC/AEIC) privately-printed abstracts (which comprise one of the two primary groupings of this document) include appreciably more detail than the usual format; the extra details are intended to assist the readers, since access to the complete references may not be feasible. The published references have been abstracted in such fashion that the readers can make their own determination as to whether they will want to check the entire reference.

To save space and simplify compilation, a standardized format was developed which is explained in the Introduction.

It is hoped that the use of this Compilation (by architects, consultants, engineers, forecasters, managers, planners, etc.) will lead to the preparation of improved estimates of the patterns and extent of electrical load requirements. Access to a broad variety of electrical usage data (and an awareness of the many direct and indirect factors which have been found to significantly influence such usage) should reduce the more-or-less natural tendency to "overspecify", i.e. as a means of compensating for uncertainties in the extent and reliability of less extensive data sources.

INTRODUCTION

This Compilation has first been separated into two primary collections, namely a group which stems from the (proprietary-type) LRC/AEIC Reports and another group which includes all remaining material. Each of the preceding groups are arranged as per the numerical list of major document classifications shown in the Table of Contents. Furthermore, within each numbered classification, the references are placed in the chronological order of their issuance date. If a document is significantly concerned with more than one major class, then more than one number will appear on the Abstract forms in the space following DOCUMENT CLASSIFICATION(S); however, the Abstract will only appear in the class indicated by the first of such numbers.

An appreciable volume of significant electrical usage information was noted for industrial applications, coincidental to the literature search reported herein. [In fact, a number of the Abstracts deal with both industrial and non-industrial areas, the latter being generally identified as "commercial".] However, it was decided not to include industrial electrical service under the subject matter of this report because the industrial uses are enormously varied and much more difficult to categorize and generalize than are the non-industrial. Additionally industrial installations strongly trend toward customization, leading to the use of specialized "hardware" and "instrumentation" which would seldom be encountered in the non-industrial installations but which nevertheless can significantly affect the magnitude and nature of electricity use. Nevertheless certain aspects of many of the non-industrial references may interest persons having to deal with the industrial uses of electricity.

The DATA USE RESTRICTIONS spaces of the Abstract forms have been filled-in (as seemed applicable) but no claim is made for complete accuracy. Copyright - and comparable restrictions - might best be rechecked if one plans to make detailed use of this abstracted material in any form of publication, or in any duplicated issuance that is not formally published. [It should be kept in mind that extensive quoting and/or any reproduction normally requires written permission from the source, although Copyright Notices frequently waive such permission under stated circumstances.]

On the Abstract forms there are spaces for filling-in the four TOTALS; the following "ground rules" for supplying these numbers were intended to promote uniformity in their use, as it appeared practicable to do so: (1) Unless otherwise noted (with an *, generally), the TOTALS apply to the entire document. [Note: all Totals are considered reasonably accurate but are a matter of personal judgment in some instances.]
(2) The "Total Pages" generally include all those labeled with roman or arabic numerals or combinations thereof; blank pages - even tho numbered - were not counted.
(3) Because of their varying format, the handling of the "Total References" is discussed in detail in the next paragraph.

(4) The "Total Graphs" excludes any pictures, sketches, schematics, etc. [Graphs grouped into Charts are identified by an * comment.]
(5) Tables which are merely listings of descriptive material (or the like) are not counted. [Numbered and unnumbered Tables are distinguished by an * comment.]

On the Abstract form there is a space for Total References; such totals have been included because it is felt that they give the reader a clue which can be considered somewhat related to the information content of the particular article. In arriving at these totals it should be noted that there is an appreciable variation in how references are introduced. In most instances they are numbered, and referred to, in accordance with a reasonably standardized format. There are some reports which include an alphabetically arranged Bibliography containing direct and/or indirect reference material (sometimes numbered, sometimes not) and still others which use a combination of Reference and Bibliographic lists. In an appreciable number of cases footnotes are used for referencing, sometimes hardly differentiated from those in a formal reference listing. Several of the "long" reports use the same reference more than once, e.g. where Reference and/or Bibliographic citations appear after major sections of a report rather than in one composite list for the entire report. [Summing up, it is often a matter of personal judgment as to what constitutes a Reference; such judgments have been exercised in totaling the references of the abstract forms herein, including not counting duplicate reference entries.]

It may be noted that the qualitative relevance of this Compilation's literature are generally indicated in the asterisked notes that precede the main body of the Abstract. [Here, relevance is used in the sense of having some significant bearing upon one or more of the many nuances of electrical load consumption.] This (*) format was judged to be helpful since the references which deal entirely with the subject matter of this Compilation constitute only about 2/3 of the total abstracted.

As previously pointed out, a rather substantial percentage of the detailed electrical load research conducted to date has been summarized in the annual reports of the Load Research Committee of the Association of Edison Illuminating Companies. Since its 1943-44 Report the LRC has prepared and edited and the AEIC has printed material covering the characteristics of customer and major appliance loads, as well as the background technical aspects pertinent to load research and analysis. For quite a few years, these reports have tended to follow a fairly standardized format which categorizes the individual (sometimes joint) utility studies as: Residential Loads; Commercial and Industrial Loads; Specific Loads (e.g., a major appliance load); General Topics (such as correlations between load parameters, load forecasting, instrumentation, statistics, etc.). The individual studies also tend towards a standardized format which covers, as applicable: Purpose(s) of Study; Summary of Major Findings; Test Procedures (including the statistical details of sampling, etc.); Load/Customer Characteristics (generally summarized in the form of Tables and Graphs/Charts); Discussions of the Data. Nearly

all of the studies make use of the extensive instrumentation and statistical procedures that have been developed and refined under the aegis of the LRC. [Note: LRC reports are prepared for the use of the utilities that are members of the AEIC and are marked as: "printed but not published by order of the Association".]

There are indications, in the literature reviewed for this Compilation, that many electrical utilities - particularly those which are "investor owned" - conduct load studies which are neither formally printed (as in the AEIC volumes) or openly published. One such indication is that several of the abstracted references mention (or use) data from such studies, which are then generally cited as "private communications". Data of this type may have been based on direct measurements made by the particular utility or may have been based on information from other sources, which the utility has seen fit to release under controlled conditions.

An informal sampling made by the author of this Compilation indicates that a significant amount of load usage data has probably found its way into the official records of the hearings before the various state utility commissions. Theoretically, this material is open to use by anyone but unfortunately there is no easy way to locate such information (other than by an individual query or search) since there is no USA central index of such utility hearings.

AUTHOR'S COMMENTS ON THE USE OF EXISTING DATA

In using this Compilation, it is important to keep in mind that since about 1970 there have been major (and relatively abrupt) changes in the availability and price of alternate energy sources and in the related details of electricity rate schedules. Additionally, there have been statistically significant - but generally less abrupt - changes in many of the numerous demographic factors which have been found to play a significant role in electrical demand. Such changes call for one to exercise judgment in the use (for estimating electrical demands) of even the best data of the recent past, unless such data can be logically updated to reflect existent conditions. Moreover, it should also be realized that oftentimes there are significant gaps in the available data; this situation can, of course, make updating a matter of both judgment and skill.

As may be seen from even a quick scan of the material abstracted herein, electrical usage data stems from a variety of sources and is of varying scope and quality. Because of this variability the potential users should carefully examine the relative "merits" of the individual data sources, since one will seldom be so fortunate as to have all requirements met by an access to data of top quality.

In view of what has just been said, assume that there is a real need to meld data from more than one source, either to fill in information gaps and/or provide a statistically sounder data base. Assume further that the data to be combined is judged to be of about equal reliability and that its reliability level merits considering the data in the first place. Nevertheless, it is still necessary to normalize the data in same logical fashion. During such a normalization process, one is trying to ensure that the various parameters considered significant to the particular study are adjusted for any mismatching between data sources. Parameters needing adjustment would commonly include at least one of the following: time-base; level of aggregation; costing schedules; constructional details; weather variations; occupant density, life-style and economic status; nature and extent of electrical equipment in use. Additional complexities may sometimes arise because parameters interact to a significant degree. [Note: in recent years the data may have been significantly influenced by various techniques loosely grouped under the field of Load Management, even tho such techniques tend to have more influence on load profile shape than they do on the area under such profiles.]

With the (general) exception of the LRC Reports, a high percentage of the existing data appears to be more-or-less inconsistent as to how well it describes the statistical background of the data source(s) or the accuracy of the measurement processes or the presentation and interpretation of the findings. Therefore, experience and judgment will be needed to deal with the various correction/adjustment factors (of varying levels of reliability) that one plans to use in normalizing composite data bases. In reporting composite data it may even be better to present the data from the various sources, along with all pertinent details plus

a tabulation of the relevant normalizing factors, and then leave it up to the reader to logically adjust the data to their own peculiar circumstances.

Nearly all electrical utilities have conducted load studies of their own and/or have participated in joint studies with other utilities or with organizations such as EEI, EPRI, ERDA and FEA. These individual utility studies have mainly been concerned with obtaining information to assist in planning additions and/or changes to generation, transmission and distribution systems and/or as an adjunct to rate hearings. Up to about 1965 the joint utility studies were basically cost sharing projects which gathered basic usage information from large areas (or the entire area) of the USA; in recent years - and especially since the existence of EPRI - these joint studies have tended to deal with investigations into new concepts, such as the various aspects of Load Management. Such studies vary appreciably in their scope and sophistication, dependent primarily on the individual circumstances that promoted the study and secondarily on the available personnel and equipment. [Note: local "policy" varies as to the amount and type of information which utility management may be willing to share with persons outside of the utility area; however, any data that is part of a rate hearing is considered to be "in the public domain".]

Essentially all electrical utilities have experienced some relatively abrupt changes in their energy delivery patterns, beginning about 1973. Prior to 1973, most forecasting techniques leaned heavily - and with generally acceptable results - on past experiences. However, from 1973 on, a "smoothed" extrapolation of historical trends failed to predict changes accurately and led (in some instances) to excessive estimates of near-future equipment needs. Such "failures" have resulted in a strong - and increasing - interest in developing better forecasting procedures.

As regards the broad problem of electrical load forecasting, this compiler noted that a relatively large amount of electrical usage literature was related to the prediction of highly aggregated values (such as annual consumption or consumption for an entire State) or to the estimation of short-term peak demands. By contrast, considerably less material was found to be related to data that could be used for estimating future daily, seasonal and annual load profiles. Major technological innovations - which have been introduced in the recent past - have already shown appreciable influence on the character of such load profiles; examples are the use of electricity to replace other "scarcer" and/or "dirtier" energy sources and a renewed and expanded interest in various types of heat-pump systems. [Additionally, the long-term effects of such multi-faceted concepts as Load Management stress their likelihood of being able to significantly alter these load profiles on a utility (or multi-utility) basis. There is also considerable interest in the ability to predict changes in load profiles at more disaggregated levels.]

At least one study on "short term" load forecasting has pointed out that altho a forecasting technique may be based on relatively short prediction times, nevertheless its results may be judiciously applied to planning-type studies extending for months or years into the future. Naturally the potential user of such results has to carefully review them for pertinence to his special circumstances and needs.

Many of the recent references - that are concerned with the projection of electrical energy demand - utilize econometric techniques which are based on statistical data dealing with the effects of combinations of such variables as: the price of electricity and alternate fuels; population and its income; appliance saturation and pricing; effects of conservation measures. [Note: EEI, FPC and similar sources of published information are also utilized directly or in combination with other projection data.] Since such projections are generally on a regional or national basis, judgmental allowances are needed if the results are to be logically applied to "small units", e.g. a community supplied by a conventional, T.E. or MIUS utility. Unless there is no alternative, such data should not be used in their original form because large-scale data aggregation can result in a large loss of detailed information; preferably the data should be adjusted, as practicable. The net result of applying (overly) aggregated data to the planning of small units would probably be that the actual growth in demand could not be reliably related to the predicted growth.

As noted above, a substantial percentage of the references dealing with the forecasting aspects of electrical demand have used econometric techniques (i.e., they have applied statistical methods to the study of the economic facets of electrical load prediction). Furthermore, it should be noted that most of the econometric-type studies cited herein employ single equation models whose parameters have been estimated by what is known as OLS or "ordinary least squares". A distinct minority of such studies use considerably more sophistication than OLS in their analysis but one is nevertheless left with an impression that this extra sophistication - while academically interesting - does not necessarily yield results that are more reliable than those obtained with simpler methods. [When appreciably improved data bases become available, the relative usefulness and accuracy of the various prediction techniques should become clearer.]

A majority of the electric energy demand forecast studies - at least as reported in the open literature - use data that has been aggregated at levels well above those for an individual household or even for an individual apartment house, school, hospital, etc. The primary reason for such use is that statistically - verifiable published data of lesser aggregation has, simply speaking, been scarce. The degree of aggregation tends to affect the various elasticity values - which are related to the relative importance and trend direction of the forecasting variables -more in degree, than in kind. [Of course, there may be unusual situations in which the trend direction reverses in moving from aggregated to disaggregated data, or vice versa.] Thus, if the only data available

is rather highly aggregated it would tend to yield predictions of increasing variance (i.e., decreasing reliability) when applied to situations which are disaggregated to increasing extents from that of the original data. This need not mean that the resulting conclusions would be incorrect as to general trends but the stronger the confidence that one can apply to his estimates the more likely one would be to make use of elasticity values obtained from a mismatched situation; i.e., the use of aggregated data for examining what one might be able to predict in a similar but disaggregated situation.

As an example: in planning/estimating the electrical supply for relatively small areas (e.g., a housing development, school, shopping center, motel), it appears best to use parameter values which have been obtained from data sources that match the size and other characteristics of the new development as closely as practicable. In considering such parameters one should at least take account of: the price of electricity (present and near-future), price and availability of alternate fuels, use of appliances and relevant demographic data.

As in all developing technological fields, the Abstracts of this Compilation indicate that there has been a continuing process of updating and/or expanding electrical load information. [Of course, some uses of electricity, and some aspects of electricity consumption, have shown more rapid changes than others and these are the ones which are more likely to be reinvestigated or newly examined.] The reasons for continuing such studies are indeed varied but the following are considered representative: (1) to reexamine a previously studied area because of reduced confidence in the older data; (2) to study a previously covered field so as to determine any time-related trends; (3) to fill a need for more accurate data, say to improve forecasting techniques; (4) to examine the changes due to increases in the number, type and construction of major appliances and lighting and air conditioning units; (5) to check on the effects of changes in building design, population shifts, energy conservation applications, variations in economic factors, etc.; (6) to evaluate proposed correlations between electrical load parameters; (7) to validate newer concepts, such as one or more of the aspects of Load Management.

As a counterpoint to the preceding, it should be pointed out that many of the older reports are still of other than historical interest since they contain basic information which doesn't really become obsolete or they may have data which can be used, in conjunction with the newer reports, to study a variety of time-related trends. As an example, as one of the (LRC) utilities has pointed out, "many load patterns - as distinguished from energy use and demand levels - remain valid even with the introduction of more efficient and/or larger and smaller appliances."

AUTHOR'S OBSERVATIONS ON DATA QUALITY

While assembling this Compilation, it was observed that some of the abstracted sources use expressions like "typical", particularly when referring to tabulated and plotted results. Unfortunately the reader can be left with a wrong impression as to the reliability and (implied) generality of such typical data, which may be even closer to atypical in that it is on a statistically shaky foundation and/or is being improperly interpreted. As an example: if what was identified as typical was actually based on a relatively small number of case histories, then the results should have been clearly identified as stemming from a "single sample" or "small sample". [Note: small samples are sometimes proper, provided they satisfy the statistical requirements of a particular application under consideration.] The existing ways of labeling electrical usage results are at least inconsistent; it therefore appears beneficial to use a graded terminology, such as is listed below, when one is making value judgments as to the usefulness of reference data when applied to a given situation.

"TYPICAL": results based on reliable state-of-the-art data collection/analysis techniques, used with a statistically valid sampling process; adaptable (with reasonable confidence) to similar sets of circumstances.

"REPRESENTATIVE": results that could be classed as "typical", if it were not for somewhat lessened data quantity and/or quality; should be useful (with precaution) for application to similar sets of circumstances.

"SMALL-SAMPLE": results derived (for example) from too small a number of case histories, which individually may have an aura of reliability but which collectively do not satisfy the statistical criteria justifying their reapplication to the new set of circumstances; such results should be used with great care and interpreted in terms of a lowered confidence level.

"SAMPLE": a single case history, for example; its results could be useful for interpreting essentially identical sets of circumstances but should never be used for generalization purposes.

"EXAMPLE": essentially an illustration of a technique in which the data may not even relate to a known situation; any "results" from the use of such examples should not be reapplied, except to help explain analogous techniques.

"LRC/AEIC"
ABSTRACTS
FOLLOW

REMINDER

The following "LRC/AEIC" Report Abstracts are firstly arranged in order of their leading documentation number on the Abstract sheets, i.e. the number to the left of the / in the space labeled DOCUMENT CLASSIFICATION(S). Secondly - within each document class number (D.C.N.) - they are arranged in chronological order of their DATE OF ISSUANCE; thirdly they are arranged in order of page number, if the issuance date is the same for more than one report in the same D.C.N. class.

Readers interested in material within a "desired" D.C.N. would first look at the Abstracts starting on the indicated page for that D.C.N., as noted in the Subject Classifications which follow this page. Next he can scan the rest of the Abstracts, noting the occurrence of the desired D.C.N. as located to the right of the /.

Note: A few of the D.C.N.'s will only be found to the right of the /. This situation is indicated by a—, instead of a page number, in the Subject Classification (listing).

At the time this Compilation was approved for reproduction, the LRC/AEIC was in the final stage of "printing" its 1976-77 Report. Altho NBS was unable to include Abstracts from the 1976-77 Report, it was allowed to include a brief summary of such reports; see two following pages. [As in the case of all LRC/AEIC data, detailed inquiries about such material has to be directed to the sponsoring Utilities.]

The 1976-77 LRC/AEIC Report consists of 5 sections. It includes 13 studies of residential, commercial/industrial and specific appliance loads, plus a Task Force report on the relationship of residential load factor to KWH usage.

Section 1 is a report from the Residential Load Subcommittee and consists of 5 separate studies of the load characteristics of residential customers. The Long Island Lighting Co. reported on the load characteristics of the all-electric customers residing in a retirement community and found their use was predictably lower than that of residential space heating customers, but double the "system average" residential customer. Central Maine Power Co. tested a subclass, namely of customers not utilizing large electric water heating or space heating. Orange & Rockland Utilities, Inc. studied the load characteristics for that Company's 3 major classes of residential service; based on annual load factors, water heating load appeared to produce a marked improvement in load factor but space heating tended to erode the load factor even though water heating was present. A study by Illinois Power Co. was made to determine the residential class peak and its contribution to the Company's system peak. Niagara Mohawk Power Corp. submitted a study which determined the load characteristics of that Company's residential class.

Section 2 is from the Commercial and Industrial Loads Subcommittee and consists of 3 separate studies. Baltimore Gas & Electric Co. reported on the total service load characteristics of what is commonly known as "fast-food" restaurants, which are considered small commercial customers; this study, which was conducted to obtain data not previously available for this type of customer, revealed that over half of their annual energy requirements occur during the peak periods (weekdays, between 8 a.m. and 10 p.m.). The Cleveland Electric Illuminating Co. submitted a study of the load characteristics of the customers served on their "general commercial" rate schedule, for customers whose demand does not exceed 30 KW. Southern California Edison Co. reported on a study (conducted over a four year interval, 1972-1975) showing the load characteristics of their large industrial and commercial customers, during periods of conservation and inflation.

Section 3 is the report of the Specific Loads Subcommittee and consists of 4 studies which provide valuable data related to load management and energy conservation. The Detroit Edison Co. studied the effects of interrupting (central residential) air cooling loads by means of radio control units; the control resulted in a demand reduction of over 20%, while not making any significant change in the maximum diversified demand and energy consumption. Consumers Power Co. submitted two studies, the first being conducted to determine the water heating load characteristics of their commercial customers and the second for the purpose of determining the load characteristics of their municipal pumping load. A joint study by six AEIC member companies (comparing the energy use of manual and automatic defrost food freezers) was compiled and reported on by the Pacific Gas and Electric Co.

Section 4 consists of a "large general service" and "master metered apartment" study prepared by Houston Lighting and Power Co., and represents the contribution of the General Topics Subcommittee. This study concentrated on developing detailed characteristics for apartment projects, as compared to the other large general service customers.

Section 5 is the report of the Task Force on the Relationship of Residential Load Factor to Kilowatthour Use. This task force was formed to determine if there was any consistency in the relations between residential load factor and KWH use of various types of customers. It concluded that the load factor tends to stabilize or increase slightly with an increase in the size of customer (once the size of customer exceeds the average KWH use) regardless of the period considered.

SUBJECT CLASSIFICATION FOR "LRC/AEIC" REPORTS

D.C.N. (a)	Classification	Page (b)
1	Air conditioning, residential (central)	21
2	Air conditioning, residential (room)	41
	All-electric homes; see Residences, all-electric (misc. topics)	
3 (c)	All-electric, single family residences (with heat pumps)	47
4 (c)	All-electric, single family residences (with resistance heating)	51
	Analysis, statistical; see Statistics of load studies	
5 (c)	Apartment buildings (all-electric)	80
6	Apartment buildings (non all-electric)	—
7	Appliances (misc. topics)	100
8	Bills, electric	—
9	Buildings, misc. topics; also see specific building types	—
	Churches; see Religious institutions	
	Class of service; see Bills, electric	
10	Clothes dryers	104

(a) D.C.N. = Document Classification Number.

(b) This number refers to the starting page for the earliest abstract which carries the designated D.C.N. in "first place" in the Document Classification(s) space on the Abstract form. [Note: a dash (-), which replaces a page number, simply means that the particular D.C.N. happens to never occur as a first place (i.e., primary) D.C.N. The reader can locate such classifications by scanning the document classification spaces of the abstracts.]

(c) Some LRC/AEIC reports, which probably deal with an "all-electric" situation, do not appear to designate it as such. Such uncertain cases have been classified as all-electric.

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14	Demand-related material (including demand/energy relationships)	167
15 (d)	Demographics	—
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16	Econometrics and Elasticity (price, etc.)	—
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	Electrical loads; refer to the specific usage D.C.N. Environmental factors; refer to Weather effects Estimation; see Forecasting studies and techniques	

(d) Many LRC/AEIC reports include some demographic-type information and/or similar data, as related to their customers.

(e) Such factors are used to characterize and/or quantify electrical loads; refer to this Compilation's GLOSSARY for factor definitions. Nearly all LRC/AEIC reports include extended data on one or more of these factors.

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35	Municipal loads; also see Buildings, misc. topics and Commercial customers and Schools	232
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	Planning; see Load forecasting (general) Population characteristics; see Demographics	
37	Power factor data	—
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38	Religious institutions	235
39	Residences, all-electric (misc. topics)	237

(f) The majority of the LRC/AEIC reports include some load profile information.

(g) Most of the LRC/AEIC reports include details of the measurement procedures and measuring systems used in obtaining the test data.

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	Saturation (of appliances); see Appliances (misc. topics)	
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43 (h)	Statistics of load studies (general topics)	297
44 (i)	Suburban loads; also see Residences (misc. topics)	301
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46	Total-class loads	—
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47	Urban loads (i.e., non-Rural/Suburban loads)	—
	Washers, clothes; see Appliances (misc. topics)	
48	Water heaters	306
49 (j)	Weather effects	329

(h) Most of the LRC/AEIC reports include details of the statistical procedures connected with the planning and implementation of the study which resulted in the printed report.

(i) Most of the LRC/AEIC reports do not clearly distinguish between (urban, suburban and rural) residential loads.

(j) Many of the LRC/AEIC reports include data related to the broad weather variations during the report period.

TITLE: RESIDENTIAL ELECTRIC CENTRAL AIR CONDITIONING

SOURCE: Consumers Power Co.

AUTHOR(S): W.J.Jefferson
PREPARED BY AUTHOR(S) AND/OR: Consumers Power Co.

DATE OF ISSUANCE: 1964-65 Report of LRC/AEIC (printed 1966)
OTHER IDENTIFIERS: Appendix B, Section 1 (pp L-18 thru L-39); data covers 5/1/66 thru 9/30/66
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with C.P.C.

TOTAL:[PAGES 22 ;REFERENCES ;GRAPHS 6 ;TABLES 9] *
DOCUMENT CLASSIFICATION(S): 1/8, 14, 16, 19, 49

ABSTRACT: *[One of Tables is unnumbered.]

All air conditioners involved in the study were manufactured since 1957, thus eliminating any of the low power factor units manufactured prior to that time. Three of the 39 houses selected had 2 central air conditioning units, zone controlled, so that each unit served a predetermined section of the house; 36 contained single units serving the entire house.

The 5-month test period was cooler than normal, requiring the KWH use of each customer to be normalized. No normalization of demands was made since the maximum temperatures experienced were in line with normal-year maximums.

At each test home, two digital demand recorders of the punched tape type were installed to record 30-minute integrated demands for the air conditioning load only and for the total residence load. The KWH use for any period could be computed from the demand tapes and, for the total residence use, verified against the billing meter. Complete load data were obtained from 33 of the 39 test locations. Diversified demand data included at least 35 customers each month.

The average home contained 1,879 sq. ft. of living area and the average air conditioning installation was rated at 3.43 tons of refrigeration.

Purposes of Study: to learn more of the appliance's characteristics for use in rate analysis, system requirement studies and sales promotion.

Summary of Major Findings (for air conditioning load only):
1. The average use was 1,859 KWH. During a normal season, the average use would have been 2,110 KWH.

2. The maximum (half-hour diversified) demand was 3.29 KW per customer (occurring on Thursday, 9/1/60, during the half-hour ending at 2:30 p.m.).

3. The group season diversified load factor was 15.4% and for a normal

season would have been 17.5%, using the maximum (diversified) demand of 3.29 KW per customer.

4. The maximum (average weekday diversified) demand was 2.37 KW and occurred from 4 to 4:30 p.m. for the weekdays of Sept. 5-9, 1960.

5. The maximum (noncoincident) demand was 4.43 KW per customer, representing a load factor of 11%. For a normal season, this would have been 12.4%.

6. The group coincidence factor for the test period was 74.3%.

7. The test results indicate that the residential air conditioning coincident peak demand is normally between 4 and 7 p.m.

8. The diversified demand varies directly with the outdoor temperature and usually peaks within 2 hours after the temperature has reached its daily maximum. The magnitude of this peak is dependent upon temperatures during the early morning hours.

Summary of Major Findings (for total residence load):

1. The average use for the 5-month period was 5,069 KWH. For a normal season, this would have been 5,320 KWH.

2. The maximum (half-hour diversified) demand was 4.66 KW per customer occurring on 9/7/60, for the half-hour ending at 6 p.m.

3. The diversified load factor for the test period was 29.6%.

4. The maximum (noncoincident)demand was 8.3 KW. An equation for predicting this demand follows:

$$\text{maximum total residence demand (in KW)} \approx 5.28 + 1.77 \times (\text{number of electric clothes dryers in household}) + 0.26 \times (\text{living area in thousands of sq. ft.})^2 \times \sqrt{\text{air conditioner size in tons}}.$$

5. The average individual load factor was 15.8% and the coincidence factor was 56.1%.

6. Air conditioning dominates the total residence demand during days of significant air conditioning load. Total residence demand peaks at the same time as the air conditioning demand. The total residence load (less the air conditioning load) appears to peak between 8 and 10 p.m., during the air conditioning season.

TITLE: RESIDENTIAL CUSTOMER LOAD STUDY: HOMES WITH ELECTRIC CENTRAL SUMMER AIR CONDITIONING

SOURCE: Baltimore Gas and Electric Co. (Baltimore, Md.)

AUTHOR(S): W.E.Miller
PREPARED BY AUTHOR(S) AND/OR: B.G.&E.

DATE OF ISSUANCE: 1965-66 Report of LRC/AEIC (Printed 1967)
OTHER IDENTIFIERS: Appendix D, Section 1 (pp L-65 thru L-86); data covers 12 months ending 10/31/64
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with B.G.&E.
TOTAL:[PAGES 22 ;REFERENCES 3 ;GRAPHS 21 ;TABLES 10] *
DOCUMENT CLASSIFICATION(S): 1/7, 8, 14, 19, 40

ABSTRACT: *[Nine of Tables are unnumbered. Graphs are grouped into 7 Charts.]

Thirty-three cases were selected at random from relatively new homes having cooling systems averaging about 39,000 BTU/hour nominal capacity; this 39,000 value is representative of the central units being installed in the Baltimore area that are on a comparable basis with similar capacity summer air conditioning using competitive energy sources.

The 33 homes are all single-family dwellings predominantly of the ranch, cottage or split-level type; they are insulated with 4" thicknesses in the roof area and 2" in the walls and are equipped with storm doors and windows. The average home has 2,048 square feet and 16,382 cubic feet of conditioned space, contains 6 rooms, kitchen and 2 baths. [Their locations reflect a good cross section of the Metropolitan Baltimore area.]

Among the major electric appliances: ranges are in 58%, dryers in 33%, freezers in 50%, dishwashers in 73%, clothes washers in 97% and standard refrigerators are in 100%. [Of these homes, 73% are equipped with gas-fired heating systems and the remainder are oil heated.]

Magnetic tape recorders (designed for load test use thru means of a contact device attached to watthour meters) were employed in this study, using a quarter-hour time interval. One recorder was connected to a meter measuring the total-service requirements and the other was attached to another watthour meter installed to simultaneously measure the load of the central compressor air cooling unit. [In all but two cases it was necessary to install a watthour meter to measure circulating air fan requirements in order to obtain the total cooling use data.] The recorders are equipped with 900 feet of tape, which is sufficient to cover a 45-day period although the practice is to change tapes monthly.

Purposes of Study: to produce data, not heretofore available for the B.G.&E. service area, in sufficient homes to provide statistically relia-

ble air conditioning load results for use in engineering, economic and rate studies and for the development of sales estimating guides.

Summary of Major Findings:

1. The annual energy requirements for cooling are a substantial portion (34% in a normal summer) of the total use per customer.
2. Of the annual total-service and cooling uses per customer approximately 50% (of each) are "on-peak", 8:00 a.m. thru 10:00 p.m., on weekdays other than holidays.
3. For an average home the annual air conditioning use, per cooling degree day per 1000 cubic feet of cooled space, is approximately 0.16 KWH.
4. Under normal temperature-humidity conditions, yearly cooling requirements are equivalent to about 720 hrs. use of cooling connected load operation.
5. During the cooling season, the diversified total-service demand normally peaks in the early evening hours on the hottest days as well as on average weekdays of hot periods.
6. The maximum diversified total-service and cooling half-hour demands (per customer) are 18% and 80%, respectively, of the average connected loads.
7. At the hour of the annual system peak load (9/11/64, 2:00 p.m.), only 14% (4.2 KW) of the average total-service connected load operates. At this same hour, 66% (3.5 KW) of the average cooling connected load operates.
8. At the "design" outdoor dry-bulb temperature of 95 F, the maximum diversified one-hour demand for cooling equipment may be about 85% of its connected load.
9. The average monthly total-service, one-hour demand (coincident with the monthly system peak loads for the test period) is 2.5 KW, of which an average of 1.2 KW is for the cooling load.
10. Annual diversified load factors for the total-service and cooling loads are 23% and 9%, respectively. Annual noncoincident load factors are 15% and 8%, respectively, for the two loads. At 95 F, the annual diversified cooling load factor remains at 9%. [The air conditioning load tends to materially lower the residential class annual load factor.]
11. For total service (during Apr. thru Oct.) the daily use and diversified demand per customer reach maximum values on a common day. The daily cooling use is at its maximum on the day of maximum diversified total-service demand, in every cooling month except July and Oct.

TITLE: RESIDENTIAL ELECTRIC AIR CONDITIONING

SOURCE: Pacific Gas and Electric Co. (San Francisco, Calif.)

AUTHOR(S): R.I.Mendes
PREPARED BY AUTHOR(S) AND/OR: P.G.&E.

DATE OF ISSUANCE: 1965-66 Report of LRC/AEIC (Printed 1967)
OTHER IDENTIFIERS: Appendix E, Section 3 (pp L-174 thru L-185); data covers "cooling season" 1964
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.G.&E.
TOTAL: [PAGES 12 ; REFERENCES ; GRAPHS 4 ; TABLES 5] *
DOCUMENT CLASSIFICATION(S): 1/2, 14, 19, 31, 49

ABSTRACT: *[Two of Tables are unnumbered.]

The test sample was selected through the use of a questionnaire that was mailed to every tenth residential customer in the city of Fresno. Information requested included: air conditioning description, size of family and type of home - single family residence or apartment house unit. [Of the questionnaires mailed, 44.3% were returned.] Customers making up the test sample were selected at random from these responses and in accord with the available metering equipment.

Test metering equipment included magnetic tape load survey recorders. Twelve recorders were installed on central air conditioning and 6 on refrigerated room coolers. Additionally, 27 watthour meters were installed on other central air conditioning systems and 6 watthour meters on other room air conditioners. [Energy data, for those units whose demand data were incomplete, were utilized in energy use calculations.]

The testing was performed during a period when the maximum temperature in Fresno reached 110°F, on a day when the minimum was 66°F. [Normal daily summer temperature range is 39°F and the maximum has reached 110°F during 8 out of the last 30 years.]

Central air conditioning systems consisted of a compressor unit outdoors and a duct system within the home. These units were controlled by thermostats and were unrestricted as to time of operation. For those systems tested with magnetic tape recorders, average connected load for the compressor units was 3.9 KVA (excluding indoor blowers) and ranged from 2.5 to 4.5. A blower motor of approximately one-third HP was an integral part of the central duct system and was not metered on the central air conditioner circuit. Refrigerated room coolers contain both a compressor and a blower, in a single unit. All units were thermostatically controlled, unrestricted as to time of operation and had an average connected load of 2.3 KVA.

Purposes of Study: to obtain factual data about load characteristics so that the impact of air conditioning on residential and system loads

might be ascertained; to establish distribution engineering standards and provide an understanding of future load growth; to obtain demand and energy data from both central air conditioning and refrigerated room coolers together with the effect of climatic conditions on these two elements of the electrical load.

Summary of Major Findings:

1. Maximum diversified demand per customer for the test sample was 3.53 KW for central air conditioners and 2.02 KW for refrigerated room coolers.

2. The daily load curve for central air conditioners reflects a maximum diversified demand per customer on 7/25/64 at 5 p.m. For refrigerated room coolers, the corresponding demand occurred on 6/24/64 at 6 p.m.; however, the load was practically constant for an eight-hour period.

3. Maximum monthly load factor (based on maximum monthly diversified demand) occurred in Aug. for both types of cooling equipment and was 31.1% for central air conditioners and 26.7% for refrigerated room coolers. Monthly coincidence factors ranged from 99.0% to 49.5%. Demand factors (based on noncoincident maximum demands) were 115% for central air conditioners and 110% for refrigerated room coolers, with these values reflecting the fact that the units were operated at inputs in excess of rated conditions.

4. Energy use per customer during the six-month cooling season was 2,409 KWH for central air conditioners and 992 KWH for refrigerated room coolers. Proportionate cooling season shares of the total service use for air conditioning averaged 51.5% for central units and 28.8% for refrigerated room units.

TITLE: RESIDENTIAL AIR CONDITIONING LOAD STUDY

SOURCE: Pennsylvania Power & Light Co. (Allentown, Pa.)

AUTHOR(S): A.J.Baldwin, Jr.
PREPARED BY AUTHOR(S) AND/OR: P.P. & L.

DATE OF ISSUANCE: 1965-66 Report of LRC/AEIC (Printed 1967)
OTHER IDENTIFIERS: Appendix F, Section 3 (pp. L-186 thru L-195); data covers 6/30 to 9/7 (1963)
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.P. & L.
TOTAL: [PAGES 10 ; **REFERENCES** ; **GRAPHS** 8 ; **TABLES** 1] *
DOCUMENT CLASSIFICATION(S): 1/2, 14, 15, 49

ABSTRACT: * [Graphs are grouped into 5 Charts.]

This survey studies the air conditioning characteristics of 4 customer groups: (A) room unit in bedroom, (B) room unit in living area, (C) room units in a combination of bedroom and living areas, and (D) central air conditioning. It defines and quantifies the characteristics and magnitude of the residential air conditioning load served by P.P.&L. and provides the necessary empirical relationships that are needed to predict this load in the future.

An original sample of 100 customers was selected and tested. Previous appliance saturation studies were used to determine the number of customers to be tested in each group for each of P.P.&L.'s operating divisions. Although the selection procedures used do not necessarily produce a true random sample, the test results were summarized in such a manner as to minimize the influence of sampling bias.

Tests were conducted on an individual customer basis. Magnetic tape load survey recorders were installed to measure the load of air conditioning units only. In the case of customers with 2 or more units, either the combined load of the multiple units was recorded by a single instrument or, if several recorders were necessary, their individual outputs were combined in a preliminary computer-run to obtain summary data representing the customer's total load.

Purposes of Study: to determine the characteristics of residential air conditioners in the P.P.&L. service area and their impact upon the system's generation, transmission and distribution requirements.

Summary of Major Findings:
1. One of the most important differences in load traits of the 4 equipment groups is the magnitude of installed capacity per customer. The mean value for Group (A) was 1.3. KW. Room units purchased for use in living areas usually have larger cooling capacity and thus greater in-

stalled capacity; the mean value for Group (B) was 2.14 KW. Central units are designed to cool the complete home and, in this sample, Group (D) units had a mean capacity of 6.71 KW. Multiple units installed in a combination of sleeping and living areas cool large portions of the home (but not usually the entire home) and an intermediate mean value of 3.52 KW was found for Group (C).

2. Installed capacity has a direct bearing on the magnitude of diversified demand, noncoincident demand and KWH use. The actual values of these characteristics vary significantly from group to group but when each of these load quantities is expressed as a % of installed capacity, the variation between groups disappears.

3. The average (weekly maximum) diversified demand per customer was 0.38, 0.80, 1.25 and 2.1 KW for Groups (A)-(D), respectively.

4. The (maximum weekly) noncoincident demand per customer was 0.73, 1.23, 1.92 and 3.5 KW for the respective (A)-(D) groups.

5. During the test period, the respective (A)-(D) groups used 202, 287, 576 and 942 KWH.

6. The location of the air conditioning unit, the time period and the hours spent in the area of the unit's location all have a direct bearing on the load characteristics of this appliance but the single variable observed to have the greatest influence is the Temperature Humidity Index (THI), which increases with the degree of "discomfort". [Note: ThI = 0.4[(dry-bulb degrees F) + (wet-bulb degrees F)] + 15.]

7. As the THI level increases, the hourly demands for each group increases and the load patterns change. A high correlation is demonstrated between THI and the following: maximum diversified demand, daily use, demand factor and daily load factor (based on installed KW); the magnitude of each of these load characteristics increases with increasing temperature and humidity.

8. Group (A) had an observed daily load factor of 48%, with peaks occurring during late afternoon and evening on very warm days. The load patterns of Group (B) have prominent afternoon peaks and the daily load factor of this group is only 39%. Groups (C) and (D) also exhibited prominent peaks at about 11 p.m. and 3 p.m., respectively; their respective daily load factors were 42 and 43%.

TITLE: RESIDENTIAL CENTRAL AIR CONDITIONING

SOURCE: Detroit Edison (Detroit, Mich.)

AUTHOR(S): L.E.Brandenburg (for E.H.Scott)
PREPARED BY AUTHOR(S) AND/OR: D.E.

DATE OF ISSUANCE: 1966-67 Report of LRC/AEIC (Printed 1968)
OTHER IDENTIFIERS: Appendix B, Section 3 (pp L-157 thru L-165); data covers summer of 1965
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with D.E.

TOTAL: [PAGES 9 ;REFERENCES 1 ;GRAPHS 5 ;TABLES 3]
DOCUMENT CLASSIFICATION(S): 1/14

ABSTRACT: *[Graphs are grouped into 3 Charts.]

Recording 30-minute demand and watthour meters were installed on the central air conditioners of 30 employee-customers who had recently purchased the units. Energy use was metered from the installation date thru mid-Sept. and estimated for the balance of the cooling season (nominally, June 1 thru Sept. 30). [Since the summer of 1965 was unusually cool, normal summer use is also estimated for each customer based on correlations of test period energy use and CDH.]

Demand data was extracted for the 5 warmest days of the test period and for a random sample of 5 days each, in 4 other degree-day groups. From these data, average day load curves are obtained for each of 5 temperature levels and correlations (of energy use and demands) with temperature are calculated.

Note: From 1956 to 1966, the air conditioning component of D.E.'s summer system loads increased by a factor of 3, in a day with 85°F mean temperature.

Purposes of Study: to develop the load characteristics of 30 central air conditioning installations in the D.E. area as a basis for determining the impact of this specific load on summer system peaks and on residential sales.

Summary of Major Findings:
1. Annual energy use per customer for the test period was 1,247 KWH. During the period there were 3,965 cooling degree-hours (CDH, at 75°F dry-bulb base temperature). [For an "average" summer (5,156 CDH), the average use is estimated as 1,615 KWH.] Individual customer use ranged from 390 to 2,930 KWH for the four-month test period (June thru Sept.).

2. The average installation tested was rated at 2.5 tons (of refrigeration) and had a one-third horsepower fan. The noncoincident maximum demand was

3.59 KW per customer.

3. The diversified maximum demand per customer was 2.85 KW, from 4 to 4:30 p.m. on Saturday, Aug. 14; the maximum temperature was 95°F. On Aug. 15, the warmest day of the cooling season, the maximum demand was 2.68 KW for the half-hours ending at 4:30 and 6 p.m.

4. The coincidence factor of the air conditioning load for the test period was 79.4%. The annual load factor was 5.0%, based on the diversified maximum demand; for a year with an average summer this factor is estimated at 6.5%.

5. Based on the 2 p.m. demand (60 minute integrated) of 2.26 KW per test customer, a 4% saturation of central air conditioners in the D.E. service area would add an estimated 116 megawatts to the system peak on a day having an 80 to 85°F mean temperature.

In spite of the subnormal (1965) summer temperatures and the potential bias of the sample because of the preponderance of employes included, the results of the study (after adjustments to normal season use) are considered indicative of the load characteristics of central air conditioners in the Detroit area. In a 1956 study of central air conditioning, annual use per customer was 1,495 KWH, for a normal summer; the diversified maximum demand was 3.31 KW; the group coincidence factor was 80.7%; the annual load factor was 5.2%. [The higher maximum demand reflects the larger size of the average test installation in the previous study.]

TITLE: RESIDENTIAL CENTRAL AIR CONDITIONING

SOURCE: Long Island Lighting Co. (Mineola, N.Y.)

AUTHOR(S): G.W.Sellar (for H.L.Parlette)
PREPARED BY AUTHOR(S) AND/OR: L.I.L.

DATE OF ISSUANCE: 1967-68 Report of LRC/AEIC (Printed 1969)
OTHER IDENTIFIERS: Appendix A, Section 3 (pp L-118 thru L-127); data covers May thru Sept. of 1962 & 1963
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with L.I.L.
TOTAL: [PAGES 10 ;REFERENCES 1 ;GRAPHS 11 ;TABLES 4] *
DOCUMENT CLASSIFICATION(S): 1/7, 14, 19, 40

ABSTRACT: *[The Tables are unnumbered. Graphs are grouped into 4 Charts.]

The test sample was drawn from recent installations where L.I.L. had been asked to make a cooling survey. Meters were installed on both the total and the air conditioning load. [As the summer of 1962 was "cool", the test was extended to the summer of 1963.] In order to compare individual units of varying sizes, test results were related to a "per ton" basis.

The ten locations were residential, single-dwelling homes containing from 2 to 7 people; floor areas and installed unit capacities ranged from 1,120 to 2,670 sq ft and 3 to 4 tons (average = 3.4).

Only 3 of the 10 units were "undersized" while 7 were "over-sized". [The apparent tendency of the customers is to select a unit with a BTU rating in excess of the calculated heat gain.] Oversizing does not assist in efficient operation of the unit since the thermostatic control for the air conditioner responds to dry-bulb temperature and an oversized unit can cycle on and off in such a short time that adequate de-humidification does not take place. The test results indicate no customer dissatisfaction due to the selection of a unit with a lesser rating than that calculated in the cooling survey; the effect (of undersizing) on the system is quite favorable since the limit on the unit maximum demand protects against high demands during severe weather conditions.

Purposes of Study: providing a means for estimating KWH sales, average cost to the customer per ton of installed capacity, contribution to the system summer peak and other parameters relating to the unit performance of this type of unit.

Summary of Major Findings:
1. The cooling season energy use - reflecting 1,188 cooling degree days (CDD) of a single unit in "continuous operation" - was determined to be 1,220 KWH per ton of refrigeration. The average energy use experienced by the group was about 1,100 KWH per ton per cooling season.

2. The presence of central air conditioning in the home may result in higher energy use of other appliances.

3. Diversity exists in the daily operation of central air conditioning at a daily average THI level below 74. At daily average THI levels of 77 and above, there is no significant diversification in the maximum hour demand per ton between the individual units and the group performance. [Note: THI = temperature humidity index = 0.4 (dry-bulb + wet-bulb; temperatures in degrees F) + 15.]

4. More than one-half of the daily group maximum diversified demands occurred from 6 to 7 p.m. and 85% between 4 and 7 p.m. As the daily average THI increases, the likelihood of an afternoon peak increases.

5. Group operation load factor for the cooling season (May through Sept.) was 24.1%, based on the maximum diversified demand, and 28.3% based on the diversified demand coincident with the system summer peak. The annual load factors on this equipment - using summer demands and energies - are 8.9% maximum diversified and 10.5% coincident with the system summer peak.

TITLE: RESIDENTIAL ELECTRIC CENTRAL AIR COOLING

SOURCE: Philadelphia Electric Co. (Philadelphia, Pa.)

AUTHOR(S): W.F.Sundermeir (for R.A.Markel)
PREPARED BY AUTHOR(S) AND/OR: P.E.

DATE OF ISSUANCE: 1967-68 Report of LRC/AEIC (Printed 1969)
OTHER IDENTIFIERS: Appendix B, Section 3 (pp L-128 thru L-134); data covers June, July, Aug. 1966
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.E.

TOTAL: [PAGES 7 ; REFERENCES 1 ; GRAPHS 6 ; TABLES 4] *
DOCUMENT CLASSIFICATION(S): 1/8, 14, 15, 19, 25, 40

ABSTRACT: *[Three of Tables are unnumbered. Graphs are grouped into 2 Charts.]

From information provided by distributors of various types of central cooling equipment, a mass sample of approximately 650 geographically distributed customers was obtained. [Only the installations made since 1/1/63 were considered in order to obtain a sample group of customers using modern air cooling equipment operating in a manner which would reflect "up-to-date" habits of customers.] A test sample of 63 customers was selected from this mass sample by using a table of random numbers.

The period of the test was for the three months normally accounting for about 82% of the total cooling season effective degree-hours.

The type of units (and number of each) tested were: apartment (1); row house (10); semi-detached (9); single homes (43). The number of rooms (including baths) averaged 9.1 and the number of occupants averaged 3.8.

Purposes of Study: new load tests to evaluate possible changes in the operating characteristics of the equipment and changes in the operating habits of the customers in order to obtain up-to-date information for system planning, rate making and profitability studies.

Summary of Major Findings:
1. For the test period the average energy use per central air cooling unit is 3,530 KWH for 7,064 effective degree-hours. [The normal effective degree-hours for this period is 6,995 and for the entire cooling season is 8,485. The energy use for a normal cooling season can be expected to be 4,240 KWH.]

2. The air cooling use of individual customers averaged 3,530 KWH and ranged from 353 to 8,158 KWH, for the three-month test period.

3. The maximum diversified demand (for the average weekday of the hottest test week) is 3.85 KW and for the hottest weekday of the test period is 4.43 KW, with both demands occurring during the half-hour ending 6:30 p.m. [The coincidence factor for the average weekday of the hottest test week is 85.5%.]

4. Compared to 1957 test data, there has not been a significant change in the daily load characteristics of central air cooling units on hot weekdays but the average annual use has increased significantly.

5. Compared to the average customer in 1957, the average volume of the conditioned space has increased from about 14,380 to 21,410 cubic feet while the average heat gain has decreased from about 36,090 to 30,470 BTU per hour, which may well be an indication that the homes of the present test sample are better insulated.

TITLE: RESIDENTIAL CENTRAL AIR CONDITIONING STUDY

SOURCE: Long Island Lighting Co. (Mineola, N.Y.)

AUTHOR(S): J.R.Crespo (for R.E.Ashburn)
PREPARED BY AUTHOR(S) AND/OR: L.I.L.

DATE OF ISSUANCE: 1969-70 Report of LRC/AEIC (Printed 1971)
OTHER IDENTIFIERS: Appendix B, Section 3 (pp L-131 thru L-143); data covers June thru Sept. 1969
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with L.I.L.

TOTAL:[PAGES 13 ;REFERENCES 1 ;GRAPHS 15 ;TABLES 3] *
DOCUMENT CLASSIFICATION(S): 1/14, 40

ABSTRACT: *[One of Tables is unnumbered. The Graphs are grouped into 6 Charts.]

A random sample of 20 customers was selected. Final results include 16 customers. Two magnetic-tape recorders were installed at each home to monitor the total and cooling demands. Results include hourly load characteristics. All recorders were installed during the early part of June 1969 and remained in service through Sept. 1969.

Purposes of Study: to obtain load characteristics (of single-dwelling homes having central air conditioning) including: group diversified demands, coincident and noncoincident demands, energy consumption and load factors.

Summary of Major Findings:
1. The cooling energy use was ≈ 50% of the total energy consumption for June thru Sept. On an annual basis, the comparable value was 23%.

2. The diversified demand - coincident with the system peak of the customers tested - was 335% greater than that of the average residential customer (4.72 vs 1.41 KW).

3. The annual "total load" load factor - based on the diversified demand coincident with the system summer peak of the customers tested - was about 33% lower than that for the (1965-68) average residential customer (33.4 vs 52.0%).

4. The annual "total load" noncoincident load factor of the customers tested was slightly higher than that for the (1965-68) average residential customer (17.7 vs 15.4%).

5. The 11% annual "cooling load" load factor - based on the diversified demand coincident with the system summer peak - compares with a 7% cooling load annual load factor based on maximum noncoincident demands.

6. The "cooling load" demands, coincident and noncoincident with the system peak, were respectively 0.88 and 1.35 KW/ton (of refrigeration).

7. The average cooling energy consumption for the period of June thru Sept. was 846 KWH/ton (of refrigeration).

8. For the test period of June thru Sept. there were 1,175 cooling degree-days, compared with a normal of 1,107.

9. Diversity exists in the daily operation of the central air conditioning units at daily average Temperature Humidity Index levels below 78. [Note: THI = 0.4(dry-bulb°F + wet-bulb°F) + 15]. Therefore, it can be expected that at THI levels above 78 all units will be in operation. Thirteen of the 16 test customers interviewed claimed to run their cooling units continuously. However, from the data collected, there are strong indications that only 7 of the 13 did, in fact, operate continuously.

TITLE: RESIDENTIAL CUSTOMER LOAD STUDY: HOMES WITH ELECTRIC CENTRAL AIR CONDITIONERS

SOURCE: Baltimcre Gas and Electric Co. (Baltimore, Md.)

AUTHOR(S): L.S.Lydard, Jr. (for W.E.Miller)
PREPARED BY AUTHOR(S) AND/OR: B.G.&E.

DATE OF ISSUANCE: 1974-75 Report of LRC/AEIC (Printed 1976)
OTHER IDENTIFIERS: Appendix A, Section 1 (pp L-7 thru L-31); data covers 12 months ending 4/30/74
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with B.G.&E.
TOTAL: [PAGES 25 ; REFERENCES 3 ; GRAPHS 9 ; TABLES 5]
DOCUMENT CLASSIFICATION(S): 1/8, 14, 19, 40, 49

ABSTRACT: This Study covers a test of the load characteristics of 31 single-family dwellings, with air conditioner and circulating-air fan and total-service energy requirements recorded simultaneously at 15 minute intervals. The sample (of 31) was selected on a systematic random basis from a population of about 2,400 single-family homes. A variety of housing styles were included in the test "sample", with the "average" home containing 5 rooms plus a kitchen and two baths.

Purposes of Study: Obtaining current data for Baltimore area for use in engineering/economic/rate studies; developement of sales estimating guides; comparison with results of a 1964 (similar) test, as printed in the 1965/66 LRC Report. [Note: a 5-step declining block structure rate prevailed for the Study, with mid-May to mid-October pricing (for use in excess of 500 KWH/month) at a 45% higher level than for the rest of the year.]

Summary of Major Findings:

1. The annual average per customer of 4,507 KWH is equivalent to 799 hours use of the cooling connected load. [On a normalized CDD basis, these values are 4,546 KWH and 806 hours.]

2. 34% of the average customer's annual total-service requirements is for cooling, with the monthly values varying between about 1% and 67%.

3. 49% of the annual total-service energy is used "on peak" (8 am to 10 pm inclusive, on weekdays other than holidays), while 52% of the cooling requirement is "on peak".

4. Annual normalized cooling use is equivalent to 0.21 KWH per CDD per 1,000 cubic feet of cooled space or 0.10 KWH per CDD per 1,000 Btu/hr of nominal cooling capacity.

5. The maximum diversified cooling demand occurred between 3:30 pm and 6 pm.

6. The average cooling use per customer is 76.3% of the total-service use per customer on the day of the annual peak (August 30, 1973; 85°F mean).

7. During the annual peak hour (August 30, 1973; 4 pm), 83.7% of the cooling connected load operated.

8. The average cooling unit adds 1.64 KW to the Baltimore load monthly peaks averaged over the 12-month period; this amounts to 29.0% of the cooling connected load.

9. Cooling maximum diversified demands (measured over a 1/4 hour interval) are from 1.4% to 14.5% greater and 1-hour demands are less, by 1.4% to 7.9% than those measured over the standard 1/2 hour interval.

10. The daily cooling uses and daily maximum diversified 1/2 hour cooling demands best correlate with CDD as linear relationships. The daily cooling uses best correlate with daily maximum diversified cooling demands as a linear relationship.

11. Annual load factors (based on maximum diversified 1/2 hour demands) are 24.6% for total service and 10.5% for cooling; comparable annual load factors (based on noncoincident maximum demands) are 15.7% for total service and 9.5% for cooling.

12. The annual demand factor for cooling is 86.4%. The cooling load tends to materially lower the average test customer's annual load factor.

TITLE: RESIDENTIAL CUSTOMER LOAD STUDY

SOURCE: Houston Lighting & Power Co. (Houston, Texas)

AUTHOR(S): T.A.Standish (for J.A.Leo)
PREPARED BY AUTHOR(S) AND/OR: H.L.&P.

DATE OF ISSUANCE: 1974-75 Report of LRC/AEIC (Printed 1976)
OTHER IDENTIFIERS: Appendix E, Section 1 (pp L-142 thru L-159); data covers Jan. 1 to Dec. 31, 1974
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with H.L.&P.
TOTAL: [PAGES 18 ;REFERENCES ;GRAPHS 4 ;TABLES 14] *
DOCUMENT CLASSIFICATION(S): 1/4, 7, 8, 14, 15, 19, 22, 24, 48

ABSTRACT: *[Four of Tables are unnumbered.]

The study provides a comparison of the relationship between energy use and peak demands for the total use of each home as well as for the three additional major loads metered. For purposes of this study, each group of items metered is treated independently. Energy and demand data for each group are summarized under Major Findings.

Sixty-one single-family all-electric homes (served from underground distribution lines) were chosen for testing. A stratified sample was selected on the basis of energy use (for 7 ranges of 5000 KWH equal intervals) to match the distribution of all-electric homes in the H.L.&P. service area. Extremes below 10,000 KWH and above 45,000 KWH were not sampled since they accounted for only 5% of the total.

Company representatives contacted each homeowner to request cooperation and to examine the feasibility of metering the desired circuits. At that time the floor area, connected appliance load, occupancy level and operating habits were determined.

The test period began with the installation of one, four channel, demand recorder at each residence. One of the three usable channels was used to meter the total load while the remaining channels were selectively used to meter two of the three additional major loads. Total demands at all locations were metered each 15 minutes and were combined to provide hourly demands for study purposes.

The homes in this program average 1,563 sq. ft. and range from 952 to 2,126 sq. ft. Central electric heating and cooling systems and electric water heaters are common to each residence. Saturation levels for major appliances are: 100% for Air Conditioning, Space and Water Heating, Ranges and Refrigerators; 96.7% for Disposals; 90.2% for Dishwashers; 83.6% for Clothes Washers; 80.3% for Dryers; 31.1% for Food Freezers.

Purposes of Study: to determine the load characteristics of all-electric

residential customers through examination of demand and use data for heating, cooling, water heating and total loads; to apply the results to rate of return analysis, load forecasting and determination of effects on system demand.

Summary of Major Findings:

1. Average Energy Use Per Customer (KWH)

Group	Annual	Monthly
Total Load	27,386	1,695 to 2,860
Air Conditioning	8,534	46 to 1,718
Space Heating	6,002	110 to 1,364
Water Heating	5,409	366 to 553

2. (KW) Demand Characteristics for:

	Total Load	Air Cond.	Space Heat.	Water Heat.
(a)	8.9	4.5	7.2	1.8
Date	1/3	8/19	11/30	2/17
Time, hour ended (b)	7 pm	4 pm	9 am	7 pm
(c)	54.6	91.8	59.0	40.0
Annual load factor, %	35.1	21.6	9.5	34.3
(d)	6.0	4.1	0.4 (e)	0.3
Date	8/20	8/20	8/20	8/20
Time, hour ended (b)	4 pm	4 pm	4 pm	4 pm
(c)	36.6	83.7	3.1	7.4
Annual load factor, %	52.1	23.8	171.3	205.8

(a) = group maximum diversified demand per customer
(b) = Central Standard Time
(c) = % of noncoincident peak demand
(d) = demand coincident with system peak
(e) In 35 of the 42 space heating installations, the air handling units for the central heating and cooling system are served from the space heating circuit. Since it was not feasible to separate the two loads, the entire circuit was metered. The operation of the air handler for air conditioning appears as space heating use and accounts for the apparent heating operation during summer months; at 300 to 500 watts per customer, this should not significantly distort study results.

3. Test year space heating use during the winter (Nov. thru Apr.) occurs at a rate of about one KWH for each 5.5 degree-hours below 65°F. This rate is reasonably constant for each heating month. [The 28,941 degree-hours for 1974 are 22.8% lower than the 25-year average of 37,487.]

4. Air conditioners operate an average of 1742 hours during the year, based on their noncoincident maximum demands. Air conditioning use averages one KWH for each 4.1 degree-hours above 72°F, with a monthly ratio ranging from 3.3 to 5.2. Cooling degree-hours for 1974 total 34,941 compared with a 25-year average of 35,436.

TITLE: RESIDENTIAL AIR COOLING with ROOM UNITS

SOURCE: Public Service Electric and Gas Co. (Newark, N.J.)

AUTHOR(S): P.F.Platt (for B.P.Dahlstrom)
PREPARED BY AUTHOR(S) AND/OR: P.S.E.&G.

DATE OF ISSUANCE: 1961-62 Report of LRC/AEIC (Printed 1963)
OTHER IDENTIFIERS: Appendix A, Part 2; Section 3 (pp L-183 thru L-194); data covers June thru Sept., 1961
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.S.E.&G.
TOTAL: [PAGES 12 ;REFERENCES ;GRAPHS 17 ;TABLES 4] *
DOCUMENT CLASSIFICATION(S): 2/14, 15, 31, 40, 49

ABSTRACT: *[The Graphs are grouped into 3 Charts.]

A random sample was selected from completed questionnaires obtained during a residential electric appliance saturation survey. Thirty customers with room air conditioning units and 2 alternates each were drawn by ordinal position for each of the 3 groups selected for study.

Tests were conducted on an individual customer basis. Magnetic tape recorders were installed to measure the load of air conditioning units only. [In the case of customers with 2 or more units, the combined load of the multiple units was measured at a single metering point.] All tapes were translated and acceptable data processed on a group basis. Corresponding hourly demands and temperature-humidity indices were correlated to obtain hourly demand and temperature-humidity index relationships from which synthesized load curves at constant hourly temperature-humidity indices were derived.

The hourly temperature-humidity index used in the demand-temperature correlation was determined by the following equation:
THI = 0.4[degrees F, dry-bulb + degrees F, wet-bulb] + 15

Purposes of Study: to obtain the load characteristics of the room air conditioning units of 3 sample groups of residential customers with: (a) single units in bedrooms, (b) single units in living rooms, (c) two or more units - in any location; to permit more accurate assessment of this type of load. [Note: The increase in the number of electric room air conditioning units used in residences has had a significant impact on summer use and system peak. The saturation of room air conditioning units increased from 11% in 1955 to 35% in 1961.]

Summary of Major Findings:
1. Energy use for (b) units exceeded that of (a) units by about 22%. Energy use per unit of the (c) class units was lower than that for the (a) and (b) classes for each of the 4 test months. However, (c) class

use per customer was higher than that for (a) and (b) for each of the 4 test months.
2. The synthesized load curve - which shows the relationship of the average hourly demand at constant THI - indicates that the demand at constant temperature is lowest from 12 noon to 3 p.m. and peaks during the evening hours.
3a. Load factors in the individual summer months for the (a) units ranged from 12 to 31% on a diversified basis and from 8 to 18% on a noncoincident basis. Coincidence factors varied from 57 to 79%. [The use per average unit can be expected to range from 64 to 150 KWH per month.]
3b. Load factors for the (b) units ranged from 10 to 25% on a diversified basis and from 6 to 15% on a noncoincident basis. Coincidence factors varied from 62 to 75%. [The use per average unit can be expected to range from 69 to 186 KWH per month.]
3c. Load factors for the (c) units ranged from 10 to 24% on a diversified basis and from 7 to 16% on a noncoincident basis. Coincidence factors varied from 61 to 72%. [The use per unit can be expected to range from 58 to 129 KWH per month.]
4a. The daily diversified load factor (DDLF) on hot days for the (a) units can be expected to be over 46%, with a coincidence factor over 57%.
4b. Similarly for the (b) units, the DDLF can be expected to be over 50%, with a coincidence factor over 62%.
4c. Similarly for the (c) units, the DDLF can be expected to be over 42%, with a coincidence factor over 60%.
5a. Diversified load curves (DLC) for the (a) units were similar during July and Aug. for both weekday and weekend. However, in June the diversified demands for weekdays exceeded weekends significantly, while in Sept. the reverse was true.
5b. The DLC for the (b) units were similar during July for both weekday and weekend. However, diversified demands during weekdays were significantly greater during June and Aug. while the reverse was true during Sept.
5c. The DLC for the (c) units were similar during July for both weekday and weekend. However, diversified demands per unit during weekdays were significantly greater during June and Aug. while the reverse was true during Sept.
6. Diversified demands vary directly with THI, as shown by the synthesized load curves.
7. Variations in the magnitude of weekday and weekend diversified demands - as noted under 5a, 5b and 5c - are not related entirely to fluctuations in THI. During June the THI was about 2% higher for weekdays than for weekends, while in July, Aug. and Sept. there was little if any difference. [Customer living habits are directly related to the magnitude in the diversified demands during the months of Aug. and Sept. It is generally recognized that people are more likely to be away during weekends in Aug. while in Sept. vacations are usually over and the requirements for air conditioning generally would then be greater for weekends.]

TITLE: RESIDENTIAL ELECTRIC WINDOW AIR CONDITIONING

SOURCE: Long Island Lighting Co. (Mineola, N.Y.)

AUTHOR(S): F.J.Kelsey (for H.L.Parlette)
PREPARED BY AUTHOR(S) AND/OR: L.I.L.

DATE OF ISSUANCE: 1966-67 Report of LRC/AEIC (Printed 1968)
OTHER IDENTIFIERS: Appendix A, Section 3 (pp L-146 thru L-156); data covers June thru Sept., 1964
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with L.I.L.
TOTAL: [PAGES 11 ; **REFERENCES** 1 ; **GRAPHS** 8 ; **TABLES** 6] *
DOCUMENT CLASSIFICATION(S): 2/7, 14, 15, 19, 40

ABSTRACT: *[Three of Tables are unnumbered. Graphs are grouped into 4 Charts.]

The test sample was drawn from the answers to an appliance saturation survey. Selections of customers with one, two and three window air conditioning units were made based on their frequency of occurrence and geographic distribution on the system; 72 units representing 54 customers were metered. [Eleven of the 72 units metered were actually not used in the analysis because of metering difficulties.] The total house load was metered with demand register meters. The 61 units, having data reported, comprised 47 bedroom units and 14 "other-units" located other than in the bedroom.

The May through Sept. cooling season energy use was derived by estimating data for May and a portion of June, based on the experience of the test period. Daily average temperature-humidity index (THI) values were derived from the following equation: THI = 0.4(dry + wet-bulb, temperatures in °F) + 15. The number of cooling degree-days [CDD = daily average THI - 60] during the summer season was 1,053; this was 13% below the 39-year average of 1,188.

The sampling error for the 61 units (based on the cooling season maximum noncoincident demand) was 10%, at the 95% confidence level.

Purposes of Study: to examine the load characteristics of window air conditioners for use in determining their effect on L.I.L.'s system and distribution demands and on sales.

Summary of Major Findings:
1. The bedroom units averaged 215 KWH annually and were (heat) rated at 7,725 BTU/hour on average. The corresponding values for the "other-units" were 313 KWH and 9,700 BTU/hour. [Note: for a normal cooling season, all 61 units would have had an average use of 297 KWH.]

2. The bedroom units had a maximum (diversified) hourly demand averaging 0.59 KW; the "others" averaged 0.91.

3. The bedroom units' load factor was 4.2%, on average; the "others" averaged out at 3.9%.

4. There is no correlation between seasonal energy use and unit size.

5. At daily average THI values of 70 or greater, the combined group "peaked" most frequently at 5 and 6 p.m. and at midnight. The group of bedroom units peaked primarily at midnight and 1 a.m.; the "other-units" at 3, 5 and 6 p.m. [Note: An increase in daily average THI moved the time of the daily peak, for the combined group, towards midnight.]

6. The day of the week had no influence on the daily peak of the 61 units.

7. Coincidence factors for the test period were 53.8% for all units, 52.2% for the bedroom units and 65.0% for the "other-units".

TITLE: RESIDENTIAL CUSTOMER LOAD STUDY: HOMES WITH ELECTRIC ROOM AIR CONDITIONER

SOURCE: Baltimore Gas and Electric Co. (Baltimore, Md.)

AUTHOR(S): L.S.Lydard, Jr. (for W.E.Miller)
PREPARED BY AUTHOR(S) AND/OR: B.G.&E.

DATE OF ISSUANCE: 1972-73 Report of LRC/AEIC (Printed 1974)
OTHER IDENTIFIERS: Appendix A, Section 3 (pp L-215 thru L-244); data covers 12 months ending 3/31/72
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with B.G.&E.
TOTAL: [PAGES 30 ;REFERENCES ;GRAPHS 16 ;TABLES 6] *
DOCUMENT CLASSIFICATION(S): 2/7, 8, 14, 19, 33, 40, 49

ABSTRACT: *[One Table is unnumbered. Graphs are grouped into 9 Charts.]

This study covers a test of the load characteristics of 32 single-family homes equipped with electric room air conditioners. The energy requirements of one such conditioner and of the total service were recorded separately and simultaneously in each home throughout the test year. These homes were selected from a total of about 260,000 (with room air conditioners) supplied by B.G.&E.. The average test unit provides cooling for about 3,600 cubic feet of space. The numbers and locations of test units were: 17 in dining rooms, 9 in living rooms, 5 in bedrooms and 1 in a kitchen. Nineteen of the 32 test customers have more than one room air conditioner; 9 customers having 2 and 10 having 3 units.

The test homes are single-family dwellings; 14 are row homes, 10 are cottages, 6 are ranch homes, 1 is a bungalow and 1 is a split-level home. The primary type of construction is brick. Insulation averages 4.1" in roofs and ceilings and 1.8" in exterior walls. The average home contains seven rooms plus a kitchen and a bathroom.

The information on appliances and connected loads was obtained by detailed inspection of the various premises. Average total-service connected load in the 32 homes is 20.0 KW and average room air conditioner connected load for the units tested is 2.5 KW. For individual customers' homes, connected loads vary from 9.2 to 45.7 KW for total service and from 0.9 to 4.2 KW for the room air conditioners tested. The average connected load statistics indicate that the uses for other than the room air conditioners are influenced predominantly by the frost-free refrigerators, water heaters, standard refrigerators and freezers.

Magnetic tape recorders designed for load test use (in conjunction with contact-equipped watthour meters) were employed for the duration of this 1-year load study which used a quarter-hour time interval. At each premise one recorder was connected to a watthour meter to measure the total-service requirements of the home and another was used to simultaneously monitor the load of a room air conditioner.

Purposes of Study: primarily conducted to obtain air conditioner data not previously available for the B.G.&E. service area for use in engineering, economic and rate studies and for the development of sales estimating guides.

Summary of Major Findings:

1. An annual use of 773 KWH by the average room air conditioner tested is equivalent to 313 hours use of connected load. [On a normalized degree-day (DD) basis these values are 764 KWH and 310 hours, respectively.]
2. Of the average customer's total-service annual requirement, which includes use by an average of 1.9 air conditioners, 10% is used by the one air conditioner that was tested per home; the monthly relationship varied between 0 and 25%.
3. Of the annual total-service energy requirement, 48% is used "on peak" (8 am thru 10 pm on weekdays other than holidays) while 55% of the measured room air conditioner requirement is used on peak.
4. For an average home with a room air conditioner, annual cooling use on a normalized DD basis is equivalent to 0.17 KWH/DD/1000 cubic feet of cooled space or to 0.04/KWH/DD/1000 BTU/HR of nominal cooling capacity.
5. The maximum (diversified) measured cooling demand occurred between 5 and 6:30 pm, in the period May thru Sept. In Oct. this maximum occurred in the half-hour ended 3:30 pm.
6. The measured cooling use per customer is 36% of the total-service energy use per customer on the day of the Baltimore Contract Load (BCL) peak (July 1, 82°F mean).
7. In the cooling months, in the hour of the monthly BCL peak, a maximum of 12.3% of the total-service and 51.6% of the measured room air conditioner connected loads operate; these occurred in the hour ended 4 pm on Sept. 9.
8. When compared to standard half-hour measurements, cooling maximum (diversified) demands for the average tested air conditioner, measured over a quarter-hour interval, are greater (by up to 19%) and measured over a one-hour interval are less (by up to 6%).
9. Each room air conditioner adds 0.43 KW to the BCL monthly peaks, averaged over the 12-month period. [This is $\approx$ 18% of the average connected load of the tested units.]
10. The daily cooling uses and daily maximum (diversified) half-hour cooling demands correlate best with DD as linear relationships.
11. The daily cooling uses correlate best with daily maximum (diversified) cooling demands as a linear relationship.
12. Annual load factors, based on maximum (diversified) half-hour demands, are 30.5% for total service and 5.5% for the measured cooling; comparable factors, based on (noncoincident) maximum demands, are 15.1% and 3.8% respectively.
13. The cooling load of the room air conditioner tends to materially lower the average test customer's annual load factor.

TITLE: RESIDENTIAL CUSTOMER LOAD STUDY: ALL-ELECTRIC HOMES with HEAT PUMPS

SOURCE: Texas Power & Light Co. (Dallas, Texas)

AUTHOR(S): L.W.Howard
PREPARED BY AUTHOR(S) AND/OR: T.P.&L.

DATE OF ISSUANCE: 1962-63 Report of LRC/AEIC (Printed 1964)
OTHER IDENTIFIERS: Appendix B, Section 1 (pp L-20 thru L-36); data covers 12 months ending 4/23/62
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with T.P.&L.
TOTAL:[PAGES 17 ;REFERENCES ;GRAPHS 9 ;TABLES 5] *
DOCUMENT CLASSIFICATION(S): 3/7, 8, 14, 15, 20, 22, 48

ABSTRACT: *[One of Tables is unnumbered. Graphs are grouped into 8 Charts.]

The test sample consisted of 29 homes of brick construction located in a newly developed subdivision of 50 such homes. Ten different floor plans were included in the test. The homes range from 9,600 to 11,200 cu. ft. of heated space. Occupants numbered from 2 to 8, with an average of 4.1 per family. All houses are fully insulated (6", ceiling; 4", walls; 2", floor) and equipped with a 2- or 3-ton heat pump plus 6 KW of supplementary resistance heating, 40 gallon quick-recovery, double interlocked-element water heater (uncontrolled) and an electric range.

All of the "sampled" homes had ranges, refrigerators, heat pumps, water heaters, garbage disposals and televisions. In addition, 83% had washers, 52% had dryers and 34% had freezers.

Two quarter-hour indicating demand meters were installed to monitor each home, on the total-service load and on the total heat pump load. In addition, all water heater loads were measured with watthour meters. Magnetic tape, load survey recorders were installed on the water heaters for a 2-week period in the summer. These tape recorders also were installed on the total-service load for a 3-week period in the summer and for a 1-month period in the winter. Note: The winter test period of total-service load was during the coldest Jan. since 1949 in this area. Temperatures for the month were 5.4 F below normal and the 27-day test period was 155 degree-days (65 F base) above normal. [Integrated demands for the load survey recorders are for half-hour time intervals.]

Purposes of Study: to gain information from accumulated test data for rate analysis, load factor improvement studies and sales promotional purposes.

Summary of Major Findings:
1. Annual average total service energy use per customer for the test group is 18,415 KWH. Heat pump energy use (8,736 KWH) is 47.5% of total-service

energy use on an annual basis. [Note: Daily total-service use and maximum demands correlate closely with heating or cooling degree-days, as the case may be.]

2. Total-service maximum (diversified) half-hour demand per customer is 9.9 KW and occurred at 8 a.m. Wednesday, on the coldest day of the heating season. The corresponding demand per customer for the cooling season is 4.5 KW and occurred at 6 p.m. on a Sunday.

3. Water heater energy use is 26.3% (4,847 KWH) of the total service energy use for the year. For the cooling season, the maximum diversified demand of the uncontrolled units occurred between 10:30 and 11:30 a.m. The coincidence factor is 26.9%.

4. Base load energy use is 26.2% (4,828 KWH) of the total-service energy use and varies from 477 KWH per customer in Jan. to 321 KWH in July.

5. Annual load factor for the group was 11.8%, based on the annual noncoincident maximum demand. Due to relatively short intervals of high peak demands during the heating season, the 10.3% annual load factor of the heat pump was lower than that of the total-service load which was 11.8%. Total-service monthly load factors, based on noncoincident demands, range from 21.5% in Jan. to 11.6% in May.

6. Winter maximum (diversified) demand is 220% of corresponding summer demand and occurs at 8 a.m. (on a Wednesday) as opposed to a 6 p.m. (Sunday) summer maximum. Winter non-coincident maximum demand is 147% of that for summer.

7. Customers with 3-ton heat pumps used an average of 6.9% (1,353 KWH) more total-service energy than those with 2-ton units. [A correlation to size of homes and families was not made.]

TITLE: ALL-ELECTRIC HOMES with HEAT PUMPS

SOURCE: The Hartford Electric Light Co. (Westerfield, Conn.)

AUTHOR(S): R.C.Fosberg
PREPARED BY AUTHOR(S) AND/OR: H.E.L. (for Northeast Utilities)

DATE OF ISSUANCE: 1964-65 Report of LRC/AEIC (Printed 1966)
OTHER IDENTIFIERS: Appendix F, Section 1 (pp L-93 thru L-111); data covers 12 months ended 5/31/64
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TOTAL: [PAGES 19 ;REFERENCES ;GRAPHS 10 ;TABLES 10] *
DOCUMENT CLASSIFICATION(S): 3/14, 17, 20, 22, 31, 49

ABSTRACT: *[Two of Tables are unnumbered. Graphs are grouped into 3 Charts.]

A group of 33 "Gold Medallion" heat pump homes in the City of Stamford, Connecticut was selected as the sample. The homes vary little in size and heat loss. All homes were at least two years old at time of test. [Note: These Medallion homes are essentially ones which use electricity exclusively for light, power and heating.]

One load recorder was installed on the total load and one on the heat pump load in each home in the sample. No attempt has been made to separately record the KWH used for heating and for cooling. Heating and cooling KWH were quite successfully identified through inspection of the daily sheets showing each customer's demands by demand periods.

Purposes of Study: to determine certain operating characteristics of these loads for economic analysis, including the pertinent demands on daily, monthly, and annual bases plus load curves on system summer peak and winter peak days and curves showing heat pump daily KWH and maximum demands as a function of heating degree-days (HDD), calculated on an average hourly basis.

Summary of Major Findings:
1. The annual KWH use by the heat pump is 9% greater than the base load use and the maximum month's (Dec.) use is 150% greater.

2. The maximum diversified heat pump demand for the winter period is 9.8 KW occurring in Dec. on a day of 53 HDD, which was the coldest of the year, at 6:30 a.m., when the temperature was -2°F. The corresponding summer maximum demand is 3 KW, occurring in July at 5 p.m., with a 97°F temperature.

3. The diversified heat pump one-hour demand, occurring at the time of the winter system peak, is 4.8 KW which is equal to 55% of the 8.7 KW calculated heat loss; at the time of the summer system peak this demand is 1.8 KW.

4. Based on diversified demands the annual load factor of the base load is 28%, that of the heat pump is 15% and that of the total load is 23%.

5. The annual load factor of the heat pump heating cycle is 14% and that of the cooling cycle is 4%, based on diversified demands. Annual KWH for the heating cycle are 11,928 and for the cooling cycle, 1,096.

6. The ratio of annual average demand to diversified demand (at the time of the one-hour winter system peak) is 31% for the heat pump, 42% for the total load and 59% for the system; at the time of the summer system peak the respective % values are 83,117 and 65.

7. The best fitting "least-squares" lines (for the relationships between daily HDD and maximum diversified heating demands and between daily HDD and heating KWH) are found to be equations of the fourth and third degrees, respectively, for the 237 daily values used in determining the curves.

8. An additional 56% saturation of heat pumps would be required to shift the 6 p.m. time of the winter system peak to 7 a.m., the time of the heating peak. Correspondingly, it would take 14% saturation to shift the noon summer system peak to 4 p.m., the time of cooling peak. [These values are based on the load curves for these system peak days.]

TITLE: RESIDENTIAL ALL-ELECTRIC HOMES with RESISTANCE HEATING by RADIANT PANEL and CEILING CABLE

SOURCE: Detroit Edison (Detroit, Michigan)

AUTHOR(S): L.Brandenburg (for E.H.Scott)
PREPARED BY AUTHOR(S) AND/OR: D.E.

DATE OF ISSUANCE: 1960-61 Report of LRC/AEIC (Printed 1962)
OTHER IDENTIFIERS: Appendix A, Section 1 (pp L-5 thru L-19); data covers 10/59 - 10/60
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with D.E.

TOTAL:[PAGES 15 ;REFERENCES ;GRAPHS 11 ;TABLES 4] *
DOCUMENT CLASSIFICATION(S): 4/7, 14, 22, 48

ABSTRACT: *[The Graphs are grouped into 4 Charts.]

Sixteen homes were selected from over 200 served by D.E. Using preliminary interviews, the list was narrowed to include only those homes that had ranges, clothes dryers, water heating and electric space heating. [None of the homes had central or room air conditioners.] Investigation eliminated locations with inadequate space for the required metering plus those that presented wiring difficulties. Pertinent data were acquired on family size, house size, calculated heat loss and connected appliance loads.

In each test home, separate (half-hour interval) demand and watthour meters were installed on: the total-service load, excluding off-peak water heaters; upper element of water heaters; lower element of water heaters (controlled); range; clothes dryer; house heating units. Demand charts were changed biweekly and watthour meters were read coincident with the chart changes.

Purposes of Study to determine the characteristics of total and major component loads; to aid in the evaluation of the all-electric home as it may affect system design and operation; to develop a program for the promotion of all-electric living.

Summary of Major Findings:
1. Since nearly 60% of the annual use of the test homes is for house heating, daily uses and maximum demands of the total-service load correlate closely with heating degree-days.

2. Noncoincident maximum demand per customer was 32% of the average connected load for the group. Demand factors of individual test customers ranged from 23.2 to 42.1%. By comparison, the noncoincident maximum demand for customers without electric house heating is estimated at about 25% of connected load, based on tests of 100 residential customers made in 1953.

3. The addition of electric house heating to the load of a home - with range, clothes dryer and water heater plus lighting and other appliances - tends to decrease the annual group load factor, based on either peak day or average weekday diversified demands, especially as design conditions are approached.

4. In these tests, 59% of the annual use per customer was for house heating and 22% was for water heating.

5. The total-service load (which included controlled water heating) for the relatively mild winter had an annual diversified load factor of 38%; it was estimated that for a normal "cold spell" (for a mean daily temperature of 8 F) the factor would have dropped to 34%.

TITLE: RESIDENTIAL CUSTOMER LOAD STUDY: ALL-ELECTRIC HOMES WITH RESISTANCE HEATING by CEILING CABLE and BASEBOARD *

SOURCE: Duquesne Light (Pittsburgh, Pa.)

AUTHOR(S): R.C.Grimstad (pp 9 thru 24); A.F.Rehberg (for R.C.Grimstad)
PREPARED BY AUTHOR(S) AND/OR: D.L.

DATE OF ISSUANCE: 1961-62 Report of LRC/AEIC (Printed 1963)
OTHER IDENTIFIERS: Appendix B, Section 1 (pp 9 thru 24) + Appendix B, Section 3 (pp L-205 thru L-214); data covers 10/60 - 9/61
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with D.L.

TOTAL:[PAGES 26 ;REFERENCES 1 ;GRAPHS 16 ;TABLES 4] **
DOCUMENT CLASSIFICATION(S): 4/7, 8, 14, 19, 22, 24, 31, 49

ABSTRACT: *[Note: Appendix B, Section 3 is entitled "Electric Residential Heating with Resistance Units".]

**[Graphs are grouped into 7 Charts.]

The tests extended over a 12-month period starting, for the individual test customer, at the billing meter reading date nearest 10/1/60. Watthour meters measuring the customer's total-service load and the heating component of the total-service load were in service during the entire period. Recording demand meters to measure the customer's total-service demand and the heating demand were installed during the heating season portion of the test period. The watthour meters were read and the demand recorder tapes were changed at monthly intervals, corresponding to the billing meter reading date. A "translator" unit was used to transfer the (integrated 30-minute) demand record from the magnetic tapes to punched cards, from which summaries were prepared by the use of standard data processing equipment.

The number of all-electric homes served by D.L. (at the time these tests were being planned) was limited, so the test customers were not selected by random sampling. Selected customers were simply canvassed for permission to make tests.

Approximately 30 homes were included in these tests. All are single-family dwellings, ranging in size from about 7,200 to 26,700 cu. ft. of heated space. The number of occupants varied from 2 to 10, with an average of 4.6 per family. With one exception, the homes tested were built within the last 5 years and are predominantly ranch type or split-level. Each home has a full basement not used for living purposes, although some have a finished "game room" in the basement. All houses are insulated in ceiling, walls and floors and are equipped with double glazing and storm doors. Heating in the living areas is supplied by ceiling cable in all but 4 of the test homes; the others - including the one house converted to electric heat - use baseboard units.

All homes tested had electric heating, ranges, uncontrolled water heaters,

clothes washers, refrigerators (107% saturation) and televisions (121% saturation). Saturation for other major appliances were: dryers (72%); water pumps (34%); freezers (31%); room and central air conditioners (7% each).

The energy used by electric water heaters is included in the total-service load. The water heaters in the test customers' homes include both NEMA standard and quick-recovery types, all double-element, operating uncontrolled.

Purposes of Study: to obtain additional information - for rate studies, system design and sales promotion - regarding the load characteristics of the total-service load and of the heating load component of modern all-electric homes utilizing resistance heating as the sole source of comfort heat, under the climatological conditions experienced in the D.L. service area.

Summary of Major Findings (Appendix B, Section 1):
1. Heating load maximum demands and annual energy use substantially exceed the corresponding values for the aggregate of all other electric applications in all-electric homes using resistance heating.
2. The maximum diversified demand of the heating load is about one-half that of the connected heating load.
3. The shape of the daily heating load curve is similar thruout the heating season, altho the magnitude of the demands may vary.
4. Heating load demand factors for individual customers range from 40.2 to 99.3%, with a weighted average value of 68.8%.
5. The annual load factor, based on noncoincident maximum demand, for the average all-electric home is 21.7%. This compares with 17.0% for all residential customers and 20.9% for large-use residential customers, as reported elsewhere. The annual load factor, based on maximum diversified demand, is 33.7% and this compares with 51.3% for all residential customers and 52.2% for large-use residential customers, also as previously reported.
6. The heating load daily load pattern (for the average day) closely follows the configuration of the hourly outdoor temperature curve, inverted.
7. The daily maximum demand of the heating load occurs in the morning between 6 and 8 a.m. The lowest demand for the day occurs in mid-afternoon, after which this load follows a rising trend for the remaining hours of the day.
8. Maximum diversified demands and daily energy uses of the heating load vary directly with degree-days.
9. Load characteristics for an average weekday are not significantly different from the corresponding data for an average day.

Summary of Major Findings (Appendix B, Section 3):
[Note: This report is a further analysis of the electric resistance heating load of the 29 residential customers in Pittsburgh, Pa., for which test data for the total load are included in Appendix B, Section 1.]
10. This analysis discloses that there are well defined relationships between daily energy use and daily individual customer and group maximum

demands. Such relationships are further demonstrated by the individual customer and group daily load factors and daily coincidence factor. The most interesting finding was a daily group load factor of about 80%, for all days over 30 daily degree-days (DDD); this means that a large part of the energy was supplied on a daily basis at a high load factor since more than 50% of the total DDD were above 80% group load factor. The daily coincidence factor is apparently approaching a maximum value of slightly above 80% at 60 DDD.

11. This analysis also indicates that the unit of energy use (KWH per DD per 1000 cu. ft. of heated space per customer) is not a constant with respect to either DDD or volume of space heated. Therefore, its use as a measure for comparison of tests of heating loads of various utilities requires some additional qualifications. [The relation of this unit to the heated volume indicates that a decrease in unit energy use can be expected for the larger houses.]

TITLE: RESIDENTIAL ALL-ELECTRIC HOMES with VARIOUS TYPES of RESISTANCE HEATING

SOURCE: Jersey Central Power & Light Co. (Morristown, N.J.)

AUTHOR(S): E.L.Huse
PREPARED BY AUTHOR(S) AND/OR: J.C.P.&L.

DATE OF ISSUANCE: 1961-62 Report of LRC/AEIC (Printed 1963)
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DATA USE RESTRICTIONS: "Not to be published or quoted"; check with J.C.P.&L.
TOTAL: [PAGES 12 ; REFERENCES ; GRAPHS 7 ; TABLES 3] *
DOCUMENT CLASSIFICATION(S): 4/14, 15, 22, 24, 49

ABSTRACT: *[Graphs are grouped into 4 Charts.]

The test dwellings available represented a variety of conditions. The study covered living quarters varying in size from 5,600 cu. ft. apartments to a 27,000 cu. ft. home. Some units were old and poorly insulated, while others were new and being occupied for the first time. The number of occupants varied from 1 to 7. Various methods of heating were used, including: a central furnace; ceiling cable; radiant heating panels. The residences were scattered thruout the J.C.P.&L. area and experienced a range of heating degree-days (HDD) for the test period from 5,093 to 6,472.

Most of the homes studied were constructed of wood and were heated by radiant panels. They had old water heaters, formerly operated off-peak but now operating uncontrolled. Twelve homes had clothes dryers and 5 had quick-recovery water heaters. The calculated hourly heat losses varied from 19,000 to 74,800 BTU per hour.

Test meters were installed on the total-service load only, for all dwelling units where it was physically possible and permission could be obtained; this provided 35 test sites and, except for 3 locations, the meters remained for 12 months.

A contact-making watthour meter was installed in place of the regular meter used for billing purposes. Leads were run from it to a recording demand meter. The removed charts were reviewed as to time of power interruptions or other notations that were required in order to provide complete information for an hour. This meant that when the tapes were translated to punch cards there would not be information from one or more customers for a portion of an hour and for the remaining customers for the complete hour.

Purposes of Study: to obtain operating information on all-electric residential customers.

Summary of Major Findings:

1. Noncoincident maximum half-hour demand per customer is 42% of average connected load. Maximum diversified demand is 25% of average connected load. [The coincidence factor is 25/42 or about 60%.]

2. There is a 3.4% average difference (i.e., increase), as between the maximum diversified quarter-hour and half-hour demands. There is a 4% average difference (i.e., increase), as between the maximum diversified quarter-hour and hourly demands.

3. The average annual load factor - based on maximum diversified demand for the hour studied - is about 36%, whether it is computed on a quarter-hour, half-hour or an hourly basis.

4. Demand factor of individual test customers ranges from 26.1 to 63.4%. [The time of the individual customer's maximum demand is "self-determined" rather than by the outside weather.]

5. For 32 homes, the average total-service energy use per DD per 1,000 cu. ft. of heated space is 0.46 KWH.

6. Average daily energy use and average maximum diversified demand may be expressed as second degree functions of HDD.

TITLE: RESIDENTIAL ALL-ELECTRIC HOMES with RESISTANCE HEATING by CEILING CABLE and BASEBOARD

SOURCE: Western Massachusetts Electric Co. (West Springfield, Mass.)

AUTHOR(S): L.W.Frank (for W.E.Miller)
PREPARED BY AUTHOR(S) AND/OR: W.M.E. (for Northeast Utilities)

DATE OF ISSUANCE: 1961-62 Report of LRC/AEIC (Printed 1963)
OTHER IDENTIFIERS: Appendix D, Section 1 (pp L-36 thru L-54); data covers winter 1960-61
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with N.U.

TOTAL: [PAGES 19 ; REFERENCES 1 ; GRAPHS 12 ; TABLES 4] *
DOCUMENT CLASSIFICATION(S): 4/7, 8, 14, 22, 31, 48

ABSTRACT: *[Two of Tables are unnumbered. The Graphs are grouped into 7 Charts.]

The 35 homes tested average 9,453 cu. ft. of heated space. This compares with an average of 9,746 cu. ft. for all of the 121 homes that have experienced a complete second winter with electric heat in the W.M.E. service area. The annual total-service use of these 35 averages 23,928 KWH, as compared with 24,402 for the 121-customer group. Each of the homes is heated by resistance heating equipment of the ceiling cable and baseboard types. [Note: By selecting customers in their second or third winter with electric house heating, the effect on the heating load of the drying-out of plaster and wood is eliminated.]

Each of the homes has 6" of ceiling, 4" of side-wall and 2" of floor insulation and is further "weather-protected" with storm doors and storm windows. In these resistance-type heated homes, multiple thermostats are installed to permit zone temperature control.

Each home tested has a storage-type water heater, with a capacity of 120 gallons. There are two 4KW elements interlocked, the lower element control being restricted to charging from 11:30 p.m. to 7 a.m.

The saturation (%) of major appliances in the 35 homes are as follows: water heater, range, clothes washer (100); refrigerator (92); clothes dryer (60); freezer (26); dishwasher (20); air conditioners, etc. (less than 10%).

Two types of metering equipment were used to simultaneously measure the total-service load and the heating load, in KW. The equipment recorded the integrated half-hour demands either on punched paper tapes or on magnetic tapes, depending on the particular equipment. These tapes were sent to "translating" centers and the raw data transcribed to punch cards. By programming the punched cards, demand data of the groups of customers were obtained in useful form. Energy data were available for these loads from meters installed (for billing and information purposes) when the homes were built.

Purposes of Study: to investigate the load characteristics in the New England area - for a substantial group of all electric homes which were experiencing their second or third winter with electric house heating - for economic studies associated with system design and pricing.

Summary of Major Findings:

[Note: The heating degree-days (HDD) during the test period exceeded those in any year in more than 4 decades of record; HDD in the test-homes area approximated 7,075.]

1. For a group of all-electric homes, with the water heating controlled, there is considerable diversity in the several components of load; at the time of the W.M.E. winter peak (5-6 p.m., 12/19/60): the total-service load is approximately 60% of its maximum, the heating load is approximately 65% of its maximum and the general service and water heating load is approximately 34% of its maximum. However, during the coldest winter week and at the time of the system peak for that month (11 a.m.-noon 1/24/61), there is little change in the 60% value noted for the total-service load but the heating load is 78% of its maximum and the general service and water heating load is 22% of its maximum.

2. The annual load factor, based on the maximum diversified demand of the total-service load, is 28%; for house heating it is 23% and for general service and water heating it is 27%.

3. The ratio of the diversified heating loads (at the time of the total-service maximum diversified demand) to the sum of the customers' noncoincident maximum heating demands approaches full diversity at 35 customers and is about 65%; this % is for the coldest week in the winter and is limited to demands in the period 7 a.m. to 11:30 p.m., so as not to include the on-cycle time period of the storage water heater. [The ratio curve for the house heating load that occurred at the time of the maximum total-service demand shows 76% at 35 customers. For the maximum heating demand not coincident with the maximum total-service demand, the ratio is about 77% at 35 customers.]

4. The hourly house heating load follows closely the inverse shape of hourly outdoor temperatures.

5. The factor of house heating KWH per HDD per 1,000 cu. ft. of heated space is 0.21 KWH; this is the same value as that for the 121 home group referred to above.

6. Annual average KWH energy usages (for the 7 a.m. to 11:30 p.m. period) were 4,547 for general service and water heating and 8,773 for house heating only. For the 11:30 p.m. to 7 a.m. period, the corresponding values were 5,557 and 5,051 KWH.

TITLE: RESIDENTIAL CUSTOMER LOAD STUDY, ALL-ELECTRIC HOMES WITH CEILING CABLE and BASEBOARD RESISTANCE HEATING

SOURCE: Baltimore Gas and Electric Co. (Baltimore, Md.)

AUTHOR(S): W.E.Miller
PREPARED BY AUTHOR(S) AND/OR: B.G.&E.

DATE OF ISSUANCE: 1963-64 Report of LRC/AEIC (Printed 1965)
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DATA USE RESTRICTIONS: "Not to be published or quoted"; check with B.G.&E.
TOTAL: [PAGES 26 ; REFERENCES 3 ; GRAPHS 31 ; TABLES 8] *
DOCUMENT CLASSIFICATION(S): 4/14, 22, 40, 49

ABSTRACT: *[Seven of Tables are unnumbered. Graphs are grouped into 13 Charts.]

Thirty-three homes were selected at random from the newer all-electric installations in the B.G.&E. service area. Ceiling cable and baseboard types of equipment predominated and the house heating capacity in new home installations averaged between 15 and 20 KW per home at the time of test customer selection. [For this reason, test homes were chosen with these kinds of equipment, of about average size, and which had been constructed within the past few years so as to have sufficiently aged to have "dry construction".]

The 32 homes for which useable data were obtained are detached, single-family dwellings predominantly of the ranch type. Their average volume and floor area are about 12,100 cu. ft. and 1,500 sq. ft. Aside from being well insulated, including storm windows and doors, the average house in this test group has a basement and a fireplace chimney. [The suburban locations undoubtedly account for the small amount of summer air conditioning equipment (8 cases) found in the group.]

Each test home is equipped with a NEMA standard hot water heater, operating uncontrolled with interlocked upper and lower elements; the average element sizes are about 1.9 and 1.1 KW, respectively.

Magnetic tape recorders designed for load test use (with contact devices attached to watthour meters) were employed in this study, using a quarter-hour time interval. One recorder was attached to a meter measuring the total-service requirements and one was attached to another meter installed to simultaneously measure the load of the house heating equipment. The load survey recorders are provided with tape sufficient for a 45-day period record altho the practice is to change the record at approximate monthly intervals.

Purposes of Study: to determine the average load characteristics of a group of (about) 30 single-family, all-electric, resistance-heated homes.

Summary of Major Findings:

1. The annual house heating energy requirement is 58% of the total use per customer.

2. Of the annual total-service and house heating uses per customer about 40% of each is "on-peak", i.e., 8 a.m. thru 10 p.m. on weekdays other than holidays.

3. The annual house heating use per degree-day (DD) per 1,000 cubic feet of heated space is 0.243 KWH.

4. At normal temperatures, the annual B.G.&E. system's house heating use is 813 KWH per KW of the heating connected load. [Note: Indications are that the installed heating capacity is about 25-30% greater than called for by the design heat loss requirements.]

5. The monthly use per customer (for all requirements) in the coldest month is almost 5 times as great as that of the minimum summer month's average use.

6. The total-service use per customer (for the day of maximum diversified total-service demand) during Apr., June, July, Aug., Sept. and Dec. is exceeded on at least one other day in the month. [This is contrary to normal expectation only for Dec., in which the maximum daily use was on the day prior to maximum demand experience.]

7. The daily house heating use is at its maximum on the day of maximum diversified total-service demand in all except 3 heating months. The exceptions were: Mar., when the prior day's use was only 3 KWH greater (121 vs 118 KWH per customer) and Apr. (74 vs 59 KWH per customer) and Sept. when the succeeding day's use was only 3 KWH greater (21 vs 18 KWH per customer). [Note: Due to the predominating influence of the heating load in the total requirements, this general finding is not surprising.]

8. During most months of the heating season, the maximum diversified total-service demand occurs between 7 and 8 a.m., on a weekday.

9. Altho "night setback" of house heating thermostats is not practiced by most of these customers,and their annual maximum house heating demands are at various hours of the day, the maximum diversified house heating demands of the group occur between 7 and 8 a.m. in every month of the heating season.

10. The half-hour maximum diversified total-service and house heating demands per customer are only 19 and 49% respectively,of the average connected loads.

11. At the hour of the annual system peak load (6/19/62, 2 p.m.), only 3% (1.4 KW) of the average total-service connected load operates; this value is 15% of the annual maximum diversified total-service 1-hour demand of 9.3 KW per customer. At the system peak hour in Jan. (6 p.m.) and

under outdoor design temperature of zero F, 20% of the average total-service connected load will be reflected as diversified demand per customer; at this time and temperature, 43% of the average connected house heating load will be in service.

12. The average monthly (diversified) total-service 1-hour demand, coincident with the monthly system peak loads for the test period is 3.89 KW of which an average of 2.03 KW is house heating load. [The diversified total-service demand normally peaks in the early mornings hours during the heating months - on both coldest days and on average weekdays of cold periods - showing the predominating influence of the house heating requirements.]

13. Annual diversified load factors are 31 and 21% respectively, for total-service and house heating loads. [At design temperature conditions (zero F), the annual diversified total-service load factor may be reduced to about 30%.] Annual noncoincident load factors are 20 and 15%, respectively, for the two loads.

14. The relationships of house heating daily uses (and daily maximum diversified demands per customer) to daily DD are straight line functions.

TITLE: RESIDENTIAL ELECTRIC HOUSE HEATING LOAD STUDY

SOURCE: Central Hudson Gas & Electric Corp. (Poughkeepsie, N.Y.)

AUTHOR(S): J.E.Smith (for C.E.Rider)
PREPARED BY AUTHOR(S) AND/OR: C.H.G.&E.

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DOCUMENT CLASSIFICATION(S): 4/7, 8, 19, 22, 25, 40

ABSTRACT: *[One of Tables is unnumbered. Graphs are grouped into 2 Charts.]

The test group consists of 19 residences which were selected as representative of the size and type of home in which electric heat is being installed in the C.H.G.&E. area; they were distributed thruout the service area so as to reflect variations in weather conditions. The group consisted of 4 older homes converted to electric heat plus 15 new homes; they averaged about 10,400 cu. ft. of continually heated space and about 1,300 sq. ft. of floor area. The average home in this test group has 7.5" of ceiling, 3.8" of wall and 3.3" of floor insulation. Seventeen of the test homes are heated with baseboard units and 2 with ceiling cable.

Two digital demand recorders were installed at each test home to seperately record 60-min. integrated demands and the KWH use of the total service load and the heating load.

In addition to being electrically heated, the 19 homes represent "typical" well-electrified homes with major appliance saturations as follows: range + water heater + automatic clothes washer, (100%); clothes dryer (58%); dishwasher (52%); freezer (42%). [Note: only one test customer had any air conditioning equipment, indicating that well-insulated homes in suburban locations in northern areas do not require summer air conditioning to maintain satisfactory comfort conditions.]

Purposes of Study: to determine the load characteristics of electrically heated homes for use in system planning, cost analysis and rate studies.

Summary of Major Findings:
1. The average annual heating energy use - for the 18 test customers for whom complete heating data was obtained - was 13,711 KWH, during a 12-month period having 6,313 heating degree days (HDD) with respect to a 65°F base temperature. The average annual heating energy use per HDD

per 1,000 cu. ft. of heated space was 0.209 KWH, with the maximum monthly value of 0.235 KWH occurring in Jan. The average total energy use during the same period - for the 17 customers for whom complete total service data was obtained - was 24,338 KWH.

2. The maximum diversified heating and total service demands occurred during the coldest week of the test period and were 7.04 and 8.98 KW per customer, respectively. The 7.04 value occurred during the hour ending at 7 a.m. on Jan. 15; the 8.98 value occurred during the hour ending at 6 p.m. on Jan. 13.

3. The average maximum noncoincident demands of the test group were 9.37 and 13.86 KW per customer for the heating load and total service load, respectively. The resulting annual coincidence factors were 75.1% and 64.8%, respectively.

4. The annual load factors were 22.2% for the heating load and 30.9% for the total service load, based on maximum diversified demands. Based on maximum noncoincident demands, the respective load factors were 16.7% and 20% for the heating load and total service load.

5. The average heating usages were 15,120 and 11,497 KWH, respectively, for homes with minimum and extra insulation; the additional insulation resulted in a 24% reduction in energy use. [The energy use per HDD per 1,000 cu. ft. of heated space was 0.229 KWH for homes with minimum insulation and 0.177 KWH for homes with extra insulation.]

6. The residences with minimum and extra insulation had respective maximum diversified heating demands of 7.57 and 6.21 KW per customer. Their average maximum noncoincident demands were 9.99 and 8.36 KW per customer, respectively.

7. The load factors for customers with minimum insulation and those with extra insulation were 22.74 and 21.08%, respectively, based on maximum diversified demands. Correspondingly the values were 17.23 and 15.66%, when based on average maximum noncoincident demands. [These results indicate that altho additional insulation significantly reduces energy use and demand it does not serve to improve load factor.]

TITLE: RESIDENTIAL ELECTRIC RESISTANCE HEATING LOAD STUDY

SOURCE: Public Service Electric and Gas Co. (Newark, N.J.)

AUTHOR(S): P.F.Platt (for B.P.Dahlstrom)
PREPARED BY AUTHOR(S) AND/OR: P.S.E.&G.

DATE OF ISSUANCE: 1964-65 Report of LRC/AEIC (Printed 1966)
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DOCUMENT CLASSIFICATION(S): 4/7, 17, 22, 46, 49

ABSTRACT: *[One of Tables is unnumbered. Graphs are grouped into 5 Charts.]

A sample of 39 heating installations (35 single-family homes plus 4 apartments) was selected geographically, so that all divisions in the P.S.E.&G. area were represented.

All homes selected for test were "fully insulated" and equipped with resistance heating of the baseboard or ceiling cable type. Two of the homes had some wall-type resistance heaters, in addition to their baseboard type. All of the test customers had an electric range, a refrigerator and a television set. Other major appliance (saturation) percentages were: clothes washers, 95; water heaters, 88; clothes dryers, 65; room air conditioners, 60; dishwashers, 48; central air conditioners, 5.

Magnetic tape load-survey recorders were installed to measure 30-minute integrated demands, for both total service and electric space heating. Tapes were translated to punched load survey cards and acceptable data processed as a group for each month of the heating season. The tests are reported on prevailing clock time, EDT for Oct. and May and EST for the other heating season months.

Purposes of Study: to investigate the load characteristics of Residential Heating Service Rate Schedule (RHS) and its possibilities for improving a declining load factor for the P.S.E.&G. system.

Summary of Major Findings:
1. About 43% of the annual total service use and about 50% of the annual heating use occurred during the off-peak water heating period, from 11 p.m. to 9:30 a.m. [There is no significant difference in this use pattern as between weekdays and weekends.]

2. The derived annual normal heating use per degree-day (DD) per 1,000 cu. ft. of heated space is 0.24 KWH. [Note: The 1963-64 heating season was warmer than the normal of 5,157 DD by 4.1% or 203 DD.]

3. The average heating use per customer for the heating season was 15,619 KWH (adjusted to the normal heating season value of 16,259). This amounted to 55.4% of the annual total service use of 28,172 KWH. Heating use per customer, adjusted to normal DD, amounted to 1,145 KWH per KW of connected load.

4. Noncoincident maximum demand per customer for total service is approximately 38% of the average total connected load; for heating, this demand is approximately 76% of the average heating connected load.

5. The annual load factor - based on maximum diversified demand - of test customers is 22% for heating use and 31% for total service. [The heating load tends to lower this annual load factor. However, under foreseeable saturation of electric space heating, sufficient diversity exists between the peak of the space heating load and the P.S.E.&G. peak (summer load) so as to warrant promotional efforts to obtain residential heating business. Under these circumstances, the heating load takes on importance in retarding the rate of decline in the annual system load factor.]

6. The annual coincidence factor for total service was 63.5% and for heating service it was 71.9%.

7. Annual load factors for total service range from 9.6 to 29.9% and for heating service from 7.3 to 24%.

8. Annual demand factors for total service range from 27.1 to 61.1% and for heating service from 47.4 to 99.5%.

9. The maximum diversified heating demand, for each month of the heating season, occurs between 7:30 and 8:30 a.m. A second peak occurs during the evening hours which - on average - is about 75% of the morning peak; under extreme weather conditions the evening peak can equal the morning peak.

10. There is a high degree of correlation between: heating use and demand; heating use and outdoor temperatures; heating demand and outdoor temperatures.

11. There is approximately 1,145 hours use of connected heating load required for a heating season with normal DD.

TITLE: RESIDENTIAL ELECTRIC RESISTANCE HEATING

SOURCE: Long Island Lighting Co. (Mineola, N.Y.)

AUTHOR(S): F.V.Kelsey (for H.L.Parlette)
PREPARED BY AUTHOR(S) AND/OR: L.I.L.

DATE OF ISSUANCE: 1965-66 Report of LRC/AEIC (Printed 1967)
OTHER IDENTIFIERS: Appendix E, Section 1 (pp. L-87 thru L-99); data covers 12/63 to 1/65
DATA USE RESTRICTIONS: "Not to be quoted or published"; check with L.I.L.
TOTAL: [PAGES 13 ;REFERENCES ;GRAPHS 15 ;TABLES 4] *
DOCUMENT CLASSIFICATION(S): 4/14, 15, 22, 25, 40, 49

ABSTRACT: * [Two of Tables are unnumbered. Graphs are grouped into 6 Charts.]

With a limited number of electric space heating customers on the L.I.L. system and a general lack of knowledge of the "universe" for this class of customer, a judgment sample was picked to represent the class. From the heterogeneous sample of 7 chosen, it was felt that "impressions" of this class of customer could be obtained.

Two factors were considered useful in comparing the test results of different utilities and for estimating annual heating requirements. One is the FHA experience factor: $K = \frac{\text{Heat loss (BTU/hour) x Degree-days}}{(\text{Indoor temp.}^\circ\text{F} - \text{outdoor temp.}^\circ\text{F}) \times \text{KWH}}$

and the other is: KWH/degree-day/1,000 cubic feet of heated space.

Purposes of Study: to review insulation practices, customer attitude, electric heating load characteristics and their relationships to weather. [Note: The average insulation was 4.7 " in the ceiling, 2.9" in the walls and 1.9" in the floor.]

Summary of Major Findings:
1. Annual KWH use averaged 18,860 for heating and 36,115 for all purposes. [Note: Degree-days during 1964 ≈ 5,000.]

2. Maximum KW (diversified) demands per customer were 11.17 (heating) and 13.85 for all purposes. These peak demands occurred during the hours ending 9:00 and 10:00 a.m., respectively, on 1/14/64 when outdoor temperatures were 10 and 12°F, respectively.

3. The annual load factor was 19.2% (heating) and 29.7% for all purposes.

4. The daily peak of the resistance heating load normally occurred between the hours ended 8:00 and 10:00 a.m.

5. For each degree change of daily average temperature, the daily maximum (diversified) demand changed by 0.17 KW and the energy use by 3.67 KWH.

6. The annual "FHA experience factor" was calculated to be 241. [Note: The FHA has estimated the ideal value of K to be 170 for direct or resistance heating.]

7. The annual (heating) KWH per degree-day per 1,000 cu.ft. of heated space was 0.21.

TITLE: ALL-ELECTRIC DWELLING UNIT LOAD STUDY

SOURCE: New Orleans Public Service, Inc. (New Orleans, La.)

AUTHOR(S): A.C.Hardy (for J.A.Leo)
PREPARED BY AUTHOR(S) AND/OR: N.O.P.S.

DATE OF ISSUANCE: 1969-70 Report of LRC/AEIC (Printed 1971)
OTHER IDENTIFIERS: Appendix B, Section 1 (pp L-22 thru L-38); data covers Oct. 1968 thru Sept. 1969
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with N.O.P.S.
TOTAL: [PAGES 17 ; REFERENCES ; GRAPHS 12 ; TABLES 1] *
DOCUMENT CLASSIFICATION(S): 4/1, 7, 8, 14, 19, 22, 44

ABSTRACT: *[The Graphs are grouped into 8 Charts.]

The test sample consisted of 23 of the 75 units in the first completed section of this proposed three-section development. The sample was selected on the basis of occupancy, with appropriate consideration given to the unit sizes as related to their overall distribution in this section; the resulting sample contained 22% "small" (869 sq. ft.), 61% "medium" (1,400 sq. ft.) and 17% "large" units (1,800 sq. ft.)

This development consists (at present) of 151 town-houses, of which 75 units were in the first completed section and 76 were completed in the second section; a third section is pending. The completed sections were designed to contain about 14 separate buildings, with 4 to 6 units per building separated by vertical fire walls. The buildings were constructed with primarily brick exteriors, front and rear windows and entrances, 4" of wall insulation, 6" of ceiling insulation and slab flooring. The small units were one floor but the medium and large units had a second floor with a small balcony. [All units were served with underground electric service through submersible transformers.]

The comfort-conditioning equipment for each individual dwelling consists of a central furnace and air conditioner, both operated from a central thermostatic control. Other electrical equipment furnished to each unit included: food disposal, oven range, automatic dishwasher, combination washer-dryer, 40-gallon water heater, supplemental 1.5 KW bathroom heater and yard lighting.

Magnetic tape load survey recorders were placed on each unit selected in the test sample. Tapes were changed on a 28-day schedule and were translated for computation, using 15-minute demand intervals. Data were arranged into calendar periods for ease in presentation and comprehension.

Purposes of Study: to determine by means of a study of the Regency Park development (one of the newest concepts of living and design for all-elec-

tric dwellings in New Orleans) the all-electric load characteristics to be used in system planning, cost analysis, sales promotion and rate analysis.

Summary of Major Findings:

1. Annual use per customer was 19,229 KWH. For the same period, the average residential customer used 7,522 KWH.

2. There were 2,751 actual cooling degree-days (CDD), measured above 65°F mean daily temperature, or 3% below the normal 2,833. Actual heating DD, measured below 65°F mean daily temperature, totaled 1,433 or 18% above the normal 1,218. [With "normal" temperatures, annual use would have been ≈ 18,950 KWH.]

3. The 7.1 KW maximum (diversified) demand per customer occurred during the winter and exceeded the 5.3 KW summer value by 24%.

4. The highest monthly (noncoincident) maximum demand, 14.3 KW per customer, occurred during the winter and exceeded the 10.9 KW summer value by 31%. The annual (noncoincident) maximum demand per customer, for the test period, was 15.3 KW.

5. Monthly coincidence factors ranged from 36.6 to 51.1%, with the highest values occurring during both the summer and winter periods.

6. Monthly load factors, based on the maximum diversified demand, ranged from 32.8 to 55.4% with an annual load factor of 30.9%. [Monthly load factors were highest during the summer period, as was monthly use.]

7. The response to changes in mean temperatures of daily energy use per customer was 1.8 KWH per degree above 65°F and 2.2 KWH per degree below 65°F.

8. The 1969 diversified demand per customer at the time of the system peak (July 9 at 4 p.m.) was 3.5 KW. This demand was about 78% of the maximum for the day (4.5 KW at 8 p.m.), about 66% (of 5.3) for the summer period and about 49% (of 7.1) for the year.

TITLE: ALL-ELECTRIC HOMES with BASEBOARD RESISTANCE HEATING

SOURCE: The Hartford Electric Light Co. (Westerfield, Conn.)

AUTHOR(S): R.C.Fosberg
PREPARED BY AUTHOR(S) AND/OR: H.E.L. (for Northeast Utilities)

DATE OF ISSUANCE: 1969-70 Report of LRC/AEIC (Printed 1971)
OTHER IDENTIFIERS: Appendix D, Section 1 (pp L-55 thru L-82); data covers 12 months ended 7/30/66
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with N.U.

TOTAL:[PAGES 28 ;REFERENCES ;GRAPHS 13 ;TABLES 7] *
DOCUMENT CLASSIFICATION(S): 4/14, 20, 22, 28, 49

ABSTRACT: *[Graphs are grouped into 5 Charts. The Tables are composite of monthly "sub-tables".]

A group of 30 homes was chosen for test in as compact an area as possible. The homes vary about three to one in size and heat loss. All homes were at least two years old at time of test.

Sixty magnetic tape load recorders, a "Translator" plus "Punch" and "Computer" were used to record and process the final data for the heating and total service loads. A printout of each half-hour demand of each customer was made on a daily sheet to facilitate data checking and to make possible drawing off additional data not originally anticipated when the computer program was written. Monthly sheets list diversified demand curve data for the maximum demand day and for the 5-day average weekday plus maximum demands for each customer and the noncoincident maximum demand for the group; also listed are: monthly KWH (by time period, by customer and by day) for the group, monthly load factors and coincidence factor (for the group) and maximum diversified and noncoincident demands for the entire test.

Two load recorders were installed in each of the 30 homes, one for the total load and the other for the resistance heating load. In addition, a chart-type recording dry-bulb thermometer was located in a permanently shaded substation area - very close to the geographical center of the test customers - as a means of obtaining "on-the-site" outdoor temperatures instead of relying on data from the Weather Bureau station which is located about 7 miles north of the substation. [For total service data, the on-the-site degree-days are lower than those of the Weather Bureau by 14% on the maximum diversified demand day and by 11% on the maximum KWH day. For resistance heating data, these figures are lower by 14 and 7%, respectively.] Note: Daily degree-days used in this report are the differences between 65°F and the average of the 24 hourly temperatures for the day in question.

Purposes of Study: to obtain operating data comparable to those obtained

from a similar test on heat pump customers (about a year before in Stamford, Conn.) with the intention of combining appropriately weighted data from the two tests so as to give load data typical of the residential heating load in the H.E.L. territory.

Summary of Major Findings:

1. The annual energy use of baseboard heating is 31% greater and the maximum month's (Jan.) use is 181% greater than the base load use.

2. The maximum diversified heating demand for the winter period is 8.2 KW, occurring in Jan. This was on a day of 48 heating degree-days (HDD), the coldest of the year, at 7:30 a.m. when the temperature was 12°F.

3. The diversified heating one-hour demand occurring at the time of the winter system peak is 4.2 KW, which is about 31% of the 13.4 KW calculated heat loss.

4. Based on maximum diversified demands the annual load factor of the base, heating and total loads is 30, 23 and 28%, respectively.

5. The ratio of annual average hourly demand to diversified demand (at the time of the one-hour winter system peak) is 45% for the heating load, 55% for the total load and 62% for the system. At the time of the summer system peak the ratio is 309% for total service and 67% for the system.

6. Suitable "least-squares" lines - for the relationships between (daily) HDD and maximum diversified heating demands and between (daily) HDD and heating KWH - are found to be equations of the exponential form for the (daily) values used in determining the annual curves; straight lines adequately portray these relationships for the monthly periods.

7. An additional 41% saturation of resistance heating would be required to shift the time of winter system peak from 6 p.m. to 8 a.m., a half-hour later than the time of heating peak.

TITLE: RESIDENTIAL ELECTRIC RESISTANCE SPACE HEATING STUDY

SOURCE: Virginia Electric and Power Co. (Richmond, Va.)

AUTHOR(S): C.E.Higgins, Jr. (for R.S.Gay)
PREPARED BY AUTHOR(S) AND/OR: V.E.&P.

DATE OF ISSUANCE: 1970-71 Report of LRC/AEIC (Printed 1972)
OTHER IDENTIFIERS: Appendix B, Section 1 (pp L-74 thru L-89); data covers 11/30/67 to 2/28/68
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with V.E.&P.
TOTAL: [PAGES 16 ;REFERENCES ;GRAPHS 13 ;TABLES 2] *
DOCUMENT CLASSIFICATION(S): 4/8, 14, 15, 22

ABSTRACT: *[One Table is unnumbered. The Graphs are grouped into 9 Charts.]

To determine the importance of electric resistance space heating to the growth of winter residential load, 50 customers were selected at random from the 14,493 residential customers known to have such heating equipment. As a result of this selection procedure, the geographic area covered by the tests corresponded roughly to Virginia's Urban Corridor.

Prior to the actual testing of these customers, each one was interviewed by a Company sales representative to determine the following data for each residence: number of residents; type of structure; connected load (by appliances) and other pertinent data. The dwelling units in this sample consisted of: 3 tenant-occupied apartments; 19 single-story, ranch-style houses; 11 two-story homes of various styles and 1 four-level house. [All but 2 of these dwelling units were constructed after 1960.]

Purposes of Study: to provide statistically reliable data (on the winter total-load characteristics of those residential customers who have electric resistance space heating equipment installed as their sole source of space heating) for use in engineering and rate studies and in the development of sales estimating guides.

Load Characteristics:
The energy use per customer during the test was obtained from meter readings taken at the start and end of the test period but the annual energy was taken from their billing records (for the 12 months ended Jul. 1968) in the following manner: First, the energy use was calculated for each month in this annual period. [In order to do this every bi-monthly use was split equally between each of the months which it covered; but, since a full year's billing record was not available for each of these customers, some of these monthly per-customer energy uses were based on data for only 33 customers.] Second, the monthly energy uses were then summed to give the annual energy use per customer.

The 22,337 KWH value (see Summary below) greatly exceeded the 6,713 KWH use for the whole residential class. The monthly per customer energy uses (in KWH) for the whole residential class during the same annual period were: 8/67 (567); 9/67 (589); 10/67 (472); 11/67 (508); 12/67 (522); 1/68 (691); 2/68 (611); 3/68 (676); 4/68 (507); 5/68 (497); 6/68 (458) and 7/68 (615).

Summary of Major Findings:

1. The customers tested had an average total-service energy use of 10,429 KWH during the test period. Their average annual total-service energy use was 22,337 KWH.

2. The total-service (noncoincident) maximum demand per customer for the test period was 15.5 KW. Their annual load factor based on this demand was 16.5%.

3. The maximum total-service (diversified) demand per customer during the test period was 8.82 KW and occurred at 7 p.m. on Thursday, 1/11/68. Based on this demand, the annual load factor was 28.9%.

4. The maximum (diversified) demand per sampled customer for the coldest day of the coldest week of the test period (Monday, 1/8/68, 8 a.m.) was 8.28 KW. Their annual load factor, based on this demand, was 30.8%.

5. For this sample, the maximum weekday (diversified) demand per customer for the coldest week of the test (Jan. 8-12, 1968) was 7.76 KW. The annual load factor based on this demand, was 32.9%.

TITLE: RESIDENTIAL CUSTOMER LOAD STUDY: HOMES with ELECTRIC FURNACES

SOURCE: Baltimore Gas and Electric Co. (Baltimore, Md.)

AUTHOR(S): L.S.Lydard, Jr. (for W.E.Miller)
PREPARED BY AUTHOR(S) AND/OR: B.G.&E.

DATE OF ISSUANCE: 1970-71 Report of LRC/AEIC (Printed 1972)
OTHER IDENTIFIERS: Appendix A, Section 3 (pp L-191 thru L-229); data covers 12 months ended 4/30/70
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with B.G.&E.
TOTAL: [PAGES 39 ;REFERENCES ;GRAPHS 19 ;TABLES 1] *
DOCUMENT CLASSIFICATION(S): 4/1, 8, 14, 19, 22, 24, 49

ABSTRACT: *[Graphs are grouped into 11 Charts.]

This study covers a test of the load characteristics of 19 single-family homes equipped with electric furnaces. The furnace and total-service energy requirements were recorded simultaneously throughout the test year. Fourteen of the homes were also equipped with central cooling units which used the same air circulating fan for both heating and cooling; in these homes, the customers' cooling energy requirements were separately metered.

The 19 homes were selected from a relatively small population (fewer than 500); each of these customers has a forced hot air heating system. All are single-family dwellings; 7 are ranch homes, 7 are split-level, 3 are split-foyer, one is a raised ranch and one is a colonial 2-story. The type of construction which predominates is a combination brick and frame house. The average home contains 7 rooms, a kitchen and 2 bathrooms (counting a "powder room" as a one-half bath).

Magnetic tape recorders - designed for load test use in conjunction with contact equipped watthour meters - were employed for the duration of this study, using a quarter-hour time interval. At each premise, one recorder was attached to a meter measuring the total-service requirements of the home and another was attached to a second watthour meter installed to measure the house heating load.

Purposes of Study: primarily to obtain electric furnace heating data not previously available for the B.G.&E. service area for use in engineering, economic and rate studies and for the development of sales estimating guides.

Summary of Major Findings:

A) Total Service and House Heating

1. The 22,374 KWH used annually for heating is equivalent to 916 hours use of the furnace connected load.

2. Of the average customer's total-service annual requirements, 59% is used for house heating with the monthly values varying between 0 and 80%.
3. Of the annual total-service energy requirement, 42% is used on peak (8 a.m. thru 10 p.m., on weekdays other than holidays) while 36% of house heating is on peak.
4. For an average electric furnace home, annual house heating use on a normalized degree-day (DD) basis is equivalent to 0.22 KWH/DD/1000 cu. ft. of heated space or 0.08 KWH/DD/1000 BTU/Hour heat loss.
5. The maximum diversified heating demand occurred between 6 and 8:30 a.m. in the months of Sept. thru May.
6. The average house heating use per customer is 86% of the average total-service energy use on the day of the Baltimore Contract Load (BCL) "winter" peak (Jan. 8, 11°F mean).
7. In the hour of the monthly BCL peak, a maximum of 23% of the total-service and 45.9% of the house heating connected load operate; both maximums occurred at 7 p.m. on Jan. 8.
8. The heating maximum (diversified) demands over a quarter-hour interval are greater (up to 18%) and the one-hour demands are less (up to 15%) than those measured over the standard half-hour interval.
9. Each electric furnace adds 3.43 KW to the BCL monthly peak hours, averaged over the 12-month period, or approximately 14% of the average furnace connected load.
10. The daily heating uses and maximum diversified demands correlate best with daily DD, as linear relationships. [Note: These 2 factors are linearly related to one another.]
11. Annual load factors - based on maximum (diversified) demands - are 25.2% for total service and 17.1% for heating; comparable annual load factors - when based on (noncoincident) maximum demands - are respectively, 16.9 and 12.4%. The heating load tends to decrease the average test customer's annual load factor.
12. Annual demand factors are 29.2% for total service and 61.3% for heating.

B) Central Cooling

1. Annual use of the 2,640 KWH used annually for cooling is equivalent to 417 hours use of the cooling connected load; on a normalized DD basis this value is 392 hours.
2. Of the annual cooling energy requirements, 51% is used on peak (8 a.m. thru 10 p.m., on weekdays other than holidays).
3. Annual cooling use on a normalized DD basis is equivalent to 0.09 KWH/CDD/1000 cubic feet (of cooled space).
4. The maximum diversified cooling demand occurred between 3 and 6 p.m., in May thru Oct.
5. The average cooling use per customer is 57% of the average total-service energy use for such customers on the day of the BCL peak for the entire year (July 17, 85°F mean). At the hour of monthly BCL peak (3 p.m., July 17), a maximum of 44.6% of the cooling connected load operates.
6. The cooling maximum (diversified) demands over a quarter-hour interval are greater (up to 11%) and one-hour demands are less (up to 6%)

than those measured over the standard half-hour period.
7. Each unit adds 1.13 KW to the BCL monthly peak hours, averaged over the 1-year period, or approximately 18% of the average cooling connected load.
8. The daily cooling uses and maximum diversified demands correlate with daily CDD as straight line relationships. [Note: These 2 factors are linearly related to one another.]
9. The annual cooling load factors, based on maximum diversified and noncoincident maximum demands, are 7.3 and 5.4%, respectively.
10. The annual demand factor for central cooling is 65.2%.

TITLE: TOTAL-ELECTRIC SINGLE FAMILY RESIDENCES

SOURCE: Alabama Power Co./Southern Company Services, Inc. (Atlanta, Ga.)

AUTHOR(S): F.W.Keith, Jr. & R.E.Clements (for C.B.Grund, Jr.)
PREPARED BY AUTHOR(S) AND/OR: A.P. Co.

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TOTAL:[PAGES 28 ;REFERENCES ;GRAPHS 29 ;TABLES 3] *
DOCUMENT CLASSIFICATION(S): 4/1, 7, 14, 19, 22, 31

ABSTRACT: *[One Table is unnumbered. Graphs are grouped into 12 charts.]

Forty medium-size, single-family homes equipped with central air conditioning systems and electric furnaces were selected for testing. The non-random selection process used was justified based on the requirement for additional data to be used in formulating promotional efforts regarding electric furnaces. Company representatives contacted each homeowner to request his cooperation and to determine the physical feasibility of installing test meters. The floor area, connected appliance load and occupancy were determined in consultation with the homeowner.

This program tested dwellings averaging 1,512 sq. ft., with a range from 865 to 2,050. The "typical" home had 4" of ceiling insulation and 3" in the walls plus wood-frame construction concrete slab flooring and a brick veneer exterior. A central heating and a central cooling system, electric range, water heater and refrigerator were in each residence. The % "saturation" levels for the other appliances are as follows: refrigerator (100), range (100), water heater (100), automatic washer (95), dryer (73), dishwasher (44) and freezer (27).

The test period began after the installation of 2 magnetic tape load survey recorders and one indicating demand meter at each residence. One of the recorders was used for total-service (30-minute) integrated demands during the entire test period; the second was alternated between the heating and cooling circuits. [Initially, this second recorder was installed to monitor (30-minute) integrated air conditioning demands, while the indicating demand meter was placed on the heating circuit. In Oct. this recorder was switched from the air conditioning to the electric furnace circuit. At the same time, the indicating demand meter was switched from the heating circuit to air conditioning circuit and the system was operated in this manner for the balance of the test period.] The magnetic tapes were changed and translated approximately every thirty days.

Purposes of Study: to obtain data for determining the characteristics of the space conditioning loads of single-family residences equipped

with electric furnaces and central air conditioning systems, and their relationship to the total service requirements; development of load data for rate and economic analyses, weather and load relationships which support load forecasting and for aid in the formulation of selective marketing policies.

Summary of Major Findings:

1. The average annual entire service KWH was 28,078 of which 5,889 was for air conditioning and 10,349 for heating. Thus air conditioning accounted for 21.0% and heating for 36.9% of the 28,078 value. In other words, the annual heating energy was 1.76 times as great as the annual air conditioning energy.
2. The average equivalent full load hours of use of the electric furnace amounted to 623 hours per year.
3. The average customer total-service maximum hourly (diversified) demand was 11.26 KW, which occurred on 1/9/70 at 7:00 a.m.
4. The average customer maximum hourly (diversified) air conditioning demand was 4.19 KW, which occurred on 6/27/69 at 5:00 p.m. Similarly, for heating, this demand was 9.20 KW on 1/9/70 at 7:00 a.m.
5. The 63.09% average customer annual load factor, calculated using the total-service (diversified) demand at the time of the summer system peak, occurred on 7/8/69 at 2:00 p.m. Based on the total-service maximum hourly (diversified) demand, which occurred at the time of the winter group peak on 1/9/70, at 7:00 a.m., the load factor was 28.47%.
6. Winter and summer (daily) total-service load profiles are dissimilar due to the seasonal use of furnaces. The time of occurrence and magnitude of the peaks for these two seasons also differ.
7. The 17.06% annual air conditioning load factor, based on a diversified demand of 3.94 KW at the time of the summer system peak, occurred on 7/8/69 at 2:00 p.m.
8. The 16.04% annual air conditioning load factor, based on a diversified demand of 4.19 KW at the time of the group peak, occurred on 6/27/69 at 5:00 p.m.
9. The 19.43% annual heating load factor, based on a diversified demand of 6.08 KW at the time of the winter system peak, occurred on 1/8/70 at 6:00 p.m.
10. The 12.84% annual heating load factor, based on a diversified demand of 9.20 KW at the time of the group peak, occurred on 1/9/70 at 7:00 a.m.
11. The ratio of peak heating to peak air conditioning diversified demand was 2.20.
12. The ratio of the total service diversified demand at the time of the winter system peak to the total service diversified demand at the time of the summer system peak was 1.81.

TITLE: ALL-ELECTRIC APARTMENT BUILDING 12-MONTH LOAD STUDY

SOURCE: Potomac Electric Power Co. (Washington, D.C.)

AUTHOR(S): F.S.Walters
PREPARED BY AUTHOR(S) AND/OR: P.E.P.

DATE OF ISSUANCE: 1963-64 Report of LRC/AEIC (Printed 1965)
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DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.E.P.

TOTAL: [PAGES 19 ; REFERENCES ; GRAPHS 6 ; TABLES 8] *
DOCUMENT CLASSIFICATION(S): 5/7, 22, 48

ABSTRACT: *[Three of Tables are unnumbered. Graphs are grouped into 4 Charts.]

Electric service to each apartment was on an individually metered basis, with each occupant responsible for usage as billed under the applicable P.E.P. residential rate. [Note: During the eighth billing month of the test year, P.E.P. filed a lower tariff for all-electric residential use but the reduced rate is not believed to have had any significant effect on the use of service during the remaining months of the study.]

The building tested is a 3-story and basement structure. There are 4 dwelling units on each floor above the basement and 3 (plus storage and utility areas) in the basement. All windows on the basement floor are above ground level. The building is of brick construction with double-pane windows and insulation of 1" thickness in the outside walls and 6" in the ceiling of the top floor. The net floor areas are 960 sq. ft. (2 bedroom) and 760 sq. ft. (one bedroom). The design values of heat loss (at zero F, outside temperature) ranged from 6.7 to 7.7 KW (two bedroom) and from 5.5 to 6.3 KW (one bedroom).

Each apartment is equipped with an electric range (12,350 watt), conventional refrigerator, waste disposal unit and an under-counter water heater (2,500 watts). Electric space heating equipment is of the resistance type, installed in baseboard units with individual thermostatic control in each room; the kitchen has no space heating units. [The connected load of space heating equipment averages 4.36 KW per dwelling unit.]

Average 30-minute demand measurements were made with magnetic-tape load survey recorders. One recorder was used for each of the 15-dwelling units and one was used to measure the house-service which comprised corridor lighting, laundry room facilities and other common usage. [Total building demand was determined by summation during data processing.]

Purposes of Study: to determine the load characteristics of a 15-dwelling unit, all-electric apartment building, including resistance space heating and uncontrolled water heating.

Summary of Major Findings:

1. Annual use per dwelling unit was 12,417 KWH for all applications, including a one-fifteenth share of "house use". [Note: Only two apartments were air-conditioned, by means of a single window unit in one unit and by 2 window units in the other. Consequently, the test data does not reflect any significant use of electricity for air-conditioning.]

2. Monthly energy use per dwelling unit, including its proportionate share of house service, ranged from 473 KWH (Oct.) to 2,011 KWH (Jan.). Over the test year the average KWH use per month was 1,035; house service use averaged 104 KWH per dwelling per month. [The month of greatest energy use (Jan.) also had the highest heating degree-day count.]

3. The highest monthly demands (including house use), on both a noncoincident and diversified basis, occurred in Jan. The noncoincident maximum demand was 8.65 KW per dwelling unit and the maximum diversified demand was 5.46 KW, resulting in a monthly coincidence factor of 0.631.

4. The annual load factor, for all service furnished to the building, was 26%; monthly load factors ranged from 33.2 to 56.9%.

5. Monthly load factor and energy use showed good correlation with weather index values. [A definite pattern was also established between outdoor temperature, at the time of monthly peak demand, and the established coincidence factor for the period.]

6. The building's measured maximum diversified demand during the 12-month period was 81.86 KW. Relating this demand to the connected load (of about 339 KW) yields a demand factor of 24.2% for the entire building.

TITLE: ALL-ELECTRIC APARTMENTS with RESISTANCE HEATING

SOURCE: The Potomac Edison Co. (Hagerstown, Md.)

AUTHOR(S): R.M.Spagnolo (for R.C.Carder)
PREPARED BY AUTHOR(S) AND/OR: P.E.

DATE OF ISSUANCE: 1964-65 Report of LRC/AEIC (Printed 1966)
OTHER IDENTIFIERS: Appendix C, Section 1 (pp L-23 + L-40 thru L-54)
data covers 11/1/62 thru 10/31/63
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.E.

TOTAL:[PAGES 16 ;REFERENCES ;GRAPHS 10 ;TABLES 2] *
DOCUMENT CLASSIFICATION(S): 5/2, 7, 14, 22, 48

ABSTRACT: *[Graphs are grouped into 3 Charts.]

Of the 36 apartments in the 4 separate apartment buildings studied during the period of this load survey, 20 were two-bedroom apartments, 14 were one-bedroom and 2 were efficiency units.

Each of the 36 apartments contained an electric range, refrigerator and water heater. Of the water heaters within the apartments, 26 were 40 gallon NEMA Standard, 4 were 40 gallon operating with no interlock and 6 were 42 gallon quick-recovery type. Of the 5 water heaters in the utility rooms, one was 52 and 4 were 66 gallon, all NEMA Standard. One apartment had a dishwasher, 2 had window-type air conditioners and 26 had waste disposal units. Ten apartments were heated by ceiling cable, 24 by baseboard units only and 2 by a combination of baseboard units and wall panels. [There was a total of 3 automatic washers and clothes dryers in the utility rooms.]

Electric service was supplied to each apartment on an individually metered basis, with each tenant responsible for his KWH use as billed under P.E.'s applicable residential rate. "House use" was billed under P.E.'s applicable commercial rate.

Fifteen-minute demand measurements (converted to 30-minute during data processing) were made with 8 magnetic-tape load survey recorders. One recorder was used to measure the total service load of 2 buildings (13 apartments each) which were served from a single transformer, another was used to measure the total service load of a third apartment building (4 apartments) and 6 were used to measure the total service load of each individual apartment in the fourth apartment building.

Purposes of Study: to determine the total service load characteristics of 4 separate all-electric apartment buildings, consisting of 36 individual apartments.

Summary of Major Findings:
1. Annual energy use per customer, including equal shares of "house use",

amounted to 11,515 KWH. The average apartment had a heated area of 714 sq. ft. with a calculated heat loss (based on zero F, outside and 70 F, inside) of 14,311 BTU/hour. Their connected heating load averaged 5.875 KW and their connected total service load was about 20.44 KW (estimated).

2. Monthly energy use per customer, including equal shares of "house use", ranged from 530 KWH in Sept. to 1,727 KWH in Jan. Average monthly energy use per customer, including equal shares of "house use", was 960 KWH.

3. January was also the month containing the highest heating degree-day (HDD) count. However, the highest demand - on a "per customer" basis, including equal shares of "house use" - occurred on Dec. 31 and was 4.38 KW. Since this peak demand occurred during the Christmas holiday season, it is appropriate to note that the next highest demand (like the highest energy use and HDD count) occurred in Jan. and was 4.01 KW; it is noteworthy that this demand occurred on the coldest single weekday during the load survey period. [Note: The KW demands quoted here are diversified demands.]

4. The annual total service load factor per customer was found to be about 30.0%, with monthly load factors ranging from about 33.9% in July to 64.2% in Feb.

5. The annual total service demand factor per customer was about 21.5%, with monthly demand factors ranging from about 6.8% (in Aug.) to about 21.4% (in Dec.).

TITLE: APARTMENT HOUSE STUDY

SOURCE: Detroit Edison (Detroit, Michigan)

AUTHOR(S): L.E. Brandenburg (for E.H.Scott)
PREPARED BY AUTHOR(S) AND/OR: D.E.

DATE OF ISSUANCE: 1965-66 Report of LRC/AEIC (Printed 1967)
OTHER IDENTIFIERS: Appendix B, Section 1 (pp. L-24 thru L-45); data covers 4/64-5/65
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with D.E.

TOTAL: [PAGES 22 ;REFERENCES ;GRAPHS 9 ;TABLES 7] *
DOCUMENT CLASSIFICATION(S): 5/6, 7, 14, 22, 29, 40, 48

ABSTRACT: * [Three of Tables are unnumbered; the numbered Tables are actually subdivided into major appliance categories. The Graphs are grouped into 3 Charts.]

Since 1962, over 25% of the dwelling units built in the Detroit Metropolitan Area have been in multiple structures and, by 1967, it is indicated that as much as 40% of residential construction will be in apartments.

The apartments in the sample have 4 to 82 units and are equipped with various combinations of electric appliances; they range from small units with only a room air conditioner to all-electric apartments with range, water heater, air conditioner and electric heat.

From a universe of over 8,000 apartment complexes in the D.E. service area, a sample of 51 buildings was selected as representative of the types currently under construction; most were built during 1953-63. Varying apartment sizes and appliance saturations were selected to provide a basis for estimating incremental use and demands.

A 15-minute demand meter and an energy use meter were installed on the total apartment load at each of the test locations. [At the time of installation each apartment was surveyed to determine the connected loads and square feet of floor area.] Connected loads were calculated on the basis of 3 watts per square foot for lighting and 1,500 watts per outlet for miscellaneous appliance loads; the actual connected loads of ranges, water heaters, air conditioners, electric heating and clothes dryers were obtained. In several cases, the total meters included house service and common basement and lighting loads which were surveyed separately. On a per apartment basis, connected loads ranged from a low of 3.74 KW (for a 428 square foot unit) to 30.65 KW for each of 4 all-electric apartment units with an average of 616 square feet.

Demand charts were changed bi-weekly and energy use meters were read concurrently. From these basic data, monthly and annual KWH use and KW maximum demands were obtained. Load patterns for each of the apartments

were obtained for the summer and winter system peak days; for the all-electric apartments, these peak curves are supplemented by demand patterns for the coldest day of the heating season.

Results of the study are summarized for the total apartment building, as well as on a per unit basis, so as to facilitate analysis and comparison.

Purposes of Study: to provide information for estimating transformer and wire sizes and for determining probable annual energy requirements.

Summary of Major Findings:

1. The energy use per dwelling unit - for representative apartments in the Detroit area with no major appliances or with only an electric range - is around 2,500 KWH annual. Air conditioning use adds about 500 KWH, water heating adds from 3,000 to 3,500 and heating adds an estimated 5,000. However, individual apartments and apartment complexes (on a per unit basis) can be expected to vary widely from these average values.

2. In general, the energy use per apartment unit is 50-75% of the use for separate homes in the Detroit area.

3. The maximum demand per apartment averaged 1.8 KW with air conditioning only or with a range and air conditioner. For apartments with air conditioning only, the maximum demand was 30% of connected load; for those with air conditioning and ranges, the demand factor was only 10%.

4. The all-electric apartments tested had an average winter peak of 4.4 KW, equivalent to 18% of their connected loads. Their annual load factor, based on the diversified demand on the coldest day of the test period, was 40%.

5. Annual load factors of the 51 apartments, based on their diversified maximum demands on the day of the system peak (12/21/64), were in the 50% range; this compares closely with the corresponding annual load factor of the residential class as a whole. However, because of the nearly 100% saturation of room air conditioners, apartments with air conditioning only (or with a range and air conditioner) had summer peaks and the annual load factors based on these summer peaks were in the 20-25% range. [The addition of electric water heating to the base loads improved annual load factors by some 5%.]

TITLE: ALL-ELECTRIC HIGH RISE APARTMENT BUILDING LOAD STUDY

SOURCE: Public Service Electric and Gas Co. (Newark, N.J.)

AUTHOR(S): P.F.Platt (for B.P.Dahlstrom)
PREPARED BY AUTHOR(S) AND/OR: P.S.E.&G.

DATE OF ISSUANCE: 1966-67 Report of LRC/AEIC (Printed 1968)
OTHER IDENTIFIERS: Appendix D, Section 1 (pp L-48 thru L-81); data covers 10/64 thru 9/65
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.S.E.&G.
TOTAL:[PAGES 34 ;REFERENCES 1 ;GRAPHS 50 ;TABLES 11] *
DOCUMENT CLASSIFICATION(S): 5/1, 7, 14, 19, 22, 24, 48, 49

ABSTRACT: *[Six of Tables are unnumbered. Graphs are grouped into 14 Charts.]

This building comprises 101 apartments on 9 floors, with 12 apartments per typical floor. [Of these, 31 apartments on 8 floors were selected for test. Included were: 3 efficiencies, 20 four and one-half room and 8 five and one-half room units.] Use and demand for total service and heating and cooling were measured, as were use and demand for electric water heating in 23 of the 31. During construction, separate circuits for these loads were installed in each apartment selected for tests since this procedure provided a practical and economical method of conducting this study.

In addition to measuring the use and demand for individual apartments, test metering equipment was installed to determine use and demand for both common use service and total building load.

Magnetic tape load survey recorders were installed to measure 30-minute integrated demands. Tapes were translated to punched load-survey cards and the acceptable data was processed and studied on a monthly basis so as to derive average load curves and related information. [Results are reported on prevailing clock time, EST during the winter and EDT during the summer.] Heating and cooling use and demand were measured by the same recorder. Test results in this study for Oct. thru May were considered to be heating use; results for June through Sept. were considered to be cooling use.

Each of the apartments contained an electric range, refrigerator, "unrestricted" quick-recovery water heater, dishwasher, room air conditioning units and miscellaneous appliances All apartments are equipped with ceiling cable resistance heating.

The apartments had brick (cavity) walls and double glass windows. Insulation of ceilings and floors were rated R25 and exterior walls were R12.5

Originally service was furnished to each apartment on an individually metered basis with each occupant being billed under Rate Schedule RHS, Residential Heating Service. Rentals were slow, as potential tenants proved reluctant to assume direct payment for utility service, so the owner changed the rental policy and increased the rents to include electricity. Thereafter, total building energy was measured through a single meter installation and billed under Rate Schedule LPL, Large Power and Lighting Service; the data for this report are taken after this billing change.

Purposes of Study: to provide load characteristics data for each month of a test year of the first high rise "Gold Medallion" apartment building in the P.S.E.&G. territory; to obtain data for (1) the development of cost determinants; (2) continuing rate studies; (3) optimizing the size of transformers and conductors; (4) estimating service requirements; (5) estimating annual use and demand for promotional purposes.

Summary of Major Findings (for Individual Apartments):

1. Annual heating use per customer per degree-day is 1.382 KWH, which is about 42% of total service use.
2. Annual water heating use per customer is approximately 25% of total service use.
3. Annual cooling use per customer is approximately 13% of total service use.
4. Noncoincident maximum demand per customer for total service is approximately 36% of the average total connected load. Noncoincident maximum demand per customer for heating is approximately 91% of the average heating connected load.
5. Annual load factor based on maximum diversified demand is: 33.1, 22.6 and 24.8% for total service, space heating and water heating, respectively.
6. The maximum diversified total service demand for each month of the year occurs between 6:30 and 8:30 p.m. This shows the effect of the evening cooking load.
7. There is a high degree of correlation between: heating-cooling demand and outdoor temperature; heating-cooling use and outdoor temperature; heating-cooling demand and heating-cooling use.
8. The ratio of connected heating load to calculated heat loss, both in BTU per hour, is 1.36. There are approximately 1189 hours use of connected heating load for a heating season, based on normal degree-days.

Note: For the entire building, the maximum weekday diversified KW demand, during the 12-month test period, is 588.0; relating this actual demand to the connected load yields a demand factor of 18.0%. Stated another way, the maximum demand for the entire building as a unit is 18% of the connected load of all facilities within the structure.

TITLE: MULTI-FAMILY APARTMENT BUILDINGS with ELECTRIC SPACE HEATING LOAD STUDY

SOURCE: Public Service Electric and Gas Co. (Newark, N.J.)

AUTHOR(S): P.F.Platt (for G.Clarkson)
PREPARED BY AUTHOR(S) AND/OR: P.S.E.&G.

DATE OF ISSUANCE: 1967-68 Report of LRC/AEIC (Printed 1969)
OTHER IDENTIFIERS: Appendix C, Section 1 (pp L-60 thru L-89); data covers 5/64 thru 4/65
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.S.E.&G.
TOTAL: [PAGES 30 ;REFERENCES ;GRAPHS 92 ;TABLES 7] *
DOCUMENT CLASSIFICATION(S): 5/7, 14, 19, 22, 31

ABSTRACT: *[Three of Tables are unnumbered. One of numbered Tables is a composite of "sub-tables" which give comparative data for each calendar month, for each building studied.]

Ten all-electric, garden-type apartment buildings (with electric resistance heating) were selected for test. Each apartment in each building contains a range, refrigerator, water heater and room air conditioning units. Each apartment in 2 of the 10 buildings has a dishwasher. Eight buildings are equipped with baseboard resistance heating and 2 with ceiling cable. All buildings are insualted in accordance with (or better than) the "all-weather comfort standards" of R19 ceiling, R11 walls and R13 floor. [Note: R=thermal resistance in degrees F per Btu/(hour) (square foot).]

Magnetic tape load survey recorders were installed to measure 30-minute integrated demands. Use and demand for total building service were measured. Tapes were translated to computer load survey cards and acceptable data was processed by individual apartment buildings. Each building was studied on a monthly basis so as to derive average load curves and related information. [Results are reported on prevailing clock time, EST during the winter and EDT during the summer.]

Purposes of Study: to provide load characteristics data of 10 all-electric apartment buildings for each month of a test year for appraising the value of this class of business; providing factual information for estimating future service requirements; assisting in promotional efforts; optimization of the size of transformers and conductors; for continuing rate studies.

Summary of Major Findings:
1. The ratio of connected heating load to calculated heat loss, both expressed in Btu per hour, ranges from 1.04 to 1.23.

2. The annual demand factor for total service ranges from 15.9 to 38.4%.

3. The annual load factor for total service ranges from 18.9 to 33.3%.

4. During the test period, there was no consistency in the hour of occurrance of the maximum demand for the individual building. During the summer period, the maximum demand occurs in the late afternoon or early evening.

5. During the winter period, one observes a morning and afternoon peak but (practically) there is no consistency as to hour of occurrence or magnitude of these peaks.

6. Winter hourly demands significantly exceed those for summer. The increase of winter maximum demands over those for summer ranges from 43.8 to 160.3%.

7. Annual KWH use range was 10,351 to 25,411; the average was 12,952.

8. Coldest day use range was 65.5 to 187.5 KWH, averaging 89.7. The maximum demand (8:30 a.m.) varied from 4.14 to 10.40 KW, with an average of 4.44.

9. Warmest day use range was 15.5 to 41.8 KWH, averaging 26.5. The maximum demand (7 p.m.) varied from 1.65 to 2.90, with an average of 1.76.

Note: above data is expressed on a "per dwelling unit" basis.

TITLE: APARTMENT HOUSE STUDY

SOURCE: Wisconsin Electric Power Co. (Milwaukee, Wisc.)

AUTHOR(S): R.J.Horn (for E.R.Watrous)
PREPARED BY AUTHOR(S) AND/OR: W.E.P.

DATE OF ISSUANCE: 1967-68 Report of LRC/AEIC (Printed 1969)
OTHER IDENTIFIERS: Appendix D, Section 1 (pp L-90 thru L-104); data covers Jan. thru Dec., 1966
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with W.E.P.
TOTAL: [PAGES 15 ;REFERENCES ;GRAPHS 11 ;TABLES 5] *
DOCUMENT CLASSIFICATION(S): 5/6, 14, 22, 49

ABSTRACT: *[Graphs are grouped into 3 Charts.]

For this study, the 3 all-electric apartment buildings in metropolitan Milwaukee in 1966 were metered; these included 40 apartments. In addition, 2 other apartment buildings were selected; one has 10 apartments and is total electric, except for water heating, and the other (having 20 apartments) is all gas except that it uses electricity for lighting and small appliances. [Note: the "gas" building was selected randomly from similar all-gas buildings available to be metered and falling within a class type determined to be representative.]

Magnetic tape (4 channel) recorders were used in each of the all-electric buildings and a 2 channel recorder was used in each of the remaining two buildings. In all cases only the total load was measured. The recorder tapes were changed once a month, on the day the billing meters were read. A "translator" converted the tape data into a form readable by a computer. From the translated data, the computer printed out the daily use and demand information, as well as summary data forming the basis of this study.

During the test specific periods were selected for a more detailed analysis, namely: the coldest day, the warmest day, day of the system peak, a "cold week" (coldest week data was unavailable), "mild heating" week, a "hot week" (hottest week data was unavailable) and a week representative of a medium heating period.

Purposes of Study: to determine some of the characteristics of total loads from electrically-heated apartment buildings. [Note: One all-gas apartment house is included for comparison purposes only.]

Summary of Major Findings:

1. There is very good correlation between KW demand, daily KWH and daily degree-days for the electrically heated apartments; this indicates the usefulness of weather statistics in estimating these loads.

2. The coincidence factor for the all-electric apartments during the coldest day was 99% and on the day of system peak was 94%. [The values for this factor will lend confidence to load forecasting done by extrapolation from sample data.]

3. This study indicates an improvement in load factors with the addition of water heating to an otherwise total electric apartment.

4. There appears to be less fluctuation in daily load factors in the electrically heated apartments with electric water heating than there is for electrically heated apartments without electric water heating.

5. The expected seasonal pattern of electric energy use is evident from the data. The demand pattern, however, varies to the extent that fall demands equal or exceed the winter demands.

6. The 3 all-electric buildings had energy uses of about 12.9, 14.8 and 16.6 KWH/square foot/year. The corresponding values for the other two buildings were: 13.2 (electric, except for water heating) and 6.2 (gas, except for lights and small appliances).

7. Maximum noncoincident KW demands (integrated over an hour) during the test year were: 3.3, 3.9, 4.8, 2.3 and 0.6, respectively as per units of "finding" number 6.

TITLE: RESIDENTIAL APARTMENT LOAD STUDY

SOURCE: New Orleans Public Service, Inc. (New Orleans, La.)

AUTHOR(S): R.O.Bernard (for J.A.Leo)
PREPARED BY AUTHOR(S) AND/OR: N.O.P.S.

DATE OF ISSUANCE: 1968-69 Report of LRC/AEIC (Printed 1970)
OTHER IDENTIFIERS: Appendix D, Section 1 (pp L-63 thru L-79); data covers Aug. 1966 - July 1967
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with N.O.P.S.
TOTAL: [PAGES 17 ; REFERENCES ; GRAPHS 8 ; TABLES 2] *
DOCUMENT CLASSIFICATION(S): 5/1, 6, 8, 14, 22, 34, 49

ABSTRACT: *[The Graphs are grouped into 7 Charts.]

The 2 apartment complexes selected for testing were of similar design and were constructed by the same contractor for the same owner. Both complexes, although of recent construction, were located in previously developed areas.

There were a total of 39 "all-electric" and 26 "conventional" apartments served by the respective meter centers selected for study. [The conventional apartment's cooking, space heating, and water heating requirements were served by gas.] Both complexes had individual central air conditioners. The average composite apartment contained slightly more than one and one-half bedrooms and 935 square feet of living area.

At each complex, 2 meter centers (serving the same proportion of one-, two-, and three-bedroom units) were metered with magnetic tape recorders. Sixty-five demand registers were used to replace the individual customer meters served through the meter centers. The load at each meter center was metered with a magnetic-tape recorder, used in conjunction with meters equipped with contacts. The magnetic tape recorders were installed to record 15-minute integrated demands. The tapes and the thermal demand register readings were collected on a meter reading schedule approximately 30 days apart.

Purposes of Study: to determine load characteristics - of the newer type residential apartment customers being added in N.O.P.S. area - for use in engineering, economic and rate studies and for sales promotion applications.

Summary of Major Findings:
1. Annual energy use averaged about 11,000 KWH per "all-electric" apartment and about 9,300 in "conventional" apartments.
2. Maximum monthly energy use per apartment occurred during the summer, at both complexes. During the winter, the all-electric apartment's average monthly energy use was twice that for the conventional.

3. The maximum monthly (diversified) hourly demands for the all-electric complex were of about the same magnitude thruout the test period; however, the winter maximums were generally established during the morning and the summer during the evening. The conventional apartment had about a 67% increase of summer over winter maximum monthly (diversified) demands, with all maximums established during the evening hours.
4. The maximum diversified demands during the test period for both types of apartment complexes were of similar values.
5. The "typical" all-electric apartment had 18.6 KW more connected load than the conventional but the average of their noncoincident maximum demands was only 3.6 KW higher than the estimated average of such demands for conventional apartments.
6. Annual load factors for both types of complexes, based on peak demands, were very high (all-electric, 52.5%; conventional 62.6%). This may be ascribed to the living and working habits of these apartment dwellers. However, even annual load factors based on the highest diversified maximum demand occurring during the test period were approximately 40 to 45%.
7. Correlation of average daily energy use per apartment to daily mean temperatures showed a relatively small change in energy use in response to temperature changes, as compared to a study of other types of residential customers. The all-electric units showed an increase of 1.0 KWH/degree-day (DD), above a 66°F mean, and the conventional apartment showed an increase of 1.1 KWH/DD above the same mean. In addition, as a result of space heating requirements, the all-electric customer had an increase of about 0.9 KWH/DD below a daily mean temperature of about 57°F.

Effect of Master Meters:

During this study the conventional complex changed from individual metering to master metering with rent inclusion. The individual customer meters were removed but the recorders on the meter center remained. Some observations of the effect of this change in billing are included in this report. At the beginning of this study, both the "all-electric" and "conventional" complexes were individually metered. About halfway thru the test period the conventional complex changed ownership and the new owners consolidated the individual residential metering so as to include the furnishing of electricity in the monthly rent.

A comparison of the (average conventional customer's) annual use for the 12-months immediately prior to consolidation with the 12-months following consolidation showed an increase in energy use of about 35%. No such increase was observed at the all-electric complex which had retained individual metering. [Note: an analysis of weather data showed similar weather during both periods so the increase in annual use could not be directly attributed to any apparent cause except rent inclusion. In evaluating this factor, it should be noted that the 35% increase in energy use is based only on one year's experience and has not been normalized for weather, apartment occupancy and the (expected) annual growth in energy requirements.

TITLE: TOTAL-ELECTRIC APARTMENTS

SOURCE: Jersey Central Power & Light Co. (Morristown, N.J.)

AUTHOR(S): B.M.Hicks (for E.L.Huse)
PREPARED BY AUTHOR(S) AND/OR: J.C.P.&L.

DATE OF ISSUANCE: 1968-69 Report of LRC/AEIC (Printed 1970)
OTHER IDENTIFIERS: Appendix F, Section 1 (pp L-119 thru L-144); data covers 8/1/67 to 7/31/68
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with J.C.P.&L.
TOTAL: [PAGES 26 ; REFERENCES ; GRAPHS 9 ; TABLES 11]
DOCUMENT CLASSIFICATION(S): 5/14, 17, 19, 46, 49

ABSTRACT:

Five, 15-minute, impulse-operated punched tape, digital demand recorders were used to measure the primary load respectively of 16, 22, 32, 40 and 48 apartments during the test period. These 158 apartments represent 100% of all such apartments on the J.C.P.&L. system at the time of initial testing.

Purposes of Study: to determine load characteristics, facility requirements and the load-temperature relationship of the average apartment (when diversified with the entire apartment complex) for purposes of rate making, sales promotion and system planning.

Summary of Major Findings:
1. The half-hour integrated diversified demand per apartment reached a maximum of 8.83 KW at 8 a.m. on Jan. 11; on this day 55 heating degree-days (HDD) were accumulated.
2. The yearly energy use is 19,214 KWH per apartment, of which 3.6% and 0.9% respectively, are used during the coldest and warmest 5-weekday period.
3. The annual load factor is 24.8%. The average monthly load factor is 37.1%. The maximum monthly load factor was 50.7% for Feb. and the minimum was 28.4% for Aug.
4. The test year HDD (65°F base) amounts to 5,387 which is 6% above normal. The test year cooling degree-days (CDD), 70°F base, was 320, with no normal established for comparison.
5. The apartment daily maximum demand (A.D.M.D.) for 67% of the year occurred from 7 to 9 a.m. and represents 85% of such demands for Oct. thru May.
6. The various half-hour time periods ending from 5 to 7 p.m. account for 23% of the A.D.M.D. for the year and for 68% of such demands during July and Aug.
7. The A.D.M.D. of Sept. and June occur 90% of the time either during the 7 to 9 a.m. or the 5 to 7 p.m. periods.
8. The apartment weekly maximum demands (A.W.M.D.) occur 31% of the time during weekends, 25% on Tuesdays and 8% on Fridays.

9. The A.D.M.D. at 65 HDD/day, is calculated to be 9.77 KW; after subtracting the basic demand of 2.16 KW at zero HDD, one is left with 7.61 KW, which may be taken to represent the diversified heating load. Dividing 7.61 by the 9.20 KW average individual heat loss requirement results in a diversity of 82.7%.
10. The A.D.M.D. at zero HDD/day is calculated to be 2.16 KW, with a 0.117 KW increase per HDD increase per day (at a 0.937 coefficient of correlation).
11. The A.W.M.D. at zero HDD/week is found to be 3.25 KW, with a 0.017 KW increase in the weekly maximum demand per HDD increase per week (at a 0.955 coefficient of correlation).
12. The apartment daily energy use at zero HDD/day is calculated to be 19.86 KWH, with a 2.049 KWH increase per HDD increase per day (at a 0.958 coefficient of correlation). [A 0.065 KWH use/DD/1000 BTU/hour (heat) loss is then determinable.]
13. The apartment weekly energy use at zero HDD/week is found to be 121.98 KWH with a 2.223 KWH increase in the weekly energy use per HDD increase per week (at a 0.976 coefficient of correlation).
14. The A.D.M.D. at zero CDD/day is found to be 1.74 KW, with a 0.076KW increase per day per CDD increase per day (at a 0.598 coefficient of correlation).
15. The A.W.M.D. at zero CDD/week is 2.48 KW, with a 0.009 KW increase in the weekly maximum demand per CDD increase per week (at a 0.245 coefficient of correlation).
16. The apartment daily energy use at zero CDD/day is found to be 22.25 KWH with a 1.125 KWH increase per CDD increase per day (at 0.736 coefficient of correlation).
17. The apartment weekly energy use at zero CDD/week is 152.69 KWH, with a 1.127 KWH increase in the weekly energy use per CDD increase per week (at a 0.780 coefficient of correlation).
18. A 0.8 KW increase in the A.W.M.D. is found for every 100 KWH increase in the apartment energy use per week during the heating season (at a 0.957 coefficient of correlation).
19. A 2.1 KW increase in the A.W.M.D. is found for every 100 KWH increase in the apartment energy use per week during the cooling season (at a 0.822 coefficient of correlation).

TITLE: ALL-ELECTRIC APARTMENT UNITS

SOURCE: Pacific Gas and Electric Co. (San Francisco, Calif.)

AUTHOR(S): W.Blumst
PREPARED BY AUTHOR(S) AND/OR: P.G.&E.

DATE OF ISSUANCE: 1968-69 Report of LRC/AEIC (Printed 1970)
OTHER IDENTIFIERS: Appendix G, Section 1 (pp L-145 thru L-158); data covers Jan. 1967 - Mar. 1968
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.G.&E.
TOTAL: [PAGES 14 ; REFERENCES ; GRAPHS 3 ; TABLES 9] *
DOCUMENT CLASSIFICATION(S): 5/8, 14, 15, 19, 22, 31

ABSTRACT: *[Seven of Tables are unnumbered.]

The first step in the determination of the test sample's distribution was to select regions representative of areas where all-electric apartment units were being built. The distribution of the 56 sample units was based on a proportionate share of the all-electric apartment unit buildings constructed in various areas. Final allocation of the sample was 8 buildings in Marin County, with 33 units, and 6 buildings in San Francisco, with 23 units. The units in Marin County averaged almost 1,000 sq. ft. vs almost 600 for San Francisco. The units in Marin County were mainly in garden-type buildings, e.g., low-rise with access provided from outside passages.

Personal calls were made on the building owners and managers to obtain their cooperation in completing survey forms and to determine the feasibility of the test meter installations. Care was taken to include a representative cross-section of units on the ground floor, top floor, corner apartments, etc. There was sufficient diversity - in size of unit, location within the building and family characteristics - for this sample to be considered representative of such units in the P.G.&E. service area.

Magnetic tape load survey recorders were used to obtain time and demand data. The survey meter was installed by plugging it into the customer's electric service meter socket, replacing the normal billing meter. The regular meter reading and billing process was unchanged.

There was a 100% (sample) saturation for ranges, garbage disposers, refrigerator-freezers and televisions. Dishwasher saturation averaged about 18%.

Purposes of Study: to determine the demand and energy characteristics of recently built all-electric apartment units on an annual, seasonal and peak demand periods basis for the purposes of: (1) directing selective selling programs; (2) advance planning for distribution systems;

(3) analyzing area electric load needs, engineering standards and rate procedures.

Summary of Major Findings:

1. Unit use averaged 6,981 KWH per year and ranged from 1,627 to 15,450.

2. The highest use months were Dec. (1,087) and Jan. (1,214 KWH), accounting for one-third of the total annual use.

3. The average connected load per unit was 17.7 KW, of which 5.29 was for electric heating. [Note: None of the apartments had cooling.] The test customers annually used 394 KWH per KW of connected load.

4. Maximum 30-min. (diversified) demand, at the time of the "sample" peak, averaged 3.65 KW; this peak was on Wed., 12/13/67, at 6:30 p.m. [Noncoincident demands averaged a highest monthly level of 6.98 KW, also in Dec. 1967.]

5. The load curve for an average weekday, during the coldest 5-day period, indicated a peak demand of 2.62 KW at 7 p.m. and a 24-hour average demand of 1.86 KW.

6. The load factor - based on maximum diversified demand - was 22% on an annual basis and 32% for the 5-month heating season.

7. The coincidence factor recorded an annual average of 48%, with a Dec. high of 52%.

TITLE: LOAD CHARACTERISTICS of an ALL-ELECTRIC HIGH-RISE APARTMENT BUILDING

SOURCE: Consolidated Edison Co. of New York, Inc. (New York, N.Y.)

AUTHOR(S): R.E.Weintraut (for J.Monsees)
PREPARED BY AUTHOR(S) AND/OR: C.E. (of) N.Y.

DATE OF ISSUANCE: 1970-71 Report of LRC/AEIC (Printed 1972)
OTHER IDENTIFIERS: Appendix C, Section 2 (pp L-134 thru L-154); data cpvers 8/22/67 to 8/21/68
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with C.E. (of) N.Y.
TOTAL: [PAGES 21 ;REFERENCES ;GRAPHS 13 ;TABLES 5] *
DOCUMENT CLASSIFICATION(S): 5/1, 14, 22, 24, 25, 34, 48

ABSTRACT: *[The Graphs are grouped into 8 Charts.]

Due to the rapid growth in air conditioning during the 1950's, the C.E. system peak load shifted (in 1957) from its historic winter position to a summer peak. Since then the gap between the summer and winter peak has continued to widen each year. In order to offset this trend major residential electric heating promotions were developed. Previous research indicated that all-electric apartments have: (1) Peak electric heating loads which occur in the winter months when system peaks are lower; (2) Twin daily electric heating peaks which occur around 7 a.m. and 8 p.m., while winter peaks for the system are around 5:30 p.m.; (3) Annual electric heating uses per apartment about 4 times as large as for annual air cooling.

For test purposes, 37 load survey magnetic tape recorders were installed to measure simultaneously: the half-hour loads for the entire 23 story building; the total loads on each of 12 risers serving all 92 apartments; additionally in each of eight apartments on Riser 8 the total load, "through-the-wall" space conditioning loads and electric water heating load.

The exterior walls of the building are cinder block and brick construction. Insulation in all exterior walls is 1-inch urethane board. The roof of the building is insulated with 3 (2-inch) sheets of expanded perlite board. All windows are metal sash Thermopane. Each room contains a through-the-wall combination electric heating and air conditioning unit. Each apartment contains a 40- or 50-gallon, quick-recovery electric water heater plus electric range and refrigerator. [A separate central laundry room for use by the tenants is located in the basement of the building.] The 8 apartments on Riser 8 were selected as typical apartments for test purposes. The size of each apartment on Riser 8 is 4 1/2 rooms, the average size for all 92 apartments in the building.

Purposes of Study: to measure the full impact of electric heating loads on the C.E. system; to develop energy use and demand relationships for

the entire building and for apartments for which the cost of energy is included in the tenants' rent.

A. Results for Eight Apartments Tested (on a "per apartment" basis):
1. Average annual energy use was 24,065 KWH. This compares favorably with the average of 24,339 KWH for the 92 apartments tested in groups on the 12 building risers.
2. Space heating use (from 9/21/67 to 5/22/68) averaged 11,645 KWH or 48.4% of total annual use. The number of heating degree-days totaled 5,164 which was 7.0% above the normal of 4,833.
3. Air cooling use for the other four test months averaged 2,068 KWH or 8.6% of total annual use. Cooling degree-days totaled 507 or 94.2% of the normal of 538 for the period.
4. Water heating use averaged 6,207 KWH or 25.8% of total energy use for the year. [The miscellaneous uses comprised 17.2% of total annual use.]
5. Maximum diversified demand (MDD) was 9.66 KW at 8 p.m. for the average of the five coldest winter weekdays. The peak was comprised of 7.13 KW for space heating 1.44 KW for water heating and 1.09 KW for all other uses. For the five warmest summer weekdays the MDD was 4.75 KW at 6 p.m. and consisted of 2.57 KW for air cooling, 1.04 KW for water heating and 1.14 KW for all other uses.
6. The MDD for the Riser 8 units during the heating season was 12.05 KW. It occurred on Thursday, 1/11/68, at 8 p.m., with an hourly outdoor temperature of 8.5°F. The corresponding MDD for the cooling season was 6.60 KW on Monday, 7/1/68, at 5:30 p.m., with an hourly outdoor temperature of 86.8°F.

B. Results for Entire Building
7. The MDD for total service (including light and power for the building) was about 1,068 KW, or about 11.6 KW per apartment. It occurred during the heating season on Monday, 1/8/68, at 8 p.m. The summer peak of 507.8 KW, or 5.52 KW per apartment, was on Monday, 7/1/68, at 7:30 p.m., the hottest day of the year. [By comparison, peaks for the Company system tend to occur around 5:30 p.m. in the winter and 3:30 p.m. in the summer.]
8. Annual energy use in the entire building was about 2,631,000 KWH. Of this total, 85.1% was used by the 92 tenants. The remaining 14.9% for building use was the difference between the master meter and the sum of the riser totals.

TITLE: THE EFFECT of MAJOR APPLIANCES on RESIDENTIAL USE of ELECTRICITY

SOURCE: Various Utilities *

AUTHOR(S): A.F.Rehberg, et al; "Special Subcommittee on Residential Lighting
PREPARED BY AUTHOR(S) AND/OR: LRC/AEIC and Appliances"

DATE OF ISSUANCE: 1956-57 Report of LRC/AEIC (Printed 1958)
OTHER IDENTIFIERS: Section 4, Parts 1 & 2 (pp L-80 thru L-121); data covers various periods (some as long as 11 mo.) from 1939 thru 1956.
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with LRC

TOTAL: [PAGES 42 ;REFERENCES 72 ;GRAPHS 41 ;TABLES 19] **
DOCUMENT CLASSIFICATION(S): 7/10, 13, 14, 18, 20, 27, 28, 31, 33, 40, 48

ABSTRACT: *[Data came from the following sources in various regions of the USA: 6 cities, for central air-cooling systems; 6 cities, for room air-cooling units; 15 cities (or larger areas), for room air-heating units for an entire dwelling; 3 cities for heat pumps used for heating only; 5 cities (or larger areas), for electric clothes dryers and ranges; 2 cities, on electric refrigerators of various types; 4 cities on televisions; 9 cities (or larger areas), on various types of hot water heaters; 2 cities, on all electric homes.]

**[Note: 42 of References are LRC Reports, printed in various issues between 1946-47 and 1955-56; the rest are identified as "Company Reports", dated between 1950 and 1956. The Graphs are grouped into 18 Charts.]

Although much of the data contained herein has been abstracted from previous reports of the LRC, a substantial amount of new data appears for the first time. The increasing interest in load research, and its consummation in the form of test data of the type included in this Report, makes possible a better understanding of the load behavior of customers.

The load relationships in this Report employ cumulative frequency distribution curves - in which values are given as a % of the average energy use - as well as daily load curves, in which values represent a % of the average demand for the day. These frequency distribution curves show, for each appliance, what portion of the test customers used at least the indicated % of the average use per customer; such curves are an expression of the probability that the average value of the universe will be obtained in a sample and thus serve to indicate unusual deviations from the average, which may be of considerable importance where the sample is small.

For the purpose of comparing the shape of daily load curves for the various appliances, the charts in this Report show the half-hour demands for the day as a % of the average value for the day; thus this % is related to the average of 48 demand values of the daily load curves, which is more stable than the single peak demand sometimes used for

the comparison of load curve shapes. Further, the ratio of the average value to the maximum value is the daily load factor. [Note: While a particular appliance may have a relatively high daily load factor during a particular test period, the monthly and annual load factors may be considerably lower because of seasonal variation in use. Air conditioning, either cooling or heating, is the principal example of seasonal variation among the major appliances covered in this study.]

Purposes of Study: to show some of the relationships of appliances to the use of electricity by residential customers living in single-family dwellings; to correlate LRC (Reports) test data related to several of the major appliances as well as to the total loads of residential customers; to present some applications and interpretations of these relationships in a manner which may assist in the comparison and general economic evaluation of the effect of a particular household appliance on the residential customers' total load.

Summary of Major Findings:

1. The common use of the major appliances in (future) all-electric homes will require as much as 10 times the present average annual residential use of electricity. While the multiplicity of miscellaneous appliances and lighting will require increasing amounts of electric energy, the more substantial increases in the average energy use will come from a greater saturation of the major appliances.
2. The diversity in the time of use of the major appliances is of particular interest because of its economic significance. This diversity is reflected by the changing annual group load factors obtained by the cumulative addition of major appliances to the lighting and miscellaneous appliance load. As an illustration, the winter loads in central latitudes indicates an annual group load factor of 37.7% for lighting and miscellaneous appliances. The cumulative addition of major appliances changes the annual group (%) load factors of the total load to the following values: 43.2, with refrigerators; 39.0, with ranges; 41.7, with clothes dryers; 61.6, with restricted use water heaters; 49.9, with heat pumps supplying both cooling and heating. These increasing and decreasing annual group load factors illustrate the complementary nature of the major appliance loads which account for the large increases in the annual energy use.
3. The data presented in this Report are limited to specified locations and conditions and other locations and conditions may cause substantial variations in the results. The lack of adequate load data for the southern latitudes, for summer periods and for some major appliances are examples of some of these limitations.

TITLE: MAJOR RESIDENTIAL APPLIANCE LOADS *

SOURCE: Various Utilities **

AUTHOR(S): A.F.Rehberg, et al; "Special Subcommittee on Residential
PREPARED BY AUTHOR(S) AND/OR: LRC/AEIC Lighting and Appliances"

DATE OF ISSUANCE: 1957-58 Report of LRC/AEIC (Printed 1959)
OTHER IDENTIFIERS: Section 4 (pp L-119 thru L-146); data covers various time periods in 1953, 1955, 1956 and 1957
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with LRC

TOTAL: [PAGES 28 ;REFERENCES 1 ;GRAPHS 26 ;TABLES 10] ***
DOCUMENT CLASSIFICATION(S): 7/10, 13, 15, 18, 31, 33

ABSTRACT: *[This Report extends studies stemming from a 1956-57 LRC Report, entitled "The Effect of Major Appliances in Residential Use of Electricity", which is abstracted elsewhere in this Compilation.]

**[Located in Conn., Dist. of Col., Ill., Mich. and Tex.]

***[The Graphs are grouped into 7 Charts.]

The studies (made during various periods from the winter of 1953 to the summer of 1957) include 2 reports on high-speed dryers and 5 reports on standard-speed dryers. The high-speed dryer studies include data on 44 units and the standard-speed dryer studies include data on 231 units.

Tests were made on 77 automatic clothes washers, 15 automatic dishwashers, 13 freezers and 45 ranges during the period 1955 to 1957. In addition, data on 49 ranges tested during 1957 are included in this Report.

In several instances the number of appliances for which complete data were available varied from month to month of the test period, consequently the number of appliances reported upon is sometimes less than the total number tested.

Purposes of Study: to summarize and amplify the data obtained from studies by several Utility companies of the load characteristics of electric clothes dryers, automatic clothes washers, automatic dishwashers, freezers and ranges.

Summary of Major Findings:
1. Maximum group demands of standard-speed dryers ranged from 1.01 to 1.35 KW for the 4 companies reporting half-hour demands. The 2 companies reporting on both winter and summer tests experienced higher demands in the winter periods.
2. Data from 4 of the 5 companies' tests on dryers confirm previous

findings that Monday is the most popular washday. The energy used on Monday, in % of the weekly total, ranged from a high of 34.9 KWH for high-speed dryers to a low of 15.1 KWH for standard-speed dryers. [The annual energy use per dryer in the southern latitudes of the country was observed to be higher than in the northern latitudes.]
3. High-speed dryers, while having higher individual demands, also have greater diversity, so that the group maximum demand is not greatly different than that of the standard-speed dryers. They also use more energy; these tests show annual KWH for the high-speed dryer of 863 compared to 807 for the standard-speed dryers.
4. The dryer increases the residential customers' noon peak but has little effect on the demands at the time of the residential-class evening peak.
5. The energy use of the automatic clothes washers does not vary greatly from month to month; the summer months averaged 7.0 compared to the winter months' average of 7.3 KWH.
6. The group maximum demand of the washers occurred about an hour earlier than the dryer load. However, the relative magnitude of the washer demand is about one-tenth that of the dryer and would have a correspondingly smaller effect on the customer's maximum load.
7. The annual dishwasher energy use of the individual customers in these tests varied from 90 to 599 KWH, with an average of 274. However, the average monthly energy use of all customers was fairly constant; a monthly high of 25 KWH in the winter compared with a low of 21 in the summer.
8. The average daily load curves show the maximum dishwasher demand occurring quite late in the evening, following by two hours the evening peak demand of the electric range. Otherwise, there is considerable resemblance in the shapes of the range and dishwasher load curves.
9. The monthly energy use for freezers varied with outdoor temperature. The highest monthly energy use of 121 KWH occurred in July, when the average daily outdoor temperature was about 89 F; by contrast it was 47 KWH in Jan., when the average daily outdoor temperature was 44 F. [If available, indoor temperatures would provide a better basis for correlation than the outdoor temperatures.]
10. The group hourly maximum demands varied in magnitude from 115 watts in Jan. to 231 in Aug. The individual customer's maximum demands ranged as high as 420 watts and averaged 300.
11. There was a pronounced difference between the energy use of ranges in "small" cities (less than 25,000 population) and that in large cities. The average monthly energy use per range of 110 KWH in the small cities is about 21% higher than that in the large cities. The seasonal variation in monthly use was less in the small cities than in large cities. The cumulative frequency distribution curve shows much greater variation in the annual energy use for the large city customers than for the small city customers. The daily load curves show the small cities to have a much higher noontime demand with a corresponding lower evening demand. [The load curve shapes were quite stable throughout the year with the evening peak reduced slightly during the summer months.] The group maximum demand was only slightly lower in the summer than in the winter.

TITLE: RESIDENTIAL ELECTRIC LAUNDRY DRYERS

SOURCE: Pacific Gas and Electric Co. (San Francisco, Calif.)

AUTHOR(S): R.I.Mendes
PREPARED BY AUTHOR(S) AND/OR: P.G.&E.

DATE OF ISSUANCE: 1965-66 Report of LRC/AEIC (Printed 1967)
OTHER IDENTIFIERS: Appendix C, Section 3 (pp L-162 thru L-169); data covers 1/14 to 7/1 (1965)
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.G.&E.
TOTAL:[PAGES 8 ;REFERENCES ;GRAPHS 2 ;TABLES 4] *
DOCUMENT CLASSIFICATION(S): 10/14, 15

ABSTRACT: *[Two of Tables are unnumbered.]

An initial sample of 24 customers was selected for testing but gaps in the test data caused the elimination of 2 of these from the final sample. The dryers were located in homes varying in occupancy from 2 to 9 persons.

The test was conducted for a period of 168 days since it was felt that this length of time adequately covers the spread of seasonal conditions for the P.G.&E. area, so that annual energy use could be readily estimated. Test metering equipment consisted of magnetic tape load survey recorders, dryer-load watthour meters and total house-load watthour meters. [The watthour meters were read every 28 days.] Demand information was processed by a "translator" and summarized as a whole, and in various subgroups, by electronic data processing equipment.

Purposes of Study: to determine the electrical load characteristics of this appliance and their impact on residential and system loads; to determine if there was a seasonal effect on the use of the laundry dryer and if there were any other customer characteristics affecting its use.]

Summary of Major Findings:
1. Energy use averaged 616 KWH for this 168-day test period, with a maximum diversified half-hour demand of 920 watts per customer.
2. A seasonal effect on energy use was seen in the test results in that 28-day KWH use varied from 92 in June to 128 during the winter months.
3. The test data reflect the homemaker's freedom from having to devote a set day to "washday." The customers used their dryers on an average of 5 days a week, with KWH use on Monday being only moderately greater than any other day of the week. Thus, during the period June 3-30, KWH use ranged from 2.7 (Tuesday) to 5.0 (Monday) and during the period Jan. 16-Feb. 12, the range was 2.7 (Tuesday) to 6.5 (Monday).
4. Size of family has a major effect on dryer energy use. This is shown by the 168-day figures of 365 KWH per dryer for families of 4 or less persons, 782 for families of 5, and 885 for families of 6 or more.
5. The dryers in the test sample accounted for 16.9% of the energy requirements of the total house.

TITLE: RESIDENTIAL ELECTRIC CLOTHES DRYERS

SOURCE: The Cleveland Electric Illuminating Co. (Cleveland, Ohio)

AUTHOR(S): J.Slipko (for C.T.Loshing)
PREPARED BY AUTHOR(S) AND/OR: C.E.I.

DATE OF ISSUANCE: 1966-67 Report of LRC/AEIC (Printed 1968)
OTHER IDENTIFIERS: Appendix D, Section 3 (pp L-176 thru L-187); data covers certain periods during summer 1964 & winter 1965
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with C.E.I.
TOTAL: [PAGES 12 ;REFERENCES 1 ;GRAPHS 7 ;TABLES 5] *
DOCUMENT CLASSIFICATION(S): 10/7, 14, 15, 40

ABSTRACT: *[Four of Tables are unnumbered. Graphs are grouped into 3 Charts.]

The dryer load study sample was drawn from C.E.I.'s 1964 "Market Research Appliance Saturation Survey". A sample of 1,300 completed interviewing forms showed 215 customers had an electric clothes dryer but not an electric range and that 200 customers had both an electric range and dryer.

The original test group of 80 was separated into "Dryer-Only" and "Range-Dryer" customers to see if their load characteristics were different. Subsequent analysis failed to reveal any significant differences; since the accuracy of sample means can be improved with larger samples, the data of both classes were combined or "pooled" for the summer test period.

Dryer energy use was measured independently with KWH meters. Installation duration for these meters was anywhere from 9 to 15 months. Dryer loads were metered with magnetic tape recording units. The tapes were changed every four weeks and translated to punched cards by a magnetic tape-to-card translator. Demands were measured on an integrated quarter-hour basis.

Purposes of Study: to investigate the load characteristics of residential electric clothes dryers as a part of a continuing program of major appliance load research; to discover if annual dryer energy use in the C.E.I. service area conformed to the published EEI average.

Summary of Major Findings:
1. Average annual use for the test sample was 903 KWH. While this is lower than the figure reported by EEI (965 in 1966), the difference isn't statistically significant at the 95% confidence level. In fact, there is only one chance in three that the EEI annual energy use figure could be different from the sample results.

2. Family size had a major effect on annual dryer energy use. Three distinct use levels were noted: (a) family sizes of 2 (520 KWH) and 3 (582 KWH); (b) family sizes of 4 (908 KWH); (c) family sizes of 5 (1,163 KWH).

3. Annual dryer energy use was 18.8% of total home use for homes without electric ranges and 12.7% for homes with electric ranges.

4. The noncoincident maximum KW demand per customer was 4.67 (summer) and 4.60 (winter). The KWH daily energy use per customer was 2.10 (summer) and 2.45 (winter). [Note: A seasonal effect could not be statistically detected at the 95% confidence level. However, the chances are only 7 in 20 that the average energy use per customer day for all dryer owners could be the same for both seasons.]

5. Maximum diversified (15 minute) demand was 0.94 and 1.08 KW for the summer and winter periods, respectively. For both periods this occurred on a Monday between 11 a.m. and 12:30 p.m.

6. Statistical tests at the 95% confidence level - performed on the day of individual customer maximum energy use - showed a definite bias toward Monday peaks. Thus, if each day had been equally likely for customers to experience their maximum energy use, about 14% would have experienced their peak use on a Monday but the tests showed 50% of the customers had Monday peaks. [There is only a 0.05 probability that such a result could occur by chance.]

TITLE: RESIDENTIAL CUSTOMER LOAD STUDY: HOMES WITH ELECTRIC CLOTHES DRYERS

SOURCE: Baltimore Gas and Electric Co. (Baltimore, Md.)

AUTHOR(S): L.S.Lydard, Jr. (for W.E.Miller)
PREPARED BY AUTHOR(S) AND/OR: B.G.&E.

DATE OF ISSUANCE: 1969-70 Report of LRC/AEIC (printed 1971)
OTHER IDENTIFIERS: Appendix A, Section 3 (pp L-104 thru L-130); data covers 12 months ending 10/31/68
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with B.G.&E.
TOTAL: [PAGES 27 ;REFERENCES ;GRAPHS 14 ;TABLES] *
DOCUMENT CLASSIFICATION(S): 10/8, 14, 19, 40

ABSTRACT: *[Graphs are grouped into 8 Charts.]

Thirty-three customers were selected at random from the relatively small population (17.7%) of homes equipped with electric dryers, constituting a representative sample of such homes in the Metropolitan Baltimore Area. The 33 test homes are single-family dwellings, namely: 14 cottages, 9 row homes, 5 bungalows, 2 Cape Cod, one bi-level, one split-level and one which was a row home for 4 months and a split-level for 8 months.

The customers' electric dryer and total-service energy requirements were recorded simultaneously thruout the test year.

Purposes of Study: to obtain data not previously available for the B.G.&E. service area and in sufficient homes so as to provide statistically reliable average load figures for dryers for use in engineering, economic and rate studies and for the development of sales estimating guides.

Summary of Major Findings:

1. The annual use of 1,183 KWH for drying is equivalent to 211 hours use of dryer connected load.

2. Of the average customer's total-service annual requirements 13% is used for drying, varying between 8 and 17% on a monthly basis.

3. Of the annual drying requirements, 69% is used on peak (8 a.m. thru 10 p.m., on weekdays other than holidays).

4. The average Monday in the month is the maximum drying use day in 11 of the 12 months; Thursday is the maximum day for Oct.

5. Each month's maximum (diversified) dryer demand occurs during one of the 5 half-hours between 10:30 a.m. and 1:00 p.m.

6. The average dryer use per customer is 5% of the average total-service energy use on the day of the B.G.&E. system peak (July 2, 84°F mean).

7. At the hour of a monthly system peak load, a maximum of 7.7% of the total-service connected load is in use (July, 2 p.m.); coincidently, 2.5% of the dryer connected load is in use.

8. Dryer maximum (diversified) demands, measured over a quarter-hour interval, are from 4 to 24% greater than the 1-hour demands are from 5 to 32% less than those measured over the standard half-hour interval.

9. Drying adds 0.15 KW per customer to B.G.&E.'s monthly peak hours, averaged over the 1-year period, which is ≈3% of the average dryer connected load.

10. Annual load factors, based on maximum diversified demands, are 36.6% for total service and 11.2% for the dryer; comparable annual load factors, based on noncoincident maximum demands, are 13.1 and 2.6%, respectively.

11. Annual demand factors are 10.5% for total service and 21.5% for the dryer.

12. The dryer load tends to slightly decrease the average test customer's annual load factor.

TITLE: LOAD STUDIES of SMALL COMMERCIAL and INDUSTRIAL CUSTOMERS *

SOURCE: Pennsylvania and Ohio Utilities

AUTHOR(S): R.C.Grimstad, et al; "General Subcommittee on Commercial and
PREPARED BY AUTHOR(S) AND/OR: LRC/AEIC Industrial Loads"

DATE OF ISSUANCE: 1956-57 Report of LRC/AEIC (Printed 1958)
OTHER IDENTIFIERS: Appendices A & B, Section 2 (pp L-38 thru L-59); data covers winter 1953-54 + summer 1954 + winter 1955-56 + summer 1956
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with LRC

TOTAL: [PAGES 22 ;REFERENCES 2 ;GRAPHS 12 ;TABLES 7] **
DOCUMENT CLASSIFICATION(S): 11/9, 14, 31, 35, 38, 41, 49

ABSTRACT: *[Less than 10% of the customers were Industrial. The Commercial customers were generally classified as food and retail stores, service shops, restaurants and taverns, multiple dwellings, office buildings and schools, churches and theatres.]

**[The graphs were grouped into 2 Charts.]

The first of these studies was made during the 1953-54 winter and 1954 summer periods (Ohio) and covered a sample of 200 small commercial customers. The second study was made during the 1955-56 winter and 1956 summer periods of a sample of 200 small commercial and industrial customers supplied under the general light and power service rate at standard secondary voltages (Penn.).

As noted, the sample of 200 customers (in the first test) was used to determine the winter and summer load characteristics of representative small commercial customers served at the commercial service rate. Although some manufacturing or industrial customers are served at this rate, for all practical purposes the sample may be considered as representative of the small commercial class. [The 40,000 customers served at this rate generally had monthly maximum demands of less than 20 KW.] The customers in the second test are billed on the basis of either their assessed demands, determined from a % of their connected loads, or by their monthly measured maximum demands; generally, customers on the "assessed-demand" basis having billing demands of less than 10 KW and those on the "measured-demand" basis have demands of 5 to 100 KW.

In the Ohio Tests, 100 (half-hour integrating) demand meters were available. In order to test approximately 200 customers, it was necessary to move the demand meters. The test meters remained in each location for a period of 2 weeks. All customers, in each of 5 groups, were tested simultaneously during their winter and summer periods.

In the Penn. tests, the customers in each of the test groups for the summer period tests were the same as those in the respective groups

for the preceding winter period. All loads were measured at the customers' billing meters and the load data are reported on the basis of prevailing clock time. The tests reflecting winter conditions were made during the period of the year when maximum lighting requirements can be expected to coincide most nearly with high commercial and industrial activity. The summer tests were conducted from mid-May to mid-Sept. in order to insure the obtaining of data for the maximum temperature conditions; after study of temperature records during this period, two weeks were selected for analysis (both in June) to give data reflecting conditions of a "cool summer" week and a "warm summer" week.

Purposes of Study: to present data on the summer and winter load characteristics of sample groups of small nonmanufacturing and manufacturing customers, made by two metropolitan utilities located in different geographical areas.

Summary of Major Findings:

1. The Penn. winter-period load curves follow the general pattern observed in previous studies, with the maximum demands of the smaller users occurring during evening hours and with predominantly daytime use indicated for customer groups having individual measured demands in excess of 15 KW.

2. The Penn. tests also indicate that the incidence of warm weather brings about varying effects on the summer load patterns of the several test groups. For the groups (of smaller customers) billed on the assessed-demand basis, the diversified maximum demands of a warm summer week are at distinctly higher levels than their demands during a cool summer week; the effect of warmer weather on the summer loads of the larger customers billed on a measured demand basis appears to be much less.

3. Under the conditions prevailing at the time of the Penn. tests: energy use during the average weekday and average week, hourly demands and test-week load factors are - for the smaller sized customers - significantly higher during the "warm summer" week than the corresponding values during the winter week. For these same customer groups the average weekday load curves for the winter and for the "cool summer" test weeks are generally quite similar, except during the evening hours when changes in the customers' lighting load reflect the seasonal changes in the hour of sunset.

4. The Ohio winter-period load curves generally follow the characteristics of the smaller-use Philadelphia customer groups, with predominantly evening peaks. The demands and energy use during the winter test weeks generally equal, or moderately exceed, the corresponding values for summer.

5. Study of the loading of the Penn. groups billed on a measured demand basis shows that generally the winter test week energy use and demands are equal to, or moderately higher than, those of the "cool" or "warm summer" test weeks. The effect of warmer weather on the

summer loads of these groups - which contain an appreciable number of manufacturing customers as well as larger commercial enterprises - appears to be much less than that for the groups of (smaller sized) assessed-demand customers. While the % of customers with air conditioning equipment is substantial for the 2 largest size measured-demand groups, the rated HP of the air conditioning load (when expressed "per average customer of the group") is relatively small compared with the total load of the average customer and its influence also appears to have been counteracted by decreased use of other loads during the warmer weather. [It should be noted that increases in the saturation of appliances whose use is affected by temperature - particularly refrigeration and air conditioning equipment - from those existing at the time of these tests, could materially alter these winter/summer relationships.]

TITLE: SMALL COMMERCIAL and INDUSTRIAL CUSTOMER LOAD STUDY *

SOURCE: Public Service Electric and Gas Co. (Newark, N.J.)

AUTHOR(S): P.F.Platt (for B.P.Dahlstrom)
PREPARED BY AUTHOR(S) AND/OR: P.S.E.&G.

DATE OF ISSUANCE: 1959-60 Report of LRC/AEIC (Printed 1961)
OTHER IDENTIFIERS: Appendix B, Section 2 (pp L-103 thru L-113); data covers winter 1957-58 + summer 1958
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.S.E.&G
TOTAL:[PAGES 11 ;REFERENCES ;GRAPHS 24 ;TABLES 1] **
DOCUMENT CLASSIFICATION(S): 11/14, 46, 49

ABSTRACT: *[Note: customers were separated into 8 groups of increasing ranges of "annual peak KW demand" but they were not descriptively categorized as "Commercial" or "Industrial"; it is stated that the Commercial category predominated.]

**[The Graphs were grouped into 6 Charts.]

The sample was divided into 8 classes grouped according to the annual peak KW billing demand of the individual customers; the annual period was from Nov. 1957 thru Oct. 1958. The same customers were tested during the Nov.-Jan. and June-Sept. test periods. Customers for testing were chosen at random from stratified subdivisions by using, for selection purposes, an ordinal position in the subdivisions varying with the size of each subdivision. [For example, if there were 3,000 accounts in one of the subdivisions and 30 test meters were to be set, every 100th customer was selected for test.]

Two types of customers are included in the study, those with "estimated" demand and those with "measured" demand. The estimated demand for billing purposes is determined by dividing the monthly KWH use by 100 which, in effect, makes the rate a block rate. Customers with load factors less than 15% have their demands estimated.

The test meter charts were read for 29 winter and 41 summer days, being selected so as to include varying weather and temperature conditions. To obtain air conditioning loads that would be considered representative for the entire summer, days were selected having small, average and large air conditioning loads. Data for the 32 half-hours ending during a 16 hour period, from 8:30 a.m. to 12 midnight, during the selected days were punched on cards for processing.

Purposes of Study: to provide load characteristics data of small commercial and industrial customers served on the General Lighting and Power Service rate. [Note: Of the two types on this rate, the commercial customers predominate.]

Summary of Major Findings:

1. Customers with annual peaks between zero and 6.0 KW show a definite trend to peak in the winter during late afternoon or early evening. Their summer load is not nearly as high as that for winter, reflecting little or no air conditioning.

2. Customers groups with annual peaks between 6.1 and 15.0 KW show definite summer peaks, due primarily to the air conditioning load.

3. Customers with annual peaks of at least 15.1 KW show little change in their hourly demand patterns between the summer and winter periods. [Small industrial customers usually fall in these groups.]

4. A secondary peak is observable during the summer evening hours for all groups and is probably attributable to the lighting sensitivity aspects of the load.

TITLE: SMALL COMMERCIAL and INDUSTRIAL LOAD SURVEY *

SOURCE: Philadelphia Electric Co. (Philadelphia, Pa.)

AUTHOR(S): A.Abramovitz (for C.W.Bary)
PREPARED BY AUTHOR(S) AND/OR: P.E.

DATE OF ISSUANCE: 1961-62 Report of LRC/AEIC (Printed 1963)
OTHER IDENTIFIERS: Appendix A, Section 2 (pp L-102 thru L-112); data covers winter 1959-60 + summer 1960
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.E.

TOTAL: [PAGES 11 ;REFERENCES 2 ;GRAPHS 5 ;TABLES 3] **
DOCUMENT CLASSIFICATION(S): 11/37, 46, 49

ABSTRACT: *[Note: the customers were divided into 2 categories, as to "basis of billing", and subdivided (in each category) into 3 groups of increasing KW "billing demand limits"; only 8 out of 106 in category 1 and 8 out of 72 in category 2 were Industrial.]
**[The Graphs are grouped into 1 Chart.]

Each of the test groups is comprised of customers whose homogeneity was reflected by the similarity in the size of their KW billing demands. The customers in each of the sample test groups were the same in both the winter and summer test periods. In category 1, customers billed on an assessed-demand basis, the KW demand groups were: 1.1 thru 2.0; 3.1 thru 4.0; 5.1 thru 10.0. In category 2, customers billed on a measured-demand basis, the KW demand groups were 5.1 thru 10.0 and 15.1 thru 25.0. [Note: demand limits were assigned on the basis of maximum billing values for the winter test period.]

The customers selected for the test groups were chosen by an individual-selective method of sampling from stratified subdivisions of the universe of customers of this class, using accepted procedures of random choice. Tests for winter conditions were made during Dec. and Jan., 1959-60; summer period tests were conducted during June, July and Aug., 1960. Two weeks in Aug. (during which the maximum temperature conditions for the test period occurred) were selected for final analysis to give data reflecting conditions of a "warm" week and a "cool" week.

Power factor tests of individual "at-random-selected" customers were made during both the winter and summer test periods on approximately one-third of the customers in each of the test groups. These tests were conducted on different days and each provided the integrated results over a single half-hour period, at about the hour of the anticipated peak period of the group.

Purposes of Study: to determine the comparative use characteristics under winter and summer conditions of representative groups of small commercial and industrial customers supplied under the general light and power electric service rate. [Note: This class of customers receives electric service at P.E.'s standard secondary voltages for business and industrial use, including the use for domestic requirements when they are electrically interdependent with the customers' business premises.]

Summary of Major Findings:

1. For groups of customers comprised of the smaller size business establishments: (a) The hourly usage patterns during the winter tests are quite similar to those in the summer "cool" period, except for the interval between 5 and 9 p.m. The winter demands are higher than the summer ones, undoubtedly due to the relative magnitudes of the lighting requirements. (b) The load levels - on an average weekday of the warm period - exceed those of the cool period; the difference becomes more pronounced during the daylight hours, caused by the use of air cooling equipment.

2. For the groups of customers representative of the larger size business establishments, the loads in summer (for either the cool or the warm periods) are significantly higher than in winter, due to the substantial saturation of air conditioning installations in these groups.

3. The average power factor of the test groups - reflecting conditions for the average customer at the time of the diversified maximum demands of the groups - is about 92% for the winter period and about 87% for the summer "warm" period.

4. The test results for the summer periods reflect the amounts of temperature-affected loads, such as refrigeration and air cooling equipment. Changes in the amounts of these loads, from those reflected in these tests, can have material effects on the relationship between winter and summer characteristics.

5. Differences in the basic load characteristics reflected for several of the groups in the current tests, as compared with those of earlier tests, are likely due to differences in the types of business mixes existing in the groups as well as to the observed differences in the amounts of connected air conditioning load.

TITLE: SMALL GENERAL SERVICE CUSTOMER LOAD STUDY *

SOURCE: Pennsylvania Power & Light Co. (Allentown, Pa.)

AUTHOR(S): A.J.Baldwin, Jr. (for R.C.Grimstad)
PREPARED BY AUTHOR(S) AND/OR: P.P.&L.

DATE OF ISSUANCE: 1961-62 Report of LRC/AEIC (Printed 1963)
OTHER IDENTIFIERS: Appendix B, Section 2 (pp L-113 thru L-126); data covers 12/59 + 1 & 2/60 + 6, 7 & 8/60
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.P.&L.
TOTAL:[PAGES 14 ;REFERENCES ;GRAPHS 16 ;TABLES 3] **
DOCUMENT CLASSIFICATION(S): 11/9, 14, 26, 31, 46

ABSTRACT: *[Note: during the summer tests, only 26 of 441 customers were Industrial; during the winter tests, 22 of 433 were Industrial. Generalized group titles were used to describe the nature of the customer's "business".]

**[The Graphs are grouped into 6 Charts.]

A systematic random sample was derived by taking every tenth customer from a listing of all customers, arranged according to geographical location and further arranged for a given billing period by KWH usage for the "block-rate" customers and in order of billing demand for the "demand-rate" customers. The resulting sample was then stratified and a further systematic random sample of 50 customers was chosen within each designated strata. The ultimate selection of 300 block-rate and 200 demand-rate customers were proportionate to the approximate number of customers actually served under the two rates. In order to develop greater homogeneity within groups of customers tested, the final selection of 500 test cases was rearranged as follows: up to 640, 641-1200, 1201-1850, 1851-2400, 2401-3800, over 3800 (block-rate, KWH annual use); up to 4.0, 4.5-7.5, 8.0-12.0, over 12.0 (demand-rate, KW demand rate).

Each seasonal test period ran for 12 consecutive weeks. The demand data for each of the above groups were measured simultaneously for a 2-week period at the customer's billing meter, by means of magnetic-tape load survey meters. [All customers were also coded, according to business classifications.]

Purposes of Study: to determine the summer and winter load characteristics of the more than 78,000 small commercial and industrial customers served under P.P.&L.'s two rates for small general service for which complete demand information was not yet available.

Summary of Major Findings:
1. This study emphasized the high degree of heterogeneity of this class of customers. A wide variety of commercial and industrial operations was

encountered with annual KWH use ranging from a few hundred to more than 25,000 in a few instances. Any generalities based on the derived data are applicable only within the confines of the territory examined.

2. Similar load shapes were observed for each weekday of each seasonal test period for each test group, as well as for the entire class. During the winter the class load peaked consistently between 7 and 8 p.m., with a maximum on Friday. In summer, the weekday class peak generally shifted to the late morning or early afternoon hours although the maximum again occurred on Friday evening at 9 p.m.

3. The estimated class load factor was 58% for the winter and 61% for the summer test period. For various types of businesses, the summer load factors varied between about 10 and 53% and the winter values were between about 12 and 56%. Lighting load factors were about 69% (summer) and 66% (winter).

4. The coincidence of demand for the entire class was estimated to be about 40%. Individual business (and lighting) varied from about 46 to 83% (summer) and 54 to 78% (winter).

TITLE: SMALL COMMERCIAL and INDUSTRIAL LOAD STUDY *

SOURCE: Philadelphia Electric Co. (Philadelphia, Pa.)

AUTHOR(S): W.D.Germond (for C.W.Bary)
PREPARED BY AUTHOR(S) AND/OR: P.E.

DATE OF ISSUANCE: 1962-63 Report of LRC/AEIC (Printed 1964)
OTHER IDENTIFIERS: Appendix A, Section 2 (pp L-100 thru L-107); data covers winter 1961-62 + summer 1962
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.E.

TOTAL: [PAGES 8 ; REFERENCES 3 ; GRAPHS 6 ; TABLES 3] **
DOCUMENT CLASSIFICATION(S): 11/31, 46, 49

ABSTRACT: *[Note: the customers were divided into 2 categories, as to "basis of billing", and subdivided (in each category) into 3 groups of increasing KW "billing demand limits"; only 4 out of 107 in category 1 and 20 out of 110 in category 2 were Industrial and therefore outside the scope of this Compilation.]

** [Graphs are grouped into 1 Chart.]

This Report has to do with customers who receive electric service at P.E.'s standard secondary voltage for business and industrial use, which includes the use for residential requirements when they are electrically interdependent with the customer's business premises. Each of the test groups is comprised of customers whose homogeneity was reflected by the similarity in the size of their billing demands. Both test periods include the same test customers in each of the sample test groups.

The sample customers comprising the test groups were chosen by an individual selective method of sampling from universe subdivisions stratified according to billing demand, using accepted procedures of random selection. [Those customers billed on an "assessed-demand basis" were grouped into KW billing demand limits, as follows: 1.1 thru 2.0, 3.1 thru 4.0 and 5.1 thru 10.0. Those customers billed on a "measured-demand basis" were similarly grouped into 5.1 thru 10.0, 15.1 thru 25.0 and 40.1 thru 100.0 KW ranges.]

After a study of temperature records, two weeks (one late in July and one early in Aug.) were selected for final analysis to give data reflecting conditions of a "cool summer" week and a "warm summer" week, respectively.

Purposes of Study: to determine the comparative use characteristics, under both winter and summer conditions, for representative groups of small commercial and industrial customers who are served under a general light and power electric service rate.

Summary of Major Findings:

1. For groups of customers comprising the smaller size business establishments, the load levels of the summer (warm average) weekday are higher than those of the summer (cool average) weekday. The greatest increase occurs during the daylight hours, which unquestionably reflects the increased use of air cooling equipment.

2. For groups of customers comprising the smaller size business establishments, the load patterns of use of the summer (cool) and winter test periods are generally similar in shape except for the early evening period between 5 and 9 p.m. when the winter period demands are higher than those of the summer, reflecting the relative requirements for lighting.

3. For groups of customers comprising the larger size business establishments, the loads for the 2 smaller demand groups (in both the cool and warm summer periods) are predominantly higher than in the winter period owning undoubtedly to the substantial saturation of air conditioning installations in these groups. For the largest size demand group the patterns of the daily load cycles are much the same winter or summer, indicating that a substantial part of the installed load of this group is not influenced by seasonal factors.

TITLE: MEDIUM-SIZE (MANUFACTURING and NONMANUFACTURING)* CUSTOMER LOAD STUDY

SOURCE: Philadelphia Electric Co. (Philadelphia, Pa.)

AUTHOR(S): F.R.Mitchell (for C.W.Bary)
PREPARED BY AUTHOR(S) AND/OR: P.E.

DATE OF ISSUANCE: 1962-63 Report of LRC/AEIC (Printed 1964)
OTHER IDENTIFIERS: Appendix B, Section 2 (pp L-107 thru L-111); data covers summer 1961
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.E.

TOTAL: [PAGES 5 ;REFERENCES ;GRAPHS 6 ;TABLES 1] **
DOCUMENT CLASSIFICATION(S): 11/14, 31, 46

ABSTRACT: *[Note: averaged data for the 2 classes of customers were each grouped into "low" and "high" load factors and subgrouped as to "hours use of monthly maximum demand" and also by KW size for the low load factor group.]

**[Graphs are grouped into 1 Chart.]

In the derivation of the total load characteristics, those customers whose loads are recorded on graphic charts are divided into specific classifications designed to facilitate the expansion of the recorded loads to class proportions. The first subdivision is into the manufacturing and nonmanufacturing categories, with each of these major strata then subdivided into "low" and "high" load factor groups on the basis of the time that the customer uses his monthly maximum demand. In the "low" load factor group a further subdivision is made on the basis of the KW size of the customers' loads. The demand records of the customers comprising these 6 groups provided the data on the average customer load characteristics presented in this study. The analysis period covered 10 weekdays during which the weather conditions were the warmest for that summer season.

Purposes of Study: determining the electric characteristics of manufacturing and nonmanufacturing customers with medium-sized loads, supplied at primary distribution voltages (2,400 and 4,000) and whose demands are measured for billing purposes with recording instruments; to obtain data to be used in developing the average weekday load characteristics of this class of customers (around the P.E. system's peak period) for use in "cost-to-serve" determination, rate design and economic studies.

Summary of Major Findings (Nonmanufacturing Category):
[Note: Customers under 300 KW and with no more than 350 hours of monthly maximum demand are identified as (A). Those over 300 KW and with no more than 350 hours of monthly maximum demand are identified as (B); those with over 350 hours are identified as (C) regardless of their KW bracket.]

1. KWH energy use (31 day month) per customer averaged about: 39,400 (A); 160,000 (B); 111,000 (C).

2. KWH energy use (average weekday) per customer averaged about: 1,540 (A); 6,760 (B); 3,930 (C).

3. KW diversified maximum (half-hour integrated) demand per customer, during the test period, averaged about: 117 (A); 534 (B); 208 (C).

4. KW noncoincident maximum demand per customer, during the test period, averaged about: 163 (A); 581 (B); 241 (C).

5. Load factor, Sept. (based on diversified maximum demand) was about: 45% (A); 40% (B); 72% (C).

6. Coincidence factor for the test period (based on maximum diversified demand) was about: 72% (A); 92% (B); 86% (C).

TITLE: LARGE COMMERCIAL and INDUSTRIAL LOAD STUDY *

SOURCE: Public Service Electric & Gas Co. (Newark, N.J.)

AUTHOR(S): P.F.Platt (for B.P.Dahlstrom)
PREPARED BY AUTHOR(S) AND/OR: P.S.E.&G.

DATE OF ISSUANCE: 1963-64 Report of LRC/AEIC (Printed 1965)
OTHER IDENTIFIERS: Appendix A, Section 2 (pp L-86 thru L-107); data covers winter 1960-61 + summer 1961
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.S.E.&G.
TOTAL: [PAGES 22 ; REFERENCES ; GRAPHS 54 ; TABLES 2] **
DOCUMENT CLASSIFICATION(S): 11/14, 31, 46, 49

ABSTRACT: *[Rate Schedule LPL, Large Power and Lighting Service with demands normally exceeding 300 KW. Because of "night use provisions" in this Schedule, 2 of the 6 Groups studied had demands under 300 KW.]

**[One of Tables is actually a composite of 6 similar "sub-tables", one for each of the 6 Groups studied. The Graphs are grouped into 9 Charts.]

This is the first study of summer use since the shift of the P.S.E.&G. system peak demand from the winter to the summer period. Two winter months and 4 summer months were selected for test since, historically, the winter system peak ususally occurred in one of two months while the summer peak could occur in any of the summer months. The applicable rate schedule is primarily for large commercial and industrial customers whose demands normally exceed 300 KW; however, because of the night use provision of the rate schedule, certain customers are served whose demands are under 300 KW. The first 2 of the 6 groups in this study contain such smaller sized customers; these together with the third group constitute customers supplied, for the most part, at secondary voltage. The fourth group of customers are normally supplied at primary voltage (regulated 4 and 13.2 KV). The fifth and sixth groups contain mainly customers whose supply voltage is classified as high tension (unregulated 13.2 and 26.4 KV or higher).

Accepted procedures of random choice from stratified subdivisions of customers were employed in selecting customers for testing. Two types of demand meters are used to meter loads served under Rate Schedule LPL, chart and indicating (non-chart); customers studied included both types.

The charts from the chart-type meters were read and data punched on load survey cards. Magnetic tape load-survey recorders were used for all non-chart test customers; tapes from these recorders were translated to punched load survey cards. Acceptable data from both sources were processed on a group basis. Each group was studied by months, so as to derive the following load curves: average weekday and weekend, peak winter and summer and related information. [Tests for the winter con-

ditions were made during Dec. and Jan. The summer tests were conducted during June, Aug., Sept., and Oct.; October has been considered a summer month because cooling can be a significant factor in that month.]

Purposes of Study: to provide load characteristics data of summer and winter use of large commercial and industrial customers under Rate Schedule LPL, Large Power and Lighting Service.

Summary of Major Findings:

1. Group 1, which includes customers with annual maximum billing demands up to 150 KW has a different load curve shape from all other groups. This results from the large proportion of commercial customers in the group, of which approximately one-half are supermarkets. Customers in this group tend to peak during the early evening in the winter and later in the evening during the summer. Summer demands exceed winter demands, reflecting the effect of summer cooling. [Note: The remaining "findings" do not apply to Group 1.]

2. Winter and summer load curves of each group are similar (differing only in magnitude), with the summer demands higher than the winter demands. This is attributable to the use of summer cooling appliances.

3. General characteristics of weekday load curves are similar for all groups.

4. During the summer, the magnitude of both the morning and afternoon maximum demands are basically the same within all groups.

5. Load curves for each of the groups tested are similar for the 4 summer months, differeing slightly in magnitude. This difference is apparently due to the effect of the temperature-sensitive portion of the load.

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6. [Group 1 customers were classified as having annual maximum billing demands between 0 and 150 KW.] For the 6 test months, the KWH monthly use per customer ranged between 33,600 and 39,000. Their weekday maximum diversified demands (per customer) varied from about 62.9 to about 79.4 KW; noncoincident maximum demands per customer varied from about 80.3 to about 98.0 KW; during weekends (Saturday and Sunday) the maximum diversified demand per customer varied from about 53.8 to about 66.1 KW. Annual load factors (based on energy use for 1961), relative to noncoincident maximum demand, varied between 49.4 and 56.5%.

TITLE: COMMERCIAL and INDUSTRIAL CUSTOMER LOAD STUDY *

SOURCE: Pennsylvania Power & Light (Allentown, Pa.)

AUTHOR(S): A.J.Baldwin (for B.R.Hartman)
PREPARED BY AUTHOR(S) AND/OR: P.P.&L.

DATE OF ISSUANCE: 1963-64 Report of LRC/AEIC (Printed 1965)
OTHER IDENTIFIERS: Appendix B, Section 2 (pp L-107 thru L-112); data covers Winter 1960-61 & Summer 1961
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.P.&L.
TOTAL: [**PAGES** 6 ;**REFERENCES** ;**GRAPHS** 6 ;**TABLES** 1] **
DOCUMENT CLASSIFICATION(S): 11/9, 14, 31, 46

ABSTRACT: *[Industrial customers are identified only as "small industrial plants".]

**[The Graphs are grouped into 2 Charts.]

Using billing records for Feb. 1960, all customers in this class were segregated by location within the 6 P.P.&L. operating divisions. They were then arrayed by their measured maximum 15-min. KW demand and further by hours use of the billing demand. A sample of 200 customers was selected by exercising proportionate weightings for each of these 3 control parameters and the final selection was divided into 5 arbitrary groups based on size of demand. At the completion of each 2-week series of tests, each customer was placed into a demand group based on the magnitude of his 30-minute kilowatt demand observed during that particular test period.

Magnetic-tape load survey recorders were used as test metering equipment. Time and demand data were transferred from magnetic tape to punched cards by a "translator", in conjunction with a "summary punch". Data were then summarized in total (and by the various groupings) by electronic data processing equipment.

Purposes of Study: to obtain load characteristics data for about 4,000 commercial and industrial customers who are served from the secondary distribution system and generally have demands of 25 KW or more. [Note: This group of customers is largely composed of retail stores, small commercial establishments and small industrial plants.]

Summary of Major Findings:
1. During both the winter and summer test periods, the morning and afternoon peaks were of about equal magnitude. Although the class-load patterns of both seasons are similar, observed maximum demands for the summer period are greater than for the winter period. The winter peak of the average customer (at the usage level during the 14-day test period) is estimated to be 68.8 KW while that of the summer period is 78.4 KW. [This variation is probably due to the importance of air conditioning,

in relation to the rest of the electric service required by this size and type of customer.]

2. During the test periods the morning and afternoon peaks for the class consistently occurred at about 11 a.m. and 2 p.m., both summer and winter, with the maximum class peak for the respective seasons occurring on Monday and Thursday.

3. Average summer demands exceed those of the previous winter by approximately 8.4%, which is slightly more than half the differential derived by comparing peak demands observed during the two 14-day test periods.

4. Coincidence factors range from 64 to 86%, with an average coincidence factor of about 79% for the class, both winter and summer. It is significant to note that, for both seasonal periods, coincidence factors steadily rise as group demands increase.

5. Load factors - based upon diversified maximum demands of the various demand groups - ranged from 46 to 62%, with an average for the class of 53% in the winter and 57% in the summer; thus there is little difference (for the class as a whole) between summer and winter operation, with regard to load factor. The largest variation occurs for the 25 KW or less Group whose load factor (based on maximum group diversified demand) improves from 49.7% in the summer to 57.7% in the winter as a result of higher levels of operation during the early evening hours.

TITLE: SMALL COMMERCIAL and INDUSTRIAL LOAD STUDY*

SOURCE: Philadelphia Electric Co. (Philadelphia, Pa.)

AUTHOR(S): A.Abramovitz & W.D.Germond (for R.A.Markel)
PREPARED BY AUTHOR(S) AND/OR: P.E.

DATE OF ISSUANCE: 1964-65 Report of LRC/AEIC (Printed 1966)
OTHER IDENTIFIERS: Appendix B, Section 2 (pp L-120 + L-135 thru L-145); data covers Winter 1963-64 & Summer 1964
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.E.

TOTAL: [PAGES 12 ; REFERENCES 5 ; GRAPHS 10 ; TABLES 3] **
DOCUMENT CLASSIFICATION(S): 11/31, 37, 46

ABSTRACT: *[Only about 9% of the "assessed demand" groups and only about 20% of the "measured demand" groups could be called Industrial.]

**[The Graphs are grouped into 2 Charts.]

The customers of this study receive electric service at a standard secondary voltage (nominally 120-240 volts, single and polyphase) for business and industrial use, including the use for residential requirements when they are electrically interdependent with the customer's business premises. Each of the test groups is comprised of customers similar in the size of their billing demands; the sample test customers were in service during both the winter 1963-64 and summer 1964 test periods.

These customers are billed on the basis of either their assessed demand - determined from a % of their connected load - or on their monthly measured maximum demands. In this survey, test groups covering the entire range of demands were studied under both winter and summer conditions, permitting comparison of their winter and summer use characteristics over a complete range of demands.

The customers selected for the test groups were chosen by an individual selective method of sampling from "universe" subdivisions, stratified according to billing demand, using accepted procedures of random selection.

Tests measuring the power factors of individual customers, selected at random, were made during both the winter and summer month test periods on approximately one-third of the customers in each of the test groups. These tests were conducted on different days and each provided the integrated results over a single half-hour period at about the hour of the anticipated peak period of the group. The winter tests were made during the month of Dec. and the summer tests were made on hot days during the summer months.

Purposes of Study: to determine the load characteristics of representative groups of small commercial and industrial customers served under a general light and power electric service rate, for both winter and summer period conditions.

Summary of Major Findings:

1. For groups of customers comprised of smaller-size business establishments, the hourly load patterns of use of the summer cooling and the winter test-week periods are for the most part similar in shape except for the early evening period between 5 and 9 p.m. During that period, the winter test-week demands are higher than those of the summer, undoubtedly reflecting the relative effect of lighting requirements.

2. For groups of customers comprised of smaller size business establishments, the load levels of the summer "hot average" weekday are higher than those of the summer "cool average" weekday, with the greatest increase occurring during the daylight hours. [This unquestionably reflects the increased use of air cooling equipment.]

3. For groups of customers comprised of the larger size business establishments, the demands of the summer hot test-week period generally exceed those of the summer cool and winter test-week periods; the exception is the highest demand group, which has a relatively small air cooling load in comparison with the customers' total load.

4. The power factor of the test groups, at the time of their diversified maximum demands, is about 91% for the winter period and about 84% for the summer hot period.

TITLE: COMMERCIAL and INDUSTRIAL SECONDARY SERVICE LOAD STUDY *

SOURCE: Consumers Power Co.

AUTHOR(S): W.J.Jefferson
PREPARED BY AUTHOR(S) AND/OR: Consumers Power Co.

DATE OF ISSUANCE: 1965-66 Report of LRC/AEIC (Printed 1967)
OTHER IDENTIFIERS: Appendix A, Section 2 (pp L-102 thru L-117); data covers certain periods during 1963-64
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with C.P.C.

TOTAL:[PAGES 16 **;REFERENCES** **;GRAPHS** 11 **;TABLES** 8 **]** **
DOCUMENT CLASSIFICATION(S): 11/9, 14, 17, 19, 26, 31, 35, 38, 41, 46

ABSTRACT: *[Customers are grouped both by monthly load factors - as to whether they are above or below 20% - and by increasing ranges (4) of KWH used per month. There is some "blurring" between Commercial and Industrial, with 19 of 41 "business descriptions" appearing in both the above and below 20% value.]

**[Five of the Tables are unnumbered. Graphs are grouped into 5 Charts.]

Note: "Rate B" is a block type rate applicable to secondary voltage customers with monthly load factors below approximately 20%. Examination of monthly billing data indicates a winter maximum energy use for this rate. Therefore, it was assumed that the peak demand for customers under this rate would also occur in the winter. [Recording demand meters were installed to measure the 30-minute demands of selected test customers during the period from 11/1/63 thru 2/29/64.]

Note: "Rate C" is a demand and energy type rate applicable to secondary voltage customers with monthly load factors exceeding approximately 20%. Monthly billing data indicates a summer maximum energy use for this rate. Therefore, it was assumed that the peak demand for customers under this rate would also occur in the summer. [Recording demand meters were installed to measure the 30-minute demands of selected test customers during July, Aug. and Sept. of 1963.]

For "Rate B" customers, the KWH/month use blocks selected as representative of winter loads were: Group 1, (200-250); Group 2, (600-700); Group 3, (2,000-2,500); Group 4, (8,000-10,000).

For "Rate C" customers, the KWH/month use blocks selected as representative of summer loads were: Group 5, (2,000-2,500); Group 6, (7,000-8,000); Group 7, (20,000-30,000); Group 8, (50,000-70,000).

A random sample was drawn from each of these groups. Various checks were made as to the representativeness of the sample and they were found satisfactory. [Metering equipment used consisted of digital demand recorders

of the punched-tape type and strip-chart meters. Data were translated into punched cards for computer use.]

Purposes of Study: to obtain information for rate analysis and future system requirements on the Consumers Power general secondary service Rates B and C, which are available to both commercial and industrial customers.

Summary of Major Findings:

1. Load factors, based on the average of the noncoincident demands for "Rate B" customers, ranged from 10.9% (Group 1) to 24.6% (Group 4), for the winter period. For "Rate C" customers, during the summer period, similar load factors ranged from 36.8% (Group 5) to 47.1% (Group 8).

2. Comparing Group 3, "Rate B" customers (for 12/63) and Group 5, "Rate C" customers (for 7/63) points out some wide differences in customer characteristics between the two rates, namely:
(a) maximum (diversified) KW demand/customer was 6.0 for B-3 vs 5.3 for C-5;
(b) average weekday maximum (diversified) KW demand/customer, 4.6 vs 4.4;
(c) maximum (noncoincident) KW demand, 15.1 vs 7.6;
(d) load factor based on maximum (diversified) demand, 44.7 vs 60.8%;
(e) load factor based on average weekday maximum (diversified) demand, 58.3 vs 73.2%;
(f) load factor based on maximum (noncoincident) demand, 17.7 vs 42.4%;
(g) coincidence factor based on maximum (diversified) demand, 39.7 vs 69.7%;
(h) coincidence factor based on average weekday maximum (diversified) demand, 30.4 vs 57.9%.
[Note: energy use in above period averaged 1,994 KWH for B-3 Group and 2,396 KWH for C-5 Group.]

3. From data compiled on "Rate B" customers, pertinent observations are summarized below:
(a) Schools, churches, gas stations and miscellaneous commercial customers (small shops, meeting halls, body shops, etc.) comprise more than 46% of the 124 (sample) "Rate B" customers and less than 6% of the 120 (sample) "Rate C" customers. These customers are apparently low load-factor types.
(b) The high coincidence factor of Group 4 during (12/63) is apparently a result of 12 of its 29 customers being schools.
(c) Group 1 customers were influenced by the number of churches in the sample, causing maximum (diversified) demands on Sunday mornings for all winter months in the test period. Average load factors - based on non-coincident demands for this group - for the test months ranged from 10.9 to 13.2%.
(d) Group 2 customers peaked in the late afternoon in Dec. and Jan., indicating the influence of the lighting load. Average load factors, based on noncoincident demands, ranged from 16.2 to 18.8% during the winter test period.

(e) Group 3 customers peaked between 7:00 and 8:00 p.m. in Dec. and Jan. Average load factors, based on noncoincident demands, ranged from 16.8 to 18.0% for the test months.
(f) Group 4 customers' peak demands for the test months occurred between the hours of 10:30 and 11:30 a.m. The number of schools (12 in Dec.) is the major influence for this group. Average load factors, based on noncoincident demands for the test months, ranged from 21.9 to 24.6%.

4. From data compiled on "Rate C" customers, observations which can be made are:
(a) Department stores, food stores, restaurants and bars comprise over 45% of the sample customers on "Rate C" and only 5% of those on "Rate B"; they have higher load factors and therefore benefit from being on "Rate C", which is lower than "Rate B" for load factors above about 20%.
(b) Group 5 customers are principally food stores and food and beverage serving establishments; this composition accounts for the peaking of demands in the evening hours after 7:30 p.m., when lighting load is imposed on the existing air conditioning load. Average load factors, based on noncoincident demands, varied from 36.8 to 42.4% during July, Aug. and Sept., 1963.
(c) Group 6 customers follow a load pattern similar to Group 5. Average load factors varied from 44.2 to 46.7%, during the 3 test months.
(d) Group 7 and 8 customers had peak (coincident) demands in the morning during July 1963; Group 7 peaked at 11:30 a.m. and Group 8 at 11:00 a.m. Average load factors for both groups varied from 41.3 to 47.1%.

TITLE: INDUSTRIAL and LARGE COMMERCIAL CUSTOMERS *

SOURCE: Long Island Lighting Co. (Mineola, N.Y.)

AUTHOR(S): F.J.Kelsey (for H.L.Parlette)
PREPARED BY AUTHOR(S) AND/OR: L.I.L.

DATE OF ISSUANCE: 1966-67 Report of LRC/AEIC (Printed 1968)
OTHER IDENTIFIERS: Appendix B, Section 2 (pp L-132 thru L-142); data covers 1/63 thru 12/64
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with L.I.L.
TOTAL: [PAGES 11 ; REFERENCES 1 ; GRAPHS 10 ; TABLES 4] **
DOCUMENT CLASSIFICATION(S): 11/14, 49

ABSTRACT: *[In 1963, 19 of the 45 "customers" studied were of various non-Industrial classifications and therefore within the scope of this Compilation. Similarly in 1964, 24 of the 55 studied were non-Industrial.]

**[One of Tables is unnumbered. Graphs are grouped into 4 Charts.]

Each of the 45 original customers selected had experienced 15-minute billed demands in excess of 800 KW. [Note: The 800 minimum reflected availability of survey equipment.] Anytime during the 1963 test that a customer exceeded 800 KW for the first time, it was noted; in this way, 10 additional customers were added to the original sample for the 1964 test.

During the test period, 3 types of test recorders were utilized. When necessary, totalizing equipment was employed to meter a customer's total load. Concurrently, existing demand and KWH meters were used to obtain maximum billed (15-min) demands and energy use.

Purposes of Study: to determine the winter and summer coincident and non-coincident load characteristics of customers with demands in excess of 800 KW, with special emphasis on determining the effect of weather conditions on these load characteristics; to determine the relationship of one-hour to 15-minute demands.

Summary of Major Findings:
1. Winter and summer daily load curves are similar, with the exception that the summer demands are larger thruout the day.

2. Daily maximum diversified demands in the summer were moderately sensitive to temperature/humidity, while the winter demands were not.

3. The daily maximum (diversified) demands - both summer and winter - occurred most frequently during the hours ended 11 a.m., 12 noon, 2 p.m. and 3 p.m.

4. The group (annual) maximum noncoincident demands, based on one hour test intervals, were 3.0 and 1.2% lower than those based on 15-minute billed demands for the two years tested.

Individual customers (45 in 1963 and 45 and 55 in 1964) had a range of annual energy use, maximum noncoincident demands and load factors as follows:

5. Annual energy use per customer ranged from 846 to 67,194 megawatts and averaged between (about) 9,300 and 10,100 megawatts.

6. Annual maximum (hourly) noncoincident demand per customer varied between 0.3 and 12.8 megawatts and averaged between 2.1 and 2.3 megawatts.

7. Individual (annual) load-factors varied (widely) between 6.9 and 87.3%, with overall averages from 49.4 to 50.8%.

TITLE: SMALL COMMERCIAL and INDUSTRIAL LOAD STUDY

SOURCE: Philadelphia Electric Co. (Philadelphia, Pa.)

AUTHOR(S): W.F.Sundermeir (for R.A.Markel)
PREPARED BY AUTHOR(S) AND/OR: P.E.

DATE OF ISSUANCE: 1968-69 Report of LRC/AEIC (Printed 1970)
OTHER IDENTIFIERS: Appendix B, Section 2 (pp L-167 thru L-179); data covers June, July, Aug. & Dec., 1967
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.E.
TOTAL: [PAGES 13 ;REFERENCES 1 ;GRAPHS 9 ;TABLES 4] *
DOCUMENT CLASSIFICATION(S): 11/8, 14, 19, 31, 37

ABSTRACT: *[One of Tables is unnumbered. Graphs are grouped into 2 Charts.]

The customers included in this study receive electric service at standard secondary voltage (nominally 120-240 volts, single phase and polyphase). Residential use on the same premises, when it is supplied in conjunction with the commercial load, is included.

The billing demands of the customers included in this study are determined either by assessment, based on % of connected load, or by actual measurement of their monthly maximum (integrated) half-hour demand. [Customers whose measured demand exceeded 25 KW are not included in this study.] Changes in the demand ranges to be sampled-and in Rate Classification, differences in the types of customers represented in the sample groups and the proportion of customers with air cooling equipment - makes comparisons with previous studies difficult.

There are approximately 90,000 "assessed demand" and 50,000 "measured demand" customers served on the general light and power rate. The universe of customers was arranged into 9 subdividions stratified according to billing demand - 5 for assessed and 4 for measured demand customers. [Customers were assigned to these subdivisions on the basis of their maximum billing demand during the 1967-68 winter period. The "assessed demand" groups were: 0-1.0, 1.1-2.0, 2.1-3.0, 3.1-4.0 and 4.1-4.9 KW. The "measured demand" groups were: 3.1-7.0, 7.1-10.0, 10.1-15.0 and 15.1-25.0 KW.] Ten sample groups were randomly selected from each of the 9 subdivisions by the individual selective method of sampling. Each of the sample groups was compared to its respective universe and a group was then selected for actual test on the basis of its geographic distribution, average customer demand and energy use and frequency distribution of the customer demands.

Approximately one-third of the customers in each of the test groups were selected at random for power factor tests. These tests were made on summer hot weekdays for a half-hour period, selected at a time when the maximum

diversified demand of the entire class of customers would be expected to occur.

Purposes of Study: to obtain up-to-date information for system planning, rate making and profitability studies.

Summary of Major Findings:
[Note: The following findings are limited to the scope of this study and to the conditions at the time of the tests. The terms "hot" and "cool" used to describe the summer test weeks are subjective. "Hot" refers to a period when substantial air cooling load can be expected, "cool" to one where this load should not be a significant part of the total load.]
1. Except for the 0 to 1.0 KW group, where only 2% had air cooling, it was found that:
(a) The maximum (diversified) demand for the "summer hot average weekday" exceeded the maximum demand for the "summer cool average weekday" and the "winter average weekday". [This clearly illustrates the influence of cooling load during the hot periods.]
(b) The hourly load patterns for the summer hot average weekday are generally higher than those for the winter average weekday. Exceptions to this occur during the 5 to 9 p.m. period, when winter lighting requirements are high.
(c) During a summer hot period, the maximum diversified demands can be expected to occur between 11:30 a.m. and 5 p.m.

2. The hourly load patterns as well as the load levels, for each of the test groups, for the summer cool average weekday and the winter average weekday are generally similar except for the apparent seasonal effect of the evening lighting requirements.

3. The level of load for the winter average weekday (for customers in the 1.0 KW test group) is higher than during either of the summer test weeks. [The load pattern, for the most part, reflects the general use requirements of the hall and basement areas of buildings having individually metered apartments.]

4. The power factor, at the time of the maximum diversified demand on summer hot days, averages approximately 88% with a range from 86 to 91%.

5. The maximum diversified demands for each of the test weeks is not substantially higher than their respective average weekday values.

TITLE: SMALL COMMERCIAL LOAD STUDY

SOURCE: Rochester Gas and Electric Corp. (Rochester, N.Y.)

AUTHOR(S): A.L.Lustik (for C.S.Kellogg)
PREPARED BY AUTHOR(S) AND/OR: R.G.&E.

DATE OF ISSUANCE: 1968-69 Report of LRC/AEIC (Printed 1970)
OTHER IDENTIFIERS: Appendix C, Section 2 (pp L-180 thru L-187); data covers July & Dec., 1966
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with R.G.&E.
TOTAL: [PAGES 8 ;REFERENCES 2 ;GRAPHS 2 ;TABLES 2]
DOCUMENT CLASSIFICATION(S): 11/9, 14, 31, 35, 38, 41

ABSTRACT:

Using accepted procedures of random selection, a sample of 80 customers was chosen from a complete listing of all commercial customers whose demands are not metered. This listing numbered approximately 15,000 and were served under an all-purpose, general service rate.

There were 10 days in the summer test period when the maximum temperature equaled or exceeded 90°F; the average temperature was 1.4°F above normal based on 1931-60 Weather Bureau data. The same customers were tested for both periods except for those few who had to be deleted due to faulty meters, illegible tapes and service shut-off; the actual number included in the study was 67 (summer) and 71 (winter).

A magnetic tape meter was installed at each test location and data for each half-hour were obtained for the periods selected.

The types and numbers of businesses represented in the study were: (A) Lodging (mainly apartments), 33 & 31; (B) Storage, 5 & 4; (C) Stores, 13 & 14; (D) Offices, 8 & 7; (E) Service Operation, 2 & 2; (F) Educational/ Meeting-Hall/Religious Institutions, 7 & 6; (G) Miscellaneous (advertising sign & playground), 3 & 3. [Note: the first number in each type is for winter and the second for summer.]

Purposes of Study: to obtain load characteristic data, for small commercial customers - assumed to have unmetered demands of 5 KW or less - under both winter and summer conditions.

Summary of Major Findings:
1. The load curves are quite similar for both the summer and winter weekday tests, except for the periods from 6 to 7:30 a.m. and from 4:30 to 9:30 p.m. During these dissimilar periods winter demands are significantly higher than summer, reflecting the relative effect of lighting and the very limited use of air conditioning.

2. Winter diversified demands were higher than summer for the entire test period, with the largest disparity occurring between 4:30 and 9:30 p.m.

3. The group peak demands for the summer and winter test periods occurred at 12 noon and at 5:30 p.m., respectively. [The peak day during the study was Monday, 12/5/66, when a maximum diversified demand of 1.043 KW per customer occurred.]

4. The average use per small commercial customer is greater in winter than in summer. The reverse was true for the entire commercial class, which is a composite of the unmetered as well as the larger demand-metered customers. [This contrast can be attributed to differences in the "saturation" and magnitude of air conditioning loads, as between the larger and smaller commercial customers.]

5. The monthly diversified load factors for the small commercial customer is 66.2% in the winter and 57.4% in the summer.

TITLE: COMMERCIAL ALL-ELECTRIC STUDY

SOURCE: The Potomac Edison Co. (Hagerstown, Md.)

AUTHOR(S): D.B.Slaybaugh & R.M.Spagnolo (for D.W.Eyler)
PREPARED BY AUTHOR(S) AND/OR: P.E.

DATE OF ISSUANCE: 1969-70 Report of LRC/AEIC (Printed 1971)
OTHER IDENTIFIERS: Appendix A, Section 2 (pp L-84 thru L-96); data covers 11/1/64 thru 10/31/65
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.E.

TOTAL: [PAGES 13 ;REFERENCES ;GRAPHS 20 ;TABLES] *
DOCUMENT CLASSIFICATION(S): 11/8, 14, 21, 31

ABSTRACT: *[The Graphs are grouped into 4 Charts.]

When this study began, very little data concerning commercial all-electric customers was available for study and evaluation. When the 10 customers in this load survey converted from steam to electric heat, an opportunity to study the operating characteristics of various types of commercial all-electric customers presented itself.

Permission was obtained from 6 of the 10 conversion customers for the installation of check meters, the primary purpose of which was to monitor each customer's total load and the heating-cooling portion thereof. Data obtained from one of the original 6 was eliminated from the study because of incomplete data. In addition, data from a seventh location was deleted because only the heating load was metered and because this load was a part of the total load of P.E.'s local offices. [It should be noted that service to 3 of the 5 customers comprising this study is supplied through 2 separate service entrances, one for 120/240-volt single-phase service and the other for 240-volt three-phase service. The remaining customers are supplied 4,160-volt three-phase service. In all cases, the heating loads are supplied from three-phase service.]

Two of the customers were in SIC (Code) group 5600 and one each was in groups 2710, 5900 and 6000. The Report gives details of operating hours, floor areas, temperature settings, etc.

Two magnetic tape load survey recorders were installed at each customer's place of business to monitor the total load and the heating-cooling portion of the total load. The demand data so obtained were recorded at 15-minute intervals; 30-minute demands, as well as energy use, were obtained during data processing.

Purposes of Study: determining the demand and energy use characteristics of a selection of 5 commercial all-electric customers under varying conditions, over an extended period of time.

Summary of Major Findings:

1. Heating use during the winter test period was approximately 4 times the cooling use during the summer. Total load use during the winter test period was about twice that during the summer.

2. Heating load demands were approximately 3 times those of the cooling loads. Demands of the total load during the winter test period were nearly twice those during the summer.

3. Load curves of the base load show that the demands are relatively constant during both business and non-business hours, altho they are at two different load levels. These curves rise sharply, from approximately zero KW upon opening, and decrease rapidly to this same level upon closing. The heating load adds a rather constant demand to the base load, while cooling adds demand to the base load mainly during the business hours.

4. In general, load factors of both total load and heating-cooling load were approximately 10% higher during the winter test period than during the summer.

TITLE: SMALL COMMERCIAL and INDUSTRIAL CUSTOMER ELECTRIC LOAD CHARACTERISTICS STUDY *

SOURCE: Public Service Electric and Gas Co. (Newark, N.J.)

AUTHOR(S): P.F.Platt (for G.Clarkson)
PREPARED BY AUTHOR(S) AND/OR: P.S.E.&G.

DATE OF ISSUANCE: 1970-71 Report of LRC/AEIC (Printed 1972)
OTHER IDENTIFIERS: Appendix B, Section 2 (pp L-98 thru L-133); data covers June 1968 thru May 1969
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.S.E.&G.
TOTAL: [PAGES 36 ;REFERENCES 1 ;GRAPHS 37 ;TABLES 6] **
DOCUMENT CLASSIFICATION(S): 11/14, 19, 31, 46

ABSTRACT: *[Rate Schedule GLP, General Lighting and Power Service; customers were grouped in accordance with Demand values, rather than by type.]

**[One of Tables is unnumbered; 2 of numbered Tables are composites of "sub-tables which give comparative data for the groups studied. Graphs are grouped into 13 Charts.]

Since there is a wide range of customer types in Rate Schedule GLP, General Lighting and Power Service, and because air conditioning - which would predominate in a large commercial group of this kind - would cause growth in certain usage areas, current knowledge of the characteristics of this class load is desirable. While both small commercial and industrial customers are served under GLP, the commercial classification predominates, comprising approximately 96% of the total. [Note: A similar study was made during the winter of 1957-58 and the summer of 1958 and was printed in the 1959-60 Annual Report of the Load Research Committee.]

Accepted procedures of random choice - from stratified subdivisions of customers according to annual maximum demand - were employed in selecting customers for testing. Two types of meters are used to meter loads served under Rate Schedule GLP: (1) a demand meter which measures KWH and the maximum KW demand of a steady load in any 30-minute interval; (2) a watthour meter which measures KWH but where the monthly maximum demand is determined by dividing such use by 100. Both groups of customers are included in the sample and are referred to in this Report as "measured" and "estimated" demand customers, respectively. Magnetic tape load survey recorders were installed to measure 30-minute integrated demands; the tapes were translated to load survey cards and acceptable data processed.

Customers were grouped according to their range of annual maximum (KW) demand per customer, as follows: #1 (0-2.0); #2 (2.1-4.0); #3 (4.1-6.0); #4 (6.1-10.0); #5 (10.1-15.0); #6 (15.1-30.0); #7 (30.1-50.0); #8 (50.1-200.0); #9 (200.1-400.0).

Purposes of Study: to determine load characteristics for small commercial and industrial customers served on the Rate Schedule GLP, for each month of the test year; to obtain data for use: (1) in estimating electric demands for service requirements; (2) in the development of cost determinants; (3) for continuing rate studies; (4) as a tool in short- and long-term forecasting of system peak loads and (5) in optimizing the size of transformers and conductors.

Summary of Major Findings:

1. The annual maximum demand (except for Group 1) occurs during the summer between noon and 4:30 p.m.; for Group 1 it occurs in Jan. at 6:30 p.m.

2. The annual load factor for each Group, based on maximum diversified demand, ranges from 36.7 to 51.0%.

3. The coincidence factor for each Group varies from 35.0% (Group 1) to 86.8% for (Group 9).

4. Annual KWH use per customer ranges from 2,016 for Group 1 to 851,761 for Group 9.

5. A comparison of load curves shows no similarity between summer and winter for Groups 2 thru 4. Summer and winter load curves for Group 1 and Groups 5 thru 9 show some similarity in shape altho differing, in general, in magnitude.

6. Except for Group 1, load curves for the summer months show the definite effects of temperature-sensitive loads.

TITLE: GENERAL SERVICE LOAD STUDY: CUSTOMERS ON ELECTRIC SCHEDULE "G" (MINIMUM) *

SOURCE: Baltimore Gas and Electric Co. (Baltimore, Md.)

AUTHOR(S): J.W.Bedinger (for W.E.Miller)
PREPARED BY AUTHOR(S) AND/OR: B.G.&E.

DATE OF ISSUANCE: 1971-72 Report of LRC/AEIC (Printed 1973)
OTHER IDENTIFIERS: Appendix A, Section 2 (pp L-29 thru L-62); data covers 12 months ending 1/31/67
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with B.G.&E.
TOTAL: [PAGES 34 ;REFERENCES ;GRAPHS 11 ;TABLES 12] **
DOCUMENT CLASSIFICATION(S): 11/9, 14, 19, 33, 46

ABSTRACT: *[25 KW, or less, of connected load for billing purposes.]

**[Six of Tables are unnumbered. Graphs are grouped into 7 Charts.]

Each group studied contains 33 customers; the first group consists of those with monthly use averages ≈ 500 KWH, the second had monthly use averages ≈ 1,500 KWH and the third had monthly use averages ≈ 2,500 KWH. Each user's energy requirements were recorded throughout the test year.

To obtain a representative sample of Schedule G (minimum) customers, from the population in the Metropolitan Baltimore Area, users were stratified into 3 groups by monthly averages. These groups were selected from a relatively large population of customers who were under the then current General Service Schedule minimum ratings. Thirty-three "business" customers from each group were then randomly selected, using the method of sampling with replacement. Prior to actual testing, each customer was interviewed by a Company representative to determine the type of structure, total appliance connected load and other pertinent data at each premises. [Note: The establishments monitored were extremely varied in nature and included just about every type encountered in a large city. Also included were a scattering of: special schools, small offices, office buildings, apartment houses and local government facilities.]

All customers are on Schedule G-Minimum, having 25 KW (or less) of connected load for purposes of billing. However, in this study all connected loads are as actually determined from total-premises inspections and do not necessarily compare with loads used for billing. [Note: For billing purposes, heat appliances are excluded, while each room "to let" and each residence as a whole is included at 100 watts and 750 watts, respectively, regardless of what load actually is connected.]

For the duration of the load study, magnetic tape recorders were employed in conjunction with contact-equipped watthour meters so as to obtain data in quarter-hour intervals. Premises load survey data is converted by the B.G.&E.'s Translator into standard load survey punch cards, using a format suitable for entry into a computer. These punched cards are

analyzed by an electronic data processing system. Average customer data are included in this report along with certain individual customer information.

Purposes of Study: a test of the total-service load characteristics of 3 groups of customers supplied electric service under General Service Schedule G (Minimum), under varying conditions over a 1-year period; to obtain data not previously available for such G.G.&E. customers; to provide statistically reliable load information for use in engineering, economic and rate studies and for sales estimating guides.

Summary of Major Findings:

1. For Groups 1, 2 and 3 the average annual use per customer is 6,457 and 20,075 and 30,829 KWH, respectively. This is equivalent to 808 and 1,169 and 1,315 hours use of the respective average connected loads per customer.
2. Of the annual energy requirement, 54, 55 and 52% is used on peak (8 am thru 10 pm on weekdays other than holidays) by Groups 1, 2 and 3, respectively.
3. For all groups, the maximum average day of use (in Jan., Feb., Mar. and May) is the average Friday in the month. In June, July and Aug. the maximum average day of use is the average Tuesday in the month. In the remaining 5 months, the maximum average use day varies among the 3 groups.
4. The monthly maximum (diversified) demands for the 3 groups are primarily concentrated in different parts of the day, as follows: Group 1 from 10:30 am to 12:30 pm, Group 2 from 3 pm to 6:30 pm and Group 3 from 5 pm to 9 pm.
5. In the hour of a Baltimore Contract Load (BCL) monthly peak, the maximum percentages of connected load in use are 17.5, 32.0 and 31.9%, respectively, for Groups 1, 2 and 3; these maximums occur on July 14 at 2 pm for Group 1, at 2 pm on June 28 and July 14 for Group 2 and on Aug. 22 at 2 pm for Group 3.
6. Customers in Groups 1, 2 and 3 add 1.10, 3.94 and 5.80 KW per customer, respectively, to the BCL monthly peak hours, which being averaged over the 12-month period amount to 13.8, 22.9 and 24.8% of the average customer's connected load.
7. Monthly maximum (diversified) demands - measured over a quarter-hour interval - are greater than those measured over the standard half-hour interval by 1.4 to 7.6% in Group 1, by 0.3 to 3.7% in Group 2 and by 0.2 to 2.7% in Group 3. One-hour demands are less by 1.4 to 7.4% in Group 1, by 0.5 to 4.1% in Group 2 and by up to 4.9% in Group 3.
8. Annual load factors - based on maximum diversified demand - are 44.7, 40.0 and 46.8% for Groups 1, 2 and 3, respectively. Based on non-coincident maximum demand, these load factors are 22.4, 26.3 and 28.6%
9. Annual demand factors for Groups 1, 2 and 3 are 20.7, 33.4 and 32.1%, respectively.

TITLE: COMMERCIAL CUSTOMER ELECTRIC LOAD CHARACTERISTICS STUDY

SOURCE: Public Service Electric and Gas Co. (Newark, N.J.)

AUTHOR(S): P.F.Platt (for G.Clarkson)
PREPARED BY AUTHOR(S) AND/OR: P.S.E.&G.

DATE OF ISSUANCE: 1971-72 Report of LRC/AEIC (Printed 1973)
OTHER IDENTIFIERS: Appendix B, Section 2 (pp L-63 thru L-96); data covers June 1968 thru May 1969
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.S.E.&G.
TOTAL: [PAGES 34 ; REFERENCES 1 ; GRAPHS 39 ; TABLES 21] *
DOCUMENT CLASSIFICATION(S): 11/14, 31, 46, 49

ABSTRACT: *[Three of the Tables are unnumbered; 3 of the 5 numbered Tables are made up of (10, 6 and 6) "sub-Tables", which report data for various groups differentiated by both demand magnitude and the procedures used to measure and/or estimate demand billings. The Graphs are grouped into 12 Charts.]

This customer class is served under Rate Schedule GLP, General Lighting and Power Service, and under Schedule LPL, Large Power and Lighting Service. There is a wide range of customer types in the commercial class. Specific loads, such as air conditioning, would cause growth in certain usage areas and, therefore, current knowledge of the characteristics of this class load is desirable.

To obtain a representative sample of commercial customers for this study, all industrial customers were eliminated from the Schedule GLP sample. A random selection of large commercial customers, served on Schedule LPL, was added to the commercial customers in the original GLP sample. This results, it is believed, in a representative sample of commercial electric customers which have been analyzed by annual (individual) maximum KW demand groups, as follows: #1 (0-2.0); #2 (2.1-4.0); #3(4.1-6.0); #4 (6.1-10.0); #5 (10.1-15.0); #6 (15.1-30.0); #7 (30.1-50.0); #8 (50.1-200.0); #9 (200.1-400.0); #10 (over 400.0).

The commercial customers studied were extremely varied in nature. In fact, 66 types are included on the SIC descriptions lists.

Purposes of Study: to determine load characteristics for commercial electric class customers for use in: (1) estimating electric demands for service requirements; (2) the development of cost determinants; (3) continuing rate studies and (4) short-and long-term forecasting of system peak loads.

Summary of Major Findings:
1. The annual maximum (diversified) demand, for all but Group 1, occurs during the summer, usually between noon and 4 p.m.; for Group 1 it occurs in Feb. at 9 p.m.

2. The annual load factor for each group - based on maximum diversified demand - ranges from 36.8 to 63.2%.

3. The annual coincidence factor ranges from 38.0% for Group 1 to 87.3% for Group 10.

4. Annual KWH use per customer ranges from 1,981 for Group 1 to 3,877,449 for Group 10.

5. There is no similarity between summer and winter load curves -- for the day of group maximum demand -- for Groups 2 thru 4. Group 1 and Group 5 thru 10 show some similarity in shape altho differing, in general, in magnitude.

6. Except for Group 1, load curves for the summer months show the effect of temperature-sensitive cooling loads.

TITLE: SMALL and LARGE GENERAL SERVICE STUDY

SOURCE: Virginia Electric and Power Co. (Richmond, Va.)

AUTHOR(S): C.E.Higgins, Jr. & S.E.King (for R.S.Gay)
PREPARED BY AUTHOR(S) AND/OR: V.E.&P.

DATE OF ISSUANCE: 1971-72 Report of LRC/AEIC (Printed 1973)
OTHER IDENTIFIERS: Appendix C, Section 2 (pp L-97 thru L-108); data covers 8/17/70 thru 9/6/70 + 12/7/70 thru 12/27/70
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with V.E.&P.
TOTAL: [PAGES 12 ;REFERENCES ;GRAPHS 8 ;TABLES 2]*
DOCUMENT CLASSIFICATION(S): 11/14, 21, 26, 31, 46

ABSTRACT: *[One Table is unnumbered. Graphs are grouped into 2 Charts.]

In an attempt to keep pace with the changing character of its customers, V.E.&P. has continually conducted load studies on its various service classes. Since a shift from a winter to a summer peak first occurred, the service area peak for the summer has continued to grow more rapidly than that for the winter.

Included in the small and large general service classes are all industrial and commercial customers. Large general service customers have contracted for 50 KW or more; the remaining ones are classified as small [The small general service rate schedules for separately metered water heaters, outdoor lights and temporary facilities were excluded from this test.] The summer and winter test customers in this study were essentially the same.

An optimally-allocated stratified random sample of 465 customers was selected. Due to meter malfunctions, the small general service results are for 242 customers in the summer and 235 in the winter. Similarly, the large general service results are for 178 customers in the summer and 175 in the winter. Where demand data existed for Aug. 1969, they were used as the basis for stratification on each rate schedule and for allocation of sample customers to the resulting strata; where such data were not available, KWH for July and Aug. 1969 were used.

Prior to the test period, each of the sample customers in the small general service classification was interviewed by a Company representative to determine the type of business and its connected load. [Alternates were assigned for the winter test for the 1.5% who had moved or permanently altered their service requirements following the summer test.]

Purposes of Study: to provide statistically reliable data on the summer and winter total-load characteristics of the Company's small and large general service classifications.

Summary of Major Findings:

A. Small General Service

1. Those tested had an average total-energy use of 1,741 KWH during the period 8/17 thru 9/16/70 and used 1,181 KW during the period 12/7 thru 12/27/70. The annual average total energy uses were 23,509 and 24,190 KWH for the summer and winter test groups, respectively.
2. The total-service (noncoincident) maximum KW demands per customer were 10.3 for the summer test period and 7.7 for the winter. Thus the annual load factor based on summer demand was 26.1%.
3. For these same customers, the maximum total-service (diversified) demands per customer during the summer and winter test periods were 6.3 and 4.3 KW, respectively. Based on this summer demand, the annual load factor was 42.6%.

B. Large General Service

1. Those tested had an average total energy use of 131,771 KWH during the 3 week summer test period and 106,754 during the 3 week winter test period. The annual average total energy uses were 2,042,777 and 2,083,075 KWH for the summer and winter test groups, respectively.
2. The total-service (noncoincident) maximum KW demands per customer were 407.9 and 363.9 for the summer and winter test periods, respectively. Based on this summer demand, the annual load factor was 57.2%.
3. For these same customers, the maximum total-service (diversified) demands per customer during the summer and winter test periods were, respectively, 359.2 and 299.7 KW. The annual load factor, based on summer demand, was 64.9%.

Customer Characteristics:
For the small general service class, the average KW connected loads for the summer (s) and winter (w) test groups are: Lighting, 5.7 (s) and 6.0 (w); Cooling, 9.3 (s); Heating 12.2 (w); other, 11.9 (s) and 12.8 (w).

The summer load curve of small general service customers declines slightly during the early morning hours, then rises sharply until the half-hour ending at noon EDT. The curve drops during the lunch hour, rises to an even higher level until 2:30 p.m. and then begins to decline rapidly until 7:30 p.m. At this time, the curve rises until 8:30 p.m., then declines steadily until 4 a.m. This evening hump possibly can be explained by lighting usage of stores with evening hours, since over 99% of service is commercial in nature; the winter curve is similar in shape but everywhere below the summer curve. However, the morning rise on the winter curve peaks at 11:30 a.m. and the evening rise has shifted back to 5:30 p.m., probably due to the change from EDT to EST and the shortness of winter days. The large separation between summer and winter profiles, from 9 a.m. to 5 p.m., is due in part to the widespread use of air conditioning.

TITLE: SMALL GENERAL SERVICE CUSTOMER LOAD STUDY

SOURCE: Consolidated Edison Co. of New York, Inc. (New York, N.Y.)

AUTHOR(S): R.E.Weintraut (for J.Monsees)
PREPARED BY AUTHOR(S) AND/OR: C.E. (of) N.Y.

DATE OF ISSUANCE: 1972-73 Report of LRC/AEIC (Printed 1974)
OTHER IDENTIFIERS: Appendix A, Section 2 (pp L-181 thru L-213); data covers Feb. 1970 to Feb. 1971
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with C.E. (of) N.Y.
TOTAL:[PAGES 33 ;REFERENCES ;GRAPHS 24 ;TABLES 11] *
DOCUMENT CLASSIFICATION(S): 11/14, 19, 46

ABSTRACT: *[Four of Tables are unnumbered; one of the numbered Tables is actually a composite of 7 "sub-Tables" representing various (increasing) KWH ranges. The Graphs are grouped into 7 Charts.]

Approximately 327,000 "small" commercial and industrial electric customers are served on the SC No. 2 rate; this rate applies to customers billed for energy use only and who have registered demands under 10 KW with an annual consumption consequently limited generally to about 40,000 KWH. These customers' watthour meters are read bi-monthly on 42 scheduled meter reading trips that cut across the total company service area.

The test customers were placed in seven groups - arranged in increasing annual KWH ranges - prior to performing load analysis, namely: (A) 0-800; (B) 801-2,050; (C) 2,051-3,200; (D) 3,201-5,200; (E) 5,201-8,500; (F) 8,501-13,300; (G) over 13,300. Each group contained roughly the same number of test customers with class group sizes ranging from about 32,000 to 77,000.

Annual energy use stratifications were established that took into consideration the impact of group consumption and tendencies toward normal distributions. Criteria for sample size determinations were first set at 95% confidence coefficient and a confidence interval of $\pm$ 8% of the sampling universe means. The total required sample size was 211 but since 360 recorders were available for test purposes, the sample sizes for the stratifications were increased proportionately to offset expected losses of test data such as usually occur during customer load test operations.

Starting 2/1/70 and for the next 12 months, special demand and energy use readings were taken around the first of the month for load research purposes; in addition, the regularly scheduled energy use readings were taken from the same meters for billing purposes.

Recorders equipped with 90-day magnetic tapes were connected to each customer's test meter and half-hour integrated demands were recorded during

the period June 15-Aug. 15, 1970. [The recorders were removed at the end of the summer load tests.] During Nov. 1970 the tape recorders were reinstalled; they were removed after Jan. 23, 1971 when winter load tests were concluded. All acceptable data were processed to produce individual customer daily half-hour demand listings.

Purposes of Study: to determine the load characteristics of the "SC No. 2 General-Small" class of electric customers (during summer and winter periods) in order to provide group and class load data for use in cost and rate analysis, system planning and commercial research.

Summary of Major Findings:

1. The group maximum diversified demands for the average of the 5 hottest summer weekdays ranged from 17.9 to 31.6% higher than those for the average of the 5 coolest summer weekdays, due to the impact of heavier air cooling loads.

2. Except for Group B, maximum diversified demands for the average of the 5 hottest summer weekdays ranged from 18.6 to 53.4% higher than those for the average of the 5 coldest winter weekdays. For Group B, the summer peak was only 1.25% higher than the winter peak.

3. All group load peaks for the average of the 5 hottest summer weekdays occurred between 11:30 a.m. and 3:30 p.m. All group peaks for the average of the 5 coolest summer weekdays occurred between noon and 4:00 p.m. [Note: The average daily dry bulb temperatures were used in specifying "hottest" and "coolest" days.] All winter peaks for the average of the 5 coldest weekdays occurred between noon and 5:00 p.m., except for Group A, which peaked from 10:30 a.m. to noon.

4. Group load factors (based on maximum diversified demands) for the two 28-day summer test series were substantially lower than those for the two winter test series.

5. Annual load factors (based on individual customers' maximum annual noncoincident demands and on annual consumption adjusted to a 360-day base) for Groups A through G were 7.7, 10.1, 12.6, 14.1, 16.6, 19.9 and 23.8%, respectively.

6. For Groups C through G, monthly energy usages per customer were higher for the summer months than those for the winter months. For Groups A and B, the opposite was true.

7. Group monthly load factors based on individual customers' maximum monthly demands were lower for the summer months than for the winter months.

TITLE: GENERAL SERVICE CUSTOMER LOAD STUDY: CUSTOMERS WITH MONTHLY DEMANDS AVERAGING 200 KW and ABOVE *

SOURCE: Baltimore Gas and Electric Co. (Baltimore, Md.)

AUTHOR(S): J.C.Spence (for W.E.Miller)
PREPARED BY AUTHOR(S) AND/OR: B.G.&E.

DATE OF ISSUANCE: 1973-74 Report of LRC/AEIC (Printed 1975)
OTHER IDENTIFIERS: Appendix A, Section 2 (pp L-33 thru L-58); data covers 12 months ending 7/31/71
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with B.G.&E.
TOTAL: [PAGES 26 ;REFERENCES ;GRAPHS 9 ;TABLES 10] **
DOCUMENT CLASSIFICATION(S): 11/9, 14, 33, 46

ABSTRACT: *[Note: of the 33 "Types of Businesses" studied, 18 can be classified as Non-Industrial and therefore within the scope of this Compilation.]

**[Four of Tables are unnumbered. Graphs are grouped into 8 Charts.]

Thirty-three General Service Schedule XGN customers were chosen from a population of about 540 such customers in the B.G.&E.'s service area. [Note: XGN customers are general service customers who are supplied at secondary voltage and who have monthly demands of 200 KW and above.] Customers were chosen on a systematic stratified basis from strata related to monthly use per customer. Before actual testing began, each customer was interviewed by a B.G.&E. representative to determine his type of business and other relevant data. Connected loads were determined from detailed total-premises inspections. Magnetic tape recorders were used along with contact-equipped watthour meters to obtain data in quarter-hour intervals.

The minimum and maximum connected loads for individual customers are 264 and 3,621 KW, respectively. The group-average connected load is 1,175 KW. The largest portion of connected load is for miscellaneous equipment and the next largest is for lighting. Cooling connected load is about 4 times greater than heating connected load.

The non-industrial "businesses" included: private country clubs, department stores, office buildings, schools, a printing plant, variety and grocery stores and a telephone exchange

Purposes of Study: a 1-year test of total-service load characteristics of general service customers who are supplied at secondary voltage and whose monthly demands average 200 KW and above; to obtain statistically reliable data not previously available for such customers in the B.G.&E. service area.

Summary of Major Findings:
1. Average annual use per customer is about 1,654,000 KWH. This is

equivalent to 1,408 hours use of the average connected load per customer.

2. Of the annual energy use, 63% is "on peak" (8 am to 10 pm inclusive, on weekdays other than holidays and the Monday following a Sunday holiday.)

3. The maximum average daily use in the months of Jan., Feb., Apr. and May is for the average Wednesday in the month. For June, July, Aug., Sept. and Nov. it is for the average Thursday. In the remaining three months, this maximum is for the average Tuesday.

4. The monthly maximum (diversified) demands occur between the span of half-hours ending 11 am thru 3:30 pm. However, about 75% of these monthly demands occur during the span of half-hours ending 11:30 am thru 2 pm.

5. In the hour of "Baltimore Contract" load monthly peak, the maximum % of connected load in use is 31.7. This occurred on Thursday, July 1, at the hour ending 2 pm.

6. An average of 286 KW per test customer is the contribution to the 12 "Baltimore Contract" load monthly peak hours. This is 24.3% of the average customer's connected load.

7. Monthly maximum (diversified) demands, measured over a quarter-hour interval, are greater than those measured over the standard half-hour interval by up to 2.5%. One-hour demands are less than the half-hour demands by 0.3% to 2.3%.

8. The annual load factor based on maximum (diversified) demand is 47.9%. The annual load factor based on (noncoincident) maximum demand is 41.1%.

9. The annual coincidence factor is 80.1%.

10. The annual demand factor is 33.5%.

TITLE: LARGE GENERAL SERVICE LOAD STUDY: COMMERCIAL and INDUSTRIAL CUSTOMERS (50-5000 KW) *

SOURCE: Carolina Power & Light Co. (Raleigh, N.C.)

AUTHOR(S): J.M.Davis, Jr. & B.J.Yarborough (for S. Behrends, Jr.)
PREPARED BY AUTHOR(S) AND/OR: C.P.&L.

DATE OF ISSUANCE: 1973-74 Report of LRC/AEIC (Printed 1975)
OTHER IDENTIFIERS: Appendix B, Section 2 (pp L-59 thru L-72); data covers summer 1971 + winter 1971-72
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with C.P.&L.

TOTAL:[PAGES 14 ;REFERENCES ;GRAPHS 11 ;TABLES 5] **
DOCUMENT CLASSIFICATION(S): 11/9, 14, 31, 43, 46

ABSTRACT: *[Note: of the 50 "Customers" listed, just about half (26) can be logically called Non-Industrial and therefore fall within the scope of this Compilation; all of the 26 were within the smaller (50-100 and 101-500) KW demand strata groupings used by the Study.]

**[One of Tables is unnumbered. Graphs are grouped into 4 Charts.]

At the end of March, 1973, the Company served 2,781 customers on rate schedule G-2. The 2,773 customers with demands under 5000 KW were surveyed by use of statistical sampling. The average kilowatt demand per customer was determined on three bases, as noted below:
A. Diversified Demand at Time of System Peak: the average number of KW at the time of the system's (service area) peak demands, in both summer and winter.
B. Maximum Diversified Demand: the average number of KW at the time of maximum demand for all sample customers combined; this was determined for each KW demand stratum and for the total rate sample.
C. Noncoincident Maximum Demand: the average number of KW calculated from a summation of the maximum demands of the individual customers; this was determined for each KW demand stratum and for the total rate sample.

The reported KW and KWH results are based on actual metered data. However, for the purpose of load analysis and utilization of the data in other studies, migration has been allowed from one KW demand stratum to another due to demand changes between the time of sample selection and actual testing; such customers were reassigned to the appropriate stratum based on their KW demand during the testing period, a procedure best suited to the Company's purpose of expanding sample data to a known, finite population.

The non-industrial "businesses" were all in the 50 to 500 KW strata. They included: grocery, variety and department stores, a bakery, restaurants, hospitals, a bank, office buildings, motels, municipal

buildings, a doctor's office center, an automobile dealership, a printing shop, a dairy cooperative.

Purposes of Study: to produce load data on the general service customers served on rate schedule G-2. [Note: These commercial and industrial customers range in size from 50 to 20,000 KW with load factors below 75%.]

Summary of Major Findings:
1. The G-2 rate group reached its maximum (diversified) demand at 11 a.m. EDT (7/19/71). The average demand per customer at that time was 289 KW or 52 KW higher than the 237 KW at 11 a.m. EST (on 1/26/72), which was the time that this group reached its maximum (diversified) winter demand.
2. Each KW stratum range indicated its own summer (non-coincident) maximum demand. The average for the total rate group was 323 KW per customer. The system service area (peak) demand, for the test period, occurred at noon on 7/19/71. The diversified KW demand (by KW stratum range) at the time of this peak was, respectively: (50-100), 60; (101-500), 178; (501-1000), 635; (1001-5000), 2254; (total rate group), 289 KW. The overall ratio of the diversified demand, at the time of the system peak, to the noncoincident maximum demand is 89.5%.
3. The load curves, for each of the strata, show similar profiles for the days of the summer and winter rate peaks and system service service area peak demands; each indicates a well-defined 11 a.m. peak plus a pronounced reduction in demand during the 12 to 1 p.m. luncheon period plus an afternoon peak, normally at 3 p.m.

Statistical Notes:
The usual methods based on probability techniques could not be applied in arriving at a sample size because the G-2 population was small, finite and severely skewed. A bill frequency distribution was obtained (from billing KW) for the month of Aug. 1970, from which the variance and standard deviation of the population was calculated. Based on this information, and the known characteristics of customers on this rate, an optimum sample size was established. The population was divided into 4 homogeneous strata (on the basis of billing KW) and the weight of each stratum was calculated. Sample customers were proportionately allocated to the different strata, on the basis of the weight of the stratum to the total rate. Having fixed the stratum size, the (sample) customers were selected by random sampling of each stratum. This selection was made from the customer billing history file.

The sampling error for the total group, as measured under the three bases outlined above, appears to be quite reasonable. The standard error of the mean (at the 95% confidence level) for G-2 sample average group totals was: 289 $\pm$ 77 (basis "A", summer); 147 $\pm$ 44 (basis "A", winter); 289 $\pm$ 76 (basis "B"); 323 $\pm$ 82 (basis "C").

TITLE: SMALL COMMERCIAL and INDUSTRIAL LOAD STUDY

SOURCE: Philadelphia Electric Co. (Philadelphia, Pa.)

AUTHOR(S): A.C.Parker & T.P.Hill, Jr. (for R.C.Williams)
PREPARED BY AUTHOR(S) AND/OR: P.E.

DATE OF ISSUANCE: 1973-74 Report of LRC/AEIC (Printed 1975)
OTHER IDENTIFIERS: Appendix D, Section 2 (pp L-90 thru L-99); data covers June, July, Aug., Dec. 1970
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.E.

TOTAL:[PAGES 10 ;REFERENCES 1 ;GRAPHS 12 ;TABLES 3] *
DOCUMENT CLASSIFICATION(S): 11/9, 14, 19, 26, 31, 37, 38, 42

ABSTRACT: *[Graphs are grouped (6 and 6) in 2 Charts: billings on "assessed demand basis" and "measured demand basis".]

This survey covers a representative sample of customers who are supplied at standard secondary voltage (nominally 120-240 volts, single and polyphase), Residential use on the same premises, when it is supplied in conjunction with the commercial load, is included.

The universe of customers was arranged into 12 subdivisions, stratified according to billing demand or winter quarter energy use, with 3 for assessed demand customers, 3 for customers billed without demand measurement and 6 for measured demand customers. Ten sample groups were chosen from each of these subdivisions, using an individual selective method of sampling. Each of the sample groups was compared to its respective universe, and the group whose characteristics compared most favorably to the universe was selected for testing. Points of comparison between each sample group and the universe were: geographic distribution, demand, energy use and frequency distribution of the demand or energy use.

For the summer period the data for the hottest week and a cool week were selected for presentation in this study; for the winter period a week in mid-Dec. was selected. [The "hot week" represents a period when substantial air cooling load can be expected and the "cool week" represents a period when such loads would not be a significant part of the total load.]

Approximately one-fourth of the customers in each of the test groups were selected at random for power factor tests. These tests were made on summer (hot) weekdays, with the outdoor temperature in excess of 85°F. Half-hour tests were conducted at a time when the maximum diversified demand of the entire class of customers would be expected to occur.

The non-industrial "businesses" studied were classified into: Food Services; Personal (and misc.) services; Food Stores; Drug (and misc.) stores; Professional, Financial (and other) Offices; Educational (and

Religious) Institutions; Lodging (mainly Apartments); Amusements (and Municipal) Establishments.

Purposes of Study: to develop load characteristics used for system planning, rate making and profitability studies. [Note: Results of a similar survey made in 1967 were reported in the 1968-69 Report of the LRC.]

Summary of Major Findings:

1. Except for the test group with a 1.0 KW assessed billing demand -- where none of the customers had air cooling equipment — and for the test group with 40.1 to 100.0 KW measured billing demand -- which has the greatest number of manufacturing type customers and educational and religious institutions -- the maximum diversified demand for the summer (hot) average weekday exceeded the maximum demand for both the summer (cool) average weekday and for the winter average weekday, in each of the respective test groups.

2. During a summer (hot) period the maximum diversified demand for each of the test groups can be expected to occur during the 10:30 a.m. to 3 p.m. period, except for the 1.1 to 3.0 KW assessed demand customers. This latter group has a large number of "lodging-type" customers whose maximum (diversified) demand occurs at 6 p.m. The maximum diversified demands for the test groups whose measured demands exceed 7.1 KW occur at or before noon.

3. In the 1967 survey noted above, the hourly load patterns were generally similar for the summer (cool) average weekday and the winter average weekday except for the difference in lighting requirements during the evening hours (5 to 9 p.m.). In this survey the demands during the 10 a.m. to 5 p.m. period are higher for the summer (cool) average weekday than for the winter average weekday, with a few exceptions.

4. The power factor of the test groups at the time of their maximum diversified demand on summer hot days is approximately 89%, with a range from 76 to 95.

TITLE: COMMERCIAL SPACE HEATING LOAD STUDY

SOURCE: Consumers Power Co.

AUTHOR(S): J.H.Climen & C.F.Belknap, Jr. (for W.J.Jefferson)
PREPARED BY AUTHOR(S) AND/OR: Consumers Power Co.

DATE OF ISSUANCE: 1973-74 Report of LRC/AEIC (Printed 1975)
OTHER IDENTIFIERS: Appendix B, Section 3 (pp L-114 thru L-128); data covers 12 months ending 12/31/70
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with C.P.C.

TOTAL:[PAGES 15 ;REFERENCES 1 ;GRAPHS 6 ;TABLES 1]
DOCUMENT CLASSIFICATION(S): 11/8, 9, 14, 15, 21, 49

ABSTRACT:
Six samples of 35 customers each, 3 primary and 3 alternate, were randomly selected from billing records. The primary samples were analyzed to determine the one that best fit certain known characteristics of the universe such as: bill frequency distribution, geographic location and "type of business" distribution. The best primary sample was then adjusted with customers from alternate samples in order to achieve the most representative sample based on the known characteristics. Further adjustments were necessary to replace those customers who declined to participate in the study. The final group was interviewed to determine characteristics such as size of business establishment and operating hours. [Due to the lack of precise data, 2 customers were deleted from the analysis, after data collection was completed.] The 33 remaining test customers consisted of: 7 schools, 6 hotels & motels, 4 apartments, 3 offices, 2 gasoline stations and 11 miscellaneous. [The final sample was metered with pulse initiating watthour meters and recorded with magnetic reel-to-reel cassette Survey Recorders.]

Purposes of Study: to obtain a greater insight into the space heating load of commercial customers.

Summary of Major Findings:
1. The average use per sample customer was 36,128 KWH as compared with 33,373 for the corresponding universe; this is a difference of $\approx 8.3\%$.

2. Actual degree days (DD) in Feb., the month of the sample maximum demands, were within 1% of "normal". There were 7,294 DD in 1970, as compared with a normal 7,104; this is a difference of 2.7%.

3. The half-hour maximum (diversified) demand for the average sample customer was 13.05 KW. This demand occurred from 6:30 to 7 a.m. on Wed., 2/4/70.

4. Monthly maximum (diversified) demands ranged from 2.17 KW (in July) to 13.05 (in Feb.).

5. In each of the months studied the diversified demand, at the time of the system peak, was lower than the corresponding maximum (diversified) demand. The sample and monthly system peaks never occurred simultaneously.

6. The (noncoincident) maximum demand of 19.8 KW per sample customer occurred in Feb. The corresponding annual average noncoincident demand was 14.1 KW.

7. Monthly load factors, based on monthly maximum (diversified) demand, achieved their greatest values during the five coldest months (Jan., Feb., Mar., Nov., Dec.).

8. The annual load factor, based on maximum (diversified) demand, was 31.6%; based on average (noncoincident) demand it was 29.3%.

9. Monthly group coincidence factors, based on the various diversified demand categories, achieved their greatest values during the 5 coldest months.

10. Based on DD, the coldest month was Jan. which was also the month of greatest use. Average use per sample customer per day was 195.4 KWH (in Jan.) while in Feb., the month of the maximum (diversified) demand, it was 189.5.

11. The correlation coefficient between average daily use and weighted average DD, during the five coldest months, was 0.8968. [The weighting of DD was based on the number of commercial space heating customers in each of the Company's divisions.]

12. The correlation coefficient between daily maximum (diversified) demand and weighted average DD during the five coldest months was 0.8338. The coefficient increased to 0.8641, when weekdays only were considered.

TITLE: SMALL GENERAL SERVICE STUDY

SOURCE: Virginia Electric and Power Co. (Richmond, Va.)

AUTHOR(S): S.E.King & J.A.Ruble (for R.S.Gay)
PREPARED BY AUTHOR(S) AND/OR: V.E.&P.

DATE OF ISSUANCE: 1975-76 Report of LRC/AEIC (Printed 1977)
OTHER IDENTIFIERS: Appendix A, Section 2 (pp L-89 thru L-98); data covers 11/1/74 thru 10/31/75
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with V.E.&P.
TOTAL: [PAGES 10 ;REFERENCES ;GRAPHS 8 ;TABLES 3]*
DOCUMENT CLASSIFICATION(S): 11/14, 46

ABSTRACT: *[The Graphs are grouped into 2 Charts.]

An optimally-allocated stratified random sample of 200 customers was selected from the Company's small general service customers for a load test which started in Aug. 1974, and continued through Oct. 1975. Maximum (non-coincident) demands, for the 12 months ended Dec. 1972, were used as the basis for stratification and for allocation of sample customers to the resulting strata. Half-hour (integrated) total-service KW demands were recorded for each of the sample customers; the recordings were continuous and simultaneous, with magnetic tapes being changed monthly. [Aug. and Jan. received special emphasis in analysis of the data because they contained the times of the service area summer and winter peaks for the last 12 months of the study. April and Oct. were included to represent spring and fall.]

Due to meter malfunctions, indeterminate outages and improper setting of test equipment, the results are for 169 customers in Aug. and 183 customers in Jan.

Since the selected sample was stratified, all of the results presented in this report are weighted results of the strata.

Purposes of Study: to provide statistically reliable data on the total load characteristics of the Company's small general service classification; determining the contributions the various classes of service were making to growing summer peaks; obtaining information about load factors. [This class of service includes industrial and commercial customers who have not contracted for 50 KW or more. The rate schedules for separately metered water heaters, outdoor lights and temporary facilities were excluded from this test.]

Summary of Major Findings:
1. The average total energy use was 2,846 KWH during the summer peak month (Aug. 1975) and 1,859 KWH during the winter peak month (Jan. 1975). The annual average total was 24,566 KWH.

2. The total-service (noncoincident) maximum demands per customer were 12.15 KW (Aug.) and 9.07 KW (Jan.). The annual load factors based on these demands were 23.08% (Aug.) and 30.92% (Jan.).

3. The Aug. maximum total-service (diversified) demand per customer was 7.00 KW, occurring during the half-hour ended 3 P.M. EDT on Monday, 8/4/75; the corresponding annual load factor was 40.06%. The Jan. maximum total-service (diversified) demand per customer was 4.50 KW and occurred on Wednesday, 1/22/75, during the half-hour ending at 10:30 A.M. EST; the corresponding annual load factor was 62.32%.

4. Looking at the load curves for the average weekday, it can be seen that for Aug. the load reaches a peak at 2:30 p.m. (EDT) then decreases for the remainder of the day, except for a small increase at 8:30 p.m. (EDT). In contrast, the Jan. load curve rises to a peak, at 11:30 a.m. (EST), which is 62.7% of the Aug. value and then slowly decreases for the rest of the 24-hour period, except for a small increase at 6 p.m. (EST).

TITLE: LARGE GENERAL SERVICE STUDY

SOURCE: Virginia Electric and Power Co. (Richmond, Va.)

AUTHOR(S): S.E.King & J.A.Ruble (for R.S.Gay)
PREPARED BY AUTHOR(S) AND/OR: V.E.&P.

DATE OF ISSUANCE: 1975-76 Report of LRC/AEIC (Printed 1977)
OTHER IDENTIFIERS: Appendix B, Section 2 (pp L-99 thru L-108); data covers 11/1/74 thru 10/31/75
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with V.E.&P.
TOTAL:[PAGES 10 ;REFERENCES ;GRAPHS 8 ;TABLES 3]*
DOCUMENT CLASSIFICATION(S): 11/14, 46

ABSTRACT: *[The Graphs are grouped into 2 Charts.]

Since nearly all of the large general service customers (who attain a demand of 750 KW) have magnetic-tape billing meters, essentially 100% of these customers could be used for the load survey. Of the large general service customers without magnetic billing meters, an optimally-allocated stratified random sample of 53 customers was selected for a load survey which started in Aug. 1974 and continued through Oct. 1975. Maximum (non-coincident) demands, for the 12 months ended Dec. 1972, were used as the basis for stratification and for allocation of sample customers to the resulting strata. Each of the non-magnetic billing meter sample customers had half-hour integrated total service kilowatt demands recorded continuously and simultaneously on monthly tapes. The magnetic billing meters recorded integrated 15 minute demands, which were later converted to 30 minute demands to allow them to be combined with the data from the test meters. [Aug. and Jan. received special emphasis in analysis of the data because they contained the times of the service area summer and winter peaks for the last 12 months of the study. April and Oct. were included to represent spring and fall.]

Since the selected sample was stratified, all of the results presented in this report are weighted results of the strata.

Purposes of Study: to provide statistically reliable data on the total load characteristics of the Company's large general service classification; determining the contributions the various classes of service were making to growing summer peaks; obtaining information about load factors. [This class of service includes industrial and commercial customers who have contracted for 50 KW or more.]

Summary of Major Findings:
1. The average total energy use was 192,181 KWH during the summer peak month (Aug. 1975) and 146,941 KWH during the winter peak month (Jan. 1975). The annual average use was 1,883,844 KWH.

2. The total service (non-coincident) maximum demands per customer were 418.4 KW (Aug.) and 334.8 KW (Jan.). The annual load factors based on these demands were 51.40% (Aug.) and 64.23% (Jan.).

3. The Aug. maximum total-service (diversified) demand per customer was 354.8 KW, occurring during the half-hour ended 2 P.M. EDT on Tuesday, 8/26/75; the corresponding annual load factor was 60.61%. The Jan. maximum total-service (diversified) demand per customer was 259.6 KW and occurred on Wednesday, 1/22/75, during the half-hour ending at noon EST; the corresponding annual load factor was 82.84%.

4. Looking at the load curves for the average weekday, it can be seen that for Aug. the load reaches a peak at 2:30 p.m. (EDT) then decreases for the remainder of the day. In contrast, the Jan. load curve rises to a peak at 11 a.m. (EST), which is 72.8% of the Aug. value and then slowly decreases for the rest of the 24-hour period, except for a small increase at 5 p.m. (EST).

TITLE: RESIDENTIAL RANGE LOAD STUDY

SOURCE: Cleveland Electric Illuminating Co. (Cleveland, Ohio)

AUTHOR(S): J.Slipko (for C.T.Loshing)
PREPARED BY AUTHOR(S) AND/OR: C.E.I.

DATE OF ISSUANCE: 1966-67 Report of LRC/AEIC (Printed 1968)
OTHER IDENTIFIERS: Appendix E, Section 3 (pp L-188 thru L-205); data covers certain periods during summer 1964 & winter 1964/65
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with C.E.I.
TOTAL: [PAGES 18 ;REFERENCES 1 ;GRAPHS 12 ;TABLES 9] *
DOCUMENT CLASSIFICATION(S): 13/7, 14, 15, 31, 40

ABSTRACT: *[Seven of Tables are unnumbered. Graphs are grouped into 6 Charts.]

The Single-Family Residential Range sample was obtained from C.E.I.'s 1964 Market Research Appliance Saturation Survey. A tally of 1,300 interviewing forms showed 160 customers had an electric range (but no electric dryer) and 200 customers had both an electric range and dryer.

The original test group sampled 40 of the 160 Range-Only and 40 Range-Dryer customers but informational gaps in the original data resulted in final sample sizes ranging from 33 to 36 customers. [Note: The demographic stratifications (economic, geographic, family size) inherent to the Appliance Saturation Survey were applied proportionately to the load study sample.] The original Apartment Range sample was randomly selected from a list of Cleveland apartments. Two practical considerations altered the original random sample: (1) tenant turnover and (2) lack of suitable metering space. Eventually 40 apartments, as near as possible to those originally selected, were metered. After the data were screened, the final sample ranged from 32 to 34 customers.

Range energy use was measured independently with KWH meters. Installation duration for these meters was anywhere from 9 to 15 months. Range loads were metered with magnetic tape recording units. The tapes were changed every four weeks and translated to punched cards by a magnetic tape-to-card translator. Demand was measured on an integrated quarter-hour basis.

Purposes of Study: to investigate the load characteristics of residential ranges as a part of a continuing program of major appliance load research; to discover if annual range use in the C.E.I service area conformed to the EEI average.

Summary of Major Findings:
1. There was a statistically significant difference in mean annual range energy use between Apartment and Single-Family Homes (718 vs 923 KWH,

respectively). [At a 98% confidence level, the chances are only 1 in 50 that these means could be the same.] The 923 value was much less than the EEI average of 1,200 in 1965 and 1,160 in 1966 but there is less than one chance in a hundred that the test mean and the EEI mean could be the same.

2. Within Single-Family Homes there is a significant difference in annual energy use for families of 2 and families of 3 to 5 members.

3. The difference between summer and winter test period energy use per customer day for Single-Family Homes (2.02 and 2.71 KWH, respectively) is statistically significant at a 95% confidence level. The chances are 7 in 10 that Apartment Ranges also have a seasonal energy difference (1.71 KWH-summer, 2.06 KWH-winter).

4. Energy use per meal varies with the type of meal. On average: dinner required 1.1 KWH; lunch, 0.7 KWH; breakfast, 0.5 KWH. [Neither residential classification nor season appeared to affect energy use per meal.]

5. There appears to be a seasonal difference in noncoincident maximum KW demand per customer. For summer the values were 3.51 (apartment) and 3.27 (single-family); for winter they were 3.74 (apartment and 3.97 (single family). [Altho there is a 50-50 chance the actual Apartment Range means are the same for both seasons, there is only a 1 per 100 chance that the means of the Single-Family Homes sample are the same.]

6. Maximum KW diversified demands per customer were as follows: apartments, summer (0.56 at 5:30 p.m. on Tuesday, 8/11/64); apartments, winter (0.57 at 5:15 p.m. on Thursday, 2/18/65); single-family, summer (0.48 at 5:30 p.m. on Friday, 6/5/64); single-family, winter (0.76 at 5:00 p.m. on Thursday, 11/12/64).

7. Average weekday (diversified) demand load curves for both test intervals show distinct breakfast and lunch periods for both Apartments and Single-Family Homes. There is no statistical difference in the largest values of these use periods. However, the largest Apartment breakfast demand (visually) appears to be greater than the largest Apartment lunch demand.

TITLE: RESIDENTIAL CUSTOMER LOAD STUDY: HOMES WITH ELECTRIC RANGES

SOURCE: Baltimore Gas and Electric Co. (Baltimore, Md.)

AUTHOR(S): D.R.Kellenberger (for W.E.Miller)
PREPARED BY AUTHOR(S) AND/OR: B.G.&E.

DATE OF ISSUANCE: 1968-69 Report of LRC/AEIC (Printed 1970)
OTHER IDENTIFIERS: Appendix A, Section 1 (pp L-11 thru L-36); data covers 12 months ended 6/30/66
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with B.G.&E.
TOTAL: [PAGES 26 ;REFERENCES 1 ;GRAPHS 13 ;TABLES 7] *
DOCUMENT CLASSIFICATION(S): 13/7, 8, 14, 19, 40

ABSTRACT: [Six of the Tables are unnumbered; the remaining Table is a composite of 12 monthly "sub-tables". The Graphs are grouped into 8 Charts.]

A representative sample of the Metropolitan Baltimore Area was obtained by selecting 33 random customers from a relatively large population of homes equipped with electric ranges. The 33 test homes used are single-family dwellings, to wit: 14 bungalows, 6 cottages, 4 Cape Cod, 3 row, 3 ranch, 2 farm and 1 split-level. Overall, frame construction predominates. The average home contains about six rooms plus a kitchen and between one and two bathrooms (counting a powder room as one-half bath.)

Information on appliances and connected loads was obtained by detailed premises inspection. Average total-service connected load in the test homes is 28.6 KW, of which 13.5 is associated with the range. For individual customers, connected loads vary from 17.6 to 53.5 KW for total service and from 10.8 to 15.7 KW for the range. The average connected load statistics reveal that the demands and uses (other than for the range) are influenced predominantly by clothes dryers, air conditioners, water heaters, refrigerators, separate food freezers, miscellaneous space heaters, dishwashers and clothes washers.

Magnetic tape recorders - designed for load test use in conjunction with contact equipped watthour meters - were employed for the duration of this study, using a quarter-hour time interval. At each premise, one recorder was attached to a meter measuring the total-service requirements of the home and another to a watthour meter simultaneously measuring the load of the range.

Purposes of Study: to obtain data not previously available for the B.G.&E. service area, so as to provide statistically reliable average load results for ranges for use in engineering, economic and rate studies and for the development of sales estimating guides.

Summary of Major Findings:

1. The annual use of 1,125 KWH for cooking is equivalent to 82 hours of range connected load.

2. Of the average customer's total-service annual requirements, 14% is used for cooking with a monthly use between 11 and 16%.

3. Of the annual cooking requirements, 59% is used on peak (8 am thru 10 pm on weekdays other than holidays).

4. The average Sunday is the maximum range use day in 11 of the 12 months; Sunday, Tuesday and Thursday are equal in July.

5. The maximum diversified cooking demand occurs in either the half-hour ending 5, 5:30 or 6 pm during 11 months; in Nov. it occurs in the half-hour ending at noon on Thanksgiving Day.

6. The average range use per customer is 8% of the average total-service energy use on the day of the B.G.&E.'s system peak (June 28, 84°F mean).

7. At the time of a monthly system peak load, a maximum of 7% of the total-service connected load operates (Nov., 6 pm); coincidently, 5% of the cooking connected load is in use.

8. Cooking maximum diversified demands, measured over a quarter-hour interval, generally are greater (by up to 32.3%) and 1-hour demands are less (by 1.5 to 26.1%) than those measured over the standard half-hour interval.

9. Cooking adds 0.18 KW per customer to the B.G.&E.'s system monthly peak hours, averaged over the 1-year period; this is ≈ 1% of the average range connected load.

10. Annual diversified load factors are 37.8% for total service and 11.6% for the range; the respective annual (noncoincident) load factors are 13.0 and 2.8%. [Note: The range load tends to decrease the residential class annual load factor.]

11. Annual demand factors are 8.6%, total service and 8.2%, range.

TITLE: RESIDENTIAL CUSTOMER LOAD STUDY: HOMES with ELECTRIC RANGES (Joint Study by 3 Western Utilities)

SOURCE: Data from: Arizona Public Service Co.; et al

AUTHOR(S): W.Blumst (Pacific Gas and Electric Co.)
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 1974-75 Report of LRC/AEIC (Printed 1976)
OTHER IDENTIFIERS: Appendix A, Section 2 (pp L-161 thru L-167); data covers 14 months (10/72 to 12/73)
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with LRC

TOTAL: [PAGES 7 ;REFERENCES ;GRAPHS 4 ;TABLES 5] *
DOCUMENT CLASSIFICATION(S): 13/7, 14, 19, 31, 40

ABSTRACT: *[Only one of Tables is formally numbered.]

The 3 participating companies tested a total of 96 units from the electric range owners within their respective territories. The original sample size was 27 for Arizona Public Service, 33 for Pacific Gas and Electric and 36 for Utah Power and Light. The three areas, as defined by the list of participating companies, each provides an adequate number of test units to depict the real characteristics of this appliance. [Note: No attempt was made to establish a random sample among the companies because of the voluntary basis for participation.]

Ranges selected for the test sample were in single family homes; the units tested are electric ranges or the combined load of electric oven and surface units. Load survey recorders were installed to measure, on half-hour intervals, the use and demand characteristics of the electric range.

Purposes of Study: to obtain data on a major residential appliance; to provide current information on electric range energy use and demand characteristics, thus facilitating better planning for energy conservation and load management. [Note: This is a joint cooperative study by the Arizona Public Service + Pacific Gas and Electric + Utah Power and Light companies.]

Summary of Major Findings:
1. Average annual energy use varied from 689 to 786 (averaging 740 KWH); the average monthly energy use varied from 49 KWH in June 1973 to 71 KWH in Jan. 1973. [Note: The annual average energy use by ranges has declined over the past 30 years, according to an analysis of range studies reported by AEIC.]

2. Total-service average annual use is 30,215 KWH for Arizona and 9,393 for Northern California and 12,324 for Utah; the overall annual average energy use being 17,311. [The electric range proportion of the total-service energy use is 2.5% in Arizona, 8.4% in Northern California and

5.6% in Utah.]

3. The annual half-hour maximum (diversified) demand is 0.95 KW for Arizona, 1.01 for Northern California and 0.58 for Utah. An approximate three company average is 0.85, if it is assumed that the individual (diversified) demands occur simultaneously.

4. Annual load factors (based on diversified demands) are 8.9% for Arizona, 8.9 for Northern California and 13.6 for Utah.

5. The average annual total-service load factor is 37.7%.

6. The annual average (noncoincident) half-hour demand is 4.1 KW and the coincidence factor is 20.7%.

7. The average daily load profile (on the day of maximum diversified demand) shows a peak at the half-hour ending 6:00 pm for Arizona and at 5:30 pm for Northern California and Utah. None of the three areas noted a secondary peak, either in the morning or at noon, that was greater than 41.4% of the maximum demand.

TITLE: RELATIONSHIP of MAXIMUM DIVERSIFIED DEMAND TO MONTHLY AVERAGE ENERGY USE PER CUSTOMER for RESIDENTIAL SERVICES OTHER THAN HOUSE HEATING or COOLING
SOURCE: Various Utilities *

AUTHOR(S): LRC's "Residential and Rural Loads Subcommittee"
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 1960-61 Report of LRC/AEIC (Printed 1962)
OTHER IDENTIFIERS: Appendix F, Section 1 (pp L-47 thru L-57); data covers *
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with LRC

TOTAL: [PAGES 11 ; REFERENCES 2 ; GRAPHS 8 ; TABLES 2] **
DOCUMENT CLASSIFICATION(S): 14/7, 17, 27, 33, 40

ABSTRACT: *[This Report is based on data supplied by 7 utility companies located in the northeast portion of USA. Data-taking extended from 1951-1959, altho the individual companies supplied data for only parts of this period.]
**[The Tables are unnumbered. The Graphs are grouped into 5 Charts.]

Diversified demands are integrated for half-hour intervals and are the maximum occurrences reported in their respective test periods. Energy uses are for the months in which these demands were metered. Both demand and energy data are customer-premises measurements and are the averages per customer for test groups each comprising 20 or more customers.

The basic information presented includes a total of 136 maximum diversified demands and the corresponding monthly average energy uses per customer for residential test groups of customers with lighting, miscellaneous applications and various major appliances. [No customers had complete electric heating or cooling.]

Purposes of Study: to initiate what is expected to be a continuing series of interpretations and applications of interest in the general area of load characteristics data.

Summary of Major Findings:
1. Direct proportion (linear) approximations were determined for the maximum diversified demands (KW) per customer vs their monthly average usage (KWH), as functions of their (%) load factors. As an example - covering energy and appliance groups, both winter and summer - if the KWH level is 1000 then the KW value, for the various load factors that follow, is about: 4.6 (30%); 3.4 (40%); 2.7 (50%); 2.3 (60%); 1.9 (70%).

[Note: Preceding values are derived from composite utility data which merely indicate the general trend and dispersion of all data presently available. The characteristics of any one utility may vary substantially from a particular trend line. It is recognized that time of the year and geographical location may affect the relationship.]

2. In a group averaging up to 500 KWH per month per customer, the occurrence of the interpolated maximum diversified demand will be in either the early or late evening; when the average use exceeds this level the indicated maximum diversified demand most likely will occur in the early evening.

3. The average conditions reflected in this presentation can be used as a check of an individual utility's test results but cannot be accepted as a substitute for actual testing.

4. New developments in the use of electricity in the home point up the increasing need for additional extensive load test data, which can be analyzed in much greater detail than was possible in this study, in order to present the maximum information possible for the benefit of the utilities as they face the future increasing demands for electricity.

TITLE: COINCIDENCE FACTOR-LOAD FACTOR RELATIONSHIP of GENERAL SERVICE (Rate GLP) and COMMERCIAL CLASS CUSTOMERS

SOURCE: Public Service Electric and Gas Co. (Newark, N.J.)

AUTHOR(S): P.F.Platt (for G.Clarkson)
PREPARED BY AUTHOR(S) AND/OR: P.S.E.&G.

DATE OF ISSUANCE: 1971-72 Report of LRC/AEIC (Printed 1973)
OTHER IDENTIFIERS: Appendix D, Section 2 (pp L-109 thru L-120); data covers July 1968 + Oct. 1968 + Jan. 1969 + April 1969
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.S.E.&G.
TOTAL: [PAGES 12 ;REFERENCES 2 ;GRAPHS 8 ;TABLES 2] *
DOCUMENT CLASSIFICATION(S): 17/11, 42, 46

ABSTRACT: *[The Graphs are grouped into 2 Charts.]

Separate analyses were made of the coincidence factor - load factor (CF-LF) relationship between: (1) customers previously included in an LRC (1970) Small Commercial and Industrial Customer Load Study and (2) customers included in the present Commercial Customer Electric Load Study.

For each test month, individual customer load factors were calculated and arranged in numerical sequence by ascending order. The monthly KW readings for each customer were converted into a % of the customer's maximum demand. [Note: Converting KW readings into % of maximum demand eliminated the effect of size and restated each customer's load on an equal basis. Therefore, the maximum (diversified) demand expressed as a % is also the coincidence factor expressed as a %.]

Customers were divided into groups of 10 by ascending load factor. The tabulations for 3 consecutive load factor groups of 10 customers were combined to obtain the maximum (diversified) demand and the sum of the (noncoincident) maximum demands for 30 customers. [The coincidence factor is the group maximum (diversified) demand divided by the group (noncoincident) maximum demand.] The load factor for the group of 30 customers is the average of the individual load factors. By continuously advancing to the next higher group of 10 customers and dropping the lowest group of 10, combinations of 3 consecutive load factor groups (of 10 customers) produce additional points indicating the CF-LF relationship for a group of 30.

Purposes of Study: to determine the relationship between group coincidence factors and individual customers' monthly load factors as an aid in studying the effect on load patterns due to changes within this class load, such as the growth of large suburban shopping centers with inherently long hours of operation and almost complete air conditioning. [Note: The CF-LF relationship is also important in the economics of the P.S.E.&G. system, since it provides a comparison of seasonal load trends.]

Summary of Major Findings:

1. The general statement, made in a 1962-63 LRC study [that, "for a large number of customers of equal size, with no artificial restrictions placed on the use of service and with other things being equal, the degree of coincidence of the maximum power requirements of a group of customers changes with a change in their individual load factors"] is confirmed by this study for the seasonal months selected.

2. The curve shape for the warm months, July and Oct., differs from the curve shape for the cold months, Jan. and Apr. This is due primarily to the high concentration of customers with air conditioning, with load factors ranging between 20 and 25% and having a high degree of coincidence.

TITLE: RESIDENTIAL "FROST-FREE" REFRIGERATOR-FREEZERS

SOURCE: Pacific Gas and Electric Co. (San Francisco, Calif.)

AUTHOR(S): R.I.Mendes
PREPARED BY AUTHOR(S) AND/OR: P.G.&E.

DATE OF ISSUANCE: 1965-66 Report of LRC/AEIC (Printed 1967)
OTHER IDENTIFIERS: Appendix D, Section 3 (pp L-170 thru L-173); data covers 1/15 to 7/2 (1965)
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.G.&E.
TOTAL: [PAGES 4 ;REFERENCES ;GRAPHS ;TABLES 2] *
DOCUMENT CLASSIFICATION(S): 18/15, 19

ABSTRACT: *[One of Tables is unnumbered.]

The 14 customers included in these tests were selected from a 1964 list of recent purchasers of "frost-free" refrigerator-freezers. Customers excluded from the testing were those in multi-family units, weekend homes, P.G.&E. employees as well as those which could not provide a convenient and practical metering location for the refrigerator.

Each customer was interviewed by a Market Analyst as to family size and refrigerator-freezer description. The average number of occupants of the homes included in the test sample was 3. The test appliances averaged 10.9 cu. ft. for the refrigerator portion and 3.6 cu. ft. for the freezer portion, with a total connected load of 0.60 KW per unit.

Standard watthour meters in specially designed cases were installed at each of the refrigerator-freezer locations inside the homes. Test meters, together with the total-house meter, were read every 28 days.

Purposes of Study: to determine the energy requirements of this type of appliance, by months, as a means of disclosing its seasonal pattern and its contribution to total house use and to provide a basis of estimating annual energy requirements.

Summary of Major Findings:
1. Energy use for the refrigerator-freezer averaged 695 KWH for the 168-day test period. A seasonal effect was reflected in the test data, with a summer period recording approximately 15% more use than a winter period.
2. Energy use is generally related to family size. Subdividing the sample showed that refrigerator-freezer units used by families averaging 4.4 persons consumed 37% more KWH than those owned by 2-person families.
3. The % that the test appliance contributes (to the total house energy use) varies inversely with the amount of the total house energy requirements. Overall, the tests reflected that 21.7% of the house requirements were attributable to the refrigerator-freezer. [Refrigerator-freezer monthly KWH use ranged from 108 to 124 and, correspondingly, the "total house" use ranged from 627 to 485.]

TITLE: RESIDENTIAL CUSTOMER LOAD STUDY: HOMES WITH FROST-FREE COMBINATION REFRIGERATORS-FREEZERS

SOURCE: Baltimore Gas and Electric Co. (Baltimore, Md.)

AUTHOR(S): S.E.Hargest & J.G.Matey (for W.E.Miller)
PREPARED BY AUTHOR(S) AND/OR: B.G.&E.

DATE OF ISSUANCE: 1966-67 Report of LRC/AEIC (Printed 1968)
OTHER IDENTIFIERS: Appendix F, Section 1 (pp L-95 thru L-114); data covers 12 months ending 11/30/66
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with B.G.&E.
TOTAL: [PAGES 20 ;REFERENCES 2 ;GRAPHS 8 ;TABLES 8] *
DOCUMENT CLASSIFICATION(S): 18/7, 8, 14, 19, 40

ABSTRACT: *[Seven of Tables are unnumbered. Graphs are grouped into 5 Charts.]

Thirty-three homes were randomly selected (from a relatively large population having frost-free, refrigerator-freezer appliances) to obtain a representative geographical cross section of the Metropolitan Baltimore Area.

These homes are single-family dwellings, 19 being row homes and the remainder cottage or ranch-style homes; brick or brick and frame construction predominated. The average home contains about five rooms and a kitchen plus one or two bathrooms (counting a powder room as one-half bath).

The homes had the following major appliance saturations: ranges, 21%; dryers, 6%; separate food freezers, 15%; dishwashers, 27%; clothes washers, 94%; room air conditioners, 24%; central air conditioning, 3%; frost-free refrigerator-freezer combination, 100%. One home has a 52-gallon standard NEMA water heater, 2 have oil, summer-winter, water heating units and 30 have gas-fired water heaters. [Note: 21 of these 33 homes are equipped with central, gas-fired, space heating systems and the remainder are oil heated.]

Magnetic tape recorders - designed for load test use with contact devices attached to watthour meters - were employed in this study, using a quarter-hour time interval. One recorder measured the total-service requirements and one simultaneously measured the load of the frost-free combination refrigerator-freezer. The load survey recorders are provided with 900 feet of tape, which length is sufficient for a 45-day record; however, the practice is to change the recorder tape at approximate monthly intervals.

Purposes of Study: to produce data, not heretofore available for the B.G.&E. service area, in sufficient homes to provide statistically reliable frost-free refrigerator average load results for use in engineer-

ing, economic and rate studies and for the development of sales estimating guides.

Summary of Major Findings:

1. The average refrigerator-freezer tested has a 13.8 cubic feet storage capacity - 10.3 in refrigerator section and 3.5 in freezer section - and used 1724 KWH annually, equivalent to 2872 hours use of the connected load. In each of the monthly periods, the daily refrigeration energy use does not vary appreciably.

2. Of the average customer's total-service annual requirements, 36% is used for refrigeration in these homes; the monthly use varied from 30 to 43%.

3. Of the annual refrigeration energy requirements, 43% are used "on peak" (8 am to 10 pm , on weekdays other than holidays).

4. The average refrigerator-freezer use per customer was 32% of the average total-service energy use on the day of the B.G.&E. system peak (July 14).

5. Refrigeration adds 0.22 KW per customer to the B.G.&E. system monthly peak hours, when averaged over the 1-year period; this is equal to 37% of the connected load of the typical refrigerator-freezer.

6. The maximum diversified refrigeration demand is 52% of the average refrigerator-freezer connected load. Demand factors for the refrigerator-freezer, based on monthly averages, do not exceed the 52% value of June, July and Aug.

7. The daily maximum (diversified) refrigeration demand most frequently occurs between 5 and 7 pm.

8. Refrigeration monthly maximum (diversified) demands, measured over a quarter-hour interval, generally are greater by 3 to 17% and the 1-hour measurements are generally less, by 3 to 8%, than those determined over the standard half-hour interval.

9. Annual diversified load factors are 38.9% for total-service use and 63.5% for refrigeration use; annual noncoincident load factors are 16.0 and 45.8%, respectively. [Note: The refrigerator-freezer load tends to materially raise the residential class annual load factor.]

TITLE: FROST-FREE REFRIGERATOR-FREEZER USE STUDY
(Joint Study by 11 Utilities)

SOURCE: Data from Alabama Power Co.; et al

AUTHOR(S): H.H.Jung (for R.E.Ashburn, Long Island Lighting Co.)
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 1972-73 Report of LRC/AEIC (Printed 1974)
OTHER IDENTIFIERS: Appendix B, Section 3 (pp L-245 thru L-255); data covers 6/2/71 to 6/2/72
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with LRC

TOTAL: [PAGES 11 ;REFERENCES ;GRAPHS 1 ;TABLES 6] *
DOCUMENT CLASSIFICATION(S): 18/7, 12, 30, 49

ABSTRACT: *[Three of Tables are unnumbered.]

Eleven participating companies tested a total of 342 units from recent purchasers of frost-free refrigerator-freezers, within their respective territories. [Note: The national cross section, as defined by the list of participating companies, provides an adequate number of test units to depict the real characteristics of this appliance. No attempt was made to establish a random sample because of the limited number of these new units on the market, at the time, in the defined type and size range. Also, the voluntary basis for company participation made national random selection impossible.]

The units selected for testing were those having the following characteristics: a. a frost-free feature; b. size between 12 and 25 cubic feet; c. either top-mounted or side-by-side freezers, with bottom-mounted units excluded; d. automatic water disposal. [Note: homes having more than one refrigerator-freezer and/or a food freezer were not excluded from the sample.]

Each customer in the sample was contacted for information about the refrigerator-freezer unit and about family characteristics which might affect energy use.

Standard watthour meters were set to record the total KWH use of the unit. Meter readings were obtained each month on a prescheduled basis. The KWH data, along with the average monthly temperature in the utilities' areas, were keypunched for centralized data processing. These readings were processed, along with customer characteristic data, using a computer program developed for this analysis by the Long Island Lighting Company.

Purposes of Study: to determine the energy requirements of frost-free refrigerator-freezer units of the type currently being marketed nationally and the characteristics which affect these requirements. [Note: This is a joint cooperative study by AEIC member companies, from several sections of the nation, who pooled their individual test readings and

characteristics in order to obtain data on how a major appliance contributed to base load. The findings of this energy use study should prove useful in the areas of: (1) customer inquiry regarding energy consumption, (2) load management and (3) energy conservation.]

Summary of Major Findings:

1. The average annual KWH use for all test units for all participating companies was 2,205.

2. The average daily use and 30-day monthly use for all test units was 6.1 and 184 KWH, respectively.

3. The average daily KWH use per cubic foot of refrigerator-freezer total unit capacity was 0.35. [This average varied only by +0.03 and -0.02 throughout the year.]

4. Side-by-side units consumed 11.8% more KWH per cubic foot than those that were top-mounted.

5. An optional feature, available in 27% of the units, was an automatic icemaker. This feature appeared not to have an effect on the KWH use of the side-by-side units but for the top-mounted units the energy use was up 9.1%, or 0.03 KWH/cubic foot.

6. Total refrigerator-freezer capacity has a direct effect on the monthly use, up to the 20-cubic foot size. However, efficiency based on use per cubic foot size has an uneven trend with a noticeable change at 18 to 19 cubic feet.

7. Monthly KWH use and KWH use per cubic foot increased with the size of the freezer compartment. They also increased as the freezer compartment represented a larger proportion of the total capacity.

8. Energy use is much more sensitive to temperature effects in the warmer geographical areas. Because the data used outdoor ambient temperature, it is probable that the energy use correlation is the result of the manner in which temperature affects living habits, rather than the direct effect of ambient temperature on refrigeration requirements.

TITLE: RESIDENTIAL CUSTOMER LOAD STUDY: HOMES WITH ELECTRIC FOOD FREEZERS

SOURCE: Baltimore Gas and Electric Co. (Baltimore, Md.)

AUTHOR(S): I.A.Mitchell (for W.E.Miller)
PREPARED BY AUTHOR(S) AND/OR: B.G.&E.

DATE OF ISSUANCE: 1975-76 Report of LRC/AEIC (Printed 1977)
OTHER IDENTIFIERS: Appendix A, Section 3 (pp L-111 thru L-138); data covers 12 months ended 9/30/74
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with B.G.&E.
TOTAL: [PAGES 28 ;REFERENCES 2 ;GRAPHS 6 ;TABLES 9] *
DOCUMENT CLASSIFICATION(S): 18/8, 14, 40

ABSTRACT: *[One of Tables is unnumbered. Graphs are identified as 5 Charts.]

Twenty-eight single-family homes were selected from a population of approximately 184,900 homes with food freezers. [The 1972 B.G.&E. Appliance Saturation Survey was used as the source for their systematic random selection.] Differences in food freezer load characteristics required that the sample be segmented into 17 homes with manual-defrost and 11 with automatic-defrost models.

Magnetic tape recorders were used in conjunction with (contact-equipped) watthour meters to obtain customer data in quarter-hour intervals. One recorder measured the total-service requirements of the home; another recorder simultaneously measured the load of the food freezer.

Average-customer and certain individual-customer data are included in this report.

Purposes of Study: to obtain data not previously available for this type of customer in the B.G.&E. service area; to provide information for use in engineering, economic and rate studies and in the development of sales estimating guides.

Summary of Major Findings:
1. The average annual use per customer for the automatic-defrost food freezer is 1,810 KWH, equivalent to 1,943 hours use. The corresponding values for manual-defrost models were 1,033 KWH and 2,039 hours.

2. The 1,810 KWH value is 17% of the average customer's total-service energy requirements, with the monthly use varying between 13% and 21%. Similarly, the 1,033 KWH value is 12% of the average customer's total-service energy requirements, with the monthly use varying between 9% and 15%.

3. Of the annual total-service energy requirements of customers with

automatic-defrost freezers, 47% is used "on peak" (8 am to 10 pm inclusive, on weekdays other than holidays); correspondingly, 41% of their food freezer use is "on peak". [The same percentages apply to the average customer with a manual-defrost freezer.]

4. The average daily use is greater in summer than in winter, for both automatic-defrost and manual-defrost models. The monthly % of variation, however, is greater for the automatic-defrost model.

5. The automatic-defrost model adds 0.21 KW per customer to the B.G.&E. system monthly peak hours, when averaged over the 12-month period. The manual-defrost adds 0.13 KW, correspondingly.

6. During the annual peak hour (7/10/74; 4 pm), 28.8% of the automatic-defrost connected load operates, compared to only 23.2% of the manual-defrost load.

7. Automatic-defrost monthly maximum (diversified) demands, measured over a quarter-hour, are greater than those measured over the standard half-hour interval, by 11.1% to 33.3%. One-hour demands are less than half-hour demands, by 6.2% to 14.8%. [For the manual defrost, quarter-hour demands exceed half-hour demands by 11.1% to 38.9%; one-hour demands are less than half-hour demands, by 10.0% to 22.2%.]

8. The annual load factors for the average customer with an automatic-defrost unit are 26.5% for total service and 55.8% for the food freezer, based on maximum diversified demands; 16.1% for total service and 39.7% for the food freezer, based on non coincident maximum demands. The corresponding load factors for the manual-defrost units are 33.6%, 59%, 15% and 31.9%, respectively.

9. The annual demand factors are 39.8% for the automatic-defrost freezer and 39.5% for the manual-defrost model.

10. Both types of freezer loads tend to materially raise the load factor of homes with these appliances.

11. The average storage capacity of the 11 automatic-defrost units is 16.5 cu. ft. The 17 manual-defrost models averaged 14.8 cu. ft.

TITLE: RESIDENTIAL HEAT PUMP LOAD STUDY

SOURCE: Detroit Edison (Detroit, Mich.)

AUTHOR(S): E.H.Scott
PREPARED BY AUTHOR(S) AND/OR: D.E.

DATE OF ISSUANCE: 1958-59 Report of LRC/AEIC (Printed 1960)
OTHER IDENTIFIERS: Appendix A, Section 3 (pp L-83 thru L-91); data covers 5/1/58 - 5/1/59
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with D.E.

TOTAL: [PAGES 9 ;REFERENCES ;GRAPHS 6 ;TABLES 3] *
DOCUMENT CLASSIFICATION(S): 20/1, 3, 14, 19, 21, 31

ABSTRACT: *[The Graphs are grouped into 2 Charts.]

Energy use by months was obtained for the heat pump and the total load - excluding unmetered use of the lower element of the water heaters - of each of the 9 test customers. Demands of the heat pump load only were metered on a 30-minute integrated basis from 6/1 to 9/15/58 and from 11/1/58 to 4/1/59. Diversified maximum demands and load curves were derived for the average weekday and for the high use and demand days of the coldest and warmest weeks of the test period, as well as for the high demand day of the test period. [For 6 of the 9 customers, meters were installed on the total load-including water heater use - as well as on the heat pump load. Diversified demands and load curves for the average weekday of the coldest week and for the high demand weekday were obtained for their total and heat pump loads.]

Note: The 9 heat pumps appeared to give satisfactory service despite below-normal temperatures during the 1958-59 heating season.

Purposes of Study: to obtain extensive data on 9 heat pump installations; to summarize energy use and demand characteristics as a guide to promotional planning and as a basis for determining service requirements. [These data supplement information on electric resistance heating in the D.E. area, as developed over the past 10 years.]

Summary of Major Findings:
1. Average annual energy use for heating was 23,465 KWH, equivalent to 0.203 KWH per degree-day (DD) per thousand cubic feet of heated space and to 0.050 KWH per DD per 1000 BTU heat loss. Annual energy use for cooling was only 948 KWH per customer; there was no appreciable use at 3 of the test locations. [Since the summer of 1958 had only 3018 dry-bulb degree hours, 44% below the 12-year average of 5341, summer use of the heat pump is probably not indicative of normal cooling requirements.] Total annual use, excluding water heater use billed at a flat rate, averaged 31,942 KWH of which 24,413 was for heating and cooling.

2. Noncoincident maximum demand per heat pump installation was 21.8 KW or 83% of the connected load. [Three of the locations had 2 heat pumps each.] The diversified maximum demand - on the average weekday of the coldest week - was 11.7 KW at 8 a.m. and the highest diversified maximum demand during the winter test period was 16.5 KW at 7:30 a.m. on Monday, 1/5/59, when the temperature dropped to zero°F.

3. The annual load factor of the heat pump was 12.8%, based on noncoincident maximum demand and 16.9%, based on the diversified maximum demand during the period of the test.

4. The annual heat pump use of the 6 all-electric homes was 22,809 KWH of which 22,437 was for heating. [This is about 7% below the average of the complete group but is in line with the smaller size of the 6 all-electric homes and their lower calculated heat loss.]

5. Heat pumps accounted for 57% of the total energy use during the 12-month test period. Of the balance, annual use of the water heaters averaged 9885 KWH. All other residential use was 7295 KWH, or about 2.5 times the use of the average residential customer served by D.E.

6. The total load patterns - for the average weekday of the coldest week and for the high demand day of the test period - were dominated by heat pump use. On the average weekday, group maximum demand per customer for the total load reached 11.4 KW at 8 p.m. Heat pump load at that time was 9.2 KW, the peak for the day, and other load (including water heater) was 2.2 KW. The maximum demand of the other load was 3.4 KW at 8:30 p.m. [Lower-element water heater load, which is restricted between 5 and 7:30 p.m. each day, was largely responsible for this peak and for the erratic pattern of the residual load.] On the peak day, 1/5/59, total load reached 17.8 KW at 8 a.m. The maximum demand for the heat pump load on this day was 14.9 KW and for other residential loads, 4.1 KW.

7. The annual load factor of the all-electric homes was 18.3%, based on average noncoincident maximum demand, and 25.6%, based on the diversified maximum demand during the test period. Corresponding load factors for the heat pump load only were 12.9 and 17.5%, respectively.

TITLE: RESIDENTIAL SERVICE DEMANDS of ALL-ELECTRIC HOMES USING AIR-to-AIR HEAT PUMPS for YEAR-ROUND AIR CONDITIONING

SOURCE: Southern California Edison Co. (Rosemead, Calif.)

AUTHOR(S): C.L.Ashley
PREPARED BY AUTHOR(S) AND/OR: S.C.E.

DATE OF ISSUANCE: 1958-59 Report of LRC/AEIC (Printed 1960)
OTHER IDENTIFIERS: Appendix D, Section 3 (pp L-115 thru L-119); data covers 1957
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with S.C.E.

TOTAL: [PAGES 5 ;REFERENCES ;GRAPHS 5 ;TABLES 3] *
DOCUMENT CLASSIFICATION(S): 20/1, 3, 7, 14, 22

ABSTRACT: *[Two of Tables are unnumbered. The Graphs are grouped into 3 Charts.]

The Report covered 19 customers, averaging 1490 sq. ft. of conditioned area per residence. The calculated hourly heat loss per customer was about 49,000 BTU per hour based on indoor/outdoor temperatures of 70/35 degrees F; the calculated hourly heat gain was about 28,000 BTU per hour based on indoor/outdoor temperatures of 75/95 degrees F.

The major electrical appliances in the test homes were: 3 HP heat pump, including 10.4 KW of supplemental resistance heating, 14 KW; range, 10.3 KW; water heater, 3.5 KW; washer/dryer, 5.0 KW.

Heating degree-days per month ranged from 0 to 353, with a total of 1,346 (65 F base) during the test year. Cooling degree-days were only 92 (total, for 75 F base) during the test year.

Purposes of Study: primarily to determine demand and diversity information for the total residential service requirements, rather than for the heat pump component alone.

Summary of Major Findings:
1. The ratio of KWH to KW (of connected loads) has a monthly range from about 28 to 60 for "total service" and from about 16 to 101 for the heat pump only.
2. Energy use per customer (based on 10 homes) averaged 17,912 KWH per year. For the coldest "week" of the heating season (Monday thru Friday) the average was 498 KWH.
3. Diversified maximum demand per customer (average weekday of coldest week) was 6.76 KW for half-hour ending 8:00 a.m.; the value for the day of maximum demand was 8.90 KW, Monday at 7:30 a.m. The noncoincident maximum (10 customers) during the test period was 15.6 KW.
4. The annual load factor, based on diversified maximum demand during the coldest week, was 23%; based on the noncoincident maximum demand it was 13.1%.

TITLE: COMMERCIAL HEAT PUMP LOAD STUDY

SOURCE: Potomac Electric Power Co. (Washington, D.C.)

AUTHOR(S): F.S.Walters
PREPARED BY AUTHOR(S) AND/OR: P.E.P.

DATE OF ISSUANCE: 1962-63 Report of LRC/AEIC (Printed 1964)
OTHER IDENTIFIERS: Appendix C, Section 2 (pp L-111 thru L-122); data covers summer 1961 and winter 1962
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.E.P.

TOTAL: [PAGES 12 ;REFERENCES ;GRAPHS 11 ;TABLES 5] *
DOCUMENT CLASSIFICATION(S): 20/9, 11, 14, 21, 22, 31, 33

ABSTRACT: *[Two of Tables are unnumbered. Graphs are grouped into 4 Charts.]

The installations in the test group include a variety of different kinds of commercial activities. These cases are some of P.E.P.'s initial commercial heat pump users and, in aggregate, reflect the manner of early development of this market. Predominant in the group are the unmanned fully automatic telephone exchanges with a total capacity (for 3 exchanges) of 140 tons. Wholesale establishments, recreation centers, a church, a bank, a country club/ballroom and a small retail store were also monitored.

Summer tests cover from 8/15 thru 9/4/61 and winter tests were conducted from 2/15 thru 2/23/62. Measurements were made with conventional watthour meters and graphic demand recording instruments, arranged to provide data for both total service and the heat pump. Test results for both total service and the heat pump were analyzed for both seasons for 11 customers.

The test group contained a total of 441 tons of heat pump capacity and had an annual energy use for all purposes (including heating) of 3,375,510 KWH. Sizes of heating installations range from 3 to 60 tons of rated capacity.

Purposes of Study: to determine the load characteristics of commercial customers with electric heat pump installations, for summer and winter conditions.

Summary of Major Findings:
1. In terms of total service, peak day and average weekday load curves differed from those of commercial customers who did not use electric heating but did follow the established general pattern to the extent that maximum diversified demand still occurred during the normal hours of business operation - early in the day in winter and late in the day in summer.

2. Considering the heating aspects separately, load variations in heat

pump equipment were surprisingly similar to patterns observed for electric heating in other types of occupancy including residential applications. Diversified demand tends to follow the inverse pattern of the hourly levels of outdoor temperature. [The demand is high during the night and continues in this manner well into daylight, lagging several hours behind temperature changes.]

3. Diversified maximum demand was established consistently during the period 6 to 8 a.m., prior to the beginning of the business day.

4. Because heating service demand is up during the early morning hours (but drops off during the rest of the day) electric heating tends to shift the time of occurrence of the total service demand to an earlier hour than would be experienced without the electric heating load. Despite this shift, the total-service peak demand still occurs during normal business hours. This is an apparent departure from general observations of residential electric heating, where heating is the controlling factor and the total load as well as the heating load tends to peak during the very early morning.

5. Looking at the cooling aspects of the operation separately, heat pumps used for such pruposes in commercial establishments follow the well recognized load patterns of electric air conditioning practice. Peaks are reached during normal business day hours, usually toward the middle or late afternoon. However, demand rises at the beginning of the business day and reaches a "plateau" from about 11 a.m. to 6 p.m.

6. Average "total load" energy use per customer (winter test month) was 34,662 KWH; the corresponding value (for the summer test month) was 25,367 KWH. The respective (winter and summer) heat pump loads averaged 17,595 and 14,238 KWH per month.

7. The noncoincident maximum KW demands per customer, during the winter (w) and summer (s) test months were: total load, 95.6 (w) and 74.0 (s); heat pump load, 58.9 (w) and 35.4 (s).

8. Annual load factors (%), based on diversified maximum demands, were: 49.5, (w) total load; 63.8 (s) total load; 32.5 (w) heat pump load; 53.6 (s) heat pump load.

TITLE: RESIDENTIAL CUSTOMER LOAD STUDY: HOMES WITH ELECTRIC HEAT PUMPS

SOURCE: Baltimore Gas and Electric Co. (Baltimore, Md.)

AUTHOR(S): L.S.Lydard, Jr. (for W.E.Miller)
PREPARED BY AUTHOR(S) AND/OR: B.G.&E.

DATE OF ISSUANCE: 1971-72 Report of LRC/AEIC (Printed 1973)
OTHER IDENTIFIERS: Appendix A, Section 3 (pp L-123 thru L-158); data covers 12 months ending 12/31/69
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with B.G.&E.
TOTAL:[PAGES 36 ;REFERENCES ;GRAPHS 23 ;TABLES 9] *
DOCUMENT CLASSIFICATION(S): 20/1, 8, 14, 19, 22, 40, 49

ABSTRACT: *[Four of Tables are unnumbered. The Graphs are grouped into 10 Charts.]

This study covers a test of the load characteristics of 31 single-family premises equipped with air-to-air electric heat pumps. The customers' heat pump and total-service energy requirements were recorded simultaneously throughout the test year.

The 31 homes were selected from a relatively small population (about 200) of homes with heat pumps; each of these customers selected has a forced air heating-cooling system. The selected units are single-family dwellings; 21 are row homes, 6 are ranch, 2 are cottages, 1 is a colonial 2-story home and 1 is a split-level. The type of construction which predominates in this test group is combination brick and frame. The "average" home contains five rooms, a kitchen and a bathroom.

Magnetic tape recorders (designed for load test use in conjunction with contact-equipped watthour meters) were employed for the duration of this load study, using a quarter-hour time interval. At each premise, one recorder was attached to a meter measuring the total-service requirements and a second was attached to a watthour meter installed to measure the total load of the heat pump, which includes the compressor, supplementary resistance heat and circulating air fan. A third recorder was attached to a watthour meter measuring the combined loads of the supplementary resistance heat and circulating air fan.

Purposes of Study: primarily to obtain electric heat pump data not previously available for the B.G.&E. service area for use in engineering, economic and rate studies and for the development of sales estimating guides.

Summary of Major Findings:
1. The 11,245 KWH used annually by the heat pump (HP) for heating is equivalent to 822 hours use of the heating connected load. On a normalized degree-day (DD) basis these values are 11,721 KWH and 856 hours, respectively. The 11,245 value is comprised of 6,160 (compressor), 4,275

(resistance heating components) and 810 (circulating air fan).

2. The 1,915 KWH used annually by the HP for cooling is equivalent to 384 hours use of the cooling connected load. On a normalized DD basis these values are 1,673 KWH and 336 hours, respectively. The 1,915 value is comprised of 1,604 (compressor) and 311 (circulating air fan).

3. Of the average customer's total-service annual requirement, 47% is used by the HP (for heating) with monthly values varying between 0 and 71%; 8% is used by the HP (for cooling) with monthly values varying between 0 and 43%.

4. Of the annual total-service energy requirement, 42% is used on peak (8 am thru 10 pm, on weekdays other than holidays). By comparison, 34% of the HP (heating) and 49% of the HP (cooling) requirement is used on peak.

5. For an average home with a HP, the annual heating use (on a normalized DD basis) is equivalent to 0.19 KWH/DD/(1000 cubic feet of heated space) or a heat loss of 0.06 KWH/DD/1000 Btu/hour. The comparable figures for cooling are 0.11 KWH/DD/(1000 cubic feet of cooled space) or 0.05 KWH/DD/1000 Btu/hour of nominal cooling capacity.

6. The maximum diversified heating demand occurred between 4:30 and 8:30 am in Jan. thru May and Sept. thru Dec. [The maximum diversified cooling demand occurred between 5 and 8 pm in Apr. thru Oct.]

7. The HP heating use is 69% of the total-service energy use per customer on the day of the Baltimore Contract Load (BCL) "winter" peak (Dec. 22, 35°F mean). Similarly, the HP cooling use is 57% of the total-service energy use per customer on the day of the BCL "summer" (also the annual) peak (July 17, 85°F mean).

8. In the heating months, in the hour of the BCL monthly peak, a maximum of 16.0% of the total-service connected load operates; this occurs at 8 pm on Jan. 6. In these same months, a maximum of 32.0% of the HP (heating) connected load operates in the hour of the monthly BCL peak; this occurred at 8 pm on Mar. 11, at which time 15.8% of the total-service connected load operates. In the cooling months, in the hour of the monthly BCL peak, a maximum of 7.8% of the total-service and 40.5% of the HP (cooling) connected loads operate; these occur at 5 pm on Aug. 25 and at 3 pm on July 17, respectively.

9. HP heating maximum (diversified) demands, measured over a quarter-hour interval, are greater by up to 20% and the 1-hour measured demands are less, by up to 18%, than those measured over the standard half-hour interval. Comparable values for HP cooling are greater than 18% and less than 19%, respectively.

10. Each HP (heating) unit adds 1.50 KW to the BCL monthly peak hours, averaged over the 12-month period, which approximates 11% of the average

heating connected load. Each HP (cooling) unit adds 0.62 KW to the BCL monthly peak hours, averaged over the 12-month period, which approximates 12% of the average cooling connected load.

11. The HP daily heating uses best correlate with DD as a curvilinear relationship. HP daily heating maximum (diversified) half-hour demands best correlate with DD as a linear relationship. HP daily cooling uses (and daily maximum diversified half-hour demands) best correlate with degree-days as linear relationships.

12. HP daily heating and cooling uses best correlate with daily maximum (diversified) demands as a linear relationship.

13. Annual load factors, based on maximum (diversified) half-hour demands, are: 28.2% for total service, 15.9 for HP heating and 7.9 for HP cooling. Comparable annual load factors, based on noncoincident maximum demands, are: 15.6% for total service, 11.0 for heating and 4.7 for cooling.

14. HP heating load tends to decrease and the HP cooling load tends to increase the average test customer's annual load factor.

TITLE: COMMERCIAL SPACE HEATING LOAD STUDY

SOURCE: Pennsylvania Power & Light Co. (Allentown, Pa.)

AUTHOR(S): R.A.Blank (for A.J.Baldwin, Jr.)
PREPARED BY AUTHOR(S) AND/OR: P.P.&L.

DATE OF ISSUANCE: 1971-72 Report of LRC/AEIC (Printed 1973)
OTHER IDENTIFIERS: Appendix B, Section 3 (pp L-159 thru L-170); data covers 10/66 to 9/67
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.P.&L.

TOTAL: [PAGES 12 ; REFERENCES ; GRAPHS 11 ; TABLES 2] *
DOCUMENT CLASSIFICATION(S): 21/9, 11, 14, 19, 35, 38, 41, 46, 49

ABSTRACT: *[Graphs are grouped into 5 Charts.]

Note: Altho the test was continuous from Oct. 1966 thru Sept. 1967, this report is comprised of observations taken only for Oct. thru May.

The customer Class was first stratified by P.P.&L. operating division boundaries in order to recognize the significant variation of weather conditions occurring simultaneously over the service area. A total of 49 test cases were then selected from the stratified groups of a universe of 765 customers. [However, the number for which data is reported varies somewhat from month to month, due to the less than 100% availability of test data.]

Each sample customer was interviewed to determine business class, type of heating system and other pertinent data. The number of customers in each class were: Office (12); Retail store (7); Church (5); Production (5); School (3); Lodging (3); Storage (3); Bank (2); Restaurant (1); Other (8).

The % of total connected load, by type of heating system was: unit ventilator, 27; baseboard, 20; in-duct heater, 20; heat pump, 9; wall units, 8; suspended units, 7; radiant units, 4; electric furnace, 2; hot water units, 2; ceiling cable, 1.

The study is confined to commercial space heating load only, supplied on separate circuitry and billed on a separately metered rate. Since the rate permits it some customers also have air conditioning, water heating and cooling. However, for the purposes of this study, it was assumed that no air conditioning equipment operated during the months reported. Separate meters were installed on the water heating devices in order to delete their demand and energy components. To record the load data, a load survey meter was placed on each customer's space heating service. An additional meter was placed on each water heater served with a space heating load. [Although the minor amount of cooking load is included in the observations made here, its effect can be considered minimal.]

Purposes of Study: providing the load characteristics and the quantities necessary to forecast class loads, estimate transformer loadings, establish marketing objectives and analyze costs.

Summary of Major Findings:

1. [The profile of a commercial space heating load is best described in terms of annual load characteristics.] A summary of characteristics for the entire study follows:

A.	Connected load per customer, KW (avg.)	145.7
B.	Use per customer, KWH (annual avg.)	122,148
C.	Use per KW of connected load, KWH (avg.)	838.4
	Demand per customer, KW	
D.	Annual, max. diversified	73.0
E.	Coldest day, max. diversified	65.7
F.	Noncoincident maximum	77.5
	Load factor, %	
G.	Based on maximum diversified demand	28.7
H.	Based on noncoincident maximum demand	27.0
I.	Coincidence factor, %	94.2
J.	Demand factor, %	50.1 (a)

(a) Ratio of maximum diversified demand to connected load.

2. The level of outside temperature has a direct effect on the magnitude of the demand and energy requirements of the class.
3. The daily load factor of the class improves as the outside temperature declines.
4. Maximum demands for service nearly always occur between 7:30 and 9 a.m.
5. Monthly space heating KWH use, maximum diversified demand and the load factors all increase steadily from Oct. to a peak in Jan. and then decline gradually from Jan. to May. The trend in coincidence factor is similar, except for Nov.

TITLE: GENERAL SERVICE SPACE HEATING LOAD STUDY

SOURCE: Pennsylvania Power & Light Co. (Allentown, Pa.)

AUTHOR(S): J.D.Hosfeld (for A.J.Baldwin, Jr.)
PREPARED BY AUTHOR(S) AND/OR: P.P.&L.

DATE OF ISSUANCE: 1973-74 Report of LRC/AEIC (Printed 1975)
OTHER IDENTIFIERS: Appendix C, Section 2 (pp L-73 thru L-89); data covers 5/69 to 4/70
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.P.&L.
TOTAL: [PAGES 17 ;REFERENCES ;GRAPHS 21 ;TABLES 2] *
DOCUMENT CLASSIFICATION(S): 21/9, 11, 14, 19, 35, 38, 41, 46, 49

ABSTRACT: *[Graphs are grouped into 10 Charts.]

The all-electric customers in the "universe" were arranged according to geographical location, within predetermined business groups. All customers were numbered consecutively and 77 potential test customers were picked, using a table of random numbers; several samples were then selected using different sets of random digits and the one yielding the most diversified sample (as to business-type breakdown) was selected. [Customers (similar in terms of business activity, demand and use) were selected as alternates to the primary selection.]

Business group allocation for the 77 test customers was as follows: Commercial Residences (19); Retail Stores, other than food (11); Retail Stores, food (7); Offices and Public Buildings (11); Schools (8); Restaurants and Taverns (6); Churches (2); Industrial Locations (8); Miscellaneous (5).

Most test locations fell in the 1000-2500 square-foot range altho individual buildings ranged from 100 to 375,500 square feet. Most "sample" customers had hot air or baseboard heating systems. The main heating equipment at most locations produced between 100,000 and 500,000 BTU/hour. Approximately 80% of the test customers had some kind of electric cooling equipment; "through the wall" was the most popular type of air conditioning.

Purposes of Study: to obtain data for use in the development of cost determinants and in rate and engineering studies; to forecast class and ultimately, system peak loads; to estimate transformer loading.

Summary of Major Findings:
1. The 30 minute maximum (diversified) demand per customer ranged from 37.6 KW in May to 139.1 in Dec., with Dec. and Jan. being appreciably higher than the rest of the months. KWH use followed a similar pattern.

2. The (noncoincident) maximum demand per customer was at its highest value (208.8 KW) in Dec.

3. Monthly load factors, based on maximum (diversified) demand, ranged from 59.2% in Oct. to 76.5% in Dec. [Note: The low-load factor months, Apr. and Oct., reflect low use of air conditioning and/or heating.]

4. Monthly coincidence factors varied from 60.9% in May to 90.6 in Jan.

5. The daily load factor improves in the winter, as the outside temperature declines.

6. The outside temperature is most influential in determining the demand and energy requirements of the class during the winter months. For each degree decrease of daily average temperature, there are corresponding increases of 1.2 KW and 26.8 KWH. [Note: The heating season experienced during the test period was 10.5% colder than a normal heating season.]

7. There is some similarity between summer and winter load profile curves for the days of monthly maximum (diversified) demand, although the winter demand occurs between 9 and 11 a.m. and the summer between noon and 2 p.m. The winter maximum diversified demand occurs in Dec.; the summer in Aug. [The winter demand is 2.28 times that for the summer.]

8. Total KWH use during the month of the winter (class) maximum was about 2.5 times that for the summer month maximum.

TITLE: ELECTRIC HOUSE HEATING *

SOURCE: Various Utilities **

AUTHOR(S): C.W.Bary, et al; "Special Subcommittee on Electric House Heating"
PREPARED BY AUTHOR(S) AND/OR: LRC/AEIC

DATE OF ISSUANCE: 1955-56 Report of LRC/AEIC (Printed 1957)
OTHER IDENTIFIERS: Pages L-1 thru L-31; data covers various periods (some as long as 12 months) between Sept. 1951 and Sept. 1955
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with LRC

TOTAL:[PAGES 31 ;REFERENCES 4 ;GRAPHS 72 ;TABLES 2] ***
DOCUMENT CLASSIFICATION(S): 22/14, 15, 33, 49

ABSTRACT: *[This report is identified as the Special Subcommittees' fourth report, with the earlier reports mainly cited for comparison with updated data. Note: a limited amount of 1951-52 gas house heating data (for Philadelphia) is included.]

**[Located in Baltimore, Cleveland, Detroit, Milwaukee, Philadelphia and St. Louis.]

***[The Graphs are grouped into 10 Charts.]

Purposes of Study: to assemble 4 sets of data on house-heating load characteristics stemming from various electric utility studies, as follows:
(A) Conventional information relating to annual use, demands, load factors, coincidence factors and daily load curves as based on tests of radiant-panel heating systems by 3 utilities and of heat-pump heating systems by a single utility.
(B) Two types of empirical relationships for the electric house-heating load; one relates to the daily mean temperatures vs diversified maximum demands and to energy uses, as derived from tests of 5 utilities, and the other relating to hourly temperatures vs diversified demands, as compiled from tests of 2 utilities.
(C) Conventional information and empirical relationships relating to gas house-heating load characteristics, from comprehensive tests recently conducted by one (electric) utility company which corroborate the results of tests on electric house heating.
(D) Illustration of the application of the empirical data on hourly demands (derived from gas house-heating tests) to develop equivalent electric data and a comparison of the derived results with actual electric load data.

Summary of Major Findings:
1. The annual diversified load factors of the 4 test groups of electric house-heating (EHH) customers range from 18.2 to 23.0 % and the annual noncoincident load factors range from 13.3 to 18.5%. [These values are similar to those developed in earlier tests in the same geographical areas and are comparable to the load factors determined in tests covered

by earlier reports.] In the geographic regions reflected by the tests the annual EHH load factor for a normal heating season can be expected to be about 20% on the basis of group coincident demands, and about 15% on the basis of noncoincident demands.

2. The annual KWH energy uses per degree-day (DD) per 1,000 cu. ft. of heated space for the 3 groups with radiant panels were: 0.333 for Baltimore, 0.258 for Detroit and 0.193 for Milwaukee.

3. The value of 0.217 for the annual energy use per DD per 1,000 cu. ft. of heated space (for the group using heat pumps) is similar to the value of 0.207 shown in a 1952-53 LRC Report for a similar group.

4. The observed relationships of daily diversified maximum demands (and of daily energy use) to daily DD indicate that both of these load characteristics can generally be expected to increase proportionally with increase in the daily temperature deficiency. The empirical relationships between hourly diversified demands and hourly temperatures are linear for most hours of the day - with the night hours at a lower level than the daytime hours - reflecting the effects of customers' habits in maintaining lower temperatures at night; around the morning peak hours, the nature of the trend is more complex and the levels of demands are higher than for other periods of the day.

5. Indications are that the basic house-heating load characteristics for groups of residential customers are generally independent of the type of utility service used for the supply of heat, reflecting (principally) the changes in outdoor temperatures, the amount of heat required and the composite of the individual customer's habits regarding the maintenance of indoor temperatures during the day and night hours. [An exception is heating systems which may employ heat storage.]

6. The use of empirical data derived from gas house-heating tests (for developing the probable characteristics of the electric house-heating load) provides results which can be of considerable value where actual electric test data are not available. [Care should be exercised in making use of these empirical relationships, especially if they are applied to areas which differ from the basic (gas) test area with respect to customers' habits regarding thermostat settings or with respect to any of the factors, other than outdoor temperature that affect the magnitude and character of house-heating requirements.]

7. Electric radiant-panel heating systems are generally controlled by a number of zone or individual room thermostats and gas central heating systems are usually controlled by a single thermostat but this difference in temperature control method appears in the majority of tests to have little, if any, effect on the level of the annual diversified load factor and the shapes of the daily load curves. This is evidenced by a comparison of the results of the electric radiant-panel heating tests with those of gas central-heating system tests.

TITLE: HOUSE HEATING LOADS *

SOURCE: Various Utilities **

AUTHOR(S): W.E.Miller, et al; "Special Subcommittee on Electric House Heating"
PREPARED BY AUTHOR(S) AND/OR: LRC/AEIC

DATE OF ISSUANCE: 1957-58 Report of LRC/AEIC (Printed 1959)
OTHER IDENTIFIERS: Section 3 (pp L-97 thru L-118); data covers varying time periods ranging up to 2 years, during 1953-1958.
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with LRC

TOTAL: [PAGES 22 ;REFERENCES 3 ;GRAPHS 9 ;TABLES 7] ***
DOCUMENT CLASSIFICATION(S): 22/3, 4, 12, 14, 17, 20, 33, 40

ABSTRACT: *[This Report references four prior LRC reports, covering the same general area of electric heating, but is essentially an independent study.]

**[A) Resistance heating in Conn., Ill., Ind., Mich., N.Y., Pa., and Wisc. B) Air-to-air heat pumps in Conn., Dist. of Col., Kan., Md., Mich., Mo., Ore., Pa., Tex. and West Va.. C) Combination installations in N. Car. and Va.]

***[The Graphs are grouped into 4 Charts.]

The use of electricity for space heating has increased steadily. In many areas, the rapid growth of the air-cooling load has focused attention on residential electric house heating as a possible means of partially balancing the cooling load.

Although heat pumps, at the time of this Report, constituted less than 10% of the total electric heating installations in service, with about two-thirds of them located in homes, their number increased by over 80% during 1957. [The newer "air-to-air" units have been generally accepted and their use promoted by utilities in the southern USA.]

This report includes resistance heating system test results for each of 3 groups of 20, 17 and 11 customers and for one individual case. Data also are given for 5 groups of customers with heat pump systems (16, 15, 15, 5 and 3 customers each) and for 5 single installations. The results of tests of the total service loads of 29 and 21 customer groups of all-electric resistance-heated homes are also presented. Heat pump and total service load data for a group of 5 all-electric homes, with heat pumps, and total service load data for a group of 19 all-electric homes, with heat pumps, are included. In addition, limited load characteristic data are given for a group of 4 heat pumps located in Southwest USA, where it was found that no supplementary resistance heaters are required, as well as for a group of 4 resistance-heated all-electric homes in western Pennsylvania where such supplementation is needed.

In the Report are data relating to the load characteristics of various resistance heating systems as tested in 4 different localities. Such data include annual energy use, demands, annual load factors, coincidence factors and ratios of KWH use and maximum diversified demands to rated capacities. Some of the physical factors affecting the test cases - such as heated house volume, design heat losses, thermostat operation and temperatures - are shown. [Similar conventional information is given for heat pumps tested in 8 somewhat widely separated areas of the USA.]

Purposes of Study: to present selected general information, as has been made available to the Subcommittee, for several groups of customers having resistance heating systems and for others having air-to-air heat pumps; to disclose similar data for various groups of all electric homes equipped with radiant-panel heating, ceiling cables and with heat pumps. [Note: The Subcommittee recognizes the accelerating interest in electric heating and believes that the "preliminary" information should be presented to encourage more testing, particularly of larger groups, since more data is needed to assure statistically stable results for average customer conditions.]

Summary of Major Findings:

1. In about one-half of the 49 resistance-heated homes, the customers lower the thermostat settings for overnight operation (night "set-back"). Under this condition, the average ratio of noncoincident maximum demand to rated heating capacity for the 4 groups is about 0.83. The maximum diversified demand per customer for each test group occurred between 7 and 9 a.m. and, for the 4 groups, averaged about 66% of the rated capacity.

2. For the 18 heat pump installations (for which thermostat operation data are available) only 2 customers materially lower their thermostat settings at night. The average ratio of noncoincident maximum demand to rated capacity for the 18 cases is about 0.85. The maximum diversified demand in one group occurred at 7:15 a.m. and in another, of equal weight, at 10:30 p.m. [Other reported maximum demand occurrences indicate no specific pattern as to timing.]

3. The cooling portion is a relatively small part of the total annual energy use of the heat pump, varying from somewhat more than 1 to less than 23% for the test periods.

4. Normal annual heating energy use, per KW of rated capacity, varies from 1094 to 1317 KWH for resistance heating systems; similar ratios for the heat pump vary from 633 to 1263,with the weighted average being 867 KWH or 28% lower than for the resistance systems.

5. Energy use per degree-day per 1000 cubic feet of heated space (sometimes called the "heat factor") averages 0.194 for the heat pump or 29% less than the similar ratio for resistance-type equipment.

6. Diversified annual load factors vary from 18 to 22% for resistance-

heated systems. [This factor, as available only for 2 heat pump test groups, was 11 and 21%.]

7. Noncoincident annual load factors are 14 to 19% (average 17%) for resistance heating installations and 10 to 20% (average 13%) for heat pumps.

8. The coincidence factor for the heating load ranges from about 0.66 to 0.85 for the average of groups of resistance installations and is about 0.94 for one group of heat pump systems. [In the "heat-pump-only" data, for a group of all-electric homes, a coincidence factor of about 0.93 is indicated.] For the total service demand in all-electric homes, the coincidence factor indicated for 2 groups of resistance-heated homes is about 0.66 and 0.69, compared with about 0.74 and 0.93 for 2 heat pump groups.

9. The maximum diversified demand, expressed as a % of rated capacity, is between 59 and 74 for resistance systems and is 85 for one heat pump group. [In the "heat-pump-only" data of one group of all-electric homes, the value is 75%.] The relationship of noncoincident maximum demand to rated capacity is 73 to 91% (weighted average, 84%) for resistance systems and about 91% weighted, for heat pump systems.

10. For one group of resistance-heated all-electric homes, and for another group of such homes equipped with heat pumps, heating and cooling energy uses approximate two-thirds of the average total annual KWH per customer.

11. The noncoincident annual load factor for the average of the heat pumps tested in Corpus Christi (Texas) is 16%, as compared with a previously reported 22.9% for central air-cooling equipment. A coincidence factor of about 0.54 is indicated for the heat pump group, as compared with about 0.91 previously found for standard central cooling units.

TITLE: RESIDENTIAL ELECTRIC HOUSE HEATING LOADS: COMPARISON of RESISTANCE-TYPE DATA

SOURCE: 17 Groups in: Ill., Ind., Md., Mo., Mich., N.J., N.Y., Ohio, Tenn., Wisc.
AUTHOR(S): R.N.Rau (for C.W.Bary)
PREPARED BY AUTHOR(S) AND/OR: LRC/AEIC

DATE OF ISSUANCE: 1960-61 Report of LRC/AEIC (Printed 1962)
OTHER IDENTIFIERS: Part 1, Section 2 (pp L-61 thru L-84); data covers 1946→1958 *
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with LRC

TOTAL: [PAGES 24 ; REFERENCES 2 ; GRAPHS 9 ; TABLES 4] **
DOCUMENT CLASSIFICATION(S): 22/4, 17, 28, 33, 40, 49

ABSTRACT: *[This Report is based on previously reported LRC data during the years indicated.]

**[The Graphs are grouped into 7 Charts.]

Purposes of Study: to consolidate the mass of existing data on this subject into a single report and to calculate average values for the significant heating characteristics; to develop and discuss the significance of the 5 "basic determinants" of heating characteristics derivable from the reported data, normalizing for differences in the sizes of houses and in the climatological conditions; to discuss the suitability of the reported and derived data for use in appraising the significance of this type of load under future substantial saturation level conditions.

Summary of Major Findings (average characteristics, 1946-58):

	Average of Values for 17 Groups	Group with the Highest Value*	Group with the Lowest Value*
Reported Quantities			
Volume of heated space, cu. ft.	8,695	53%	-33%
Design heat loss, BTU/hour	36,944	31	-62
Normal annual energy use, KWH	13,883	58	-45
Diversified maximum demand ("cold spell"), KW	6.3	52	-27
Basic Determinants			
Measure of heat loss (a)	58.3	43	-41
Measure of heater sizing (b)	0.95	44	-39
Measure of annual energy use (c)	5.07	51	-30
Measure of diversified maximum demand (d)	0.61	84	-33
Measure of annual load factor (e)**	25.5	17	-19

*These are variations from "average of values for 17 groups".
** Since annual load factors have a continuously varying relationship

with annual degree-days, the data of each group were compared with the probable values indicated by a constructed curve of "annual load factor" vs "annual degree-days".

(a) $$\frac{\text{BTU (hourly design value) x 1000}}{\text{°F design differential x cubic feet of heated space}}$$

(b) $$\frac{\text{rated KW capacity}}{\text{calculated KW heat loss}}$$

(c) $$\frac{\text{annual KWH x °F design differential x 1000}}{\text{annual degree-days x BTU (hourly design value) heat loss}}$$

(d) $$\frac{\text{div. max. demand, avg. weekday, normal "coldest spell"}}{\text{calculated KW heat loss}}$$

(e) $$\frac{\text{annual KWH x (100/8760)}}{\text{div. max. demand, avg. weekday, normal "coldest spell"}}$$

TITLE: ELECTRIC RESIDENTIAL HEATING with RESISTANCE UNITS

SOURCE: The Connecticut Light and Power Co. (Berlin, Conn.)

AUTHOR(S): B.P.Dahlstrom
PREPARED BY AUTHOR(S) AND/OR: C.L.&P. (for Northeast Utilities)

DATE OF ISSUANCE: 1961-62 Report of LRC/AEIC (Printed 1963)
OTHER IDENTIFIERS: Appendix A, Part 3 of Section 3 (pp L-195 thru L-204); data covers 1960-61 heating season
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with N.U.

TOTAL:[PAGES 10 ;REFERENCES ;GRAPHS 14 ;TABLES 4] *
DOCUMENT CLASSIFICATION(S): 22/4, 14

ABSTRACT: *[Graphs are grouped into 3 Charts.]

A sample of 15 resistance space heating customers was selected from the approximately 400 in C.L.&P.'s five operating divisions. The selection was made to cover the range of house sizes of annual "full-use customers" served, based on C.L.&P. survey data. [Note: Only 2 of the houses in the study do not meet the "accepted" standards of insulation, i.e. ceiling 6 ", walls 4" and floors 2".]

Recording demand meters (60-minute integrated demand) were installed to record the heating load of each test customer and remained in place over the 1960-61 heating season. The 60-minute interval was used because system peaks are measured for clock-hours, as well as to cut down on electronic data processing time.

Purposes of Study: to determine the load characteristics of the heating load of this type of customer during Dec., Jan. and Feb.

Summary of Major Findings:
1. The group maximum diversified demand of the heating load was about 9.39 KW per customer. It occurred during 8 to 9 a.m., on the coldest weekday of the heating season. On an equally cold Sunday, this demand was 8.81 KW. The maximum diversified demand in Dec. was 8.85 KW at 10 a.m. on the coldest day of the month, which also was the system peak day. During the system peak hour, 5-6 p.m., the demand averaged 8.07 KW.
2. Available data indicate that installed capacity of resistance heating averages 1 KW for each 840 cu. ft. of heated space; the average for the sample is 1 for each 758.
3. The heat factor for the sample of heating customers, KWH per degree-day per 1,000 cu. ft., is about 0.25.
4. The average heating customer used 1,285 KWH per KW of their connected heating load.
5. The individual customers' annual maximum demand averaged 74.5% of the connected heating load.
6. The coincidence factor of resistance heating is high, namely 80.5%.

TITLE: ELECTRIC RESIDENTIAL HEATING

SOURCE: Consumers Power Co.

AUTHOR(S): W.J.Jefferson (for E.Gates)
PREPARED BY AUTHOR(S) AND/OR: Consumers Power Co.

DATE OF ISSUANCE: 1963-64 Report of LRC/AEIC (Printed 1965)
OTHER IDENTIFIERS: Appendix D, Section 3 (pp L-170 thru L-184); data covers 10/1/59 to 9/30/60
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with C.P.C.

TOTAL: [PAGES 15 ;REFERENCES ;GRAPHS 14 ;TABLES 5] *
DOCUMENT CLASSIFICATION(S): 22/7, 8, 14, 19, 49

ABSTRACT: *[One of Tables is unnumbered. The Graphs are grouped into 6 Charts.]

The test group was composed of 35 customers who heat their homes entirely with electricity and who were so distributed over the lower peninsula of Michigan as to represent system-wide conditions. Demand meters were installed on the electric space heating load of each of these customers to record the half-hour integrated KW demands plus KWH use of this load, for the entire test period. In addition, combination watthour indicating demand meters were installed on the total residence load to record the monthly KWH use and the maximum monthly KW demand. Weather data including wind velocities, as well as representative hourly temperatures, were accumulated. [Data for all 12 months of the test period were obtained at 28 of the 35 test locations.]

Each of the 35 customers had an electric range and water heater. The number of the test residences having other selected appliances was: room air conditioner, 4; clothes dryer, 22; freezer, 18; water pump, 24.

The installed heating capacity was 12.9 KW per customer, for an annual demand factor of 76.7%. These figures are for a continually heated area of 1,449 square feet per customer, for upper middle class homes.

Purposes of Study: to obtain and assemble information on electric residential heating loads for rate analysis, future system requirement studies and sales promotion purposes.

Summary of Major Findings:
1. The annual heating energy use (of the 28 customers monitored for the entire 12 months) was 16,525 KWH per customer for 7,056 degree-days (DD, base temperature 65°F). For a "normal" heating year, with 6,832 DD it would be 16,029 KWH.

2. The test period half-hour heating maximum demand was 5.9 KW per customer in Nov. and Jan. and occurred between 7 and 9 a.m. The heating de-

mand at the time of the system peak (10 to 11 a.m. on 1/25/60) was 4.9 KW or 90.7% of the heating maximum demand for that day. The annual heating group load factor was 31.9%; assuming the same group maximum demand, it would be 30.9% for a normal heating year.

3. The individual customers' heating annual maximum demand per customer was 9.9 KW, for the group of 28 customers, for an annual load factor of 18.5% for a normal year and an annual coincidence factor of 59.6%. The highest monthly coincidence factor was 72.0% in Nov.

4. The annual energy use per customer for the total dwelling was 26,828 KWH for the test period or 26,332 KWH for a normal year. The annual maximum demand was 14.3 KW per customer, for an individual customer's load factor of 21.4% for the test year and 20.8% for a normal year.

5. It was found that the heating demand varies inversely with the temperature. Wind velocities were also found to have an effect on the heating demands. The highest wind velocities usually occur during the afternoon hours, the period of warmest temperatures and lowest demand; however, high wind velocities in the early morning hours will increase the peak demand for the day.

TITLE: RESIDENTIAL ELECTRIC SPACE HEATING

SOURCE: Pacific Gas and Electric Co. (San Francisco, Calif.)

AUTHOR(S): W.Blumst (for R.I.Mendes)
PREPARED BY AUTHOR(S) AND/OR: P.G.&E.

DATE OF ISSUANCE: 1966-67 Report of LRC/AEIC (Printed 1968)
OTHER IDENTIFIERS: Appendix F, Section 3 (pp L-206 thru L-230); data covers 9/65 - 8/66
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.G.&E.
TOTAL: [PAGES 25 ;REFERENCES ;GRAPHS 6 ;TABLES 13] *
DOCUMENT CLASSIFICATION(S): 22/8, 14, 19

ABSTRACT: *[Five of Tables are unnumbered. Graphs are identified as 5 Charts.]

A majority of the test homes were heated with resistance-type, baseboard units supplemented by radiant wall or ceiling units. The heating circuits in a representative sample of electrically-heated (resistance-type) single-family dwelling units were measured by recording demand meters in an actual field test.

Sample size in the initial phase of the project totaled 75 homes with electric space heating. However, 8 test installations had to be excluded from the final analysis due to such factors as partial occupancy, poor magnetic tape translation, human errors and test meter failures during the test period.

Purposes of Study: to determine the KW demand and KWH use characteristics of the customers' electric space heating circuits; to obtain the facts on seasonal operating and use characteristics of electric space heating for use in: (1) properly directing selective selling programs; (2) advance planning on distribution systems; (3) analyzing area electric load requirements, engineering standards and rate procedures.

Summary of Major Findings:
1. Annual KWH use for electric space heating in the sample homes averaged 10,269. This use represents 44.6% of the total for all-electric applications in the homes of the sample customers.

2. Monthly KWH use for space heating recorded the highest averages in Dec. (2,295) and Jan. (2,208). These two months account for 43.9% of the annual use for heating.

3. The average connected load for space heating is 12.8 KW and the test customers used 802 KWH per KW of this load.

4. Maximum diversified (simultaneous) KW demand - at the time of the

electric space heating peak demand - averaged 5.4 KW; this peak occurred on Sunday, 1/2/66, at 10 a.m.

5. The daily load curve on an average weekday (during the coldest 5-day period) noted a peak of 4.8 KW at 8 a.m. and a 24-hour average demand of 3.7 KW.

6. Load factors were recorded as 22% on an annual basis and 41% for the 6-month heating season. The monthly load factor was highest in Dec., 58%; the daily load factor reached 76%, on the day of maximum diversified demand.

7. Coincidence factor for the annual test period recorded at an average of 57%. The highest monthly value was 69%, in Mar.

8. The space heating demand factor of about 73% may be interpreted to mean that at no time was more than three-fourths of the space heating connected load in use.

TITLE: RESIDENTIAL ELECTRIC RESISTANCE SPACE HEATING

SOURCE: Philadelphia Electric Co. (Philadelphia, Pa.)

AUTHOR(S): W.F.Sundermeir (for R.C.Williams)
PREPARED BY AUTHOR(S) AND/OR: P.E.

DATE OF ISSUANCE: 1970-71 Report of LRC/AEIC (Printed 1972)
OTHER IDENTIFIERS: Appendix B, Section 3 (pp L-230 thru L-237); data covers 10/69 to 5/70
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.E.

TOTAL:[PAGES 8 ;REFERENCES ;GRAPHS 5 ;TABLES 5] *
DOCUMENT CLASSIFICATION(S): 22/8, 14, 15, 19, 40, 49

ABSTRACT: *[Four of Tables are unnumbered. Graphs are grouped into 3 Charts.]

In June 1966 a residential electric space heating rate was introduced that made it competitive with other conventional heating methods. Since that time there has been a rapid increase in the number of electric heating customers. [In Oct. 1969 there were approximately 5,400 such customers and it is estimated that by 1976, ten years after the introduction of the rate, this number will increase to 60,000.]

The universe of electric space heating customers involved in this Study consisted of the approximately 4,000 residences having electric heating installed after 1/1/67. From this universe, 10 sample groups of 44 customers each were selected at random; these groups were then compared to the universe and the group with the most representative geographic distribution and average energy use was selected for testing. [It should be noted that the same 44 were used for the entire test period.]

The customers in the test sample have the underdescribed characteristics. There were 3 apartments, 5 row houses, 4 semi-detached homes and 32 single houses in the test sample. The average number of rooms (including baths) was 8.3, average members per family was 3.4 and average space to be heated was about 14,600 cubic feet. The heat loss per dwelling averaged about 50,000 Btu/hour, with a connected heating load of 16.1 KW.

The test period extended from 10/15/69 thru 5/15/70 altho the normal heating season in the Philadelphia area is considered to be from Sept. 1 to June 14; however, the period of the test accounts for about 96% of the total degree-days (DD) that can be expected during the heating season. [The heating load of each customer was measured at his distribution panel with 30-minute magnetic-tape demand recorders.]

Purposes of Study: to determine the characteristics of the rapidly expanding residential electric heating load in order to obtain information for system planning, rate making and profitability studies.

Summary of Major Findings:

1. The average energy use per customer for heating for the test period is 17,573 KWH. The DD figure for the test period was 5,223, which is 9.8% above normal. The normal number of DD for an entire heating season (Sept. 1 to June 14) is 4,955; therefore, an average of 16,670 KWH can be expected during a normal heating season.

2. The maximum diversified demands for the coldest weekday and the average weekday of the coldest week are 8.77 and 7.92 KW, respectively; both demands occurring at the half-hour ended 7:30 a.m. The maximum diversified demand for the total test period is 8.83 KW and also occurs at 7:30 a.m.

3. Based on the maximum diversified demand, the load factor for the total test period is 38.9%. The annual load factor, based on a normal heating season, is 21.6%. For Dec. thru Mar., the factor ranges from 59.8 to 64.0%. On the coldest day of the test period the load factor was 91.2%.

4. The coincidence factor for the total test period is 73.5%, with a % range of 68.1 to 78.0 for the four cold months. On the coldest day the factor is 85.3%.

5. The space heating use of individual customers ranged from 3,876 to 35,491 KWH during the seven-month test period.

6. The energy use per DD for the test period is 3.36 KWH. The derived relationship between daily energy use and daily DD indicates that: for each change of one DD, above ten DD, the daily energy use per customer can be expected to change 3.39 KWH; also, for each such change of one DD, the maximum diversified demand per customer can be expected to change 0.148 KW.

TITLE: RESIDENTIAL STUDY of TOTAL-ELECTRIC MOBILE HOMES

SOURCE: Arkansas Power & Light Co./Middle South Services, Inc. (New Orleans, La.)
AUTHOR(S): H.S.Piazza (for J.A.Leo)
PREPARED BY AUTHOR(S) AND/OR: A.P.&L.

DATE OF ISSUANCE: 1972-73 Report of LRC/AEIC (Printed 1974)
OTHER IDENTIFIERS: Appendix D, Section 1 (pp L-134 thru L-144); data covers 12 months ending 9/30/72
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with M.S.S.

TOTAL:[PAGES 11 ;REFERENCES ;GRAPHS 8 ;TABLES 3] *
DOCUMENT CLASSIFICATION(S): 23/7, 8, 14, 22, 39, 44

ABSTRACT: *[One Table is unnumbered. Graphs are grouped into 5 charts.]

The addition of total-electric mobile home customers to the A.P.&L. system has grown steadily. During 1972, 640 homes (or 11.5% of the 5,562 mobile homes connected) were total-electric.

A representative test group of 33 customers was selected from 6 of the Company's 7 geographic divisions. Total-service 15-minute integrated demands were recorded. Data for the customers were collected with magnetic tape load-survey recorders. All of the monthly KW demands and KWH use were taken from the magnetic tape record; customer billing histories were not used. [Note: Because of the difficulty of acquiring full 12-month usable data for every customer and because of certain recorder problems, the number of customers summarized varied monthly. For these reasons the data have been reduced to averages, per customer and per month.]

The homes tested ranged in size from 500 to 1,560 sq. ft. The average family size was 2.4. The average furnace was of 16.5 KW capacity. Appliance "saturation" (for television, ranges, water and space heaters) was 100% or more. Other major appliances had saturations ranging from about 20% for dishwashers to about 70% for refrigerators.

Purposes of Study: to determine the load characteristics of total-electric mobile homes for use in engineering and rate studies.

Summary of Major Findings:
1. The homes used an average of 22,067 KWH during the test period. During the same period, the average residential customer used only 8,017 KWH.

2. Average monthly (mobile home) KWH use varied from 918 in Oct. to 3,018 in Jan. Correspondingly, the average use by residential customers varied from 458 in Nov. to 1,105 in Aug.

3. The maximum noncoincident (15-minute) demand per customer was 18.82

KW and the corresponding monthly load factor was 21.6%, with a range from 7.4% in Oct. to 21.6% in Jan.

4. The maximum diversified (60-minute) demand per customer was 9.81 KW and occurred at 9 a.m. on 1/15/72. The monthly load factor based on this demand was 41.3%, with a range from 33.5% in Dec. to 51.7% in Nov.

5. The relationship between maximum noncoincident demand and average daily use in the peak winter month was found to be: KW=6.43 + 0.278 (KWH).

TITLE: RESIDENTIAL ELECTRIC RESISTANCE HEATING
(Comparison of Super and Standard Insulation)

SOURCE: The Potomac Edison Co. (Hagerstown, Md.)

AUTHOR(S): R.M.Spagnolo (for R.C.Carder)
PREPARED BY AUTHOR(S) AND/OR: P.E.

DATE OF ISSUANCE: 1964-65 Report of LRC/AEIC (Printed 1966)
OTHER IDENTIFIERS: Appendix C, Section 3 (pp L-167 + L-175 thru L-185); data covers 1961 thru 1964
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.E.

TOTAL:[PAGES 12 ;REFERENCES ;GRAPHS 19 ;TABLES] *
DOCUMENT CLASSIFICATION(S): 25/14, 22, 24

ABSTRACT: *[The Graphs are grouped into 5 Charts.]

The majority of homes in this study were of the single-story type with attic space and a full basement but there were 5 split-level homes, one with a split foyer, 5 two-story, 3 were story-and-a-half and one was constructed on a slab. Twc homes had partial basements, 2 had partial basements with enclosed crawl spaces and 4 had enclosed crawl spaces only. Subdividing these test homes shows the following: (a) 26 customers with ceiling cable heating and "super" insulation; (b) 26 customers with baseboard heat and "super" insulation; (c) 23 ceiling cable customers with "standard" insulation; (d) 21 baseboard customers with "standard" insulation.

No attempt was made to analyze each home as to glass exposure, number of occupants, type of construction or exposed surface, except where these elements affected the heat loss calculations.

P.E. installed a watthour meter on the heating load of these homes in order to check energy use estimates, as per their policy. Data from these check meters, together with calculated heat loss and connected heating load, provided the basis for this Report. [Note: Data were obtained from individual homes for periods ranging from one to three years.]

Purposes of Study: to compare electric heating load characteristics, calculated heat loss, connected heating load and annual energy use relationships for homes with super insulation (thickness 10, 4 and 6 inches in ceiling, walls and floors, respectively) and for those with standard insulation (thickness 6, 4 and 3 inches in ceiling, walls and floors, respectively); to compare baseboard heating with ceiling cable heating.

Summary of Major Findings:
1. As the heated volume of a house increases, the connected load and calculated heat loss and annual energy use per unit of volume decrease. [Note: The heated volume for those homes with standard insulation was 4.8% less than for homes with super insulation.]

2. The annual energy use per unit of volume for homes with super insulation was 11.4% less than for homes with standard insulation, although the calculated heat loss was only 5% less. This disparity may be due to the fact that the method for calculating heat loss was not entirely uniform. [Nonetheless, this indicates that appreciable savings may be realized through the use of increased insulation.]

3. Annual energy use per unit of volume for homes with standard insulation increases with an increase in calculated heat loss at a faster rate than it does for homes with super insulation.

4. The connected load per unit of volume for homes with super insulation was 12% less than for homes with standard insulation. However, it was observed that the homes with super insulation had connected loads averaging about 21% more than indicated by the heat loss calculations, whereas the homes with standard insulation had connected loads averaging about 31% more than indicated by the heat loss calculations. [If the same margin of excess capacity had been utilized in both cases, the differences in connected load per unit of volume would have been in the same proportion as indicated by the calculated heat loss.]

5. In comparing homes with ceiling cable and baseboard heating, the size of the sample was not necessarily sufficient to give statistically stable results. [Therefore, it was felt that definite conclusions should not be drawn from this group until after the results have been either confirmed or adjusted on the basis of additional studies.] The following results are summarized as a matter of general interest: (a) The connected heating load exceeded the calculated heat loss by 26% and 36% for homes with baseboard heating as compared to 16% and 26% for homes with ceiling cable, for super and standard insulation, respectively. (b) Annual energy use per unit of volume by homes with super insulation and baseboard heating increases (with an increase in calculated heat loss per unit of volume) at a faster rate than super insulated homes with ceiling cable. (c) Annual energy use per unit of volume by homes with standard insulation and ceiling cable increases (with an increase in calculated heat loss per unit of volume) at a slightly faster rate than standard insulated homes with baseboard heating.

TITLE: NATIONAL SURVEY of RESIDENTIAL LIGHTING LOADS (First Report) *

SOURCE: Various Utilities *

AUTHOR(S): A.F.Rehberg, Chairman of "Specific Loads Subcommittee"
PREPARED BY AUTHOR(S) AND/OR: LRC's S.L.S.

DATE OF ISSUANCE: 1959-60 Report of LRC/AEIC (Printed 1961)
OTHER IDENTIFIERS: Part 4, Section 3 (pp L-153 thru L-182); data covers various 2-week periods in 6/56, 4/57, 12/57, 2/58, 6/58, 7/58, 10/58
DATA USE RESTRICTIONS: "Not to be published or quoted" check with LRC

TOTAL: [PAGES 30 ; REFERENCES 2 ; GRAPHS 14 ; TABLES 34] **
DOCUMENT CLASSIFICATION(S): 27/14, 28, 33

ABSTRACT: *[The Second and Third Reports were printed in 1962 and 1963 and are abstracted elsewhere in this Compilation. This Report is based on data supplied by 22 utility companies thruout the United States.]

**[Graphs are grouped into 2 Charts.]

This is the first time that the LRC has presented a report on the characteristics of the residential lighting load. Previous information on the use of electricity for these loads has always included the use for small appliances, which to some degree obscured the characteristics of the lighting load. This is also the first instance in which planned load tests of any kind were undertaken on a country-wide basis for a particular type of load. Generally, the only data available to the Load Research Committee for analysis have been obtained from tests made by individual companies for their own purposes.

Various relationships between the connected lamp wattage, energy use, demand and other data related to residential lighting load are partially developed in this analysis. It is believed that the results of the study of some of the basic relationships are of sufficient interest and importance to warrant their advance presentation.

Purposes of Study: to obtain a better understanding of the characteristics of the residential lighting load in relation to the wattage of the lamps sold by the manufacturer and the electric energy supplied by the utility company.

Summary of Major Findings:
1. Residential lighting averaged 21.8% of the total annual energy use of the sample customers in this study. The averages for 4 groups of 31 customers - arranged in order of ascending connected lamp wattages - were all near the average value of the total sample. However, when rearranged in order of ascending annual lighting energy use, the averages for lighting for the 4 groups varied between 15.0 and 27.2%. [The annual energy use per customer for lighting was 854 KWH for the total sample.]

2. While lighting has declined from 100 to 22% of the total residential use of electricity since its introduction in 1883, the KWH per customer used for lighting have substantially increased. The increase has been due to the use of more and larger wattage lamps for more hours to provide more adequate lighting in the home. This increased energy use has occurred even though there has been marked improvement in the efficiency of the lamps during this period.

3. The analysis of some of the basic lighting data relate demands to the connected lamp wattage (and to the annual lighting energy use) and indicate a high degree of diversity between the connected lamp wattage and the combined group maximum demands during the maximum lighting load period. The summer demands are substantially less than those in the winter period; this makes residential lighting an attractive load in areas where air cooling in summer is producing class and system peak loads.

4. The annual group load factor for lighting - based on the group average weekday maximum demands - is less than 20%. In comparison, it is known from other tests that the comparable annual group load factor of the residential customers' total load is about 40%.

5. The average lamp size for the total sample, exclusive of Christmas lighting, was 82.6 watts with 30.5 lamps per customer. The average dwelling in the sample housed 3.8 persons in 5.5 rooms. The average connected lamp wattage per square foot of living area was 1.66 watts. It is apparent from the test results that all of these factors have a bearing on the lighting energy use.

TITLE: NATIONAL SURVEY of RESIDENTIAL LIGHTING LOADS (Second Report) *

SOURCE: Various Utilities *

AUTHOR(S): A.F.Rehberg, Chairman of "Specific Loads Subcommittee"
PREPARED BY AUTHOR(S) AND/OR: LRC's S.L.S.

DATE OF ISSUANCE: 1960-61 Report of LRC/AEIC (Printed 1962)
OTHER IDENTIFIERS: Part 5, Section 2 (pp L-105 thru L-155) **; data covers the same time period as for the First Report.
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with LRC

TOTAL:[PAGES 51 ;REFERENCES 1 ;GRAPHS 86 ;TABLES 20] ***
DOCUMENT CLASSIFICATION(S): 27/14, 28, 31, 33

ABSTRACT: *[The First Report was included in the 1959-60 LRC/AEIC Report, which is abstracted elsewhere in this Compilation. This Report is based on data supplied by the same 22 utility companies throughout the United States, which supplied data for Report No. 1.]

**[Note that pp L-105 thru L-114 cover a recapitulation of the results of this Report plus Report No. 1; pages L-115 thru L-155 are concerned with Report No. 2.]

***[Graphs are grouped into 23 Charts, some having up to 7 "curves" plotted on a single "figure". One of Tables is unnumbered.]

The analyses of data were directed toward determining: (1) factors which contribute to the increasing use of electric energy for residential lighting; (2) demand and energy use relationships; (3) shapes of the residential lighting daily load curves; (4) the relationship of the lighting and total residential loads.

While it is obvious that the number (and size) of lamps, family and home size, and seasonal factors would affect the use of electric energy for residential lighting, there has been little information available as to the actual extent of such influence.

The test sample was not selected as being representative of the overall national customer frequency distribution but was selected as a stratified sample in order to study the residential lighting characteristics at several levels of total energy use.

Purposes of Study: to determine and discuss the shapes of the daily load curves for lighting, the relation of lighting to total residential load for the sample customers as well as other relationships that were found to be of interest.

Summary of Major Findings:
1. The "First Report" indicated that the number of persons in the family was important in the use of electric energy for residential lighting;

additional analysis in this Report shows that connected lamp wattage is an equal (or even more important) factor in increasing the use of electric energy. [Note: It is not anticipated that the increase will be directly proportional to the increased lamp wattage but this study suggests that the increase will approach proportionality.]

2. The combination of appliances with lighting load results in a substantial reduction in the group load factors from those obtained with lighting only. Because of its wide seasonal variations from the high winter load, lighting is particularly important in the improvement of the annual load factor in those situations where a substantial use of electric energy for air cooling creates a summer peak.

3. In the "First Report", it was indicated that an average of 21.8% of the total load was used for lighting. It should be noted that 21.8% is the average value derived from the stratified sample customers included in this study, which does not purport to represent the national average. [If the "weighting" of the high-use customers was reduced, the average for the lighting portion of the total load would be somewhat higher than 21.8%.]

TITLE: NATIONAL SURVEY of RESIDENTIAL LIGHTING LOADS (Third Report) *

SOURCE: Various Utilities *

AUTHOR(S): A.F.Rehberg, Chairman of "Specific Loads Subcommittee"
PREPARED BY AUTHOR(S) AND/OR: LRC's S.L.S.

DATE OF ISSUANCE: 1961-62 Report of LRC/AEIC (Printed 1963)
OTHER IDENTIFIERS: Part 1, Section 3 (pp L-147 thru L-182); data covers various months during 1952
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with LRC

TOTAL:[PAGES 36 ;REFERENCES 3 ;GRAPHS 14 ;TABLES 24] **
DOCUMENT CLASSIFICATION(S): 27/14, 28, 33

ABSTRACT: *[The 2 preceding Reports were included in the 1960-61 and 1959-60 Reports of LRC/AEIC, which are abstracted elsewhere in this Compilation. This Report is based on data supplied by 11 utility companies located in Ariz., Conn., Ill., Mich., Mo., N.J., N.Y., Pa. and Tex.] **[The Graphs are grouped into 7 Charts.]

The number and size of lamps used for residential lighting are of greatest interest to the lamp manufacturers, whereas the utility's interest is primarily in the amount of energy used and in the resulting load factors and diversity. Because this is a study of the relighting of residences, it discusses changes made in the number and size of lamps before proceeding with an evaluation of the resulting changes to the customer's load.

Purposes of Study: This Report is devoted primarily to showing the effects of a relighting program by comparing the relationships presented in previous studies (for 124 customers) with those for the sample of 34 customers before and after relighting. [Note: The relighting program generally followed the standards established by the American Home Lighting Institute.]

Summary of Major Findings:
1. The modernization of lighting in the 34 residences (to the American Home Lighting Institute standards) resulted in an increase of 85.3% in the connected lamp wattage, exclusive of Christmas lighting. The total connected lamp wattage, including Christmas lighting, increased 75.6%. These changes were largely the result of the use of a greater number of lamps but there was also more use in the larger sizes of lamps.
2. The increase in connected wattage resulted in a 48.3% increase in the lighting annual KWH, a 41.5% increase in the individual customers' lighting annual maximum demands and an increase of only 28.1% in the group average weekday maximum demand for lighting during the Christmas season. [After relighting, the group load factors in most of the test periods and for the year were improved because of greater diversity.]
3. The lighting annual energy use was 17.7% of the total annual use of these customers and it became 22.0% of the total after relighting.

TITLE: OGIVE CURVES USED in FORECASTING (CLASS) PEAK LOADS

SOURCE: Pennsylvania Power & Light Co. (Allentown, Pa.)

AUTHOR(S): D.L.March; et al (for A.J.Baldwin, Jr.)
PREPARED BY AUTHOR(S) AND/OR: P.P.&L.

DATE OF ISSUANCE: 1973-74 Report of LRC/AEIC (Printed 1975)
OTHER IDENTIFIERS: Appendix A, Section 5 (pp L-131 thru L-142); data covers various periods during 1963-72
DATA USE RESTRICTIONS:

TOTAL: [PAGES 12 ; REFERENCES ; GRAPHS 4 ; TABLES 2]
DOCUMENT CLASSIFICATION(S): 29/33, 36, 43, 46

ABSTRACT:

One of the problems facing a forecaster is how to project (e.g., 5 to 10 years ahead) the number of customers that will fall into each of a load study's strata. The ogive curve is found to be a very convenient and useful tool for this purpose. [An ogive is here defined as a plot or a curve representing a cumulative frequency distribution.] The use of ogives in electric utility work was first developed to determine the effect that a rate change would have on revenue. The curves are plots of the KWH block limit divided by the average KWH per bill of the rate class vs the cumulative KWH total (or cumulative number of bills) at each step, expressed as a % of the rate class total.

Once an ogive curve has been developed that corresponds most closely to the actual distribution of the rate class for one year, this same curve will usually also represent the distribution in future years. Customers may be increasing their load over the years (which may result in increasing the average KWH use of a class) but this does not affect the accuracy of the ogive curves; they are valid for a wide range of average uses. The knowledge of such distributions (especially of future distributions) combined with data obtained in load research can also be of great help in forecasting loads.

By converting the monthly distributions of a rate class into ogives and comparing them on a month-to-month and also on a year-to-year basis, it is found that each month has a different curve. [However, from year to year, each month's curve remains relatively invariant.] For whatever unit is being distributed (either bills, KWH or noncoincident demand), 12 curves can be established for each rate class so as to provide its distribution for any monthly period in the past, present and future.

In constructing ogives, rate classes are separated into those with customers classified by annual or monthly KWH use and those with customers having demand meters and classified by annual or monthly hours use. The method of constructing the ogives and the method of using the distribution data obtained from the ogives to project future loads differs for these two types. The Report discloses these methods in detail.

Using ogive curves in the development of load forecasts provides an opportune method for converting estimates of customers and KWH sales into estimates of class loads. This is particularly true for residential and the small commercial/industrial classes which encompass large numbers of customers. Load research and the load patterns generated by such studies play a major role in this conversion process.

TITLE: PEAK LOAD CONTROL STUDY

SOURCE: Arkansas Power & Light Co./Middle South Services, Inc. (New Orleans, La.)
AUTHOR(S): R.H.Teed, Jr. (for J.A.Leo)
PREPARED BY AUTHOR(S) AND/OR: A.P.&L.

DATE OF ISSUANCE: 1975-76 Report of LRC/AEIC (Printed 1977)
OTHER IDENTIFIERS: Appendix C, Section 3 (pp L-161 thru L-171); data covers 6/15/75 thru 9/15/75
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with M.S.S.

TOTAL: [PAGES 11 ;REFERENCES ;GRAPHS 6 ;TABLES 1]
DOCUMENT CLASSIFICATION(S): 30/1, 14, 36

ABSTRACT:
A "base" (uncontrolled) primary circuit and a "test" (controlled) primary circuit, each with approximately the same number of houses, were selected at the Little Rock Air Force Base and at the Colony West - Sturbridge area of West Little Rock. The four (residential load) circuits were monitored with magnetic tape recording as well as chart meters. The readings from these meters were telemetered by telephone lines to A.P.&L.'s Little Rock Control Center, where similar chart recorders were installed.

Twelve controlled and 12 uncontrolled air conditioners were equipped with individual magnetic tape meters; the 12 controlled residences were also equipped with temperature recorders to monitor inside temperature changes. The outside temperature was continuously monitored and recorded on a chart at the Control Center; this recorder contained a switch which inhibited tone transmission until the temperature reached 85°F.

Radio-control switches were installed on the air conditioning compressor units. Each such switch controlled the operation of the compressor and outside fan motor, but not the inside blower motor. The switches were actuated by tone-coded signals from an encoder and transmitter.

Note: Service to the Little Rock Air Force Base is provided by A.P.&L. at primary voltage. The distribution facilities inside the base are owned, operated and maintained by the Little Rock Air Force Base. Ninety Base residences, served with central heat pumps, were selected on the test circuit for remote control. In the West Little Rock area, 261 residential customers were contacted to determine if they were willing to participate in the test. Of the 261, 218 on the test circuit were qualified and willing to participate in the test.

All tests were conducted on weekdays between June 15 and Sept. 15 and were limited to between 1:00 and 5:00 P.M. Between June 26 and July 23 all controllable air conditioning units on the test circuits were "switched-off" once each hour for a period of 5 to 9 minutes (average

of 7 1/2 minutes), when outside temperatures reached 85°F. The total KW on each of the two test circuits and the corresponding outside temperature was recorded before and after each switching operation; the difference yielded the loads dropped. The load dropped divided by the number of air conditioning units "switched-off" gives an average (coincident) load per unit, for various degrees of temperature and humidity.

Purposes of Study: to determine if part of the air conditioning load could be systematically "switched-off" for short time intervals during peak load periods so as to reduce the peak demand; to investigate whether a controlled method for shifting loads would also provide a means of shedding non-essential loads during critical generation capacity shortages, if they should occur.

Summary of Major Findings:

1. As much as 4.17 KW of (coincident) demand per central air conditioned residence could be dropped during peak load conditions, as experienced during the test period. [The 93°F maximum temperatures during the test period were below normal.]

2. Due to indoor temperature increases, it appears that residential air conditioners cannot be interrupted more than 25% of the time. With this method of control the reduction in hourly demand would be (.25 x 4.17KW).

3. About 79% of the customers (in response to a questionnaire) did not feel house temperature changes after the remote controls were installed.

4. The Company's maximum hourly demands in any recent year occurred during the hottest hours of the day on weekdays during the summer period. This high summer peak is caused primarily by air conditioning and is about 60% higher than the winter peak.]

TITLE: TEMPERATURE ACTIVATED AIR CONDITIONING DEMAND CONTROL

SOURCE: Georgia Power Co./Southern Co. Services, Inc. (Atlanta, Ga.)

AUTHOR(S): R.D.Bauerband & W.W.Hines (for C.B.Grund, Jr.)
PREPARED BY AUTHOR(S) AND/OR: Ga. Power Co.

DATE OF ISSUANCE: 1975-76 Report LRC/AEIC (Printed 1977)
OTHER IDENTIFIERS: Appendix D, Section 3 (pp L-172 thru L-194); data covers 6/75 - 8/75
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with S.C.S.I.
TOTAL:[PAGES 23 ;REFERENCES 1 ;GRAPHS 8 ;TABLES 7] *
DOCUMENT CLASSIFICATION(S): 30/1, 14, 15, 33

ABSTRACT: *[Two of Tables are unnumbered.]

The Air Conditioning Demand Control (ACDC) devices employed an outside thermostat on the residence to activate a motor-driven rotary switch (connected in series with the low voltage system of the central air conditioning unit) so that beyond preset activation levels the compressor would be allowed to run for at most 15 minutes and would then be forced to shut-down for at least 15 minutes following a running period.

The aggregate population was considered to be made up of single family residences in Georgia having electrical central air conditioning. It was established that the statistical accuracy objectives would be attained from a sample of 600; 300 with and 300 without the ACDC device. [For both groups, it was necessary to install a load survey meter.]

The state of Georgia was stratified into 7 geographic regions, according to company division classification, for ease of study as well as for whatever variance reduction might be achieved. The sites allocated to each stratum were evenly and randomly divided into two groups, namely those assigned a load test meter and those assigned a load test meter plus ACDC device. A random sample of residences was obtained for each stratum.

Purposes of Study: to test the effect of an interrupter device (activated by an outside thermostat) on demand, consumption and customer acceptance for residences with central air conditioning.

Specific Objectives:
1. estimation of the average customer demand, as a function of time of day during the period of summer peak demand on the Georgia Power system, for residences with and without the ACDC device;

2. estimation of the difference in the average and total demand between residences with and without the ACDC device, at the time of system peak demand;

3. estimation of the difference in daily energy consumption between

residences with and without the ACDC device for certain selected days, including the system peak day;

4. determining customer acceptance of this type of external control device on central air conditioning;

5. determining incentive tolerance associated with having the ACDC device in a specific home.

Summary of Major Findings:

1. On Mon. (8/25/75), the day of the system peak, the hourly difference in the average demand during the morning hours before 11 a.m. are slight and statistically insignificant. However, by 12 noon, when most of the ACDC devices were activated, the ACDC sites have an average demand significantly less than those without the device; for example at 5 p.m. EDT, the hour of the system peak demand, the difference in the averages is 1.40 KW.

2. On June 18 and Aug. 16 (the selected "hot" days), the estimated reduction at the ACDC sites in average demand (at the hour of maximum demand on the system) was 0.93 and 1.11 KW respectively, which represent 18%, and 21% decreases. On Aug. 25, the peak day, the estimated decrease (as previously noted) was 1.40 KW or 25%. On June 19, the "intermediate" day, the average demand for ACDC sites exceeded that for sites without the ACDC device for all hours except the 3 and 4 p.m. hours. For the "cool" days, July 16 and July 26, the differences in average demand are small and (for most hours) statistically insignificant.

3. When questioned in mid-July, 59% of the customers expressed relatively "high" acceptance of the air conditioner demand control device in their homes while only 6% expressed "low" satisfaction; the median rating was quite favorable. When questioned at the end of Sept., the median rating was about the same; consistent with their July expression, 58% endorsed the device; a few more gave low acceptance ratings (12% as the summer ended vs 6% earlier).

4. In mid-July, the participating customers gave high acceptance to the incentive of $5 per ton of A/C per month. For 275 home interviews, the average rating was 7.2 on a 1-9 "satisfaction scale"; the median of 8.0 indicates very high tolerance for the incentive feature.

TITLE: CUMULATIVE INDEX of SUBJECTS: LOAD RESEARCH COMMITTEE REPORTS

SOURCE: AEIC

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: LRC's General Topics Subcommittee

DATE OF ISSUANCE: 1943-1970 and 1959-1974 *
OTHER IDENTIFIERS:

DATA USE RESTRICTIONS: Printed for AEIC members (but check with AEIC)

TOTAL: [PAGES ;REFERENCES ;GRAPHS ;TABLES] **
DOCUMENT CLASSIFICATION(S): 32

ABSTRACT: *[A supplement was issued, for attachment to the 1943-1970 Index, covering the years 1970-71 and 1971-72.]

**[Not considered pertinent to this form of publication.]

Each year, beginning with the 1943-44 Report, the LRC has submitted and printed detailed studies covering the characteristics of customer and major appliance loads, as well as the technical aspects of load research and analysis. From time to time a cumulative index of these reports has been prepared.

The latest index covers annual Reports from 1959-60 thru 1973-74 and partially supersedes the "Cumulative Index of Subjects, Load Research Committee Reports, 1943-70". [References to reports printed prior to 1959 are omitted from the present cumulative index.] References to special reports are included and identified by the letter "S" following the date of the report.

This index is divided into 5 sections, corresponding to the subcommittee organization and areas of study of the LRC, namely:
(1) Residential and Rural Loads;
(2) Commercial and Industrial Loads;
(3) Specific Loads (air-conditioning including space heating, range, clothes dryer, water heater and other major residential and commercial appliances and applications);
(4) General Topics, including reports of the Steering Subcommittee (organization and procedure, standards for preparing reports, methods of load survey and analysis, customer classifications, power factor, coincidence factor-load factor relationships, weather and other studies related to Load Research and its applications);
(5) Load Forecasting.

[Note: Within each major section the subject matter is indexed alphabetically by main topic heading and, in some cases, by subheadings. References are by report year, with the most recent listed first. The geographical areas covered by each reference are shown.]

TITLE: LOAD RESEARCH SEMINAR
(A collection of papers and technical lecture notes.)

SOURCE: LRC (of AEIC)

AUTHOR(S): J.A.Leo; et al
PREPARED BY AUTHOR(S) AND/OR: LRC

DATE OF ISSUANCE: Various; the most recent listed was Oct. 18 & 19, 1976.
OTHER IDENTIFIERS:

DATA USE RESTRICTIONS: Normally available only to Seminar attendees; check with Chairman of LRC as to current availability
TOTAL:[PAGES 375 ;REFERENCES 22 ;GRAPHS 14 ;TABLES 60] *
DOCUMENT CLASSIFICATION(S): 32/7, 9, 11, 14, 15, 22, 29, 33, 43, 46, 49

ABSTRACT: *[Information of direct and secondary relevance to the subject matter of this Compilation is scattered thruout this rather lengthy collection of "printed" (but unpublished) data. Because of overlaps in subject matter, the Totals are for the entire volume even though same data on Industrial type customers is included.]

The LRC has continuously printed selected reports from both member and nonmember utility companies since 1943-44. In addition, each year since 1946, the Chairman has presented a detailed report to the AEIC Annual Meeting on the activities of the Committee. All of these reports contain the connotation "printed but not published"; this means that although the data are available to member utility companies, no data shall be utilized or published without the consent of the company performing and reporting on the load research project.

If another company's data and results are reapplied, it is emphasized that due care has to be exercised. Precautions are needed since the variations in economic, political, geographical, topographical, customer density, weather or other prime factors might make substantial differences in the results. For example, certain appliances show definite daily patterns when plotted as coincident demands but the level of the demands can differ greatly from utility to utility.

The Introduction to the Load Research Seminar volume states that there are a number of ways in which a company can benefit from a continuing program of load research, namely:
(1) The results can be used as one of the important tools in designing its rate structure.
(2) The company can be guided, in its selective load-building and appliance promotions, by its increased knowledge as to the type of load needed to improve its overall load factor picture.
(3) It can improve its system engineering by having a better knowledge of the types, locations and characteristics of its existing loads and of future loads.

The volume (together with its associated seminars) is intended to answer the questions: What customers should be tested?; What information should be secured?; How should the test be carried out? Suitable modifications can be made in the described procedures to fit individual company situations so that no company need forego the benefits of customer load studies. Even a small company need not assume that analyses of load characteristics would be beyond the possibility of accomplishment with its existing operating personnel.

The knowledge of customer loads characteristics is stated to be a prerequisite in all the important phases of rate making. Thus, special considerations in pricing for water heating, house heating or air conditioning (depending upon whether the company has a winter or summper peak) were all developed from load research on the various major appliances. A detailed knowledge of the characteristics of the major appliances or loads in any class of service - coupled with obtainable appliance saturation values - can be used in the forecasting of future sales. Also, the rising cost of capacity, coupled with the long lead times for installing same, make it essential to be able to more accurately forecast peak loads. Furthermore the forecasting of energy requirements will assume increased importance, considering the current energy situation.

The basic use of load research in marketing is in appliance load testing; to determine diversity, for example. There are many diversities of load involved, namely: within the home, at the distribution transformer, the primary feeder, the substation and (ultimately) at the generating station. The only way that these diversities can be determined is by multiple testing of individual appliances and customers. [A secondary use of such data can be in helping the customers understand the effects of weather on his monthly usage.]

Another vital area in which load research can play a major role is as an aid to engineering, planning and design. Load research can provide management with the necessary knowledge to forecast not only the future, in terms of the kinds and amounts of load growth to be expected on the various parts of a utility system, but also can provide the best way to carry additional load on the existing facilities.

The principal subject areas covered by the seminar notes are: (1) types of testing programs; (2) types of equipment and instrumentation used for load research; (3) procedures and problems in load research sampling; (4) steps in processing data from "field" tapes to data base; (5) compilation and analysis of data; (6) costs of research and the effects of regulatory actions and customer cooperation.

Many tables, graphs and sample calculations - mostly taken from actual situations - are included in this volume to provide illustrations of the points being discussed. The material is for a rather diverse class of customers, ranging from "very large" to "residential". The subject matter is also diverse, including: the comparative load characteristics of customers; domestic service schedules; electric space heating; consumption and demand data for a department store and bank.

TITLE: MANUAL of PROCEDURE for LOAD SURVEYS: SECOND EDITION

SOURCE: AEIC

AUTHOR(S): Special Subcommittee of LRC
PREPARED BY AUTHOR(S) AND/OR: AEIC

DATE OF ISSUANCE: 5/61
OTHER IDENTIFIERS:

DATA USE RESTRICTIONS: Printed, but not published, by order of AEIC; check with AEIC
TOTAL: [PAGES 184 ; REFERENCES 22 ; GRAPHS 4 ; TABLES 23] *
DOCUMENT CLASSIFICATION(S): 33/7, 9, 14, 15, 17, 19, 29, 31, 32, 40, 46

ABSTRACT: *[Most of the Manual deals with material of direct or secondary relevance to the general subject matter of this Compilation. Therefore the Totals are for the entire Manual, with various illustrative data Forms included in the Tables total.]

Customer load characteristics can differ significantly as between Utilities, from year to year or from season to season. [Unfortunately there are no universally applicable or permanent load characteristics for a particular class of service or application.] The expansion of facilities, new appliances and new applications of service create the need for a continuous study of the components comprising system loads.

The manner in which a customer uses electrical energy influences the cost to the serving utility, as much as does the quantity purchased. The demand created, the time of occurrence of maximum demand and the length of the period during which service is supplied, all influence the cost of service. Time is a very important element in the determination of load and coincidence factors, both of which affect cost; these factors affect the loads of individual, groups and classes of customers and are the properties which distinguish (and characterize) types of load or groups of loads.

Load curves (which show the time variation in the load requirements of different classes of service and different major uses), together with associated data (on diversities, maximum demands and the like), find application in the solution of many utility problems. In engineering studies, such data can be used in load forecasting for system planning, in setting limits on the load-carrying capacity of equipment under different conditions of operation and in the determination of losses. In economic studies, these data find use in problems dealing with the rate of return on investments for different classes of service and in determining sales policies for best economic load building results; in rate studies, they serve as guides for development and justification of rates for different classes of service.

Included in the Manual are the steps and processes generally used in making load tests and field surveys, as well as methods for collecting and analyzing the load data which result from such tests and surveys. For those inexperienced in Load Research, a broad understanding of the subject will be gained from a perusal of the entire Manual prior to planning any specific survey or study.

Suitable modifications can be made in the Manual's procedures to fit individual test/survey situations. Even a small Utility need not assume that analyses of load characteristics would be beyond the possibility of accomplishment with normal operating personnel since, in actuality, there will be very few cases where a satisfactory load study cannot be performed with the regular personnel. Because the ramifications of any Load Study involve work details, proper timing, the cooperation of personnel in various departments, and budgetary expense, each phase of the project must be planned with regard to all details. If some seemingly "minor" point should be left out of the outlines of the analysis (as discussed in Chapter 1), that omission might nullify the values which otherwise could be developed from the analysis.

The outlines of specific planning and techniques included in the Manual are based on the actual experience of companies long engaged in load research. The use of similar procedures for collecting and analyzing load characteristics data, as specified in the Manual, is strongly recommended by the LRC since data so obtained will have added value when compared with previously reported Studies which also used the Manual's "guidlines". [Procedures of some specific Utilities will be found in the Manual's appendices.]

TITLE: RESIDENTIAL CUSTOMER LOAD STUDY: MAIN STUDY + SUPPLEMENTARY STUDY of a SIMULATED TEST CONDITION (pp L-66 thru L-71)

SOURCE: Public Service Electric & Gas Co. (Newark, N.J.)

AUTHOR(S): P.F.Platt (for B.P.Dahlstrom)
PREPARED BY AUTHOR(S) AND/OR: P.S.E.&G.

DATE OF ISSUANCE: 1962-63 Report of LRC/AEIC (Printed 1964)
OTHER IDENTIFIERS: Appendix D, Section 1 (pp L-50 thru L-71); data covers winter 1958-59 + summer 1959)
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.S.E.&G.
TOTAL: [**PAGES** 22 ; **REFERENCES** ; **GRAPHS** 71 ; **TABLES** 1] *
DOCUMENT CLASSIFICATION(S): 33/13, 14, 27, 31, 40, 46

ABSTRACT: *[The Graphs are grouped into 14 Charts.]

Accepted procedures of random choice from stratified subdivisions were employed in selecting customers for testing. Therefore, the customers selected for test in each group were representative of all customers within the same use range and the load characteristics of the sample are considered indicative of the system. The sample was divided into 9 groups according to average monthly KWH use, namely: 0-50, 51-100, 101-150, 151-200, 201-400, 401-1000 (2 groups) and over 1000 (2 groups); where 2 groups are indicated one had an electric range and one didn't.

Test equipment was installed on poles in steel boxes whereever possible in order to minimize customer inconvenience. Both chart type meters and magnetic tape, load-survey recorders were used in this study. The winter tests were conducted during Nov. and Dec. 1958 and Jan. 1959. The summer tests were conducted during July, Aug. and Sept. 1959.

Purposes of Study: to provide load characteristics of residential customers, during both winter and summer months, for comparative purposes.

Summary of Major Findings:
1. In each group with the exception of Group 1 (customers using up to 50 KWH per month) there is a definite relationship of demand with temperature during the summer months.

2. The electric range load peaks around 6 p.m., both winter and summer, and shows diversity with the lighting and miscellaneous appliance loads which peak later in the evening. The winter peaks of the 2 groups of customers with electric-ranges exceeded the summer peaks, even though these groups have a high % saturation of comfort cooling appliances.

3. Comparison of winter and summer maximum (diversified) demands per customer indicates that the summer peak load exceeded the winter peak load in 6 of the 9 groups. [Comfort cooling appliances are prime factors in causing these differences in 6 of the 7 groups with no electric

ranges. It is considered significant that the winter peak exceeded the summer peak in the 2 groups having electric ranges even though they had a high % saturation of comfort cooling appliances.]

4. For the largest energy user, no-range, group the maximum diversified demand for the summer period was about 18% greater than for the winter period. For the largest energy user, with-range, group the maximum diversified demand for the winter period was approximately 11% greater than for the summer period. [Both of these groups had high % saturations of both central and room air conditioning.]

5. The demand at constant temperatures is lowest during early morning hours and peaks between 9 and 11 p.m. for groups without electric ranges. An additional peak is noticeable around 6 p.m. for groups with electric ranges, indicating the influence of the cooking load.

6. During the winter test period, demands show little variation with temperature. However, during the summer test period, each group (with the exception of Group 1) shows a definite response to temperature change.

7. During the winter test period, use per customer shows little variation with temperature. During the summer test period, however, each of the 9 groups shows a definite increase in use as the temperature increases; comfort cooling appliances are the major factors responsible for these increases.

In its pages L-66 thru L-71, this Report incorporates a "Supplementary Study of a Simulated Test Condition".

This supplementary study was made to provide load characteristics under a simulated condition wherein only one-third of the test recorders would have been available for testing purposes. It was assumed that, for each of the 9 groups, test equipment would have been installed in the homes of one-third of the customers being tested during each of 3 successive test weeks. These data were processed collectively, for each one-third in its respective group, to permit comparison with the analysis based on data for all customers tested simultaneously.

It was recognized that the results obtained by testing a large number of customers for the entire selected period are nearer to the exact characteristics of the system than are the results from testing a smaller number of test locations for shorter periods, on a rotational basis. However, the latter procedure is acceptable for some studies depending upon the degree of accuracy required. [Note: It was found that a larger sample is desirable when temperatures are a significant factor.]

TITLE: DEMAND CHARACTERISTICS of LARGE ENERGY USE HOUSING PROJECTS

SOURCE: Consolidated Edison Co. of New York, Inc. (New York, N.Y.)

AUTHOR(S): A.F.Rehberg
PREPARED BY AUTHOR(S) AND/OR: C.E. (of) N.Y.

DATE OF ISSUANCE: 1966-67 Report of LRC/AEIC (Printed 1968)
OTHER IDENTIFIERS: Appendix C, Section 1 (pp L-34 thru L-47); data covers year ending Nov. 1963
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with C.E. (of) N.Y.
TOTAL: [PAGES 14 ; REFERENCES 1 ; GRAPHS 19 ; TABLES 1] *
DOCUMENT CLASSIFICATION(S): 34/9, 14, 28, 40, 49

ABSTRACT: *[The Graphs are grouped into 8 Charts.]

[Note: Because of their distinctive resemblance to groups of residential customers, it was believed desirable for the load characteristics of these "master-metered" projects to be considered separately from those of other general service customers.]

The 110 customers consisted of privately and publicly owned housing projects. For the purpose of this study, they were subdivided into two equal groups according to their annual energy use; Group 1 covers from 306,000 to 851,000 KWH and Group 2 from 853,000 to 8,530,000 KWH. [Although there were tests for a few even larger energy use housing customers, they were not included in this study.] In order to further identify this sample, a customer frequency distribution of the two groups in relation to their annual energy use was determined. These distributions vary somewhat from log-normal distributions. The interval for Group 2 annual energy use is 3.6 times that for Group 1. The slope of a Group 2 log-normal curve is about twice that for Group 1.

Purposes of Study: to determine the load characteristics of large energy use housing projects in New York City and Westchester County, for which the cost of electric energy is included in the tenant's rent.

Summary of Major Findings:
1. There was little variation in the average annual use of energy by the tenants in the two groups; use per dwelling unit for Groups 1 and 2 are 3774 and 3721 KWH, respectively, including the "common area" building use.

2. The individual customers' monthly load factors (which ranged from about 43 to 60%) were 5 to 10% higher for Group 2 than for Group 1. The monthly maximum and average (KWH/hour) demands per customer show different seasonal behavior for the two groups; Group 1 customers have a definite monthly maximum demand in the summer and Group 2 customers have a monthly maximum demand in the winter and the monthly average demands have similar seasonal relationships.

3. The coincidence factors for Group 2 are very high, irrespective of the temperature; this is partially the result of the large numbers of dwelling units included in each project. The coincidence factors for Group 1 (with smaller numbers of dwelling units in each project and with more air cooling) increases more rapidly than Group 2 with an increase in outdoor temperature.

4. Outdoor dry-bulb temperatures had little effect on the demands in the winter. However, there is a marked influence shown in the summer test period, particularly on the Group 1 customers' demands; this can be associated with more air cooling for these customers than for those in Group 2.

TITLE: HIGH RISE APARTMENT BUILDINGS with SINGLE METER INSTALLATION: LOAD CHARACTERISTICS STUDY

SOURCE: Public Service Electric and Gas Co. (Newark, N.J.)

AUTHOR(S): P.F.Platt (for G.Clarkson)
PREPARED BY AUTHOR(S) AND/OR: P.S.E.&G.

DATE OF ISSUANCE: 1968-69 Report of LRC/AEIC (Printed 1970)
OTHER IDENTIFIERS: Appendix E, Section 1 (pp L-80 thru L-118); data covers Mar. 1967 thru Feb. 1968
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.S.E.&G.
TOTAL:[PAGES 39 ;REFERENCES ;GRAPHS 56 ;TABLES 6] *
DOCUMENT CLASSIFICATION(S): 34/5, 9, 14, 19

ABSTRACT: *[Three of Tables are unnumbered. Graphs are grouped into 14 Charts.]

A 100% sample of the buildings was obtained. The 152 buildings were investigated to determine if the meter location was suitable for the installation of test equipment and a few locations were rejected, resulting in a test sample of 145. Magnetic-tape load survey recorders were installed to measure 30-minute integrated demands. The tapes were translated to punch cards and acceptable data processed.

Test customers were coded as to: A) Type of apartment building (low-cost, medium cost and luxury) and B) Major appliances (range and air conditioning).

Load data were studied on a monthly basis so as to derive average load curves and related information. Data for the major appliance groups for each type of apartment building were analyzed to provide a comparison of winter and summer load characteristics.

Purposes of Study: to obtain information, for each month of the test year, pertaining to demands and patterns of energy use of high-rise apartment buildings of 6 or more floors and having a single meter. [Note: Knowledge of the characteristics of such total service is necessary: in estimating electric demands; in optimizing the size of transformers and conductors; for continuing rate studies; for the development of cost determinants; to assist in sales promotional efforts.]

Summary of Major Findings:
1. Average annual energy use per building tested is 1,139,905 KWH and per occupied dwelling unis is 5,340 KWH.

2. The annual maximum (diversified) demand is 226.8 KW per building and 1.047 per occupied dwelling unit; this peak occurred in July. The monthly maximum (diversified) demand occurs between 7 and 7:30 p.m. during the winter and between 8 and 10 p.m. during the summer.

3. For all apartments, the load factor based on maximum diversified demand is 57.2% (on an annual basis) and 62.0 to 70.0% (on a monthly basis). Based on noncoincident demand, the load factor (on a monthly basis) was 55 to 65%, for all apartments combined.

4. The monthly (diversified) maximum demand per occupied dwelling unit for "low-cost" apartments shows different seasonal patterns than for "medium-cost" and "luxury" apartments. For low-cost apartments it is higher in the winter, while for the other two, it is higher in the summer. [The noncoincident maximum demand exhibits similar seasonal relationships.]

5. All apartments (as a group) and the medium-cost and luxury groups show a good correlation existing between demand and use per building, on a daily basis.

TITLE: MASTER METERED APARTMENT ELECTRIC LOAD STUDY

SOURCE: Texas Power & Light Co. (Dallas, Texas)

AUTHOR(S): D.Brown (for E.F.Lewis & L.W.Howard)
PREPARED BY AUTHOR(S) AND/OR: T.P.&L.

DATE OF ISSUANCE: 1975-76 Report of LRC/AEIC (Issued 1977)
OTHER IDENTIFIERS: Appendix D, Section 1 (pp L-70 thru L-86); data covers 12 months ending 1/31/75
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with T.P.&L.
TOTAL: [PAGES 17 ;REFERENCES ;GRAPHS 9 ;TABLES 5]
DOCUMENT CLASSIFICATION(S): 34/5, 6, 7, 8, 14, 15, 19

ABSTRACT:

The study covered a test of the load characteristics of 39 master-metered apartment complexes whose annual energy use is between 150,000 and 3,000,000 KWH. Of the 39, 24 have natural gas as the energy source for space and water heating; for the purpose of this report, these 24 were referred to as "non all-electric". The remaining 15 are "all-electric". In order to select a representative sample of test customers, a cumulative-bill frequency table was generated from the billing records of all master metered apartments. From their digital distribution, a graph was drawn. Apartments that qualified were chosen to fit this curve. The customers were then interviewed to determine apartment size, large appliance saturations, number of units and occupancy rate. Survey instrumentation recorded the customer's KWH use during every 15-minute period.

Purposes of Study: to determine various load characteristics of master metered apartment customers, within the area surrounding Dallas served by T.P.&L.; to provide the basis for a statistically accurate base for future estimations of electric demand, cost allocation studies, forecasting of system peak loads and rate studies.

Summary of Major Findings:
1. The average annual energy use per apartment is 10,813 KWH.

2. The non all-electric and all electric units experienced a summer peak between 3 and 7 pm. In the winter months, the non all-electric customers experienced their peak between 6 and 9 pm; the all-electric experienced theirs between 8 am and 12 noon.

3. The monthly group peak for all-electric apartments was 37% larger in the winter than in the summer.

4. The all-electric group peak was on a weekend day (Sunday, Jan. 12, 1975) at 11 am; the minimum temperature was 24°F. [Colder temperatures

on weekdays did not result in a peak.]

5. Both all-electric and non all-electric apartments had their summer group peak between the hours of 5 and 6 pm on July 23, 1974. [This was exactly the same hour the Company had its maximum load.]

6. The summer group peak for the all-electric apartments is 3.26 KW and is 1.80 KW for non all-electric customers. [Note: The air conditioner size is 17% larger in the all-electric apartments and the apartment size is 8% larger.]

7. The annual coincidence factor (at system peak) for non all-electric apartments is about 94.7% but for all-electric apartments it is about 71.2%. [Note: For the test year, CDD were 18% lower than average; HDD were 10 % lower than average.]

TITLE: MUNICIPAL PUMPING STUDY

SOURCE: Detroit Edison (Detroit, Mich.)

AUTHOR(S): R.M.Thomas (for L.E.Brandenburg)
PREPARED BY AUTHOR(S) AND/OR: D.E.

DATE OF ISSUANCE: 1971-72 Report of LRC/AEIC (Printed 1973)
OTHER IDENTIFIERS: Appendix C, Section 3 (pp L-171 thru L-186); data covers June, Aug., Dec. 1971 + Jan. 1972
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with D.E.

TOTAL:[PAGES 16 ;REFERENCES ;GRAPHS 8 ;TABLES 8] *
DOCUMENT CLASSIFICATION(S): 35/14, 19, 31, 35, 41, 46, 49

ABSTRACT: *[Two Tables are unnumbered. Graphs are grouped into 2 Charts.]

The study covers three classes of municipal pumping accounts:
Large Customer-a large integrated system served from 15 primary pumping and 3 secondary pumping locations.
Primary Pumping-high annual usage, with service voltage of 4800 volts or higher.
Secondary Pumping-low annual usage, with service voltage less than 4800 volts; divided into 4 groups by horsepower ratings, namely: 0-50, 51-100, 101-200, over 200.

Magnetic tape demand meters were used, in conjunction with contractor-equipped KWH meters, to obtain demand data for one month each, summer and winter, for all primary pumping customers and for a sample of 33 secondary pumping customers. An assortment of demand meters (magnetic tape, printed tape, punched tape and chart) are permanently installed at the 18 locations serving the large customer and these provided 4 months of demand data for this customer. Survey demand meters were installed on the primary pumping customers in June 1971 and Jan. 1972 and on the secondary pumping customers in Aug. and Dec. 1971. The maximum one-hour demand registered during each survey period is recorded for each test location, as is energy use for the survey period (from 30 to 33 days) and annual use "as billed". For the large customer, energy use is "as billed" and load factors are calculated on the basis of a 730-hour month.

Daily load patterns were developed for each sample group for the day of the monthly system peak only. For the secondary pumping class, the load curves for the system peak days are estimates based on the demand patterns of the 4 horsepower groups, weighted by monthly sales data applicable to each subgroup.

Purposes of Study: to determine the load characteristics of 88 municipal and sewer pumping customers, with emphasis on their contribution to sys-

tem peak day demands and their monthly use and demand characteristics; for use in cost and rate analyses and for system planning.

Summary of Major Findings (Note "limitations", at end of summary):
1. Load factors tend to be lower in summer than in winter, probably due to the amount of booster water pumping and storm pumping accounts. !These factors reflect higher temperatures and greater precipitation in the summer test period.l

2. For the one large customer, summer maximum demands-both diversified and noncoincident-more than double those for winter. Diversified maximum demands for the primary and secondary pumping classes are estimated at 59 and 34% higher, respectively, in summer than in winter, when based on monthly system peak day results.

3. The (%) annual load factor (based on monthly system peak day diversified demands) of the large customer was only 48.6, compared with 62.8 for the primary pumping group and an (estimated) 71.5 for the secondary pumping customers.

4. The individual customer's energy use, demand and load factor varied widely within each pumping group; such variations are traceable, in part, to the type of pumping load, seasonal use patterns and horsepower ratings.

5. During the year ending 1/31/72, the "large" customer used about 225 million KWH, the "primary pumping" usage was about 99 million and the "secondary pumping" usage was about 34 million KWH.

Limitations:
a) Major findings are limited to the scope of the study and to the conditions in existence at the times of the tests.

b) Diversified demands and load curves are for the days of the monthly system maximum demands.

c) The effects of temperature and precipitation are indicated only by the variation in summer and winter usage and demands and in the pattern of the Aug. 10 load curves, on which day a thunderstorm occurred at 1:00 p.m. with rain continuing through the balance of the day.

d) The one large customer and the primary pumping customers include all pumping locations in these classifications. The secondary pumping sample of 33 accounts is from a heterogeneous universe of some 750 small pumping accounts, hence results for this group should be considered as indicative, rather than as representative, of this class.

TITLE: WEATHER-SENSITIVE LOAD FORECASTING MODEL*

SOURCE: Virginia Electric and Power Co. (Richmond, Va.)

AUTHOR(S): S.L.Corpening, Jr. (for R.S.Gay)
PREPARED BY AUTHOR(S) AND/OR: V.E.&P.

DATE OF ISSUANCE: 1971-72 Report of LRC/AEIC (Printed 1973)
OTHER IDENTIFIERS: Appendix D, Section 5 (pp L-213 thru L-220); data covers various time periods of up to 20 years
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with V.E.&P.
TOTAL:[PAGES 8 ;REFERENCES 1 ;GRAPHS 2 ;TABLES 1]
DOCUMENT CLASSIFICATION(S): 36/28, 29, 49

ABSTRACT: *["Complete Sample Calculation" is included.]

The Model discussed in this Report is a tool for the Electric System Planner; use of this tool allows forecasting peak loads with an improved degree of accuracy.

To develop a weather-sensitive model, it is necessary to develop a function that will measure weather severity. Computation of summer weather severity requires accurate knowledge of how electrical load relates to summer weather. This relationship may be expressed by the simple equation: PEAK LOAD = B + (CDF x W); where "B" is the non-weather dependent base load; "CDF" is the cooling demand factor proportional to installed weather-sensitive load and "W" is the weather variable representing conditions at the time of the peak.

The weather variable is the weather function upon which the model is based. [This function will differ for each power system.] The variable for Vepco was developed by regression analysis on past load and weather data. The function contains: dry-bulb temperatures for the present and 3 preceding days, the dew point for the peak hour, sky cover opaqueness, wind speeds and a correction factor based on the nonlinear temperature function. The function is computed for three weather stations and the results are combined to form a system weather variable.

Once an accurate weather variable is developed, and trends in base load and cooling load growth are established, the system peak load can be estimated for any weather conditions desired. With the Model presented in this Report, the Electric System Planner can select a proper load-"weather risk" criteria for capacity planning.

TITLE: CHURCH LOAD STUDY

SOURCE: Duquesne Light (Pittsburg, Pa.)

AUTHOR(S): L.A.Meyer & V.E.Hill
PREPARED BY AUTHOR(S) AND/OR: D.L.

DATE OF ISSUANCE: 1966-67 Report of LRC/AEIC (Printed 1968)
OTHER IDENTIFIERS: Appendix A, Section 2 (pp L-117 thru L-131); data covers certain periods during 10/65 - 7/66
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with D.L.

TOTAL: [PAGES 15 ; REFERENCES ; GRAPHS 14 ; TABLES 5] *
DOCUMENT CLASSIFICATION(S): 38/8, 14, 15

ABSTRACT: *[Graphs were grouped into 4 Charts.]

The churches tested consisted of a random sample of all those having over 5 KW demand, stratified according to denomination. This resulted in testing the following numbers and denominations: 19 Protestant, 8 Roman Catholic, 4 Orthodox Catholic and 6 Jewish; a total of 37.

In each of the test periods (namely 3 week periods in Oct. 1965 + Feb., Apr. and July 1966 and 4 weeks in Dec. 1965) the data for at least one of the Protestant churches was unsatisfactory and was not included in the study. This is also true for one or more periods for the other denominations, except Roman Catholic and accounts for the number of churches being less than 37 in all 5 cases. Because the 6 Synagogues represented a higher % of their subtotal than other test churches were of their subtotals, only one-third of the total synagogue load was added to the church loads. [After this adjustment, the sample is considered to be typical of churches in the Pittsburgh area.]

Churches had sanctuaries with seating capacity ranging from 150 to 1,500 people; many also had other auditoriums and meeting rooms which had combined capacities of from 75 to 1,500 people (not including classrooms). About half had classrooms varying in number from 2 to 28. Most of these rooms were for Sabbath use but several of the churches included classrooms for parochial schools. A few churches also included rectories.

All buildings were heated by gas. Practically every one had one or more kitchens. None had all-electric kitchens, 17 used gas and 7 used both electricity and gas. Only 7 churches had air conditioning (electric) in the church proper or in the auditorium and some of the rectories had air conditioning, usually the window type. One church had electric snow melting in the sidewalks.

Magnetic tape recorders plus watthour meters were installed to record the total load of the church service, including other load such as rectories, convents, schools, etc. Tapes were processed on a Load

Survey Translator and a Printing Card Punch. Listings were made on a High Speed Printer, via a computer which was fed data from the Printing Card Punch output.

Purposes of Study: to obtain the load characteristics of churches for use in rate studies.

Summary of Major Findings:

1. Some individual churches have weekday (noncoincident) maximum demands which approach, and in some cases exceed, the Sunday noncoincident maximum demands but churches in the Pittsburgh area, as a class, create a greater maximum diversified demand on Sundays. The average of the weekday maximum (diversified) demands for the 5 test periods was only 40% of the comparable average Sunday maximum (diversified) demands. [Note: Average weekday energy use was 72% of the Sunday average, indicating higher weekday load factors.]
2. The Sunday maximum (diversified) demand per church was 24.9 KW (Apr., 10:30 a.m.); this demand was quite consistent for each test month, as evidenced by the fact that the average for the 5 test periods was 22.9 KW. [Note: Individual maximum demands varied from about 6 to 190 KW.]
3. The Sunday noncoincident maximum demand per church was 33.0 KW and also occurred in Apr. When compared to the above noted 24.9 KW, a coincidence factor of 75.5% results.
4. The weekdays maximum (diversified) demand per church for Apr. was 11.4 KW, which was 46% of that for Sunday. This weekday maximum occurred during Apr., at 8 and 8:30 p.m.; their average for the five test periods was 9.1 KW, or 80% of the Apr. maximum.
5. The weekday noncoincident maximum demand per church was 28.8 KW (in Apr.) and results in a coincidence factor of 39.6%, when compared to the above noted 11.4 KW. [This % was only slightly more than half of that for Sunday and this shows that, while churches may have a high individual demand during the week, such demands are scattered so much that the weekday maximum is considerably below that for Sunday.]
6. The Saturday maximum (diversified) demand per church was 10.6 KW.
7. Altho most individual church maximum demands occur on Sunday some also occur on other days of the week, including Saturday. Thus, individual Christian Church maximum demands occurred 73% of the time on Sunday but Synagogues experienced maximum demands on Sundays only 41% of the time and only 14% of the Synagogue peaks occurred on Saturdays.
8. Load factors based on the Sunday maximum (diversified) demands were quite uniform and averaged 31.8% for the 5 test periods. Load factors based on weekday maximum (diversified) demands ranged between 52.1 and 62.6% and averaged 58.2%.
9. Test period load factors - based on individual church maximum demands - varied between 3.2 and 43.4%. The average load factor for all churches by test periods, based on individual maximum demands was: Oct., 13.3%; Dec., 15.2%; Feb., 17.0%; Apr., 16.0%; July, 13.6%.

TITLE: "MEDALLION" HOME LOAD STUDY

SOURCE: Pacific Gas and Electric Co. (San Francisco, Calif.)

AUTHOR(S): R.I.Mendes
PREPARED BY AUTHOR(S) AND/OR: P.G.&E.

DATE OF ISSUANCE: 1965-66 Report of LRC/AEIC (Printed 1967)
OTHER IDENTIFIERS: Appendix C, Section 1 (pp L-46 thru L-64); data covers 7/64 thru 6/65
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.G.&E.
TOTAL: [PAGES 19 ;REFERENCES ;GRAPHS 5 ;TABLES 7] *
DOCUMENT CLASSIFICATION(S): 39/8, 14, 17, 19, 22, 24, 31

ABSTRACT: *[Four of Tables are unnumbered.]

The sample group of homes was obtained from a master list of residential electric customers in the San Francisco Bay Area that had been awarded a "Medallion Certificate". From this universe, the test group was selected using random sampling techniques. The 40 "Medallion Homes" comprising the final test sample were made up of 13 "Gold", 3 "Bronze" with electric water heaters and 24 "Bronze" with gas water heaters.

The test metering equipment used to obtain demand data was the magnetic tape load survey recorder. Time and demand data were transferred from the magnetic tape to punched cards by a "translator". Demand data were then summarized in total and in the various subgroups by electronic data processing equipment. [Note: Demand and use data were simultaneously gathered originally for 51 customers. However, 11 of these installations were eliminated from consideration because the data was incomplete due to meter failure, poor magnetic tape translation and other causes.]

Purposes of Study: (1) to aid effective sales promotion and advertising planning; (2) to provide aids in load forecasting; (3) to review the effect on peak demands and load shapes; (4) to develop data applicable in setting engineering standards in the conduct of rate proceedings.

Summary of Major Findings:
1. Average annual energy use in "Gold" Homes was 29,066 KWH and in "Bronze" was 6,912. [Note: All residential customers in the area averaged 4,365 KWH during the comparable 12-month period.]

2. Monthly average use ranged from 4,193 to 1,017 KWH for "Gold" and from 733 to 487 KWH for "Bronze" homes.

3. Maximum diversified demand per customer was 10.42 KW for the "Gold" and 2.98 KW for "Bronze" homes.

4. Daily load curves indicate that during a typical weekday, "Gold" homes reached maximum diversified demands of 8.84 KW during the winter season and 2.19 KW during the summer season. "Bronze" Homes had maximum diversified demands of 2.01 KW in the winter and 1.67 KW in the summer.

5. Load factors (on a monthly basis) were highest in Mar. 1965 for "Gold" homes at 55.8% and averaged 31.8% during the test period. "Bronze" homes load factors peaked at 42.9% in Sept. 1964 and averaged 26.5%.

6. The coincidence of demand was highest during Dec., with the coincidence factor for "Gold" at 64.3% and for "Bronze" at 45.0%. [Note: The homes comprising this load research project are located in areas where air conditioning equipment is generally not installed.]

The standard for a Gold Medallion Home is that electricity shall be the sole source of energy for light, power and heating. [Electric heating has minimum specifications on size and installation, thermostatic controls and thermal insulation.] In addition, these homes conform to the following minimum specifications: (a) An electric range and at least 3 other major appliances, selected from an optional list of 12 appliances; (b) Service entrance equipment of not less than 100 amperes, along with special purpose and general purpose branch circuits as determined by the size of the living area; (c) Some form of fixed electric lighting in all rooms, hallways and entrances.

The standard for a Bronze Medallion Home (in areas where natural gas service is available) is the same as for items A, B and C for a Gold Medallion Home. In these homes natural gas is used for water heating and space heating.

The standard for a Bronze Medallion Home (in areas of electric service only) is the same as above, except that the appliance requirement includes an electric water heater and at least 2 additional major appliances.

TITLE: LOAD SURVEY of ALL-ELECTRIC HOMES

SOURCE: Pennsylvania Power & Light Co. (Allentown, Pa.)

AUTHOR(S): A.J.Baldwin, Jr.
PREPARED BY AUTHOR(S) AND/OR: P.P.&L.

DATE OF ISSUANCE: 1966-67 Report of LRC/AEIC (Printed 1968)
OTHER IDENTIFIERS: Appendix E, Section 1 (pp L-82 thru L-94); data covers 10/63 thru 5/64
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.P.&L.
TOTAL:[PAGES 13 ;REFERENCES 1 ;GRAPHS 24 ;TABLES 2] *
DOCUMENT CLASSIFICATION(S): 39/3, 4, 7, 13, 14, 15, 19, 22, 46, 48, 49

ABSTRACT: *[Graphs are grouped into 5 Charts.]

The original sample on which this survey was based contained 100 all-electric customers, systematically selected from geographically stratified groups. This type of selection was necessary because of the significant variation of weather conditions occurring simultaneously over the service area. To facilitate the stratification, the boundaries of the six operating divisions of the Company were used as the boundaries of each stratum.

Included in the sample were single, multiple and row homes and apartments. Also included were the various designs of electric heating installations: baseboard, ceiling cable, heat pump and electric furnace. Prior to the test each sample customer was interviewed to determine the design of the heating installation and the design of the home, its location and the ages of its occupants. Appliance saturations were also obtained.

To record the load data a load survey meter (utilizing a magnetic tape) was placed on each customer's main service. An additional load survey meter was placed on each customer's heating circuit. The resulting magnetic tape records were then translated into 30-minute integrated demands which were processed and summarized into useful load data with the aid of a Computer System.

Purposes of Study: providing the load characteristics and quantities necessary to forecast class loads, estimate transformer loading and establish price objectives for a class of residential customers using electricity for space heating, water heating and cooking.

Summary of Major Findings:
1. An electric home heating customer is best described in terms of annual load characteristics, as follows:
(a) annual KWH use per customer was 28,570 for "total service" and 17,430 for "heating service only";

(b) annual KW diversified maximum demand per customer was 10.2 for "total" and 8.4 for "heating";
(c) noncoincident maximum KW demand per customer was 18.6 for "total" and 12.7 for "heating";
(d) load factor, based on diversified maximum demand, was 32.0% for "total" and 23.7% for "heating";
(e) load factor, based on noncoincident maximum demand, was 17.6% for "total" and 15.7% for "heating";
(f) coincidence factor was 54.8% for "total" and 66.1% for "heating".

2. It is apparent that the significant segment of the all-electric home energy requirements is the heating load. This load not only contributes heavily to the makeup of the class load characteristics but during the winter months it controls the time of class peaks.

3. The level of outside temperature - via the temperature sensitive heating load - has a direct effect on the class load characteristics. A very good correlation is established between the basic load quantities and outside temperature. Typically, as outside temperature decreases, the daily load factor of the class increases. [An inconsistency to this "axiom" is noticed when the daily load factors for the day of class peak and coldest day of the period are compared; the load factors for peak days were higher and analysis indicates this is indeed logical. Peak days are established during extended periods of relatively cold weather; consecutive cold days and the associated increases in coincidence of customer operation produce the peak day. The influence of a single day of minimum temperature does not contain the cumulative "pressures" of several cold days in a row.]

TITLE: RESIDENTIAL ALL-ELECTRIC HOMES

SOURCE: The Potomac Edison Co. (Hagerstown, Md.)

AUTHOR(S): L.S.Rider, D.B.Slaybaugh & R.M.Spagnolo (for D.W.Eyler)
PREPARED BY AUTHOR(S) AND/OR: P.E.

DATE OF ISSUANCE: 1969-70 Report of LRC/AEIC (Printed 1971)
OTHER IDENTIFIERS: Appendix C, Section 1 (pp L-39 thru L-54); data covers 9/1/67 thru 8/31/68
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.E.

TOTAL:[PAGES 16 ;REFERENCES ;GRAPHS 19 ;TABLES 4] *
DOCUMENT CLASSIFICATION(S): 39/14, 15, 17, 22, 31

ABSTRACT: *[The Graphs are grouped into 6 Charts.]

The total number of electrically heated residences on the P.E. system have increased from 109 in 1958 to 1,691 in 1963 and to 11,919 in 1968, representing 0.08, 1.07 and 6.53%, respectively, of all residential customers.

Thirty-nine houses were selected for testing throughout the P.E. service area on the basis of area saturation of this type of customer. The selection covered a range of conditions (house type, heated area, family size and appliance saturation) in order to best simulate the company's average all-electric residential house customer. During the last two months of the test period, data were available for only 27 and 26 customers, respectively but since the last two months were a part of the non-heating season (and had only about 7 customers less than the average for the first 10 test months) the entire test was considered to be valid.

Thirty-minute demand measurements of the customers' total loads were metered with magnetic tape load survey recorders. Combined 30-minute readings were obtained during data processing, as were the individual customer's maximum demands and energy use.

Purposes of Study: to determine the load characteristics of all-electric homes on an average customer basis, including an average air conditioning saturation of 30%. [Note: this type of load has been increasing at an extremely rapid rate so that it is becoming more important to learn its demand and energy use characteristics.]

Summary of Major Findings:
1. Daily load curves varied with and were dependent upon seasonal temperatures. During mild periods of both summer and winter, they were similar and had peaks of almost equal magnitude occurring in the mid-morning and again in the early evening hours. On hot (summer) days, a sharp peak occurred between the hours of 6 and 7 p.m.; on cold (winter) days this peak became a secondary peak, with a new peak occurring between 7:30 and 8:30 a.m.

2. During the winter months, maximum 30-minute (diversified) demands per customer increased sharply with a decrease in temperature (e.g., from 5.41 KW during the average weekday of the "mild" test week to 9.05 KW on the coldest day). Summer peak demands were much lower and increased less than one KW when comparing the "cool" summer week to the hottest day (1.89 to 2.67 KW); a possible reason for this measured statistic could be the fact that the hottest month was also the only one with no heating degree days (HDD). The 9.05 KW value was the peak for the entire test period and occurred at 8:30 a.m. on Friday, Jan. 12. [It is interesting to note that the temperature at 8 a.m. was -7°F and had been below zero since 1 a.m.]

3. Energy use per customer was similar in characteristic to demands. Annual use was 27,446 KWH. Monthly use ranged from 1,021 KWH in July (the month having the greatest cooling degree-hours) to 4,423 in Jan. (the month having the greatest number of HDD, whereas July was the only month having no HDD).

4. Daily weekday energy use ranged from 31.3 KWH (on the average day of the cool summer week) to 37.6 on the hottest day. The winter ranges were 114.2 (on the average day of the mild winter week) to 183.2 on the coldest day.

5. Load factors, based on maximum 30-minute diversified demands, for the average day of the cool summer week and the hottest day were 69.0 and 58.7%, respectively. Load factors for the corresponding mild winter week and coldest day were 88.0 and 84.3%, respectively. Monthly load factors were also seasonally related, ranging from 43.9 to 49.9% in the hottest months and between 59.3 and 67.1% in the coldest months.

6. Coincidence factors, based on 30-minute demands, ranged from 34.8 to 39.1% in the hottest months and from 54.5 to 62.8% for the coldest months. [All the remaining months, except Mar., fell between the high summer and low winter ranges.]

7. The hourly demand, at the time of the winter system peak, was 88.8% of the customers' maximum hourly demand during the winter test period. The ratio of the hourly demand (at the time of P.E.'s summer system peak) to the customers' maximum summer hourly demand was 67.9%.

TITLE: LOAD STUDIES of RESIDENTIAL ELECTRIC CUSTOMERS *

SOURCE: Various Utilities **

AUTHOR(S): W.E.McFarland, et al; "General Subcommittee on Residential Loads"
PREPARED BY AUTHOR(S) AND/OR: LRC/AEIC

DATE OF ISSUANCE: 1956-57 Report of LRC/AEIC (Printed 1958)
OTHER IDENTIFIERS: Section 1 (pp L-1 thru L-37); data covers various time periods for 1951thru 1956
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with LRC

TOTAL:[PAGES 37 ;REFERENCES ;GRAPHS 69 ;TABLES 13] ***
DOCUMENT CLASSIFICATION(S): 40/7, 14, 27, 28, 31, 33, 46, 49

ABSTRACT: *[The Report includes data from 8 surveys made in 6 major cities.]

**[Located in Dist. of Col., Ill., Mo., N.Y., Ohio and Pa.]

***[Three of Tables are unnumbered. The Graphs are grouped into 15 Charts.]

This report includes results from 8 studies of residential electric loads, the data of which have been made available to the LRC. These 8 surveys, covering customers having a wide range of annual use of energy, are described briefly below.

A survey in Buffalo, N.Y., measured the loads of 6 transformers serving 121 customers and also the individual customers' loads. Transformer groups of customers were combined according to appliance saturation and load characteristics were derived for an average day in each of the months of Dec. 1954 and April and Aug. 1955. [The tests extended over the year ended Aug. 1955.]

Another study was made in Chicago, Ill., utilizing load data obtained by the selected area method of testing. Twenty-five areas, including 1,748 residential customers, were tested during the entire year 1955. The 25 transformers served groups of 20 to 173 customers (average 70).

Two studies were made in Cleveland, Ohio. One was based on data taken from recording meters on individual customers divided into 6 groups by KWH use for the winter of 1951-52; the other covered 5 groups of customers, selected by their major appliances, for tests in the summer of 1953 and the winter of 1953-54.

A survey made in Kansas City, Mo., included tests conducted over the entire year 1956 on 13 high-use customers with air conditioning installations. [The saturation of air conditioning in the area was very high, producing a summer maximum load almost twice that of the winter period.]

One of 2 studies made in Philadelphia, Pa., included 140 individual customers divided into 4 special groups selected from 16 groups comprising 540 sample customers. All data were taken over a nine-week period, during the winter of 1952-53, to determine any significant differences in daily load curve shapes during the test period. The other study presents a comparison of winter 1954-55 and summer 1955 load characteristics of 5 groups of customers (30 to 40 in each group) selected on the basis of annual energy use. Two of these groups have electric ranges and 3 have lighting and miscellaneous loads but no ranges. [Each of the 5 groups included the same customers for both the winter and the summer tests.]

A survey of the entire residential class was made in Washington, D.C. and was based on data from recording meters installed on approximately 350 individual customers for both the winter of 1953-54 and the summer of 1954. The test customers were divided into 11 groups by energy use and were also regrouped into 9 groups by major appliances.

Purposes of Study: to present the results of 8 surveys of residential electrical loads, several of which include information on summer load characteristics not available heretofore. [Note: Because of the different purposes for which these surveys were made and the different methods that were followed in carrying them out, it was not practical to draw general conclusions covering all of them.]

Summary of Major Findings (Buffalo, N.Y.):
Note: It was recognized that the sample was too small to give more than an indication of the various load characteristics and it is planned to supplement this study with a continuing program of similar studies. The data obtained were, however, of significant value as a guide for rate, transformer loading, loss analysis and power factor studies.
1. Annual average KWH usage per customer varied from about 1,520 to 7,570; monthly values varied from about 130 to 630.
2. The maximum group coincident KW demands per customer (for an average weekday) had the following ranges: 0.57 to 1.76 (Apr.); 0.39 to 1.12 (Aug.); 0.58 to 1.64 (Dec.). [All maxima were during the period 5:00 to 9:00 p.m.]
3. The noncoincident maximum KW demand per customer (integrated over an hour) varied from about 1.6 to 5.7.
4. Annual load factors (based on average Dec. weekday maximum demands) varied between 41.1 and 52.7%.
5. Coincidence factors (based on average demand for an average weekday) ranged from about 27 to 33%.
Summary of Major Findings (Chicago, Ill.):
1. The average annual energy use per customer ranged from 1,334 to 6,134 KWH with only the latter group exceeding 3,350 KWH.
2. The annual group load factors trended slightly upward with increasing annual energy use per customer. However, the highest use group had the lowest load factor (19.9%) of all the groups, due to an unusual amount of Christmas decorative lighting in this area. The lowest use group (1,334 KWH) had a load factor of 28.1%. Other groups

had load factors ranging from 23.7 to 37.0.
3. The average diversified demand per customer for the 25 groups ranged from 476 to 3,510 watts. However, only 3 groups had demands averaging 1,000 or more.
4. The sum of the noncoincident maximum demands (of the 25 transformers) amounted to an average of 728 watts per customer. On the basis of this demand value, the annual load factor of the entire test sample was 28.9%.
5. During the morning hours, most groups showed slightly higher demands in the summer than in winter; during the afternoon and evening hours, winter demands substantially exceeded summer demands. [The saturation of air conditioning among the customers in these groups is low, as the seasonal differences in load would indicate.]

Summary of Major Findings (Cleveland, Ohio):

1. The 17 groups tested had average KWH usages per month ranging from about 70 to 1490.
2. For the entire test period, the maximum group coincident KW demand per customer varied from 0.26 to 3.59 (integrated over a 30-minute interval). The time of occurrence of these demands varied considerably between groups, altho most maxima were between 5:30 and 9:00 p.m. [Note: the demand values increased in approximate proportion to the KWH values previously cited.]
3. The noncoincident maximum KW demand per customer (integrated over a 30-minute interval) had values from 0.8 to 8.1.
4. Test period load factors (average weekday) based on maximum group coincident demand varied from 45.0 to 71.8%. For the entire test period, the load factors (same basis) varied from 30.9 to 61.7%.
5. Based on the test period group maximum demand, the coincidence factors ranged from 26.9 to 52.0%. These values ranged from 16.6 to 44.6%, when based on average weekday group maximum demands.
6. Cleveland residential customers who had no major electrical appliances produced the highest coincidence factors, both summer and winter, of all the groups tested. Those groups in which each customer had a range, a clothes dryer and a water heater had the highest group load factors; the groups with dryers only had the lowest load factors (based on the test period maximum demand) and also had the lowest coincidence factors of all groups tested.

Summary of Major Findings (Kansas City, Mo.):

1. The quantities of energy used during the 12 month test period by the individual customers in the group ranged from 7,833 to 29,365 KWH (average of 23,104). On a monthly basis, average usage ranged from 1,269 (mid-Apr. to mid-May) to 3,831 KWH (mid-July to mid-Aug.)
2. The monthly values of the group coincident maximum KW demand per customer (integrated over a half-hour) ranged from 3.2 (on 3/2/56) to 9.1 (on 7/30/56).
3. The noncoincident maximum KW demand per customer (integrated over a half-hour) had monthly values in the range 6.8 (3/21/56) to 14.5 (7/30/56).
4. Load factors (based on maximum group coincident demand) varied from 30.8 to 58.2%; based on noncoincident maximum demand the variation was from 16.9 to 34.4%.
5. Coincidence factors varied between 42.4 and 63.0%.

6. For the average weekday (as well as on the day of peak group demand), the load curves show that the hourly summer demands were nearly twice as great as corresponding winter demands at the time of the maximum demand for the day and were about 3 times as great as the corresponding winter demands during the "night valley" of the load curve. [These relationships are reflected by substantially higher daily load factors in summer than in winter.] Another interesting relationship that may be observed from these curves is that the maximum daily demand occurred during the afternoon in the summer but was after 6:00 p.m. in the winter.

Summary of Major Findings (Philadelphia, Pa.):

1. The daily load curves for the average weekday for each of the selected sample groups show that such curves (for each of the 7 "non-holiday" weeks) fall within a relatively narrow envelope.
2. For each of the selected sample groups, there is a great similarity between the magnitudes of the respective groups' average weekday maximum diversified demands for all of the 7 "non-holiday" weeks. Similarly, the weekly maximum diversified demands and the weekly customers' non-coincident maximum demands show little change in the magnitude of their respective weekly maximum demands for the same 7 weeks.
3. The summer average weekday load curves show that the loads of the "hot summer" week are significantly greater than that for the "cool summer" week, during the entire day, with the increase being most pronounced during the late night and early morning hours. These increases reflect the more extensive use of fans, room coolers and greater refrigeration requirements on hot days. The groups with relatively high saturations of room coolers have the highest % increase in energy use.
4. Comparison of the loading for the average weekday of the winter test week with that of the hot summer test week indicates that the winter peak loads exceeded the hot summer week maximum demands in all groups. This result is most pronounced in the case of the 2 groups of customers with ranges, reflecting the almost complete diversity in the summer between the early evening peak of the range and the much later peak of the lighting load. Changes in the saturation of appliances whose use is affected by outdoor temperature (particularly room coolers) could materially alter these winter/summer relationships.
5. Altho the energy use for the winter and hot summer test weeks are about the same (particularly for groups without ranges) the level of the test week load factor for the hot summer week is considerably higher than that for the winter test week.
6. During the winter test week, the loads of groups of customers with and without ranges both reach their peaks at about the same hour; during the summer test weeks, the peaks of the groups with ranges occur during the early evening while those without ranges peak in the late evening hours.

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7. The detailed results from the 2 Philadelphia studies are very extensive and do not lend themselves too well to further abstraction in this Compilation. A few representative results follow:

(a) Annual KWH usage for the various groups varied from about 1,960 to 5,540;

(b) For a winter (7 day) week the KWH usage range was about 42 to 123 and

for a "cool" summer week it was about 33 to 74 and for a "hot summer" week, it was about 41 to 123;
(c) The annual maximum demand (based on the highest demand during the summer and winter test periods) varied between 0.54 and 1.67 KW and corresponding values of noncoincident demand were 1.17 to 4.41;
(d) Load factors (based on noncoincident maximum demands) ranged from 9.4 to 19.1%, on an annual basis, and based on average weekday maximum demands the range was 32.8 to 46.9%, on an annual basis.

Summary of Major Findings (Washington, D.C.):

1. Annual energy use per customer for the 11 selected groups ranged from about 690 to 20,590 KWH; corresponding monthly values ranged from about 65 to 1,650.
2. Maximum KW demand per customer (integrated over a half-hour) varied from about 0.26 to 4.57, when based on group coincident values; based on noncoincident demands, the variation was from about 0.66 to 8.63 KW.
3. Annual load factors varied from 30.2 to 55.0%. Monthly load factors (average of individual customers) varied from 15.4 to 26.3%. Monthly load factors (based on maximum group coincident demands) varied from 32.7 to 51.7%.
4. Monthly coincidence factors varied from 36.2 to 52.9%.

Note: Above 4 findings are derived from summer tests; the next 4 findings derive from winter tests.

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5. Annual energy use per customer for the 11 selected groups ranged from about 620 to 21,970 KWH; corresponding monthly values ranged from about 67 to 1,950.
6. Maximum KW demand per customer (integrated over a half-hour) varied from about 0.24 to 5.02, when based on group coincident values; based on noncoincident demands, the variation was from about 0.60 to 8.59 KW.
7. Annual load factors varied from 29.3 to 50.0%. Monthly load factors (average of individual customers) varied from 16.4 to 30.8%. Monthly load factors (based on maximum group coincident demands) varied from 36.4 to 53.1%.
8. Monthly coincidence factors varied from 38.1 to 58.4%.
9. During the winter tests the groups of customers using less than 200 KWH a month developed their peak demands between 8:00 and 9:00 p.m., while all of the groups at the higher levels of use consistently reached their peaks at 6:30 p.m. A similar shift was experienced during the summer tests, when the groups of smaller customers developed maximum loads between 9:00 and 10:00 p.m. and the groups of larger users established theirs at approximately 6:00 p.m.
10. After classifying the test customers into groups according to their major appliances, both the winter and summer tests reflect the improvement in load factor of some groups resulting from the addition of a refrigerator and the reduction in load factor resulting from the addition of a range. [Although the remaining groups contain too few customers to reflect full diversity of demands, an indication of the effect of other appliances upon the load characteristics of these groups may be gained from the test data.]

TITLE: RESIDENTIAL LOAD SURVEY

SOURCE: Philadelphia Electric Co. (Philadelphia, Pa.)

AUTHOR(S): A.Abramovitz (for C.W.Bary)
PREPARED BY AUTHOR(S) AND/OR: P.E.

DATE OF ISSUANCE: 1961-62 Report of LRC/AEIC (Printed 1963)
OTHER IDENTIFIERS: Appendix E, Section 1 (pp L-55 thru L-66); data covers winter 1960-61 + summer 1961
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.E.

TOTAL: [PAGES 12 ;REFERENCES 2 ;GRAPHS 7 ;TABLES 2] *
DOCUMENT CLASSIFICATION(S): 40/7, 13, 14, 27, 37, 48

ABSTRACT: *[The Graphs are grouped into 2 Charts.]

The test customers making up the representative sample groups were chosen by the use of accepted procedures of random choice, from stratified subdivisions reflecting the individual-selective method of sampling. Those selected were arranged into 2 main categories, one comprising persons who use electricity for lighting and miscellaneous appliances (termed "customers without ranges") and the other of persons who use electricity for lighting, miscellaneous appliances and cooking (termed "customers with ranges").

From the classification "customers without ranges", 4 groups made up approximately 30 customers each were selected for test; these groups (A, B, C and D) had annual uses averaging 850, 1855, 3642 and 7213 KWH, respectively. Similarly 3 groups (E, F and G), of approximately 40 customers each, were selected for test from the classification "customers with ranges"; their annual KWH usages averaged 2879, 4818 and 7034, respectively. [Water heating, supplied off-peak under controlled conditions, is separately metered and its energy use is not included with the loads of either of these categories.]

The winter tests were made during Dec. and Jan., with all customers of a group being tested during the same week. The summer tests were conducted from June to the middle of Sept. Although the total effective cooling degree-hours (CDH) for this period were about normal, the season did not develop any periods of sustained high outdoor temperatures which could be characterized as "hot spells." [Two 1-week periods, both in July were selected for analysis to give data reflecting conditions of a "cool" summer week and a "warm" summer week.] All loads were measured at the customers billing meters. The tests are reported on the basis of the prevailing clock time.

Power factor tests (of individual "at-random-selected" customers) were made on warm days of the summer season, on about one-fifth of the cus-

tomers in each of the test groups. These tests were conducted on different days and each provided the integrated results over a half-hour period between 5:30 and 6:30 p.m. This period was selected as indicative of power factor conditions over the anticipated peak periods of the groups because, while it is the peak period for the groups of customers with ranges, it is also a period of high level of use for the groups of customers without ranges. Power factor tests were not conducted for the winter test period because previous tests provided sufficient information of a stable nature regarding power factors under winter conditions.

Purposes of Study: to examine comparative use characteristics for winter and summer conditions as part of a biennial review of the loads of representative groups of residential customers.

Summary of Major Findings:

1. The load on the warm average weekday is substantially greater than that for the cool average weekday, for each of the test groups, with the most pronounced differences occurring during the late evening and early morning.
2. Under conditions existing at the time of these tests, the winter average weekday peak loads exceed those of the summer warm average weekday in all groups, except for the largest group without electric ranges which has a 54% saturation of room coolers.
3. The peak periods of both main categories occur between 6 and 8 p.m. during the winter test period. During the summer test periods, while the peak loads of the groups with ranges occur between 6 and 8 p.m., those of the groups without ranges occur later in the evening.
4. For warm summer periods, the average of the power factors - indicative of conditions for the average customer over the time of the diversified maximum demands - for the customers without ranges is about 83% and for customers with ranges is about 91%.
5. The current study confirms a previously established finding that the annual load factors of customers with ranges are lower than those without ranges. However, this lower load factor can be more than counterbalanced by the addition of a proper number of controlled water heaters, particularly with the use of a dual-cycle, time-control schedule.
6. Based on the highest demands during the winter and summer test weeks, the annual average weekday diversified maximum KW demands per customer were: 0.246, 0.461, 0.904, 1.747 (for the customer groups without ranges) and 0.934, 1.417 and 2.018 (for the customer groups with ranges). [The annual diversified maximum demands were: 0.295, 0.481, 1.064, 2.207, and 1.099, 1.674, 2.211, correspondingly.]
7. Load factors (in %), based on diversified demand, ranged about: 33-61 (Group A); 47-70 (Group B); 39-73 (Group C); 37-65 (Group D); 30-50 (Group E); 33-53 (Group F); 36-61 (Group G). [Based on noncoincident maximum demand the load factors were much lower, generally about one-half to one-third of the values just listed.]

TITLE: INTERMEDIATE - and LARGE - USE RESIDENTIAL CUSTOMER LOAD STUDY

SOURCE: Consolidated Edison Co. of New York, Inc. (New York, N.Y.)

AUTHOR(S): A.F.Rehberg
PREPARED BY AUTHOR(S) AND/OR: C.E. (of) N.Y.

DATE OF ISSUANCE: 1961-62 Report of LRC/AEIC (Printed 1963)
OTHER IDENTIFIERS: Appendix F, Section 1 (pp L-67 thru L-80); data covers winter 1957-summer 1958
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with C.E. (of) N.Y.
TOTAL: [PAGES 14 ;REFERENCES 1 ;GRAPHS 12 ;TABLES 3]*
DOCUMENT CLASSIFICATION(S): 40/1, 2, 7, 14, 27, 44, 47, 49

ABSTRACT: *[One of Tables is unnumbered. Graphs are grouped into 5 Charts.]

Tests were made on a stratified sample of 300 large-use residential customers in New York City and Westchester County. Recorded demand data were obtained in Dec. 1957, for a 3-week period and then for an 8-week summer period, June 22 to Aug. 16. Although the tests were started with more than 300 customers in the sample this analysis has been limited to 239 customers, in 3 groups of approximately 80 customers each, for which complete data were available for the entire test year. [The annual KWH usage ranges of these Groups (identified as 1, 2 and 3) were about: 2,030-2,870; 2,880-4,010; 4,050-16,750.]

The approximate % values for major appliance "saturation" (for Groups 1, 2 and 3, respectively) were: 16, 44 and 78 (room air cooling units); 0, 0 and 4 (central air conditioning); 6, 4 and 14 (auxiliary heating units); 1, 9 and 18 (ranges); 3, 17 and 33 (dishwashers); 1, 6 and 28 (dryers); 60, 66 and 79 (clothes washers); 5, 15 and 38 (freezers); 93, 89 and 99 (single-door refrigerators); 13, 19 and 25 (double-door refrigerators); 116, 128, 168 (televisions).

Purposes of Study: to analyze the effect of increased air cooling and the increased saturations of other large-use appliances on the demands of residential customers using over 2,000 KWH annually, where it was anticipated that the changing saturations of these appliances would have the greatest influence on load characteristics.

Summary of Major Findings:
1. The group (average weekday) maximum demand per customer is slightly higher in winter than in summer, when compared on a 5-day average basis. The tests of the 3 groups of sample customers, who were selected in accordance with increasing annual energy use, show that the summer group maximum demands were 93.1, 97.5 and 91.0%, respectively, of the winter group average weekday maximum demands. [This indicates some tendency toward a

balance between summer and winter group (average weekday) maximum demands.] On the other hand, the average weekday energy use in summer has exceeded the use in winter for Groups 2 and 3. The tests show that the energy use in summer for Groups 1, 2 and 3 were 94.2, 116.1 and 112.0%, respectively, of the winter use; since this condition occurred during a relatively cool summer, it can be seen that a very hot summer could shift the maximum loads of these large-use customers to a summer peak for both group demand and energy use. However, the influence of customers using less than 2,000 KWH annually will continue to produce a winter peak for the residential class in the C.E. service territory.

2. The group average weekday load factor for the 3 groups varied between 53 and 55% for the winter and between 55 and 70% for the summer test period. The annual group average weekday load factors were 48.5, 49.7 and 50.4%, respectively. Under these conditions, an increase in the daily load factor over an appreciable period of time is necessary for any substantial improvement in the annual load factor; shifts in the relative balance of summer and winter loads from this "optimum" would tend to lower the annual load factor, unless there was a material increase in daily load factors.

3. Outdoor temperatures appeared to have little effect on the winter maximum demands, altho they varied between 20.3 and 56.0 F during the test period. [The higher temperatures usually were accompanied by a cloudy sky which increased the need for lighting sufficiently to essentially offset the decreased operation of auxiliary motors used for heating equipment; decorative lighting at the Christmas season also would be an important factor in this relationship.] With a change of the average hourly temperature from 28.5 to 46.2 F for 5 weekdays in winter, group average weekday maximum demands for Groups 1, 2 and 3 decreased by 2.0, 3.9 and 3.4%, respectively. In summer, changes in outdoor temperature caused a wide variation in demand and energy use; e.g., a change in the average temperature from 72.0 to 80.9 F for 5 weekdays in summer increased group maximum demands by 29.0, 42.4 and 34.9 per cent, respectively.

TITLE: LARGE-USE RESIDENTIAL CUSTOMER LOAD STUDY

SOURCE: West Penn Power Co. (Greensburg, Pa.)

AUTHOR(S): V.D.Gibson (for R.C.Carder)
PREPARED BY AUTHOR(S) AND/OR: W.P.P.

DATE OF ISSUANCE: 1961-62 Report of LRC/AEIC (Printed 1963)
OTHER IDENTIFIERS: Appendix G, Section 1 (pp L-81 thru L-85); data covers 12/60 + 1/61 + 7 & 8/61
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with W.P.P.
TOTAL: [PAGES 5 ;REFERENCES ;GRAPHS 2 ;TABLES 1]
DOCUMENT CLASSIFICATION(S): 40/7, 14, 48

ABSTRACT:

The test sample was selected from the top 10% of the residential customers, on the basis of their energy use which varied from 476 to over 3,000 KWH per month. Controlled water heating energy was excluded as a factor in selecting the test cases but was included as part of energy use and demands if the test customers happened to have this type of water heating. Additionally, customers with complete or partial electric house heating were not included.

Water heaters in the test group are NEMA standard heaters operating on a controlled pattern which restricts lower element operation to the periods 9 p.m. to 8 a.m. and noon to 4 p.m., EST, winter and summer.

Average values of appliance saturation (%) during the test periods were: televisions (112); refrigerators or refrigerator-freezers (102); washers (100); ranges (91); dryers (72); freezers (46); controlled water heaters (40).

The customers were tested simultaneously for 4-week periods during the winter of 1960-61 and the summer of 1961. The recorded loads were at quarter-hour intervals and were averaged to clock-hour intervals based on EST, winter and summer. A magnetic-tape automatic load survey recording meter was attached to the (billing) watthour meter of each customer.

Purposes of Study: to determine the winter and summer load characteristics of large-use residential customers, without electric house heating, served by W.P.P.

Summary of Major Findings:

1. The load pattern for the (present) large-use customer is indicative of the (future) load pattern of average-use customers. Where house heating is not a factor, the pattern shows a maximum demand in the evening during the winter period. The present summer load shown by the test has

no contribution from air conditioners and because of the climate in the W.P.P. area the residential air conditioning load is not expected to establish summer peak conditions. Summer demands for individual customers are slightly lower and more diversified than winter demands.

2. The average annual energy use per customer was about 8,730 KWH.

3. The maximum diversified demands per customer, during the winter test period, was 2.42 KW; the corresponding summer value was 1.79 KW. For the average week the respective demand values were 1.96 and 1.57 and for the average week day they were 1.88 and 1.34 KW.

4. Noncoincident maximum demands per customer were 5.23 and 4.95 KW, winter and summer test periods, respectively.

5. Load factors, based on noncoincident maximum demands and energy use during the test periods, were 22.9% (winter) and 17.9% (summer).

TITLE: RESIDENTIAL LOAD SURVEY

SOURCE: Philadelphia Electric Co. (Philadelphia, Pa.)

AUTHOR(S): A.Abramovitz (for R.A.Markel)
PREPARED BY AUTHOR(S) AND/OR: P.E.

DATE OF ISSUANCE: 1963-64 Report of LRC/AEIC (Printed 1965)
OTHER IDENTIFIERS: Appendix A, Section 1 (pp L-9 thru L-19); data covers winter 1962-63 + summer 1963
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.E.

TOTAL: [PAGES 11 ;REFERENCES 3 ;GRAPHS 6 ;TABLES 2]*
DOCUMENT CLASSIFICATION(S): 40/14, 37, 44, 46, 47

ABSTRACT: *[Graphs are grouped into 2 Charts.]

The test customers making up the representative sample groups were chosen by the use of accepted procedures of random choice, from stratified subdivisions of customers reflecting the individual-selective method of sampling. They were arranged into 2 main categories, one comprising customers within the corporate limits of the City of Philadelphia (termed "customers in urban area") and the other comprising customers contiguous to the City (termed "customers in suburban area".)

The urban residences are mostly of the single-family, row-type with some semi-detached and detached dwellings and apartments. The suburban residences are mainly of the single-family, single-dwelling type but with some substantial urban and rural residential sections.

In each of the two categories, further subdivisions of the customers were made into groups of limited bands of energy use; for each of the geographic classifications, 3 groups made up of approximately 35 customers each were selected for test. Annual KWH use for the 3 "urban" groups was about: 2,000; 4,500; 7,800. Annual KWH use for the 3 "suburban" groups was about: 1,700; 4,000; 7,200. [Note: Water heating, supplied "off-peak" under controlled conditions, is separately metered and its energy use is not included with the loads of these test customers.]

The summer test period, on the basis of total effective degree-hours, was substantially below normal and periods of sustained high outdoor temperatures which could be characterized as "hot spells" did not materialize. Two 1-week periods were selected for analysis to provide data reflecting conditions of a "warm" summer week and a "cool" summer week. All load measurements were made at the customers' billing meters and the tests are reported on the basis of the prevailing clock time.

The power factors of individual customers (selected at random) were obtained by tests made on warm days during the summer season. These tests,

comprising approximately one-sixth of the customers in each of the test groups, were conducted on different days and each provided the integrated results over a half-hour period between 5:30 and 6:30 p.m. This period was selected in the expectation that it would provide a suitable measure of power factor conditions over a period of high level of use for the groups.

Purposes of Study: sample groups of residential customers representative of those served in the Philadelphia urban and suburban areas were studied to determine their comparative use characteristics for both winter and summer conditions; to use results of the sample group tests for the development of the class load characteristics of residential customers in the Philadelphia urban and suburban areas individually, by expansion of sample group characteristics.

Summary of Major Findings:

1. For each of the test groups of both the urban and suburban area categories, the KW load on the summer (warm) average weekday is substantially greater than that of the summer (cool) average weekday with the largest increase in load occurring during the late evening hours. Based on the average weekday maximum diversified demand, the approximate respective group differences (with the first 3 pairs of numbers referring to the urban groups) were: 0.36 to 0.51, 0.69 to 1.16, 1.18 to 2.13, 0.28 to 0.36, 0.68 to 0.91 and 1.13 to 1.38. [This difference is more pronounced for the urban customers, reflecting their relatively high saturation of room coolers as compared with those of the suburban customer groups.]

2. For all urban groups, the summer (warm) average weekday peak loads - under conditions existing at the time of these tests - exceed those of the winter average weekday; this increase reflects their moderate to high saturation of room coolers. Based on noncoincident (maximum) KW demand per customer, the respective pairs of group values are: 1.15 and 0.94, 2.81 and 2.60, 4.56 and 4.31.

3. For the suburban customers, the winter average weekday peak loads are greater than those of the summer (warm) average weekday; these increases probably reflect their relatively high saturation of cooking ranges and low saturation of room coolers, as compared with those of the urban customers. Based on noncoincident (maximum) KW demand per customer, the respective pairs of group values are: 1.18 and 1.15, 3.05 and 2.74, 4.91 and 4.44.

4. For all groups, the peak periods for the winter average weekday tests generally occur around 6 p.m. During the summer (warm) test period the average weekday peaks generally occur around 10 p.m.

5. The average of the group power factors for summer warm conditions - indicative of average customer loading over the period of diversified maximum demands - is about 83% for the urban customers and about 86% for the suburban customers.

TITLE: LARGE RESIDENTIAL CUSTOMER LOAD STUDY

SOURCE: The Cleveland Electric Illuminating Co. (Cleveland, Ohio)

AUTHOR(S): T.W.Masbach (for C.T.Loshing)
PREPARED BY AUTHOR(S) AND/OR: C.E.I.

DATE OF ISSUANCE: 1965-66 Report of LRC/AEIC (Printed 1967)
OTHER IDENTIFIERS: Appendix A, Section 1 (pp. L-13 thru L-23); data covers 4/63 thru 3/64
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with C.E.I.
TOTAL: [PAGES 11 ;REFERENCES ;GRAPHS 17 ;TABLES 1] *
DOCUMENT CLASSIFICATION(S): 40/14, 22, 48, 49

ABSTRACT: *[Graphs are grouped into 5 charts.]

A list of customers who used at least 3,000 KWH/month (between Feb., 1962 and Feb., 1963) was obtained from billing records. Using systematic random sampling techniques, a 10% sample was chosen from this list. [Apartments, homes of Company employees, and accounts which were inactive subsequent to attaining the 3,000 KWH use level were excluded.] The test sample consisted of 44 customers. As expected for high use customers, the sample had a high saturation of electric water heating (77%) and electrical space heating (66%); 27 of the 44 had both.

All-electric water heaters in the C.E.I service area are of the "uncontrolled" type and most are high-recovery units. No attempt was made to classify the sample customers according to water heater size.

Each customer's total load was metered by means of magnetic tape load survey meters located at the customer's service entrance. The tapes were changed every 4 weeks and translated to punched cards by a magnetic tape-to-card translator. The resultant (quarter-hour) integrated demands were combined within a computer program into clock half-hour demands on the prevailing times, EST or EDT, in order to conform to the billing demand interval.

Purposes of Test: to maintain current load data on the various classes of customers in the C.E.I. service area; to study the load characteristics of exceptionally large residential consumers.

Summary of Major Findings:
1. During the winter months, the noncoincident (maximum) demand per customer varies directly with the combination of outside and tap water temperatures. The derived demand equation, [demand $\approx$ 11.4 - 0.056 (°F, outside temp.) - 0.034 (tap water °F)], adequately explains 96% of the variations in demands. The relationship is less pronounced during the summer because it appears that the air conditioning load was small.

TITLE: SMALL COMMERCIAL and INDUSTRIAL CUSTOMER LOAD STUDY: EFFECT of AIR CONDITIONING LOAD *

SOURCE: Public Service Electric and Gas Co. (Newark, N.J.)

AUTHOR(S): P.F.Platt (for B.P.Dahlstrom)
PREPARED BY AUTHOR(S) AND/OR: P.S.E.&G.

DATE OF ISSUANCE: 1961-62 Report of LRC/AEIC (Printed 1963)
OTHER IDENTIFIERS: Appendix C, Section 2 (pp L-127 thru L-132); data covers summer 1958
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.S.E.&G.
TOTAL:[PAGES 6 ;REFERENCES ;GRAPHS 12 ;TABLES 2] **
DOCUMENT CLASSIFICATION(S): 49/11, 33, 46

ABSTRACT: *[The customers were separated into 8 groups, according to specified (increasing) ranges of annual peak KW.]

**[The Graphs are grouped into 3 Charts.]

Two determinations were made by these tests, namely the relationship between temperatures and demands for all customers at various hours during the day and that between temperatures and demands by demand groups. Data were determined for all customers in the class as well as for those having air conditioning. [Data shown for all customers in the class are weighted, since two types of customers are included in the study: those having estimated demands and those with measured demands.]

The 8 demand groups had annual peak KW demands in the following ranges: 0-2, 2-4, 4-6, 6-10, 10-15, 15-30, 30-50, over 50.

Purposes of Study: to determine the correlation existing between diversified demands and outdoor ambient temperature, during selected days of the test period (June thru Sept.), of small commercial and industrial customers supplied at the general lighting and power rate schedule.

Summary of Major Findings:

1. The temperature-demand relationship for customers with air conditioning shows that the 11 a.m. to noon and 2 to 3 p.m. patterns are practically identical. This is logical since nearly all air conditioning in this rate classification is located in neighborhood or specialty stores and shops.

2. For the entire class of customers the 11 a.m. to noon load, compared with the 2 to 3 p.m. load, is slightly higher at the higher temperatures and the slope of the curve is steeper. This is probably because of the influence of the small industrial customers who have some temperature-activated loads. [The industrial group normally has its peak load at around 11 a.m. and use begins to fall off at about 3 p.m., when peak daily temperatures tend to occur.]

3. For all customers as a class, there is a positive temperature-demand relationship for every group altho in some groups there is little if any air conditioning. In addition to the known connected air conditioning loads (where one would expect such a relationship) there are other temperature-activated parameters which contribute to the increases in demands as the temperature increases, say from 70 to 90 F; these include: (a) Circulating fans for comfort cooling: (b) Longer hours' use of refrigeration for food preservation; (c) Coincidence of both higher temperature and commercial activity in the afternoon. [Note: This study was limited to determining the effect of known amounts of compressor-type air conditioning loads. No such study has been made as regards the other kinds of temperature-activated parameters or their magnitude.]

4. Expressed in watts and for an outdoor dry-bulb range of 70 to 90 F, the increase in diversified demand per customer per ton of air conditioning per degree F temperature rise is: 17.8 for "all" and 9.8 for "air conditioning" customers (8:00 to 9:00 a.m.); 30.5 and 18.4, respectively (11:00 a.m. to 12:00 noon); 16.8 and 14.7, respectively, (2:00 to 3:00 p.m.); -14.0 and 4.8, respectively, (8:00 to 9:00 p.m.).

TITLE: AVERAGE DAILY OUTDOOR TEMPERATURE CHARACTERISTICS

SOURCE: Consolidated Edison Co. of New York, Inc. (New York, N.Y.)

AUTHOR(S): A.F.Rehberg & L.H.DeLeau
PREPARED BY AUTHOR(S) AND/OR: C.E. (of) N.Y.

DATE OF ISSUANCE: 1967-68 Report of LRC/AEIC (Printed 1969)
OTHER IDENTIFIERS: Appendix B, Section 4 (pp L-188 thru L-204); data covers 15 years: 1952-1966
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with C.E. (of) N.Y.
TOTAL:[PAGES 17 ;REFERENCES ;GRAPHS 13 ;TABLES 2 .] *
DOCUMENT CLASSIFICATION(S): 49/43

ABSTRACT: *[Graphs are grouped into 11 Charts.]

The source of daily average temperatures was the monthly reports of the U.S. Department of Commerce on Local Climatological Data for Central Park, New York City. [The "daily average" temperatures from this report are the averages for the maximum and minimum temperatures for each day.]

The number of observations in each month varied from 424 to 465 for the 15-year period. Normal cumulative frequency distributions of temperatures were computed for each month using "least squares" procedures.

Purposes of Study: to establish monthly probability patterns that would be useful in the analysis of monthly energy use for cooling and heating; to study outdoor dry-bulb temperatures over a 15-year period in connection with annual energy data obtained from a continuing test program of electric loads with about a 10-year cycle.

Summary of Major Findings:
The daily average temperatures for the 15-year period, 1952-1966, were found to approach a normal frequency distribution in each month, with standard deviations ranging from 0.26 to 0.69%. The dispersions of temperatures in the summer months were somewhat less than in the winter. The distribution for an annual period is not a normal frequency distribution. [Recall that for a "normal distribution" the median and average values are the same.]

TITLE: EVALUATION of WEATHER-SENSITIVE LOADS

SOURCE: Baltimore Gas and Electric Co. (Baltimore, Md.)

AUTHOR(S): C.R.Williams (for W.E.Miller)
PREPARED BY AUTHOR(S) AND/OR: B.G.&E.

DATE OF ISSUANCE: 1971-72 Report of LRC/AEIC (Printed 1973)
OTHER IDENTIFIERS: Appendix F, Section 5 (pp L-223 thru L-230); data covers 1961-71
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with B.G.&E.
TOTAL: [PAGES 8 ;REFERENCES ;GRAPHS 5 ;TABLES]
DOCUMENT CLASSIFICATION(S): 49/14, 19, 26, 31

ABSTRACT:
Electric loads are, in general, responsive to changes in temperature, humidity, wind velocity and cloudiness. The effects of all these variables (except wind velocity) are measured and factored into the input data used for system load forecasts by B.G.&E. The techniques of measurement are under continuing development, as progressively more use is made of digital computers in load analysis and forecasting.

More than a few attempts have been made to develop "indexes" of the weather variables which exhibit an optimum correlation with the weather-sensitive components of load. For energy sales studies, the simplest- and usually quite effective - measures of temperatures are HDD in winter and CDD in summer. For studies of hourly summer heat sensitivity, an index has been developed that gives about equal weight to hourly dry - and wet bulb temperature and to the average dry-bulb temperature over the preceding 24 hours; this allows for the phenomenon of "heat buildup". This Heat Sensitivity Index is a numerical value calculated for each hour of the day; the dry-and wet-bulb temperatures are used to select from a graph the "effective temperature" for that hour which is then used, with the average dry-bulb temperature over the preceding 24 hours, to choose the Index value from another graph. [A similar Heat Sensitivity Index for winter is also used.]

For the measurement of the effects of outside light intensity, a "Light Index" (with 0-100 range) has been derived which is directly linear with the load changes resulting from cloudiness. The Index values are calculated from records of light intensity on the roof of B.G.&E.'s downtown office building, about 280 feet above ground level.

The magnitude of weather effects is calculated by a linear regression of peak hourly loads (in megawatts) or by daily energy use (in megawatt-hours), against the appropriate weather index. Since the effect of a given change in temperature varies seasonally, the regression calculations are made for a period of not longer than 5 successive weeks. The analysis is repeated weekly, the new week (of data) being added and the

oldest week being dropped from the primary data. Included in the calculation for the period is a determination of "normal" load, i.e. the load value on the regression line that corresponds to the "normal" weather index for that period.

Weather sensitivity is usually expressed as a % of "base" (or non-weather-sensitive) load, rather than in absolute power or energy units. B.G.&E. has found that the best measure of "base" load is obtainable in the brief periods of late Apr., early May, late Oct. and early Nov. when both heating and cooling loads are minimal. ["Base" load for other periods is obtained by interpolation between spring and autumn values, after a minor adjustment is made to the autumn base to correct for its slightly greater lighting load component.] Weather sensitivity can also be expressed either in % per unit change in weather index, in % excess of "normal" or in % of peak load above "base" for any period - a week, a month, or an entire season. The seasonal measure - the seasonal "amplitude" - is an important indicator of the historical trend of weather sensitivity since it demonstrates the explosive increase of heat-sensitive load during recent summers. Although the past trend of winter sensitivity exhibits little change, the future will be closely watched since the widespread use of electric heating could eclipse even the air conditioning load growth record of the 1960's.

Although past data on the relative saturation of the B.G.&E. system with air conditioning is not plentiful, close correlation between such figures as are available and the summer seasonal amplitude is indicated by available records. The "normal" peak load can be used to advantage as an indicator of system forecast accuracy. Comparison of the calculated "normal" peak with the forecast normal peak demonstrates that the system peak loads fell below the forecast level shortly after the forecast was prepared in Oct. 1970 and remained below it for an entire year. [This indicator served as part of the supporting data for the reduction in the system forecast made in Sept. 1971.]

TITLE: FORECASTING WEATHER-RELATED LOADS

SOURCE: Houston Lighting & Power Co. (Houston, Texas)

AUTHOR(S): T.A.Standish (for J.H.Ferguson)
PREPARED BY AUTHOR(S) AND/OR: H.L.&P.

DATE OF ISSUANCE: 1971-72 Report of LRC/AEIC (Printed 1973)
OTHER IDENTIFIERS: Appendix G, Section 5 (pp L-231 thru L-239); data covers 1964-71
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with H.L.&P.
TOTAL: [PAGES 9 ;REFERENCES ;GRAPHS 3 ;TABLES 1]
DOCUMENT CLASSIFICATION(S): 49/11, 16, 19, 29, 40

ABSTRACT:

The Report directs its primary attention, in analyzing temperature-sensitive loads, to the summer air conditioning load. ["Summer" is defined in terms of cooling degree-hours or CDH (the degrees for which each hour is above a 72°F base) and other factors; "summer" consists of the months May thru Nov. for the residential class and April thru Nov. for the commercial class.] Since the methods of treating and projecting accumulated data are different for the residential class and the commercial class, each class is analyzed separately.

In forecasting residential load, one first determines the % saturation of air conditioning which will exist in the forecast year. [For illustrative purposes, 1980 was used as the forecast year.] H.L.&P. studies indicated that of customers who use 1,500 KWH or more in Aug. nearly all have central air conditioning or the equivalent in room air conditioners; therefore, the % of such customers is taken as the % saturation. Historical data are available for a projection of the % saturation, using regression analysis. [Increases in saturation from Aug. to the following July are assumed to be evenly spread over the 12 months.] The Aug. 1980 projected saturation was found to be 81.2%.

One next separates the "historical base" and "historical variable" KWH/customer and then extrapolates the base KWH/customer. Note: Historical base KWH/customer is defined as the lowest monthly use per customer in each year of the historical period. [These lowest values occur in either March or April, when both CDH and heating degree-hours or HDH (the degree-hours below a base of 65°F) are small. Therefore, these low points are assumed to represent base use at particular points in time.] Base use for all historical months is then estimated by regression analysis on a time series of these low points. Future base use is obtained by extrapolating this growth trend and for Aug. 1980 it was estimated to be 875 KWH/customer. The estimates of historical base use are then subtracted from total use to obtain historical variable use per customer.

Step 3 is the determination of the relationship of variable KWH/customer

to CDH. The CDH data is calculated using a base temperature of 72°F and hourly dry-bulb temperature as measured at a central location. The relationship is: (variable KWH/customer) ÷ (actual CDH). H.L.&P. calls this ratio the "Variable Use Factor"; it is calculated for May thru Nov. of the historical period. It may be described as the response in KWH/customer for each additional degree-hour. [Other studies showed some evidence that this response is different for different ranges of degree-hours. Indications were that for a given level of saturation the curve describing the response for various levels of degree-hours is not linear, but rather is "S-shaped".]

Step 4 relates the variable use factor and % saturation. Based on available data, it is assumed that a direct linear relationship exists for any given month altho not between months. Linear regressions of variable use factor on saturation for each of the 7 summer months were calculated, yielding 7 equations which were then used to project the variable use factor for 1980. The above-noted estimated saturation of 81.2% results in an estimated variable use factor of 0.1959. Variable KWH/customer is then calculated by multiplying the variable use factor by the 24-year average CDH for Aug. (7,765), which gives a variable KWH/customer of 1,521.

The final step includes the calculations to reach from the present point to a demand forecast. Base KWH/customer (from Step 2) is combined with variable KWH/customer (from Step 4) and multiplied by the estimated number of customers - which is based on an extrapolation of historical data - to obtain total KWH sales for the class. System losses, attributable to the class, are added to KWH sales to obtain generation requirements. Load factors calculated as the class contribution to the monthly system peak - using historical data developed from a sample type load study adjusted to normal weather conditions - are applied to KWH sales to obtain an estimate of the class contribution to the monthly system peak.

Forecasting commercial temperature-sensitive loads requires somewhat different techniques than those used for the residential class, for several reasons; e.g., reliable data are not available on saturation levels. Indications are that the energy use of rate groups which contain primarily apartment projects, and small commercial establishments, is seasonal and also significantly affected by abnormal weather conditions; the larger commercial establishments, such as large department stores and office buildings, are "seasonal" but not significantly affected by abnormal weather. [The load forecasting methods described in the following paragraphs apply to the former rate group.]

The first step determines the historical variable KWH/customer and the historical base KWH/customer, in the same manner as for the residential class.

Step 2 adjusts the historical variable KWH/customer to levels appropriate to normal weather conditions, "normal" being defined as the 24-year average degree-hours for the month in question. It is assumed that the

ratio of average degree-hours to actual degree-hours is proportional to the ratio of "normal" variable KWH/customer to actual variable KWH/customer. Thus, for each month of the historical period, the ratio of average to actual degree-hours is multiplied by the observed values of variable KWH/customer (as derived in the first step) to obtain variable KWH/customer at its normalized level. This normalized variable KWH/customer is then added back to the base KWH/customer to obtain historical normalized total KWH/customer.

Step 3 includes the final calculations to obtain the demand forecast. Historical normalized total KWH/customer is extrapolated, using regression analysis and the application of seasonal factors. The number of customers, as projected from historical data, is multiplied by the projected historical normalized KWH/customer to obtain KWH sales for the rate group. The various components of the commercial class are added to obtain class KWH sales. Class contribution to monthly system peak is then derived in the same manner as for the residential class.

2. During the heating season, the average weekday noncoincident (maximum) demand per customer consistently occurs during the evening; during the summer this demand can occur almost any time during the afternoon or evening.

3. The average (winter) monthly energy use per customer is 3,222 KWH; during the summer it is 1,279 KWH.

4. The monthly diversified demand per customer can be as reliably measured by monthly energy use per customer as it can by monthly individual load factor.

5. The average monthly individual load factor (during Dec., Jan., Feb.) is 38.0%; for June, July, Aug., it is 21.9%. The average monthly diversity factor is 1.67 (winter) and 2.65 (summer).

6. The monthly average noncoincident (maximum) demand per customer, for the 44 customers tested, was 9.7 KW. The highest monthly value was 12.0 KW (during Dec.) and the lowest was 7.8 KW (during July).

TITLE: RESIDENTIAL LOAD SURVEY

SOURCE: Philadelphia Electric Co. (Philadelphia, Pa.)

AUTHOR(S): A.Abramovitz (for R.A.Markel)
PREPARED BY AUTHOR(S) AND/OR: P.E.

DATE OF ISSUANCE: 1966-67 Report of LRC/AEIC (Printed 1968)
OTHER IDENTIFIERS: Appendix B, Section 1 (pp L-17 thru L-33); data covers winter 1964-65 & summer 1965
DATA USE RESTRICTIONS: "Not to be published or quoted"' check with P.E.

TOTAL:[PAGES 17 ;REFERENCES 1 ;GRAPHS 12 ;TABLES 5] *
DOCUMENT CLASSIFICATION(S): 40/7, 14, 37, 44, 46, 47

ABSTRACT: *[Three of Tables are unnumbered. Graphs are grouped into 2 Charts.]

[The results of a similar P.E. study were printed in the 1963-64 Report of the LRC. The present study covers 12 sample groups, as compared with only 6 in the earlier survey.]

P.E.'s residential customers are classified geographically into 2 main categories, namely those located in the service area which is defined by the corporate limits of the City of Philadelphia (termed "customers in urban area") and the other comprising customers residing in the service area contiguous to the City (termed "customers in suburban area"). In the urban area the residences are mainly of the single-family, row-type but with some semi-detached and detached dwellings and apartments. The suburban homes are mainly of the single-family, single-dwelling type but there are some substantial urban and rural residential sections. In each of these categories, the customers were first arranged into 6 strata, by their range of energy use. Twelve sample groups, each comprising 30 to 40 customers (and each representative of an energy stratum) were selected for testing by systematic random procedures. [A total of 432 customers were studied.]

The customers included in each test group are essentially homogenous with respect to amounts of energy use during the winter period. Since this criteria served as the basis for defining the energy use limits of the sample test groups, the spread in the annual use of the customers is a greater % than that of the winter period use. The groups cover annual use levels from about 1100 to nearly 9600 KWH per customer. The same sample test customers (in the 2 main categories) are included in both of the test periods.

The entire summer of 1965 - on the basis of total effective degree-hours (EDH) - was 13% below normal. [Periods of sustained high outdoor temperature plus high humidity were not present.] The EDH for the 3 test months were about 20 to 25% below normal. Two, 1-week, periods were

selected for this study to provide data reflecting summer load conditions for a "cool" week and a "warm" week, respectively. The maximum hourly temperature during the warm week was 90°F and the highest daily EDH for a weekday was 178.

[During both the winter and summer month survey periods, tests were made to obtain the power factor of the loads of individual customers.] The energy use of water heating, which is supplied under controlled conditions and is separately metered is not included with the loads of those test customers using this service.

Purposes of Study: to determine patterns of energy use of residences for a winter "high-use" period and for summer periods reflecting low and high temperature conditions; development of the class load characteristics of residential customers in P.E.'s urban and suburban areas.

Summary of Major Findings:

1. For "urban" customers, the hourly loads during the summer warm test period exceed those of the winter test period; primarily this reflects the moderate to high saturation of air cooling appliances among these customers. The summer cool average weekday hourly patterns of use are quite similar to those of the winter period, except for somewhat lower levels of use during the early morning hours and the hours between the times of winter and summer sunset.
2. For the "suburban" customers, the winter peaks (with one exception) exceed those for the summer warm period, with the daily energy use being about the same in both periods; this pattern can be attributed to the relatively high saturation of ranges and low saturation of air cooling appliances of the suburban groups, as compared with the urban areas. The "summer cool" and winter period hourly load patterns are similar except for lower levels of use during the early morning and evening hours in the summer cool period.
3. For all groups of customers the load during the "summer warm" period is substantially greater than that of the "summer cool" period. For the urban customers, the increases in maximum demands and energy use are significantly greater than for the suburban groups; this reflects the lower saturation of air cooling appliances in the suburban area. [With one exception, the air cooling appliance saturations of the urban groups are more than twice that of the suburban group of nearly similar level of winter period energy use.]
4. For the urban areas, the (average) maximum summer month use exceeds that of Dec. by about 20%. For the suburban areas, the maximum summer month use (with one exception) is smaller than that of Dec. by an average of about 15%.
5. The average level of annual load factor, based on diversified average weekday demands, is 39% (urban) and 46% (suburban). Annual noncoincident load factors average about 14 and 13%, respectively.

TITLE: RESIDENTIAL LOAD STUDY

SOURCE: The Cleveland Electric Illuminating Co. (Cleveland, Ohio)

AUTHOR(S): R.J.Thompson (for C.T.Loshing)
PREPARED BY AUTHOR(S) AND/OR: C.E.I.

DATE OF ISSUANCE: 1967-68 Report of LRC/AEIC (Printed 1969)
OTHER IDENTIFIERS: Appendix A, Section 1 (pp L-10 thru L-30); data covers Summers of 1965 & 1966 + Winters of 1964-65 & 1966-67
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with C.E.I.
TOTAL: [PAGES 21 ; REFERENCES 1 ; GRAPHS 28 ; TABLES 5] *
DOCUMENT CLASSIFICATION(S): 40/8, 14, 19

ABSTRACT: *[One of Tables is unnumbered. Graphs are grouped into 12 Charts.]

The customers were selected by systematic random sampling, choosing one of every 200 or so customers in each usage range. [The number chosen was sufficiently large to include replacement customers in the event of a customer refusal or metering difficulties.] The summer and winter samples were selected independently, with different customers in each group. The basis of the initial selection was the customer KWH use in the month one year prior to the test period, excluding customers who had experienced a 40% increase in use in the 12-month period ending at the time of the initial selection on the premise that they had probably grown out of the desired KWH zone. [Appliance saturation data was not obtained.]

Customers whose use fell into a stratification different than was expected in the original sample selection were retained in the study but were placed in the appropriate group. This, however, was done only if the coincident time period was maintained. Stratification groups (KWH in 730 hours) were: 10-150, 151-250, 251-350, 351-600 and over 600.

Test data were grouped into 35-day periods for analysis. The KWH use was adjusted by ratio to a 730-hour month. Likewise, weekdays of five consecutive weeks were averaged to develop the average weekday, and weekend days of five consecutive weekends were similarly averaged to obtain the average weekend day. Holidays were not excluded.

Test data for the five groups of customers were collected by magnetic tape load survey recording units. Data were translated from the field magnetic tapes to punch cards and then processed on a computer system.

Purposes of Study: to provide updated, statistically reliable data for use in engineering and rate studies as part of C.E.I.'s continuing program of load research.

Summary of Major Findings:

1. Weekday evening peak periods are quite pronounced in each of the groups. The winter maximum demands occur after dark, between 6 and 7:30 p.m. (EST). There are dual summer maximum demands, the first being reached between 5 and 7 p.m. and the other between 9:30 and 10:30 p.m. (EDT), as darkness sets in.

2. The relationship of 30-minute maximum diversified demands to monthly (defined as 730-hour) energy use indicates that about 1 KW of diversified demand is the mean expectancy for a customer using 400 KWH. [The linear regression equation is KW=0.14 + 0.00256 KWH; the "coefficient of determination" is 0.980, indicating an excellent fit.]

3. The relationship of 30 to 15-minute maximum diversified demand shows that the longer period of integration produces maximum readings ranging from 4 to 10% lower. [The equation is: Y(30-minute KW) = -0.04 + 0.994 X (15-minute KW); the coefficient of determination was 0.995, a near-perfect fit.]

4a. From Table A-1 (which covers the winter period for the maximum weekday and the maximum weekend day) the load factor, based on the diversified maximum weekday demand per customer, is seen to vary from 40% for the smallest use group to 53% for the larger groups and diversity factors vary from 1.36 to 1.89.

4b. Table A-2 covers comparable data for the summer period. Load factors vary from 45% to 53% and diversity factors range from 1.70 to 2.15 for this period.

4c. Table A-3 lists similar data for the average weekday and weekend day during the winter period. Here load factors range from 56% to 61% and diversity factors from 2.48 to 2.83.

4d. Table A-4 summarizes the summer period average weekday and weekend day data. Load factors from 54% to 70% prevail, with diversity factors ranging from 2.80 to 3.55.

TITLE: RESIDENTIAL CUSTOMER LOAD STUDY

SOURCE: New Orleans Public Service, Inc. (New Orleans, La.)

AUTHOR(S): A.C.Hardy (for J.A.Leo)
PREPARED BY AUTHOR(S) AND/OR: N.O.P.S.

DATE OF ISSUANCE: 1968-69 Report of LRC/AEIC (Printed 1970)
OTHER IDENTIFIERS: Appendix C, Section 1 (pp L-50 thru L-62); data covers Nov. 1966 - Nov. 1967
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with N.O.P.S.
TOTAL: [PAGES 13 ;REFERENCES ;GRAPHS 5 ;TABLES 2]
DOCUMENT CLASSIFICATION(S): 40/1, 7, 8, 14, 24, 44

ABSTRACT:

The area selected for this test was one of the newest and largest subdivisions being developed in the N.O.P.S. service area. The ultimate goal of 1,000 homesites was being developed in 6 individual sections, with from 35 to 241 per section. [One section selected had 241 homesites completed and a second, with only 129, was partially completed at the time of test.] In the first section, 22 homes were chosen based on their being served by three transformers that had an average 12-months' use which was close to the average of the whole section. In the second section, there was not a sufficient history of energy use as a proper basis for a sample. Therefore, 20 homes were selected based on a history of occupancy and on being served by three transformers.

The 42 homes are all single-family dwellings; 22 were built by one builder and ranged from 1,400 to 2,000 sq. feet while 20 others were built by another builder and were either 1,400 or 1,600 square feet. The average home contained: 1,600 square feet, a brick exterior, modern insulation consisting of 3 5/8-in full batt fiber glass insulation in the walls and 6-in poured insulation in the ceilings, slab flooring, central electric air conditioning, central gas heating, gas water heating, and built-in kitchens with the same type and number of major appliances. Moreover, the customers in this test had a "saturation" of 2.4% electric ranges, 35.7% regular refrigerators, 64.3% frost-free refrigerators, 100% clothes washers, 16.7% electric dryers and 100% dishwashers.

For the first section, the regular watthour meter of each sample customer was replaced with a load survey recorder. Due to a limited supply of load survey recorders, in the second section individual watthour meters were replaced with thermal demand registers and a single load survey recorder was installed on each transformer to record the diversified data. Appropriate adjustments were made for street lighting and to compensate for the losses between the transformers and the customers.

Purposes of Study: to determine load characteristics - of the newer type residential customers being added in the N.O.P.S. service area - for use

in engineering, economic and rate studies and for sales department applications.

Summary of Major Findings:

1. The annual energy requirements were ≈14,500 KWH per customer.

2. Air conditioning accounted for about 65% of the summer and about 50% of the annual energy use.

3. The correlation of daily energy use per customer to daily mean temperature revealed a 3.4 KWH increase per degree-day above a mean of 66°F.

4. Highest monthly energy use per customer occurred during the summer and was more than 4 times that for the lowest month.

5. Monthly (maximum) diversified hourly summer demands generally occurred during the evening (4 - 6 p.m.) and were about 3 times those of the similar winter demands.

6. The per customer hourly demand of 4.2 KW, coincident with the system peak (6/27/67 at 2:00 p.m.), was ≈ 33% less than the maximum diversified hourly demand during the test period of 5.6 KW (6/19/67 at 6:00 p.m.).

7. Summer hourly demands were significantly greater than winter, for all hours of the day, with the smallest excess being in the early morning and the largest in the evening.

8. The annual load factor, based on the demand coincident with system peak demand, was 39.9%; based on maximum diversified demand it was 29.9%.

TITLE: RESIDENTIAL LOAD SURVEY

SOURCE: Philadelphia Electric Co. (Philadelphia, Pa.)

AUTHOR(S): W.F.Sundermeir (for R.C.Williams)
PREPARED BY AUTHOR(S) AND/OR: P.E.

DATE OF ISSUANCE: 1969-70 Report of LRC/AEIC (Printed 1971)
OTHER IDENTIFIERS: Appendix A, Section 1 (pp L-9 thru L-21); data covers June, July, Aug. & Dec. 1968
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.E.

TOTAL: [PAGES 13 ;REFERENCES 1 ;GRAPHS 12 ;TABLES 5] *
DOCUMENT CLASSIFICATION(S): 40/7, 9, 14, 31, 44, 46, 77

ABSTRACT: *[Graphs are grouped into 2 Charts. Three of Tables are unnumbered; the numbered Tables are composed of "sub-tables" containing comparative data for the various groups tested.]

Approximately a million customers are served on the residential rates, almost equally divided between the urban and suburban areas. The universe of customers was arranged into 12 subdivisions, 6 each for urban and suburban area customers, in accordance with their energy use during the 1967-68 winter period. Ten sample groups (of 39 customers each) were selected at random from each of the 12 subdivisions, using a systematic random sampling procedure. [One of the 10 sample groups from each of the subdivisions was selected for actual test, based on a comparison with its respective universe. Points of comparison between each sample group and its respective universe were: geographic distribution, average customer energy use and frequency distribution of such average energy use.]

The urban residences selected for test are primarily of the apartment and rowhouse types, with the average annual energy use for the test groups ranging from about 1,000 to about 8,200 KWH per customer. The suburban residences are primarily single-family, semi-detached and detached, homes with the average annual energy use for the test groups ranging from about 2,000 to about 10,000 KWH per customer.

The effective degree-hours for the months of June, July and Aug. (1968) were 1423, 3442 and 3383, respectively; the normal effective degree-hours for these 3 months are 1550, 3050 and 2395, respectively. The total degree-days for Dec., 1968, was 1010 compared to a normal total of 964.

Note: the data and conclusions presented in this survey do not include the effects of water heating because such loads are metered separately and excluded from these tests.

Purposes of Study: to obtain data from a (periodic) survey of residential customers for use in rate making, system planning and sales promotion.

[Note: The results of a previous survey were reported in the 1966-67 Report of the LRC. Since the parameters of the sample groups in each of these surveys are similar, some comparisons can be made with the previous survey; however, any comparisons should allow for the differences in temperature conditions for the 2 surveys.]

Summary of Major Findings:

1. In each of the test groups (except for the suburban area "largest use" group where there is a high saturation of electric ranges and dryers) a comparison of the load data from the 3 test weeks shows that the average weekday maximum diversified demand occurs during the "summer hot" week. Also, a comparison of the maximum diversified demand in each of the test weeks shows that the demands of the "summer hot" week are substantially higher than either the "summer cool" week or the winter week. [These data clearly reflect the importance of the space cooling load on the residential class of service.]
2. In the urban area, the loads for the "summer hot" average weekday are higher than those for the winter average weekday. [This is accounted for by the high saturation of space cooling equipment relative to the saturation of electric ranges and dryers.] In the suburban area, the loads for the "summer hot" average weekday are generally higher than those for the winter average weekday. Exceptions to this occur in 3 of the test groups where the loads around 7 to 8 a.m. are slightly higher in the winter, as well as for one test group where the load is slightly higher in the winter around 6 p.m. [These loads reflect a high saturation of electric ranges and dryers relative to the saturation of space cooling equipment.]
3. The load patterns for the "summer cool" average weekday are generally similar to but slightly lower than for the winter average weekday. Exceptions to this similarity occur during the morning and evening hours, due to the seasonal effect on the lighting requirements.
4. The average of the ratios for each sample group shows that the maximum summer month energy use exceeds that for Dec. by 43% and 10%, in the urban and suburban areas, respectively.
5. The average annual load factor (based on the average weekday maximum diversified demand) is 36% for the urban and 43% for the suburban area test groups. The annual load factor (based on noncoincident maximum demand) is 14% and 12% for the urban and suburban groups, respectively.
6. Tests conducted on hot weekdays (at 5:30 to 6:00 p.m.) show an average power factor of 83%, urban and 87%, suburban.
7. The 6 "urban area" Groups had monthly KWH usages per customer ranging, as follows: 81 to 757 (June); 109 to 1020 (July); 106 to 984 (Aug.); 76 to 728 (Dec.).
8. The 6 "suburban area" Groups had monthly KWH usages per customer ranging, as follows: 152 to 806 (June); 211 to 975 (July); 212 to 1001 (Aug.); 164 to 988 (Dec.).

TITLE: RESIDENTIAL STUDY

SOURCE: Virginia Electric and Power Co. (Richmond, Va.)

AUTHOR(S): C.E.Higgins, Jr. (for R.S.Gay)
PREPARED BY AUTHOR(S) AND/OR: V.E.&P.

DATE OF ISSUANCE: 1970-71 Report of LRC/AEIC (Printed 1972)
OTHER IDENTIFIERS: Appendix A, Section 1 (pp L-9 thru L-73); data covers 7/8 to 7/28, 1968 + 1/27 to 2/16, 1969
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with V.E.&P.
TOTAL:[PAGES 65 ;REFERENCES 2 ;GRAPHS 164 ;TABLES 5] *
DOCUMENT CLASSIFICATION(S): 40/7, 14, 15, 24, 44, 46

ABSTRACT: *[The Graphs are grouped into 50 Charts.]

Since 1957, when V.E.&P. experienced a shift from a winter to a summer peak, the summer one has grown more rapidly than that for the winter. To determine what contributions the various classes of service were making to these growing peaks, this study was conducted and its results have been used for both cost and rate analyses.

Separate, optimally-allocated stratified random samples of 400 each were selected from the residential service customers for the summer and for the winter load tests. For the summer test, KWH for Aug. and Sept. 1967 were used as the basis for stratification on each rate schedule and for allocation of sample customers to the resulting strata; similarly, for the winter test, KWH for Jan. and Feb. 1968 were used as the basis. [The residential class, as defined for this study, was made up of two rate schedules; namely, one covering customers without water heating on the basic residential meter and the other covering customers with water heating on the total-service meter.]

Prior to the actual testing of these customers, each one was interviewed by a Company representative to determine for each residence the number of residents, type of structure, connected load (by appliances) and other pertinent data. Since the sample customers for these two test periods were drawn from the entire residential classification, they include apartments (single floor and townhouse), duplexes, single-family homes (all numbers of levels and floors), trailers and residential-farms.

The half-hour (integrated) total-service KW demands of each sample customer were recorded simultaneously during their respective test periods on 30-day tapes using magnetic tape recorders designed for load research. After eliminating test cases due to meter malfunctions, indeterminate outages and improper setting of test equipment, the residential results cover 344 customers in the summer and 349 in the winter.

Purposes of Study: to provide statistically reliable data on the summer 1968 and winter 1968-69 total load characteristics of V.E.&P.'s resi-

dential service classification; to furnish information on the total-load characteristics for customer groups with similar appliance combinations.

Summary of Major Findings:

A) Summer Sample

1. The sample of 344 customers had an average total energy use of 516 KWH during the test period. The average annual energy use was 6,907 KWH (12 months ended Dec. 1968), compared to a system average of 6,835 during the same period.
2. The total-service (noncoincident) maximum demand per customer during the test period was 4.85 KW. The average annual load factor based on this demand was 16.3%.
3. The maximum (diversified) total-service demand per customer during the test period was 1.82 KW and occurred at 6 p.m. EDT on Wed., 7/24/68. Based on this demand, the annual load factor was 43.3%.
4. Again on 7/24/68, the maximum diversified demands per customer for those without air conditioning, those with unit air conditioning and those with central air conditioning were, respectively, 0.90, 2.63 and 4.64 KW. The respective annual load factors based on these demands were 63.8, 36.7 and 31.0%.

B) Winter Sample

1. The sample of 349 customers had an average total energy use of 429 KWH during the test period. The average annual energy use was 7,247 KWH (12 months ended June, 1969), coinciding with a system average of 7,247 during the same period.
2. The total-service (noncoincident) maximum demand per test customer was 4.27 KW. The average annual load factor based on this demand was 19.4%.
3. The maximum total-service (diversified) demand per customer during the test period was 1.37 KW and occurred at 7 p.m. EST on Sat., 2/15/69. Based on this demand, the annual load factor was 60.4%.

TITLE: RESIDENTIAL STUDY

SOURCE: Houston Lighting & Power Co. (Houston, Texas)

AUTHOR(S): T.A.Standish (for R.E.Ashburn)
PREPARED BY AUTHOR(S) AND/OR: H.L.&P.

DATE OF ISSUANCE: 1971-72 Report of LRC/AEIC (Printed 1973)
OTHER IDENTIFIERS: Appendix A, Section 1 (pp L-8 thru L-26); data covers Jan. 1 to Dec. 31, 1970
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with H.L.&P.
TOTAL:[PAGES 19 ;REFERENCES ;GRAPHS 3 ;TABLES 12] *
DOCUMENT CLASSIFICATION(S): 40/1, 2, 4, 7, 8, 14, 48

ABSTRACT: *[Four of Tables are unnumbered.]

This study provides a comparison of the relationship between energy use and peak demand for each home, based on its installed equipment, and offers information concerning the diversified demand obtained from groupings of comparable homes.

A total of 164 homes were metered. Fifty-three (4 channel) recorders were used to measure demands of customers served from overhead distribution lines. Homes were essentially metered in groups of three by recording the total-service load of each of them on each of the three demand channels. There were also 21 homes served from underground distribution lines which were metered individually with demand recorders. The demands, as recorded every 15 minutes, were combined into hourly demands for study purposes.

There are 44 homes in Group A representing about 5,600 such customers in the H.L.&P. service area. They meet all wiring specifications to permit the use of an electric range, dishwasher, disposal, clothes washer, 230-volt dryer and two or more 230-volt room air-conditioning units or central air conditioning; they did not meet standards for inclusion in Groups B or C. Floor area and air conditioning averaged 1,796 sq. ft. and 3.4 tons.

The 71 customers in Group B represent a population segment of about 28,000 homes. These homes meet all requirements of Group A and have built-in electric ranges and 3 or more optional equipment appliances which can include dishwasher, disposal, 230-volt room or central air conditioning or heat pump equipment and built-in refrigerator or food freezer. Floor area and air conditioning averaged 2,206 sq. ft. and 3.9 tons.

There were 49 total-electric customers in Group C, representing the 5,400 plus total-electric homes systemwide. They satisfy all requirements of Group A and have built-in ranges, space heating, cooling, water heating and one or more of the optional equipment appliances

listed under Groups A and B. Floor area and air conditioning averaged 1,999 sq. ft. and 3.5 tons.

Purposes of Study: to determine the load characteristics of 3 types of residential customers namely, Group A - wired for all-electric exclusive of space and water heating but having no specific major appliance requirements; Group B - all-electric except space and water heating but includes at least 3 major electric appliances; Group C - all-electric including heating and cooling systems. [These group characteristics were intended to aid incremental profitability and rate of return analysis.]

Summary of Major Findings:

1. The average annual KWH use per customer was: 15,486 (Group A); 19,961 (Group B); 30,934 (Group C); 10,590 (entire Service Area). The corresponding monthly ranges were: 637-2,354 (A); 831-3,020 (B); 1,937-4,023 (C); 469 to 1,613 for entire S.A.

2. The maximum KW diversified demand per customer for Groups A, B and C, respectively was: 4.9 (on 6/29 at 7 p.m. and also on 8/22 at 5 p.m.); 6.4 (on 7/7 at 6 p.m.); 11.4 (on 1/7 at 8 a.m.).

3. The annual load factor based on maximum diversified demand was 36.1, 35.6 and 31.0% for Groups A, B and C, respectively.

4. Although the homes in group C have electric water heaters, their average demand per customer at the time of the summer annual system peak was only 0.1 KW higher than for the homes in Group B which do not have electric water heaters. The effect of the water heaters on the demand in Group C is offset by the larger size home in Group B, which averaged 207 sq. ft. more area and contained 0.4 more tons of air conditioning than the average home in Group C.

TITLE: RESIDENTIAL STUDY

SOURCE: Carolina Power & Light Co. (Raleigh, N.C.)

AUTHOR(S): J.M.Davis, Jr. & B.J.Yarborough (for S.Behrends, Jr.)
PREPARED BY AUTHOR(S) AND/OR: C.P.&L.

DATE OF ISSUANCE: 1972-73 Report of LRC/AEIC (Printed 1974)
OTHER IDENTIFIERS: Appendix A, Section 1 (pp L-9 thru L-34); data covers summer 1970 + winter 1970-71
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with C.P.&L.
TOTAL:[PAGES 26 ;REFERENCES ;GRAPHS 12 ;TABLES 10] *
DOCUMENT CLASSIFICATION(S): 40/14, 15, 19, 22, 31, 46, 48

ABSTRACT: *[One Table is unnumbered. Graphs are grouped into 8 Charts.]

The customers studied were served on three residential rate schedules: R-2, Residential Service - All Electric; R-3, Residential Service - Water Heating; R-4, Residential Service - General. [The load study was accomplished by recording KWH usage data of sample customers at their individual service meter locations.]

Stratified random sampling was used to select the customers to be included in the load study. Bill frequency distributions (based on KWH usage in Aug., 1969) were obtained for each of the 3 residential rates: R-2, R-3 and R-4. Each rate was then divided into 4 strata (based on KWH usage) to achieve a high degree of homogeneity within each such subgroup. The average KWH usage for each subgroup was calculated and the KW demand was estimated for use in determining variance.

Customer-service representatives interviewed each customer and they were informed of the purpose of the testing and shown photographs of the actual testing equipment to be installed. Their permission was obtained and a load survey form was filled-in to indicate the type of residence and its electrical equipment. Demand information was recorded on magnetic tape by load survey recorders, on an individual customer basis. [Recorders were mounted on dual socket meter troughs, with the customer's original billing meter connected in series with the pulse initiating meter. Battery carry-over units were installed in 150 recorders. This carry-over capability allowed the recorder to maintain the correct time sequence on interruptions of as much as seven hours.] By computer programs the recorded demand data were analyzed on an individual customer and group basis for each calendar month.

Purposes of Study: to obtain statistically reliable data on the load characteristics of residential customers for use primarily in rate studies, with additional uses in engineering, sales profitability and load forecast studies; the determination of kilowatt demand and load factor information for each (of the 3) residential rate schedules noted above.

Summary of Major Findings:

1. The residential class reached its maximum (diversified) demand at 6:30 p.m. on 1/27/71; the average demand per customer at that time was 2.506 KW. [This demand was slightly higher than the 2.465 per customer at 6:30 p.m. (on 8/3/71), which was when the class reached its maximum diversified summer demand.]

2. The system service area (peak) demand occurred at 5:00 p.m. (on 8/31/70). Each residential rate's diversified KW demand per customer at the time of this peak was: 3.610 for R-2; 2.262 for R-3 and 1.183 for R.4. The average annual KWH use per customer was: 22,404 for R-2; 10,161 for R-3 and 4,966 for R-4. These KW demands and annual KWH values resulted in the following load factors: R-2, 70.84%; R-3, 51.27% and R-4, 47.92%.

3. Substantial (per customer) diversity existed, on all 3 schedules, between: (A) the noncoincident maximum demand and (B) the diversified demand at the time of the system summer peak and (C) the diversified demand at the time of the system winter peak. Thus for R-2; (A) was 13.655 KW and occurred in the winter; (B) was 3.610 and (C) was 7.235. And, for R-3: (A) was 6.796 KW (summer); (B) was 2.262 and (C) was 2.177. And, for R-4: (A) was 3.244 KW (summer); (B) was 1.183 and (C) was 0.918. The entire residential class [12.35%, R-2; 59.98%, R-3 and 27.67%, R-4] developed, in Jan. 1971, a noncoincident maximum demand of 6.269 KW/customer. The diversified demands were 2.127 KW for the summer system peak and 2.452 KW for the winter system peak.

4. Load curves for the average weekday (and for days of class and system peak demands) all showed similar profiles. The winter peak periods had a pronounced peak between 6:00 and 7:00 p.m., EST; a pronounced, but lesser peak, occurred between 7:00 and 8:00 a.m. [Rate R-2 was the only residential class which reached a winter peak demand in the morning period.] The system winter peak demand occurred between 6:00 and 7:00 p.m.

The summer peak periods had dual evening peak demands. The first was reached between 5:00 and 6:00 p.m., EDT, with a second between 8:00 and 9:00 p.m. when darkness had set in. [Each residential rate followed this characteristic dual peak curve.] The system summer peak occurred earlier, between 4:00 and 5:00 p.m.

TITLE: RESIDENTIAL STUDY

SOURCE: Public Service Electric and Gas Co. (Newark, N.J.)

AUTHOR(S): P.F.Platt (for G.Clarkson)
PREPARED BY AUTHOR(S) AND/OR: P.S.E.&G.

DATE OF ISSUANCE: 1972-73 Report of LRC/AEIC (Printed 1974)
OTHER IDENTIFIERS: Appendix B, Section 1 (pp L-35 thru L-102); data covers Sept. 1970 thru Aug. 1971
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.S.E.&G.
TOTAL: [PAGES 68 ;REFERENCES ;GRAPHS 157;TABLES 20] *
DOCUMENT CLASSIFICATION(S): 40/14, 19, 31, 46

ABSTRACT: *[Four of the Tables are unnumbered; the 2 Tables that are formally numbered are each made up of 8 "sub-Tables", which report data for 8 groups differentiated by their annual use characteristics. The Graphs are grouped into 42 Charts.]

Test data from 8 groups of customers were obtained by installing magnetic tape load survey recorders to measure 30-minute integrated demands. Data from the tapes were translated to load survey cards and the acceptable data was processed on a computer system. [The annual KWH ranges for groups 1 thru 8 were, respectively: 0-168, 169-480, 481-1200, 1201-2400, 2401-3600, 3601-6000, 6001-12000 and over 12000.]

The customers were selected by systematic random sampling according to annual KWH use. The number of customers chosen was sufficiently large to include replacement customers, in the event of customer refusal or metering difficulties.

Load data were studied on a monthly basis to derive average load curves and related information. Customers with various appliance combinations were studied as separate entities. [Note: When analyzed separately, there were not always enough customers in certain appliance groups for statistical reliability.]

Purposes of Study: to determine load characteristics for residential electric customers served on the rate schedule RS, Residential Service, for each month of the test year; to provide updated and statistically reliable information for use in: estimating electric demands for service requirements, developing cost determinants, continuing rate studies and helping to forecast short- and long-term system peak loads.

Summary of Major Findings:
1. Except for Group 1, the annual maximum demand occurs during the summer between 5:30 and 10:00 p.m. [Group 1 maximum occurs in March at 5:30 a.m.]

2. Except for Group 1, the winter maximum demands are reached after darkness between 6:30 and 9:30 p.m. [The maximum for Group 1 occurs at 6:30 a.m.]

3. With the exception of Group 1, the annual load factor based on maximum diversified demand ranges from 21.2 to 32.0%. [For Group 1 it is 8.7%.]

4. Annual % load factors, based on noncoincident demand, increased progressively from 2.0 (Group 1) to 17.5 (Group 2). The biggest change was from Group 1 to Group 2 (at 6.8%).

5. The annual coincidence factor ranges from 23.6% for Group 1 to 61.7% for Group 8.

6. Annual KWH use per customer ranges from 87 for Group 1 to 18,364 for Group 8.

7. Load curves for the summer months (for all groups with high saturation of air conditioning) show the effect of temperature sensitivity.

TITLE: RESIDENTIAL STUDY: NON SPACE HEATING CUSTOMERS

SOURCE: Consumers Power Co.

AUTHOR(S): J.H.Climen & C.F.Belknap (for W.J.Jefferson)
PREPARED BY AUTHOR(S) AND/OR: Consumers Power Co.

DATE OF ISSUANCE: 1972-73 Report of LRC/AEIC (Printed 1974)
OTHER IDENTIFIERS: Appendix C, Section 1 (pp L-103 thru L-133); data covers 12 months ending 12/31/70
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with C.P.C.

TOTAL: [PAGES 31 ;REFERENCES 1 ;GRAPHS 8 ;TABLES 5] *
DOCUMENT CLASSIFICATION(S): 40/8, 14, 17

ABSTRACT: *[Graphs are grouped into 6 Charts.]

Within the scope of this study, a sample of 120 non space heating residences were metered. This sample provides reliable data concerning this class of customer. The sample size allowed for division into three subgroups: Group I contains customers whose monthly use was less than 300 KWH, Group II was for use between 300 and 600 KWH and Group III contains customers whose monthly use was over 600 KWH. [Note: Two customers were eliminated for grouping purposes due to the lack of quality data.]

Purposes of Study: to provide comprehensive cost of service data for all classes of electric customers.

Summary of Major Findings:

A. Total Sample

1. The average annual KWH use per customer was 6,206 for the sample customers and 6,033 for the corresponding universe. This represents a difference of approximately 2.9%.
2. The maximum half-hour (diversified) demand during the study was 1.53 KW and occurred between 7:00 and 7:30 p.m. on Monday, Dec. 21.
3. Monthly maximum (diversified) demands varied from 1.18 KW in July to 1.53 in Dec. Such demands always occurred in the evening. The earliest occurrence was in Jan. between 6:00 and 6:30 p.m., and the latest was in Apr., June and July between 9:00 and 9:30 p.m.
4. The highest average (noncoincident) demand, of 4.45 KW per customer, occurred in Dec. [The annual average was 4.27 KW.]
5. The annual load factors, as based on maximum (diversified) demand and on average (noncoincident) demand, are 48.2 and 16.6% respectively.
6. Diversified demand at the time of the system peak was considerably lower than the corresponding maximum (diversified) demand for each of the months studied.
7. Maximum (diversified) demand for the annual average weekday was 1.05 KW. The maximum (diversified) demand for the annual average day was 1.01 KW. Both occurred between 8:30 and 9:00 p.m.
8. The three groups' coincidence factors, based on monthly maximum (diversified) demand, ranged from 27.0% in May to 34.4% in Dec.

B. Group I, Monthly Usage 0-300 KWH

1. The average annual KWH use per customer (32 customer base) was 2,219.
2. The maximum half-hour (diversified) demand during the study was 0.81 KW and occurred on Thursday, Dec. 24, between 7:00 and 7:30 p.m.
3. Monthly maximum (diversified) demands varied from 0.40 KW in Apr. to 0.81 in Dec. Such demands occurred 6 times during weekends.
4. The highest average (noncoincident) demand, of 2.40 KW per customer, occurred in Oct. [The annual average was 1.95.]
5. The annual load factors, as based on maximum (diversified) demand and on average (noncoincident) demand, are 31.3 and 13.0%, respectively.
6. Monthly maximum (diversified) demand and the system maximum demand never occurred simultaneously.
7. Maximum (diversified) demand for the annual average weekday and for the annual average day was 0.38 KW and occurred between 8:00 and 8:30 p.m.
8. The group coincidence factors, based on monthly maximum (diversified) demand, ranged from 25.1% in June to 41.9% in Feb.

C. Group II, Monthly Usage Between 300 and 600 KWH

1. The annual average KWH use per customer (50 customer base) was 5,525.
2. The maximum half-hour (diversified) demand for the year was 1.50 KW and occurred on Monday, Dec. 21, between 7:00 and 7:30 p.m.
3. Monthly maximum (diversified) demands varied from 0.97 KW in July to 1.5 in Dec. Such demands always occurred in the evening, including 6 times on a Monday.
4. The highest average (noncoincident) demand, of 4.25 KW per customer, occurred in Dec. [The annual average was 3.91.]
5. The annual load factors, as based on maximum (diversified) demand and on average (noncoincident) demand, are 42.0 and 16.1% respectively.
6. Maximum (diversified) demand for the annual average weekday was 0.92 KW and occurred between 8:00 and 8:30 p.m. For the annual average day, it was 0.91 KW and occurred between 9:00 and 9:30 p.m.
7. The group coincidence factors, based on monthly maximum (diversified) demand, ranged from 25.5% in July to 35.4% in Dec.

D. Group III, Monthly Usage in Excess of 600 KWH

1. The annual average KWH use per customer (36 customer base) was 10,726.
2. The maximum half-hour (diversified) demand for the year was 2.74 KW and occurred on Thursday, Jan. 8, between 8:30 and 9:00 p.m.
3. Monthly maximum (diversified) demands varied from 2.19 KW in May to the high of 2.74 in Jan. Such demands occurred 7 times on a Monday evening. [Diversified demands occurred in the late evening in 11 months.]
4. The highest average (noncoincident) demand per customer occurred in Jan. and was 7.18 KW. [The annual average was 6.88.]
5. The annual load factors, as based on maximum (diversified) demand and on average (noncoincident) demand, are 44.7 and 17.8% respectively.
6. Maximum (diversified) demand for the annual average weekday was 1.80 KW and occurred between 6:30 and 7:00 p.m. Similarly, for the annual average day it was 1.75 KW and occurred at the same time.
7. The group coincidence factors, based on monthly maximum (diversified) demand, varied from 32.1% in May to 39.6% in Feb.

TITLE: RESIDENTIAL CUSTOMER LOAD STUDY

SOURCE: Rochester Gas and Electric Corp. (Rochester, N.Y.)

AUTHOR(S): P.Punt (for C.S.Kellogg)
PREPARED BY AUTHOR(S) AND/OR: R.G.&E.

DATE OF ISSUANCE: 1974-75 Report of LRC/AEIC (Printed 1976)
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DATA USE RESTRICTIONS: "Not to be published or quoted"; check with R.G.&E.
TOTAL: [PAGES 24 ;REFERENCES 1 ;GRAPHS 8 ;TABLES 8] *
DOCUMENT CLASSIFICATION(S): 40/1, 2, 7, 12, 14, 27, 49

ABSTRACT: *[One Table is unnumbered; another Table is made up of 5 "sub-Tables" of various KWH groups. Graphs are grouped into 6 Charts.]

Stratified random sampling was used to select "sample" customers. A billing frequency, based on annual energy use, was divided into 6 sub-groups. The limits of the first group (annual use less than 1,801 KWH) and of the sixth group (annual use greater than 14,400 KWH) were preset, based on judgment. Values between 1,801 and 14,400 were then stratified into 4 groups so as to optimize homogeneity for each of the four; the initial number in each stratum was 40, 37, 44 and 48 for groups designated 1, 2, 3 and 4 respectively.

The 4 preceding groups represent 87.1% of the number of, and 87.5% of the energy sold to, the residential customers. The first and sixth stratum were eventually eliminated from further considerations and 4 sets of random numbers were generated to select sample customers from each of the four strata. Interviews were used to obtain customer characteristics, with emphasis on connected electric appliances. Demand information on a 15-minute basis was recorded on magnetic tape survey recorders. [Sample customer's attrition was foreseen at the outset by installing recorders on a few more than the planned number in each stratum.]

Purposes of Study: to determine the monthly and annual load characteristics of residential electric customers; to provide updated and statistically reliable information on the contribution to the Rochester system peak by the residential class. [Note: The study was extended 2 months so as to evaluate the effect of energy conservation on load characteristics.]

Summary of Major Findings:

A. Total Sample

1. The maximum (diversified) demand - after normalizing Dec. data to reflect energy conservation - is 1.516 per customer (for Dec.) and 1.420

(for Aug.) The (noncoincident) maximum demand is 3.861 KW per customer (in Aug.) and 4.250 (in Dec.)
2. Annual load factors (based upon the Dec. maximum demands) have improved when compared with those for a 1966 study. [This improvement is due to the addition of certain summer loads (namely air conditioners and swimming pool filters). The filters, with their factory-recommended 24-hour duty cycle, are calculated as adding 1,441 KWH per installation to the summer energy use. Window air conditioners and central air conditioning, during this particularly warm summer, added 581 and 2,182 KWH (respectively) per installation to the summer energy use.]
3. Of the annual energy, 44% is used on peak (8 a.m. to 9 p.m., weekdays only). In the winter more energy is used during weekends; in the summer, less. On an annual basis, average daily weekend use approximates average weekday use.
4. During the summer, 7 of the 8 sample customers with central air conditioners and 32 of the 51 sample customers with window air conditioners impress their (noncoincident) maximum demand for the year.
5. Variations in annual energy use per customer are related to appliance saturation with the electric range, freezer, dryer, central air conditioner and swimming pool filter accounting for most of the differences.
6. Data derived on a "calendar month" basis are not directly transferrable to a "billing month" basis, particularly during the months of greatest seasonal change (May and Sept.). The Sept. (calendar month) energy use and (noncoincident) demand of 473 KWH and 3.683 KW per customer compares with a Sept. (billing month) energy use and (noncoincident) demand of 534 KWH and 3.789 KW.
7. Energy use curves for the winter best correlate with daily heating degree-days (HDD) as essentially linear relationships. Even though the sample population did include a few customers with electric water heating and no customers with electric space heating, it is noteworthy that a high correlation exists between HDD and incremental energy use. This correlation is attributed to the use of auxiliary heating installations and furnace ancillary equipment such as the blower motor, hot water circulation pump and oil furnace fuel injection. [Daily energy use on a 63 HDD increases by about 3 KWH, or 20%, when compared with that for a 25 HDD.]
8. At the time of the summer system peak (9/4/73) customers without air conditioners impress a one-hour diversified demand of 0.779 KW, whereas customers with air conditioners impress 2.530 KW. At the time of the winter system peak (1/8/73) those customers without air conditioners impress a one-hour diversified demand of 1.766 KWH, whereas those customers with air conditioners impress 1.515 KW. On an annual rather than a seasonal basis, customers with air conditioners contribute 43% more to the system peak. Each group's annual energy use is comparable; namely 5,552 vs 5,634 KWH per customer, respectively.

B. Subgroups

1. The annual maximum (diversified) demand for groups 1, 2 or 3 occurs during the winter between 5 and 7:30 p.m.; for group 4 it occurs in Aug.,

during the half-hour ending at 5 p.m.
2. The summer maximum (diversified) demand for each group is between 4 and 10 p.m.; the corresponding winter value occurs between 5 and 7:30 p.m.
3. Annual load factors (based on maximum diversified half-hour demands) are 39.6, 40.1, 40.8 and 47.0% for groups 2, 3, 4 and 1 respectively.
4. Annual load factors (based on noncoincident maximum half-hour demands) are 12.5, 14.5, 15.0 and 15.9% for groups 2, 3, 4 and 1 respectively.
5. Annual coincidence factors are 31.6, 33.9, 36.1 and 36.8% for groups 2, 1, 3 and 4, respectively.
6. Annual use per customer averages 2,643; 4,875; 6,887 and 10,655 KWH for groups 1, 2, 3 and 4, respectively. The range of individual customer's annual (noncoincident) maximum half-hour demand (for groups 1, 2, 3 and 4, respectively) is 1.05-3.65; 2.00-7.65; 2.70-9.80 and 4.65-10.55 KW.
7. Average daily use per customer almost doubles from 26 KWH at 66°F to 51 KWH at 85°F. (Based on data from Group 4, for Aug.)

Energy Conservation:

Comparison between energy use for the winters of 1973 and 1974 reveals the effect of conservation on energy use. The difference is due to the lowering of thermostat settings which, as has been found with gas customers, has a greater effect at relatively mild temperatures than at "bitter cold" temperatures. Thermostat setbacks reduce the hours of operation, particularly at the milder temperatures. It is calculated that a thermostat setback loses its effect at an equivalent 71 HDD. This equivalency of an extremely cold day is higher than might be expected, due to auxiliary heating installations which remained shut off.

Customers used about 9.1% less energy in the winter of 1974 than in the winter of 1973 (Dec. thru Feb.). It is calculated that: 1.7%, or 29 KWH, is due to lower thermostat settings and reduced use of auxiliary heating installations; 0.7%, or 12 KWH, to fewer Christmas lights; 6.7%, or 113 KWH, to less intensive use of other electric loads. [The less intensive energy use also reveals itself when comparing the load factor and coincidence factor during the two winter periods; for 1973 the load factors, based on maximum diversified demand and on noncoincident demand, were respectively 54.0 and 19.1%, as compared to 1974 values of 51.8 and 17.1%. Accordingly, the coincidence factor reduced from 35.4 in 1973 to 34.7% in 1974.]

TITLE: STUDY of RESIDENTIAL CLASS LOADS on MONTHLY WISCONSIN ELECTRIC NATIVE SYSTEM PEAK DAYS

SOURCE: Wisconsin Electric Power Co. (Milwaukee, Wisc.)

AUTHOR(S): R.J.Vinent; et al (for E.R.Watrous)
PREPARED BY AUTHOR(S) AND/OR: W.E.P.

DATE OF ISSUANCE: 1974-75 Report of LRC/AEIC (Printed 1976)
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TOTAL: [PAGES 50 ;REFERENCES 1 ;GRAPHS 3 ;TABLES 6] *
DOCUMENT CLASSIFICATION(S): 40/14, 15, 46, 48

ABSTRACT: *[Only 3 of the Tables are formally numbered and 2 of these 3 are made-up of 12 monthly "sub-Tables". Actually the 3 Graphs (called "Charts") consist of 27 monthly and seasonal plots.]

[The Residential classes encompass 87.9% of the 630,000 customers served by Wisconsin Electric and constitute 30.8% of the KWH sales]. The selection of the 530 "sample" customers was done through the use of a stratified random sample, which was based on the latest available KWH analysis. The sampling produced a 95% confidence level by the use of 303 Regular Residential (Rate 11) and 227 Residential All-Electric (Rate 14) test sites. The upper KWH bounds of the 5 (final) stratification blocks were as follows: for Rate 11 - 250, 450, 700, 1200, 2000 and for Rate 14 -- 600, 950, 1400, 2250, 3000. The customers which had monthly usage above 2000 and 3000, respectively, were not sampled since a large number would have had to be selected to adequately cover these diverse "tail groups"; their characteristics were simply estimated from those of the last sampled stratum.

Each sample customer completed a confidential questionnaire which included information about the residence, family and the family's appliance load. The collection of demand data was conducted through the use of magnetic cassette and magnetic cartridge survey recorders. The magnetic tapes, which recorded information on 15 minute intervals, were collected monthly and processed at a central location.

Purposes of Study: to provide information about the load characteristics of the principal classes of customers served by the Company; to examine the load characteristics of residential customers on the day of the monthly Wisconsin Electric Native System (W.E.N.S.) peak. [Note: The customers studied fall under the Regular Residential Rate (those without electric water or space heating) or the Residential All-Electric Rate, those with electric water heating and in some cases both water and space heating.]

Summary of Major Findings:

1. The Regular (Rate 11) diversified demand, on the day of the monthly maximum system demand, occurs between 4:00 and 9:00 pm (CST) regardless of the season of the year.

2. The All-Electric (Rate 14) maximum (diversified) demand, on the monthly system peak day, was not predictable either in time of occurrance or seasonal variation.

3. The W.E.N.S. and Rate 11 peak day load has a greater coincidence in the winter than in the summer.

4. The W.E.N.S. and Rate 14 peak day load profiles were essentially the same during Jul. and Aug.

5. All usage strata had higher demands during the summer months, except for the 2250 to 3000 KWH stratum of the Rate 14 Class.

6. The daily load factors for Rate 11 show a seasonal pattern, being higher during the summer months.

7. The Rate 14 load factors have no distinct pattern, however, the Rate 14 daily load factor is generally higher than that for Rate 11, in any given month.

8. Within Rate 11, the daily load factor of the low usage strata is generally lowest and more prone to change from month to month.

9. Average KW demand per customer (at time of "Native System Peak") for the "Regular Residential" Class: Block 1, 0.59 summer (s) and 0.49 winter (w); Block 2, 1.19 (s) and 0.82 (w); Block 3, 1.80 (s) and 1.34 (w); Block 4, 2.80 (s) and 1.71 (w); Block 5, 4.59 (s) and 2.46 (w).

10. Average KW demand per customer (at time of "Native System Peak") for the "Residential All-Electric " Class: Block 1, 1.17 (s) and 1.06 (w); Block 2, 2.83 (s) and 1.79 (w); Block 3, 3.00 (s) and 2.43 (w); Block 4, 4.13 (s) and 3.86 (w); Block 5, 5.31 (s) and 7.02 (w).

TITLE: RESIDENTIAL ELECTRIC CUSTOMER LOAD STUDY

SOURCE: Potomac Electric Power Co. (Washington, D.C.)

AUTHOR(S): W.E.Davis, Jr. & T.C.Butash (for F.S.Walters)
PREPARED BY AUTHOR(S) AND/OR: P.E.P.

DATE OF ISSUANCE: 1974-75 Report of LRC/AEIC (Printed 1976)
OTHER IDENTIFIERS: Appendix D, Section 1 (pp L-106 thru L-141); data covers Aug. 1973 and Jan. 1974
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.E.P.

TOTAL:[PAGES 36 ;REFERENCES 1 ;GRAPHS 40 ;TABLES 4] *
DOCUMENT CLASSIFICATION(S): 40/7, 8, 14, 15, 19, 22, 24, 31, 33

ABSTRACT: *[Two of Tables are unnumbered; one of the numbered Tables is actually a composite of 9 "subtables" representing various (increasing) KWH ranges, which differ for summer and winter. The Graphs are grouped into 4 Charts.]

A bill analysis program was developed to summarize the billing data for various stratified KWH ranges. After analyzing trial results from the bill analysis program, the residential class was divided into 10 groups to yield an equal number of KWH for each group. Under closer examination, however, it was found that the first group contained over one fourth of the total number of residential customers; consequently, the first group was again divided into two groups of an equal number of KWH, resulting in 11 groups. [It was hoped that this stratified grouping by KWH would tend to distribute the coincident kilowatt class demand equally among the 11 groups.]

The customers who agreed to participate in the survey study were interviewed to determine what appliances they had, dwelling unit size, type of dwelling constuction, number and ages of occupants and other related data. Survey recorders were then installed at the service meter location of each of the customers in the survey. These recorders, equipped with magnetic cartridge tapes, recorded the customer's KWH use for every 15-minute interval for each of the study months. The data on the magnetic cartridge tapes were then translated to magnetic tape. The translated tape was then processed by programs which allowed a thorough analysis of each individual customer, group and the residential class.

Analysis of the data from the summer survey indicated the need for restructuring the original 11 groups, which resulted in the present 9 groups. Certain problems combined to reduce the number of residential survey customers from an expected 482 to the present 374 and 387, respectively, for summer and winter. [The customers were regrouped using actual survey data and methods similar to those employed to stratify the original 482 customers into 11 groups.] The same procedure was used in conducting the interviewing and collection and analysis of data for the winter

(1973-74) survey. The residential selection process was slightly modified in order to retain as many possible summer customers who would also be suitable for the winter survey.

Seven major data categories were evaluated for each group, namely: energy use (KWH) per customer, maximum demands (KW) per customer, load factor, coincidence factor, diversity factor, weather parameters and electric appliance saturations. Each major category was further subdivided into such divisions as monthly, annual, diversified, coincident, noncoincident, weekday and weekend data. Weighting factors were used for the various groups which were derived from the ratio of the number of residential bills, whose monthly KWH use fell within the limits of the group, to the total number of residential bills for the given month; zero KWH bills are excluded.

Purposes of Study: to determine various load characteristics of residential electric customers within the P.E.P. portion of the Washington, D.C. Metropolitan area; to acquire data for a statistically accurate base for future studies involving the estimation of electric demand and associated distribution service requirements, cost allocation studies, forecasting of system service area peak loads, and rate studies.

Summary of Major Findings:

1. The maximum diversified demands (MDD) for all Groups occurred in Aug., between 3:00 and 10:00 p.m.
2. Groups 1 thru 8 - which had electric heating saturations of less than 6% - experience their winter MDD between 6:00 and 9:00 p.m.; for Group 9, which had a significant saturation of electric heating, this demand occurred at 8:00 a.m.
3. All groups had electric air conditioning saturations in excess of 50% and experienced their summer MDD between 3:00 and 10:00 p.m.
4. For all groups, the ratio of the diversified demand (at the time of the system peak) to the MDD is greater during the summer than during the winter test period. Also as the KWH use increases so does the coincidence factor.
5. During the winter, there were negligible differences between the MDD for weekend days and weekdays . Groups 3, 4, 5 and 7 and the class as a whole attain their MDD on weekend days, while 1, 2, 6, 8 and 9 experience their MDD on weekdays.
6. During the winter test months all groups (except 9) had average weekday load shapes which exhibit MDD between 6:00 and 10:00 p.m., with somewhat lesser peaks between 6:00 and 10:00 a.m. Group 9 has an average weekday load shape with a MDD in the morning hours, followed by an evening peak of lesser magnitude.
7. The average weekday load shapes, for the summer test month, have their MDD values during the evening hours for all groups.
8. The average KWH use per customer was about 1090 in Aug. and 717 in Jan.
9. The average annual KWH consumption by the 374 summer customers was 9,408; it was 11,089 for the 387 winter customer.
10. The MDD - for Monday thru Friday - was about 2.84 KW for the summer customers and about 1.57 KW for the winter customers.

TITLE: RESIDENTIAL CUSTOMER LOAD STUDY: LOW-USE RESIDENTIAL (Domestic) CUSTOMERS

SOURCE: Detroit Edison (Detroit, Mich.)

AUTHOR(S): A.P.Slominski (for L.E.Brandenburg)
PREPARED BY AUTHOR(S) AND/OR: D.E.

DATE OF ISSUANCE: 1975-76 Report of LRC/AEIC (Printed 1977)
OTHER IDENTIFIERS: Appendix A, Section 1 (pp L-9 thru L-20); data covers 12 months ending 12/31/74
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with D.E.

TOTAL:[PAGES 12 ;REFERENCES ;GRAPHS 9 ;TABLES 5] *
DOCUMENT CLASSIFICATION(S): 40/6, 14, 31, 46

ABSTRACT: *[One Table is unnumbered. Graphs are grouped into 4 Charts.]

A random sample of 5,650 residential customers was selected and stratified by average monthly use over the 12-month period. From the 100 to 200 KWH/month strata, a random sample of 49 "low-use" customers was then selected for metering; included were 28 single and 15 multiple family homes plus six apartments. Demands were recorded for 30-minute intervals but are summarized as 60-minute integrated demands. Equipment failures, vandalism, errors in tape changes, long periods of vacancy, and occupancy changes (accompanied by unusually high increases in monthly use) resulted in the exclusion of 14 accounts from the analysis.

Purposes of Study: to compare and contrast the seasonal energy use patterns and demands, on the days of the 12 monthly system peaks in 1974, of low-use customers with those of the average D.E. domestic customer, excluding water heating use and "all-electric" installations. [Note: the customers in the sample are included in the domestic (rate) class; none had electric water or space heating.] "Low-use" customers were defined as those with monthly energy use averaging between 100 and 200 KWH for the 12-month period of the initial sample selection. Month-to-month variations were, in general, between 75 and 300 KWH.

Summary of Major Findings:
1. They account for an estimated 24.6% of D.E.'s 1,495,000 domestic customers but for less than 10% of the annual sales to this rate class.

2. Their monthly use pattern is similar to that of the whole domestic class (w.d.c.) but had a slightly higher % during the winter.

3. Their maximum diversified demand occurred at 9 pm on July 9 (annual system peak day) and maintained high demands through the night-time hours when the (w.d.c.) also had its peak.

4. The daily load patterns were similar to those of the (w.d.c.), altho night-time loads were disproportionately lower. On the system peak days

for April, July, Oct. and Dec., their energy use from 1 to 8 am was 22% of the daily total; the corresponding value for the (w.d.c.) was 26%.

5. Five of the 26 survey accounts included in the July data had air conditioning. Excluding those five, the diversified demand per customer (at system peak) was reduced from 0.53 to 0.29 KW/customer. The maximum diversified demand for July was 35% lower, excluding low-use air conditioning customers, but July energy use decreased only 4% and annual use was virtually unchanged.

6. At the time the sample was selected, all 35 customers used between 100 to 200 KWH per month. By the end of the test period, the average use of customers was over 200 while at 5 locations it was below 100. However, the average of the sample remained in the 100 to 200 range and had not increased significantly during the test period. Customer changes and periods of vacancy (in some instances with no indicated change in the customer of record) did create data collection and analyses problems.

TITLE: RESIDENTIAL STUDY

SOURCE: Virginia Electric and Power, Co. (Richmond, Va.)

AUTHOR(S): S.E.King & J.A.Ruble (for R.S.Gay)
PREPARED BY AUTHOR(S) AND/OR: V.E.&P.

DATE OF ISSUANCE: 1975-76 Report of LRC/AEIC (Printed 1977)
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TOTAL: [PAGES 27 ;REFERENCES 1 ;GRAPHS 24 ;TABLES 3]*
DOCUMENT CLASSIFICATION(S): 40/14, 15, 46, 48

ABSTRACT: *[The Graphs are grouped into 12 Charts.]

An optimally-allocated stratified random sample of 200 customers was selected from the Company's residential service customers. Half-hour integrated total-service KW demands were recorded simultaneously during the test period on monthly tapes. KWH for the months of June through Sept. 1973 were used as the basis for stratification of the customers and for allocation of sample customers to the resulting strata. Because the selected sample was stratified, all of the results presented in this report are weighted results of the strata and rates.

The residential class as defined for this study was made up of two rate schedules; namely, customers with and without electric water heaters. The dwelling units for these sample customers were of no particular type and included apartments (single floor and townhouse), duplexes, single-family homes (varying numbers of levels and floors), trailers and residential farms. Due to meter malfunctions, indeterminate outages and improper setting of test equipment, the results are for 186 customers in Aug. and 194 in Jan.

Purposes of Study: to provide statistically reliable data on the total load characteristics of the Company's residential service classification, to determine the contributions that the various classes of service were making to growing summer peaks, and to obtain information about load factors.

Summary of Major Findings:
1. The customers had average total monthly uses of 1,059 KWH during the Aug. (summer) peak and 921 KWH during the Jan. (winter) peak. Their average total energy use was 9,712 KWH for year ending Oct. 1975.

2. The total-service (non-coincident) maximum demands per customer were 6.65 KW for Aug. and 5.98 for Jan. The annual load factors based on these demands were 16.7% (Aug.) and 18.5% (Jan.).

3. The maximum total-service (diversified) demand per customer was 2.88 KW, occurring during the half-hour ended 6 pm EDT on Tues., Aug. 26, 1975; based on this demand, the annual load factor was 38.5%. The corresponding value for Jan. was 2.04 KW, on Tues., Jan. 14, 1975, during the half-hour ending at 8 pm EST; the annual load factor based on this demand was 54.3%.

4. Looking at the load curves for the average weekday: it can be seen that for Aug. the load decreases until 4:30 a.m., EDT, then steadily rises until 6 p.m., EDT (which is the peak), decreases until 8:30 p.m. EDT (when a small secondary peak occurs until 9:30 p.m. EDT) and then sharply decreases for the remainder of the day. In contrast, the Jan. load curve rises sharply to a secondary peak at 7:30 a.m. EST, drops until midafternoon, rises to its peak at 6:30 p.m., EST and then slowly decreases for the rest of the 24-hour period.

Note: In preliminary work to determine an adequate sample size for this Study, it was found that 200 samples would be needed for a 2.21% margin of error (based on KWH) at a 95% confidence level. The sample of 200 customers designed for load research purposes produced a coefficient of variation of 1.29%. For the residential customers tested, the KWH per customer are within 2% of V.E.&P.'s billing record KWH figures. [All methods used for sampling, and calculation of sampling accuracy, are according to "Stratified Random Sampling Methods for Class Load Surveys for Electric Utilities" by C.E.Higgins, Jr., as printed in the AEIC Applied Statistics in Load Research, Vol. III; July, 1974.]

TITLE: A COMPARISON of AVERAGE RESIDENTIAL CLASS LOADS

SOURCE: Wisconsin Electric Power Co. (Milwaukee, Wisc.)

AUTHOR(S): P.H.Holtz & E.R.Watrous
PREPARED BY AUTHOR(S) AND/OR: W.E.P.

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TOTAL: [PAGES 22 ; REFERENCES 1 ; GRAPHS 12 ; TABLES 5] *
DOCUMENT CLASSIFICATION(S): 40/12, 14, 15, 46, 48

ABSTRACT: *[One of Tables in unnumbered.]

This report covers a period which extended from Nov. 1973 through Oct. 1975. Nov. 1973 through Oct. 1974 was designated as Period I; months during which there was substantial emphasis on energy conservation. Period II is made up of the months from Nov. 1974 through Oct. 1975; during Period II there appeared to have been a significant waning of the emphasis on energy conservation.

The original sample consisted of 530 customers selected by a stratified random sampling technique, which gave an initial 95% confidence level. Each of the selected customers were interviewed to request their participation in the study. Each customer completed a questionnaire which included information concerning the residence, family and appliances owned. Survey recorders were used to collect demand data by 15-minute intervals; individual tapes were collected and processed on a monthly basis. The Regular Residential Class (no electric space or water heating) of about 450,000 customers was represented by a sample of 303; the Residential All-Electric Class (electric water heating) of about 110,000 customers was represented by 227. [As of Oct. 1975, there were 267 Regular Residential and 177 Residential All-Electric customers still involved in the survey.] The overall debasement of the sample caused a decrease in the confidence level from about 95% to 85%.

Purposes of Study: to compare, over a 2 year period, load characteristics on similar days during the week in which the monthly Wisconsin Electric Native System Peak occurred; to examine the effects of the conservation ethic brought about by the Arab Oil Embargo of Nov. 1973; to examine the "erosion" of the original test sample and the reasons for this erosion.

Summary of Major Findings:

1. For a majority of the days, Period I coincident and class maximum diversified demands were lower than for the corresponding Period II demands.

2. During the early morning and late evening hours, Period I hourly demands were lower than those for the corresponding demands in Period II, during most months.

3. The Period I "Regular Residential" total KWH usages, during a majority of the selected weekdays, were lower than the corresponding Period II usages.

4. Class maximum diversified KW demands, for the "Regular Residential" Class, ranged from 0.73 (June) to 1.76 (Aug.) during Period I and from 0.77 (May) to 1.84 (Aug.) during Period II. Corresponding values for the "Residential All-Electric" Class were: 1.69 (June) to 2.85 (Aug.) during Period I and from 1.72 (Oct.) to 3.56 (Jan.) during Period II.

5. Range of average KWH usage per customer on similar weekdays (for the various months) were, as follows:

(a) Regular Residential, Period I; 12.0 (May) to 26.2 (Aug.).
(b) Regular Residential, Period II; 13.4 (Oct.) to 33.0 (Aug.).
(c) All-Electric Residential, Period I; 28.3 (Oct.) to 45.0 (Jan.).
(d) All-Electric Residential, Period II; 27.1 (Oct.) to 57.0 (Jan).

TITLE: ALL-ELECTRIC SCHOOLS with RESISTANCE HEATING

SOURCE: Jersey Central Power & Light Co. (Morristown, N.J.)

AUTHOR(S): E.L.Huse
PREPARED BY AUTHOR(S) AND/OR: J.C.P.&L.

DATE OF ISSUANCE: 1961-62 Report of LRC/AEIC (Printed 1963)
OTHER IDENTIFIERS: Appendix D, Section 2 (pp L-133 thru L-143); data covers 9/1/60 - 6/30/61
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with J.C.P.&L.
TOTAL: [PAGES 11 ;REFERENCES ;GRAPHS 9 ;TABLES 2] *
DOCUMENT CLASSIFICATION(S): 41/9, 14, 21, 35

ABSTRACT: *[The Graphs are grouped into 6 Charts.]

The elementary schools ranged from 15,846 sq. ft. (with a capacity of 290 pupils) to 30,600 sq. ft. (with a capacity of 540 pupils). The schools are distributed throughout the J.C.P.&L. system, with a variation of heating degree-days (HDD) from 5,432 to 6,962.

A contact-making watthour meter was installed adjacent to the regular meter and connected to the same metering transformers. Leads were run from it to a recording demand meter. [Since heating circuits are taken from scattered distribution panels, it was not possible to measure the heating load by itself.] The removed charts were reviewed as to time of power interruption or other notations that were required in order to provide complete information for an hour. Information on the tapes was transferred to punch cards for analysis.

Purposes of Study: to examine the load characteristics of all-electric schools, including 5 elementary and one high school which were available for test during the full school year, 1960-61.

Summary of Major Findings (Elementary Schools):
1. The maximum diversified demand fell on Wednesday of the coldest week at 8 a.m.; generally these maxima are between 8 and 8:30 a.m.

2. The maximum diversified demand (on the day of maximum demand) is 0.170 KW per HDD per 1,000 cu. ft. and on the average day of the coldest week is 0.156.

3. The noncoincident half-hour demand per school is 61% of the average connected load. [Demand factors of individual schools range from 51.7 to 71.2%.]

4. Using diversified demands, the load factor on the day of maximum demand is 69.8%. The factor for the average weekday of the coldest week is 69.9% and the schoolyear load factor is 22.9%.

5. The coincidence factor for the average weekday of the coldest week is 99.0%. The factor for the school year is 87.6%.

6. The average total energy use per 1,000 cu. ft. per HDD is 0.277 KWH.

Summary of Major Findings (High School):

7. The maximum demand fell on Tuesday, Dec. 20, a day not in the coldest week. This demand generally occurs at 8:30 or 9:00 a.m.

8. The maximum demand on the peak day is 0.13 KW per HDD per 1,000 cu. ft. and is 0.11 KW on the average weekday of the coldest week. [The demand factor is 44.6%.]

9. The load factor is 53% on the day of maximum demand and 60.9% on the average day of the coldest week. [The school-year factor is 23.6%.]

10. The total energy use per HDD per 1,000 cu. ft. is 0.176 KWH (average).

TITLE: LOAD CHARACTERISTICS of FOUR ELECTRICALLY HEATED SCHOOLS

SOURCE: Duquesne Light (Pittsburgh, Pa.)

AUTHOR(S): W.V.Callin & L.A.Meyer (for V.E.Hill)
PREPARED BY AUTHOR(S) AND/OR: D.L.

DATE OF ISSUANCE: 1965-66 Report of LRC/AEIC (Printed 1967)
OTHER IDENTIFIERS: Appendix B, Section 2 (pp. L-118 thru L-134); data covers winter of 1963-64
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with D.L.

TOTAL: [PAGES 17 ; REFERENCES ; GRAPHS 27 ; TABLES 5]*
DOCUMENT CLASSIFICATION(S): 41/14, 21, 31, 35

ABSTRACT: * [Graphs are grouped into 7 Charts.]

This report summarizes the results of an analysis of the total load of 4 electrically heated schools served by the Duquesne Light Company.

A test period was selected for each month from Nov. thru Mar. The periods chosen were the consecutive two-week periods which most nearly approximated the average daily heating degree-days (HDD) for the month. In several instances where data from one of the schools for the chosen test periods were not available, an alternate period was selected for that school.

The volume of heated space varies considerably among the schools, ranging from 232,600 to 443,000 cubic feet. [In spite of this variation in volume, the weekday energy use was relatively stable, varying only from 0.199 to 0.268 KWH/HDD/1000 cubic feet.]

School data were assembled from available meter charts which recorded 15-minute demands; 30-minute demands were taken as the mid-point of two consecutive 15-minute readings. Data were grouped, summarized and averaged on a computer. [The heating load was not separately metered.] Distribution circuit data were read on the hour from continuous-line, circular-meter charts and summarized and averaged manually. [System load data are the averages of the weekday 60-minute integrated loads for the test period.]

Purposes of Study: to analyze the daily load pattern of 4 electrically heated schools, as compared to the patterns of the system load and the loads of the distribution circuits serving the schools.

Summary of Major Findings:
1. Though the schools investigated varied considerably in size, the weekday energy use per HDD per unit volume did not vary greatly. [Total connected loads ranged from 470 to 732 KW.]

2. For all practical purposes, there is no diversity among the 4 schools considered in the analysis.

3. The peak load consistently occurs during the mid-morning hours, when the load of the D.L. system, as a whole, is about 90% of its daily maximum. Conversely, at the time of the system peak load, the school load is only about 10% of its maximum.

4. Because of the diversity between the daily peaks of the school and system load, substantial blocks of school load could be added to the system with minimal investment because existing facilities would be adequate to supply the increased load.

5. Load factors (based on noncoincident demand) ranged from 26.2 to 34.3%.

6. Demand factors ranged from 58.1 to 73.8%.

TITLE: ALL-ELECTRIC and NON ALL-ELECTRIC SCHOOLS: ELECTRIC LOAD CHARACTERISTICS STUDY

SOURCE: The Hartford Electric Light Co. (Wethersfield, Conn.)

AUTHOR(S): C.C.Wing (for R.C.Fosberg)
PREPARED BY AUTHOR(S) AND/OR: H.E.L. (for Northeast Utilities)

DATE OF ISSUANCE: 1970-71 Report of LRC/AEIC (Printed 1972)
OTHER IDENTIFIERS: Appendix E, Section 2 (pp L-165 thru L-188); data covers 12 months ended 4/30/69
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with N.U.

TOTAL:[PAGES 24 ;REFERENCES ;GRAPHS 7 ;TABLES 8] *
DOCUMENT CLASSIFICATION(S): 41/14, 19, 31, 35

ABSTRACT: *[The Graphs are grouped into 4 Charts.]

Twenty-seven magnetic tape load recorders and associated readout devices were used to record, translate and compute the final data. A printout of each half-hour demand for each customer was made a daily sheet to facilitate data checking and to make possible the drawing off of additional data not originally anticipated when the computer program was written.

Purposes of Study: to obtain operating data relative to the magnitude of demand at the time of monthly system peak, as compared to the connected load of the customer; to obtain current information as to the load characteristics of this class for use in estimating electric demands for service requirements,as compared to connected loads; and for continuing rate studies and in optimizing distribution system design.

Summary of Major Findings:
1. The demand of the all-electric school at the time of the system monthly peak was less than 20% of the connected load in 11 of the 12 months. In Mar. the system experienced an 11 a.m. peak, at which time the all-electric school's demand was 28.9% of its connected load. The demand of the non-electric (i.e., non-all-electric) school at the time of the system monthly peak ranges from 8.3% of connected load in Aug. to 37.5% in May.

2. The all-electric school's maximum diversified demand (MDD) occurs during the winter. For the test period, the demand occurred between 8 and 11:30 a.m. The non-electric school's MDD occurs during the winter; for the test period, this demand occurred between 9:30 a.m. and 12:30 p.m.

3. The % load factor for the all-electric school ranges from 20.0 in (Apr.) to 38.2 (Feb.) whereas for the non-electric school it ranges from 25.2 (June) to 42.3 (Aug.).

4. The % coincidence factor for the all-electric school ranges from 60.4

(July) to 90.3 (Dec.) whereas for the non-electric school it ranges from 68.4 (Aug.) to 91.8 (Dec. and Feb.).

5. A comparison of the KWH use per school shows a similar pattern for the period May through Oct. Thereafter, the electric-heating load becomes very evident, peaking in Jan.

6. A comparison of load curves for all-electric and non-electric schools for summer and winter shows a marked similarity but the former shows a higher demand in the morning hours and a lower demand in the evening hours as compared to the latter.

7. The connected load averages 19.9 watts per sq. ft. for the all-electric school and 4.4 watts for the non-electric school.

TITLE: COMMERCIAL CUSTOMER LOAD STUDY

SOURCE: Rochester Gas and Electric Corp. (Rochester, N.Y.)

AUTHOR(S): C.S.Kellogg (for F.E.Drake, Jr.)
PREPARED BY AUTHOR(S) AND/OR: R.G.&E.

DATE OF ISSUANCE: 1959-60 Report of LRC/AEIC (Printed 1961)
OTHER IDENTIFIERS: Appendix A, Section 2 (pp L-98 thru L-103); data covers Aug. & Dec., 1969
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with R.G.&E.
TOTAL:[PAGES 6 ;REFERENCES ;GRAPHS 1 ;TABLES 2]
DOCUMENT CLASSIFICATION(S): 42/9, 11, 14

ABSTRACT:

The rapid growth in recent years of shopping plazas makes the study of their demands and KWH use increasingly important. The wide acceptance of air conditioning - as an indispensable aid to comfort in these plaza developments - has created such a new pattern of load characteristics that these "commercial communities" may reasonably be considered a blueprint of the future commercial class.

Five shopping plazas in metropolitan Rochester were chosen and demand recording devices were installed on the high-voltage side of the transformer banks feeding each plaza. Tests for summer conditions were made during a 3 week period in Aug. and winter conditions were tested during 3 weeks in Dec. prior to Christmas week. [The sample shopping plazas are the same for both periods and the individual customers within the plazas are practically the same.]

A variety of stores were tenants of the 5 plazas, namely: apparel/accessories, food, general merchandise, hardware/paint, home furnishings/equipment, personal services and miscellaneous retail. Also included were banks and financial offices and eating and drinking establishments.

Purposes of Study: determining the summer and winter load characteristics of shopping plazas served at commercial service rates.

Summary of Major Findings:
1. Comparison of the maximum demands for the summer and winter test periods reveals that, for all plazas, the summer demands are greater than the winter.

2. From an analysis of the diversified demands on the day of the plaza 3-day average peaks, it is seen that evening store hours influence this particular type of commercial customer's load characteristics extensively. Generally, the summer peak was between 7:30 and 8:30 p.m. on a Friday

evening and the winter peak occurred on a Thursday or Friday between 5 and 7 p.m.

3. Diversified annual load factors, based on plaza peak-day demands, range from 33.5 to 38.8% with an average of 35.5%.

4. Evidence of the homogeniety of these "commercial communities" is exhibited in the average plaza coincidence factors which (based on the plaza peak day diversified demands) are approximately 87% annually and 92% for both the Aug. and Dec. tests. However, in the Rochester area it is generally true that 3 or 4 large customers of each plaza group contribute 50% or more of the total plaza load and therefore influence the group load characteristics significantly.

TITLE: APPLIED STATISTICS in LOAD RESEARCH: VOLUME I
(Note: Pagination continues into Volume II)

SOURCE: AEIC

AUTHOR(S): General Topics Subcommittee of LRC
PREPARED BY AUTHOR(S) AND/OR: AEIC

DATE OF ISSUANCE: 5/64
OTHER IDENTIFIERS:

DATA USE RESTRICTIONS: Printed, but not published by order of AEIC.
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TOTAL: [PAGES 92 ; REFERENCES 4 ; GRAPHS 7 ; TABLES 9] *
DOCUMENT CLASSIFICATION(S): 43/31, 32, 49

ABSTRACT: *[Most of the Volume deals with material of direct or secondary relevance to the general subject matter of this Compilation. Therefore the Totals are for the entire Manual.]

The application of statistical analysis offers great potential for implementing and improving the usefulness of load research results to the Utility industry and its customers. In its series of papers, "Applied Statistics in Load Research" covers some of the many important facets of statistical analysis which are applicable to load research problems. It is intended that these Volume I Papers should provide information about certain statistical methods which may be directly of interest to Load Research.

As conceived, these Papers present statistics from a "practical" point of view. In fact, most cases involve only the use of basic statistical concepts in the analysis of typical load study results. Advanced procedures are reserved for unusual problems, work of an exploratory nature and studies requiring detailed statistical documentation. [Technical aspects are discussed in separate appendixes that furnish the technician with detailed explanations of the formulae and mathematics involved in each analysis.]

The methods discussed in this Volume are, for the most part, not new; some have long been accepted as an integral part of load research, others illustrate the use of statistics to solve problems of an unusual nature. No method, or application, should be considered an exclusive or infallible solution to a specific problem. The statistical techniques are not designed to supplant experience and skill in the development and presentation of load research data. Some of the data are purely hypothetical and conclusions exemplify possible, not actual, results. The Papers focus not on specific load research results but on statistical methods.

Load research represents one of the very successful applications of statistical sampling achieved since about 1940. Thru data obtained from extremely small proportions of customer classes and appliances, Utility management has effectively solved difficult problems of system design, cost allocation, rate determination and sales promotion. Consequently more definitive data on the electrical characteristics of customers, processes and appliances are being demanded on a continuing basis.

Volume I covers five topics, namely: (A) "The Role of Statistical Analysis in Load Research"; (B) "Statistical Sampling Procedures for Load Surveys"; (C) "Since Load Study Results are Sample Statistics"; (D) "Variability of Load Shapes"; (E) "Diversity and Temperature Related Loads". These 5 Papers do not represent an exhaustive list of applications; additional "case studies" are covered in Volumes II and III. Each of the 5 Papers is intended to illustrate one or more typical load research problems that can be solved with a particular technique. [Papers (C), (D) and (E) also have appendices in which the detail of the particular analysis is discussed.] The emphasis is on load research problems, not statistical theory or mathematics, so that any competent analyst should be able to apply the same techniques to his own load studies.

Some of the load study data are taken from actual surveys, some have been modified to suit the purpose of the presentation and some are entirely fictitious. The figures and conclusions should be viewed as illustrating techniques which are not necessarily applicable to an actual Utility or situation. The equations used for load behavior should likewise not be construed as the preferred mathematical representation of the particular relationships represented by the equations.

The tenor of this Volume is that statistical analysis of load research results will lend quantitative support to evidential data which would be criticized if it were only based on judgment and experience. Furthermore, the Volume shows that better analytical techniques can improve accuracy and value while (often) reducing the cost of load surveys. It is indicated that the versatility of sound statistical analysis can significantly advance the theory and application of Utility load research.

TITLE: APPLIED STATISTICS in LOAD RESEARCH: VOLUME II
(Note: Pagination continues from Volume I and into Volume III)

SOURCE: AEIC

AUTHOR(S): General Topics Subcommittee of LRC
PREPARED BY AUTHOR(S) AND/OR: AEIC

DATE OF ISSUANCE: 6/65
OTHER IDENTIFIERS:

DATA USE RESTRICTIONS: Printed, but not published, by AEIC. Prior permission required from AEIC, for use.
TOTAL: [PAGES 120 ; REFERENCES 6 ; GRAPHS 14 ; TABLES 14] *
DOCUMENT CLASSIFICATION(S): 43

ABSTRACT: *[Most of the Volume deals with material of direct or secondary relevance to the general subject matter of this Compilation. Therefore the Totals are for the entire Manual.]

This second Volume contains three Papers dealing with linear regression, multiple regression and "Chi-Square" testing; technical details have been relegated to the appendix accompanying each paper. These Papers generally involve more complex topics than those discussed in Volume I; consequently they are based, in part, on the principles developed in Volume I. [To sustain a continuity with the first volume, and for easier referencing, the papers of Volume II are designated (F), (G) and (H).]

Paper (F), "Least Squares" and Load Research, discusses the problems of determining the relationships between two variables. Paper (G), Measuring the Effect of Several Variables, describes techniques and problems and applications of multiple regression and correlation analysis. Paper (H), "Chi-Square" Tests and Load Research, illustrates the use of Chi-Square analysis in the comparison of sets of data.

Note: All of the limitations stated in the "Foreword" to Volume I apply equally well to Volume II. For example, some of the data are hypothetical and the resultant conclusions therefore exemplify possible, not actual, results.

TITLE: APPLIED STATISTICS in LOAD RESEARCH: VOLUME III
(Note: Pagination continues from Volume II)

SOURCE: AEIC

AUTHOR(S): General Topics Subcommittee of LRC
PREPARED BY AUTHOR(S) AND/OR: AEIC

DATE OF ISSUANCE: 7/74
OTHER IDENTIFIERS:

DATA USE RESTRICTIONS: Printed, but not published, by AEIC. Prior permission required from AEIC, for use
TOTAL: [PAGES 78 ;REFERENCES 4 ;GRAPHS 2 ;TABLES 17] *
DOCUMENT CLASSIFICATION(S): 43

ABSTRACT: *[Most of the Volume deals with material of direct or secondary relevance to the general subject matter of this Compilation. Therefore the Totals are for the entire Manual.]

This third Volume contains two Papers which discuss aspects of sample sizing, including stratification methods and cost evaluation. [Papers in this volume are designated as (I) and (J), in order to maintain the sequence developed in the previous volumes.]

Paper (I), What Size Sample?, tells how to determine the sample required for a given objective, including a method of cost evaluation. Major sub-sections of Paper (I) relate to: sampling a single, homogeneous group; sample stratification; stratification, with cost consideration. Paper (J), Stratified Random Sampling Methods for Class Load Surveys for Electric Utilities, discusses the techniques and applications in the design of stratified samples.

Note: The limitations stated in the "Foreword" to Volume I apply equally well to Volume III. For example, some of the data are hypothetical and the resultant conclusions therefore exemplify possible, not actual, results.

TITLE: RURAL CUSTOMER LOAD STUDY

SOURCE: The Connecticut Light and Power Co. (Berlin, Conn.)

AUTHOR(S): R.R.Beauregard (for J.W.Hummer)
PREPARED BY AUTHOR(S) AND/OR: C.L.&P. (for Northeast Utilities)

DATE OF ISSUANCE: 1962-63 Report of LRC/AEIC (Printed 1964)
OTHER IDENTIFIERS: Appendix F, Section 1 (pp L-77 thru L-88); data covers Dec. 1960 to Dec. 1961
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with N.U.

TOTAL:[PAGES 12 ;REFERENCES ;GRAPHS 10 ;TABLES 5] *
DOCUMENT CLASSIFICATION(S): 44/7, 14, 46, 48

ABSTRACT: *[Two of Tables are unnumbered. The Graphs are grouped into 4 Charts.]

The study started with meters on 30 premises (selected from an initial list of 150) but due to discontinuance of some farm operations during the test period only 26 remained through the full test. [Of the 26, 10 were "Dairy", 10 were "Poultry" and the remaining - grouped as "Other" - were nursery and greenhouse, livestock, vegetable, fruit and general farms.]

The saturation of major residential appliances owned by the test customers was 62% for ranges, 58% for water heaters and 42% for those with bath. [Note: All the electric water heaters operate uncontrolled and most are of the quick-recovery type, having 4.5 KW upper and lower elements interlocked.]

To obtain complete demand and use data the rural customers' loads were divided into residential, farm and total-service use. Two recording demand meters (hourly integrated demand) and 2 watthour meters were installed on each farm to obtain the residential and farm uses; the total-service use was derived from these readings.

Purposes of Study: to obtain data on the electrical load characteristics of 26 farms located in the C.L.&.P. service area.

Summary of Major Findings:
1. The annual load factor, based on the maximum diversified demand of the test group, is 47.3%. For farm customers with uncontrolled electric water heaters the factor was 44.7% and for customers without electric water heaters it was 44.9%.
2. The annual total-service energy use averaged 21,925 KWH. Farm use accounted for 14,870 KWH (or 67.8% of total-service energy use), while residential use averaged 7,055 KWH. [In 1961, farm customers served under C.L.&P.'s "Live Better Electrically" rate - without electric space heating - averaged 24,721 KWH use and farm customers served under C.L.&P.'s commercial and industrial rates averaged 18,842 KWH, exclusive of residential use.]

TITLE: RESIDENTIAL STUDY: NON SPACE HEATING CUSTOMERS

SOURCE: Philadelphia Electric Co. (Philadelphia, Pa.)

AUTHOR(S): A.C.Parker (for R.C.Williams)
PREPARED BY AUTHOR(S) AND/OR: P.E.

DATE OF ISSUANCE: 1972-73 Report of LRC/AEIC (Printed 1974)
OTHER IDENTIFIERS: Appendix F, Section 1 (pp L-173 thru L-180); data covers June, July, Aug., Dec. 1971
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.E.

TOTAL:[PAGES 8 ;REFERENCES 1 ;GRAPHS 6 ;TABLES 3] *
DOCUMENT CLASSIFICATION(S): 44/31, 37, 40, 46

ABSTRACT: *[Two of Tables are unnumbered. Graphs are grouped on a single Chart.]

The present study deals only with the Philadelphia suburban area outside the city limits and thus excludes the Philadelphia urban area. The Company has approximately 500,000 customers residing in this service area. The universe of customers was arranged into 6 strata, on the basis of their 1970-71 winter (quarter) energy use. Ten sample groups of 39 customers each were selected from each of the strata by a systematic random sampling procedure. Each such group was compared to its respective universe and the one whose characteristics compared most favorably to the universe was selected for testing. Points of comparison between each sample group and the universe were: geographic distribution, average customer energy use and the frequency distribution of the average energy use.

The residences selected for test are primarily single-family, semi-detached and detached, with an average annual energy use (for the 6 strata) ranging from about 3,000 KWH per customer to about 15,000. [The 1971 annual average use of the universe customer was 6,540 KWH.]

The data presented in this survey are for a "hot week" and a "cool week" during the summer plus a week in mid-Dec. during the winter. The hot week represents a period when substantial space cooling load can be expected and the cool week represents a period when such loads would not be a significant part of the total load.

Approximately 15% of the test customers in each test group were selected for power factor tests. These tests were made between 5:30 and 6 p.m. on hot weekdays during the 3 summer months; this half-hour was chosen in order to provide representative power factor data during a period of high energy use.

Purposes of Study: to determine load characteristics for both summer and winter conditions of a representative sample of residential customers in the Philadelphia suburban area; the development of class load characteristics that reflect current-use habits and appliance saturations.

Summary of Major Findings:

1. For each of the test groups, the load patterns for the summer (hot) average weekday are higher than those of the summer (cool) average weekday. This reflects the important effects of space cooling load on the residential class of service.

2. The average of the ratios for each sample group shows that the maximum summer month energy use exceeds the Dec. use by 24%.

3. The Power Factor tests show an average value of 85%; this is 2% less than 1968 survey findings.

4. The average level of the annual load factor, based on average weekday maximum diversified demand, is 48% or 5% above the 1968 survey findings. The annual noncoincident load factor is 13%.

TITLE: COLOR TELEVISION SET ENERGY USE STUDY
(Joint Study by 7 Utilities)

SOURCE: Data from: Alabama Power Co.; et al

AUTHOR(S): D.R.Schwoegler (for W.Blumst, Pacific Gas and Electric Co.)
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 1973-74 Report of LRC/AEIC (Printed 1975)
OTHER IDENTIFIERS: Appendix A, Section 3 (pp L-101 thru L-113); data covers 10/72 to 1/74
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with LRC

TOTAL: [PAGES 13 ; REFERENCES ; GRAPHS ; TABLES 13] *
DOCUMENT CLASSIFICATION(S): 45/15, 19

ABSTRACT: *[10 of Tables are (unnumbered) and of data summary type.]

This is a cooperative study by AEIC member companies from several sections of the nation, namely: Alabama Power, Baltimore Gas and Electric, Cleveland Electric Illuminating, Long Island Lighting, New Orleans Public Service, Pacific Gas and Electric and Pennsylvania Power & Light. [Members have pooled their individual standard watthour meter readings and equipment characteristics in order to obtain actual test data on this popular, contemporary appliance.] The study notes television (TV) set contribution to the total residential use of electric energy. The findings should prove useful in the areas of: customer inquiries regarding energy use, utility management knowledge of electricity use for facilities planning and energy conservation counseling.

A total of 207 households were initially selected, of which 199 studies were completed. However because of such factors as "drop-outs", disqualifications, missed readings and internal problems experienced by some of the participants, the test produced 2,150 monthly readings with the number per month varying from 196 to 161. Households were selected on the basis that they received all 3 major television networks on at least 3 separate channels. Additional requirements: only one color and no more than one additional black and white TV in the household; color set less than 24 months old at the time the test began; optional "battery operation feature"sets (or those which were a part of a combination television-stero console unit) were excluded.

Purposes of Study: to determine the energy use of color TV sets of the types currently being marketed nationally, as used in actual residences; to investigate the effects, on KWH use, of variables relating to the equipment being tested and of the conditions under which they were being operated.

Summary of Major Findings:
1. The average energy use for all test units was about 1.64 KWH/day. This yields an average annual (365 day) use of about 600 KWH.

2. The KWH/day use showed strong seasonal sensitivity, building gradually from 1.41 in June and July to a 1.83 high in Jan. and Nov.

3. The average "rated" power input of all units tested was 286 watts. This rated value (when divided into 600 KWH) yields an average annual viewing time of 2,098 hours or about 40.3 hours/week/set.

4. Average KWH/day use varied among the 7 participating companies, from 1.82 to 1.35. Correspondingly average viewing hours per day varied from 4.8 to 6.4 with an average daily viewing time being 5.7 hours, as derived from connected load information.

5. Of the 11 variables studied, relationship to television energy use was established by correlation as noted below.

A. Strong Relationship to Energy Use: rated power, total number of viewers, number of daytime viewers, size of screen, number of channels;

B. Minor Relationship to Energy Use: presence of black and white set in same household, air conditioning in viewing room;

C. Little or No Relationship to Energy Use: set location, signal source, "instant-on" feature, remote control feature.

6. As an example, KWH/day use (by set location) is approximately proportional to the distribution of sets among particular room locations, indicating that no particular usage pattern can be associated with the location of the set within the household. [Note: With the exception of rated power, the absence of any one dominant variable (with equally low importance of several variables) makes this appliance a poor candidate as a load management tool.]

TITLE: HIGH-WATTAGE WATER HEATERS

SOURCE: Various Utilities *

AUTHOR(S): E.H.Scott, et al; "Special Subcommittee on Water Heating Loads"
PREPARED BY AUTHOR(S) AND/OR: LRC/AEIC

DATE OF ISSUANCE: 1953-55 Report of LRC/AEIC (Printed 1956)
OTHER IDENTIFIERS: Pages L-1 thru L-15; data covers various time periods for 1951-52 and 1953-55
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with LRC

TOTAL: [PAGES 15 ; REFERENCES ; GRAPHS 15 ; TABLES 5] **
DOCUMENT CLASSIFICATION(S): 48/14, 15, 31, 33, 40

ABSTRACT: *[Located in Ga., Md., Mich., Ohio, Pa., and Wisc.]

**[The Graphs are identified by 12 Charts, subclassified into 7 Groups.]

This report contains the results (some of them preliminary) of water heater tests conducted by 7 utilities. Data included are:
(A) A comparison of certain load characteristics of high-wattage water heaters, as determined from results of tests by 6 utilities.
(B) A summary of individual company test methods and comparisons of high-wattage and standard-wattage water heater operation, where available. [This section also includes average weekday and highest demand weekday load curves for each test group.]
(C) A Philadelphia study showing the effect of controlled vs uncontrolled water heater operation on the residential-class load curve. A method of limiting group demand of controlled heaters, after a restricted period, is also indicated.

Purposes of Tests: primarily to determine the load characteristics of high-wattage water heaters, with the length of the charging period unrestricted (i.e., uncontrolled operation); to find out if the recovery of hot water with a 40- or 50-gallon tank is rapid enough to fulfill customer requirements.

Summary of Major Findings:
1. Winter (average weekday) maximum coincident demands per customer for high-wattage heaters can be expected to range from about 1.20 to 1.75 KW. The 6:00 p.m. demand per heater varies from 700 to 900 watts and the 7:00 p.m. demand varies from 800 to 1,200. [The variations are caused in part by differences in the saturation of automatic washers and in customer habits. However, significant differences in the sizes of the sample groups should also be considered in interpreting the demand figures obtained by the individual companies.]
2. Greater diversity in the use of high-recovery units, as compared with standard heater operation, can be expected. This improvement in diversity, however, does not compensate for the higher element wattages and

average winter weekday demands may be as much as 75% higher.
3. The energy use of high-wattage water heaters appears to be greater than that of standard heaters. [This may imply a more adequate supply of hot water for the customer.]
4. By proper use of controlled periods of operation and a cycling of the "turn-on" times of the controlled heating elements, residential peaks caused by high saturations of water heaters can be minimized or eliminated.
5. The average weekday KWH use per customer varies from 11.3 in Ohio to 20.5 in Detroit. The fact that the Ohio tests were made in summer may account for their low figure; the 95% saturation of automatic washers accounts, at least in part, for the high use in Detroit. The maximum daily use per customer varies from 13.2 to 23.4 KWH, with the same geographical areas at the extremes. [Monday predominates as the day of highest use of electricity.]
6a. There is a wide variation in magnitude, time and in the day of the week of the maximum weekday demand. The peak winter (30-minute) integrated demands varied from 1.96 KW in Georgia and Pittsburgh to 3.15 KW in Milwaukee; Baltimore tests recorded a maximum of 2.86 KW and Detroit, 2.63 KW. Factors affecting this value include: size of test group, inlet water temperature, saturation of automatic washers, variations in family size and customer habits. [However, no attempt has been made to evaluate the relative importance of these factors on the basis of evidence available to date.] The Ohio test made under summer conditions show a significantly lower maximum coincident demand of 1.60 KW, due to higher inlet water temperatures.
6b. In 5 of the 6 areas, maximum weekday coincident demands occurred between 9:00 a.m. and noon. Pittsburgh indicated a 7:00 p.m. maximum. Three companies reported Monday as the highest demand weekday; one maximum occurred on Wednesday and two on Thursday.
6c. The average weekday maximum coincident demand per customer varies from 1.20 to 1.75 KW. Here again morning maximums predominate, influenced by washing habits. During the residential peak periods, it appears likely that the average winter weekday demand per water heater will range from 700 to 900 watts at 6:00 p.m. and from 800 to 1,200 watts at 7:00 p.m.
7. The 5 tests reporting noncoincident maximum demand per customer show a variation of from 4.40 to 4.63 KW per heater. These figures agree closely with the nominal 4.5 KW nameplate wattage of the heating elements.
8. The average weekday load factor, based on the maximum weekday coincident demand, is between 20 and 30%; based on the maximum demand on the average weekday, it may approach 50%.
9. In Baltimore, Detroit and Milwaukee, 59 to 70% of the heaters were on at the same time, while Georgia and Pittsburgh figures indicate only 44 and 42%, respectively. The Ohio test shows a summer coincidence factor of 36%.

TITLE: WATER HEATING LOADS *

SOURCE: Various Utilities **

AUTHOR(S): E.H.Scott, et al; "Special Subcommittee on Water Heating Loads"
PREPARED BY AUTHOR(S) AND/OR: LRC/AEIC

DATE OF ISSUANCE: 1957-58 Report of LRC/AEIC (Printed 1959)
OTHER IDENTIFIERS: Section 5 (pp L-147 thru L-187); data covers various periods (some as long as 12 months) from 1949 thru 1958
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with LRC

TOTAL: [PAGES 41 ;REFERENCES ;GRAPHS 50 ;TABLES 12] ***
DOCUMENT CLASSIFICATION(S): 48/7, 14, 15, 28, 31, 33, 40, 49

ABSTRACT: *[Data is included from 10 water heater studies by 10 utilities.]

**[Located in Conn., Dist. of Col., Ill., Mich., N.J., Pa. and Va.]

***[Graphs are grouped into 11 Charts.]

NEMA standard water heaters of about 50-gallon size have been used in past years by many families with average hot water requirements; customers with higher-than-average hot water needs have utilized tanks with capacities of 80 gallons or more. To meet the large-volume hot water demands of some families at satisfactory rates per KWH, many utilities have been confronted with the need of reviewing their water heating practices. Uncontrolled operation, extended hours of charging, midday booster periods, unrestricted use of an upper heating element and higher wattage (upper and lower) elements have been proposed as methods of providing better service. The most appropriate method(s) for a particular utility will depend on the hot water requirements of its customers and on the characteristics of the water heater load with respect to other loads on the system.

If electric water heating is to be accepted at preferential rates, little or no water heater load should coincide with the peak periods on the distribution and bulk supply systems. Since the timing and duration of these peak periods vary from utility to utility, a system with predominant summer maximum demands faces a different problem in its choice of charging hours than does a (northern) utility with an historic 6 p.m. winter peak. A company with equal morning and evening demands is more limited in its designation of off-peak hours than is one with, for instance, a 10% difference between the two peaks.

At the distribution level, optimum heater charging hours from the utility standpoint depend on present and prospective saturations of both ranges and water heaters and on the existing pattern of residential loads. In local areas where water heater saturations exceed 20%, peak distribution loads and low-voltage conditions are common at the start of the water heating period.

Data in this Report include load curves on average or "typical" weekdays for heaters with various element wattages and schedules of operation. Load curves indicating the effect of alternate water heating schedules on total residential loads are also included. Energy use, coincident and noncoincident maximum demands and load factors are shown in tabular form. [Several of the studies cover less than a full year of operation and, in some cases, data are based on samples too small to be statistically stable. However, the load curves and the use and demand figures do point out significant aspects of the most familiar methods of electric water heating.]

Purposes of Study: to coordinate water heating load studies by 10 companies; to substantiate findings of earlier reports and summarize basic load data for both controlled and uncontrolled water heating service.

Summary of Major Findings:

1. Average annual use ranged from 3041 KWH (for a New Jersey test of 60 water heaters operating on a 10 hour "off-peak" schedule) to 6350 KWH (for 82 high-wattage water heaters in the Detroit, Michigan area). Tests by 3 utilities in Connecticut, Washington, D.C. and Virginia showed an annual use of around 4000 KWH per customer and a group of high-use customers in Connecticut averaged more than 5000 KWH per year. In the Detroit sample, the lowest annual use of a test customer was 2,880 KWH and the maximum annual use was about 15,600 KWH. Water heater use (lower element only) ranged from 1,448 to 12,204 KWH annually in the Connecticut sample.
2. Monthly energy use for water heating reaches a peak in the winter and early spring because of lower inlet water temperatures and higher stand-by losses. The Virginia study showed energy use during the winter test periods exceeding summer use by at least 12%. The District of Columbia study shows a maximum of 12.8 KWH per day in Feb. and a minimum of 9.5 KWH per day in Aug. altho the (estimated) daily water use was highest during the summer.
3. The average daily use per customer was affected by the characteristics of the test group and by the season of the year, as well as by tank size, connected load of the upper and lower elements and method of operation. Daily use was as low as 7.0 KWH, for one test group with tanks heated only by the lower element during an 8 hour off-peak period. The maximum use of 21.92 KWH was reported in a Connecticut test of 16 customers, all with automatic washers. The 87 Detroit customers with high-wattage water heaters averaged 19.72 KWH during the spring test period. In general, use per customer was in the range of 10 to 15 KWH per day during the test periods. [The higher energy uses normally were associated with longer charging periods, indicating that the shorter charging periods did not always furnish an adequate water supply.]
4. Water heater use between midnight and 6 a.m., probably the hours of the lowest production cost, is of interest. With unrestricted operation, only about 10% of the total energy for water heating is used during this period. With an 18-hour charging period, nighttime energy use accounts for about 20 to 30% of the total; with an 8 to 10 hour off-peak charging period, 50% or more of the total use occurs between midnight and 6 a.m. [The addition of a noon "booster" reduces the proportion of night

use by as much as 20%.]
5. The noncoincident maximum demand per water heater (including upper and lower elements) was, in general, equivalent to the nominal rating of the lower element; the range was from 1.47 KW for the NEMA units in the District of Columbia tests to 4.5 KW for the high-wattage elements in the Detroit study. In several other tests noncoincident maximum demands in some cases exceeded nominal lower-element ratings, reflecting the use of higher-wattage upper elements.
6a. Diversified maximum demands of water heaters with controlled operation fell between 1.5 and 2.5 KW per unit, depending on the size of the heating element. The Detroit tests of water heaters with 3 KW lower elements and an 18-hour charging period produced a diversified maximum demand of 1.68 KW with a split cycle, compared with maximums of 2.62 and 2.44 KW for the component groups. Philadelphia tests show maximum diversified demands with the split cycle of 1.37 and 1.80 KW per water heater; lower-element connected loads are 1.84 and 3.51 KW, respectively. [Diversified maximum demands with the split cycle all occurred after midnight.]
6b. The greatest diversity, hence lowest coincident maximum demand in relation to element size, is found with uncontrolled operation. Based on average weekday loads, the coincident demand of a water heater with NEMA units may exceed 75% of the connected load of the lower element. With higher-wattage elements, the average weekday diversified maximum demands drop to less than 50% of the connected load. Average weekday diversified maximum demands ranged from 0.528 to 1.64 KW. The majority of values are in the 0.7 to 0.9 KW range. [Maximum test period diversified demands exceeded average weekday demands by about 30% in summer and 19% in winter.]
6c. In diversity considerations, the time of the peak is as important as its magnitude. Although uncontrolled operation usually produces the lowest diversified maximum demand in relation to element size, the peaks normally occur between 7 and 8 p.m. (coinciding with the residential peak) or between 10 and 11 a.m., coinciding with high industrial and air conditioning loads. On some systems, off-peak periods of longer than 10 hours (or the use of a supplementary noon booster period) produces a similar situation. Morning and early afternoon demands of heaters with an 18-hour charging period are roughly equivalent to those found with unrestricted operation. Even an 11-hour charging period (extending to 9 or 10 a.m.) produces a morning maximum of over 0.6 KW per unit prior to the end of the charging period. The noon booster results in early afternoon demands of up to 80% of the peak for the day.
7. Average weekday group load factors, for controlled heaters, were below 30%, except where turn-on schedules were diversified by a split cycle. Use of a split cycle improves group load factors by more than 10%. With uncontrolled operation, the group load factor on an average weekday exceeded 50% in most of the tests. [Data on annual load factors were available for only 3 tests, but appear to be in the range of 40 to 50% for uncontrolled service, and 25% with the off-peak operation.
8a. The Detroit customers with high-wattage water heaters averaged nearly 60 gallons of water per day during the two test periods; daily draw-offs exceeding 100 gallons by some individual customers were not uncommon.

Diversified patterns of water use for an average weekday in spring and summer show a peak of 5.48 gallons per hour. Energy use (per gallon of water) was 0.32 KWH during the spring test and 0.29 KWH in summer, reflecting warmer inlet water temperatures. [Hot water temperatures during spring and summer tests averaged 155 F.]

8b. The Connecticut study of 16 high-use customers was made in the summer of 1953. Average weekday use was 79 gallons per customer. The maximum draw-off recorded for the group was 8.75 gallons for the hour ended at 9 a.m. on a Monday. Based on the average weekday, energy use per gallon was 0.36 KWH. [Inlet water temperatures averaged 57.4 F and outlet temperatures 161.0 F for average weekday.]

8c. In the District of Columbia study, daily hot water use by months was derived from monthly energy use and estimated stand-by losses. These computations show usages ranging from 45.1 gallons in Jan. to 55.6 in Sept. Energy use was equivalent to 0.27 KWH per gallon (Jan.) and 0.19 (Sept.). [Lower hot water temperatures (140 F) and higher inlet water temperatures account for the rather low KWH per gallon values.]

TITLE: HOMES WITH ELECTRIC HIGH WATTAGE QUICK-RECOVERY WATER HEATING

SOURCE: Baltimore Gas and Electric Co. (Baltimore, Md.)

AUTHOR(S): W.E.Miller
PREPARED BY AUTHOR(S) AND/OR: B.G.&E.

DATE OF ISSUANCE: 1964-65 Report of LRC/AEIC (Printed 1966)
OTHER IDENTIFIERS: Appendix E, Section 1 (pp L-59 + L-69 thru L-93)
data covers 12 months ending 3/31/63
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TOTAL: [PAGES 26 ;REFERENCES 5 ;GRAPHS 11 ;TABLES 9] *
DOCUMENT CLASSIFICATION(S): 48/8, 14, 40

ABSTRACT: *[Seven of the Tables are unnumbered. The Graphs are grouped into 7 Charts.]

After excluding customers using electricity for house heating and those in multiple-apartment houses, 27 were selected at random from a relatively small universe of homes having high-wattage, quick-recovery water heaters. This selectivity also allowed approximating the non-water heating load characteristics that would be indicative, for single-family detached homes, of the total service connected load level of this group (25-30 KW).

The 23 homes for which usable data were obtained are single-family dwellings, only one of which is a row house; there was about a 50/50 division between frame and masonry construction, basically in "cottage" or "ranch" styles. The average home contains about 6 rooms, a kitchen and between one and two bathrooms (counting a powder room as one-half bath). Each test home is equipped with a 40 gallon high-wattage, quick-recovery, automatic-storage water heater, operating uncontrolled; each had interlocked upper and lower elements of 4.5 KW (nominal rating) each.

Magnetic tape recorders (designed for load test use with contact devices attached to watthour meters) were employed in this study, using a quarter-hour time interval. One recorder measures the total service requirements and one simultaneously measures the load of the water heating equipment. [The load survey recorders are provided with tape sufficient for a 45-day record, although the practice is to change the recorder tape at approximate monthly intervals.] Average customer and certain individual customer data are included in this Report. They are derived from punched card outputs from a "Translator" unit, using a standard Load Survey Card form. The punched cards become the input for analysis by an electronic data processing unit.

Purposes of Study: to determine the average load characteristics of a group - ranging from 17 to 23 installations - of "so-called" high wattage, quick-recovery type water heaters; to determine the effect of such water

heaters on the average total service loads and other characteristics of the test group in order to produce data useful for engineering, economic and rate studies and for the development of sales guides for possible residential water heating promotion.

Summary of Major Findings:

1. Annual use for water heating and can be estimated at about 1,470 hours of the connected load.

2. About 45% of the average customer's total service annual requirements is used for water heating.

3. Of the annual water heating requirements, 55% is used on-peak.

4. Monday is the maximum water heating use day of the week.

5. The daily (maximum) diversified water heating demand most frequently occurs between 9:30 am and noon; this is true also for average weekdays in both winter and summer periods.

6. The individual customer's full water heating demand occurs over a quarter-hour interval but the maximum diversified demand is only 67% of the average 15 minute water heater connected load.

7. Water heating adds one kilowatt to the B.G.&E.'s system monthly peak, averaged over the one-year period, or about 22% of the average connected load.

8. Annual diversified load factors are 36% for total service use and 28% for water heating use; annual noncoincident load factors are 15 and 16%, respectively.

9. Demand factors for water heating uses - based on monthly averages - do not exceed 60% (Dec.); for the one-year period, the result is 51%.

TITLE: RESIDENTIAL ELECTRIC WATER HEATING

SOURCE: Public Service Electric and Gas Co. (Newark, N.J.)

AUTHOR(S): P.F.Platt (for B.P.Dahlstrom)
PREPARED BY AUTHOR(S) AND/OR: P.S.E.&G.

DATE OF ISSUANCE: 1964-65 Report of LRC/AEIC (Printed 1966)
OTHER IDENTIFIERS: Appendix A, Section 3 (pp L-149 thru L-163); data covers Summer 1963 & Winter 1963-64
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with S.E.&G.
TOTAL: [PAGES 15 ;REFERENCES 1 ;GRAPHS 22 ;TABLES 5] *
DOCUMENT CLASSIFICATION(S): 48/7, 14, 15, 40

ABSTRACT: *[Graphs are grouped into 4 Charts.]

Standard and quick-recovery-type water heaters were tested. Standard-type heaters were subdivided into groups of above and below 65 gallon capacity. Of the small heaters, 75% were rated in accordance with NEMA standards with the balance averaging 32 watts per gallon for both the upper and lower elements. Of the large heaters, 35% were NEMA-rated units and the balance averaged 26 watts per gallon for the upper element and 32 watts per gallon for the lower element. The test conditions were in accordance with the following 3 methods of operation for the standard-type heaters and in accordance with the last two methods only for the quick-recovery-type water heaters: (1) Interlocked upper and lower elements, with the lower element controlled so as to restrict its operation beginning with 11 p.m. of one day and ending with 9:30 a.m. of the following day; (2) Uncontrolled, with an interlock on the heating elements; (3) Uncontrolled, without an interlock.

The test customers with standard-type storage water heaters were chosen by accepted procedures of random choice from stratified subdivisions. [Since there were so few customers with quick-recovery water heaters, all customers in this group suitable for test were selected.] Family sizes averaged from 3 to 4 people and homes averaged slightly over one bathroom each. The saturations of hot water appliances show that nearly 80% of the test customers had automatic washers. The saturation of dishwashers of customers with standard-type water heaters was about 20%, whereas for customers with quick-recovery-type water heaters this figure was about 50%.

Magnetic tape load survey recorders were installed on each test water heater to measure 30-minute integrated demands. The summer tests were conducted during July, Aug. and Sept. The winter tests took place during Dec., Jan. and Feb. Each method of operation was tested for 3 weeks each, in both the summer and winter periods. [One week was allowed between methods of operation to make the necessary alterations for the next method of operation.]

Purposes of Study: to provide load data for storage-type water heaters for residential customers under varying conditions concurrently with a study on commercial water heating, abstracted elsewhere in this Compilation.

Summary of Major Findings:

1. The seasonal effect on energy use of water heaters is apparent, as found in previous water heating studies. Winter energy use is higher than summer and can be attributed to colder tap water temperatures.
2. Energy use, with and without interlock, for uncontrolled operation tends to be higher than that for the controlled operation.
3. Controlling the time of operation of the lower element apparently has the following additional effects: (a) 75% of the KWH use occurs during the unrestricted nighttime hours, whereas the reverse is true for uncontrolled operation; (b) Diversified demands during the restricted hours are considerably lower; (c) Water heater group load factors are lower.
4. The effect of an interlock is small with respect to diversified demands and KWH. However, noncoincident demands are as much as 40 % higher for those heaters without interlocks, with the larger differences occurring in the winter periods.
5. Larger tank sizes reflected higher energy use, as might be expected.
6. Quick-recovery water heaters have higher diversified demands with correspondingly lower load factors. KWH use is somewhat higher but this could be attributed to differences in customer characteristics.
7. Automatic clothes washers - because of their need for large quantities of hot water - appear to have a major influence on the load (vs time) curves of water heaters, as evidenced by the morning peaks established. [Such peaks are particularly pronounced for quick-recovery water heaters.]

SUMMARY OF RESIDENTIAL WATER HEATING DATA

		Average Weekday per Customer					
		Summer			Winter		
	Interlock	KWH	(1)	(2)	KWH	(1)	(2)
Under 66 gal. (avg. size-52 gal.)							
Controlled	Yes	8.23	0.91	1.83	10.56	1.20	1.94
Uncontrolled	Yes	8.32	0.53	1.59	12.15	0.71	1.73
Uncontrolled	No	9.32	0.55	2.15	11.39	0.68	2.57
Over 65 gal. (avg. size-78 gal.)							
Controlled	Yes	11.87	1.76	2.76	12.96	1.89	2.70
Uncontrolled	Yes	12.77	0.84	2.67	14.10	0.96	2.51
Uncontrolled	No	12.88	0.85	2.95	14.68	0.93	3.14
Quick-recovery (40 gal.)							
Uncontrolled	Yes	10.96	1.00	4.69	18.91	1.83	4.72
Uncontrolled	No	12.66	1.32	4.91	20.53	1.75	5.71

(1) Average weekday maximum diversified demand per customer, KW.
(2) Noncoincident maximum demand per water heater, KW.

TITLE: COMMERCIAL ELECTRIC WATER HEATING *

SOURCE: Public Service Electric and Gas Co. (Newark, N.J.)

AUTHOR(S): P.F.Platt (for B.P.Dahlstrom)
PREPARED BY AUTHOR(S) AND/OR: P.S.E.&G.

DATE OF ISSUANCE: 1964-65 Report of LRC/AEIC (Printed 1966)
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TOTAL: [PAGES 12 ; REFERENCES 1 ; GRAPHS 16 ; TABLES 4 .] **
DOCUMENT CLASSIFICATION(S): 48/11, 14

ABSTRACT: *[Twelve types of customers, of whom all but 3 were businesses.]

**[Graphs were grouped into 3 Charts.]

Standard-type water heaters, subdivided into two groups of above and below 65-gallon capacity, were tested. Each group consisted of approximately 50% NEMA rated units. The balance had upper and lower element sizes averaging 39 watts per gallon and 44 watts per gallon, respectively, for the smaller tank size group and 25 watts and 31 watts per gallon, correspondingly, for the larger capacity group. [These water heaters were generally located in the wash rooms of commercial establishments, most of which were small specialty shops; others were installed in schools, restaurants, garages, markets, etc.] Both groups were tested under the following conditions: (1) Interlocked upper and lower elements, with the lower elements controlled so as to restrict it operation beginning with 11 p.m. of one day and ending with 9:30 a.m. of the following day; (2) Uncontrolled, with an interlock on the heating elements; (3) Uncontrolled without an interlock.
[Note: Those water heaters under 66 gallon capacity averaged 52 gallons per heater, whereas the large sizes averaged 83 gallons.]

The test customers were chosen by accepted procedures of random choice from stratified subdivisions. The types of business in which the test water heaters were located generally fell into the following categories: store, school, restaurant, tavern, garage, market, office and machine shop.

Magnetic tape load survey recorders were installed on each test water heater to measure 30-min integrated demands. The summer tests were conducted during July, Aug. and Sept. The winter tests took place during Dec., Jan. and Feb. Each method of operation was tested for three weeks each in both the summer and winter periods. [One week was allowed between methods of operation to make necessary alterations for the next method of operation.]

Purposes of Study: to provide load data for storage-type water heaters for commercial customers under varying conditions, concurrently with a study in Residential water heating abstracted elsewhere in this Compilation.

Summary of Major Findings:

1. Energy use by commercial water heaters can be expected to be greater during the colder periods of the year.
2. Controlling the time of operation of the lower element has the following effects: (a) 75% of the KW use occurs during the unrestricted nighttime hours, as compared to 30% for uncontrolled water heaters; (b) Diversified demands are substantially lower during the restricted hours, which include times when system and most class peaks can be expected to occur; (c) Load factors based on group peak demands are lower; (d) KWH use is generally less.
3. The effect of an interlock is small with respect to diversified demands and KWH. However, noncoincident demands are 6 to 12% higher for those heaters without interlocks.
4. The KWH use was greater for the larger tank sizes, as might be expected.

SUMMARY OF COMMERCIAL WATER HEATING DATA

		Average Weekday per Customer					
		Summer			Winter		
	Interlock	KWH	(1)	(2)	KWH	(1)	(2)
Under 66 gal.(avg.size-52 gal.)							
Controlled	Yes	9.49	1.36	2.03	8.30	1.45	2.06
Uncontrolled	Yes	6.97	0.60	1.92	10.38	0.62	2.11
Uncontrolled	No	8.19	0.58	2.09	10.67	0.75	2.25
Over 65 gal.(avg.size-83 gal.)							
Controlled	Yes	9.01	1.36	2.48	10.93	1.73	2.40
Uncontrolled	Yes	9.34	0.62	2.25	14.17	0.88	2.23
Uncontrolled	No	10.96	0.68	2.43	14.52	0.99	2.49

(1) Average weekday maximum diversified demand per customer, KW.
(2) Noncoincident maximum demand per water heater, KW.

TITLE: SUPPLEMENTAL REPORT on RESIDENTIAL ELECTRIC WATER HEATING

SOURCE: Detroit Edison (Detroit, Mich.)

AUTHOR(S): L.E.Brandenburg (for E.H.Scott)
PREPARED BY AUTHOR(S) AND/OR: D.E.

DATE OF ISSUANCE: 1966-67 Report of LRC/AEIC (Printed 1968)
OTHER IDENTIFIERS: Appendix C, Section 3 (pp L-166 thru L-175); data covers 5/65 - 6/66
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TOTAL: [PAGES 10 ; REFERENCES 1 ; GRAPHS 4 ; TABLES 5] *
DOCUMENT CLASSIFICATION(S): 48/14, 15, 17, 19, 40

ABSTRACT: *[Graphs are grouped into 2 Charts.]

A one-year study of 30 (50-gallon) and 30 (80-gallon) water heaters was completed in June 1966. An initial D.E. report covering: estimated annual use, hourly patterns of hot-water use and summer/winter demand data (with lower element operation restricted by time clock) was included in the 1965-66 Annual Report of the LRC/AEIC. The initial report - not abstracted in this Compilation - also discussed in detail the operation of the water heaters tested and the test procedures used.

This report's summary of average customer load characteristics (and its tabulations of individual customer data) include energy use for both upper and lower elements of the water heaters, as metered, and other use as billed, for the one year of the test. All meters were read monthly thruout the test period.

Demand data were obtained during 3 test periods which included two weeks each in summer and winter (with lower element operation restricted to a 20-hour off-peak charging period) and one week in the spring of 1966, with lower element use uncontrolled. [Since the test groups are not identical in each of the 3 periods, the demand data and load curves are adjusted by ratio to equivalent annual use. While such an adjustment may not completely compensate for the differences in the sample groups, the resultant demand data are more nearly comparable with the annual energy uses, as reported.]

Hot water use was measured for at least 2 weeks, both summer and winter. Annual use estimates are based on use per day and KWH use per gallon, as derived from metered hot water use.

Purposes of Study: to briefly review certain aspects of a previous study of demand and hot water use data; to determine actual energy use for water heating and other residential purposes for the full year of the test; to estimate hot water use for the average day and for the high use day, by customer; to measure energy use per gallon of hot water use; to

determine average weekday load characteristics with lower element operation unrestricted.

Summary of Major Findings:

1. Annual energy use for the average 50-gallon water heater tested was 5,113 KWH, of which 95 KWH was upper element use; for the 80-gallon units it was 7,769 KWH, with upper element use accounting for 245 KWH. [Other residential uses of electricity averaged 5,359 and 6,389 KWH for the 50 and 80-gallon customers respectively.]

2. Annual energy use (for water heating only) ranged from 2,358 to 8,818 KWH for the 50-gallon water heater customers and from 3,320 to 15,782 KWH, for the 80-gallon units. As a general rule, customers with "high-use" for water heating also had high use for other residential purposes. Higher levels of water heating use are also associated with such factors as large families, infants, automatic washers, dishwashers and occasionally running out of hot water but none of these "criteria" are conclusive in determining an individual customer's energy use for water heating.

3. Based on records for a minimum of 4 weeks for each test customer, average daily hot water draw-offs average 80% of tank capacity and on a high use day exceed capacity by some 75%. [The cumulative distribution of water heater customers by water use indicates that only 25 to 30% of all water heater customers exceed capacity on an average day but that over 80% exceed it on a high use day.]

4. Test results show that the KWH per gallon value was substantially higher for the 50 than for the 80-gallon test group. These results reflect the lower inlet water temperatures found in the 50-gallon tests as well as differences in standby losses that are influenced by tank size, patterns of water use and basic differences in tank construction.

5. The average weekday maximum demand (hourly integrated) of the 50-gallon units, with unrestricted lower element operation, was 1.06 KW at 11 a.m. The 80-gallon peak of 1.32 KW occurred at 9 p.m. and was 0.21 KW higher than the midday peak. At the time of the winter system peak (normally 6-7 p.m.) the water heater demand was 0.83 and 1.20 KW for the 50 and 80-gallon heaters, respectively. [With existing time-clock controls, this demand is reduced to only 0.1 KW per heater at the time of the winter peak, altho the summer peak demand is not affected.]

TITLE: RESIDENTIAL CUSTOMER LOAD STUDY: HOMES WITH NEMA STANDARD WATER HEATERS

SOURCE: Baltimore Gas and Electric Co. (Baltimore, Md.)

AUTHOR(S): D.R.Kellenberger (for W.E.Miller)
PREPARED BY AUTHOR(S) AND/OR: B.G.&E.

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DOCUMENT CLASSIFICATION(S): 48/7, 8, 14, 19, 40

ABSTRACT: *[Seven of Tables are unnumbered. Graphs are grouped into 7 Charts.]

Thirty-three customers were selected at random (from the relatively small total population of homes equipped with NEMA standard electric water heaters) so that a representative sample of the metropolitan Baltimore area could be obtained. The 33 test homes used are single-family dwellings; 9 are ranch homes; 9 are cottages; 6 are Cape Cod; 6 are bungalows and 3 are row homes. Overall, frame construction predominates. The average home contains about 5 rooms, a kitchen and between one and two bathrooms (counting a powder room as one-half bath.)

Major appliance saturation percentages are: frost-free refrigerators (6); standard refrigerators (94); ranges (91); clothes washers (85); separate food freezers (36); room air conditioners (18); dryers (12); dishwashers (6). A 52-gallon NEMA standard water heater, with a 1.0 KW lower element and 1.5 KW upper element operating interlocked and uncontrolled, is installed in each home.

Magnetic tape recorders - designed for load test use with contact devices attached to watthour meters - were employed for the duration of this load study, using a quarter-hour time interval. One recorder was attached to a meter measuring the total-service requirements of the home and one was attached to another watthour meter installed to simultaneously measure the load of the water heating equipment. The load survey recorders are provided with 900 feet of tape, which length is sufficient for a 45-day record altho the practice is to change the recorder tape at approximately monthly intervals.

Purposes of Study: to obtain data not previously available for the B.G.&E. service area and from sufficient homes so as to provide statistically reliable standard water heating load results for use in engineering, economic and rate studies as well as for the development of sales estimating guides; comparison of data with a one-year test of high-wattage quick-recovery water heaters, conducted in 1963 and reported-on in the 1964-65 Report of the LRC/AEIC.

Summary of Major Findings:

1. An annual use of 4,121 KWH (equivalent to 2,747 hours use at 1.5 KW) for water heating by means of a 52-gallon standard water heater with a nominal 1.5 KW upper element plus a 1.0 KW lower element, operating interlocked and uncontrolled. [The variation in number of occupants and of hot water using appliances accounts for the major part of the differences in water heating KWH between the 33 homes studied.]

2. Of the average customer's total-service annual requirements, 47% is used for water heating; range for the monthly relationship varyied between 43 and 53%.

3. Of the annual water heating requirements, 51% are used "on peak" (8 a.m. to 10 p.m., inclusive, on weekdays other than holidays).

4. The maximum water heating use day is Monday in 7 months; Saturday is the maximum in 3 mo.; Monday and Saturday are equal in the other 2 mo.

5. The daily water heating maximum diversified demand (MDD) occurs between noon and 2 p.m. in 6 months; in the remaining six months it was between 7 and 9:30 p.m. Additionally, the maximum demand for average weekdays (in both the warmest and coldest weeks) occurs at 7 p.m.

6. The average water heating use per customer is 40% of the average total-service energy use on the day of the B.G.&E.'s system peak (Aug. 17, 82°F mean), 39% on the coldest day (Jan. 29, 8°F mean) and 39% on the warmest day (July 25, 87°F mean).

7. Water heating MDD measured over a quarter-hour interval generally is up to 4% greater, and one-hour loads are 1 to 7% less, than those measured over the standard half-hour interval.

8. At the time of a monthly system peak load, a maximum of 9% of the total-service connected load operates (Nov., 6 p.m.); coincidently, 51% of the water heating connected load is in use.

9. Water heating adds 0.6 KW per customer to B.G.&E.'s system monthly peak hours, averaged over the one-year period; this is 40% of the average connected load.

10. Annual diversified load factors are 41.5% for total-service use and 47.5% for the water heating use; comparable annual noncoincident load factors are 16.2% for total service and 29.2% for water heating.

11. Demand factors for total service vary from 7.3% (July) to 10.6% (Dec.) and for water heating from 54.0% (July) to 66.0% (Apr.).

TITLE: RESIDENTIAL ELECTRIC WATER HEATING

SOURCE: Philadelphia Electric Co. (Philadelphia, Pa.)

AUTHOR(S): W.D.Germond (for R.A.Markel)
PREPARED BY AUTHOR(S) AND/OR: P.E.

DATE OF ISSUANCE: 1967-68 Report of LRC/AEIC (Printed 1969)
OTHER IDENTIFIERS: Appendix C, Section 3(pp L-135 thru L-144); data covers Jan/Feb. & June/July/Aug. 1966
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with P.E.

TOTAL:[PAGES 10 ;REFERENCES ;GRAPHS 6 ;TABLES 3] *
DOCUMENT CLASSIFICATION(S): 48/14, 40

ABSTRACT: *[Graphs are grouped into 3 Charts. One of Tables is unnumbered.]

This report details the results of tests made on sample groups of both 50 and 80 gallon water heaters. The "major findings" summarized below as numbers 1 thru 4 had both the lower and upper heating elements operating on a controlled basis with a 17 1/2 hour split-cycle charging period and an "off" period beginning at 4 p.m.; those summarized as 5 thru 8 had the lower heating element operating on a controlled basis and the upper element operating uncontrolled.

Purposes of Study: to determine the electric use characteristics of 4500 watt, two element interlocked, quick-recovery electric water heaters operating under 3 combinations of controlled and uncontrolled conditions.

Summary of Major Findings:
1. The maximum average weekday (diversified) demands per unit occur at the start of the late evening recharging period. For the 50-gallon water heaters this demand is 1.38 KW in the winter test period and 1.31 KW in the summer test period. The corresponding demands for the 80-gallon units are 1.95 and 1.84, respectively.

2. A secondary average weekday (diversified) peak demand occurs in the late morning period (10 a.m. to noon) for both sizes of water heaters. In the winter this peak is approximately 70% and in the summer approximately 54%, of the late evening peak demand.

3. The average weekday KWH use per unit for the 50-gallon water heaters in the winter and summer test periods respectively, are 11.1 and 8.0. For the 80-gallon water heaters, the corresponding energy use is 18.2 and 11.9. [In both cases, the summer period use is approximately 70% of that for winter.]

4. The upper element energy use for both sizes amounts to less than 5%

of the total test period use in the winter and only 2% in the summer.

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5. The maximum average weekday (diversified) KW demands per unit occur at the beginning of the late evening recharging period. Demands are 1.65 in the winter and 1.50 in the summer for the 50-gallon units. The 80-gallon units have demands of 2.19 and 1.77, winter and summer respectively.

6. A secondary peak also develops in the late morning period and amounts to an average, for both sizes, of 64% of the maximum demand in the winter and 46% in the summer.

7. The average weekday KWH use per 50-gallon unit amounts to 11.7 in the winter and 7.4 in the summer; the values for the 80-gallon are 19.8 and 10.6, winter and summer respectively. [The summer period use approximates 60% of that for winter.]

8. For the 50-gallon unit, the upper element energy use amounts to 3% of the total energy use in the winter and 1% in the summer; the 80-gallon unit uses 6% in the winter vs 3% in the summer. [Note: During the off-period of the lower element, the upper element use is found to be negligible.]

TITLE: RESIDENTIAL ELECTRIC WATER HEATING

SOURCE: Detroit Edison (Detroit, Mich.)

AUTHOR(S): L.E.Brandenburg
PREPARED BY AUTHOR(S) AND/OR: D.E.

DATE OF ISSUANCE: 1969-70 Report of LRC/AEIC (Printed 1971)
OTHER IDENTIFIERS: Appendix C, Section 3 (pp L-144 thru L-158); data covers Dec. 1968 - Nov. 1969
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with D.E.

TOTAL: [PAGES 15 ; REFERENCES 2 ; GRAPHS 11 ; TABLES] *
DOCUMENT CLASSIFICATION(S): 48/14, 15, 17, 19, 40

ABSTRACT: *[The Graphs are grouped into 4 Charts.]

The test group was a randomly selected sample of 65, 50-gal., and 66, 80-gal., water heaters located thruout the D.E. service area. Lower elements of all heaters were radio controlled; upper elements of most were interlocked and operated without restriction. However, in one case where the upper element was not interlocked (and in several where they were turned off) the heaters were metered as found.

At the time the sample was selected, D.E. served 197,000 electric water heaters; some 75% were 50-gal. and the balance primarily 80-gal. Two rate schedules were applicable to this service: a flat rate determined by tank size and a floating block component of the residential rate, with the size of the block increasing with tank size. In mid-1968, some 60% of heater customers were on the flat rate but by April 1970 only 45% of the 203,365 water heaters were on this rate, which had by then been closed to new business.

Recording meters, installed on both elements of all water heaters, were read at about one-month intervals; billing meters were read at the same time. Energy uses were adjusted to calendar month bases for summary. When meters were removed before the end of the test period, results were extrapolated to a full year. [At several locations, customers moved during the test year but metering continued. Since such occurrences are considered normal, annual use is reported as metered even though the individual customers using the same water heater may have had substantially different usages.] Upper element use was metered separately for each test customer but results are reported only for the average customer. In several cases, unusual upper element use was registered and excluded from the averages because of irregularities in lower element operations.

Purposes of Study: (1) review annual and seasonal energy use of electric water heaters and compare the results with previous test data; (2) determine range of individual customer usage; (3) examine relationships be-

tween water heater use and rates, family size and other residential loads; (4) develop diversified summer and winter load curves for water heaters having radio-controlled lower elements.

Summary of Major Findings:

1. Annual use averaged 4,813 KWH for the 50-gal. heaters and 6,851 for the 80-gal. [Note: There was a significant difference in use as between water heaters on the "flat rate" and those on the "floating block" rate.]
2. With normal operation of the lower element, the upper element had 3.4% of the total use of the 50-gal. water heaters and 2.1% for the 80-gal. Of the 131 customers in the sample, 33.6% had no upper element use while 14.5% had upper element use in excess of 5% of the total use.
3. Energy use per day was highest in Feb. (15.7 KWH) and lowest in Aug. (13.2 KWH). As in previous studies, Monday continues to be the high use day.
4. The maximum one-day energy use of the sample customers was, on average, 85% higher than their use for the average day in the (2) two-week test periods. The highest single-day use for an individual customer was 43.9 KWH (50-gal.) and 62.9 KWH (80-gal.).
5. Based on average customer data, water heater use is $\approx$ 45% of total use. On an individual customer basis, such use does not have a high degree of correlation with that for other residential purposes.
6. Annual water heater use increases nearly 1,000 KWH for each person based on test data grouped by family size. However, individual customer use is determined only in part by size of household; type of dwelling, type and age of water heater, wash-day habits and vacation patterns also influence such use.
7. Lower element (noncoincident) maximum demands averaged 2.4 KW (for the 50-gal.) and 3.1 for the 80-gal. sample. The group coincident demand, based on weighted average demands for typical week days, indicates midday and evening peaks of 0.8 to 0.9 KW. [With radio control, a 50% reduction in load was accomplished at the time of the summer peak. The corresponding winter load reduction is indicated as 40%; this lesser decrease reflects the use of overlapping control cycles on the test days, hence, greater diversity at the time of maximum load reduction.]
8. Average use per water heater (for both size tanks) did not vary significantly from average use derived in a 1966 water heater study. Block rate customers had significantly lower use than corresponding flat rate. The variations are due in part to the differences in average family size. Comparisons with prior D.E. heater studies also point to average family size as a significant consideration in the comparisons of such test results.

TITLE: RESIDENTIAL NONFARM ELECTRIC WATER HEATING LOAD STUDY

SOURCE: Consumers Power Co.

AUTHOR(S): K.L.Brockway for W.J.Jefferson
PREPARED BY AUTHOR(S) AND/OR: Consumers Power Co.

DATE OF ISSUANCE: 1975-76 Report of LRC/AEIC (Printed 1977)
OTHER IDENTIFIERS: Appendix B, Section 3 (pp L-139 thru L-160); data covers 12 months ending 6/30/75
DATA USE RESTRICTIONS: "Not to be published or quoted"; check with C.P.C.

TOTAL:[PAGES 22 ;REFERENCES ;GRAPHS 29 ;TABLES 4] *
DOCUMENT CLASSIFICATION(S): 48/7, 14, 15, 17, 19, 30, 40, 46

ABSTRACT: *[Graphs are grouped into 7 Charts.]

[Participation in the study was on a voluntary basis.] From the Company's customer records, 3 samples (of 75 customers each) were randomly selected. The universe (186,220 accounts) was composed of all active/nonseasonal/nonfarm electric water heating customers being billed on the Company's Rate A (Residential Service) or Rate A-1 (Residential Electric Heating Service). Each sample was then compared with known universe characteristics such as geographic and Rate distributions; they were designated "Primary", "Alternate A" and "Alternate B', based on their respective degrees of representativeness. The "Primary" sample was adjusted (with 23 substitutions randomly selected from the "Alternate A" sample) when customers refused to participate, presented unsafe or impossible metering situations or violated the basic selection criteria. In total, 34 substitutions were made since 11 of the "Alternate A" customers were also rejected and replaced by "Alternate B".

The 75 customers in the final sample were subjected to a personal interview to obtain basic demographic and appliance saturation data. Magnetic tape recorders, in conjunction with pulse initiating watthour meters, were employed to collect the data. Two units were installed at each customer's premises; one recorded water heater use, while the other recorded total load.

Purposes of Study: (primarily) to obtain statistically reliable use and demand data for Residential Nonfarm Electric Water Heating Customers. [Note: In addition to the evaluation/design of rate schedules, the data is also a key input with respect to Residential Load Management Feasibility Studies since water heating constitutes a major deferrable load.]

Summary of Major Findings (Water Heating Load):

[Note: Water heater elements are not required to be interlocked.]
1. The average monthly heater use ranged from 396 KWH (in Jan. 1975) to 339 KWH (in June 1975), a difference of 57. The average use for the

twelve months was 4,410 KWH.
2. The maximum (noncoincident) demand per customer was 7.78 KW (in Oct. 1974). The annual average (noncoincident) demand per customer was 3.67 KW.
3. The half-hour maximum (diversified) demand for the average customer was 1.20 KW (from 12:00 to 12:30 P.M.; Sat. 3/1/75).
4. Monthly half-hour maximum (diversified) demand ranged from 1.01 KW (in June 1975) to the previously cited 1.20 KW. The timing of this factor was highly variable, ranging from intervals ending 10:30 A.M. through 8:30 P.M.
5. Monthly half-hour maximum (diversified) demands were the least from May thru Aug. For these months, the maximum occurred during the late morning hours.
6. The maximum (diversified) demand per customer, at the time of each monthly system peak, was consistently lower than the monthly maximum (diversified) demand. On an annual basis, this relationship was 2/1.
7. Differences between maximum (diversified) demand per customer, whether based on the average weekday or on the average day of the test period, were insignificant. The largest variation was 0.03 KW.
8. The annual load factor, based on average (noncoincident) demand, was 13.7%; based on maximum (diversified) demand it was 42.0%. Under either basis, monthly variation was minimal.

Summary of Major Findings (Total Load):

1. The average monthly use per customer ranged from 1,293 KWH (in Jan. 1975) to 840 (in June 1975). The average use for the twelve months was 12,419 KWH.
2. The maximum (noncoincident) demand per customer was 18.34 KW (in Mar. 1975). The annual average (noncoincident) demand per customer was 9.40 KW.
3. The half-hour maximum (diversified) demand for the average customer was 3.14 KW. This demand occurred from 6:00 to 6:30 p.m.; Thurs. 12/26/74.
4. Monthly maximum (diversified) demands ranged from 3.14 KW (in Dec. 1974) to 2.00 KW (in June 1975). These maxima occurred between 6:00 and 9:00 P.M., in 10 of the 12 months studied.
5. The maximum (diversified) demand per customer, at the time of each monthly system peak, was consistently lower than the monthly maximum (diversified) demand. The differences in these values ranged from 0.07 KW to 1.08 KW.
6. Differences between maximum (diversified) demand per customer, based on the average weekday or on the average day of the test period, were insignificant. The largest variation was 0.03 KW.
7. The annual load factor, based on average (noncoincident) demand, was 15.1%, based on maximum (diversified) demand it was 45.7%.
8. The annual load factor, based on the maximum (diversified) demand per customer at the time of system peak, was 92.7%.

General Comments (about test period results):

1. There were 6,938 (weighted average) actual degree-days (DD) as com-

pared to 6,931 (weighted average) normal or a variance of 0.1%. [Note: The weighting of DD was based on the total monthly use of residential water heating customers in each of the Company's Electric Divisions.]
2. The average use per water heater constituted 35.5% of the average use per customer. This value ranged from 41.05% (in May 1975) to 30.5% (in Feb. 1975).
3. The relationship between the timing of the water heater and total load (maximum diversified) demand per customer was minimal. [They occurred simultaneously only during Apr. 1975.] However, a strong relationship existed (for the timing) when based on the average day of each month of the study, since such values occurred within the same hour in 10 of the 12 months.

"PUBLISHED"
ABSTRACTS
FOLLOW

REMINDER

The following "Published" Report Abstracts are firstly arranged in order of their leading documentation number on the Abstract sheets, i.e. the number to the left of the / in the space labeled DOCUMENT CLASSIFICATION(S). Secondly - within each document class number (D.C.N.) - they are arranged in chronological order of their DATE OF ISSUANCE.

Readers interested in material within a "desired" D.C.N. would first look at the Abstracts starting on the indicated page for that D.C.N., as noted in the Subject Classifications which follow this page. Next he can scan the rest of the Abstracts, noting the occurrence of the desired D.C.N. as located to the right of the /.

Note: A few of the D.C.N.'s will only be found to the right of the /. This situation is indicated by a—, instead of a page number, in the Subject Classification (listing).

SUBJECT CLASSIFICATION FOR "PUBLISHED" REPORTS

D.C.N. (a)	Classification	Page (b)
1	Air conditioning (equipment)	346
	All-electric buildings, non-residential; see Buildings, all-electric	
2 (c)	All-electric, single family residences	349
	Analysis, general; see Computer-related topics and Load analysis Analysis, statistical; see Statistics-related information	
3	Apartment buildings	350
4	Appliances (misc. topics)	354
	Bibliographic listings; see Energy information sources	
5	Bills, electric utility	363
6 (c)	Buildings, all-electric; misc. topics	367
7	Buildings, misc.; also see specific building types	374
	Churches; see Religious institutions Class of service; see Bills	
8	Clothes-cleaning equipment	—

(a) D.C.N. = Document Classification Number.

(b) This number refers to the starting page for the earliest abstract which carries the designated D.C.N. in "first place" in the Document Classification(s) space on the Abstract form. [Note: a dash (-), which replaces a page number, simply means that the particular D.C.N. happens to never occur as a first place (i.e., primary) D.C.N. The reader can locate such classifications by scanning the document classification space of the abstracts.]

(c) An appreciable number of the Published reports probably relate (at least in part) to "all-electric" situations, without specifically designating them as such.

D.C.N.	Classification	Page
9	Commercial customers (misc. topics)	375
10	Computer-related topics	379
11	Conservation of energy	390
	Construction details; see Housing, etc. characteristics	
	Control equipment; see Load management and Load surveillance	
12	Cooking equipment	—
	Cooling; see Air conditioning	
	Costs; see Economics	
	Curves, load; see Load profiles	
	Customer characteristics; see Demographics	
	Customers, large-use; see Commercial customers	
	Data acquisition; see Computer-related topics and Load surveillance	
	Data analysis; see Computer-related topics and Statistics-related information	
	Demand; see specific usage D.C.N.	
	Demand control; see Load management	
13 (d)	Demand-related material (including demand/energy relationships)	406
14	Demographics	410
15	Design-related information; also see Computer-related topics	—
	Dryers; see Clothes-cleaning equipment	
	Dwelling characteristics; see Housing, etc.	
16	Econometrics; also see Elasticity	415
17	Economics (misc. topics)	423
18	Elasticity (of demand, price, etc.)	426

(d) It should be noted that Demand, in this case, is supposedly expressable in KW. Quite a few of the abstracts - using "Demand" as part of their title - deal (at least in part) with "Economic Demand".

D.C.N.	Classification	Page
19 (e)	Electrical factors (misc. data)	433
	Electrical loads; refer to the specific usage D.C.N. and other "Load" topics	
20	Elevators and escalators	435
21	Energy consumption, electrical (as affected by factors such as income, price, time, etc.); also see Demographics	436
22	Energy data, misc. (not exclusively electrical)	443
23	Energy information (source references listings)	446
	Environmentally-related factors; refer to Weather, etc.	
	Estimation; see Forecasting and Load forecasting topics	
24	Food refrigeration equipment	449
25	Forecasting studies and techniques; also see Load forecasting (general)	450
	Freezers; see Food refrigeration equipment	
	Furnaces; see Heating, space	
	Government buildings; see Municipal loads	
26	Handbook (and similar) data sources	468
27	Heat pumps; also see Air conditioning and Heating, space	473
	Heaters, water; see Water heaters	
	Heating, resistance; see Heating, space	
28	Heating, space	475

(e) Such factors are used to characterize and/or quantify electrical loads; refer to this Compilation's GLOSSARY for factor definitions. Note: many of the Published reports contain some data on one or more of these factors.

D.C.N.	Classification	Page
29	Homes, mobile	482
	Homes, non-mobile; see Residential D.C.N.	
	Hot water usage; see Water heaters	
30	Housing (and other buildings) characteristics; i.e., as part of data related to energy use	—
	Instrumentation; see Load surveillance	
31	Insulation, thermal (as related to electrical use)	—
	Interruptible loads; see Load management	
32	Lighting, commercial and misc. uses	483
33	Lighting, residential	—
	Lighting, street; see Municipal loads	
34	Load analysis	484
	Load control, planned; see Load management	
35	Load forecasting (general topics); also see Econometrics and Forecasting	490
36	Load management	506
37	Load profiles (misc. topics)	521
38	Load studies (misc. topics); also see specific usage D.C.N.	526
39 (f)	Load surveillance (equipment and procedures)	530
	Loads, electrical; see specific usage D.C.N.	
	Loads, peak; see Peak load information	
	Measurement equipment; see Load surveillance	

(f) Most of the Published reports do not include details of the measurement procedures and measuring systems used in obtaining the test data.

D.C.N.	Classification	Page
40	Metering, master	536
41	MIUS (and IUS); also see Total Energy	540
	Modeling; see Computer-related topics	
42	Municipal loads; also see Buildings, misc. and Commercial customers and Schools	554
43	Occupancy data; also see Demographics	—
44	Office buildings	555
45	Peak load information	562
	Planning; see Load forecasting (general) Population characteristics; see Demographics Power factor data; see Electrical factors Projections; see Forecasting topics	
	Ranges, electric; see Cooking equipment Rate studies and schedules; see Bills Refrigerators; see Food refrigeration	
46	Religious institutions	—
47	Residences (misc. topics related to energy use)	566
	Residences, multi-family; see Apartment Resistance heating; see Heating, space Rural loads; see Total-class loads	
	Sampling procedures; see Statistics Saturation (of appliances); see Appliances (misc. topics) and specific appliance D.C.N.	
48	Schools; also see Municipal loads	588
49	Shopping centers; also see Commercial	600
	Space heating; see Heating, space	
50 (g)	Statistics - related information	601

(g) Most of the Published reports do not include details of the statistical procedures connected with the planning and implementation of the study which resulted in the printed report.

D.C.N.	Classification	Page
	Suburban loads; see Total-class loads	
51	Television sets; also see Appliance (misc. topics)	—
	Temperature effects; see Weather, etc.	
	Testing; see Load surveillance	
52(h)	Total-class loads; also see Utility-related information	—
	Total electric; refer to All-electric topics	
53	Total Energy (and allied concepts); also see MIUS	608
54	(Total) Energy Management; also see Conservation	634
	Trend forecasting; see Forecasting D.C.N.	
	Urban loads; see Total-Class loads	
55	Utility-related information	638
	Washers, clothes; see Clothes cleaning equipment	
56	Water heaters	650
57 (i)	Weather and environmental effects; also see Energy consumption, electrical	657

(h) Most of the Published reports do not clearly distinguish between (urban, suburban and rural) residential loads.

(i) Most of the Published reports contain only minimal information about weather conditions during the period for which they report data.

TITLE: THE ROOM AIR CONDITIONER as an ENERGY CONSUMER

SOURCE: ORNL

AUTHOR(S): J.C.Moyers
PREPARED BY AUTHOR(S) AND/OR: ORNL (for NSF/RANN)

DATE OF ISSUANCE: 10/73
OTHER IDENTIFIERS: ORNL-NSF-EP-59; Environmental Program

DATA USE RESTRICTIONS:

TOTAL:[PAGES 6 ;REFERENCES 2 ;GRAPHS 1 ;TABLES 1] *
DOCUMENT CLASSIFICATION(S): 1/11, 14, 17, 45

ABSTRACT: *[Material of secondary relevance to the subject matter of this Compilation is scattered thruout this Study. The Total(s) are for the relevant data.]

In all-electric homes air conditioning ranks third in the use of electricity, behind space heating and water heating. In air-conditioned homes having non-electric space heating and water heating, air conditioning is by far the largest single electricity-consuming function. Air conditioning is particularly important as a power consumer because of its contribution to (or because it is a cause of) the annual peak load that occurs in the summertime for many utility systems.

This Study was undertaken to determine: the range of operating efficiencies offered by the many models of room air conditioners available on the market; the extent to which adequate information is available to the prospective air conditioner purchaser; and to develop a method for comparing differences in purchase price with differences in performance. [Note: A "conjectural" estimate was made as to effect on USA power use due to a change in average operating efficiency.]

The investigation has shown that there is a wide variation in the power consumption of room air conditioners that accomplish the same amount of cooling. Efficiencies ranged from 4.9 to 12.2 BTU/watt-hr. An improvement in average efficiency of from 6 to 10 BTU/watt-hr is estimated to result in a total saving of 212 billion KWH during the 1973-80 period and a reduction in connected load to the electrical utilities (in 1980) of almost 58,000 megawatts. [A method for predicting the change in efficiency due to a change in design is developed and used to estimate the additional cost entailed in providing higher efficiency.]

TITLE: SUMMER AIR CONDITIONING and APPLIANCE USE PATTERNS: A GRAPHICAL ANALYSIS

SOURCE: Princeton University/Center for Environmental Studies

AUTHOR(S): J.A.Robinson & J.Yeung
PREPARED BY AUTHOR(S) AND/OR: Princeton University/C.E.S.

DATE OF ISSUANCE: 5/75
OTHER IDENTIFIERS: C.E.S. Report No. 22 (Sponsored by NSF/RANN)

DATA USE RESTRICTIONS:

TOTAL: [PAGES 33 ;REFERENCES ;GRAPHS 24 ;TABLES] *
DOCUMENT CLASSIFICATION(S): 1/4, 6, 12, 21, 33, 37, 56

ABSTRACT: *[This Report contains material of (mainly) direct relevance to the subject matter of this Compilation. The Total(s) apply to the relevant data.]

This Report is a "first step" toward understanding how electricity is consumed in residential housing during the summer. It is stated that, altho the Report's graphs exhibit very suggestive patterns of air conditioning and electrical appliance consumption, caution in generalizing from these data to other residences in different parts of the country is warranted. The primary concern of the authors was to understand the patterns of electric consumption for individual appliances across time as well as to relate such consumption with outside weather conditions, especially temperature.

The sources of the data for this study are 3 highly instrumented residences located in the planned community of Twin Rivers, N.J. The houses occupy adjacent positions in a row of townhouses and are identical 3-bedroom units, except that one is on the end of the row and thus has an additional outside wall as well as an extra upstairs window. The 3 families all have young children. The houses have identical air conditioning systems, electric ranges and hot water heaters. Many of the smaller appliances are also identical in the 3 units but the refrigerator/freezers are not.

The Report includes a summary of the tests conducted during Aug./Sept. (1974). In general, the results are expressed in terms of KWH used by the various loads during successive 20-minute periods of each day. The graphs include the average daily values of energy used by the air conditioners, electric ranges, lights plus "minor" appliances and hot-water heaters; except for a few "gaps", these results are for the summed use of the 3 houses tested.

TITLE: ROOM AIR-CONDITIONER LIFETIME COST CONSIDERATIONS: ANNUAL OPERATING HOURS and EFFICIENCIES

SOURCE: ORNL

AUTHOR(S): D.A.Pilati
PREPARED BY AUTHOR(S) AND/OR: ORNL (for NSF)

DATE OF ISSUANCE: 10/75
OTHER IDENTIFIERS: ORNL-NSF-EP-85 (may be ordered from NTIS by this number); Environmental Program
DATA USE RESTRICTIONS:

TOTAL:[PAGES 10 ;REFERENCES 4 ;GRAPHS 4 ;TABLES 2] *
DOCUMENT CLASSIFICATION(S): 1/11, 15, 57

ABSTRACT: *[Material of (mainly) secondary relevance to the subject matter of this Compilation is scattered thruout this Report. The Total(s) are for the relevant data.]

The Report calculates the annual hours of air-conditioning compressor operation for two types of use, namely: a house that is naturally ventilated to temperatures between 75 and 78°F when the outdoor temperature and wind speed will permit - and which is air conditioned at 78°F, as required - and a house that remains closed-up and is air conditioned at 78°F. For the 10 cities investigated, compressor savings from natural ventilation ranged from 12% in Phoenix to 73% in San Diego. [These results were generalized to estimate the compressor-operating hours for any USA location.]

The variation of an air conditioner's energy efficiency ratio (EER), with outdoor conditions, is given. For units having continuously operating fans, the EER decreases markedly at lower outdoor temperatures. For example, a high efficiency model is shown to suffer a 40% decrease in EER when the outdoor temperature is 75°F compared to that when temperatures are in the low 90's.

Seasonal EERs are given for four units in 10 cities. Units with continuously operating circulating fans have EER values that average 8.5% below the nameplate value. For the cities and four units investigated, the use of an automatic circulating fan that only operates during the cooling cycle would increase the EER from 12 to 34% over an identical unit using a continuous fan.

As electrical rates increase, consumers will tend to pay more attention to the operating costs of their electrical appliances. For an air conditioner, the costs (neglecting maintenance) are proportional to: the price of electricity, the unit's capacity, the compressor-operating hours and the inverse of the unit's (seasonal) EER. Compressor-operating hours are, in turn, primarily a function of the installation's geographical location and the behavior of the user.

TITLE: SEVEN THINGS TVA HAS LEARNED about ITS HOUSE HEATING LOAD

SOURCE: Electrical World, 11/14/55, pp 139-144

AUTHOR(S): W.R.New
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 11/55
OTHER IDENTIFIERS: Electric House Heating

DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL: [PAGES 6 ;REFERENCES ;GRAPHS 5 ;TABLES 5] *
DOCUMENT CLASSIFICATION(S): 2/13, 15, 19, 21, 28, 31, 37, 45, 55

ABSTRACT: *[Contains material of direct and (mainly) secondary relevance to the subject matter of this Compilation.]

In the service area of the Tennessee Valley Authority more than every tenth home today is heated electrically. TVA's accumulation of facts and figures for the economical design and operation of distribution, transmission, and generation with the space heating load resulted in the observations summarized below:

1. Where heating installations are engineered for thermostatic control and the size of the connected load, about 50% of the installed heating adds to the peak system demand at design temperatures.
2. The average diversified monthly load factor of the all-electric home normally ranges from 45 to 50%, with the annual load factors approximating 25%. [The annual load factor should increase to better than 30% as air conditioning is added.]
3. An annual load factor as low as 25% (when produced by heating) has desirable features because of the small capacity of the needed distribution facilities.
4. The electrically heated home should be well insulated and its connected load should not exceed the calculated heat loss.
5. All energy uses in the house actually contribute to heating the home and should therefore reduce the required connected heating load.
6. The evening peak of the all-electric TVA home has grown faster during the past several years than the morning peak. Thus evening peaks are likely to equal morning peaks, thereby improving system load factors.
7. Distribution transformer loads of 200% of rated capacity are economical for the heating peaks.

TITLE: ELECTRIC POWER DEMANDS for GARDEN APARTMENTS

SOURCE: Washington Gas Light Company (Washington, D.C.)

AUTHOR(S): L.B.Nye, Jr. & E.C.Moran
PREPARED BY AUTHOR(S) AND/OR: W.G.L. Company

DATE OF ISSUANCE: 2/65
OTHER IDENTIFIERS: Approved by L.Ourusoff

DATA USE RESTRICTIONS:

TOTAL: [PAGES 12 ;REFERENCES ;GRAPHS 8 ;TABLES] *
DOCUMENT CLASSIFICATION(S): 3/13, 15, 37, 38, 53, 55, 57

ABSTRACT: *[This "informal" analysis contains data relevant to the subject matter of this Compilation.]

A T.E. system (to be effective and economically competitive) must be based on sound electric demand and consumption data. A system design based on estimated demands, liberally interlaced with safety factors, is likely to be oversize and as a result will either operate inefficiently or, because of its high first cost, will never be installed.

This Report analyzes actual KW demand charts from 2 apartment groups, with electric equipment loads similar to those expected with gas fired T.E. systems. The results of the analysis gave a basis for equipment selection for other garden apartment developments and indicated a maximum power generation requirement 30% below that by local consulting engineers, which was estimated from installed equipment capacities. Due caution is called for in applying the results of this study to apartments with different selections of appliances, occupied by substantially different socio-economic groups or located in widely different areas. [The selection of equipment capacities, to provide adequate reliability at the loads determined, is considered to be a matter of individual judgment.]

The Report includes the following graphs of KW demand for the specified "typical" days: (1) winter weekday, 268 dwelling units, various HDD; (2) winter weekend, 268 units, various HDD; (3) summer day, 268 units, various maximum outdoor °F; (4) winter weekday, 100 units, various HDD; (5) winter weekend, 100 units, various HDD; (6) summer day, 100 units, various maximum outdoor °F. There is also a comparison of the winter power demand profiles (per 100 dwelling units) for 2 apartment groups and for 2 different HDD. Additionally, there is a "histogram" plot which shows the distribution of annual operating hours (at various KW levels) for a group of 100 dwelling units.

TITLE: ELECTRIC ENERGY CONSUMPTION in APARTMENT HOUSES

SOURCE: Florida Power Corporation (St. Petersburg, Florida)

AUTHOR(S): T.I.Wetherington, Jr.
PREPARED BY AUTHOR(S) AND/OR: F.P.C.'s Competitive Research Dept.

DATE OF ISSUANCE: 6/6/69
OTHER IDENTIFIERS: Bulletin #118 **

DATA USE RESTRICTIONS:

TOTAL:[PAGES 7 ;REFERENCES 1 ;GRAPHS 14 ;TABLES 1] *
DOCUMENT CLASSIFICATION(S): 3/1, 6, 14, 21, 22, 43, 47, 55

ABSTRACT: *[Contains material of direct relevance to the subject matter of this Compilation.]

**[Also presented as a Paper at the 1969 Industrial and Commercial Power Systems and Electric Space Heating and Air Conditioning Joint Technical Conference; 5/12-5/15, 1969; Baltimore, Md.]

Electrical energy consumption in apartment houses aggregating 3,490 units are statistically analyzed according to building type (high rise or garden) and by installed appliances and comfort conditioning systems. The objective was to refine energy consumption estimating data and to study differences in the magnitude and patterns of usage as related to appliance and comfort conditioning system types. [This statistical approach yields more accurate results than does a cursory engineering analysis which falls short of considering all of the actions and interactions of systems, occupants, management and design of apartment buildings.]

All the high-rise units utilized electricity for cooling. Some of the all-electric garden units had heat pumps, others used a mixture of heat pumps and resistance heating. It was found that the total KWH, per occupied apartment, is reduced somewhat over 200 KWH per month when gas is used for cooking, water heating and space heating.

The following conclusions were reported:
(A) Maximum economy in electric energy consumption occurs when the apartment systems are individualized to the maximum extent.
(B) Low occupancy rates affect all apartment houses adversely but do so to a much greater extent where central cooling systems are used.
(C) Losses and waste produce a base load for central chiller and hot water systems that more than absorb the apparent economics of size usually associated with large units.
(D) Electric usage differentials - with electric heating, cooking and water heating - are lower than normal estimating procedures would predict due to failure of such procedures to take into account: (1) reduced physical occupancy below rental occupancy and (2) the system loads imposed by auxiliary electric consumption, system losses and parasitic heat interchange.

TITLE: APARTMENT HOUSE (HI-RISE and GARDEN TYPE) 1968 ANNUAL DATA, ENERGY USE

SOURCE: Florida Power Corporation (St. Petersburg, Florida)

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: F.P.C.'s Competitive Research Dept.

DATE OF ISSUANCE: 7/8/69 (for #124) and 7/9/69 (for #125)
OTHER IDENTIFIERS: Bulletins #124 and #125; Hi-Rise and Garden Type, respectively
DATA USE RESTRICTIONS:

TOTAL: [PAGES 4 ;REFERENCES ;GRAPHS 2 ;TABLES 2] *
DOCUMENT CLASSIFICATION(S): 3/1, 5, 37, 40, 55

ABSTRACT: *[Totals for each Bulletin are 2, 1 and 1 respectively. Contains material of direct relevance to the subject matter of this Compilation.]

These Bulletins contain tabulated data on: (1) total KWH usage per apartment per year; (2) monthly average and maximum values of KWH per apartment, for all consumption billed directly to the apartment management under Commercial and Water Heating Rates; (3) annual KWH billed to the individual tenants under a Residential Rate.

The apartments were separated into categories as to how they were air-conditioned and as to whether they were individually or "master" metered. Monthly values of KWH usage are plotted (for 1968) for the 3 categories of high-rise and 3 categories of garden-type apartments.

TITLE: METERED DATA; APARTMENT HOUSE SUMMARY; 1969 ENERGY USE

SOURCE: Florida Power Corporation (St. Petersburg, Florida)

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: F.P.C.'s Competitive Research Dept.

DATE OF ISSUANCE: 7/6/70
OTHER IDENTIFIERS: Bulletin #179

DATA USE RESTRICTIONS:

TOTAL: [PAGES 2 ;REFERENCES ;GRAPHS 2 ;TABLES 1]*
DOCUMENT CLASSIFICATION(S): 3/1, 5, 37, 40, 55

ABSTRACT: *[Contains material of direct relevance to the subject matter of this Compilation.]

This Bulletin is a follow-up on F.P.C. Bulletins #124 and #125. It reports data for the year 1969, whereas #124 and #125 covered 1968, for high-rise and garden-type apartments, respectively. However, the 1969 tests did not include all of the apartment houses studied in 1968.

Altho there were significant variations in some of the data, as between 1968 and 1969 values, no comparative analysis is given. [Some of the garden-type apartment variations can be ascribed to changes in occupancy levels.]

This Bulletin contains tabulated data on: (1) total KWH usage per apartment per year; (2) monthly average and maximum values of KWH per apartment, for all consumption billed directly to the apartment management under Commercial and Water Heating Rates; (3) annual KWH billed to the individual tenants under a Residential Rate.

TITLE: THREE TEXAS COMPANIES STUDY CHARACTERISTICS of FIVE APPLIANCE LOADS

SOURCE: Electrical World, 8/11/58, pp 40-46

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: E.W.

DATE OF ISSUANCE: 8/58
OTHER IDENTIFIERS: Distribution-Testing. [The Companies were: Dallas Power & Light, Texas Power & Light and Texas Electric Service.]
DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL: [PAGES 7 ;REFERENCES ;GRAPHS 16 ;TABLES 3] *
DOCUMENT CLASSIFICATION(S): 4/8, 13, 24, 47, 51, 55

ABSTRACT: *[Contains material of direct relevance to the subject matter of this Compilation.]

Objectives of the Study included: determining the saturation of various appliances; determining the diversity inherent in various appliance loads; providing data that will facilitate the most economical distribution system designs; improving service to customers.

Fifteen typical residential areas were surveyed. These were lateral feeder areas selected for their loads and the number of homes. The feeders had load characteristics similar to those of the overall residential load of the combined systems.

Data from the survey have been compiled and correlated for 5 appliances: home freezers; dishwashers with heating elements; television sets; automatic clothes dryers; automatic clothes washers. [Data on television sets were obtained from tests by a Dallas television station.] The test on each appliance was for 12 months, altho on different appliances at various times. Composite figures for each group of freezers, dishwashers, clothes washers and clothes dryers were used, except for maximum non-coincident demands. [A composite Tuesday for example, is an average of the test results for all Tuesdays.] KWH were derived from all data available.

The Article includes a tabulated summary of annual data for the 5 appliances mentioned. The summary covers annual usage plus demands, coincidence factors and load factors (all of these three being expressed on various bases).

TITLE: MINIMIZATION of RESIDENTIAL ENERGY CONSUMPTION

SOURCE: Proceedings of 7th IECEC (held at San Diego, Calif., Sept. 25-29, 1972), pp. 1247-1255
AUTHOR(S): D.G.Harvey; et al
PREPARED BY AUTHOR(S) AND/OR: Hittman Associates, Inc. and HUD

DATE OF ISSUANCE: 9/72
OTHER IDENTIFIERS: Paper No. 729187

DATA USE RESTRICTIONS: Copyright by American Chemical Society

TOTAL: [PAGES 9 ;REFERENCES 17 ;GRAPHS 10 ;TABLES 1] *
DOCUMENT CLASSIFICATION(S): 4/11, 47, 52

ABSTRACT: *[This Paper contains information of direct and (mainly) secondary relevance to the subject matter of this Compilation. Total(s) are for the entire Paper, even though same gas use data is included.]

The Residential consumption of power has been increasing at an accelerating rate. This growth rate is attributable to two major factors: the increases in the number of residential units and in the usage of power consuming devices within these residences. The growth in residential power consumption is expected to continue due to expansion of the population and the increased demand for year-round climate control and power consuming appliances within the individual residences.

Data concerning the usage of residential power consuming components were obtained from various trade journals and power utilities, as referenced. This historic demand for various electrical appliances on the national level is represented in terms of "percent saturation". Appliances such as the refrigerator and washing machine have essentially stabilized at the 100% saturation level; consequently, the future demand for such appliances would follow the growth rate of total residences (i.e., they would be population controlled). Other appliances, which as yet have not reached the 100% level, have exhibited a rapid increase in recent years. [It should be noted that the saturation level of items such as room air coolers and TV's could be well in excess of 100%.] Therefore, the power consumption per residence is expected to continue to increase in future years and possibly the rate will accelerate under the impetus of new appliances.

The annual power consumption of the various appliances, common in residences, are listed. Included is the listing of the energy consumed, at an approximately 31% thermal efficient electrical generating plant, to supply the residential appliances. It should be noted that this list of common appliances uses in excess of 12,000 KWH annually - about double the national average in 1970. The point again emphasizes the continuing expansion of residential power consumption. [An evaluation of the respective appliances, from the viewpoint of power conservation, is given in summary form.]

TITLE: LOAD RESEARCH PINPOINTS APPLICANCE USE

SOURCE: Electrical World, 9/1/74, pp 72-73

AUTHOR(S): K.B.Powell
PREPARED BY AUTHOR(S) AND/OR: Utah Power & Light Co.

DATE OF ISSUANCE: 9/74
OTHER IDENTIFIERS: Energy Marketing

DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL: [PAGES 2 ;REFERENCES 2 ;GRAPHS 1 ;TABLES 1] *
DOCUMENT CLASSIFICATION(S): 4/1, 10, 19, 37, 39, 55

ABSTRACT: *[This Paper contains material of (mainly) direct relevance to the subject matter of this Compilation.]

At the time this "modeling" study began, additional load information was desired for:
(1) Cost of service and profitability analysis of individual appliances to provide evidence for continuing (or discontinuing) promotional rates for space heating and water heating.
(2) Data for better distribution-transformer load management.
(3) Data on average appliance use for the Customer Service Dept. to use in analyzing customer bills, particularly with regard to "high bill" complaints.
(4) Data on customer peaks and energy use to be able to better forecast long-term capabilities required for overhead and underground transmission and distribution equipment.

The following (individual) appliance parameters were to be determined by the study: (a) peak KW; (b) average KW; (c) time of peak; (d) load pattern; (e) noncoincident peak; (f) coincident peak and its time; (g) composite load pattern; (h) coincidence/diversity factor. [A "typical" summer-day demand curve is used to show the contribution of residential appliances to total residential load.]

One finding that came to light concerns air conditioning. Preliminary results indicate much lower (10-15%) coincidence of air-conditioning peaks in total-electric homes than in conventional homes. It is thought to be caused by the better insulation in total-electric homes. This type of data is a direct result of the decision to meter individual appliances.

TITLE: APPLIANCE ENERGY USE

SOURCE: Center for Advanced Computation (University of Illinois at Urbana-Champaign)
AUTHOR(S): R.A.Herendeen
PREPARED BY AUTHOR(S) AND/OR: C.A.C. (Energy Research Group)

DATE OF ISSUANCE: 1/75
OTHER IDENTIFIERS: CAC Document No. 180

DATA USE RESTRICTIONS:

TOTAL:[PAGES 19 ;REFERENCES 7 ;GRAPHS ;TABLES 5] *
DOCUMENT CLASSIFICATION(S): 4/14, 22

ABSTRACT: *[This Paper contains information of direct and (mainly) secondary relevance to the subject matter of this Compilation. Total(s) apply to entire Document.]

Energy is required to make and maintain appliances, as well as to operate them. In this report, the author evaluates the relative importance of operating energy for 30 household and kitchen appliances; he also looks at the total energy (gross energy requirement) for 3 "example" kitchens - from "plush" to rather "spartan" - and discusses the economic aspects of more efficient room air conditioners.

Various energy use data is tabulated for 30 appliances. [This energy use is sub-divided into the energy required to manufacture, to maintain and to operate the appliance.] The data includes KWH usage per year and yearly operating energy in BTU. The appliances are further classified as to whether they are gas or electric and as to which ones are to be assumed as (arbitrarily) installed in the plush, moderate or spartanly equipped kitchen.

The "fully-equipped" kitchen is assumed to contain 20 electrical appliances (with gas clothes dryers, ranges and water heaters considered as "options", as are any available frost-free features). This kitchen has a yearly energy impact of about 120 million BTU (gas) and 150 million BTU (electric). The "moderate" kitchen differs from the "full" in: (a) its substitution of conventional freezer and refrigerator for frostless models, where possible; and (b) its absence of a dishwasher and many smaller appliances (blender, can opener, disposal, exhaust fan, electric frying pan, hot plate, electric knife and waffle iron). Its energy impact is about 80% of that of the full kitchen. [Note: many of the omitted appliances are small energy users.] The spartan kitchen retains only basic appliances: range, clothes washer, water heater and refrigerator (not frostless) and its energy cost is about 55% of the full kitchen; thus, these 4 appliances are responsible for over half the energy required by the full kitchen set of 20. [Note: the reduced water heater use due to a lack of a dishwasher was not considered because, roughly, hand and machine dishwashing require the same amount of hot water.]

TITLE: MERCHANDISING (MONTHLY) STATISTICAL and MARKETING REPORT

SOURCE: Merchandising (Monthly)

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: Billboard Publications; New York City

DATE OF ISSUANCE: 3/76 *
OTHER IDENTIFIERS: Magazine was known as Merchandising Week prior to 1976
DATA USE RESTRICTIONS: Copyright by Billboard Publications

TOTAL: [PAGES ;REFERENCES ;GRAPHS ;TABLES] **
DOCUMENT CLASSIFICATION(S): 4/14, 26

ABSTRACT: *[Issued annually, during first quarter of year, to cover previous year's data as well as summaries of previous 10 year data; 1977 was the latest issue when this sheet was prepared.]

**[The magazine contains material of secondary relevance (in its "Statistical and Marketing Report" discussions) to the subject matter of this Compilation. The Total(s) are not considered particularly pertinent for this form of publication.]

The data of these Reports has been cited a number of times in the literature associated with this Compilation. Most of the statistics are tabulated in a USA-wide basis but some are also broken down into regional, state and local patterns.

In addition to marketing data (which can be related to appliance saturation values) the Report contains: (1) saturation values for essentially all appliances; (2) average values of personal income; (3) size distribution of freezers and refrigerators; (4) average annual KWH use per home.

TITLE: PROCEEDINGS: TECHNICAL OPPORTUNITIES for ENERGY CONSERVATION in APPLIANCES

SOURCE: ERDA Conference held at Boston, Mass. on 5/11/76

AUTHOR(S): K.W.Riegel (Chairman); et al
PREPARED BY AUTHOR(S) AND/OR: Arthur D. Little, Inc.; Cambridge, Mass.

DATE OF ISSUANCE: 1976
OTHER IDENTIFIERS: CONF 7605139, uc95d; Contract No. E(11-1)-2796; Available from NTIS
DATA USE RESTRICTIONS:

TOTAL: [PAGES 8 ;REFERENCES 2 ;GRAPHS ;TABLES 6] *
DOCUMENT CLASSIFICATION(S): 4/11, 15, 24, 56

ABSTRACT: *[Information of mainly secondary relevance to the subject matter of this Compilation is scattered thruout these Proceedings, primarily on the following pages: xix, 24, 25, 51, 92, 134. The Total(s) are for the relevant material only.]

ERDA's Division of Buildings and Community Systems is responsible for research, development and "demonstrations" to promote the acceptance of technology for the more effective use of energy in buildings, community systems and consumer products.

A tabulated classification of energy consumption (BTU per unit per year) covers major appliances plus water heaters and HVAC equipment; annual average energy consumption (in KWH/year) is also listed. Saturation indexes are included for most major appliances. Estimates of water usage trends (i.e., as regards % of "hot", "warm" and "cold" users) are shown for 1972, 1975 and 1980. The efficiencies of gas and electric hot-water heating units are tabulated for various model sizes, for 1972 and 1976.

Among the individual conference papers were "Energy Consumption of a Domestic Refrigerator Appliance" and "Performance of Electric Water Heaters and the Part-Load Performance of Gas Furnaces and Air Conditioners".

TITLE: APPLIANCE USE FIGURES NEED REVISIONS

SOURCE: Electrical World, pp 50-51

AUTHOR(S): W.Blumst & L.D.Hoffman
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 8/1/77
OTHER IDENTIFIERS: Energy Management

DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL:[PAGES 2 ;REFERENCES 2 ;GRAPHS ;TABLES 1] *
DOCUMENT CLASSIFICATION(S): 4/38

ABSTRACT: *[Contains material of relevance to this Compilation.]

This Paper points out that annual average appliance-use data, now in general use, are based on data that was developed for forecasting and not for labeling or conservation purposes. It notes that a recently completed appliance research study has resulted in recommendations that certain appliance-use figures be revised and that others be researched more thoroughly before any changes are made. These research results have significant implications in current efforts to improve appliance efficiency, to encourage adoption of "point-of-purchase" labeling and to aid conservation by utilities and government.

Some of the research findings show that there has been a sharp rise in the average annual energy use attributed to manual-defrost refrigerator-freezers, a more modest hike for automatic-defrost refrigerator-freezers, a slight drop in use for both manual- and automatic-defrost food freezers and a sharp drop in the use attributed to electric ranges. The average annual energy use by water heaters is said to require more study.

The Paper recommends specific changes in EEI Publication No. 75-61, "Annual Energy Requirements of Electric Household Appliances". [It also says that dishwashers, microwave ovens, water heaters and central air conditioners are among the major appliances which require additional load research.] The results and recommendations of a survey of appliance energy consumption are tabulated; the Table includes survey data on average annual (range of KWH) use of most major appliances, plus recommended average annual values.

TITLE: PATTERNS of ENERGY USE by ELECTRICAL APPLIANCES STUDY (Draft Final Report)

SOURCE: Midwest Research Institute

AUTHOR(S): R.D.Harper; et al
PREPARED BY AUTHOR(S) AND/OR: MRI; for DOE (formerly FEA) Office of Appliance Programs
DATE OF ISSUANCE: 12/15/77 *
OTHER IDENTIFIERS: MRI Project No. 4098-L; Contract No. CO-04-50116-00, DOE and Contract No. RP576, EPRI
DATA USE RESTRICTIONS: Check with DOE, Office of Appliance Programs, as to availability after "final review"
TOTAL:[PAGES 225 ;REFERENCES 35 ;GRAPHS 5 ;TABLES 73] **
DOCUMENT CLASSIFICATION(S): 4/1,5,8,10,12,14,17,21,22,23,24,28,50,55,56

ABSTRACT: *[This Study includes data collected from questionnaires and field measurements, during the year Aug. 1976-July 1977. The "Draft Final Report" updates three previously submitted quarterly reports.] **[Information of (mainly) direct and secondary relevance to the subject matter of this Compilation is interspersed in nearly all sections of the Report; therefore, for simplicity, Total(s) are given for the entire document. Note: many of the References are rather informal in their documentation.]

The broad objectives of this project were the determination of the energy usage patterns of major electrical appliances and an examination of the factors that influence such usage. The collected data included: the results of a survey of households who consented to an interview, household electric/gas usage and actual electrical usage of major household appliances. [Note: 579 appliances were metered for KWH usage during the full year and about 20% additional appliances were metered for less than a year.]

The detailed objectives were concerned with: (1) the compilation of a comprehensive data base, on residential electrical energy use, that is statistically reliable on the national level; (2) the analysis of geographic and demographic factors which influence energy use and ownership; (3) the determination of national/regional appliance energy use patterns.

It is noted that many electric utilities have been investigating appliance energy use for a number of years. It is also stated that prior to 1975, the valuable information developed by such studies did not lend itself to cumulative tabulations of appliance use on a national basis because much of the data was compiled during different time frames and with different objectives in mind. Hence, a comprehensive data base needed to be developed that would contain appliance energy use coupled with other household factors.

Personal interviews were conducted on a random sample of 1,985 households in 16 representative cities across mainland USA. The number of households per city was selected on the basis of population distribution and represents a statistically reliable sample. The interviews constituted the primary survey portion of the data base (eventually established) and provide data on the following: (1) Demographic factors; (2) Geographic location; (3) Physical characteristics of the home; and (4) Appliance ownership.

Usage and cost information (taken from the electric utility bills for the 1,985 households) are included in the data base; the bills were supplied by the various electric utilities that serve these households. Another component of the data base is the gas usage data, supplied for 702 households in cities that were served by a combined gas and electric utility company. [Note: altho the analysis portions of this Report make extensive use of the electric billing data, similar analyses of the gas billing data were considered outside the project's scope.] A final component to the data base was the electric appliance energy consumption. The electricity used was recorded on KWH meters monitoring the appliances; monthly readings were taken on each meter.

The type (and number) of electrical appliances, metered for an entire year, were: refrigerator and refrigerator-freezer (118); freezer (55); "range" (56); "cooktop" (13); "oven" (11); water heater (17); dishwasher (29); clothes washer (115); clothes dryer (67); room air conditioner (51); central air-conditioner (41); central furnace (3); swimming pool pump (3).

Summary of Reported Findings:

(1) The survey results indicate that electric cooking is used in about 45% of the households. Freezers are present in about 35% and dishwashers are available in about 40%. Air conditioning is utilized in about 65%. As many as 85% of the homes have a clothes washer.

(2) Ownership of appliances relates to many factors. For example, family income and residence location (urban or suburban) tend to have a connection with the ownership of electric cooking equipment and dishwashers. Other attributes that correlate to appliance ownership are home-heating methods and number of persons per household.

(3) Analysis of the recorded data indicate an annual average (KWH) consumption for the metered appliances, as follows: refrigerator units (1,665); freezer (1,342); "range" (782); "cooktop" (553); "oven" (401); clothes washer (88); clothes dryer (1,032); dishwasher (149); water heater (4,046); room air-conditioner (978); central air conditioner (3,573); central furnace (2,558); swimming pool pump (1,307). [The report contains in-depth analysis of the usages of all these appliances and the factors that affect their usage.]

TITLE: FEA'S ELECTRIC RATE and LOAD MANAGEMENT DEMONSTRATION PROGRAM *

SOURCE: FEA

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: FEA's Office of Conservation and Environment
DATE OF ISSUANCE: Various dates, starting in Jan. 1975
OTHER IDENTIFIERS: Electric Utility Projects

DATA USE RESTRICTIONS: Check with FEA as to availability of this information
TOTAL: [PAGES ; REFERENCES ; GRAPHS ; TABLES] **
DOCUMENT CLASSIFICATION(S): 5/13,14,16,18,21,22,36,37,38,50,52,55,57

ABSTRACT: *[These informational summaries have been prepared and up-dated, as necessary. They describe the purposes and mechanics (of implementation) of the Program and summarize the basic facts about each of the 16 Projects which have been initiated to date.]
**[These Total(s) are not particularly pertinent to this form of documentation.]

Basically all 16 Projects include rate effects among their primary objectives. The rates under investigation include: "declining block" (used as a control for comparison to other rates), "time-of-use", "flat", "lifeline", "inverted", "three-part" and a combination of time-of-use plus lifeline.

The various Projects have other objectives, directly (or secondarily) related to rate structuring. Among these objectives are: (1) testing customer acceptance and response to the various rates; (2) determining potentials for demand deferral and cost savings; (3) investigating changes in electricity consumption patterns; (4) studying feasibility of load control, heat storage and related techniques; (5) analysis of price and demand elasticity; (6) comparative measurement of energy use before and after inplementation of energy management programs; (7) relationships between income, weather, dwelling characteristics and energy use and between class of customers and energy use.

The various Load Management methodologies being examined can be seperated into direct and indirect methods. The direct methods are: time switches, load limiting devices, central control systems and (industrial) interruptible load. The indirect methods can be classified as: demand controllers, customer storage (of heat), (hybrid) space heating and warning devices.

Note: At the time this Abstract was prepared, "final" reports had been submitted to FEA from 3 of the Projects; these Projects (from Arizona, Connecticut and New York) are abstracted elsewhere in this Compilation.]

TITLE: ELECTRIC RATE CONCEPTS and STRUCTURES

SOURCE: Bonneville Power Administration (Portland, Oregon)

AUTHOR(S): R.H.Sarikas & H.Herz
PREPARED BY AUTHOR(S) AND/OR: Foster Associates, Inc. (Decatur, Ill.)

DATE OF ISSUANCE: 5/76
OTHER IDENTIFIERS: NTIS PB-252 905

DATA USE RESTRICTIONS:

TOTAL:[PAGES 58 ;REFERENCES 30 ;GRAPHS 2 ;TABLES 1] *
DOCUMENT CLASSIFICATION(S): 5/14, 17, 18, 23, 36, 45, 52, 55

ABSTRACT: *[Material of (mainly) secondary relevance to the general subject matter of this Compilation is scattered thruout this rather lengthy Report. The Total(s) reflect the relevant material. Note: 238 References are listed in the Report, separated into 10 categories; some of these are of general interest.]

The Report identifies the most generally encountered electric rate schedule concepts and examines the social, economic and/or political policy behind each concept. It also explores the impact on the locations where the concept is implemented and determines the probable reaction of Bonneville's utility customers in terms of retail rate design. The role of utility rate setting and the justification for classes of retail consumers are covered. The objectives, which act as guides for those persons who set BPA's rates, are also considered.

Six different "cost-based" pricing concepts are covered, namely: (1) "average cost" [this most commonly used concept recovers the share of total cost ascribed to each service, without regard to the market structure]; (2) "capacity only", which charges only for demand and not for the amount of energy used; (3) "energy only"; (4) "marginal cost" and "long-run incremental cost and usage"; (5) "summer-winter differential"; (6) "time-of-day" [which attempts to flatten the load of systems with low load factors and which are not in a position to store energy]. Three different "noncost-based" concepts are also discussed: (a) "two-tier" rates; (b) "inverted" rates; and (c) "lifeline" rates.

Among other things, the Report goes into the effects on load pattern and utility economics of the various pricing schemes mentioned above. Data is tabulated which is concerned with estimating the price elasticity of electric service and with (peak week) daily load factors; a simple relationship is explained (and graphed) which correlates the price and use of electricity.

TITLE: TYPICAL ELECTRIC BILLS: RESIDENTIAL (CITIES of 2,500 and MORE); COMMERCIAL/INDUSTRIAL (CITIES of 50,000 and MORE)

SOURCE: FPC

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: FPC

DATE OF ISSUANCE: 1976 *
OTHER IDENTIFIERS: FPC R88

DATA USE RESTRICTIONS:

TOTAL: [PAGES ;REFERENCES ;GRAPHS ;TABLES] **
DOCUMENT CLASSIFICATION(S): 5/9, 17, 47, 50, 52, 55

ABSTRACT: *[This Publication has been issued annually to (primarily) reflect data as of the first of the preceeding year; thus the 1976 issue contains data as of 1/1/76 and was the latest available at the time this sheet was prepared.]

**[The data is of (mainly) secondary relevance to the subject matter of this Compilation. The Total(s) are not considered particularly pertinent to this type of Reference.]

This Report provides comprehensive coverage of the cost to consumers of representative amounts of electricity used per month for residential, commercial and industrial service in all sections of the USA. Bills for residential electric service are reported for 5 different energy consumption levels in all communities with populations of 2,500 or more. For commercial and industrial service, bills are presented for all large cities. Commercial bills are shown for 5 combinations of billing demands (in KW) and monthly consumption levels (in KWH); industrial bills cover 5 billing demand and 10 consumption levels.

Tables are used to present long-term trends and current levels of average electric bills for the same 3 classes of service for the total USA, for each State and the District of Columbia and for 9 geographic regions. The information on bills for residential service is supplemented with the latest statistics on average (annual) residential use of electricity in all large cities.

There is no attempt to evaluate the many factors that produce differences in the level of bills as, for example: the proximity of fuel sources, type and size of prime mover used in generation, customer density and nature of utility ownership.

TITLE: (A) PEAK-LOAD PRICING: ONE POINT OF VIEW *
(B) RATE RESTRUCTURING USING MARGINAL COST *
(C) TIME-DIFFERENTIATED RATES and the REAL WORLD *
SOURCE: [Electrical World] (A), pp 70-72; (B) pp 51-53; (C) pp 118-120

AUTHOR(S): J.R.Crespo, (A); S.Streiter, (B); W.J.Jefferson, (C)
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: (A), 8/15/77; (B), 9/1/77; (C), 9/15/77
OTHER IDENTIFIERS: Energy Management

DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL: [PAGES 9 ;REFERENCES 5 ;GRAPHS 4 ;TABLES 5] **
DOCUMENT CLASSIFICATION(S): 5/17, 36, 45, 52, 55

ABSTRACT: *[The Articles constitute a three-part series, containing material of (mainly) secondary relevance to the subject matter of this Compilation.]
**[Totals are for all 3 Articles, each of which had 3 pages.]

J.C. Crespo discusses the "embedded-cost" method as one solution to the question of how to establish the cost and set the price for peak-load pricing (which embraces both time-of-day and seasonally differentiated price levels). He concludes that peak-load pricing should be implemented only after conclusive load research and the accumulation of strong evidence that benefits will accrue. He points out that time-of-day rates (applying over substantial time periods) may encourage reduction at off-peak hours and thus not reduce actual peak demand.

S. Streiter advocates the "marginal-cost" approach to rate restructuring; this approach looks to setting the price of the "next" KW (or KWH) used, based on the cost of producing that particular KW (or KWH). She points out that economists have a strongly positive attitude toward this form of rate-structure revision while emphasizing that its basic purpose is "not to level load, but to charge the right price". [The Paper includes a summary of the activity - by various States - currently connected with time-of-day rate studies and hearings.]

W.J. Jefferson examines the various facets of time-differentiated rates from the viewpoint of a utility rate manager who has been active in the fields of rate studies. His company's experience with such rates began in 1924 and has dealt mainly with the larger commercial and industrial customers; altho the results have been "good", it is stated that this conclusion may not necessarily apply to all utilities. As for residential and smaller commercial/industrial customers, further research is needed (and being done) to determine whether they will benefit from such time-differentiated rates.

TITLE: LOAD CHARACTERISTICS of the RESIDENTIAL CONSUMER USING ELECTRICITY for HOUSE HEATING

SOURCE: TVA, Division of Power Utilization

AUTHOR(S): W.R.New
PREPARED BY AUTHOR(S) AND/OR: TVA

DATE OF ISSUANCE: 1/31/55
OTHER IDENTIFIERS: Conference paper submitted to AIEE Committee on Domestic and Commercial Applications; AIEE meeting; 1/31-2/4, 1955
DATA USE RESTRICTIONS:

TOTAL: [PAGES 18 ; REFERENCES 2 ; GRAPHS 7 ; TABLES 6] *
DOCUMENT CLASSIFICATION(S): 6/3, 19, 21, 28, 38, 52, 55

ABSTRACT: *[Information of direct or secondary relevance to the general subject matter of this Compilation are scattered thruout this paper. The Totals are for the entire paper.]

This Paper investigates the load characteristics of very large housing developments by examining the data collected from 3 apartment groups (of 400, 600 and 1200 units); the groups were electrically heated with radiant convection units totaling 3,902 KW, 6,202 KW and 12,120 KW respectively. [Note: The smallest project was of the "urban, low-rent" type. The others were part of Army bases.]

Summary of Major Findings:
(1) Where heating installations are engineered as to thermostatic control and the amount of connected load, approximately 50% of the installed heating will add to the peak system demand at design temperatures.
(2) The average diversified monthly load factor of the all-electric home (heated but not air-conditioned) will normally range from 45 to 50%, with the annual load factors approximating 25%. This annual load factor should increase to 30-35%, as air conditioning is added.
(3) The electrically heated home should be well insulated and have a connected load which does not exceed the calculated heat loss.
(4) Essentially all of the energy uses in the house actually contribute to heating the home, and thereby reduce the required connected heating load.
(5) The evening peak on the all-electric home in the TVA area has been growing faster during the past several years than the morning peak; consequently, evening peaks should eventually at least equal the morning peaks thereby improving system load factors.
(6) Experience shows that distribution transformer loads of 200% of rated capacity are economical for the heating peaks.
(7) Opposition to electric heat has been associated with the poor experiences with the uncontrollable use of small plug-in heaters. The surest way to eliminate their use is to "sell" the complete house heating installation, with its thermostatic controls and materially better load factor.

TITLE: SERVICE to the ALL-ELECTRIC HOME

SOURCE: TVA

AUTHOR(S): W.R.New & W.A.Bell, Jr.
PREPARED BY AUTHOR(S) AND/OR: TVA

DATE OF ISSUANCE: 1956
OTHER IDENTIFIERS: Conference Paper No. CP 56-387; submitted to AIEE Committee on Domestic and Commercial Applications; AIEE Meeting; New York City; 1/30-2/3,1956
DATA USE RESTRICTIONS:

TOTAL:[PAGES 24 ;REFERENCES 2 ;GRAPHS 4 ;TABLES 11] *
DOCUMENT CLASSIFICATION(S): 6/4, 13, 19, 28, 34, 47, 55, 57

ABSTRACT: *[Information of direct or secondary relevance to the general subject matter of this Compilation are scattered thruout this Paper. The Totals are for the entire Paper.]

[The term "All-Electric Home" may have several meanings. For purposes of this Paper, it refers to the home in which all the heating and mechanical energy is supplied through the service wires.] For many sections of the country, as in the TVA area, electric space heating is now the chief load component of the all-electric home. It is reported that there has been ample opportunity to observe operating experiences of TVA systems, as the electric heating load developed. The benefits of this growing load have outweighed its disadvantages.

Another beneficial feature of the electric heating load is its balancing effect on the rapidly growing summer air-conditioning load. Due to the occurrence of heating peaks in cold weather (and the near unity power factor of the heating load) distribution facilities can carry a KW load of electric heat about twice that of summer air conditioning.

Since the heating load is such a large part of the total load and since the consumption for this component can be so closely identified with the weather, it is most convenient to separate the heating and non-heating portions for purposes of analysis. One of the most important uses of this separation has been in devising techniques for estimating day-to-day changes in peak and average load requirements. One of the techniques of analysis is the calculation of "change in peak load per degree of minimum temperature change" and "change in daily energy per degree-day (DD) change." By correlating temperature/demand data and DD/energy data, constants may be obtained which (for any given set of weather conditions) will separate the load that varies with temperature from the load that does not. [These have somewhat inaccurately been referred to as the heating and non-heating loads.] The change in energy or demand then is obtained by the product of the DD change or the temperature change times the respective constant.

Note: There are a number of indications that the use of the conventional 65-degree base results in estimates of heating energy for the electrically heated home which are too low during the midwinter months.

The Paper includes information on the following topics:

(A) Average monthly energy use of residential customers, with or without electric heating, in KWH/customer.

(B) A comparison between actual and theoretical load factors based on specified minimum temperature, degree-day relationships.

(C) Relationship of electric heating and major appliance (i.e., range and water heater) saturations to average annual KWH used per customer.

(D) Basic KW and KWH data for a 600-unit Air Base Housing Project; load factor, minimum temperature and HDD values are also listed. Similar data are supplied for a 400-unit Low Rent Housing Project and a 1200-unit Army Base Housing Project.

(E) Tabulations of DD comparisons by "conventional" and "degree-hour" methods.

(F) Tabulations of electric heat energy constants.

(G) Values of energy consumption by major appliances in various apartment houses, for several different combinations of such appliances with other uses (e.g., lights plus refrigerator and range).

(H) Values for demands and load factors for major appliances installed in various apartment houses.

(I) Appliance saturation values for various TVA areas; saturations for electric heating and air conditioning units are also listed.

TITLE: ANALYSIS of ELECTRIC ENERGY USAGE in AIR FORCE HOUSES EQUIPPED WITH AIR-TO-AIR HEAT PUMPS

SOURCE: NBS

AUTHOR(S): P.R.Achenbach; et al
PREPARED BY AUTHOR(S) AND/OR: NBS

DATE OF ISSUANCE: 7/13/62; reprinted 9/72
OTHER IDENTIFIERS: NBS Monograph 51

DATA USE RESTRICTIONS: Available from GPO, as 1972-511-318(49)

TOTAL: [PAGES 36 ;REFERENCES 4 ;GRAPHS 24 ;TABLES 36] *
DOCUMENT CLASSIFICATION(S): 6/2, 4, 12, 13, 27, 28, 36, 37, 56

ABSTRACT: *[Contains material of (mainly) direct relevance to the subject matter of this Compilation.]

This Monograph discusses an analysis of the electric energy usage in 16 sample houses selected from a total of 1,535 houses (built at Little Rock Air Force Base to house Air Force personnel). Of principal interest was (1) the energy used by the "air-to-air" heat pumps installed for all-year air conditioning and (2) the effect of the electric energy used by other appliances on the heating and cooling loads in the houses.

The data revealed that the usage in the 16-house sample averaged 25,300 KWH/year/house; approximately half was used by the heat pump and its auxiliary resistance heaters, about one-fourth was used for water heating and the remainder was used for the electric range and miscellaneous devices. It was determined that the energy used by appliances - other than the heat pump - which contributed toward heating the house, was about half the amount used by the heat pump during the winter months. An analysis of the demand charts revealed that the monthly maximum power demand, for the entire housing area, was probably caused by a moderately high sustained demand in many houses rather than by a coincidence of the maximum demands in a smaller number of houses.

The effect of several types of programing devices (which are described), on the pattern of power demand, is discussed. The basic interest was in whether such devices, and/or associated methods, might be useful in controlling demand.

TITLE: NIAGARA MOHAWK DATA SHEET

SOURCE: Niagara Mohawk Power Corporation

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: N.M.P.C. (Syracuse, New York)

DATE OF ISSUANCE: *
OTHER IDENTIFIERS: Electric heating case history; numbered in lower right-hand corner
DATA USE RESTRICTIONS:

TOTAL:[PAGES ;REFERENCES ;GRAPHS ;TABLES .] ** 55,56
DOCUMENT CLASSIFICATION(S): 6/1,3,4,5,7,9,17,21,28,30,32,42,44,46,48,49,

ABSTRACT: *[Issued from time-to-time during 1967-1972. Some are not identified as to exact period covered by data listed. Most are (issue) dated in lower left-hand corner.]

**[With one exception, all information for these case histories is on a single page. Data is (mainly) relevant to the general subject matter of this Compilation, altho rather highly aggregated in most instances.]

The data sheets are grouped into the following general categories: apartments/motels, educational/institutional buildings, medical buildings, office/banks, retail stores and miscellaneous buildings (churches and synagogue school).

A representative data sheet includes: description of the physical characteristics of the building(s), including its total volume and total heated area; a basic description of the space and hot water heating systems; a summary of the major connected electrical loads, e.g. for space heating, water heating, lighting and cooking; annual HDD and/or CDD; KW and KWH demand and usage, on a monthly basis; type of electric service and its rate schedule; annual energy use and cost and maximum demand on a unit basis such as per apartment or per square foot; operating hours, e.g. for stores.

The following summarizes the major types of buildings covered:
(a) 5 "high-rise" apartments, ranging in size from 117 to 201 units;
(b) 2 "garden-type" apartment developments of 110 and 132 units;
(c) municipal housing, 35 units;
(d) 5 "motels", size from 2 to 10 floors and 34 to 168 "guest rooms";
(e) 18 educational institutions, ranging in size from about 28,000 to 265,000 sq. ft. of heated area (and including elementary, high, college, technical and business schools);
(f) 4 nursing homes and a hospital (ranging from 66 to 120 "beds");
(g) 3 churches and a religious school (heated areas of about 5,000 to 14,000 sq. ft.);
(h) 2 banks and 11 office buildings (ranging from "small" to "very large");
(i) 10 retail establishments, ranging in size from about 11,000 to 90,000 sq. ft. of heated area.

TITLE: ALL ELECTRIC HOMES in the UNITED STATES
(Annual Bills - January 1, 1975; cities of 50,000 and more)

SOURCE: FPC

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: FPC

DATE OF ISSUANCE: 1976 *
OTHER IDENTIFIERS: FPC R-87. Available from GPO; Stock No. 015-000-00329-4
DATA USE RESTRICTIONS:

TOTAL: [PAGES 29 ; REFERENCES 1 ; GRAPHS 4 ; TABLES 4] **
DOCUMENT CLASSIFICATION(S): 6/1, 2, 5, 13, 17, 26, 28, 47, 55

ABSTRACT: *[This Publication has been revised at irregular intervals. This is the date of most recent issuance at the time this sheet was prepared.]

**[Report contains information of (mainly) secondary relevance to the general subject matter of this Compilation.]

This Report presents information on the average annual costs, for representative amounts of electricity, to consumers in homes utilizing electricity for all purposes. Averages for annual electric bills, charges/KWH and KWH consumption are shown on a nationwide basis and for each State and for individual (larger) communities thruout the USA. [The information is based on data obtained from the FPC's thirteenth consecutive annual survey of electric rate levels and energy consumption patterns applicable to all-electric homes.]

The Report includes data for 121 investor-owned utilities, 65 publicly-owner utilities and 4 cooperatives. Annual bills are shown for 413 communities. In addition, in States with fewer than 3 such communities, the 3 largest (regardless of population) have been included. The combined population of these 443 cities represents more than 1/3 of the total population of the United States.

Four consumption levels (15,000; 20,000; 25,000; and 30,000 KWH) were selected as generally representative of the range of annual energy use in residences which utilize electricity exclusively for heating, cooling, cooking, water-heating and all other domestic uses. The use of electricity for these 4 levels is segregated to show: (1) total use for all residential purposes; (2) amount for space heating only; and (3) amount for cooling, by customers with total cooling.

A total of 169 utilities reported serving about 4.75 million customers in all-electric homes in 1974. The average annual energy consumption (based on partial returns from reporting utilities) decreased from 21,096 KWH in 1973 to 20,326 in 1974. The average annual consumption for heating purposes only, as reported, decreased from 8,187 KWH in 1973 to 8,093 in 1974.

Reports from 142 utilities showed that about 44% of their all-electric customers used less than 17,500 KWH annually for all purposes, another 22% used between 17,500 and 22,500 KWH, 16% used between 22,501 and 27,500 KWH and the remaining 18% used more than 27,500 KWH.

TITLE: ENERGY for HOSPITALS

SOURCE: Air Conditioning, Heating and Ventilating, 9/67, pp 49-52

AUTHOR(S): T.W.Mayer
PREPARED BY AUTHOR(S) AND/OR: Nuffield Provincial Hospital Trust and University of Glasgow (Scotland)

DATE OF ISSUANCE: 9/67
OTHER IDENTIFIERS: A.C.H. & V. now called "Building Systems Design"

DATA USE RESTRICTIONS: Copyright by BSD, Inc.

TOTAL: [PAGES 4 ;REFERENCES 2 ;GRAPHS 4 ;TABLES 1] *
DOCUMENT CLASSIFICATION(S): 7/13, 15, 39

ABSTRACT: *[Information of relevance to the subject matter of this Compilation is contained in the Paper.]

The Paper states that the engineer's task in the design of physical systems is two-fold: assessment of the demand that will be made on the system and providing a plant that is physically capable of meeting this demand. The object of this study was: to develop techniques for gathering basic demand information and for analyzing this information; to establish, where possible, design principles.

Those aspects of hospital services on which attention was focused are: (1) sizing and the degree of centralization of hot-water storage; (2) sizing of central plant, such as the boilerhouse and electrical substation; (3) sizing and layout of electrical cables and piping; (4) form(s) of energy that can most economically meet the demand; (5) selection of a stand-by generating plant for emergency situations.

During this study electrical demand was measured: (A) by magnetic-tape recording of the instantaneous current (to each hospital department) at 5-minute intervals and (B) by photographing, at 30-minute intervals, the meters which kept track of the accumulative KW and KWH for the entire hospital. [Typical records are shown which were obtained by the preceding measurement systems.]

TITLE: IEEE RECOMMENDED PRACTICE for ELECTRIC POWER SYSTEMS in COMMERCIAL BUILDINGS

SOURCE: IEEE Industrial and Commercial Power Systems Committee

AUTHOR(S): I.M.Stochmal (Editorial Consultant)
PREPARED BY AUTHOR(S) AND/OR: IEEE Industry Applications Society

DATE OF ISSUANCE: 1974
OTHER IDENTIFIERS: IEEE "Gray Book"; Std 241-74

DATA USE RESTRICTIONS: Copyright by IEEE (Written permission required to cite detailed material)
TOTAL:[PAGES ;REFERENCES ;GRAPHS ;TABLES] * 34,38
DOCUMENT CLASSIFICATION(S): 9/1,6,7,12,13,15,19,20,21,23,24,25,26,28,32,

ABSTRACT: *[The comprehensive and (sometimes) overlapping nature of the material in this lengthy Standard does not lend itself to meaningful Total(s). Information of direct and secondary relevance to the subject matter of this Compilation is scattered thruout the volume although Chapters 1, 2, 10, 11, 12 and 16 contain most of the relevant discussion and/or data.]

The "Gray Book" will probably be of greatest value to the power-oriented engineer with somewhat limited commercial-building experience. It can also be an aid to all engineers responsible for the electrical design of commercial buildings. However, it is not intended as a replacement for the many engineering texts and Handbooks commonly in use, nor is it detailed enough to be a Design Manual. It should be looked upon as a guide and general reference on electrical design for commercial buildings.

Chapter 1 summarizes the system requirements for commercial, residential and institutional buildings; the various primary systems (lighting, communications, space conditioning, transportation, plumbing, etc.) are tabulated. The electrical design elements that are common to virtually all such buildings (and which must be considered in the design of the various systems) are listed as:
(1) Magnitudes, characteristics, demand, coincidence or diversity of loads, and load factors.
(2) Service, distribution and utilization voltages and voltage regulation.
(3) Flexibility and provisions for expansion.
(4) Reliability. (5) Safety of personnel and property.
(6) Initial and maintenance costs.
(7) Operation and maintenance.
(8) Short-circuit currents.
(9) Power sources. (10) Distribution systems.
(11) Standby and emergency power.

Chapter 1 also contains information on the applicable Codes and Standards, plus a listing of Periodicals and Textbooks related to the general areas covered by Standard 241-74. Among other topics, the chapter also summarizes: "design considerations", "system flexibility", "estimating practices" and "environmental considerations".

Chapter 2 deals with the general topic of "Load Characteristics". It points out that designing an electrical system for a commercial building should begin with the determination and study of the size and nature of the various loads to be supplied. Data for such an analysis usually come from the building's heating, ventilating, air-conditioning and transportation service requirements and from the lighting system design. Useful information may also be obtained from the engineer's own records of similar buildings, from electric utilities and from manufacturers' publications on equipment and appliances. [In using estimating data, it should be noted that "typical" data apply only to the conditions from which the data were taken. An adjustment to fit the particular building is generally required.]

Chapter 2 lists examples of the classes of electrical equipment which should be considered when estimating a building's initial and future loads. The characteristics peculiar to the various types of loads (e.g., lighting, air-conditioning, refrigeration, heating, kitchen equipment, elevators) are summarized. Typical loads - for different building types - are listed for: air-conditioning, commercial kitchens and apartments. Data is tabulated for the maximum demands (on a square footage basis) for a variety of businesses; data is also included on the size of the connected loads and certain calculated demand factors.

Chapter 10 includes a general discussion of "Lighting" and its special terminology. [Sample calculations are used to illustrate design principles.] The chapter includes tabulations of the approximate electric load for various illumination levels. Recommended levels of illumination (current as of 1974) are listed for essentially all the commercial building types, for both their exteriors and interviews.

Chapter 11 deals with "Electric Space-Conditioning" and the related ecological considerations and energy conservation aspects. [It is pointed out that "all-electric" buildings (including homes, apartments, offices, motels, hotels, schools, offices) have become quite common.] In addition to a rather comprehensive general discussion, the chapter contains specific data on the effects of lighting heat loads, heating and cooling costs, selection of electric heating equipment and the effects of line voltage variation on heater performance.

Chapter 12 is concerned with "Vertical Transportation", i.e. mainly elevators. It includes a general discussion of this field, along with information on the electrical characteristics of elevators including typical electrical consumption range of values. Typical diversity factors are given in terms of the type of service and numbers of elevators in use.

Chapter 16 has material of (mainly) general interest on "Special-Occupancy Buildings".

TITLE: A STUDY of the PHYSICAL CHARACTERISTICS, ENERGY CONSUMPTION, and RELATED INSTITUTIONAL FACTORS in the COMMERCIAL SECTOR

SOURCE: Hittman Associates, Inc. (Columbia, Md.)

AUTHOR(S): H.M.Bernstein & P.M.McCarthy (of H.A., Inc.); et al
PREPARED BY AUTHOR(S) AND/OR: H.A., Inc. (for FEA)

DATE OF ISSUANCE: 12/75
OTHER IDENTIFIERS: Final Report HIT-630; FEA/D-76/053; available from NTIS as PB-249 470
DATA USE RESTRICTIONS:

TOTAL: [PAGES 50 ;REFERENCES 5 ;GRAPHS 8 ;TABLES 7] *
DOCUMENT CLASSIFICATION(S): 9/5,7,11,14,17,21,22,30,32,52,55

ABSTRACT: *[Material of direct and (mainly) secondary relevance to the subject matter of this Compilation is scattered thruout this rather lengthy Report. The Total(s) refer to the relevant data.]

This Report represents a first effort at incorporating original data and research, known information and informed estimates, so as to produce a unified study of commercial-sector energy consumption and conservation potential. The specific areas covered are: (1) Physical characteristics of existing commercial buildings (in Baltimore, Md. and Denver, Col.); (2) Energy consumption of the Baltimore buildings; (3) Institutional factors related to constructing and/or operating more energy-efficient commercial buildings; (4) Policy options and their feasibility for inducing energy conservation by retrofit.
[The utility and limitations of the study are explained in light of the findings.]

The Report's discussion of physical characteristics presents the data obtained from a field survey of all commercial establishments (defined here as excluding schools and hospitals) in the central business districts (CBD's); the survey covered about 2600 establishments. Data was collected on the height, age, floorspace, heating system, cooling system, heating fuel, extent of exterior glass and functional use of these buildings and on the distribution of the dependent variable-commercial square feet - over the various values of each indepenndent variable.

The discussion of energy consumption presents a quantitative analysis of the empirical relationships between various building physical parameters (such as age, height and floorspace) and the annual values of the Energy Use Index (EUI). The energy consumption data for a total of 383 establishments was obtained from Baltimore Gas and Electric Co. records.

The discussion of institutional factors presents a qualitative description of the constraints and incentives which have led to the current energy-used patterns observed in the commercial sector. Numerous areas

of institutional concern were looked into, including the practices of regulatory bodies and of trade and professional groups, microeconomic incentives and disincentives and the macroeconomic implications of the increased use of "retrofit devices" to improve energy-use efficiency.

The discussion of policy options (and their capability for inducing energy conservation through retrofit) incorporates the information gained from, plus the quantitative analysis of,8 possible Federal policy options capable of inducing greater use of retrofitting as an energy conservation alternative. The quantitative policy analysis has included estimates of the probable energy savings, costs to the building owners and costs to the U.S. Government associated with implementation of each policy option. In addition, a comparison of the 8 policy options is presented along with a rank-ordering of the options, based on a series of hypothetical government goal orientations.

A Chapter of this report presents the results of the collection and analysis of energy consumption data (electricity, gas and district steam) for the 383 establishments referred to above. [This data was collected for the period from May 1974 thru Apr. 1975.] This effort attempted to define empirical energy use rates for buildings which housed different modes of commercial activity, based on a large sample of commercial space, and to identify any relationships which may exist between building energy use rates and building physical parameters (such as height, age, glass fraction, etc.). The mean annual energy use rates for 12 commercial types of establishments (in thousands of BTU per sq. ft. per year) were found to be about as follows:
Restaurants (300); Night Clubs (253); Drug Stores (233); Food Stores (207); Department Stores (164); Hotels/Motels (147); Banks (145); Offices (125); Personal Services (117); Small Stores (95); Theaters (76); Warehouses (62).

The framework of the CBD energy consumption analysis embodied 4 major areas of inquiry; these were: (1) The overall characteristics of EUI in the buildings; (2) Characteristics of specific "partial" EUI values, for specific building functions; (3) Sensitivity of EUI to variation in building physical parameters; (4) Other related topics, such as the nature of the "billing" used for the commercial spaces.

The report includes average annual EUI data, disaggregated by energy type (i.e., electricity, gas and centrally-supplied steam). A (frequency) histogram is presented for average EUI,by commercial use type. The average monthly electricity and steam use is shown for 7 office buildings, ranging in size from about 28,000 to 610,000 square feet. There is an estimate of the % of the total electricity which is used for lighting; this ranged from about 5% for warehouses to 95% for "small" stores. Normalized values are presented for the average EUI (as a function of glass/floorspace area ratios, age of building, etc.) of the various types of commercial buildings.

TITLE: (E-CUBE) COMPUTERIZED ENERGY ANALYSIS: ENERGY-EQUIPMENT-ECONOMICS

SOURCE: ASHRAE Journal, 9/71, pp 46-53

AUTHOR(S): W.E.Evers
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 9/71
OTHER IDENTIFIERS: E-Cube is a GATE/AGA acronym for the "Energy-Equipment-Economics" aspects of the E-Cube computer program
DATA USE RESTRICTIONS: Copyright by ASHRAE

TOTAL: [PAGES 8 ;REFERENCES 3 ;GRAPHS ;TABLES 2] *
DOCUMENT CLASSIFICATION(S): 10/17, 21, 22, 37, 43, 53, 57

ABSTRACT: *[Contains material of (mainly) secondary relevance to the subject matter of this Compilation.]

Calculations of energy requirements are, in themselves, complex enough. Then there are the evaluations of alternate systems, or combinations of systems, for meeting those needs - a vast range of possibilities. The data to be examined ranges from equipment characteristics to local weather profiles, from fuel and electric costs to taxes and the interest rates on money. Calculations may involve thousands of design points for many combinations of equipment; computers are essential.

The first GATE sponsored computer program was developed by Southwest Research Institute. It was tested against actual buildings for which measured values were available and the results demonstrated the validity of the approach. The 1971 version was renamed E-Cube, an Acronym derived from the relationship between the three basic programs in the series: Energy Requirements, Equipment Selection & Energy Consumption and Economic Comparison. These E-Cube Programs can evaluate all systems, from T.E. (with gas generating electrical power) to a total electric system.

It is pointed out that all well-designed programs must be able to compute the energy requirements using weather data by integrating hourly heat losses/gains of a building along with a consideration of hourly electrical loads, internal loads, ventilation, sensible and latent loads from people, and processing loads within the building. The programs must take the hourly requirements of a building to develop the consumption for operating schedules for each of the mechanical systems, including all components required for each system. The ability to do this accurately depends upon the program's ability to determine the hourly changes in all the areas affecting the energy usages. Hand computation of the hourly requirements (for a year) would require 8,760 calculations for each segment being considered; this would be economically unsound.

TITLE: COMPARISON BETWEEN MEASURED and CALCULATED HOURLY HEATING and COOLING LOADS for an INSTRUMENTED BUILDING

SOURCE: ASHRAE Symposium on a field study of load profiles, etc.

AUTHOR(S): W.D.Mast
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 1/72
OTHER IDENTIFIERS: Paper presented at ASHRAE Semiannual Meeting; New Orleans, Louisiana; Jan. 23-27, 1972
DATA USE RESTRICTIONS: Copyright by ASHRAE

TOTAL:[PAGES 6 ;REFERENCES 1 ;GRAPHS 6 ;TABLES]*
DOCUMENT CLASSIFICATION(S): 10/1, 7, 28, 39, 42

ABSTRACT: *[Information of secondary relevance to the subject matter of this Compilation is scattered thruout this Report.]

The necessity for more refined heating and cooling load calculations has resulted in the development of computerized load calculation programs. One such program (developed for the U.S. Postal Services) has been used to determine the air-conditioning loads of an instrumented 4 story building. Calculated heating/cooling loads were then compared with measured values, in order to evaluate the accuracy of the computerized techniques.

As a means of comparison, the calculated and measured values of the total building loads were plotted for a week in early Nov. From this data, it appears the load program slightly over-predicts the cooling load for the daylight hours. [The solar heat gain computer routine for the windows is currently being modified and updated, in an effort to provide for increased accuracy in the radiant and conductive heat transfer calculations for windows, in the hope of correcting this trend.] However, the overall agreement is encouraging in that the load program calculations follow closely the actual dynamic load on the building. Altho these results are preliminary, considerations of the data in the Report (and additional data obtained to date in the field validation study) indicate that the load calculations follow the trends of the measured loads quite well. However, since accurate heating and cooling load determination is an intricate process, it will only be after further extensive data evaluation and load program development that the results of this field validation test can be fully appreciated.

TITLE: THE ENGINEERING COSTS SECTION of AXCESS (ALTERNATE CHOICE COMPARISON for ENERGY SYSTEM SELECTION)

SOURCE: Electric Energy Association

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: EEA/EEI

DATE OF ISSUANCE: (around) 11/72
OTHER IDENTIFIERS: AXCESS Energy Analysis Computer Program

DATA USE RESTRICTIONS: Those interested in using AXCESS should check with EEI
TOTAL: [PAGES 29 ; REFERENCES ; GRAPHS 47 ; TABLES 1] *
DOCUMENT CLASSIFICATION(S): 10/1, 3, 7, 20, 22, 28, 32, 42, 43, 44, 48, 49

ABSTRACT: *[Contains material of direct and (mainly) secondary relevance to the subject matter of this Compilation. Total(s) apply only to Sections 3A and 3B of the report, which primarily consist of input computer data.]

The Document tabulates and plots data for a large variety of structures but (non-apartment) residences are excluded, as are industrial buildings. The tables list: occupancy (in square feet/person); lighting (in watts/sq. ft.); receptacles available (in watts/sq. ft.); air conditioning (in sq. ft./ton or in tons/person or in cubic feet/minute/sq. ft.); heating (in BTU/hour/cubic foot). [Note: some of the data is expressed as a range of values and some types of buildings have certain data items omitted.]

Occupancy profiles are shown for such structures as an: airline terminal, apartment house, bank, cafeteria, dormitory, hotel/motel, library/museum, medical/professional center, movie, office building, restaurant, school and shopping center. Some of the profiles are for weekdays and some are for Saturdays and/or Sundays. Generally the profiles are plotted as "% of design occupancy" vs "time of day".

A limited number of profiles are included for lighting loads (plotted as "% of connected load" vs "time of day") and for elevator usage (plotted as "% of connected KW" vs "time of day").

TITLE: MODELING of ELECTRIC POWER DEMAND GROWTH

SOURCE: Massachusetts Institute of Technology, Energy Laboratory

AUTHOR(S): J.B.Woodward, Jr.; et al
PREPARED BY AUTHOR(S) AND/OR: M.I.T.

DATE OF ISSUANCE: 2/73
OTHER IDENTIFIERS: Report #MIT-EL 73-015, for NSF; may be ordered from NTIS as PB-224 045
DATA USE RESTRICTIONS: Copyright by MIT as Chapter A-5 of Proceedings of Conference on "Energy: Demand, Conservation and Institutional Problems"
TOTAL: [PAGES 35 ;REFERENCES 10 ;GRAPHS 3 ;TABLES 1] *
DOCUMENT CLASSIFICATION(S): 10/16, 17, 21, 35

ABSTRACT: *[Information of (mainly) secondary relevance to the general subject matter of this Compilation is scattered thruout this Report.]

This Paper describes a model (presently under development) of the growth in demand for electric power. The emphasis is on developing a mathematical model which can be used for the analysis of detailed questions, such as: how will changes in air conditioning power demand, electric rate structures, population, etc., affect daily load profiles as well as peak power and the overall electric energy consumption? Detailed answers to such questions are needed for planning of generating capacity and plant mix (nuclear, fossil and pumped-hydro), as well as for the evaluation of the resulting environmental and economic impacts. These issues require detailed models, combining economic factors with engineering considerations affecting the dynamics of load behavior. Modeling of this kind can be limited by the available data and an important aspect of this effort is to identify the data required for a detailed understanding of the loads. [The approach to be employed is a combination of "state space" dynamic models, driven by stochastic processes, with econometric models.]

TITLE: E-CUBE APPLICATIONS MANUAL

SOURCE: American Gas Association

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: AGA's Energy Systems Committee

DATE OF ISSUANCE: 12/73
OTHER IDENTIFIERS: Supplement to the (E-Cube) Program Input Instruction Manual
DATA USE RESTRICTIONS: Copyright by AGA

TOTAL: [PAGES 60 ; REFERENCES 8 ; GRAPHS 36 ; TABLES 1] *
DOCUMENT CLASSIFICATION(S): 10/9, 13, 15, 17, 21, 37, 43, 44, 45, 55

ABSTRACT: *[Information of direct or secondary relevance to the general subject matter of this Compilation is scattered thruout the Manual; the Total(s) cover the relevant material, a considerable portion of which stems from data furnished by the Northern Natural Gas Co. of Omaha, Nebraska.]

The specific goal of this Manual is to assist the E-Cube program user in developing proper input data by showing common sources of errors and by setting forth additional techniques for energy analysis. It contains information about methods and procedures which should be helpful to the user in avoiding common pitfalls, plus additional data on extending the usefulness of the E-Cube program series. The desire to avoid "small" errors is obvious but the user will often desire to extend or refine the building energy analysis; e.g., to incorporate more sophisticated combinations of air-side systems or heating and cooling systems.

The E-Cube Programs are 3 distinct programs, distinguished by an appropriate title and part number: Part I - Energy Requirements; Part II - Equipment Selection & Energy Consumption; Part III - Economic Comparison. These programs are dependent upon heat losses and gains that should be calculated in a manner such as is described in the ASHRAE "Handbook of Fundamentals".

The Manual states that actual data detailing the hourly loading for people in buildings is difficult to find and to apply to other buildings. Yet the coming and going of people reflects upon the type of structure, its specific use (as an office, school, etc.) and the usage of energy for lighting, heating and cooling. [Thus, this interdependency of the "people load" is reflected in the electric load profile.] Derivation of a people profile is not a precise calculation because it relies upon an interpretation of the building's projected usage; e.g., consider a neighborhood school which was supposed to have only a session of 9 months duration but which is actually being operated year-round as a school and in the evenings for recreation. Obviously, the people load profile is different than anticipated but so is the electrical profile

and building operation. Projections of building use are thus often in error and this suggests examining the alternative possible uses (prior to construction) thru energy analysis.

The electrical load profiles (and associated data sheets) in this Manual provide much of the basic load information needed to make an energy system analysis. [For example, the expected peak demand for a new building can be calculated by projecting information from a similar building type by using the ratio of recorded peak demand to total connected electrical load. This estimated peak demand times the load factor gives an hourly average base load which is needed to calculate annual KWH consumption.] Electrical load profiles and data sheets are presented for 16 installations covering 9 classes of commercial buildings. The data on each electric load profile data sheet indicates the total connected electrical load and measured peak demand in KW per 1,000 square feet of usable building space; expressing this data on a unit basis allows one to estimate the connected load and peak demand for similar building types. Data for the load profiles were obtained by metering actual buildings,at the incoming electrical service,with a four current element recording AC wattmeter. Each facility was metered and data recorded for a period of about two weeks.

To illustrate the use of electrical load profiles, an example is worked out for a preliminary T.E. feasibility analysis for a proposed 100,000 square foot, two-story office building. The Manual's load profile data presents information for 3 different office buildings ranging in size from 79,917 to 232,930 square feet. Of these three alternatives,the one that came closest to matching the operating characteristics and size of the proposed building was used to extrapolate electrical load information for the preliminary analysis.

TITLE: THE ENERGY SYSTEMS OPTIMIZATION COMPUTER PROGRAM (ESOP) DEVELOPED for MODULAR INTEGRATED UTILITY SYSTEMS (MIUS) ANALYSIS

SOURCE: Proceedings of 9th IECEC (held at San Francisco, Calif.; August 26-30, 1974); pp 541-546

AUTHOR(S): S.L.Ferden (AMD/LEC) & A.E.Brandli (NASA-JSC); et al
PREPARED BY AUTHOR(S) AND/OR: AMD/LEC + NASA-JSC

DATE OF ISSUANCE: 8/74
OTHER IDENTIFIERS: Paper Number 749058; AMD/LEC=Applied Mechanics Dept. of Lockheed Electronics Co.
DATA USE RESTRICTIONS: Copyright by ASME

TOTAL:[PAGES 6 ;REFERENCES 21 ;GRAPHS 2 ;TABLES 1] *
DOCUMENT CLASSIFICATION(S): 10/3, 37, 38, 41, 57

ABSTRACT: *[Information of primary and secondary relevance to the subject matter of this Compilation is scattered thruout this Report; the Total(s) apply to the entire paper although most of the References are not too specifically related to electrical loads.]

This paper presents a general description of ESOP, including the requirements determined by the program for a single building or a group of buildings, namely: (1) potable hot and cold water; (2) waste water management; (3) solid waste disposal; (4) building heating and cooling loads; (5) electricity generation. Alternate methods of meeting these requirements are discussed, along with the energy analysis. An economic data base for evaluating capital costs and operating and maintenance costs for both MIUS and conventional systems is described.

The Report summarizes the heating and cooling loads for a 648 unit apartment complex in Houston, Tex. The ESOP results are compared with those from another publically available computer program for a variety of seasonal conditions. A daily load profile of heating/cooling loads is shown for various weather situations thruout the year.

It is concluded that the ESOP provides a useful tool in performing analysis of integrated utility systems and in comparing these systems with the conventional means of supplying utility services. Program modifications, underway or being considered, include: solar energy utilization; incorporation of dual cycle prime movers; an enlarged data base for equipment performance; a weather data base. These modifications should significantly increase the scope of the analyses and simplify program input.

TITLE: A MODEL of RESIDENTIAL ENERGY USE in WISCONSIN

SOURCE: Institute for Environmental Studies; University of Wisconsin-Madison
AUTHOR(S): D.A.Frey
PREPARED BY AUTHOR(S) AND/OR: I.E.S.

DATE OF ISSUANCE: 12/74
OTHER IDENTIFIERS: IES Report 37; Energy Systems and Policy Research Report No. 11; NSF/RANN Grant #GI-43088
DATA USE RESTRICTIONS:

TOTAL: [PAGES 25 ;REFERENCES 11 ;GRAPHS 14 ;TABLES 5] *
DOCUMENT CLASSIFICATION(S): 10/4, 14, 21, 34, 47

ABSTRACT: *[Information of (mainly) secondary relevance to the general subject matter of this Compilation is contained in this Report. The Total(s) are for the entire Report, although most of the References are rather general in character.]

This Report is one of a series of descriptions of research conducted by the Energy Systems and Policy Research Group at the University of Wisconsin - Madison. The primary goal of the research group is the development of quantitative tools for energy policy analysis.

One focal point of this research is the development of a regional energy model. The model treats the state's energy system within a multidimensional framework that describes energy demand, conversion, transport and usage; technological, economic and environmental considerations are taken into account.

The Wisconsin residential energy use model is designed to provide a means of analyzing energy demand for the residential sector. The model is rather highly disaggregated in that it relates energy demand to ownership fractions and average use for 13 major appliances. Space heating, water heating and air conditioning parameters are further broken down according to the type (i.e., urban, apartment, rural) of home and its age. By varying new home construction rates, appliance blends and annual use a variety of alternative futures may be created and analyzed.

TITLE: BIBLIOGRAPHY on AVAILABLE COMPUTER PROGRAMS in the GENERAL AREA of HEATING, REFRIGERATING, AIR CONDITIONING and VENTILATING

SOURCE: ASHRAE & Battelle Columbus Laboratories (subcontractor)

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: ASHRAE (for NSF)

DATE OF ISSUANCE: 10/75 *
OTHER IDENTIFIERS: NSF-RA-760002 (5559); ASHRAE Research Project GRP-153
DATA USE RESTRICTIONS: Copyright by ASHRAE, Inc.

TOTAL: [PAGES ;REFERENCES ;GRAPHS ;TABLES] **
DOCUMENT CLASSIFICATION(S): 10/1, 23, 28

ABSTRACT: *[ASHRAE "anticipates" periodic up-dates of this Bibliography. This was the latest version available at the time this sheet was prepared.]

**[Contains material of (mainly) secondary relevance to the general subject matter of this Compilation. The Total(s) are not considered particularly relevant to a Bibliography.]

In recent years there has been a rapid increase in the number of computer programs designed to improve and facilitate design calculations relating to heating, refrigeration, air conditioning and ventilation equipment and systems. This increase has resulted from an increasing need for such programs, particularly in the area of energy conservation.

The descriptions of computer programs included in this Bibliography were developed with the objectives of informing potential program users of the programs that are available, telling what the programs do and who to contact for more information. The Bibliography was not intended as a means for expressing judgments as to the relative merits of any of the included programs and readers are cautioned not to attempt to extract such information. It should be pointed out that many of the program descriptions were prepared based on a minimum of information which was understandably "promotional" in nature. Readers are, therefore, urged to query the program developers directly, before selecting a specific program for use.

TITLE: NBSLD, the COMPUTER PROGRAM for HEATING and COOLING LOADS in BUILDINGS

SOURCE: (Sponsored by) HUD & NBS

AUTHOR(S): T.Kusuda
PREPARED BY AUTHOR(S) AND/OR: NBS

DATE OF ISSUANCE: 7/76
OTHER IDENTIFIERS: NBS Building Science Series 69; GPO Catalog No. (SD) C13.29/2:69
DATA USE RESTRICTIONS:

TOTAL:[PAGES 50 ;REFERENCES 43 ;GRAPHS 4 ;TABLES 3] *
DOCUMENT CLASSIFICATION(S): 10/1,4,7,15,22,23,28,31,32,37,43

ABSTRACT: *[Information of direct and (mainly) secondary relevance to the subject matter of this Compilation is scattered thruout this rather lengthy Report. The Total(s) reflect only the relevant data, except that all References are included.]

This engineering manual contains the algorithms for the "exact" calculations needed to accurately determine heating and cooling loads for the thermal design of buildings. NBSLD - which is based upon the methodologies presented in this publication - has been available for some time for the purpose of evaluating various building constructions and systems, including "unconventional" designs. [The program documentation is being made available so engineers can use it for accurate load determination, as they seek to conserve energy through improved thermal design of buildings.]

NBSLD, the NBS Load Determination program, has been developed to account for the time change of the many parameters which are pertinent to the accurate estimation of a building's energy usage for heating and cooling. The current status of heating and cooling load techniques is first reviewed. A summary of various subroutines of NBSLD is then given, along with the detailed procedures for using them. [These subroutines constitute the recommended subroutine algorithms of the ASHRAE Task Group on Energy Requirements.] Complete Fortran listing of NBSLD and data preparation forms are included for those who wish to use the program.

The NBSLD computation is on the basis of the detailed solution of simultaneous heat balance equations at all the interior surfaces of a room or space. Transient heat conduction through exterior walls and the interior structures is handled by using conduction transfer functions. The use of heat balance equations, although time consuming in calculation, can avoid the vagueness and uncertainties inherent in the more popularly used weighting factor approach. In addition, it is more accurate for a specific build-design.

The document includes electrical consumption as part of its input-operating data. One of its algorithms calls for 24-hour load profiles for lights, equipment (i.e., appliances) and occupancy; electrical demand values are normalized in terms of peak KW.

TITLE: A REVIEW of COMPUTER SOFTWARE APPLICABLE to the MIUS PROGRAM

SOURCE: NBS

AUTHOR(S): W.L.Carroll & J.R.Schaefgen, Jr.
PREPARED BY AUTHOR(S) AND/OR: NBS (for HUD)

DATE OF ISSUANCE: 10/77
OTHER IDENTIFIERS: NBSIR 77-1307; available from NTIS

DATA USE RESTRICTIONS:

TOTAL: [PAGES 101 ; REFERENCES 28 ; GRAPHS ; TABLES] *
DOCUMENT CLASSIFICATION(S): 10/17, 22, 41

ABSTRACT: *[This Report contains information of secondary relevance to the subject matter of this Compilation; the Total(s) are for the entire Report.]

The Report examines and evaluates 13 computer programs for their potential application to the MIUS concept. These programs calculate all (or partial) combinations of: heating and cooling loads; the simulation(s) of physical systems to determine the energy requirements necessary to satisfy such loads; the prediction of optimal operation schedules and their associated costs; the accomplishment of full "life-cycle" economic analyses.

A set of criteria is presented for evaluation of this software. Information regarding the programs - obtained from user manuals and a series of seminar presentations - is systematically summarized in a standardized format using information available as of June 1974 (mainly), altho two programs are described which are currently (1977) under development. Conclusions regarding the applicability, validity and utility of the programs are reached. Recommendations are also made concerning future software development and utilization.

The Report contains (scattered) references to data sources pertinent to load calculations and utility services, including the electrical demands.

TITLE: ALTERNATIVE STRATEGIES for OPTIMIZING ENERGY SUPPLY, DISTRIBUTION and CONSUMPTION SYSTEMS on NAVAL BASES: VOLUME I: NEAR-TERM STRATEGIES

SOURCE: Booz-Allen and Hamilton, Inc.

AUTHOR(S): T.Consroe; et al

PREPARED BY AUTHOR(S) AND/OR: B.-A. & H., Inc.

DATE OF ISSUANCE: 11/16/73

OTHER IDENTIFIERS: Report No. CR 74.006; NTIS No. AD777 471. Prepared for: Defense Advanced Research Projects Agency (Civil Eng. Lab.)

DATA USE RESTRICTIONS: Unclassified, Security-wise

TOTAL: [PAGES 21 ;REFERENCES 7 ;GRAPHS 1 ;TABLES 7] *

DOCUMENT CLASSIFICATION(S): 11/17, 31, 33, 39, 40, 42, 47

ABSTRACT: *[Information of direct or secondary relevance to the general subject matter of this Compilation is scattered thruout the Report. The Totals are for the relevant material, which is mainly concentrated in Sections V and X.]

This Report contains the results of cost/benefit analyses of 6 "near-term" energy conservation strategies, as applicable to continental USA naval bases. Basically, these energy conservation areas deal with: (1) solid waste as an energy source; (2) savings resulting from steam distribution system improvements; (3) improving thermal insulation; (4) metering on an individual unit basis; (5) window air-conditioning improvements; (6) better lighting design. These energy strategies would not require research and development expenditures and would result in an energy savings roughly equivalent to 11% of current use. This Report also includes a discussion of the availability of data related to Navy energy use. The results of trend analyses of national statistics on Navy energy consumption patterns are presented. Fuel price and energy consumption projections to the year 1990 are developed and used in the cost/benefit analysis.

Section V includes Navy-wide data concerned with the population and heating/cooling interrelationships for hospitals and air stations. The pertinent data sources are discussed and trend analysis results are interpreted. Section X deals with the metering of electricity for family housing, on an individual unit basis. The analysis demonstrates that, notwithstanding institutional constraints, a change to individual metering and billing of utilities for naval family housing will cause a general decrease in the level of electricity consumption which is more than enough to offset the cost of such a change. [Note: Electricity usages in naval housing appears to be substantially higher than those for comparable civilian housing. Because such usage is a complex function of many physical and human variables, an explicit and detailed comparison of military and civilian housing units and consumption patterns was outside the scope of this analysis.] The decrease in usage due to implementation of this technique cannot be determined precisely; however, reductions of 10 and 20% were postulated as being well within the possible savings range. This assumption is based on the results of empirical analyses of savings attributed to the installation of meters.

TITLE: ENERGY CONSERVATION in HOUSING: FIRST YEAR PROGRESS REPORT, 7/1/72 to 6/30/73

SOURCE: Princeton University/Center for Environmental Studies

AUTHOR(S): J.Fox; et al
PREPARED BY AUTHOR(S) AND/OR: Princeton University/C.E.S.

DATE OF ISSUANCE: 8/73; revised 12/73
OTHER IDENTIFIERS: C.E.S. Report No. 6 (sponsored by NSF/RANN)

DATA USE RESTRICTIONS:

TOTAL:[PAGES 58 ;REFERENCES 3 ;GRAPHS 4 ;TABLES 5] *
DOCUMENT CLASSIFICATION(S): 11/4, 14, 22, 47, 50, 52

ABSTRACT: *[Information of (mainly) secondary relevance to the subject matter of this Compilation is scattered thruout this Report.]

This Report summarizes certain initial results of a research project, "Energy Conservation in Housing". The project is studying a residential community (Twin Rivers, N.J.), which is partially occupied and partially under construction, from a variety of complementary perspectives. The gross measures of energy utilization used in the Report, monthly gas and electric consumption, are considered amenable to statistical analysis because the community contains large numbers of dwelling units which are alike in floor plan and appliance packages and contain documented and standardized variations. A regression analysis of 400 townhouses, in which gas is used exclusively for heating, does identify a "saving" due to double-glass and a "cost" due to being an end-unit in a row of townhouses. However, the analysis fails to establish a significant correlation between gas and electric consumption as well as between gas consumption and either family size or faimily income, when the type of dwelling unit is held constant. [Note: The unexplained variation in consumption between identical units must be due in part to physical differences in what are superficially identical units and in part to differences in user behavior.]

In addition to its analysis of Monthly Gas and Electric Consumption, the Report discusses the Twin Rivers monitoring/instrumentation system and analyzes its development history by looking at its financing, utilities, building codes, construction and design practices and residential patterns.

TITLE: REPORT on ENERGY CONSERVATION in SPACE CONDITIONING

SOURCE: PSC of New York

AUTHOR(S): *
PREPARED BY AUTHOR(S) AND/OR: PSC of New York

DATE OF ISSUANCE: 1/31/74
OTHER IDENTIFIERS: Case 26292 of State of New York Public Service Commission
DATA USE RESTRICTIONS: Case documentation should be available for inspection at various offices of the PSC of New York
TOTAL: [PAGES 56 ; REFERENCES 5 ; GRAPHS ; TABLES 42] ** 57
DOCUMENT CLASSIFICATION(S): 11/1,3,6,9,10,13,15,21,22,28,31,44,47,53,55,

ABSTRACT: *[The Report describes and discusses studies and/or testimonies of numerous interested groups and individuals, as related to energy conservation measures in the service territory of Consolidated Edison Company of New York, Inc.]

**[Information of direct or secondary relevance to the subject matter of this Compilation is scattered thruout this rather long Report; the Total(s) are for the relevant material.]

The initial phase of Case 26292 was particularly concerned with the heating and cooling of buildings. Nationally, space conditioning (and allied functions such as domestic hot water) account for approximately 25% of all energy usage but in the Consolidated Edison service area the % is estimated to be almost 45, principally because of the absence of energy intensive industry in the area and an energy consumption for transportation which is lower than the national average. [Thus, space conditioning is a significant area to consider in any energy conservation program and particularly so in the C.E. territory.]

Much of the evidence submitted was concerned with whether electricity for space heating was wasteful of fuel resources, in comparison to other modes of space heating. [It is stated that the use of electric resistance heaters consumes substantially more source energy than alternate heating modes.] Assuming use of electricity for air-conditioning (and parity in building design, insulation and thermostat control), a building using electric resistance heaters will annually consume the following amounts of "source energy": (A) 35 to 40% more than an office building heated with purchased steam or with oil; (B) 20 to 47% more than an apartment building heated with purchased steam or with oil; (C) 99 to 144% more than a private residence heated with gas or with oil.

In order to permit the use of electricity for space heating with a view to improving local air quality, while at the same time reducing inefficient use of source energy, it was recommended that the use of electric heat pumps be permitted in C.E.'s service territory but that electric resistance heating generally be prohibited.

The initial phase was also concerned with insulation practices and related matters of space conditioning design. Improvements in insulation were recommended which would permit annual savings in source energy of: 40% in private residences, 60% in apartment buildings and 50% in small commercial buildings. It also is recommended that future apartment buildings have a separate thermostat in each room since such multiple thermostats could achieve very substantial energy savings.

With respect to large commercial buildings, an energy conservation review (e.g., by a local government agency) is recommended prior to construction, with a view to minimizing energy consumption thru the use of more insulation, etc. The cumulative effect of incorporating such features in large commercial buildings could result in an estimated 50% reduction in energy use.

Another matter considered in the proceeding was T.E. systems. For "small" (less than 10 MW) T.E. systems in C.E.'s service territory, both feasibility and desirability are uncertain. However, development of such systems is facilitated to some degree by C.E.'s new policy of entering into electric interchange agreements with such systems. As to "large" projects or complexes (10 MW or more), a more affirmative policy was recommended in view of the greater feasibility and desirability of these larger T.E. systems.

The detailed testimony included a substantial amount of energy usage data, (mainly) for a variety of office buildings, apartments and single-family homes. The buildings discussed had computer-based studies covering a variety of heating systems and (in some cases) varying insulation standards. Usage characteristics were assumed and heating/cooling systems were called upon to meet the requirements of occupants under the varying usage conditions (and the weather conditions) during a "typical" year.

It must be emphasized that Case 26292 is concerned with conservation measures considered appropriate to C.E.'s service area. Altho the analysis techniques are believed to be generally applicable, conclusions on specific issues may vary in the case of other electric utilities because of differences in: electric generation patterns, fuel utilization, energy consumption patterns, climate and meteorology of the area served and prevailing building practices.

TITLE: LIMITING the DEMAND for ENERGY: POSSIBLE? PROBABLE?

SOURCE: Resources for the Future, Inc.

AUTHOR(S): J.Darmstadter
PREPARED BY AUTHOR(S) AND/OR: Resources for the Future, Inc.

DATE OF ISSUANCE: 7/74
OTHER IDENTIFIERS: Reprint Number 116

DATA USE RESTRICTIONS: Reprinted with permission from "Environmental Affairs", Volume II, No. 4; pp 717-731
TOTAL: [PAGES 15 ;REFERENCES 3 ;GRAPHS 1 ;TABLES 2] *
DOCUMENT CLASSIFICATION(S): 11/13, 35

ABSTRACT: *[Contains material of (mainly) secondary relevance to the subject matter of this Compilation.]

The Article tabulates an extensive list of the effects of trends in energy conservation practices, in terms of whether they are energy saving or non-energy saving. These "practices" are further categorized as: (1) raw energy resources; (2) end-use energy consumption; (3) electric generating capacity. Major components of USA energy consumption are tabulated, both in terms of their (1968) % of total USA energy use and as to their rate of change during the period 1960-68. [Conservation possibilities are briefly examined.]

The Article states that it is easy for someone too close to the energy conservation issue to come away with exaggerated notions of its efficacy. It is well to recall that (in sum total) most conservation steps are likely to make modest, but not decisive, inroads into the energy problems confronting this country. Plotted trends indicate that even the full range of long-term conservation practices in 1990 merely gets one down to the level of national energy consumption that would have occurred around 1982; or, alternately, postpones for perhaps a decade the excess amount of energy consumed in the absence of conservation.

TITLE: ENERGY CONSERVATION and the ENVIRONMENT: PROGRESS REPORT - JUNE 30, 1974

SOURCE: ORNL

AUTHOR(S): G.S.Gill & M.P.Guthrie; et al
PREPARED BY AUTHOR(S) AND/OR: ORNL-NSF Environmental Program

DATE OF ISSUANCE: 9/74
OTHER IDENTIFIERS: Available from GPO, as ORNL-NSF-EP-77

DATA USE RESTRICTIONS:

TOTAL: [PAGES 28 ;REFERENCES 20 ;GRAPHS ;TABLES 5] *
DOCUMENT CLASSIFICATION(S): 11/9, 10, 13, 16, 18, 25, 38, 57

ABSTRACT: *[Information of (mainly) secondary relevance to the general subject matter of this Compilation is to be found in Sections III, V and VI of this Report; the Total(s) apply to these three Sections.]

This Report outlines a program for investigating the nature of electricity demand growth. Its objective is to provide power planners, policy makers, environmental protection agencies and the "concerned public" with reliable predictions and predictive tools and to analyze alternative policy options aimed at achieving specific social goals. The program has included the development of electricity demand models for the 3 major consuming sectors (residential, industrial and commercial) and the use of these models to provide electricity demand forecasts. More recently the effort has been mainly concentrated on: (1) further refining and updating of the existing demand models and the testing of their predictive performance; (2) regional application, verification and extension of these models by using the TVA service area as the test case; (3) implementing the results obtained.

The Report summarizes the following aspects of the demand for electricity: (1) econometric demand models; (2) testing the stability of the demand structure in the context of rising electricity prices; (3) estimation of cross-price elasticities for natural gas; (4) industrial demand for electricity in the USA.

A major significance of the Report's findings is that the future demand growth estimates, made using the elasticity and time-rate of response estimated from historical data based on rising-price experience, are likely to be substantially different from those based on elasticities from the falling-price data. This being the case, forecasts based on demand models estimated largely from falling-price data should be viewed with caution. Appropriate conclusions can be drawn for other explanatory variables, although the price of electricity continues to be the most critical causal factor.

TITLE: A SYSTEMS ANALYSIS of the ECONOMIC UTILIZATION of WARM WATER DISCHARGE from POWER GENERATING STATIONS

SOURCE: Oregon State University (Engineering Experiment Station)

AUTHOR(S): L.Boersma; et al
PREPARED BY AUTHOR(S) AND/OR: O.S.U./E.E.S.

DATE OF ISSUANCE: 12/74
OTHER IDENTIFIERS: Bulletin No. 48 (11/74); Final Report

DATA USE RESTRICTIONS: Check with E.E.S. (Corvallis, Oregon)

TOTAL: [PAGES 104 ; REFERENCES 27 ; GRAPHS 14 ; TABLES 25] *
DOCUMENT CLASSIFICATION(S): 11/1, 27, 28, 37, 52, 55, 56

ABSTRACT: *[Information of direct and secondary relevance to the subject matter of this Compilation is concentrated mainly in Part 4, "Urban Utilization", of this relatively extensive Bulletin. The Total(s) are for the relevant material.]

Part 4 of this Bulletin states that the use of thermal energy from steam-electric power plants to supply the space heating, air conditioning and domestic water heating requirements of an urban community can be economically feasible. The major factors that influence this economic feasibility, in addition to energy resource costs are: (1) Population; (2) Plant-City Distance; (3) System Type; (4) Climate; (5) Population Density. This study examined the engineering and economic constraints for: (a) city populations of 200,000 (serviced population of 129,000) and 33,000 (serviced population of 21,500); (b) plant-city distances up to 8.5 miles; (c) two system types, the Bleed-Off System (BOS) and the Heat Pump System (HPS). The studies were for the Portland climate and specified population densities. [Note: BOS takes steam, before it has fully expanded thru the turbine, and heats water that is then circulated to the city where it cools, while providing space heating and domestic water heating and air conditioning. HPS circulates some of the condenser water between the power plant and the city. In the city the water is the low-temperature energy source for heat pumps during heating; during periods of high air conditioning loads, reservoir water rather than condenser water would be circulated.]

Part 4 includes detailed electrically-related data, as follows: (a) heating and air conditioning design and yearly use values in Portland and other Oregon areas; (b) domestic hot water requirements; (c) design energy requirements per unit, for both residential and commercial units; (d) yearly HVAC requirements for a variety of buildings; (e) cost estimates for various HVAC systems; (f) energy use profiles (on daily, monthly and annual basis) for various utilities.

TITLE: ENERGY CONSERVATION STUDIES: ("FINAL") PROGRESS REPORT, 12/31/74

SOURCE: ORNL (Energy Division)

AUTHOR(S): W.S.Chern; et al
PREPARED BY AUTHOR(S) AND/OR: ORNL-NSF Environmental Program

DATE OF ISSUANCE: 3/75
OTHER IDENTIFIERS: ORNL-NSF-EP-84 *

DATA USE RESTRICTIONS:

TOTAL: [PAGES 13 ;REFERENCES 9 ;GRAPHS ;TABLES 4] **
DOCUMENT CLASSIFICATION(S): 11/10, 13, 16, 17, 18, 35, 47

ABSTRACT: *[These reports were issued from time-to-time, each identified by a different ORNL-NSF-EP number. Others in the series were -29, -40, -55, -66 and -77.]

**[Information of direct or secondary relevance to the general subject matter of this Compilation is found in Section III of this Report and is so reflected in the Total(s), which exclude Industrial demands.]

Section III of this Report deals with the demand for electricity. From their study of 160 TVA electric distributors, the authors state that they have (in general) verified that the same causal factors have about the same same influence on electricity demands at the distributor level as they had at the state level. Data at the distributor level also allowed investigation of the impacts of electricity prices (and consumer availability of gas) on residential electricity usage.

Current work in the area of econometric forecasts is said to be related to questions of forecasting theory and the future status of the pertinent exogenous variables. Some of these questions are: How should forecasts be made? What is the future of the price of electricity? How is this price derived from generation, transmission and distribution costs? Is the declining block rate structure efficient or is it even necessary? [These are considered among the major problems which remain to be studied.]

Based on economic theory and earlier empirical work by ORNL, the residential demand for electricity was estimated as a function of: "own" price; the price of natural gas; population; per capita income; prices of household electrical appliances. [The demand equations were estimated from pooled time series (years) and cross-sectional (distributor) data. A dynamic demand model incorporating a geometric lag, to reflect gradual adjustment to changes in important demand determinants, was specified.] The estimation techniques provide fairly comparable long-run elasticities with respect to own price, population and per capita income. However, long-run elasticities with respect to the price of gas are significantly different. Price of appliances remains insignificant; this may be partly attributable to the fact that a national price index was used as a proxy for this variable.

TITLE: ENERGY CONSERVATION in NEW BUILDING DESIGN

SOURCE: ASHRAE Standard 90 Project Committee

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: ASHRAE

DATE OF ISSUANCE: 10/75
OTHER IDENTIFIERS: ASHRAE Standard 90-75

DATA USE RESTRICTIONS: Copyright by ASHRAE

TOTAL: [PAGES 15 ;REFERENCES 7 ;GRAPHS 7 ;TABLES 5] *
DOCUMENT CLASSIFICATION(S): 11/1, 15, 28, 32, 56

ABSTRACT:*[This Standard contains information of direct and (mainly) secondary relevance to the subject matter of this Compilation. Most of the "direct use" data is related to the sections dealing with Illumination. The Total(s) reflect only the relevant data.]

This Standard (in its present form) concentrates on the energy conservation aspects of new building design, regardless of the nature of the energy source. ASHRAE intends to add material which will relate to the varying impact of such sources, on conservation. The basic purpose is to outline design requirements which will improve energy utilization.

A Section of the publication deals with electrical distribution systems, in a highly summarized manner. Another Section deals rather extensively with the general area of "lighting power budgets"; the detailed data is said to be consistent with IES standards.

Discussions that are of general interest to the subject matter of this Compilation are found in the Sections relating to HVAC systems and service water heating.

TITLE: CONSERVATION INFORMATION: THE ENERGY CRISIS and ELECTRICITY CONSUMPTION in an APARTMENT COMPLEX

SOURCE: Energy Systems and Policy, Vol. 1, No. 2, pp 105-117

AUTHOR(S): T.A.Heberlein
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 1975
OTHER IDENTIFIERS: Edited by S.W.Gouse, Jr.

DATA USE RESTRICTIONS: Copyright by Crane, Russak & Co., Inc.

TOTAL: [PAGES 13 ;REFERENCES 10 ;GRAPHS 1 ;TABLES 1] *
DOCUMENT CLASSIFICATION(S): 11/3, 14, 21, 37, 50

ABSTRACT: *[Contains material of (mainly) secondary relevance to the subject matter of this Compilation.]

Informational material designed to either increase or decrease the amount of electricity used by apartment dwellers (located near Madison, Wisc.) showed no significant effect on consumption. In March and April 1973, the mean daily use was about 8.72 (with a standard deviation of 2.98)KWH across apartment units. In 1974 electricity use during comparable days was measured to determine the effect of the 'energy crisis' on consumption. Apartment units showed no changes in electricity consumption during the energy crisis. The reasons for the lack of effect of informational appeals on household consumption of electricity are discussed.

The conclusion of this Paper is not that appeals for energy conservation should be discontinued. The data measured only one of many possible impacts of energy conservation; many beneficial aspects that have not been examined may exist. Rather, the study suggests that reasoned appeals alone may not have a clear, measureable impact on consumption and that structural alternatives may be more effective.

The Paper includes a time-series plot which shows the electricity used (in KWH/day) for each day of the month, for 4 different groups. One of the groups was a "control", for which there were no attempts to propagandize in favor of decreasing their consumption. The other 3 groups were exposed to various forms of information about the benefits to be derived from energy conservation.

TITLE: HEAT LOAD REQUIREMENTS in MULTI-UNIT HOUSING (for Senior Citizens)

SOURCE: ASHRAE Journal, June 1976, pp 41-45

AUTHOR(S): M.A.Atwater & J.T.Ball
PREPARED BY AUTHOR(S) AND/OR: The Center for the Environment and Man, Inc. (Hartford, Conn.)
DATE OF ISSUANCE: 6/76
OTHER IDENTIFIERS: Funded by ERDA + NSF

DATA USE RESTRICTIONS: Copyright by ASHRAE

TOTAL:[PAGES 5 ;REFERENCES 5 ;GRAPHS 1 ;TABLES 4] *
DOCUMENT CLASSIFICATION(S): 11/3, 10, 21, 28

ABSTRACT: *[Contains material of (mainly) secondary relevance to the subject matter of this Compilation.]

Connecticut, thru its Department of Community Affairs (DCA), provides capital grants to local housing authorities for the construction of housing for low income elderly families and individuals. The State underwrites the full development costs of the housing so that the rent need cover only the management, maintenance and operating costs. The trend in utility costs is said to be a critical problem which could threaten the viability of the State's investment in the housing projects by forcing the housing expenses to exceed the means of those for whom the housing was built.

This Paper examines the energy conservation aspects of a proposed solar-heated housing project at Hampden, Conn. The examination was based on the use of NBS's Load Determination computer program and utilized utility data from two existing multi-unit housing projects for the elderly, previously built by DCA. [The existing utility data showed these projects used an average of 2800 to 3800 BTU/DD/(housing) unit, which would be reduced to an estimated 1672 to 1738 BTU/DD/unit with the proposed design.]

The Paper contains a limited amount of data on electrical usage of one-bedroom and efficiency apartments. It also lists the heating "sources" and "sinks" for the heating system and for lights, occupants and equipment, etc. The effects (on heating requirements) of a number of construction changes is outlined.

TITLE: THE TWIN RIVERS PROGRAM on ENERGY CONSERVATION in HOUSING: FOUR-YEAR SUMMARY REPORT

SOURCE: Princeton University/Center for Environmental Studies

AUTHOR(S): R.H.Socolow & R.C.Sonderegger
PREPARED BY AUTHOR(S) AND/OR: Princeton University/C.E.S.

DATE OF ISSUANCE: 8/76
OTHER IDENTIFIERS: C.E.S. Report No. 32
Sponsored by NSF/RANN, ERDA and U.S. Department of Commerce
DATA USE RESTRICTIONS:

TOTAL:[PAGES 51 ;REFERENCES 10 ;GRAPHS 15 ;TABLES 3] * 57
DOCUMENT CLASSIFICATION(S): 11/1,3,4,5,9,10,14,22,28,30,34,37.39,47,50,56,

ABSTRACT: *[Information of direct and secondary relevance to the subject matter of this Compilation is scattered thruout this rather lengthy Report. The Total(s) reflect only the relevant data.]

Since July 1, 1972, the C.E.S. has been engaged in a program to document and model (and to learn how to modify) the amount of energy used in housing. The principal target of the study was the energy for space heating; subordinate targets have been hot water heating, air conditioning and appliances. The research approach has strongly emphasized field studies at a single site, the recently built (planned) unit development of Twin Rivers, N.J. where about 12,000 people are living in close to 3,000 homes. C.E.S has: (1) monitored the construction; (2) interviewed many of those responsible for energy-related decisions in the planning and construction phase; (3) formally surveyed, and informally interacted, with the residents; (4) obtained a complete record of monthly gas and electric utility meter readings; (5) built a weather station at the site; (6) placed monitoring instruments in 28 townhouses (all identical in floor plan) and used another townhouse for a field laboratory.

Twin Rivers consists of a mix of industrial and commercial structures and residences (namely: single family homes, townhouses and apartments). The 3 bedroom townhouses are of conventional construction, with masonry bearing walls and wood framing for floors and roof, and provide approximately 720 sq. ft. of space on each of their two floors. The majority of the work described in this Report was carried out in two-floor townhouses but some was done in all parts of the town.

The residents of the townhouses are not "identical" altho, from the viewpoint of some of the social sciences, they would be regarded as a (realistic) homogeneous sample. Nearly all of the families have small children, typically one when they moved in and another since. Most of the fathers are "professionals" and the family annual income (at time of purchase) averaged $20,000. A large number of the fathers commute to New

York City. However, the population is not homogeneous from the standpoint of energy use. They differ in the following respects: (a) the interior temperatures of their apartments show a standard deviation of $\pm$ 2°F in winter; (b) in the interest they have for "fixing-up" their homes; (c) in their attitudes toward sun and toward dryness; and (d) in their - at least "vocal" - concern for saving money.

This Report is divided into two main parts plus 8 appendices. Part One cites the results that could, in principle, have been obtained without doing measurements within the houses. C.E.S. strove to invent analytical methods by which a population of homes could be monitored, using only data from the gas and electric meters and from a nearby weather station. It is stated that, in principle, this portion of the research could be widely imitated and at relatively low cost. The overwhelming dominance of outside air temperature, as a predictor variable in the winter heating season, renders the monitoring of performance (across residences and over time) a very productive exercise. Part One also presents a quantitative description of both the voluntary conservation, which occurred following the "energy crisis" in the autumn of 1973, and of the results of subsequent deliberate modifications of the townhouses.

Part Two describes results which required entry into the townhouses, first of all to look around but also to leave instruments behind. Three highly instrumented townhouses have produced a total of 200 channels of data which have been transmitted over telephone lines to the research laboratory; three winters and two summers of data have been obtained. Part of the instrumentation involved a bank of electric meters, by means of which the electric load was broken down into its major components; e.g., the very significant contribution of the hot water heater. The remaining townhouses have been more lightly instrumented by using a 9-channel package that writes data onto a tape cassette within the home.

The Report contains considerable detailed data related to energy consumption; examples follow:
(1) Mean and standard deviation values for 1973 gas and electricity use, on a "per 30 day" basis.
(2) Rate (1973) of thermal energy release (in the house) and rate (1973) of energy use.
(3) Average monthly electricity and gas bills for 1971 and 1975.
(4) Load profiles of hot water energy use in 2 townhouses, for a summer day.
(5) Load profiles of hot water energy use in 3 townhouses, for a winter day.
(6) Load profiles (for air conditioner fan, refrigerator compressor and clothes dryer) for a summer day.
(7) Load profiles of 3 refrigerator compressors for a winter day.
(8) Load profiles of lights and appliances (excluding water heater, dryer and range) for a summer day, for 3 homes.
(9) Load profile (all uses of electricity) for 2 houses, for a summer day.
(10) Average energy consumption (month-by-month), for 2 "identical" townhouses using gas and 2 using electricity.

TITLE: RESIDENTIAL ENERGY REQUIREMENTS and OPPORTUNITIES for ENERGY CONSERVATION

SOURCE: ASHRAE Transactions, Volume 82, pp 417-434

AUTHOR(S): J.W.Jones & B.J.Hendrix
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 1976
OTHER IDENTIFIERS: Sponsored by City of Austin (Tex.) thru its Electric Utility Department
DATA USE RESTRICTIONS: Copyright by ASHRAE

TOTAL:[PAGES 18 ;REFERENCES 5 ;GRAPHS 3 ;TABLES 16]*
DOCUMENT CLASSIFICATION(S): 11/4,10,14,21,30,37,38,47,55

ABSTRACT: *[Contains material of direct and (mainly) secondary relevance to the subject matter of this Compilation.]

A computer-based model was chosen as a means of isolating the effects of various factors related to residential energy use. Since it was also necessary to assure realism, the model was used to simulate the energy needs of 4 existing homes. Construction plans, specifications and equipment and appliance use data were obtained and used as the basis of the energy calculations. The simulation results were then compared with utility billing data (for 4 or more years) for each home. Utility data for a larger sample of 200 homes were also examined to attempt to identify the range of variation in energy use which might occur due to differences in life-style and/or equipment types. The results obtained in this study are summarized and presented in terms of a single "typical" size (1630 sq. ft.) home, whose other parameters are described. The influence of variations in insulation, infiltration of outside air, thermostat setting, glass type, attic ventilation, lighting and appliance loads, exterior shading, equipment efficiency and occupant action are discussed.

Several conclusions are drawn from the results of this study. First, the study shows that there are significant opportunities for conservation in Austin residences. [This is perhaps best illustrated by combining the various factors considered in this analysis into 2 sample homes. The first is not the worst possible case but does represent a "typical" wasteful residence; the other represents an energy "conservative" home where a reasonable effort has been made in design, construction and operation to reduce energy consumption. The contrast between the two types of homes is rather startling since there is a 56% decrease in annual energy consumption with conservation.] Second, altho the form of energy used has an important effect on the quantities of energy required for a residence, the major opportunities for conservation are related to the quality of construction and the operation of appliances and equipment.

Residential energy use profiles are listed (for Austin and Washington/Baltimore) to show the % of annual energy used for space heating, for air conditioning, for appliances and lighting and for hot water heating.

TITLE: EFFICIENT ELECTRICITY USE (A Practical Handbook for an Energy Constrained World)

SOURCE: Applied Nucleonics Company, Inc.; Santa Monica, California

AUTHOR(S): C.B.Smith, Editor; separate authors listed for each Chapter
PREPARED BY AUTHOR(S) AND/OR: A.N.C., Inc. (for EPRI under its Contract RP 211-1)

DATE OF ISSUANCE: 1976
OTHER IDENTIFIERS: Pergamon Press, Inc.

DATA USE RESTRICTIONS: Copyright by EPRI and A.N.C., Inc.

TOTAL: [PAGES 303 ; REFERENCES 38 ; GRAPHS 10 ; TABLES 27] *
DOCUMENT CLASSIFICATION(S): 11/9,10,13,23,26,27,32,44,47,52

ABSTRACT: *[Information of direct and (mainly) secondary relevance to the subject matter of this Compilation is scattered thruout the Handbook's 960+ pages. The Total(s) reflect the relevant material but there is some duplication of References and Data between Chapters. The Chapters of main interest are: #3, "Commercial Energy Use"; #4, "Residential Energy Use"; #8, "Light Energy Sources"; #11, "Energy Use in Urban and Suburban Dwellings"; #12, "Energy Use in Non-Residential Buildings."]

Total energy use in commercial establishments was 14.5% of the nation's energy budget in 1968. Roughly 1/3 of that was electrical energy, or about 24% of the nation's electricity use. The major use of electricity in this sector is for air conditioning, refrigeration, lighting and electric motors (for elevators, escalators and office machinery). Over the period 1960-1968, the fastest growing electricity use was for air conditioning and lighting. Electricity use in the commercial sector grew at the rate of 9.6% per year from 1962-1972, increasing faster than either the residential or industrial sectors.

The residential sector's energy input was about 19% of USA total energy use for 1968. The average direct residential energy use was about 17,000 KWH/person/year. Over the past 25 years, home equipment purchase and usage have evolved to the following percentages of energy use by appliances: space conditioning (29); food preservation (25); water heating (16); lighting (11); cooking (7); entertainment (6); clothes drying (4); other (2). Energy wastage is estimated as at least 30% of the residential total. The most important causes are: (1) insufficient thermal insulation; (2) undesired air infiltration; (3) excessive lamping; (4) appliance operation; and (5) the "up-to-now" low cost of energy.

The Handbook devotes over 25% of its space to Case Studies for nearly all of its chapters. Representative selections from these Studies (i.e., ones which are related to this Compilation) are: energy use in a small office; internal heat gains from lighting; T.E. systems for commercial buildings; measurement of direct energy use in residences; residential application of heat pumps; computer models of residential energy use; peak demand reduction for electric motors.

TITLE: ENERGY MANAGEMENT (for the CONSERVATION of ELECTRICITY)

SOURCE: Ontario Hydro, Energy Conservation Division (Toronto, Ontario, Canada)
AUTHOR(S): *
PREPARED BY AUTHOR(S) AND/OR: O.H., E.C.D.

DATE OF ISSUANCE: **
OTHER IDENTIFIERS: Sequence number and date and subtitles

DATA USE RESTRICTIONS: Check with O.H., E.C.D. Some of the design details are marked as: "All Rights Reserved".
TOTAL: [PAGES ;REFERENCES ;GRAPHS ;TABLES] ***
DOCUMENT CLASSIFICATION(S): 11/1,5,7,9,13,15,27,28,31,32,54,55,56

ABSTRACT: *[Only a few mention author(s) by name.]

**[These constitute an ongoing series, issued from time-to-time. Study No. 1 is dated 4/75 and Study No. 18 - the latest available when this sheet was prepared - is dated 11/77.]
***[Nearly all "Case Studies" are 4 pages; other Total(s) vary. Data is of (mainly) secondary relevance to the subject matter of this Compilation.]

The primary purpose of these case studies is to present technical information on effective energy management to engineers, architects and building owners.

Included in the described installations are those for office buildings, universities, government buildings, "senior citizen" apartments, warehouses and various industrial plants. Topics covered include data on lighting, thermal storage of excess energy, hot water heating systems, thermal insulation, HVAC systems, utility bills and central control systems. Most of the reports contain sample calculations.

Studies of particular relevance to this Compilation are:
No. 3: "Hot water pipe insulation saves energy and money";
No. 4: "Design lighting to save energy";
No. 7: "Energy savings realized by reducing the supply temperature of hot water";
No. 10: "ASHRAE 62-73 can save on your building's energy bill";
No. 12: "Lowering hot water supply temperature cuts energy use by 25 per cent";
No. 13: "Reduced lighting waste helps save 27 per cent of this 4 1/2 acre plant's electric energy use";
No. 18: "Split system air-to-air heat pump saves electrical energy at St. Martin de Porres" (school).

TITLE: DIVERSIFIED DEMAND METHOD of ESTIMATING RESIDENTIAL DISTRIBUTION TRANSFORMER LOADS

SOURCE: Edison Electric Institute Bulletin, 10/15/40, pp 469-473 + 496

AUTHOR(S): C.E.Arvidson
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 10/40
OTHER IDENTIFIERS: Paper presented at meeting of EEI's Transmission and Distribution Committee; Atlanta, Ga.; Oct. 15, 1940
DATA USE RESTRICTIONS: Copyright by EEI

TOTAL:[PAGES 6 ;REFERENCES 1 ;GRAPHS 3 ;TABLES 3]*
DOCUMENT CLASSIFICATION(S): 13/4,12,19,21,24,25,33,38,47,52

ABSTRACT: *[Contains material relevant to the subject matter of this Compilation.]

The Paper states that this diversified demand load estimating method has been checked for reliability. [The Paper includes a comparison of estimated vs actual loads, to illustrate the accuracy of the method.]

As a matter of background: residential loads consist of many combinations of various types of energy-using equipment whose natural hours of use and inherent characteristics govern the time of occurrence, the duration and the magnitude of the component demands. The resultant demands on the transformers vary on both a short and long-time basis and, altho it is difficult to determine peak demands by "spot" checks, they can be predicted with reasonable accuracy by statistical data.

Curves are shown which indicate the average (or per customer) maximum demand of ranges, refrigerators and lighting plus miscellaneous appliances; these diversified demands are plotted as a function of the number of customers or appliance units. The values (of the curves) are for demand intervals of at least 5 minutes duration but it can be noted that these values would not change appreciably if the interval were increased to 15 minutes, provided there were more than a few customers connected.

A tabulation is included for the hourly demand variation factors (of urban residential customers) for ranges, refrigerators and lighting plus miscellaneous appliances.

TITLE: RESIDENTIAL and INDUSTRIAL DEMAND for ELECTRICITY: AN EMPIRICAL ANALYSIS

SOURCE: Cornell University Thesis for the Degree of Doctor of Philosophy

AUTHOR(S): J.W.Wilson
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 6/69
OTHER IDENTIFIERS: No record of formal publication (in its entirety) but thesis has been cited and/or abstracted in several other studies. *
DATA USE RESTRICTIONS: Copies available from "University Microfilms" (as of 1970)
TOTAL: [PAGES 145 ; REFERENCES 15 ; GRAPHS 3 ; TABLES 13] ** 52,55,56,57
DOCUMENT CLASSIFICATION(S): 13/5,8,9,10,12,14,16,17,18,19,22,28,24,47,50,

ABSTRACT: *[This Compilation's Abstract is based, in part, on one included in Appendix A of "The Studies of the Residential Demand for Electricity: A Critique" by L.A.Guth of National Economic Research Associates, Inc. Mr. Guth's entire Paper is abstracted elsewhere in this Compilation.]

**[Information of direct and secondary relevance to the subject matter of this Compilation is to be found mainly in Chapters 1 and 2, plus those portions of Chapter 5 and Appendix B which refer to Residential data. The Total(s) reflect only the relevant material in this 332 page Thesis.]

In the first part of his thesis the author analyzes total residential consumption per customer, using a sample of 77 USA cities. The cities are selected on a nonrandom basis. Residential consumption per customer is "regressed" on: (a) average revenue per KWH or on the 500 KWH "typical" electric bill; (b) average gas price; (c) level of income; (d) climate; (e) average size of household.

A wide range of estimates of price elasticity were obtained which are dependent on: (1) the form of the relationship employed; (2) price measure used; (3) an inclusion in the analysis of explanatory variables, in addition to the price of electricity. For the total demand by residential customers, the price elasticity estimates ranged from -1.07 to -1.74; the respective range of values of the cross-elasticities (in terms of residential gas prices) are +0.20 and +0.39. When divided into "high-price" and "low-price" sample subsets, the elasticity coefficient is not statistically significant in the high-price equation and is -1.51 in the low-price equation, when using the typical utility bill as the price measure.

In the second part of his thesis the author studied a selected sample of SMSA's, again nonrandomly selected. Here each electric appliance's (1960) saturation was regressed on the same set of explanatory variables, as listed above. For individual electric appliance saturations, the range of price elasticity estimates were as follows: cooking ranges (-1.13 to -2.38); water heaters (-2.00 to -3.91); space heating (-3.57 to -6.48); clothes dryers (-0.84 to -2.45); food freezers (-0.58 to -0.95); air conditioners (Not Significant).

The cross-elasticity of demand that was obtained in the appliance regressions with the highest direct elasticity estimate was: +0.71 (for ranges); +1.51 (for water heaters); +1.83 (for space heating); +0.37 (for dryers). [Note: in the electric dryer regression, the income variable also emerged as statistically significant.]

Among the topics which the Thesis discusses in depth are: (a) multiple regression of cross-sectional data; (b) "short-run" and "long-run" elasticities; (c) interdependence of economic phenomena; (d) price elasticity of demand, as compared to other elasticities; (e) relation between electricity prices and rate schedules; (f) procedures for determining the relative importance of the independent variable in the regression equations; (g) qualitative relationship between marginal and average costs and demand; (h) data on average annual KWH usage of residential customers; (i) system peaks and average use factors; (k) alternatives, available to the residential consumer, for "high-cost" power and the stimulation of use of electricity by the availability of "low-cost" power.

The Thesis also contains extensive tabulated data which were used as the basis for its demand estimating equations and their related demand elasticities. [The author states that most of the values are not directly available elsewhere but have been calculated from basic data from a number of reputable and authoritative sources, which he specifies.] The basic tables are titled: (1) Primary Data Pertaining to Residential Demand for Electric Power; (2) Percentage of Households with Selected Major Electric Appliances, by SMSA's in 1960; (3) Industrial Electricity Consumption and Other Variables, for SMSA's in 1963; (4) Statistics for Two-Digit (SIC Code) Industry Groups.

TITLE: THE STUDIES of the RESIDENTIAL DEMAND for ELECTRICITY: A CRITIQUE

SOURCE: National Economic Research Associates, Inc.

AUTHOR(S): L.A.Guth
PREPARED BY AUTHOR(S) AND/OR: n/e/r/a, Inc.

DATE OF ISSUANCE: 8/73
OTHER IDENTIFIERS:

DATA USE RESTRICTIONS: Check with n/e/r/a, Inc.

TOTAL:[PAGES 80 ;REFERENCES 50 ;GRAPHS 2 ;TABLES 3] *
DOCUMENT CLASSIFICATION(S): 13/14, 17, 21, 23, 47

ABSTRACT: *[Material of direct and (mainly) secondary relevance to the subject matter of this Compilation is scattered thruout this Critique. The Total(s) are for the entire Report, since essentially all of it has some pertinency.]

Households consume a significant portion of the electrical energy produced in the USA, accounting for 88% of all ultimate customers of electric utilities and for 33% of the KWH delivered to such customers and providing for about 42% of the revenues received by the electric utility industry. The demand for electricity of this group of consumers has been studied by a number of economists, using various approaches and data bases; reference to 8 of the "better-known" studies are made in this report. The primary purpose of this Critique is to review these studies and catalog their characteristics, including "flaws".

It is stated that in personally evaluating such studies, the reader should have in mind two questions. The first is: "How well has the researcher performed his task?" and secondly: "How relevant are the findings?" Moreover, the question of relevance seems to be two-fold, namely: (1) the extent to which results can be usefully employed in, for example, predicting the effects that changes in rate schedules - or portions of rate schedules - will have on demand; and (2) to what extent results based upon historic data are relevant to current electricity problems. [Note: the 8 studies mainly used data from the 1960's or even earlier. However, recent years have witnessed major changes in the level and structure of electricity rates around the country and, perhaps even more important, dramatic alterations in the level of rates and availability of competing fuels have occurred.]

The Report reviews the main basis of the 8 studies referred to above, namely the application of economic demand theory to the residential demand for electricity. It states that, in aggregate, the studies tend to confirm the importance of: income, climate and other "taste - preference" factors (including housing characteristics and the rural/urban mix of population) upon the consumption of electricity by USA households.

TITLE: NATIONAL SURVEY of HOUSEHOLD ACTIVITIES (A NEW SOURCE of DATA on AMERICAN HOUSEHOLD CHARACTERISTICS and BEHAVIOUR)

SOURCE: The Washington Center for Metropolitan Studies (Washington, D.C.)

AUTHOR(S): E.S.Grier
PREPARED BY AUTHOR(S) AND/OR: W.C.M.S.

DATE OF ISSUANCE: 12/75
OTHER IDENTIFIERS: Household Activities Survey

DATA USE RESTRICTIONS:

TOTAL:[PAGES 21 ;REFERENCES 5 ;GRAPHS ;TABLES 1] *
DOCUMENT CLASSIFICATION(S): 14/21, 30, 39, 43, 47, 50

ABSTRACT: *[Material of (mainly) secondary relevance to the subject matter of this Compilation is scattered thruout this Survey. The Total(s) are for the relevant data.]

This Paper describes a new survey process, and a body of data, on a representative panel of American households. The survey was initially developed and run in 1973 under the aegis of the Ford Foundation's Energy Policy Project. An improved and extended version has been supported in 1975, under a contract with the FEA.

The Survey was principally designed to analyze and monitor the household consumption of energy and its relationships to household characteristics and behavior, as well as changes in consumption and behavior patterns over time. [For these purposes the survey is said to be the most complete and current data source now available.] Because household energy consumption is related to so many variables the survey also obtains detailed data on a wide range of other subject areas, including: housing characteristics; car ownership and commuting behavior; and lifestyles. The 1975 sample (with 3,200 households) is large enough to enable many kinds of detailed breakdowns, cross-tabulations and sub-analyses. The ability to compare many of the results for 1973 and 1975 adds an important longitudinal dimension.

Advanced multi-stage, area probability, procedures were coupled with rigorous fieldwork controls to assure a sample that would be closely representative of the universe of USA households. Thus, the sampling frame draws on locations nationwide and contains households that are closely representative of those residing in: urban, suburban and rural communities; in all major regions of the nation; in all housing types (for all ages and economic levels). To assure adequacy of results for lower-income households, selective oversampling was employed to increase the representation of these households in the total sample. The same procedures which are used to expand the lower-income segment of the sample also provided some oversampling of the elderly, of minority groups and of "female-headed" households; this increased the reliability and utility of the analysis results for these special groups.

TITLE: LOW KWH USE DOESN'T MEAN LOW INCOME

SOURCE: Electrical World, 3/15/76, pp 140-141

AUTHOR(S): J.A.Moriarty
PREPARED BY AUTHOR(S) AND/OR: Southern Services, Inc. (Atlanta, Ga.)

DATE OF ISSUANCE: 3/76
OTHER IDENTIFIERS: Energy Marketing

DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL: [PAGES 2 ;REFERENCES ;GRAPHS 3 ;TABLES 2] *
DOCUMENT CLASSIFICATION(S): 14/5, 17, 21, 55

ABSTRACT: *[Material is (mainly) directly relevant to the subject matter of this Compilation.]

The Article states that there is increasing evidence that low-income people are not necessarily low-energy-use customers because, for example, they cannot afford to dine out frequently or leave home on weekends. Also, the appliances and housing they can normally acquire are not (in general) very efficient. Conversely, some of the low-energy-use customers are higher-income people who have second homes or travel regularly.

To get an objective insight into the use and income patterns of customers, two of the operating companies in the Southern Co. system conducted studies on this subject. The conclusions of both companies were the same, namely that there are a significant number of low-income people who do not qualify as low-energy-use customers and therefore would receive no benefits from "lifeline" rates. On the other hand, there are a significant number of low-energy-use customers who are not low-income and would therefore benefit from lifeline rates.

One of the companies conducted a 12-month analysis which showed that 58% of the low-income (defined as less than $4,500/year) customers were not "low-use" and 31% who were low-use were not "low-income". The second company found that 50% of the customers who used an average of 100 KWH, or less, per month had incomes greater than $5,000/year and 25% had incomes greater than $10,000; of the first group, 71% used more than 300 KWH/month and 35% used more than 600 KWH/month.

TITLE: INCOME DETERMINES LEVEL of KWHR USE

SOURCE: Electrical World, 7/1/76, pp 54-55

AUTHOR(S): A.W.Lacy; et al
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 7/76
OTHER IDENTIFIERS: Energy Marketing

DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL:[PAGES 2 ;REFERENCES 2 ;GRAPHS ;TABLES 2]*
DOCUMENT CLASSIFICATION(S): 14/10, 18, 21, 47, 55

ABSTRACT: *[Contains material of (mainly) secondary relevance to the subject matter of this Compilation.]

Alabama Power Co. studied the residential use of electricity during an 8-year period, from early 1967 through the first 4 months of 1975. The study showed that the use of electricity was price inelastic (coefficient, - 0.45) and that family income was of more importance than the cost of a KWH because income accounted for 92% of the increase in consumption.

The basic purpose of this study was to model design demand equations for residential electricity, so that a determination of elasticity coefficients could be made. [The study area included all 6 divisions of Alabama Power.]

The final model included independent variables on: price of electricity; price of related goods; income; weather; and a measure of unemployment. A log-linear transformation of all variables was used, allowing the direct expression of the elasticity coefficients. [Several other variables, including a patriotism "dummy" and a trend factor were tested but were eventually eliminated. The "patriotism" variable was used to represent the effect of the President's appeal, in late 1973, to save fuel. The "trend" was used to represent variables not otherwise included.]

All the variables except unemployment were significant at the 1% level, using ordinary least-squares regression. The analysis explained 85% of the variability in electricity use over the 8-year period.

TITLE: DETAILED GEOGRAPHICAL ANALYSIS of RESIDENTIAL ENERGY CONSUMPTION

SOURCE: Proceedings of 11th IECEC (held at State Line, Nevada; September 12-17, 1976); pp 1703-1710
AUTHOR(S): T.Alereza; et al
PREPARED BY AUTHOR(S) AND/OR: Hittman Associates, Inc. (Columbia, Md.)

DATE OF ISSUANCE: 9/76
OTHER IDENTIFIERS: Paper No. 769295

DATA USE RESTRICTIONS: Check with American Institute of Chemical Engineers
TOTAL:[PAGES 8 ;REFERENCES 7 ;GRAPHS ;TABLES 7] *
DOCUMENT CLASSIFICATION(S): 14/1,15,21,22,28,30,35,43,47,57

ABSTRACT: *[Contains material relevant to the subject matter of this Compilation; Total(s) are for the entire Paper.]

This Paper has three major goals: (1) to define "characteristics" single-family, townhouse and low-rise residential buildings for 10 major metropolitan areas; (2) to quantify heating/cooling loads for each residence type, at each location, over a typical weather year; (3) to assess the annual energy use in the characteristic buildings, based on the calculated loads and on the efficiencies and operational characteristics of the heating and cooling systems in the buildings. The Paper is also intended to: (a) be useful as a background document for analysts and researchers in studying or calculating national energy use patterns; (b) provide well-founded, regionally specific and structurally-typical heating and cooling loads so as to enable researchers to estimate energy use associated with a variety of heating and cooling systems applied to the characteristic houses; (c) provide information on the regional variations in construction techniques, design and materials used.

Altho specific lifestyles were not prescribed for the residents of the characteristic residences, a number of lifestyle parameters were needed for the analyses. Examples of such parameters included: thermostat and relative humidity setpoints; type and number of appliances; daily profile of appliance and ventilation fan usage. Most parameters were defined for average conditions; no allowance was made for variations caused by weekends or holidays, vacations, entertaining of large groups, difference in age or affluence of the residents, etc. Occupancy loads were, however, adjusted for weekends.

The annual energy use for heating and cooling the characteristic single-family residences (on a BTU per sq. ft. basis) varied from: 31,000 (Los Angeles area) to 140,000 (Minneapolis area). Corresponding values for the multi-family townhouses varied from 18,000 (San Francisco area) to 82,000 (Minneapolis area). Corresponding values for the low-use housing varied from 19,000 (Los Angeles area) to 59,000 (St. Louis area). [Note: the other cities included in the study were Atlanta, Boston, Chicago, Denver, Houston and Miami.]

TITLE: CHANGING PATTERNS of ENERGY CONSUMPTION and COSTS in U.S. HOUSEHOLDS

SOURCE: The Washington Center for Metropolitan Studies (Washington, D.C.)

AUTHOR(S): E.S.Grier
PREPARED BY AUTHOR(S) AND/OR: W.C.M.S.

DATE OF ISSUANCE: 9/76
OTHER IDENTIFIERS: Paper presented at Allied Social Science Association Meeting; Atlantic City, New Jersey; 9/18/76
DATA USE RESTRICTIONS:

TOTAL:[PAGES 15 ;REFERENCES 4 ;GRAPHS ;TABLES 4] *
DOCUMENT CLASSIFICATION(S): 14/5,17,21,22,30,43,47,50

ABSTRACT: *[Contains material of direct and secondary relevance to the subject matter of this Compilation. The Total(s) are for the relevant data.]

This Paper presents some of the findings of two consecutive national surveys, both conducted by the W.C.M.S. Both surveys employed in-depth interviews (about one hour in length) coupled with direct measurements of utility consumption and costs. They were intended to help determine how a representative sample of American households use energy in their daily lives and how energy use varies with income levels, lifestyles, features of the housing unit and various other characteristics.

The two surveys (one in the spring of 1973 and the other in the spring of 1975) provide "pre-energy crisis" and "post-energy crisis" measures of residential energy consumption, as well as of many of the practices and attitudes which can influence it. These variables can be cross-analyzed against a variety of household and housing unit characteristics since both surveys asked closely similar questions, for the most part.

This paper deals exclusively with energy consumed directly within the dwelling unit and especially with the two major in-house energy sources, electricity and "piped-in" natural gas. The survey data on consumption and costs of these fuels can be considered quite reliable. Rigorous sampling and fieldwork procedures were employed and the findings about key household characteristics correspond closely to statistics from the Census Bureau's Current Population Survey for each of the two survey years. In addition, consumption and cost figures were not derived from retrospective estimates by householders but from actual billing data furnished by utility companies.

Representative tabulated data is included for: (a) the consumption and cost of electricity and natural gas per USA household for 1973 and 1975; (b) consumption and cost of household electricity - for 1973 and 1975 - by household income, structure type, region of country, community location and age of head of household; (c) % change in consumption and cost - between 1973 and 1975 - for the same selected variables as in (b); and (d) changes in household energy behavior between 1973 and 1975.

TITLE: CONSUMER DEMAND in the UNITED STATES: ANALYSES and PROJECTIONS

SOURCE: Harvard University Press

AUTHOR(S): H.S.Houthakker & L.D.Taylor
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 1970
OTHER IDENTIFIERS: Second (and enlarged) Edition

DATA USE RESTRICTIONS: All rights reserved (by H.U.P.)

TOTAL:[PAGES 34 ;REFERENCES 14 ;GRAPHS 4 ;TABLES 3] *
DOCUMENT CLASSIFICATION(S): 16/4, 10, 13, 17, 23, 35

ABSTRACT: *[Information of direct and (mainly) secondary relevance to the subject matter of this Compilation is scattered thruout this Book. The Total(s) reflect the relevant material. Note: material of general interest may be found in the 69 other References.]

This monograph is primarily an econometric demand study designed for projecting all items of USA private consumption expenditures thru 1975. [Some data is also contained for Canada, Sweden and the Netherlands.] Since the components that determine the demands are, to some extent, interrelated the projections are shown in the form of a system of (estimated) demand functions.

The main emphasis (for reasons that are explained in the monograph) is on time-series, as contrasted to cross-section, analysis. The general considerations relative to time-series analysis are discussed, along with the basic dynamic model that is utilized in the study. The (almost exclusive) use of "per capita" data is explained, as is the use of "total consumption expenditure" as the independent variable.

Expenditure data is included for: (1) household appliances; (2) household utility electricity; (3) household utility gas; (4) water; (5) radio and television receivers, etc.

TITLE: ELECTRICITY DEMAND in the UNITED STATES: An ECONOMETRIC ANALYSIS *

SOURCE: NSF/RANN Symposium on "Energy Demand, Conservation and Institutional Problems";held at Mass. Institute of Tech., 2/12-2/14, 1973
AUTHOR(S): T.D.Mount; et al
PREPARED BY AUTHOR(S) AND/OR: ORNL

DATE OF ISSUANCE: 2/73
OTHER IDENTIFIERS:Chapter 24, pp 318-329 of Proceedings

DATA USE RESTRICTIONS: MIT Copyright on Symposium Proceedings

TOTAL:[PAGES 12 ;REFERENCES 9 ;GRAPHS 1 ;TABLES 3] **
DOCUMENT CLASSIFICATION(S): 16/4, 13, 14, 17, 18, 21, 25

ABSTRACT: **[Information of direct or (mainly) secondary relevance to the subject matter of this Compilation is scattered thruout this Paper. The Total(s) are for the entire Paper.]

[The quantity of electricity used in the USA has been growing steadily since the end of World War II. If past trends are extrapolated to the year 2000, the demand will increase to at least 6 times the 1970 level: it is quite questionable whether these trends will remain unchanged in the future.] In economic theory, demand is related to various causative factors and if the direction of change of one or more of these factors is reversed demand will be affected. For example, the relative price of electricity has decreased in the past but will (almost certainly) increase significantly during the next decade. Such increases will retard the growth of demand for electricity, unless price is an unimportant determinant of demand. The main objective of this analysis is to determine the magnitude of the relationships between the quantity of electricity demanded and (1) population, (2) income, (3) the price of electricity, (4) the price of substitute fuels such as gas and (5) the price of complementary products, such as household appliances. The demand elasticity of each of the 5 factors is estimated; its magnitude indicates how important the factor is as a determinant of demand.

The Paper estimates "long-run" elasticities in 1970 dollars, evaluated at the 1971 levels of the 5 factors. It concludes that these estimates demonstrate that electricity demand is generally price elastic (for the Residential, Commerical and Industrial user classifications) and becomes increasingly so as prices continue to rise. In contrast, demand was found to be generally inelastic with respect to income, approaching zero for the Residential and Industrial users as income increased;

income elasticity for Commercial users is only slightly inelastic, over a wide range of income levels. Population exhibits approximately unit elasticity for all classes. The price of gas and of electrical appliances do not appear to influence electrical demand, i.e. these factors are inelastic with respect to demand.

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*Note: A longer version of this paper (which contains more statistical analysis details) has since been published under the same title, as ORNL-NSF-EP-49; this version is abstracted elsewhere.

TITLE: ELECTRICITY DEMAND - ONE UTILITY'S ECONOMETRIC MODEL

SOURCE: NSF/RANN Symposium on "Energy Demand, Conservation and Institutional Problems";held at Mass. Institute of Tech., 2/12-2/14,1973
AUTHOR(S): R.B.Comerford & W.G.Michaelson
PREPARED BY AUTHOR(S) AND/OR: Public Service Electric & Gas Co. (of New Jersey)
DATE OF ISSUANCE: 2/73
OTHER IDENTIFIERS: Chapter 29, pp 386-400 of Proceedings

DATA USE RESTRICTIONS: MIT Copyright on Symposium Proceedings

TOTAL:[PAGES 15 ;REFERENCES 5 ;GRAPHS 7 ;TABLES] *
DOCUMENT CLASSIFICATION(S): 16/10, 14, 17, 35, 37, 55

ABSTRACT: *[This Paper contains material of (mainly) secondary relevance to the subject matter of this Compilation. The Total(s) are for the entire Paper.]

P.S.E.&G. reports on its use of a small annual model which assists in the forecasting of future electric peak and energy demands. This model (which contains only 25 equations) provides a vehicle for examining the effects of the economic sector upon future energy use.

The econometric model that was formulated is designed to explain the behavior of the endogenous factors and to determine how well each of these variables can be forecast. The approach used was to specify a set of hypotheses that can be tested in a regression framework. Each hypothesis, formulated as a single equation, is examined separately. Ordinary least squares is used to determine the parameter estimates.

The Paper includes plots (covering 1972 to 1985) of the effects of: price increases, on total KWH use; introducing a state income tax, on Commercial KWH consumption; "zero population growth", on Residential KWH usage; "investment tax credit", on Industrial KWH consumption; a 1970 "steel strike", on Industrial KWH use. [Note: The preceding examples are simply used to illustrate the broad possibilities of this type of model.]

It is stated that the application of econometric methods to planning for future energy needs has proved to be a valuable tool in studying these needs; however, it should be emphasized that models are just tools, not the full and complete answer. The major strengths of econometric techniques in energy forecasting are that they allow the user to attribute an economic/energy event to its various causes and also permit the prediction of components (of such events) on a consistent basis.

TITLE: MODELING ELECTRICITY DEMAND GROWTH (Note: This is an edited version of Papers by Messrs Chapman, Mount & Tyrrell)

SOURCE: Resources for the Future, Inc.

AUTHOR(S): D.Chapman & T.Mount (Cornell University); T.Tyrrell (ORNL)
PREPARED BY AUTHOR(S) AND/OR: M.F.Searl, Editor

DATE OF ISSUANCE: 3/73
OTHER IDENTIFIERS: Working Paper EN-1 (for Seminar on Energy Modeling); Washington, D.C.; Jan 25-26, 1973; pp 253-265
DATA USE RESTRICTIONS: All rights reserved by R.F.F., Inc.

TOTAL: [PAGES 13 ;REFERENCES 6 ;GRAPHS 1 ;TABLES 3] *
DOCUMENT CLASSIFICATION(S): 16/10, 13, 14, 18, 21, 35

ABSTRACT: *[Contains material of (mainly) secondary relevance to the subject matter of this Compilation.]

Many observers of electricity demand believe that electricity consumption will continue to increase at about a constant compound growth rate for the rest of the century. Acceptance of such growth possibilities appears to be based on a belief that this growth is largely autonomous, or that the net effect of the primary factors influencing electricity demand will continue to develop according to past patterns. This Working Paper states its opinions and beliefs that projections (until the year 2000) of compound electricity growth rates at or near historic rates are generally incorrect, in spite of the fact that such simple projections of continued growth have been quite accurate in the past.

The Paper projects electricity demand by means of an econometric equation which includes the effect of electricity prices, population size, per capita income and the price of (natural) gas. Economic elasticities are tabulated for electricity and gas prices, population and income; these values are seperately calculated for Residential, Commercial and Industrial consumers.

It is noted that (perhaps) the most appropriate conclusion is to observe that energy demand growth is partly a matter of choice. Decisions about the quality of the natural environment, our material standards of living and equity will influence our demand for energy and will, in turn, be affected by our use of energy.

TITLE: ELECTRICITY DEMAND in the UNITED STATES: An ECONOMETRIC ANALYSIS

SOURCE: ORNL

AUTHOR(S): T.D.Mount; et al
PREPARED BY AUTHOR(S) AND/OR: ORNL

DATE OF ISSUANCE: 6/73
OTHER IDENTIFIERS: ORNL-NSF-EP-49; NSF Environmental Program

DATA USE RESTRICTIONS:

TOTAL:[PAGES 27 ;REFERENCES 16 ;GRAPHS 1 ;TABLES 6] *
DOCUMENT CLASSIFICATION(S): 16/4, 9, 14, 17, 18, 21, 25, 47, 50

ABSTRACT: *[Information of direct or secondary relevance to the subject matter of this Compilation is scattered thruout the Report; the Total(s) are for the entire Report.]

The growth of demand for electricity since 1945 is atttibuted to 5 factors: population, income and the prices of electricity, substitute fuels (i.e., natural gas) and demand-related products such as household appliances. Single-equation models are fitted for 3 consumer classes (Residential, Commercial and Industrial), with the quantity of electricity as the dependent variable. Both constant and variable elasticity models are estimated. In all cases, a lagged dependent variable is used as a regressor implying that demand adjusts through time to changes of the explanatory variables. [The data used in modeling are rather aggregated since they are described as "annual" observations for 48 continguous states from 1946 to 1970.]

The estimated long-run elasticities, as summarized in the Report, demonstrate that electricity demand is generally price elastic for all 3 consumer classes and becomes increasingly elastic as prices rise. In contrast, demand is generally inelastic with respect to income and, for Residential and Industrial classes, approaches zero as income increases. The income elasticity for Commercial demand is only slightly inelastic over a wide range of income levels. Population exhibits approximately unit elasticity for all classes and the elasticities for the prices of gas and appliances are consistently found to be inelastic. [Note: Generally, demand is found to be income inelastic in other studies, but the nature of the price elasticity is more controversial.]

The relative importance of price as a determinant of demand has implications as to the future needs for generating capacity. If prices increase over the next few years (in response to increased fuel costs, etc.) the growth of electricity demand will gradually decrease from the present rate, with no accelerated growth of population or income being expected to offset this price effect. In summary, the authors consider that planning new generating capacity by simply extrapolating past trends significantly overestimates the future need for additional capacity.

TITLE: RESIDENTIAL ENERGY USE: AN ECONOMETRIC ANALYSIS

SOURCE: The Rand Corporation (Santa Monica, Calif.)

AUTHOR(S): K.P.Anderson
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 10/73
OTHER IDENTIFIERS: Report #R-1297-NSF (prepared for NSF)

DATA USE RESTRICTIONS: Published by the Rand Corporation

TOTAL:[PAGES 86 ;REFERENCES 12 ;GRAPHS 2 ;TABLES 18] *
DOCUMENT CLASSIFICATION(S): 16/4, 18, 21, 22, 35, 47, 52

ABSTRACT: *[Information of (mainly) secondary relevance to the general subject matter of this Compilation is scattered thruout this Report. Data on non-electrical energy sources is excluded from the Total(s), other than for Total of Pages.]

The Report states that price elasticity estimates (from some studies of residential gas and electricity demands) leave one in doubt as to the nature of responses to price and to the role of inter-fuel substitution, as compared with the role of alterations in usage rates or in the size, efficiency and features of new and renovated equipment. The own- and cross-price elasticities obtained in these studies imply that large, equal %, increases in the prices of energy sources would eventually lead either to marked increases in energy conservation or to a shift from utility gas and electricity to other sources of energy. The latter interpretation is (intuitively) implausible for price increases that would apply to all types of energy; however, a quantitatively significant link between energy price and the degree of energy conservation is not well supported by casual observation.

The "predicting" equations estimated in the study fall into 2 classes: those for stocks of energy-using equipment and those for energy consumption. [The analysis of equipment stocks yields information about the importance of fuel choice, relative to rates of energy use by residential customers.] Both static and dynamic relationships are estimated using cross-sectional data for 50 states for the years 1960 and 1970. The explanatory variables include energy and appliance prices, household income and size, urbanity, housing structure and winter and summer temperatures; each explanatory variable appears only in those equations for which it is appropriate. The energy equations estimate average consumption per household of utility gas and electricity, both independently and simultaneously, with a constraint upon the cross-elasticity coefficients for gas and electricity prices.

The Report tabulates the 1970 estimated patterns of electricity (and gas) consumption for various household functions.

TITLE: THE DEMAND for ELECTRICITY: A SURVEY

SOURCE: The Bell Journal of Economics; Spring 1975, pp 74-110

AUTHOR(S): L.D.Taylor
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 1975
OTHER IDENTIFIERS: Vol. 6, No. 1. Revision of study prepared for EPRI.

DATA USE RESTRICTIONS: Copyright by American Telephone and Telegraph Co.

TOTAL:[PAGES 37 ;REFERENCES 50 ;GRAPHS 10 ;TABLES 4] *
DOCUMENT CLASSIFICATION(S): 16/5, 9, 10, 13, 23, 38

ABSTRACT: *[Information of (mainly) secondary relevance to the general subject matter of this Compilation is contained in this Report, which is concerned mainly with non-industrial studies. The Total(s) are for the entire report, although many of the References are rather general in character.]

This Paper presents a survey and critique of the econometric literature related to the demand for electricity. Most of the literature is on residential demand but the few available studies analyzing commercial and industrial demand are also reviewed. Special attention is given to the singular features of electricity demand, namely: the fact that electricity is purchased according to multipart decreasing block tariffs; the need to distinguish between demand in the short run and demand in the long run; etc. In particular, it is noted that the proper modeling of decreasing block tariffs requires inclusion of both a "marginal" and "average" price as predictors in the demand function. The Paper also has some suggestions for future research in this general area.

TITLE: ENERGY SYSTEM ECONOMICS

SOURCE: "Power Generation Systems"; pp 367-390

AUTHOR(S): B.G.A.Skrotzki (Associate Editor)
PREPARED BY AUTHOR(S) AND/OR: Editors of"Power" (magazine)

DATE OF ISSUANCE: 1967
OTHER IDENTIFIERS: Part of Energy Systems Engineering Volumes

DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL: [PAGES 24 ;REFERENCES 1 ;GRAPHS 18 ;TABLES 3] *
DOCUMENT CLASSIFICATION(S): 17/13, 15, 37, 45, 57

ABSTRACT: *[Information of (mainly) secondary relevance to the subject matter of this Compilation is scattered thruout this Chapter. The Total(s), except for Page(s), are for the relevant material.]

To design a plant for maximum economy, one must know the nature of the loads it will be supplying. It is stated that the easiest way to describe these loads is by plotting chronological or duration curves. The chronological daily load curve shows the total load at every interval of the day; since KW are plotted vs time (in hours) the area under the curve is a measure of the KWH usage for the day. [A curve of this type is important to plant operation since it lets the operators know what loads to expect on certain types of days; they can thus be prepared to take off prime movers when load drops, so as to maximize system economy.] The (load) duration curve is a simple - but convenient - rearrangement of the chronological curve, with the daily load curve being cut into many time segments which are then rearranged in descending order of their magnitude. [This type of curve summarizes loads; e.g. for a day, week, month or year. This is a great help in plant design since on one curve a whole year can be summarized to show: peak demand, variations in demand and their duration and the total energy involved.]

Nearly all municipal, regional and industrial loads are made up of recognizable components; their sum at any given moment creates the total demand. Since it is unlikely that component demands will peak at the same time, the resulting diversity of peak demand helps make central-station generation an economical energy system. The cited Chapter shows an assortment of typical daily-load curves for various load groups. With the exception of street lighting, most of them sink to the minimum level during the early morning hours. Each individual curve tends to vary with the type of day, weather and season. The % distribution of these load types on a central-station system determines the shape of the system load curve. Diversity usually flattens the load curve.

TITLE: THE EFFECTS of PRICE on CONSUMPTION

SOURCE: Public Utilities Fortnightly, 11/6/75, pp 17-21

AUTHOR(S): J.V.Thornton
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 11/75
OTHER IDENTIFIERS:

DATA USE RESTRICTIONS: Copyright by Public Utilities Reports, Inc.

TOTAL: [PAGES 5 ;REFERENCES 20 ;GRAPHS ;TABLES] *
DOCUMENT CLASSIFICATION(S): 17/10, 13, 21, 35

ABSTRACT: *[This Paper contains material of (mainly) secondary relevance to the subject matter of this Compilation. Some of the References are rather general in their coverage.]

In recent years the declining trend in the real price of electricity has reversed in most of the USA. The nominal price to the average residential consumer rose 22% in 1974 and in 1975 it is expected to rise another 13 to 15%; such increases exceed the overall rate of inflation and consequently represent increases in the real price of electricity. Thus, if there is a relation between price and demand, increasing prices will tend to reduce demand over the next few years. This does not mean that this demand will decrease in terms of absolute magnitude. [Many factors other than price influence demand and there is general agreement that other factors will outweigh the braking effect of price increases.] But the effect of price - if it affects demand - will be to slow down the rate of increase in demand.

A major difficulty with assessing attempts to forecast the impact of price increases on demand is that there is little empirical evidence against which to test the theoretical models. Nevertheless, the weight of evidence supports the proposition that electricity consumption is responsive to price. The degree of responsiveness may well vary among localities, companies and customers. Utilities may not yet regard it as feasible to "plug into" their forecasting a specific numerical factor for price elasticity but it is an element that cannot be overlooked and it is likely to be given more attention as prices continue to rise.

The author emphasizes that a concern with price does not suggest that other factors are unimportant in determining demand. Demand depends also on: the consumer's desire and need for electricity; his level of income; availability and price of other "fuels"; price of appliances; growth of population; rate of family formation, their size and living habits; geographical location; technological change; temperature; energy conservation programs; decisions of regulators and other public agencies. [Indeed, one of the more difficult problems in studying the impact of price is to separate out the myriad factors which affect demand.]

TITLE: ELECTRIC ENERGY USAGE and REGIONAL ECONOMIC DEVELOPMENT (Final Report)

SOURCE: Research Foundation of State University of New York (at Albany)

AUTHOR(S): J.H.Savitt (Principal Investigator)
PREPARED BY AUTHOR(S) AND/OR: R.F. of S.U.N.Y. (for EPRI)

DATE OF ISSUANCE: 8/76
OTHER IDENTIFIERS: EPRI ES-187; Research Project 334 (R.T.Crow, Project Manager)
DATA USE RESTRICTIONS:

TOTAL: [PAGES 30 ;REFERENCES 16 ;GRAPHS 2 ;TABLES 8] *
DOCUMENT CLASSIFICATION(S): 17/9, 10, 14, 18, 21, 47

ABSTRACT: *[Contains material of (mainly) secondary interest to the subject matter of this Compilation; the Total(s) apply to the relevant material. The Chapters of particular interest are: II-"The Residential Demand for Electricity" and III-"The Commercial Demand for Electricity".]

This Study determines the impact of changes in electricity prices on the key economic variables associated with the economic development of the Buffalo SMSA. A state equation is postulated, in accordance with conventional demand theory, wherein the amount of electricity used is a function of: its own price; the price and amount of gas consumed; disposable income; and the stock of electricity and gas-using goods. Electricity demand equations are developed for the three major classes of consumers, inserted into the model of the Buffalo Economy and simulations of various price assumptions are then determined.

The Report (in summary) says that there is substantial evidence that habit formation is the predominant behavior, regarding the residential demand for electricity. Further, electricity is both price and income elastic in the short-run and probably fairly elastic in the long-run.

In contrast to residential and industrial (i.e., manufacturing) demands for electricity, commercial or non-manufacturing customers have received relatively little attention from analysts. The dearth of such studies is probably attributable to the diversity of commercial institutions since such diversity precludes assumptions regarding homogeneity of output or even of inputs. [Note: Such operations as restaurants, office buildings, schools, shopping plazas, football stadiums and "very small" manufacturers would ordinarily qualify for electric power under a commercial tariff.] Commercial establishments may exhibit a fair amount of household-type behavior in that they have lighting and heating/cooling needs which are independent of the level of output. Further, those requirements are a much larger proportion of the total electricity used than heating/cooling and lighting would be for manufacturing establishments. The remainder of the electricity demanded would be used for various business machinery such as elevators, office equipment, refrigeration and the like; this portion would be expected to vary with output altho some of those uses may have a substantial fixed component.

TITLE: PRICE ELASTICITY CAN BE MISLEADING

SOURCE: Electrical World, 12/15/73, pp 74-75

AUTHOR(S): K.B.Powell
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 12/73
OTHER IDENTIFIERS: Energy Marketing

DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL: [PAGES 2 ;REFERENCES 8 ;GRAPHS ;TABLES 1] *
DOCUMENT CLASSIFICATION(S): 18/13, 14, 52, 55

ABSTRACT: *[Contains material of secondary relevance to the subject matter of this Compilation. Some of the pertinent References are rather general in character.]

Many studies of price elasticity in the electric utility industry are available and some of the most widely cited are briefly discussed in this Article.

By way of summary, in each case where the area studied was state size or smaller (and data were analyzed for a single load class) price elasticity of demand ranged from -1 to -2. If the geographic area was small enough, price elasticity was found for total demand. The conclusion was: Price elasticity does exist and, if the proper parameters are used, each utility can determine the factors for its service area. Unfortunately, few if any utilities have made elasticity studies of their own service areas.

Elasticities in other areas were investigated in some of these studies, and are significant enough to be reported. As might be expected, there was an elasticity of +1 between population and demand. The elasticity between income and demand was not significant, except possibly in commercial loads. Several studies verified the conclusion that there is no relationship between gas price and electric demand. This suggests that the two energy sources are not good substitutes for each other.

TITLE: HOW TO EVALUATE ELASTICITY STUDIES

SOURCE: Electrical World, 1/15/74, pp 88-90

AUTHOR(S): L.Guth
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 1/74
OTHER IDENTIFIERS: Energy Marketing

DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL: [PAGES 3 ;REFERENCES 2 ;GRAPHS ;TABLES] *
DOCUMENT CLASSIFICATION(S): 18/11, 16, 52

ABSTRACT: *[Contains material of direct and (mainly) secondary relevance to the subject matter of this Compilation.]

With regard to electric energy, many economists have tried to provide insight into the extent of price elasticity of demand. Mostly these studies have focused on residential demand, although some analyzed commercial and/or industrial demand as well. The results that have been obtained do not always agree but they seem to suggest that industrial demand is the most elastic and residential demand the least elastic, with the latter having a value of roughly -1.0.

Four standards should be used to interpret and judge the merits of the results of a particular study. The first is current applicability of the results. [Note: Most studies currently available are based on "historic" data, with electricity and competitive-fuel price variables markedly different from the levels they have currently reached. This does not mean that such results are completely useless but that they must be interpreted carefully, particularly with regard to the relative price movements of electricity and competing fuel prices.]

Second, there is the question of how quickly price elasticity effects may be achieved. [It may take several years for consumers to adjust fully to changes in electric rates relative to competing fuel prices. This is particularly true if the elasticity results are - in large part - determined by the relative distribution of household appliances or capital equipment.]

Third, there is a question as to whether the results of a particular study are applicable (at all) in assessing the effects of changes in rate structure on electricity consumption. [Studies that use a single electricity price variable are incapable of providing any guidance in this area.]

Finally, given current needs, one must evaluate the applicability of a study's results in terms of curbing energy demand, as opposed to electricity demand.

TITLE: THE PRICE ELASTICITY of RESIDENTIAL ENERGY USE

SOURCE: The Rand Corporation; Santa Monica, Calif.

AUTHOR(S): K.P.Anderson
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 2/74
OTHER IDENTIFIERS: Paper P-5180 in The Rand Paper Series

DATA USE RESTRICTIONS:

TOTAL: [PAGES 21 ; REFERENCES 13 ; GRAPHS ; TABLES 5] *
DOCUMENT CLASSIFICATION(S): 18/16, 22, 25, 47

ABSTRACT: *[Information of (mainly) secondary relevance to the general subject matter of this Compilation is contained in this Paper.]

The author states that an econometric analysis of household energy demand would ideally take the household as the unit of observation. However, as has been the case with preceding investigators, he was constrained to use data aggregated over regions. In particular, he used 50-state data for the years 1960 and 1970.

The conclusions of the Paper are offered as conjectures rather than as matters of fact, since they are said to rest upon a number of interesting clues rather than decisive proofs. With respect to estimation techniques: aggregation across different household energy-using functions may lead to acceptable estimates of the "own-price" elasticities of total consumption but almost surely will produce erroneous estimates of the "cross-price" elasticities. The cross-price elasticities of saturation can be taken as fairly accurate estimates of the cross-price elasticities of total consumption. Interdependencies among energy demands are important and should be modeled explicitly; energy demand equations should account for the effects of varying installation levels upon price elasticities. As regards household energy-consumption behavior: the difference between the own-price elasticity of total consumption and that of saturation is a measure of the responsiveness of conservation to price. According to the estimates developed in the Paper, the mean usage level elasticity for electricity is probably about one-third; that for utility gas is of more uncertain size but is perhaps of roughly the same magnitude. The mean saturation elasticities (with respect to own- and competing-energy prices) indicate that most of the observed "long-run" elasticity of energy consumption, with respect to price, reflects substitution of one form of energy for another.

TITLE: ELASTICITY HAS LITTLE EFFECT ON LOAD GROWTH

SOURCE: Electrical World, 7/15/74, pp 80-81

AUTHOR(S): D.Myhra
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 7/74
OTHER IDENTIFIERS: Energy Marketing

DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL: [PAGES 2 ;REFERENCES 2 ;GRAPHS 2 ;TABLES] *
DOCUMENT CLASSIFICATION(S): 18/13, 17

ABSTRACT: *[Contains material of secondary relevance to the subject matter of this Compilation.]

Many economists are now reporting that electrical loads are price-elastic, for several reasons. First, and most important, generation costs are going up and are being passed along to the user in the form of higher KWH rates. Second, there is a decisive trend toward smaller families, and the birth rate is going down. In addition, there is the belief that electrical demand will slow because home appliances are becoming use-saturated. All these factors could lead to lower KWH use per capita. [Relative to the overall price index, the price of electricity has gone down.] Critics now believe, however, that this situation is rapidly changing, and that the cost of electric energy vis-a-vis the overall price index is beginning to rise.

However, alternatives must be available if price-elasticity arguments are to be meaningful. With increasing restraints placed on the use of gas and oil, electricity elasticity arguments may prove to be meaningless.

It is stated that electricity will have to assume a greater role in all sectors of the American economy. This includes transportation, space heating, process steam, direct heat, feedstocks, water heating, cooking and other uses.

TITLE: RELATIONSHIP BETWEEN SUPPLY/DEMAND and PRICING for ALTERNATE FUELS in TEXAS: A STUDY in ELASTICITIES

SOURCE: The State of Texas Governor's Energy Advisory Council

AUTHOR(S): R.G.Thompson; et al
PREPARED BY AUTHOR(S) AND/OR: University of Houston

DATE OF ISSUANCE: 1/75
OTHER IDENTIFIERS: Project No. S/D-4

DATA USE RESTRICTIONS:

TOTAL: [PAGES 15 ;REFERENCES 13 ;GRAPHS 1 ;TABLES 2] *
DOCUMENT CLASSIFICATION(S): 18/17, 21, 25, 57

ABSTRACT: *[This study contains material of secondary relevance to the subject matter of this Compilation, mainly in its Appendix A. The Totals are for the relevant content.]

The primary purpose of the study was to estimate the effects of economic factors, particularly price, on electricity consumption in the Texas residential sector. Price and personal income are said to be the two primary factors affecting consumer demand and are therefore included in the demand function derived by this Study. [As for the use of gasoline, the demand for electricity can be hypothesized to depend in part on a stock of equipment. Changes in this stock of equipment (e.g., electricity-consuming appliances) in turn depend on many physical, technical and social factors which cannot be explicitly identified; however, the effects of such changes can be accounted for thru a "flow adjustment" model.]

A demand function for electricity was estimated using price and consumption data for 20 major (public and private) Texas utilities plus personal income and weather data for one or more representative SMSA's within each utility service area. [The data account for more than 96% of electricity use in Texas for the years 1968-1972.] Appendix A provides detailed descriptions of the data, estimation procedure and statistical properties of the model.

The results indicate that the demand for residential electricity is relatively insensitive to price for both the short-run (one year) and the long-run (about 6 years); on average, the demand would decline 1% in the short-run and 6.5% in the long-run, with each 10% increase in price. Personal income seems to be more important than price in determining electricity demand; a 10% increase in per capita personal income would influence a 3% increase in demand in the short-run and 18% increase in the long-run.

Weather and habit are also factors which determine the demand for electricity. Years which are "hotter-than-average" (as indicated by an increase in the average CDD) tend to have higher consumption of electricity, with a 10% increase in average CDD influencing a 1.6% increase in consumption.

Electricity use in the long-run is also affected by the stocks of electricity-consuming appliances, the types of residences and offices built and the life styles of consumers. This effect was measured in the model by the appropriate inclusion of the use of electricity in previous years. The results indicate that, on average, a change in a factor affecting consumption takes approximately 6 years to reach its full effect.

TITLE: NEW WAY to MEASURE PRICE ELASTICITY

SOURCE: Electrical World, 12/1/75, pp 52-54

AUTHOR(S): L.Hoffman; et al
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 12/75
OTHER IDENTIFIERS: Energy Marketing

DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL: [PAGES 3 ;REFERENCES 2 ;GRAPHS ;TABLES 3] *
DOCUMENT CLASSIFICATION(S): 18/21

ABSTRACT: *[This Paper contains material of (mainly) secondary relevance to the subject matter of this Compilation.]

Many of the studies that estimate price elasticity are said to be given considerable importance in the development of national energy policies. It is essential that users of these estimates - or of any related research - should not accept results at face value nor should they confine their examinations simply to comparing the results of the different studies. The research and regression techniques must be considered for their adequacy in answering fundamental questions regarding customer response to specific pricing signals.

The individual electrical consumer - whether a residential, commercial, industrial or public unit - has some degree of control over his consumption. If one reduces use in response to an increased price, then one participates in whatever aggregate change occurs. Ultimately, any estimation procedure must be judged on how well it summarizes these individual responses. [A 1973 sample of residential customers of the Public Service Co. of New Mexico indicated that there was no short-run response of these customers to a change in the cost of electricity to them.]

The essential characteristic of the sampling methodology proposed here (that distinguishes it from the aggregate, regression approach) is the use of information on the individual consuming unit in forming answers to questions concerning the consumers' collective response to electrical price changes. [The exact form of the procedures employed and the information to be obtained will vary with the sector of electrical demand being addressed and with the particular aspect of that sector's demand which is of interest.] The basic principle underlying the procedures, which is applicable to any of these sectors, is the measurement of the individual unit's response to a changed price of electricity.

TITLE: THE RESIDENTIAL USER and the ELECTRICAL LOAD FACTOR

SOURCE: University of Pennsylvania; National Center for Energy Management and Power
AUTHOR(S): K.A.Fegley
PREPARED BY AUTHOR(S) AND/OR: N.C.E.M.P.

DATE OF ISSUANCE: 7/73
OTHER IDENTIFIERS: N.C.E.M.P. name changed to Univ. of Penn. Energy Center
DATA USE RESTRICTIONS:

TOTAL: [PAGES 36 ;REFERENCES 15 ;GRAPHS 1 ;TABLES 10] *
DOCUMENT CLASSIFICATION(S): 19/9, 11, 47, 52

ABSTRACT:*[Information of (mainly) secondary relevance to the general subject matter of this Compilation is scattered thruout this Report. The Total(s) are for the entire Report, although most of the References are rather general in character.]

The electrical load factor (the ratio of the average load to the peak load) has a significant effect on the cost of delivering electrical energy. The present use pattern for the "average" residential customer yields a rather low load factor which, in turn, appreciably lowers the total electric utility company load factor. It is noted that the relative importance of the residential customer, in influencing the total load factor of the electric utility company, is not likely to decrease. The Report outlines a number of possible means for improving the residential load factor which would lead to the very large savings that accompany a high total load factor.

The load factor for most residential customers (based on non-coincident maximum demand) was about 0.14, for an average (1968) residence. [Note: in many households there is relatively little use of electricity between midnight and 6 a.m. and there is relatively heavy use in the late afternoon or early evening. On hot summer days the peak load may even occur early in the afternoon.] The average use of electrical energy by the residential customer is far less than that of the large industrial or commercial customer but the number of residential customers is far larger.

For some customers (such as manufacturing firms which operate continuously) the load factor is already quite high, frequently over 0.85. For other industrial customers, which operate mainly during the day, the load factor may be less than 0.45. Electric utility rates encourage the large industrial and commercial users to maintain a high factor and a majority of these customers have a load factor that exceeds the average load factor of about 0.53 (1969).

This Report lacks sufficient data for an accurate calculation of the savings from increases in the load factor of the average residential customer. Nevertheless, it appears clear that important monetary savings can be associated with even relatively modest improvements in the load factor.

TITLE: DISTRIBUTION LOAD STUDY DEFINES LOAD and LOSS FACTORS

SOURCE: Electrical World, 5/3/76, pp 74-77

AUTHOR(S): R.F.Propst & M.W.Gangel
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 5/76
OTHER IDENTIFIERS:

DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL:[PAGES 4 ;REFERENCES 1 ;GRAPHS 3 ;TABLES 1]*
DOCUMENT CLASSIFICATION(S): 19/13, 39, 55

ABSTRACT: *[Contains material of (mainly) secondary relevance to the subject matter of this Compilation.]

The primary purpose of this study was to accurately determine the annual load factor and annual loss factor at the distribution transformer. In terms of metered quantities, these factors may be obtained from the following:

$$\text{Annual Load Factor} = \frac{\text{annual KWH}}{8760 \times \text{max. KW}}$$

$$\text{Annual Loss Factor} = \frac{\text{annual (current)}^2 - \text{hour}}{8760 \times \text{max. (current)}^2}$$

For a period of approximately one year, monthly readings of load data were obtained in the field by 55 participating utilities, using especially-designed test kits installed at the secondary terminals of distribution transformers serving predominantly residential loads. [More than 600 such installations were located throughout the country, on all sizes of distribution transformers.]

One of the meters in the test kit responds to the KW component of the load and the other meter responds to the KVA component. This distinction was recognized by one of the data processing computer programs used to develop a consistent set of load and loss factors for the total load. As it turned out, the load factors of the KW load and total load components are almost identical and can be used interchangeably. Both meters of the test kit record demand by means of a 30-minute integrating demand register.

TITLE: KW DEMANDS and PEAKS for ELEVATORS in VARIOUS TYPES of BUILDINGS

SOURCE: Monthly Information Digest (GATE); no longer published

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: M.I.D.

DATE OF ISSUANCE: 5/68
OTHER IDENTIFIERS: Answer to "Question of the Month."

DATA USE RESTRICTIONS: Data collected in 1967 by Northern Natural Gas Company (Omaha, Nebraska).
TOTAL: [PAGES 1 ;REFERENCES 1 ;GRAPHS ;TABLES 2] *
DOCUMENT CLASSIFICATION(S): 20/7

ABSTRACT: *[Data is relevant to the subject matter of this Compilation.]

Data is tabulated for motor horsepower, peak KW, running KW and daily KWH usage for passenger and freight elevators. HP values ranged from 15 to 40, peak KW from 44 to 140, running KW from 11 to 53 and daily usage from 17 to 210. The elevators were installed in motels, apartment houses, retirement homes, high schools, hospitals and office buildings.

TITLE: THE CONSUMPTION of ELECTRICITY in the UNITED STATES

SOURCE: ORNL

AUTHOR(S): O.L.Culberson
PREPARED BY AUTHOR(S) AND/OR: ORNL

DATE OF ISSUANCE: 6/71
OTHER IDENTIFIERS: ORNL-NSF-EP-5; ORNL/NSF Environmental Program

DATA USE RESTRICTIONS:

TOTAL:[PAGES 26 ;REFERENCES 68 ;GRAPHS 7 ;TABLES 7 .] *
DOCUMENT CLASSIFICATION(S): 21/1, 4, 9, 23, 28, 47

ABSTRACT: *[This "survey" Report contains information of direct and secondary relevance to the subject matter of this Compilation; it also covers Industrial consumption. Except for the References - although many are rather general in character - the Total(s) exclude the Industrial sector.]

The production or consumption of energy is inherent to essentially all forms of technology and electrical energy is a major component of the total energy used. The primary objective of this Report is to identify the end-uses of electricity, the quantities consumed and the significant characteristics of each market. Attention is also given to the generation of electricity and the forecasts which have been made for the future consumption of electricity. The approach taken is to present a "skeletal" description of the industry's characteristics and quantities and to identify additional references from which the readers can gain more detailed information according to their particular interests and needs.

This Report provides a condensed survey of the USA's consumption of electricity. Such usage is first summarized on an overall basis and then in terms of residential, commercial, industrial and other customers. Each of these markets is described in terms of its: total and average KWH annual consumption, number of customers and the average price paid for electricity. [Considerable information exists on residential usage for heating, air conditioning, appliances and miscellaneous applications but that for commercial usage is relatively sparse. Industrial usage is described primarily in terms of individual industries and of unit electricity consumption by individual products.]

Under Residential Consumption, data is included on: (1) power usage in a military housing project; (2) consumption for heating and air conditioning; (3) usage by major appliances for 1949, 1954, 1959, 1964 and 1969; (4) saturation levels of appliances for 1960 thru 1969. Under Commercial Consumption, the primary data deals with electric heating. It is also stated that "the tremendous variety existing in the commercial sector makes it difficult to analyze power usage and accurately forecast demand."

TITLE: ESTIMATING the DEMAND for ELECTRICITY by TIME of DAY

SOURCE: Applied Economics; 1971-Issue #3; pp 233-246

AUTHOR(S): T.F.Cargill & R.A.Meyer
PREPARED BY AUTHOR(S) AND/OR: Purdue University

DATE OF ISSUANCE: 1971
OTHER IDENTIFIERS: A.E. is a quarterly printed in Great Britain

DATA USE RESTRICTIONS: Crown Copyright by Chapman and Hall Ltd.

TOTAL:[PAGES 14 ;REFERENCES 10 ;GRAPHS 1 ;TABLES 3] *
DOCUMENT CLASSIFICATION(S): 21/13, 18, 25, 35, 37

ABSTRACT: *[Contains material of direct and (mainly) secondary relevance to the subject matter of this Compilation. The Total(s) are for the relevant data.]

The objective of this Paper is to investigate the factors determining the demand for electricity by time of day and to extend the level of disaggregation used in prior studies. Emphasis is placed on estimating the demand over a 24 hour load curve, and to ascertain the sensitivity of demand to price.

The continued increasing demand on the facilities of the electric utilities highlights the need for estimates of electricity usage, both for short and long-run forecasting purposes. Among other difficulties, electrical demand estimation faces the peak-load phenomenon common to many public utilities. Unfortunately, the majority of the studies dealing with industries exhibiting the peak-load phenomenon have emphasized the theoretical aspects of the problem. There has not been the same concerted attempt to provide detailed empirical investigations of the factors determining the demand for the services of a utility exhibiting such a peak-load characteristic.

The Paper briefly reviews the prior studies of the demand for electricity but it mainly deals with estimates of aggregate hourly demand for 4 principal classes of customers, namely: (a) Residential; (b) Commercial; (c) Industrial; (d) all other sales, to ultimate users. The data is represented in the form of the total demand for electricity, integrated over hourly intervals for a "midwest USA industrial city" and for a "west coast USA city"; price elasticities of demand are developed, on an hourly basis, for both of these cities.

The need to investigate the demand for electricity over the entire 24 hour load curve is emphasized in this Paper. The results indicate that the demand for electricity over the 24 hour period is influenced by price and a measure of industrial activity, such as "manufacturing employment". [The role of per capita income appears slight.]

TITLE: DAYLIGHT SAVING INFLUENCES ENERGY USE

SOURCE: Electrical World, 11/1/73, pp 104-105

AUTHOR(S): E.K.Amir
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 11/73
OTHER IDENTIFIERS: System Engineering

DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL: [PAGES 2 ;REFERENCES 4 ;GRAPHS ;TABLES 4] *
DOCUMENT CLASSIFICATION(S): 21/11, 13, 32

ABSTRACT: *[Contains material of direct and secondary relevance to the subject matter of this Compilation.]

This Study addresses itself only to the question of the impact of year-round daylight saving time (DST) on electric energy requirements during the winter months. It is not intended to estimate savings stemming from DST currently in effect during summer months, nor the impact that year-round DST might have on other than electric energy requirements.

The expectation of energy and capacity saving is based on two premises. The first is that demand for electricity during the winter usually reaches its peak in the evening hours. The second is that an early return from work due to daylight saving, in terms of sunset, would result in a reduced lighting load during the peak evening hours.

It is to be expected, therefore, that extending DST to the full year would reduce winter peak-load requirements and would produce some saving in energy consumption. From the standpoint of individual electric utilities, systems that peak in the winter stand to gain most in capacity saving under DST.

A limited amount of tabulated energy usage data is presented to illustrate the premises of the preceding paragraphs.

TITLE: AFFLUENCE and ENERGY DEMAND

SOURCE: Mechanical Engineering, 10/74, pp 18-22

AUTHOR(S): R.A.Herendeen
PREPARED BY AUTHOR(S) AND/OR: University of Illinois, Center for Advanced Computation

DATE OF ISSUANCE: 10/74
OTHER IDENTIFIERS: Based on a paper contributed by ASME Energetics Division

DATA USE RESTRICTIONS: Copyright by ASME

TOTAL:[PAGES 5 ;REFERENCES 4 ;GRAPHS 3 ;TABLES 3] *
DOCUMENT CLASSIFICATION(S): 21/10, 11, 14, 17

ABSTRACT: *[Information of (mainly) secondary relevance to the general subject matter of this Compilation is contained in this Report.]

This Paper discusses how best to slow energy demands in times of shortages, in view of the fact that personal consumption accounts for 2/3 of the USA energy bill. [Note: direct needs - residential heat and light, etc. plus private auto fuel - account for 1/2 of this amount. The other half goes for goods and services and is thus an indirect consumer demand.] The relative importance and implications for conservation schemes of these 2 types of energy demand, as a function of income, are compared.

To evaluate direct and indirect needs, use is made of energy input/output (I/O) analysis, which provides a conversion from dollars spent to total energy demanded for a wide range of consumer goods and services. I/O analysis, as used here, is a linear model relating the outputs of the sectors of the economy. The I/O coefficients are then applied to detailed consumer expenditure data.

The Paper includes tabulations for 1960-61 (arranged by expenditure and income classes) of: (A) Consumer Expenditures and (B) Energy Impact of Consumer Expenditures. Electricity is one of the factors listed in these tabulations, with average expenditures ranging from about $44 to $189 per year and average BTU used per year ranging from about 24 to 105 million.

The main conclusion drawn from this study is the increasing importance of indirect energy impact with income. This suggests certain points regarding energy conservation and future demand: (1) Attempts to conserve energy through more efficient residential or automobile use will have less effect on a % basis, on the energy impact of the affluent, since such measures deal only with direct energy use. (2) With increasing affluence, people will spend more for services that are of relatively low energy intensity.

TITLE: THE EFFECTS of HIGHER PRICES on ELECTRICITY CONSUMPTION

SOURCE: The Bell Journal of Economics and Management Science; Vol. 5, No. 2 (Fall 1974); pp 515-539
AUTHOR(S): J.M.Griffin
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 1974
OTHER IDENTIFIERS:

DATA USE RESTRICTIONS: Copyright by American Telephone and Telegraph Co.

TOTAL:[PAGES 25;REFERENCES 18;GRAPHS ;TABLES 5] *
DOCUMENT CLASSIFICATION(S): 21/10, 16, 17, 35

ABSTRACT: *[Information of direct or secondary relevance to the general subject matter of this Compilation are scattered thruout this paper. The Totals are for the entire paper.]

This Paper utilizes an econometric model of the electric utility industry to simulate the effects of higher fuel prices on electricity demand and on the mix of fuel inputs to electricity generation. The model relates electricity demand to: electricity prices, the efficiency of fuel conversion and the choice among coal, natural gas, residual fuel oil, and nuclear fuel. The results suggest that, given projected fuel input prices, the short- and long-run impacts on electricity demand are likely to be small. The effects on fuel mix appear quite substantial in the intermediate and long run but, in the period of one year or less, fuel substitution possibilities appear fairly limited.

The model attempts to characterize the determinants and interrelations of electricity demands, fuel inputs and electricity prices by using a simultaneous equations system. The model is stated to be best suited for simulation and forecasting exercises over the intermediate term (five years); use of it for longer term simulations is feasible, provided one is aware of its limitations. The model is an annual model estimated with time series observations over the post war period for the aggregate USA. It consists of 25 equations, of which 12 are stochastic. There are 10 behavioral equations, 4 linking equations and 11 identities.

TITLE: ENERGY (VOLUME I): DEMANDS, RESOURCES, IMPACT, TECHNOLOGY and POLICY

SOURCE: Addison-Wesley Publishing Co., Inc.

AUTHOR(S): S.S.Penner & L,Icerman
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 1974
OTHER IDENTIFIERS: One of a three-volume set of Lecture Notes

DATA USE RESTRICTIONS: Copyright by Addison-Wesley

TOTAL:[PAGES 50 ;REFERENCES 30 ;GRAPHS 9 ;TABLES 12 .] *
DOCUMENT CLASSIFICATION(S): 21/1,4,13,22,25,28,31,33,47

ABSTRACT: *[Information of direct and secondary relevance to the subject matter of this Compilation is to be found mainly in Chapters 1 & 5 of these relatively extensive Lecture Notes. The Total(s) reflect only the relevant material.]

Energy demands are stated to be time-dependent functions that reflect the condition (or level) of technology and our economic well being, social system, leisure-time habits and existing political realities. Energy-demand functions are thus seen as evolutionary variables which must be reexamined and changed when important determining factors are changed. For example, in times of shortages, the demand function tends to shrink because concerned citizens conserve and conversely, when a utility offers reduced rates for large-volume users, electricity use may grow because it may become more economical to use more electricity.

Chapter 1 includes a study of the residential and commercial electricity demand projections, to the year 2000,for the San Diego region of California. It is shown that demand growth between 1950 and 1970 was primarily associated with increasing saturation levels of appliances. The authors estimate that actual consumption, by the year 2000, will be only 24 to 31% of the value obtained by straightforward extrapolation of current (and past) energy-use rates.

Chapter 5 contains data on: (a) energy consumption of electrical appliances; (b) efficiencies of gas and electric appliances; (c) energy use for space heating, air conditioning and illumination; (d) reduction of energy use by insulation; (e) illumination costs.

TITLE: CONSUMPTION PATTERNS for ELECTRICITY *

SOURCE: Journal of Econometrics, No. 5, pp 135-153

AUTHOR(S): W.Hendricks & R.Koenker (Univ. of Illinois); R.Podlasek
PREPARED BY AUTHOR(S) AND/OR: (Illinois Commerce Commission)

DATE OF ISSUANCE: 1977
OTHER IDENTIFIERS: Includes data from Commonwealth Edison Co. (Chicago, Illinois)
DATA USE RESTRICTIONS: Copyright by North-Holland Publishing Co.

TOTAL: [PAGES 19 ;REFERENCES 14 ;GRAPHS 2 ;TABLES 6] **
DOCUMENT CLASSIFICATION(S): 21/13, 14, 16, 37, 47, 50

ABSTRACT: *[A preliminary version was presented at the Univ. of Calif. at Los Angeles Conference on "Public utilities: Economics and finance", Aug. 10-13, 1975.]

**[Contains material of (mainly) secondary relevance to the subject matter of this Compilation. Two of the tables are unnumbered.]

This Paper presents a discussion of the dependence of electrical demand on time of day and then investigates the specification of a functional form (i.e., an empirical model) suitable for combining time-series and econometric approaches to an analysis of the demand cycle. A periodic cubic spline (which is a continuous piecewise cubic polynonial, with continuous first and second derivatives) was chosen as a convenient parameterization of the demand cycle and the influence of income, appliance ownership and a variety of other household characteristics (on the level and shape of the demand cycle) was then analyzed. [The focus of the investigation is on hourly demand for electricity in Chicago, during the peak usage week for both 1972 and 1973.]

The authors believe, on the basis of their experience, that the periodic cubic spline can be a valuable tool for statistical analysis of time-series, especially in contexts in which periodicities in the data are of fixed duration and can be specified analytically. Interpretation of the spline's parameters is straightforward and its linear parameterization offers substantive computational advantages over other time - or frequency - domain methods.

The Paper contains graphs which compare actual and predicted KW usage for a single sample site over a 5 week day period; the correlation is (generally) quite good. Tables are employed to summarize the regression coefficients of the demand equations for the 1972 and 1973 peak usage weeks. A discussion is included of the demographic variable's effects on demand.

TITLE: 1974 SURVEY of ENERGY USE in WISCONSIN

SOURCE: Institute for Environmental Studies; University of Wisconsin-Madison
AUTHOR(S): M.M.Dietz & W.K.Foell
PREPARED BY AUTHOR(S) AND/OR: I.E.S.

DATE OF ISSUANCE: 10/74
OTHER IDENTIFIERS: IES Report 25; Energy Systems and Policy Research Report No. 3; NSF/RANN Grant #GI-43088
DATA USE RESTRICTIONS:

TOTAL: [PAGES 18 ;REFERENCES 4 ;GRAPHS ;TABLES 4] *
DOCUMENT CLASSIFICATION(S): 22/10, 34, 35, 55

ABSTRACT: *[Information of secondary relevance to the general subject matter of this Compilation is found mainly in Part VI of this Survey; the Totals are for the relevant material.]

This Report is one of a series which describes research conducted by the Energy Systems and Policy Research Group at the University of Wisconsin - Madison. The overall goal of the project is the development of quantitative policy analysis "tools" and the analysis of policy alternatives related to the energy futures of Wisconsin. One focal point of this research is the construction of a state energy model to reveal significant energy trends, causes and relationships and to provide a better basis for understanding their implications for the future. An initial version of the model is currently being applied to the description of alternative energy futures for Wisconsin thru the year 2000.

The purpose of this energy survey is to describe Wisconsin's energy usage and to indicate current trends; for example, it is noted that in 1972 electricity use increased by 4.5% and was responsible for 25.5% of total primary energy consumption. The survey does not seek to make forecasts (as such) but rather strives to provide a data base which may be helpful in assessing the effects of past and current policies.

Part VI includes electrical utility data for Wisconsin, generally aggregated at the state level.

TITLE: ANNUAL REVIEW of ENERGY

SOURCE: Annual Reviews, Inc. (Palo Alto, California)

AUTHOR(S): J.M.Hollander & M.K.Simmons (Editors); et al
PREPARED BY AUTHOR(S) AND/OR: Annual Reviews, Inc.

DATE OF ISSUANCE: 1976
OTHER IDENTIFIERS: Volume 1; supported by NSF Grant OEP74-11470A02

DATA USE RESTRICTIONS: Copyright by Annual Reviews, Inc.

TOTAL: [PAGES 8 ;REFERENCES 13 ;GRAPHS ;TABLES 2] *
DOCUMENT CLASSIFICATION(S): 22/10, 16, 17, 35

ABSTRACT: *[In this nearly 800 page Volume, the section on "Energy and the Economy" (mainly) contains the material pertinent to the subject matter of this Compilation. The Total(s) are for the relevant material.]

This Review provides an introduction to the scope, application, methodology and content of various energy models that have been used for forecasting future energy market conditions and also used in the formation and analysis of energy policy. The review of models is not exhaustive, but rather is intended to illustrate the structure of recent and current efforts by energy system modelers to provide constructive tools for energy system forecasting, planning and policy analysis.

Energy models may be simple or complex, depending upon the purpose for which they were designed. They range from detailed engineering/process models of particular energy conversion processes (to) econometric models of energy markets (to) total energy/economic system models. The engineering/process models tend to be descriptive in character, whereas the econometric types emphasize the behavioral aspects of the agents which enter into production, conversion and utilization decisions. [The more comprehensive efforts include both types of models as components.]

Energy models may also be classified as: (1) "sector", for the supply or demand of a specific energy type; (2) "industry market", for the supply and demand of a specific form; (3) "energy system", which include supply and demand for all energy types; and (4) "energy/economic", which encompass the interrelations between the energy sector and the overall economy. Whatever the model type, energy models are used in forecasting and in planning and in policy analysis.

The direction of current research is toward developing models that integrate engineering/process models with more behavioral models so as to form energy/economic systems that treat the demand for, and supply of, energy types simultaneously with those for other factors of production.

TITLE: AN IMPROVED ENGINEERING-ECONOMIC MODEL of RESIDENTIAL ENERGY USE (Version III) [Updates ORNL/TM-5470: "An Engineering-Economic Model of Residential Energy Use", issued 7/76.]
SOURCE: ORNL (Energy Division)

AUTHOR(S): E.Hirst; et al
PREPARED BY AUTHOR(S) AND/OR: ORNL (for FEA and ERDA)

DATE OF ISSUANCE: 4/77
OTHER IDENTIFIERS: ORNL/CON-8; may be ordered from NTIS by this number

DATA USE RESTRICTIONS:

TOTAL:[PAGES 16 ;REFERENCES 8 ;GRAPHS 6 ;TABLES 4 .] *
DOCUMENT CLASSIFICATION(S): 22/10, 14, 17, 35, 47

ABSTRACT: *[Material of secondary relevance to the subject matter of this Compilation is scattered thruout this Report. The Total(s) are for the relevant data.]

This Report describes a comprehensive engineering/economic computer model used to simulate energy use in the residential sector from 1970 to 2000. The purpose of the model is to provide an analytical tool with which to evaluate a variety of conservation policies, technologies and strategies for their impacts on residential energy use and fuel expenditures (as a function of time).

This version of the model deals with energy use at the national level for 4 fuels (electricity, gas, oil and "other"); 8 end uses (space heating, water heating, refrigeration, food freezing, cooking, air conditioning, lighting and "other"); and 3 housing types (single-family units, apartments and mobile homes). Each of these fuel uses is determined for each year of the simulation as the product of: (1) stock of occupied housing units; (2) fraction of homes using each fuel for each end use; (3) average annual energy requirement for each type of equipment; (4) average thermal "adequacy" for each housing type; (5) household usage behavior for each fuel and end use. [Note: Simulations of energy use from 1960 to 1975 show that the model reliably forecasts historical fuel use data, in aggregate, by fuel and by end use.]

Most of the data used to develop this model - and its predecessors - are from the 1960's, a time when: fuel prices were low and declining; incomes were steadily rising; and attitudes toward energy and energy conservation were more relaxed than they are now. To the extent that attitudes toward energy use have changed, the model's results are in error. The model captures some of the economic and demographic determinants of household fuel use but intangibles such as comfort, convenience, reliability, safety, attitudes of neighbors (and whatever else goes into decisions on household equipment choice and usage) are not included in this model.

TITLE: ELECTRIC POWER CONSUMPTION (CITATIONS from the "ENGINEERING INDEX DATA BASE", for SEARCH PERIOD 1970-MAY 1976)

SOURCE: NTIS

AUTHOR(S): A.S.Hundemann (Editor)
PREPARED BY AUTHOR(S) AND/OR: NTIS

DATE OF ISSUANCE: 6/76
OTHER IDENTIFIERS: NTIS/PS-76/0477

DATA USE RESTRICTIONS: Copyright by NTIS and Engineering Index, Inc.

TOTAL: [PAGES ;REFERENCES ;GRAPHS ;TABLES] *
DOCUMENT CLASSIFICATION(S): 23/3, 6, 9, 10, 11, 21, 35, 36, 47

ABSTRACT: *[Not particularly significant to this type of Publication. Note: Most of the abstracted material deals with the Industrial sector.]

Citations are included from worldwide research on electric power consumption in the residential and industrial sectors of the USA and many foreign countries. The primary topic areas cover: methods of forecasting electric power demand, computerized load control and trends in electric power consumption. A few of the 127 abstracts pertain to the economics of supply and to conservation measures.

TITLE: ELECTRIC POWER CONSUMPTION (CITATIONS FROM the "NTIS DATA BASE", for SEARCH PERIOD 1971-MAY 1976)

SOURCE: NTIS

AUTHOR(S): A.S.Hundemann (Editor)
PREPARED BY AUTHOR(S) AND/OR: NTIS

DATE OF ISSUANCE: 6/76
OTHER IDENTIFIERS: NTIS/PS-76/0476; supersedes NTIS/PS-75/363

DATA USE RESTRICTIONS: Copyright by NTIS

TOTAL: [PAGES ;REFERENCES ;GRAPHS ;TABLES]* 42,44,47,53
DOCUMENT CLASSIFICATION(S): 23/3,4,9,10,11,13,14,16,18,21,22,25,30,35,38

ABSTRACT: *[Not particularly significant to this type of Publication. Note: most of the abstracted material deals with the Industrial sector.]

These Citations are taken from Federally-funded research dealing with the industrial, commercial and residential aspects of electric power consumption and demand. The primary topic areas deal with the economics of supply as well as the amount of consumption. A few Abstracts cover projections of future demand and conservation measures to reduce electric power consumption. [This updated bibliography contains 188 abstracts, 99 of which are new entries to the "superseded" edition.]

TITLE: FEDERAL POWER COMMISSION PUBLICATIONS and SPECIAL REPORTS LISTS

SOURCE: FPC

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: FPC

DATE OF ISSUANCE: 9/76 (for publications); 10/76 (for Special Reports)*
OTHER IDENTIFIERS:

DATA USE RESTRICTIONS:

TOTAL: [PAGES ;REFERENCES ;GRAPHS ;TABLES] **
DOCUMENT CLASSIFICATION(S): 23/26

ABSTRACT: *[These Lists are updated at irregular intervals; the dates indicated were the latest available when this sheet was prepared.]

**[Not considered pertinent to this form of publication.]

Reports and Publications of some application to this Compilation are: (1) All-electric Homes, Annual Bills; (2) Typical Electric Bills (residential in cities of over 2,500 persons plus commercial/industrial in cities of over 50,000 persons); (3) Statistics of Private and Publicly Owned USA Utilities; (4) Special Report on Current National Power Survey; (5) Energy Conservation Studies.

TITLE: ENERGY INFORMATION MATERIALS

SOURCE: Edison Electric Institute

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: EEI

DATE OF ISSUANCE: 1976/1977 *
OTHER IDENTIFIERS: Publication No. 76-45

DATA USE RESTRICTIONS:

TOTAL:[PAGES ;REFERENCES ;GRAPHS ;TABLES] **
DOCUMENT CLASSIFICATION(S): 23/26

ABSTRACT: *[This Publication is revised periodically and supplementary sheets may be issued between complete revisions. This was the latest issue when this sheet was prepared.]

**[Not considered pertinent to this form of publication.]

This Catalog lists (by a Code Number and Title) the publications, reports, books, films and other material available from EEI. The range of subjects covers essentially all aspects of the electric utility industry, plus some aspects of the broader fields devoted to Energy in general. [The listings are grouped according to the EEI Division/Section most directly concerned with their subject matter.]

TITLE: ENERGY and COST ANALYSIS of RESIDENTIAL REFRIGERATION

SOURCE: ORNL (Energy Division)

AUTHOR(S): R.A.Hoskins & E.Hirst
PREPARED BY AUTHOR(S) AND/OR: ORNL (for FEA and ERDA)

DATE OF ISSUANCE: 1/77
OTHER IDENTIFIERS: ORNL/CON-6 (may be ordered from NTIS by this number); Conservation/Division of Buildings and Community Systems
DATA USE RESTRICTIONS:

TOTAL: [PAGES 13 ; REFERENCES 3 ; GRAPHS 5 ; TABLES 2] *
DOCUMENT CLASSIFICATION(S): 24/10, 11, 15, 17, 35

ABSTRACT: *[Material of secondary relevance to the subject matter of this Compilation is scattered thruout this Report. The Total(s) are for the relevant data.]

The purposes of this Report are to develop a computer model of energy flows and electricity uses in residential refrigerators and to then use this model to evaluate the energy and costs impacts of alternative energy-conserving designs. Outputs from these analyses are used as inputs to a detailed engineering/economic model of residential energy use developed at ORNL. The simulation estimates the distribution of new residential equipment each year (from 1970 thru 2000) as functions of fuel prices, consumer demand functions and the technological characteristics of each type of equipment. This study provides the (simulated) relationship between operating energy requirement and initial cost of refrigerators. [Model equations are derived from applications of the first law of thermodynamics, analysis of manufacturers' literature and related studies.] The model is sufficiently flexible to handle different sizes, configurations (e.g., top-freezer) and operating environments (e.g., room temperature, food loads and number of door openings); the resulting estimates of daily electricity consumption are in good agreement with previously reported measurements.

Model results show that 56% of the total heat gain in a "typical" (16 cu. ft.), top-freezer refrigerator is due to conduction through the cabinet walls and doors. The other 44% is from door openings, heaters, fans, food, gasket area infiltration and miscellaneous heat sources. Operation of the compressor to remove this heat and to maintain the refrigerated spaces at constant temperatures accounts for 70% of the unit's electricity use, which was calculated at 4.62 KWH/day (total). The remaining 30% is for operation of heaters and fans.

Several energy-saving design changes are examined using the energy model. Application of all these changes would reduce refrigerator electricity use 71% and increase initial cost 5%. Implementing all these changes, except for elimination of the "frost-free" feature, would reduce electricity use 52% and increase initial cost 19%.

TITLE: LOAD FORECASTING on the TVA SYSTEM (Part I - Substation Loads)

SOURCE: AIEE Winter General Meeting; New York, N.Y.; 1/28-2/2, 1962

AUTHOR(S): W.R.New
PREPARED BY AUTHOR(S) AND/OR: TVA

DATE OF ISSUANCE: 6/62
OTHER IDENTIFIERS: Paper 62-68; AIEE System Engineering Committee; also in collected papers of June 1962, pp 101-105.
DATA USE RESTRICTIONS:

TOTAL: [PAGES 5 ;REFERENCES 2 ;GRAPHS 9 ;TABLES] *
DOCUMENT CLASSIFICATION(S): 25/50, 55

ABSTRACT: *[Contains material of secondary relevance to the subject matter of this Compilation. All plotted data is for same substation.]

Efficient planning and design of electrical transmission systems depends upon reasonably accurate forecasts of the loads served. Substation load forecasts are prepared by TVA, 15 years in advance. For the first 5 years, preliminary forecasts are by months using time-series analysis, carefully collected information and personal judgment; loads for another 10 years are extended largely on the basis of judgment. These preliminary forecasts are subjected to three critical reviews, resulting in necessary modifications. The sum of adjacent substation loads is additionally compared with larger area forecasts.

Reasonably accurate forecasts for 400 substations are useful and flexible tools of the system planner. These forecasts may be grouped in varying combinations, thru use of appropriate diversity factors. Such combinations provide the means for testing a wide range of generator, primary substation and transmission line locations and designs. Substation load forecasts for 15 years in the future cannot be too accurate but if loads grow faster than predicted, planned construction can be accelerated or (conversely) delayed. Forecasts need review and adjustment at intervals to take into account recent load history, later information and new substations.

TITLE: LOAD FORECASTING on the TVA SYSTEM (Part II - Commercial and Industrial)

SOURCE: AIEE Summer General Meeting; Denver, Colorado; 6/17-6/22, 1962

AUTHOR(S): W.R.New
PREPARED BY AUTHOR(S) AND/OR: TVA

DATE OF ISSUANCE: 1962
OTHER IDENTIFIERS: AIEE Conference Paper No. 62-1111; AIEE System Engineering Committee; Meeting at Denver, Colorado; 6/17-6/22, 1962
DATA USE RESTRICTIONS:

TOTAL:[PAGES 15 ;REFERENCES 1 ;GRAPHS 5 ;TABLES]*
DOCUMENT CLASSIFICATION(S): 25/9, 34, 38, 50, 55

ABSTRACT: *[Contains material of secondary relevance to the subject matter of this Compilation. Total(s) apply to Commercial Loads or combined Commercial/Industrial data.]

This Paper discusses the forecasting of power use by TVA commercial and industrial consumers. Loads are analyzed for 6 areas by 4 groups, based on size of load; the load ranges used were: under 50 KW, 50 to 1,000 KW, 1,000 to 5,000 KW and over 5,000 KW. The forecasting process is two-fold: the preparation of preliminary forecasts and a series of critical reviews. Each of the groups differ in the types of business and industry they include, in their pattern/rate of growth, and in their response to the business cycle. Each presents the forecaster with different problems in collecting and analyzing information needed for the forecast and each requires different judgment processes in load forecasting.

Preparation of preliminary forecasts is thru a series of steps which include load data collection, informal discussions, statistical analyses, the weighing and sifting of data and information, forming opinions and evaluation. In the Paper, no attempt is made to describe every step but the major steps are discussed in order to illustrate some of the possibilities for analysis and evaluation available to the forecaster.

The preliminary forecasts are subjected to a series of critical reviews at management levels. Each review broadens the range of factors considered and additional analytical skills and experience are brought to bear. [Some modification of forecasts may result from these reviews.] Management interest in load forecasts is intense because the load forecast is the basis for planning all major activities of a utility. The final decision as to what forecasts are most reasonable affects nearly all other decisions and in many instances is the dominant factor. A trained staff of forecasters and analysts is stated to be necessary to study possibilities for growth and to appraise new economic forces.

Plotted values are shown for the seasonally adjusted average KWH usage by commercial and industrial customers in the first 3 of the 4 load ranges mentioned above; these were for the period 1952-1966.

TITLE: LOAD FORECASTING on the TVA SYSTEM (Part III - Residential)

SOURCE: AIEE Winter General Meeting; New York, N.Y.; 1/27-2/1, 1963

AUTHOR(S): W.R.New
PREPARED BY AUTHOR(S) AND/OR: TVA

DATE OF ISSUANCE: 1963
OTHER IDENTIFIERS: IEEE Conference Paper (CP)63-222; AIEE Power System Engineering Committee
DATA USE RESTRICTIONS:

TOTAL:[PAGES 22 ;REFERENCES 8 ;GRAPHS 11 ;TABLES 1] *
DOCUMENT CLASSIFICATION(S): 25/4, 6, 14, 17, 21, 34, 50, 55, 57

ABSTRACT: *[Material of direct and secondary relevance, to the subject matter of this Compilation, is scattered thruout this Paper. The Total(s) are for the entire Paper.]

This paper discusses techniques used in forecasting residential electricity use in the TVA service area. The prediction of the number of customers, average use and energy sales are discussed separately,with emphasis on average use. The procedure involves preliminary forecasts and a series of critical reviews. The types of analyses upon which judgments are based include a variety of approaches which reduce the probability of a costly oversight. Research findings are related to past growth in energy use and are also used in judgments concerning future growth.

Residential customer growth ultimately depends on economic development; a first step in forecasting customers is to study the effect on growth of such factors as households, population, employment, housing construction and number of farms. For example, trends of TVA area population and households (expressed as percentages of corresponding USA data) may be examined for direction and rate of change. Using such percentages, plus knowledge of regional development, the forecaster formulates a projection of residential customers that represents a consensus of the conclusions from the several factors examined.

Residential customer growth is also studied and projected using the method of time-series analysis. Historical data, on such customers for each of 6 geographic areas, are collected and seasonally adjusted and then plotted against "years". [Farm customers are analyzed separately from urban and non-farm customers for each of the areas.] Projections are made on the basis of the historical growth pattern of each series, modified by the forecaster's knowledge of the characteristics of the series and the area under consideration. Forecasts from the time-series analysis are compared with estimated levels arising from the foregoing economic analysis. Where there is a significant difference, both estimates are analyzed further and adjusted to bring them into agreement. Thus, each method serves as a control or check on the other.

The key element in estimating future electricity sales is said to be "average use per customer". Average use is projected using 4 principal techniques - the appliance method, appliance group method, correlation analysis and trend analysis. [The projections are supported by a variety of studies.]

The appliance method correlates average use in terms of uses by the individual appliances. The estimated saturation of each appliance, when multiplied by the estimated annual energy requirement, provides its contribution to total average annual residential use. The contributions of individual appliances are summed to obtain annual average use per customer. The estimated saturations come from appliance surveys, census reports and a study of relationships of saturations to energy use levels. For example , a study of the results of these surveys revealed a strong relationship between the % of residential customers using over 150 KWH in Oct. and saturation of ranges; a similar relationship was found between the % of customers using over 400 KWH (in Oct.) and water-heater saturation.

The appliance group method divides the customers into groups according to (their) ownership of certain appliances. The estimated % of customers in each group are multiplied by their estimated average uses so as to obtain their contribution to total average use. The sum of these contributions, for all groups, is the basis for total residential average use per customer for each year of "history" and future estimates. This method measures total residential average use in terms of customers classified by ownership of major appliances; while similar to the appliance method, in computation, it differs in that it focuses attention on how electric power is used in homes.

The use of correlation techniques in forecasting residential average use provides several additional approaches. In one application, average annual use is related to estimated appliance saturations. Similar forecasts may be obtained through multiple correlation using heating saturation projections with other appliances. Another application of correlation, to average use estimation, involves relating average use for a specific area to USA average use. Serial correlation offers still another method which may be helpful; this technique relates future levels of a variable to past changes of that variable. Correlation techniques used in forecasting do share a common weakness in that the underlying assumption (in the estimating equations) is that the historical relationship will remain the same in the future; nevertheless, these techniques can contribute to the final forecast by focusing attention on relationships and variables which otherwise might be overlooked.

The use of the time-series is a standard forecasting technique. Historical average use data are collected, adjusted to "normal" weather conditions and for seasonal variation, and plotted. Farm and urban and non-farm data are analyzed separately by 6 geographic areas, 4 major metropolitan areas and by small municipalities and cooperatives. Trend projections of average use are made within the framework of the forecaster's knowledge of growth characteristics of each average use series.

TITLE: LOAD FORECASTING on the TVA SYSTEM (PART IV - System Forecasting)

SOURCE: IEEE Summer General Meeting and Nuclear Radiation Effects Conference; Toronto, Ontario; 6/16-6/21, 1963
AUTHOR(S): W.R.New
PREPARED BY AUTHOR(S) AND/OR: TVA

DATE OF ISSUANCE: 1963
OTHER IDENTIFIERS: IEEE Conference Paper (CP)63-955; IEEE Power System Engineering Committee
DATA USE RESTRICTIONS:

TOTAL: [PAGES 18 ; REFERENCES 6 ; GRAPHS 8 ; TABLES .] *
DOCUMENT CLASSIFICATION(S): 25/17, 34, 55, 57

ABSTRACT: *[Information of (mainly) secondary relevance to the general subject matter of this Compilation is scattered thruout this Paper. The Total(s) are for the entire paper.]

The Paper discusses problems related to "total system" load forecasting; included are the importance of certain assumptions which underlie the forecast and the problem of estimating the probabilities of deviations in future load from the forecast. Two kinds of assumptions are discussed as examples, namely weather and economic conditions. A method of combining class-of-service projections to obtain system peak forecasts is described, including projection of the effect of losses and diversity on system load.

It is noted that even a straight-line extension of past loads (to some future year) assumes that loads will continue to grow at the same rate as in the past. Because of their importance assumptions affecting future loads, such as business and weather conditions, require careful thought. As a minimum, every factor which might significantly affect future loads should be analyzed and its underlying assumptions should be recorded. Generally, assumptions should be stated as specifically as is reasonable; they should be arranged in a form suitable for convenient review. [The making and recording of assumptions should be considered an integral step in any forecasting procedure. While the procedure may be exacting, the resulting advantages more than offset the expense and time it requires.]

The usefulness of a forecast is increased if the probabilities of various deviations are estimated. [Much additional development work is needed in this area but the results obtained to date clearly indicate that such additional work is desirable.] The total system forecast is the sum of forecasts of many parts of the system load; these "partial" forecasts are generally prepared using a variety of methods, with 2 or more methods used for each forecast. Use of a number of methods helps increase the number of variables considered and the resulting forecasts serve as checks, one upon the other. Forecasting in detail increases the reliability of the forecast since changes in trends are more likely to be anticipated.

TITLE: DO UTILITIES UNDERESTIMATE KWH USAGE?

SOURCE: Electrical World, 2/10/64, pp 44 & 63

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: E.W.

DATE OF ISSUANCE: 2/64
OTHER IDENTIFIERS:

DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL:[PAGES 2 ;REFERENCES 1 ;GRAPHS 1 ;TABLES 1] *
DOCUMENT CLASSIFICATION(S): 25/4, 8, 14, 21, 55, 57

ABSTRACT:*[Contains material of (mainly) secondary relevance to the subject matter of this Compilation.]

A study made by Portland General Electric Co. indicates that by comparing its results with figures issued on a national basis (1963 EEI data) it can be seen that KWH usage in P.G.E. territory is higher than the national average. Local conditions account for most of the differences, e.g. the high saturation of electric water heaters in the Pacific Northwest means that the dishwasher energy usage is increased by the electrically heated hot water used in the dishwasher. Likewise, the additional hot water used used by the automatic clothes washer increases the KWH for this purpose.

Clothes dryer usage seems to be boosted by the rain and clouds in winter months. Clothes dryer saturation is high (58%) and once installed, most dryers are used all year.

Annual KWH are obtained from the records for each customer surveyed. Then the surveyed customers are grouped according to appliances in use. Major appliance KWH are determined by comparing average annual consumptions for customers with, and without, the appliance in question.

The study gives some indication that customers with many electric appliances tend to use more energy per appliance. Conversely, customers with few major appliances tend to use those few to a lesser degree. This might be explained (in a general way) by the observation that customers with a few electric appliances may be in a lower salary bracket and therefore might feel that they should minimize their use of electricity.

TITLE: LOAD FORECASTING

SOURCE: TVA, Division of Power Marketing

AUTHOR(S): J.A.McMahon
PREPARED BY AUTHOR(S) AND/OR: TVA

DATE OF ISSUANCE: 10/9/70
OTHER IDENTIFIERS: Presented at the Georgia Office Managers-Bookkeepers Conf., Atlanta, Georgia; 10/22-10/23, 1970
DATA USE RESTRICTIONS:

TOTAL: [PAGES 18 ;REFERENCES 8 ;GRAPHS 7;TABLES 3] *
DOCUMENT CLASSIFICATION(S): 25/1, 4, 5, 14, 28, 55, 57

ABSTRACT: *[Information of (mainly) secondary relevance to the general subject matter of this Compilation is scattered thruout this Report.]

The Report notes that a forecast need not be absolutely accurate to be useful. The real test of a forecast is not whether actual loads closely follow predicted loads but whether decisions based upon the forecast are generally right. As examples: Was planning - using the forecast as a basis - good in that money was borrowed in the right amounts at the right time? Were facilities added in time to meet the needs? Were rate schedules set which covered all the costs?

The 3 major forecasting functions by electric systems are finance, marketing and system engineering. The various activities carried on under these 3 headings include: budgets; loan studies; market development; programs, agreements and contracts; power supply planning; distribution system engineering. Historical data (including weather, economic, demographic, utility KW and KWH load information) is important in forecasting and careful editing and adjusting of such data are justified. Electric systems use numerous forecasting methods, the 2 main categories being extrapolation, and correlation where loads are related to other factors such as weather and economic data. [All electric systems plan, in one fashion or another, and all need sound load forecasts to plan effectively.]

The Report correlates system (average) demand to CDD (base, 65°F). It contains tabulations of the major contributions - of major appliances and electric heating and air conditioning - to the total residential average use of power in the TVA area. Plotted data shows past (1961-70) and predicted (1971-80) residential energy sales.

TITLE: PROJECTIONS of ELECTRICITY DEMAND*

SOURCE: NSF/RANN Symposium on "Energy Demand, Conservation and Institutional Problems";held at Mass. Institure of Tech., 2/12-2/14,1973
AUTHOR(S): T.J.Tyrrell
PREPARED BY AUTHOR(S) AND/OR: ORNL

DATE OF ISSUANCE: 2/73
OTHER IDENTIFIERS: Chapter 26, pp 342-359 of Proceedings

DATA USE RESTRICTIONS: MIT Copyright on Symposium Proceedings

TOTAL:[PAGES 18 ;REFERENCES 12 ;GRAPHS 7 ;TABLES 6] **
DOCUMENT CLASSIFICATION(S): 25/4, 10, 13, 14, 16, 21, 22, 49

ABSTRACT: **[Information of direct or (mainly) secondary relevance to the subject matter of this Compilation is scattered thruout this Paper. The Total(s) are for the entire Paper.]

For decades electricity demand has followed an exponential growth rate: acceptably accurate predictions have been made using simple extrapolation techniques. This Paper points out that a recent study of this demand (and the factors contributing to its growth) has shown that such simple techniques may no longer provide accurate predictions. Preliminary findings of that study describe demand growth as a function of: population, per capita personal income, the price of electricity and the price of natural gas. Using an econometric model of this demand relationship, and the (likely) futures of the 4 causal factors, electricity demand projections were made and compared to other government and industry estimates. [Similar comparisons from other sources are listed.]

Since the study (referred to above), models have been refined to more accurately reflect the behavior of each class of electric customers. Refinements include the addition of the price of electric appliances as an explanatory variable, the formulation of a variable-elasticity model and the use of additional statistical techniques. Several alternative models were presented, discussed and compared to the demand models of other studies. Finally, elasticity estimates were given for each model, for the major consumer classes (Residential, Commercial and Industrial).

In this paper electricity demands are projected to the year 2000. While the model used is different (and some of the assumptions about the future of causal factors have changed) the range of resultant demand projections is consistent with prior (cited) results.

Long-run (econometric) projections of electricity demand show significant growth in the future, but not as fast as some predictions. However, there is considerable uncertainty due to the sensitivity of the model described in this Paper to alternative assumptions about the explanatory variables; e.g., the future of the price of electricity seems very critical to demand projections as a result of its high elasticity.

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*Note: A somewhat different version of this paper, of the same title, has since been published as ORNL-NSF-EP-50; this version is abstracted elsewhere.

TITLE: PROJECTIONS of ELECTRICITY DEMAND

SOURCE: ORNL

AUTHOR(S): T.J.Tyrrell
PREPARED BY AUTHOR(S) AND/OR: ORNL

DATE OF ISSUANCE: 11/73
OTHER IDENTIFIERS: ORNL-NSF-EP-50; NSF Environmental Program

DATA USE RESTRICTIONS:

TOTAL:[PAGES 22 ;REFERENCES 12 ;GRAPHS 7 ;TABLES 7]*
DOCUMENT CLASSIFICATION(S): 25/4, 10, 13, 14, 16, 18, 21, 22, 35, 50

ABSTRACT: *[Information of direct or (mainly) secondary relevance to the subject matter of this Compilation is found in this Report.]

In its analysis of the growth in demand for electricity this Report identifies 5 factors as being particularly important, namely: (1) population, (2) per capita personal income, (3) the price of electricity, (4) the prices of competing energy sources and (5) the prices of electrical appliances. For quite a few years all of these factors have consistently moved in the direction that would cause the demand for electricity to increase. However, the prices of electricity (and other energy sources) have recently reversed direction and are now increasing; if this trend continues - as now seems quite probable - there may be important implications for the future demand for electricity.

The methodologies used in this analysis (and the resulting models) are described in the cited literature. Several alternative models were also described, discussed and compared to those of other investigators. Each model recognizes the 5 variables, listed above, and includes as an essential component the computation of the time-lag associated with the response function. [Note: Alternative procedures in the regression analysis and in the formulations of the equations give rise to several, slightly different, models.] In the present Report, one of the models is used to obtain projections of electricity demand over the period 1970-2000 and the resultant long run elasticities.

Long-run projections of demand (using the selected econometric model) show significant growth, but not as fast as some predictions. The Report's base case indicates probable trends that may occur but there is uncertainty due to the sensitivity of the model to alternative assumptions about explanatory variables; of these: (1) the future of the price of electricity seems very critical to demand projections; (2) the prediction of future appliance prices is important due to their relatively high elasticity and uncertainty about its future trends; (3) demand projections were not strongly effected by even a wide range of natural gas price projections because of the low cross-elasticity of such estimates; (4) alternative predictions of income and population seem of moderate importance.

TITLE: SHORT - and LONG - TERM LOAD FORECASTING MODELS

SOURCE: TVA, Division of Power Marketing

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: TVA

DATE OF ISSUANCE: 7/25/74
OTHER IDENTIFIERS: Presented at a Conference on the TVA Experience; International Institute of Applied Systems Analysis; Schloss Laxenburg Austria; 10/74
DATA USE RESTRICTIONS:

TOTAL: [PAGES 24 ; REFERENCES 4 ; GRAPHS 5 ; TABLES 2] *
DOCUMENT CLASSIFICATION(S): 25/10, 14, 17, 45, 55, 57

ABSTRACT: *[Information of (mainly) secondary relevance to the general subject matter of this Compilation is scattered thruout this Report.]

Reasonably accurate forecasts are necessary for the efficient planning of the operation and design of an electric system. A number of factors have increased both the difficulty and importance of such forecasts, namely: rapid load growth; the large financial investments to serve growing loads; long lead-times for planning and construction; rapidly rising fuel and other costs; fossil fuel shortages; the effectiveness of conservation programs; consumer responses to rising prices.

Load forecasting has to do with estimating the loads to be (reasonably) expected in some future year, based upon a study of past and present conditions and upon assumptions about the future. Forecasting methodology exists and has progressed because planning is typically more effective when it is based upon appraisal of future risks and opportunities than when based only upon historical growth patterns.

A variety of load forecasts are estimated by the TVA, prepared to meet a range of planning needs. Nine year forecasts of monthly peak demands and energy use are prepared, because 9 years is the approximate (current) lead-time for the planning and construction of nuclear plants. [Long-range forecasts to 1990, and beyond, are essentially extensions of those for the first 9 years.] These (TVA, total area) predictions are supplemented by: (A) seasonal peak forecasts, for the next 20 years, for each of the approximately 700 delivery points at which TVA delivers bulk power; (B) forecasts of normal weather MWH loads for all hours of the future years under study plus extremely "hot" and "cold-week" hourly loads, these being used in planning the optimum mix of the various types of base-load and peaking generators.

The Report includes tabulations of TVA-area demographic information (at 5 year intervals) from 1940 to 1980. A listing of appliance saturation and use data is shown for 1973 and for 1983 (estimated). It is also pointed out that the selection of forecasting methods is influenced by the load characteristics; e.g., in the TVA area about 4 out of 10 residences are electrically heated - which results in annual winter peaks - and about 6 out of 10 residences (and nearly all commercial establishments) are air conditioned, which results in (somewhat lower) summer peaks.

TITLE: ENGINEERING INSTRUCTIONS for PREPARATION of FEASIBILITY STUDIES for TOTAL ENERGY, SELECTIVE ENERGY and HEAT PUMP SYSTEMS

SOURCE: Office of the Chief of Engineers, U.S. Department of Defense

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: Office of the Chief of Engineers

DATE OF ISSUANCE: 7/1/75
OTHER IDENTIFIERS: DAEN-MCE-U

DATA USE RESTRICTIONS: Check with Office of the Chief of Engineers

TOTAL: [PAGES 17 ; REFERENCES 11 ; GRAPHS 4 ; TABLES 2] *
DOCUMENT CLASSIFICATION(S): 25/7, 10, 14, 15, 22, 27, 37, 44, 53, 57

ABSTRACT: *[Information of (mainly) secondary relevance to the subject matter of this Compilation is scattered thruout this Report; the Total(s) apply to the relevant material.]

The appendix of this Report includes a series of "sample" tables to be used (by the architect/engineer) for the preparation of electrical and thermal load profiles; these are listed below. [It is noted that the tables should be modified to suit the type of computer program(s) selected for the feasibility study. These programs are summarized.]

Table 1 relates to the internal heat gain profile due to people; Table 2 covers the same type of profile for the electrical input and heat output of lights. Table 3 has to do with miscellaneous electrical load profiles and Table 4 is for process (thermal) loads. Tables 5 and 6 supply data on the "shut-off hours" for HVAC systems. Tables 7 and 8 supply information as to the classification of environmental conditions for various "types" of days plus values of "setback" temperature assumptions.

Examples are worked out to illustrate the daily load factor calculations for a "typical" office building and hospital. Graphs are shown for the electrical usage (during a "typical operating" day) for an office building and hospital. Heating and cooling load profiles are given for the office building for a typical working day.

The Report states that there are essentially 3 demand estimation methods for the construction of daily load profiles, namely: (1) Metered profiles that have been developed for similar buildings. [They will be used to the maximum extent possible.]; (2) Standardized profiles, based on "typical" demand profiles; (3) Derived profiles which use (1) and (2), to the extent possible, for making a detailed analysis of the projected peak, diversified demands and the building operating characteristics thruout a 24-hour period.

TITLE: PROJECTED ELECTRIC POWER DEMANDS FOR the POTOMAC ELECTRIC POWER COMPANY (POWER PLANT SITE EVALUATION: ELECTRIC ENERGY DEMAND FORECASTS)

SOURCE: Division of Research Programs, Maryland Department of State Planning

AUTHOR(S): J.W.Wilson

PREPARED BY AUTHOR(S) AND/OR: D.R.P., M.D.S.P.

DATE OF ISSUANCE: 7/75

OTHER IDENTIFIERS: PPSE 4-2, Volume 3; Douglas Point Site

DATA USE RESTRICTIONS: Check with Maryland Dept. of State Planning

TOTAL: [PAGES 110 ; REFERENCES 53 ; GRAPHS 11 ; TABLES 27] * 56,57

DOCUMENT CLASSIFICATION(S): 25/4,9,10,14,16,17,21,23,28,42,45,47,50,55,

ABSTRACT: *[Material of direct and secondary relevance to the subject matter of this Compilation is scattered thruout this rather comprehensive Evaluation. The Total(s) are for the relevant (non-industrial) material but include all the References, since nearly all have some pertinency.]

The author states that a large number of vital factors which are closely related to demand growth are now undergoing substantial change. Among these changes is the fact that inflationary conditions are presently outpacing the electric utility industry's technological and productivity advancements. Second, an increasing awareness of domestic energy supply limitations has given greater urgency to energy conservation considerations. Third, high interest rates and tight capital markets tend to have increasing weight in planning for future growth in an industry that is as capital intensive as electric production. Fourth, environmental concerns have encouraged energy conservation efforts which have further contributed to the industry's capital investment requirements. Fifth, rate structure revisions - like higher overall rate levels - tend to impact on consumer demands in ways that were not generally experienced during past periods of price decline. [While this list of changing (major) factors is not exhaustive, it does serve to illustrate the fact that future electricity demand trends in the USA are not likely to be a simple numerical extrapolation of times past.]

In 1973, the residential use of electricity in the USA averaged over 8,000 KWH per metered household. This average represents an increase of about 82% over 1963. In addition, there was also a 25% increase in the number of residential customers during the same period. All told, there was an average annual compound growth rate of over 8.5% per year. [Industrial and commercial electricity sales have also experienced substantial historical growth. Nonresidential demand has grown at an annual rate of nearly 7% between 1963 and 1973.] Electric power demand (in 1974) remained at about the same level nationally as in 1973 but, as of the first quarter of 1975, indications are that demand is again increasing altho at a slower pace than during the past decade.

This Evaluation examines major factors which appear most likely to influence Pepco's future demand picture thru 1990. The factors include: (a) the regional employment "mix" - as between government, service industries, commercial, industrial and agriculture; (b) economic projection of earnings - from personal income, manufacturing and construction; (c) growth in electricity usage levels - in the "residential", "general service" and "high voltage" markets. [Note: the Federal Government offices are Pepco's largest customer, accounting for about 20% of the retail sales. For one thing, this means that the system load is more influenced by climate than would be case for the equivalent amount of relatively stable industrial load.]

The report discusses procedures, for forecasting future demand, which are based on the overall effect of the estimated impacts of each major (quantifiable) causative factor on such demand. The estimating process resulted in several parametric statistical models which can be used for forecasting future electricity demand growth and peak generating needs in Pepco's service area. [It is noted that similar models can be developed for estimating future demand conditions in other markets but because of the unique characteristics of Pepco's customer mix these other models would differ appreciably - at least in detail.] The developed forecasting models can be assumed as applying specifically to Pepco but the procedures for deriving them may serve as a prototype for similar applications to other utility systems.

Among other things, the volume summarizes the results of other studies on: (a) the price and income elasticities of electricity demand; (b) the partial elasticities of the various explanatory variables used in the better known econometric studies; (c) the long-run price elasticities of electricity demand. Tabulations are given for residential demand models on an annual basis, as well as for summer and winter. Presentations are included for the effects on the models of assumed "high" and "low": electricity prices; income; natural gas prices; customer growth; and combined effects of the preceding.

The report contains graphed data for: (1) USA 1971 residential electric sales per capita - by States - vs its average price; (2) residential electric sales per capita in Md. (1962-71) vs space heating saturation; (3) "ditto" vs. electric water heating saturation; (4) "ditto" vs. saturation of central air conditioners; (5) "ditto" vs. % of families with annual income - 1967 dollars - in excess of $15,000; (6) "ditto" vs. % of families with annual income - 1967 dollars - less than $15,000; (7) "ditto" vs. total Md. income in 1967 dollars.

The Appendices of this study cover: (A) listings of the variable factors that were evaluated and analyzed in developing Pepco demand models; (B) a state-wide residential demand forecasting model based on appliance saturation levels; (C) Fortran Program for projecting KWH usage and peak KW, monthly demand; (D) Pepco's monthly sales by region (1961-72), residential and nonresidential.

TITLE: ENERGY (VOLUME II): NON-NUCLEAR TECHNOLOGIES

SOURCE: Addison-Wesley Publishing Co., Inc.

AUTHOR(S): S.S.Penner & L.Icerman
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 1975
OTHER IDENTIFIERS: One of a three-volume set of Lecture Notes *

DATA USE RESTRICTIONS: Copyright by Addison-Wesley

TOTAL:[PAGES 14 ;REFERENCES 3 ;GRAPHS 2 ;TABLES 3] **
DOCUMENT CLASSIFICATION(S): 25/21

ABSTRACT: *[Chapter numbers continued from Volume I.]

**[Information of (mainly) secondary relevance to the subject matter of this Compilation is to be found in parts of Chapter 20 of these relatively extensive Lecture Notes. The Total(s) reflect only the relevant material.]

Electricity production in the USA during 1960 and 1970, as well as predictions for 1985 and 2000, are summarized in Chapter 20 and compared with total equivalent energy consumption. More detailed long-range demand projections to the year 2000 are shown for 3 different estimates, namely: (A) National Petroleum Council extrapolated growth; (B) a reduced economic and population growth scenario; (C) a reduced growth coupled with price increases.

The effects of 6 alternative assumptions about the effects of population growth and electricity price on the growth rate of electricity demand are indicated by the summarized data. These electricity-demand projections are plotted to the year 2000 and their "spread" (of about 5 to 1, at year 2000) shows that there is considerable uncertainty about where the USA is heading, insofar as electricity growth rates are concerned.

TITLE: THE TVA JULY 1976 LOAD FORECAST

SOURCE: *

AUTHOR(S): J.A.McMahon
PREPARED BY AUTHOR(S) AND/OR: TVA (Office of Power, Division of Power Utilization, Analysis Branch)
DATE OF ISSUANCE: 1976
OTHER IDENTIFIERS: Session III; Marketing - Tariffs and Load Forecasting

DATA USE RESTRICTIONS:

TOTAL:[PAGES 30 ;REFERENCES 12 ;GRAPHS 3 ;TABLES 11] **
DOCUMENT CLASSIFICATION(S): 25/4,6,9,11,14,16,17,22,55,57

ABSTRACT: *[Eighth Biennial Conference (among Central Electricity Generating Board, Ontario Hydro Corporation and TVA); October 12-19, 1976; Knoxville and Chattanooga, Tennessee.]

**[Material of direct and (mainly) secondary relevance to the subject matter of this Compilation is scattered thruout this relatively lengthy Forecast. The Total(s) are estimates for the relevant material since there is some overlap in the presentation of non-industrial and industrial data.]

This Paper presents the methodologies, information, logic and results of the July 1976 load forecast for the region served with TVA power. Demographic and economic factors are said to be the major determinants of the consumption of electricity. Those factors are discussed which modify the connection between population and economic growth and the increase in electricity consumption; these include conservation, substitution of electricity for fossil fuels in end-use applications and the effects of environmental regulation.

Residential sales now account for about 30% of total TVA area energy requirements. The rate of growth of residential customers is expected to be larger for the next decade than for the past decade, despite slower population growth. The more rapid addition of customers should partially result from the skewed age distribution of people in the region, a result of the postwar "baby boom". Another factor supporting faster growth of residential customers is the broad migration to the southern part of the USA, including Tenn. Note: Population in Tenn. increased 6.7% from 1970 to 1975, compared with a national increase of 4.8%. [In 1975 there were 1.09 residential customers per household and by 1985 this ratio is expected to be about 1.13, roughly the same as in 1975.]

Data is tabulated (1960 thru 1976) for "actual" and "adjusted" average annual residential usage, correlated with HDD and CDD. Actual data show that such use has been relatively flat since 1970, at about 14,000 to 15,000 KWH/year. However, 1970 was 17.3% colder than normal (the coldest

winter in the last 16 years) while the following 6 years were much warmer, with 4 of them warmer than normal. After adjustment of average uses to normal weather, the figures show continuous growth from year to year through 1973; furthermore thru 1973 there was no obvious response to the substantial rate increases which began in 1967, with price effects apparently offset by rising incomes and other factors. Growth of adjusted average use was negligible in fiscal year 1974, declined in 1975 and further declined (slightly) in 1976. The lowering in average use can be (at least) partially explained by the following "economic", "demographic" and "other" factors:
(a) The combined effects of declining or constant real income, associated with layoffs and inflation; (b) TVA ongoing conservation programs; (c) The rise in price of electricity; (d) The gradual shift toward fewer people per household; (e) The greater proportion of multi-family, as opposed to single-family residences; (f) The smaller cubic footages in many new dwellings; (g) Appeals to conserve in the fall of 1973 following the "oil embargo"; (h) TVA emergency appeals to conserve, in connection with the coal shortage during the winter of 1974-75.

Data is included for fiscal years 1975 and 1986 for appliance saturation, annual appliance KWH usage and the contribution to average use by appliances. Saturations for 1986 are based upon historical trends, the fact that some appliances already have very high saturations and the effect of the natural gas shortage. Annual usages of some appliances in 1986 are adjusted judgmentally for the effects of: higher price of electricity, conservation programs, the Energy Policy and Conservation Act of 1975 and some shift toward multifamily housing. [The average use per residential customer is expected to grow at 2.1% per year and to reach about 18,800 KWH by 1986, with nearly all of this growth due to (expected) increases in appliance saturations.]

The appliance forecast was reviewed by the trend method. The conclusion reached following this trend review was that all of the 21 series of trend projections (7 geographic categories for sales, average use and customers) appeared reasonable and that the trend method generally supported the forecasts of customers, average use and sales reached by other methods.

A forecast of residential energy was also made with a multiequation econometric model. This model disaggregates residential energy growth into customer growth and annual average use. Customer forecasts are exogenously provided and annual average use is forecast using several equations. In order to forecast residential energy with an econometric model, forecasts of the causal factors (personal income per capita, price of electricity, price of natural gas) in the chosen model must be provided; the growth rates of these factors is specified. The model provides annual forecasts of residential energy for the period 1976-86.

The Paper reviews recent forecasts of growth rates (to 1985) and finds that they range from about 5.7 to 6.4%. All of these forecasts postdate the trough of the recent severe recession, oil embargo and the (worst of the) surge of rate increases.

TITLE: ELECTRIC UTILITY ENGINEERING REFERENCE BOOK: DISTRIBUTION SYSTEMS

SOURCE: Electric Utility Engineering Department of Westinghouse Electric Corporation
AUTHOR(S): L.W.Manning (Chapters 2 & 11) *
PREPARED BY AUTHOR(S) AND/OR: Electric Utility Engineers of W.E.Corp.

DATE OF ISSUANCE: 12/1/59; reprinted 1965
OTHER IDENTIFIERS: Vol. 3; Vols. 1 and 2 were not actually published.
First Edition, Fourth Printing
DATA USE RESTRICTIONS: Copyright by Westinghouse Electric Corporation

TOTAL: [PAGES 27 ;REFERENCES 31 ;GRAPHS ;TABLES 4] * 45,47
DOCUMENT CLASSIFICATION(S): 26/4,7,9,13,15,19,21,23,33,34,35,37,38,39,

ABSTRACT: *[Virtually all of the material relevant to the general subject matter of this Compilation is in Chapter 2, entitled "Load Characteristics"; the Totals are for this Chapter. However, Chapter 11 contains a short summary of Load Survey Recorders.]

A listing of the main section headings of Chapter 2 of this "standard" Reference Book discloses the variety of its subject matter, namely: Classification of Loads; Definitions and Examples (of various types of power, demand, maximum demand, demand factor, utilization factor, load factor, diversity factor, coincidence factor, load diversity, diversified demand, loss factor); Power Factor; Load and Voltage Balance; Load Distribution and Density; Load Growth; Service (quality) Requirements; Applications of Load Characteristics to Distribution Problems (especially Demand and Diversity/Coincidence Factors); Determining Load Characteristics (field measurements, in particular); Estimating Load Characteristics.

Plots or "families" of curves are shown for: (a) the variation in demand, with demand interval; (b) loss factor, as a function of load factor; (c) average maximum diversified demand per customer vs number of customers or units, for various residential electrical loads; (d) maximum diversified 30-minute demand characteristics of various residential loads, as a function of the number of loads.

Tables are presented for: (a) Classification of Loads; (b) Hourly Variation Factors, for the ratio of the demand of a particular type of load coincident with the group maximum demand to the demand of that particular type of load (e.g., lighting and miscellaneous loads, refrigerators, freezers, ranges, hot-water heaters); (c) Starting and Running Currents, for motor-driven residential loads.

TITLE: STANDARD HANDBOOK for ELECTRICAL ENGINEERS

SOURCE:

AUTHOR(S): D.G.Fink & J.M.Carroll (Editors)
PREPARED BY AUTHOR(S) AND/OR: McGraw-Hill Book Co.

DATE OF ISSUANCE: 1968
OTHER IDENTIFIERS: Tenth Edition; pp 16-79,-80 + 17-27 thru 17-32 + 20-75,-76,-77
DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL: [PAGES 11 ;REFERENCES 2 ;GRAPHS 3 ;TABLES 7] *
DOCUMENT CLASSIFICATION(S): 26/13,14,15,20,32,34,43

ABSTRACT: *[These Totals refer only to those pages of the Handbook that are considered relevant to the general subject matter of this Compilation. Much of the tabulated material is ascribed to the NFPA/NEC.]

The "relevant" data of general interest is summarized below:
(a) Listings of (typical) Demand and Diversity Factors;

(b) Excerpts from the NEC, covering General Lighting Loads (by occupancy type) and Feeder Demand Factors (for lighting loads);

(c) Standard Illumination Loads (in watts per square foot) for Commercial and Public Buildings;

(d) Data (and discussion) related to Demands and Energy Consumption (of elevators and escalators).

TITLE: MECHANICAL and ELECTRICAL ENGINEERING: A GSA HANDBOOK

SOURCE: GSA

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: GSA

DATE OF ISSUANCE: 6/16/71
OTHER IDENTIFIERS: PBS P 3460.1c

DATA USE RESTRICTIONS: Intended for use by Public Buildings Service architect/engineers and PBS contractors (but check with GSA).
TOTAL: [PAGES 113 ; REFERENCES 9 ; GRAPHS ; TABLES 6] *
DOCUMENT CLASSIFICATION(S): 26/15, 20, 32, 34, 44

ABSTRACT: *[These Totals refer to Chapters 8, 10, 11 and 12 since they are the ones with some material of at least secondary relevance to the general subject matter of this Compilation. The Handbook refers extensively to NFPA/NEA and IES data.]

This Handbook is for the guidance of (contract) architect-engineers engaged in the design of new construction or alteration projects for the Public Buildings Service (PBS) and also for the information of architectural and engineering personnel of PBS. It contains criteria pertinent to the design of mechanical and electrical systems and deals mainly with general purpose office buildings erected or maintained by PBS. This handbook, and other GSA criteria, are to be considered as for general guidance rather than for use as rigid standards.

Chapter 8 discusses aspects of "Electrical - Lighting and Power" installations. Chapter 10 deals with "Electrical - Communication and Signaling Systems" details. Chapter 11 discusses "Illumination". Chapter 12 has information on "Elevators, Escalators and Dumbwaiters".

TITLE: NFPA HANDBOOK of the NATIONAL ELECTRICAL CODE
(Based on the Current 1975 Code)

SOURCE: NFPA/NEC

AUTHOR(S): W.I.Summers (Editor)
PREPARED BY AUTHOR(S) AND/OR: McGraw-Hill Book Co.

DATE OF ISSUANCE: 1975
OTHER IDENTIFIERS: Fourth Edition; pp 60-73 + 746-755

DATA USE RESTRICTIONS: Copyrights by NFPA and McGraw-Hill, Inc.

TOTAL: [PAGES 24 ;REFERENCES ;GRAPHS ;TABLES 12] *
DOCUMENT CLASSIFICATION(S): 26/8, 9, 12, 13, 15, 32, 34, 47, 48

ABSTRACT: *[These Total(s) refer only to those portions of the Handbook that are considered relevant to the general subject matter of this Compilation. The pages include 15 examples illustrating various sections of the NEC.]

The "relevant" (Tabulated) data is as follows:
(a) General Lighting Loads (by building type);
(b) Lighting Load Feeder Demand Factors (by building type);
(c) Demand Factors for Household Electric Clothes Dryers;
(d) Maximum Demand and Demand Factors (for various electric household cooking appliances);
(e) Demand Factors (for commercial electric kitchen equipment);
(f) Demand Factors for single and multi-family dwelling units;
(g) Demand Factors for Schools.

There are a number of examples (worked out) to illustrate (simplified) electrical load calculations for: single-family dwellings, multi-family dwellings, store buildings and the maximum demand of electric ranges.

TITLE: AMERICAN GAS ASSOCIATION PUBLICATIONS CATALOG

SOURCE: AGA

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: AGA (Arlington, Virginia)

DATE OF ISSUANCE: 1/76 *
OTHER IDENTIFIERS: 76-497

DATA USE RESTRICTIONS:

TOTAL: [PAGES ;REFERENCES ;GRAPHS ;TABLES] **
DOCUMENT CLASSIFICATION(S): 26/10, 11, 23

ABSTRACT: *[This Catalog has been revised on a regular basis, with publications listed for the first time identified with an asterisk. This was the current issue when this sheet was prepared.]

**[Not considered pertinent to this form of publication.]

The Catalog contains a limited number of listings directly related to electricity. Other entries may be of general interest to the readers of this Compilation, particularly in the energy conservation areas and their associated computer programs.

TITLE: HEAT PUMPS vs RESISTANCE HEATING from the VIEWPOINT of the CUSTOMER and the UTILITY

SOURCE: IEEE Winter Power Meeting; Industry and General Applications Div. New York City; 1/31-2/5, 1965
AUTHOR(S): W.R.New
PREPARED BY AUTHOR(S) AND/OR: TVA

DATE OF ISSUANCE: 2/65
OTHER IDENTIFIERS: Paper No. (CP) 65-230; Electric Space Heating, Heat Pumps and Air Conditioning Subcommittee
DATA USE RESTRICTIONS:

TOTAL:[PAGES 10 ;REFERENCES 1 ;GRAPHS 3 ;TABLES 3] *
DOCUMENT CLASSIFICATION(S): 27/2, 4, 13, 19, 28, 30, 55, 57

ABSTRACT: *[Contains material of (mainly) direct and secondary relevance to the subject matter of this Compilation.]

This paper presents load data on two all-electric housing projects, one having heat pumps and the other resistance heating. A second purpose is to summarize recent trends which emphasize the importance of the electric heating load, its rapid growth and the need for utilities to exchange information and data as a means of providing a fuller understanding of these heating systems.

The Paper contains electrical load information for a housing project of 480 units, located on a military base in a TVA-supplied area of Mississippi; this project utilized heat pumps. Comparative data is also given for a second project of 340 units (on the same base) using central electrical resistance furnaces with air conditioning. [The size of the houses and types of appliances used were considered similar.] Basic data, as listed for both projects, included: diversified demand in KW/unit; KWH used/unit; monthly load factors; monthly ambient temperature ranges; HDD (65° base); CDD (70° base). Appliance consumptions are also listed.

Summary of Major Findings:
1. A heat pump provides the customer with air temperature control, with a minimum of power consumption. It assures the electric utility of an all-electric consumer with high energy use and a reasonable load factor.
2. The coefficient of performance of the heat pumps averaged about 2.2.
3. At design temperature, the diversified demand of the heat pump units was less than the calculated heat loss while the demand of the resistance units exceeded the calculated heat loss.
4. Proper installation and maintenance of the heat pumps are of vital concern to both the consumer and the supplying utility.
5. Electric water heater energy use is higher than that of other home appliances where a clothes washer, dryer and dishwasher are used. The monthly pattern of such use correlates with the average daily temperature.

TITLE: HEAT PUMPS PROVIDE ECONOMICAL SERVICES for APARTMENT TENANTS

SOURCE: Heating, Piping and Air Conditioning, Jan. 1968, pp 124-131

AUTHOR(S): J.W.Megley
PREPARED BY AUTHOR(S) AND/OR: Boston Edison Co.

DATE OF ISSUANCE: 1/68
OTHER IDENTIFIERS: Subtitled "how economy was provided, and how it was estimated"
DATA USE RESTRICTIONS: Copyright by Rheinhold Publishing Co., Inc.

TOTAL: [PAGES 8 ; REFERENCES ; GRAPHS 17 ; TABLES 2] *
DOCUMENT CLASSIFICATION(S): 27/3, 13, 15, 25, 37, 55, 56, 57

ABSTRACT: *[Contains material of direct relevance to the subject matter of this Compilation, particularly in the section entitled "How Electric Demand Estimates Were Made".]

In discussing how the electric demand estimates were made, it is pointed out that one of the first considerations was the question as to the time of occurrence of the maximum demand. Heating and domestic water heating loads are normally maximum around 8 am and, if electric resistance heating and water heating to be used, the magnitude of such peaks would make them the maximum demands during most of the heating season. Since the COP of the heat pumps would act to substantially reduce the electrical requirements for these heating services - and perhaps result in a shift of the overall maximum demands to the evening period - it was considered necessary to make an in-depth appraisal.

A set of 9 curves is shown to graphically illustrate the steps taken to develop the necessary data relative to combining the electrical demands of the project. These curves are identified as: (1) design and operating heat losses for various outdoor temperatures; (2) hourly temperatures for days of coldest morning and coldest afternoon; (3) gross space heating loads; (4) domestic hot water usage for maximum day; (5) total gross load on heat pumps for space and domestic water heating; (6) net load on heat pumps; (7) electric demand for heat pumps, including variable auxiliaries; (8) electric demand for direct use by tenants; (9) electric demand for (7) plus (8). [Note: curves (3), (5), (6), (7) and (9) are plotted for both days shown under (2).]

Curves are also included for: (a) monthly billing demands, thruout the year, for the various load components considered; (b) monthly energy consumption of these components; (c) characteristics of booster water heater, which stores heat in a closed tank system at a maximum of 280°F.

TITLE: ELECTRIC HOUSE HEATING - IT FLATTENS CURVE of RESIDENTIAL LOAD

SOURCE: Electrical World, 2/8/54, pp 90-92

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: E.W.

DATE OF ISSUANCE: 2/54
OTHER IDENTIFIERS: Data was collected by the Union Electric Co. of Missouri.
DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL: [PAGES 3 ;REFERENCES 1 ;GRAPHS 5 ;TABLES 1] *
DOCUMENT CLASSIFICATION(S): 28/13, 37, 47, 52

ABSTRACT: *[Contains material of (mainly) secondary relevance to the subject matter of this Compilation.]

The Article states that a definite morning peak is characteristic of the electric house heating load. The effect of this peak will be to improve the shape of the residential class load curve, as the number of heating customers rises to as high as 10% or more of the class total. The highest demand of the heating load is not likely to coincide with either that of the peak system load or that of residential load. [A small % increase in number of heating installations will cause a large % increase in volume of residential energy sales.]

On the day of the Residential Class peak, the residential load per customer (non-heating) ranged from about 0.1 to 0.7 KW. The corresponding loads for customers using electric (space) heating ranged from about 1.9 to 4.4 KW.

TITLE: ELECTRIC HEATING in the TENNESSEE VALLEY - A PATTERN for the FUTURE

SOURCE: TVA, Division of Power Utilization

AUTHOR(S): W.R.New
PREPARED BY AUTHOR(S) AND/OR: TVA

DATE OF ISSUANCE: 3/57
OTHER IDENTIFIERS: American Power Conference; 19th Annual Meeting; Chicago, Illinois; 3/27-3/28, 1957
DATA USE RESTRICTIONS:

TOTAL:[PAGES 14 ;REFERENCES 3 ;GRAPHS 6 ;TABLES 1] *
DOCUMENT CLASSIFICATION(S): 28/37, 47, 55, 57

ABSTRACT: *[Information of direct or secondary relevance to the general subject matter of this Compilation are scattered thruout this Paper. The Totals are for the entire Paper.]

The residential market for complete electric heating consists of original installations in new homes and replacements, for systems using other fuels, in older homes. Because wiring and insulation updating in older homes are costly, the new home market is the more important: however in some communities as many as a third of the heating consumers are in old homes.

The all-electric home is considered as one in which all artificial light, heat and power are provided by electricity. Most of the electrically heated homes in the TVA area are all-electric. However (as yet) relatively few of these consumers have complete year-round air conditioning. Because of this, and the fact that heating and cooling loads are influenced directly by temperature, the characteristics discussed in this Paper should not be considered applicable to other systems and areas without suitable allowance for local conditions.

The Paper states that, in the long run, the most desirable load from the utilities standpoint will be the year-round air-conditioned home. If both heating and cooling cannot be obtained initially, the heating load is preferable since electricity has little competition in the cooling field. Compared with most other residential loads, electric heat makes better than average use of the system's facilities. In many locations on the system, it may be served in low saturations, using only the available excess cold weather capacity.

The Paper graphs year-long comparisons of the average monthly residential energy consumption for customers with (and without) electric space heating. It also contains information (developed by TVA) which correlates demand and use with outdoor temperatures and degree-days (DD). This correlation is summarized in plots which relate (day-to-day) changes in demand vs. temperature at the time of demand and (day-to-day) changes in energy vs. changes in the number of DD.

TITLE: ELECTRIC HEATING IMPROVES LOAD FACTOR

SOURCE: Electrical World, 2/2/59, pp 45-46 and 69

AUTHOR(S): S.L.Forsyth
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 2/59
OTHER IDENTIFIERS:

DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL:[PAGES 3 ;REFERENCES 1 ;GRAPHS 6 ;TABLES] *
DOCUMENT CLASSIFICATION(S): 28/14, 19, 21, 37, 57

ABSTRACT: *[Contains material of secondary relevance to the subject matter of this Compilation.]

It is pointed out that the electric heating load profile for a single house depends upon several factors. Of these factors, the "life style" of the occupants plays a predominant role but weather and the type of heating equipment in use are also quite significant.

The Article contains load curves which compare "periodic" and "continuous" controls; the periodic type use unit heaters with built-in thermostats and the continuous type is controlled by external (adjustable) thermostats. Comparing the curves, it was concluded that the continuous type resulted in less demand, better load factors and more comfortable surroundings at no greater cost. [Graphs are included to show daily and monthly variations in the electric heating load of residences having connected loads ranging from 15 to 20 KW.]

TITLE: CALCULATING the ELECTRIC HEATING LOAD

SOURCE: AIEE Winter General Meeting; New York, N.Y.; 1/31-2/5, 1960

AUTHOR(S): W.R.New
PREPARED BY AUTHOR(S) AND/OR: TVA

DATE OF ISSUANCE: 1960
OTHER IDENTIFIERS: Conference Paper (CP) 60-414; AIEE Subcommittee on Domestic and Commercial Applications
DATA USE RESTRICTIONS:

TOTAL:[PAGES 10 ;REFERENCES 2 ;GRAPHS 3 ;TABLES 2] *
DOCUMENT CLASSIFICATION(S): 28/14, 21, 25, 47, 50, 55, 57

ABSTRACT: *[This Paper contains information of direct and (mainly) secondary relevance to the subject matter of this Compilation.]

Because it is highly weather-sensitive, electric heating service has led to some new concepts in load forecasting and promotion, system planning, distribution engineering and consumer relations. All these concepts involve estimates of the magnitude of the heating load and related factors. As an example, the contribution of the heating load to the total system load must be determined. As another example, the heating load characteristics in regard to climatological changes and load density changes must be considered, as well as the changes in these characteristics with time.

The Paper summarizes certain information related to TVA's electric heating load-estimation techniques, namely: (a) annual increase in electric heating and in total residential customers, 1953-59; (b) distribution of residential customers by level of energy consumption during Jan., for 38% saturation of electric heating; (c) monthly energy sales per customer, for 1956 and 1959, for customers with and without electric heating; (d) average annual KWH use, for 1951-59 plus 1959-65 estimates, for customers with and without electric heating; (e) low-rent housing electric load characteristics, KW/unit plus load factors, both on a monthly basis.

TITLE: ESTIMATING ELECTRICAL HEATING LOADS from CUSTOMER USE

SOURCE: IEEE Industrial and Commercial Power Systems and Electric Space Heating and Air Conditioning Joint Technical Conference
AUTHOR(S): W.R.New
PREPARED BY AUTHOR(S) AND/OR: TVA

DATE OF ISSUANCE: 1970
OTHER IDENTIFIERS: pp 187-190 of record of Conference held at San Francisco, California; 5/4-5/7, 1970
DATA USE RESTRICTIONS:

TOTAL:[PAGES 4 ;REFERENCES ;GRAPHS 1 ;TABLES] *
DOCUMENT CLASSIFICATION(S): 28/13, 25, 34, 55, 57

ABSTRACT: *[Contains material of (mainly) secondary relevance to the subject matter of this Compilation.]

The Article states that Utilities have often used customer billing information to estimate transformer and system loads. It is also noted that heating and air-conditioning loads are different from other loads because they are weather sensitive; the KWH used to heat or cool is in proportion to the HDD or CDD. When the monthly KWH use of a home is plotted against the degree-days in the billing period, the slope of the line will indicate whether there is electric heating and, if present, the magnitude of the load. [The intercept (at zero DD) will approximate the nonheating use.] An equation has been developed which uses the intercept and the slope of the line to estimate the customers' load. The constants of the equation for any particular system may be developed from test metering. This approach will: first, identify those customers using electricity for heating or cooling; second, estimate the magnitude of the load in both KW and KWH, based on the weather which has occurred; third, estimate loads for both normal and extreme weather conditions. Formulas have been developed to identify a variety of load information for each customer and each transformer.

Whether one is using load information data for estimating the generating capacity needed for the next hour or for the system load 20 years from now, it is best to break the load into its major components for accurate forecasts. As costs of electrical equipment increase and delivery time gets longer and longer, the job of load forecasting takes on increasing importance. The costs of not having adequate capacity - with the resulting interruptions, low voltage, high cost of purchased power and poor public relations - are sometimes hard to measure; on the other hand, the installation of equipment (much) ahead of its need results in higher fixed charges. [One way to reduce costs is to maximize the use of facilities; such maximization will be reflected in high monthly and annual load factors.]

TITLE: EVALUATION of HEATING LOADS in OLD RESIDENTIAL STRUCTURES

SOURCE: Hittman Associates, Inc.

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: Hittman Associates, Inc.

DATE OF ISSUANCE: 1/74
OTHER IDENTIFIERS: HUD-HAI-7; HUD-PDR-29-17; NTIS PB 227-167

DATA USE RESTRICTIONS:

TOTAL:[PAGES 6 ;REFERENCES 26 ;GRAPHS 1 ;TABLES] *
DOCUMENT CLASSIFICATION(S): 28/3, 11, 22, 23, 37, 38, 47

ABSTRACT: *[Contains material of (mainly) secondary relevance to the subject matter of this Compilation. The Total(s) are for the relevant material, although some of the References are rather general in content.]

HUD, in conjunction with the National Science Foundation and the Environmental Protection Agency, has been conducting an extended program to determine energy consumption in residential structures and to examine various means by which energy can be conserved. This document describes the quantification of heating energy consumption in "old" (pre-1940) residences and compares such consumption with the energy consumed in "new" construction. The types of residences included in this study were new and old units representative of single-family detached units, townhouses, low-rise and high-rise apartments; two of each residence type were selected for study. Because of the greater uncertainties associated with older residences, including the thermal properties of their construction, the calculated heating requirements were complemented with field measurements of energy consumption within the residences.

The energy consumption in each of the 8 residences was measured for a 10-day period during the 1973 winter. Furnace energy consumption was determined by monitoring the furnace "on-time" with a recorder and determining the rate of gas consumption during furnace operation from the gas meter in the house. [The furnaces in all the structures were either full-on or off, with no gas throttling capability, thus justifying the procedure.] Internal heat gains from lights and appliances were determined by reading the utility meters at the beginning and end of the period.

Daily ("assumed") load profiles are shown for appliances, lights and occupancy (seperately for weekday and weekend). The profiles are normalized as fractions of maximum load.

TITLE: SEASONAL FUEL UTILIZATION EFFICIENCY of RESIDENTIAL HEATING SYSTEMS

SOURCE: ORNL

AUTHOR(S): E.C.Hise
PREPARED BY AUTHOR(S) AND/OR: ORNL (for FEA + NSF/RANN)

DATE OF ISSUANCE: 4/75
OTHER IDENTIFIERS: ORNL-NSF-EP-82; Environmental Program

DATA USE RESTRICTIONS:

TOTAL:[PAGES 12 ;REFERENCES 6 ;GRAPHS 1 ;TABLES 2] *
DOCUMENT CLASSIFICATION(S): 28/2, 13, 15, 56

ABSTRACT: *[Material of secondary relevance to the subject matter of this Compilation is scattered thruout this Report. The Total(s) are for the relevant data.]

The Report analyzes three residential heating systems - electric resistance, fired furnaces with forced circulating air and electric driven air-to-air heat pumps - and compares them for their present and potential fuel utilization efficiency. The sources of inefficiency are discussed and quantified, where adequate information is available; a program is proposed to obtain data not found in the literature. [The definition of heating season "fuel utilization efficiency" (FUE), as used in this report, is: "seasonal useful heat supplied by the system divided by seasonal fuel consumption."]

Data is included on: heating performance of heat pumps, including KW demands; variation of the COP with outdoor temperature; variation of COP with DD, for various region of USA; results of heat pump tests in Pittsburgh, Pa.

Summary of Major Findings:
1. Resistance heating systems cannot exceed the FUE of the electrical system and are thus limited to a maximum efficiency of about 29%.
2. The heat pump and the (furnace) combustion systems offer the possibility of an FUE of 70 to 75%. However, considerable care must be exercised in the design, construction, installation and maintenance of the systems to consistently achieve such FUE values and their costs and benefits can be quite different.
3. The heat pump combines the ability to heat and cool in one machine, whereas the furnace can only heat. It requires less investment in resources to fabricate the heating-cooling system, creates less seasonal peaking load problems but costs more money.
4. The heat pump, as opposed to a furnace, imposes daily electrical peaking loads.
5. The efficiency of a "best" heat pump possible can exceed that of a "best" furnace in a warm climate, whereas the reverse would be true in a cold climate.

TITLE: MOBILE HOMES Are Not VERY MOBILE

SOURCE: Electrical World, 2/1/77, pp 48-49

AUTHOR(S): J.W.Coleman
PREPARED BY AUTHOR(S) AND/OR: Alabama Power Company

DATE OF ISSUANCE: 2/77
OTHER IDENTIFIERS: Energy Marketing

DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL: [PAGES 2 ;REFERENCES 1 ;GRAPHS ;TABLES 1] *
DOCUMENT CLASSIFICATION(S): 29/4, 50, 55

ABSTRACT: *[Contains material relevant to the general subject matter of this Compilation.]

Mobile homes have presented some rather unusual "problems" (for most electric utilities) for a long time but not until fairly recently did the number of units served reach such proportions that the problems involved could be termed serious. For example, Alabama Power Company found that about 7% of their residential customers were in "mobile" homes. The utility also found that almost 2/3 of these homes were still at the same location where they first received electrical service and that about 4 out of 5 owners plan to be "non-mobile" for at least 5 more years.

Alabama Power drew a random sample of 405 mobile-home customers from their accounting records. These were customers who had had 12 continuous months of billing history. The sample was designed to give a degree of accuracy in the range of ± 5%, at a 95% confidence level. [Of the 405, 78 were subsequently "thrown out" because the mobiles involved were located in recognized mobile-home parks.] The survey showed that 92% of the mobile homes served were the "primary residences" of the customers involved and that 83% were located in rural or semirural areas.

The Article tabulates the electrical use of single family, multi-family and mobile homes (for the year ending Feb. 1975). The annual KWH energy use for each class was found to average: 11,105 for single family; 10,027 for multi-family; and 9,801 for the mobiles. Data is also included (for sub-categories of the preceding three types), which covers residences having various arrangements for heating and cooling; such variations produced a range of annual KWH usage for the mobile home, which averaged from somewhat under 9,000 to somewhat over 13,300. [Saturation percentages are listed for all major electric appliance, for each of the sub-categories.]

TITLE: IES LIGHTING HANDBOOK

SOURCE: Illuminating Engineering Society

AUTHOR(S): J.E.Kaufman & J.F.Christensen (Editors)
PREPARED BY AUTHOR(S) AND/OR: IES

DATE OF ISSUANCE: 1972
OTHER IDENTIFIERS: Fifth Edition *

DATA USE RESTRICTIONS: Copyright by Illuminating Engineering Society, reproduction requires specific permission
TOTAL: [PAGES ;REFERENCES ;GRAPHS ;TABLES] **
DOCUMENT CLASSIFICATION(S): 32/7,9,15,26,33,42,44,48,49

ABSTRACT: *[This was the current Edition when this sheet was prepared.]

**[Not considered particularly pertinent to this form of publication. Note:"Recommended illumination levels"are scattered thruout this rather lengthy Handbook.]

The Handbook includes the latest levels of illumination, as recommended by IES. Data is covered relating to the overall designing of the luminous environment and to the latest information on specific areas of application of such design techniques, e.g. offices, schools and hospitals.

Sections of the Handbook are devoted (among other things) to: (1) lighting calculations; (2) offices and schools; (3) institutions and public buildings; (4) lighting for merchandising; (5) residential lighting; (6) lighting system design factors; (7) outdoor lighting applications; (8) sports and roadway lighting; (9) advertising lighting; (10) entertainment facility lighting.

TITLE: OBSERVATIONS on LOAD RESEARCH by an ELECTRIC UTILITY (CAROLINA POWER & LIGHT COMPANY; RALEIGH, NORTH CAROLINA)

SOURCE: AEIC Load Research Seminar

AUTHOR(S): S.Behrends, Jr. (of AEIC's LRC)
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 2/27/75
OTHER IDENTIFIERS: Presented to NARUC Executive Committee (et al) at a Washington, D.C. meeting on 2/27/75
DATA USE RESTRICTIONS:

TOTAL:[PAGES 8 ;REFERENCES 1 ;GRAPHS ;TABLES]*
DOCUMENT CLASSIFICATION(S): 34/19,21,38,39,55

ABSTRACT: *[This"informal"Paper contains material of secondary relevance to the subject matter of this Compilation.]

Load research is normally directed toward finding the relationship between the KWH used by customers, the rate at which they consume those KWH and the time of the day or year. For the great majority of C.P.&L. customers, billing meters show only the KWH used over a fairly long period, usually a month. [That is all that a utility usually measures about the way most of its customers use electricity.] For the larger commercial and industrial customers the billing meters are of the type which also shows the highest rate of KWH use during the month; this is the maximum KW demand. For purposes of knowing the effect of the customer's consumption and demand on the utility's system and on its need for facilities, the missing ingredient is the time when this demand and consumption occur in their varying amounts. For instance, if a customer uses 1,000 KWH per month, how much of this use occurs at the time of the system peak? Answers to this (and other questions) can severly affect the amount of facilities the utility must install and can play a major role in studies which apportion costs among classes of customers. Load research undertakes to supply the missing ingredient; it does this by installing some meters which record the customer's use each hour of the day. [This record is now generally made on magnetic tape, which then must be translated and converted to computer input, from which a written record can be developed for study. The result is to give the analyst a record of the amount of use, the rate of use and the time when it occurred.]

The Paper outlines the primary steps in conducting a load study, namely: (a) determining the objectives as precisely as possible; (b) designing the type of sample so that it will produce data to answer the "questions" raised by the objectives; (c) determining the sample size,including the number of alternate customers for each item to be sampled; (d) selecting recording equipment; (e) nature of "interview" with sample customers; (f) collection and analysis of the recorded data. [A "sample" interview form is included.]

TITLE: INTRODUCTION to LOAD RESEARCH

SOURCE: AEIC Load Research Seminar

AUTHOR(S): J.A.Leo (of AEIC's LRC)
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 2/27/75
OTHER IDENTIFIERS: Presented to NARUC Executive Committee (et al) at a Washington, D.C. meeting on 2/27/75
DATA USE RESTRICTIONS:

TOTAL:[PAGES 13 ;REFERENCES 2 ;GRAPHS ;TABLES] *
DOCUMENT CLASSIFICATION(S): 34/38,55

ABSTRACT: *[This"informal"Paper contains material of secondary relevance to the subject matter of this Compilation. It parallels certain information in "printed" (but unpublished) notes used as part of AEIC's utility industry Seminars, conducted by the LRC from time-to-time.]

Load Research is herein defined as the measurement and study of the characteristics of electrical loads to provide a thorough and reliable knowledge of trends in - and the general behavior of - the load characteristics of the more important electrical services rendered by the electric utility industry.

The beginning of formalized cooperative load research activities, by the investor-owned utilities, was in 1938 when the AEIC organized the Special Committee on Load Studies. In Oct. 1943 the AEIC established the Load Research Committee (LRC). Each year since its 1943-44 report, the LRC has printed detailed studies covering the characteristics of customer and major appliance loads as well as the technical aspects of load research and analysis. The load research objectives of the LRC are:

(1) To assemble annually, in a consistent and uniform fashion, those results which will be of general value to the industry.
(2) To encourage the participation of utilities in individual and joint projects appropriate to the needs of the industry.
(3) To provide a forum for discussing matters pertinent to such research.
(4) To develop improved applications of the research results and associated techniques.
(5) To foster the application of technological progress to this field of inquiry.

TITLE: THE "COMMON SENSE" and MANAGEMENT ASPECTS of LOAD RESEARCH

SOURCE: AEIC Load Research Seminar

AUTHOR(S): C.T.Loshing (of AEIC's LRC)
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 2/27/75
OTHER IDENTIFIERS: Presented to NARUC Executive Committee (et al) at a Washington, D.C. meeting on 2/27/75
DATA USE RESTRICTIONS:

TOTAL:[PAGES 9 ;REFERENCES ;GRAPHS ;TABLES] *
DOCUMENT CLASSIFICATION(S): 34/55

ABSTRACT: *[This "informal" Paper contains material of (mainly) secondary relevance to the subject matter of this Compilation. It parallels certain information in "printed" (but unpublished) notes used as part of AEIC's utility industry Seminars, conducted by the LRC from time-to-time.]

The author presents some ideas on load research but emphasizes there is no substitute for experience. First, the establishment of a load research program necessarily takes time; efforts to shorten the "required" time will (generally) result in a deterioration in the quality of the findings. Second, there are some shortcuts that can be followed "at least once", if a hurry-up program is unavoidable. Third, acquiring a load research capability requires a sizable commitment of money, time and corporate energy which is appropriately carried out by the individual company, not by the regulatory commission. Fourth, properly done, load research is (and will be) of benefit both to the utility and to the consumer since it can provide the basis for equitable and innovative rate design and can assist in providing economical, reliable service; common sense application is the key to attaining successful results.

The Paper discusses the following topics, in a generalized manner: (a) procedures for establishing a load research project quickly to meet an "emergency" need; (b) the increasing needs for load research, on a "must" basis; (c) regulatory commission interest and involvement in load research; (d) costs of load research in terms of money, people and time. [Note: an example of a cost breakdown is included to illustrate the detailed considerations that are involved.]

TITLE: SUMMER AIR CONDITIONING and APPLIANCE USE PATTERNS: A GRAPHICAL ANALYSIS

SOURCE: Princeton University/Center for Environmental Studies

AUTHOR(S): J.A.Robinson & J.Yeung
PREPARED BY AUTHOR(S) AND/OR: Princeton University/C.E.S.

DATE OF ISSUANCE: 5/75
OTHER IDENTIFIERS: C.E.S. Report No. 22 (Sponsored by NSF/RANN); available from NTIS as PB-252 686
DATA USE RESTRICTIONS:

TOTAL:[PAGES 33 ;REFERENCES ;GRAPHS 24 ;TABLES] *
DOCUMENT CLASSIFICATION(S): 34/1,4,8,14,21,24,33,37,47;56,57

ABSTRACT: *[Information of (mainly) direct and secondary relevance to the subject matter of this Compilation is scattered thruout the Report. The Total(s) are for the entire Report.]

The authors were primarily concerned with understanding the patterns of electric usage for individual appliances across time, as well as relating this consumption with outside weather conditions, especially outside temperature. The sources of the data for this study are 3 highly instrumented townhouses located in the planned community of Twin Rivers, N.J. The houses are situated adjacently in a row of townhouses and are identical 3-bedroom units. Various plots and graphs cover: measurements on outside temperature; use of air conditioning in each house; use of lights, appliances and hot water; thermostat settings; use of air conditioning vs outside temperature; use of air conditioning fan, refrigerator and dryer, per hour; and the total electric consumption for each house. The general form of these graphs are influenced a great deal by air conditioning use. In addition, peaks in the hot water heater and range consumption appear as peaks in the total electric consumption trends.

The aim of this Report is to take a first step toward understanding how electricity is consumed in residential housing during the summer. Although the report's graphs exhibit distinctive patterns of air conditioning and electrical appliance usage, caution is warranted in generalizing from these data to other residences in different parts of the country. More detailed analyses of these data will be undertaken, which include studying the homes in terms of heat conduction and storage and in attempting to balance the inputs vs the outputs. In addition, the data base is being expanded to include more townhouses, which will provide a better estimate of the magnitude of house-to-house variation in electricity consumption.

TITLE: ENERGY USE and CONSERVATION in the RESIDENTIAL SECTOR: A REGIONAL ANALYSIS (NSF-RA-N-75-307)

SOURCE: RAND Corporation

AUTHOR(S): S.H.Dole
PREPARED BY AUTHOR(S) AND/OR: Rand Corporation (for NSF/RANN)

DATE OF ISSUANCE: 6/75
OTHER IDENTIFIERS: Rand Report R-1641-NSF; available from NTIS as PB-254 468
DATA USE RESTRICTIONS:

TOTAL:[PAGES 60 ;REFERENCES 12 ;GRAPHS 14 ;TABLES 16] * 56,57
DOCUMENT CLASSIFICATION(S): 34/1,4,8,11,12,16,17,22,24,25,28,31,33,47,52,

ABSTRACT: *[Material of direct and (mainly) secondary relevance to the subject matter of this Compilation is scattered thruout this rather lengthy Analysis. The Total(s) refer to the relevant data.]

This Study estimates consumption of all forms of energy in the residential sector by their major end uses, for each of the 9 census regions of the USA, for the base year 1970. A methodology, based in part on econometrics, then makes projections to the year 2000. Various conservation measures are then considered for future application and alternative sets of policy actions are postulated. The region-by-region effects of these actions, in producing reductions in energy consumption, are estimated. The objective of this study has been to axiomize various residential energy conservation policies, as to their effectiveness in producing energy savings. A regional approach was adopted to account for the possibility of significant differences among climatic regions.

The analysis states that space heating is by far the largest user of energy in the USA residential sector. The procedure for estimating energy use for space heating in each region was based on residential gas consumption figures. Correlation with HDD (per calendar quarter) permitted excluding the non-space heating uses in each region; these data were then combined with gas-heating saturation figures (from the 1970 Census of Housing) to obtain estimates of the "quality" of the average house in each region, with respect to its ability to retain heat. A thermal integrity factor is introduced, defined as a house's heating requirements in BTU per sq. ft. of floor area per HDD. Note: The average value of the factors range from about 10, in 5 of the regions, to over 15 in the West South Central region. [Energy use levels for space heating with electricity, oil and other fuels were estimated from these factors.]

The second largest household use of energy is water heating. Consumption levels by regions were estimated from 1970 water heater saturation data and mean ground-water temperatures, which were used to give an indication of regional climatic variations. The average USA electricity use (at 3413 BTU/KWH) was estimated at about 15 million BTU/year per housing unit; the 9 regional averages ranged from about 13.2 to 16.2 million.

Consumption of energy for air conditioning was estimated from: 1970 Census data on saturation; the number of hours over 80°F in each region for room units; the number of CDD in each region for central installations; and average EER levels for the stock of air conditioners. Note: The average room air conditioner was estimated as using 11,570 BTU/hour at an EER = 6.5.

Energy consumption levels in the other major end uses in the residential sector were estimated from (1970 Census) saturation and appliance shipment data plus national average per-unit consumption figures, from various published sources. Regional variations in consumption levels appear to be small.

The projection technique used in this analysis computes future saturations of 4 major appliances (space heating, water heating, cooking and clothes drying) according to the fuels that are used in them plus saturation computations for two electric appliances with rapidly increasing saturations (air conditioning - both room and central - and home food freezers). This methodology compares actual saturations in 1970 (i.e., Census values) with estimated 1970 saturations computed from actual 1960 values, using fuel prices as the predictive variables. This comparison enables one to separate the effects of fuel prices from other effects on the saturations of appliances in a region. Nonprice factors, influencing the decisions of consumers as to whether (for example) to buy a gas-fueled or an oil-fueled appliance or their electric counterpart, would include convenience, comfort and cleanliness. Other factors than price are not specified but their combined effect may be quantified by comparing observed saturations with those that would be predicted on the basis of price alone.

The analysis contains several Figures and Tables relating to the broad aspects of electrical consumption. Examples from the Figures: residential energy use in the USA; heating/cooling requirements of several houses, with various thermal installations; energy required for space heating; relative efficiency of unit air conditioners; energy consumption of refrigerators. Examples from the Tables: summary of residential energy use, 1970; data from previous studies; characteristics of single-family housing; heating/cooling requirements in 6 different climates; energy consumption by air conditioners, water heaters, cooking stoves, clothes dryers, refrigerators and for lighting; annual-average energy consumption of consumer products; 1970 appliance saturation; estimates of the residential use of energy for 1980 and 1990 and year 2000.

TITLE: THE 1970 NATIONAL POWER SURVEY (in FOUR PARTS)*

SOURCE: FPC

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 12/71 for Part I; 1970 & 1972 for (assembled) Part IV**
OTHER IDENTIFIERS:

DATA USE RESTRICTIONS: May be ordered from GPO; for example, Part IV is identified as: GPO 1972 (0-356-241)
TOTAL: [PAGES 124 ; REFERENCES 96 ; GRAPHS 52 ; TABLES 30] *** 57
DOCUMENT CLASSIFICATION(S): 35/4,5,9,10,16,17,23,25,34,37,38,47,50,52,55,

ABSTRACT: *[Part I contains the report of the FPC and the independent report of the Task Force on Environment. Parts II and III contain the reports of the six Regional Advisory Committees. Part IV contains the reports of the Technical Advisory Committees on: Generation, Transmission, Distribution and Load-forecasting Methodology.]

**[Parts II and III have essentially no material applicable to this Compilation. The individual reports that comprise Part IV were issued in 8/71 (for Generation), 2/71 for Transmission, 6/69 for Distribution and during 1969 for Load-Forecasting Methodology.]

***[Information of direct or secondary relevance to the subject matter of this Compilation is scattered thruout these extensive volumes. The Total(s) cover the relevant material in Parts I and IV, which is found mainly in Chapters 3 and 14 of Part I and in the Distribution and Load-Forecasting Methodology Reports of Part IV.]

The Report projects electric load growth until 1990 and discusses: changing power technology; growing concerns for all developments, including use of resources and various impacts on air and water and land; increasing problems in meeting schedules for needed new power facilities; power plant fuel supply problems and the probable effect of these on the cost of power. This FPC report is intended to serve as a general, long-range guide rather than a directive or firm plan; it illustrates possible patterns of efficient development (based upon assumptions outlined in the report) and, with the passage of time, modifications to reflect variances from the assumptions will be in order.

Part I tabulates data on: (1) the number of electrically heated dwellings in the USA, for the period 1964-90; (2) % saturation levels of various appliances, for 1960 and 1965 and 1970; (3) approximate (1969) wattage ratings and estimated annual KWH usages of 58 appliances, with wattages ranging from 2 to over 12,000 and annual KWH ranging from 5 to about 16,000; (4) annual KWH energy sales per new residential customer (single-

family as well as multi-family) for 1965 and (estimated) for 1970, 1980, 1990.

The Survey calls attention to the fact that the electric utility industry is a composite of many individual utilities, operating under widely different types of organizations with different financial structures and controls and regulatory requirements. Investor-owned utilities comprise the largest segment of the industry. They distribute about 77% of the total electric power requirements of the USA. Publicly-owned utilities include those owned by the federal, state and municipal governments as well as public power districts and rural electrification cooperatives; this sector distributes nearly all of the remaining 23% of the requirements. [Note: The electric power produced and used internally by individual industrial plants is not here considered part of the electric utility industry and is outside the scope of this Report.]

Under "General Considerations," Part IV contains information on: (1) 1970 energy sales by customer class; (2) estimates - by customer class - of the growth in annual energy use, for 1970-90; (3) growth in area load densities.

Part IV contains an Appendix which deals with distribution system loads; of principal concern are the energy-use and demand characteristics of the distribution customer, both today and as projected to the year 1990, altho it is evident that any projection of loads and demands over a 20 year period can serve only as a general guide reflecting the best judgment of the electric utility industry at this time. The information in the Appendix consists of national averages for the contiguous USA (excluding Alaska and Hawaii). More than 99% of the customers are classified as non-farm residential, farm (excluding drainage and irrigation pumping) and commercial. These classes of customers use only about 50% of the energy sold. [The industrial customers, who are relatively few in number, use most of the remainder.] The Appendix has tabulations of: (1) the number of "end-use" customers, by class, for 1965 (actual) and for 1970, 1980, 1990 (estimated); energy sales, by class, for 1965 (actual) and for 1970, 1980, 1990 (estimated); energy sales, by region of USA, for nonfarm residential and commercial customers, for 1965 (actual) and, 1970, 1980, 1990 (estimated); energy sales per new residential customer (by regions and type of dwelling and by annual KWH as "small," "medium" and "large" user) for 1965 (actual) and 1970, 1980, 1990 (estimated).

The nature and purpose of "forecasting" are discussed in general terms in Part IV. It is stated that the process of forecasting electric utility loads follow the same principles that apply to all forecasting. [Forecasting (as the term is used in this Report) refers to the systematic process of defining the future in sufficient quantitative detail to permit important decisions to be made.] It is pointed out that a fundamental uncertainty exists in forecasting no matter how much data are collected or how sophisticated the approaches used may be; even so, it is reasonable to expect that the collection of better measures and the application of improved techniques will improve forecasting accuracy. Methods and

techniques used for each type of load forecast (and their relative accuracies) are discussed. Special circumstances that have an effect on load characteristics and trends are pointed out. The Report also emphasizes the need for the development of new methods that are responsive to changes in the nature of demand and energy growth. Attention is also given to the possible further impact on forecasting of the expanded use of modeling techniques and computer applications. Included are detailed descriptions of specific forecasting methods, a bibliography of selected papers on the various topics covered in the Report and a list of historical and forecasted data available from government and industry.

Part IV contains a Section which deals with the use for forecast purposes of the consumption patterns of residential, commercial and industrial customers; it states that the patterns vary substantially. The residential component of load, while having the most constant annual growth rate, is probably the most seasonally volatile load of the three; its influence on its proportion of total load and the promotion and acceptance of air conditioning and space heating. This Section has: (1) graphs of seasonal energy use patterns for the 3 preceding classes of customers; (2) daily load demand patterns for selected residential appliances; (3) monthly plots which reflect the seasonal changes in residential electricity use as affected by climate control devices, in both the residential and commercial class of customers.

Part IV discusses (in some detail) the data requirements for load forecasting, explaining that such data may be grouped into 3 broad categories: utility, weather and economic, both national and regional; each of these is important in load forecasting. Utility data is defined as that which originates in the utility itself but which also may be collected and presented by other agencies. [Note: The trend of "historical" data is an important element in considering the future, especially when interpreted in the light of other information such as weather and economic data.] Weather data reflect meteorological factors and these may affect load in an important way; the predominant weather factor for most systems appears to be temperature. Economic data (mainly national and regional) comprise a large body of information measuring the status and performance of the economy; they are important because customer growth and increasing power consumption depend ultimately on economic development. The Report reviews some of the data in general use by electric utilities in load forecasting. Some of the problems and inconsistencies of such data are discussed, as are the methods for its preparation and treatment. Attention is also directed to: (1) data adjustment; (2) the specifics of weather and economic data; (3) basic forecasting methods; (4) statistical analysis of data.

Other sections of Part IV (which are also related to the general topic of load forecasting) deal with: (1) various modeling techniques, generally categorized as economy-based or non-economy-based; (2) the use of computers for data accumulation and adjustment and for analysis and probability forecasting; (3) data collection techniques; (4) a description of TVA's forecasting practice; (5) descriptions of econometric models, e.g. for forecasting residential electricity demand.

TITLE: ALTERNATIVE FUTURE ELECTRICITY GENERATION REQUIREMENTS for the STATE of WISCONSIN

SOURCE: Institute for Environmental Studies; University of Wisconsin-Madison
AUTHOR(S): W.A.Buehring; et al
PREPARED BY AUTHOR(S) AND/OR: I.E.S.

DATE OF ISSUANCE: 10/74
OTHER IDENTIFIERS: I.E.S. Report 26; Energy System and Policy Research Report No. 4; NSF/RANN Grant #GI-43088
DATA USE RESTRICTIONS:

TOTAL: [PAGES 33 ;REFERENCES 10 ;GRAPHS 7 ;TABLES 10] *
DOCUMENT CLASSIFICATION(S): 35/10, 21, 34

ABSTRACT: *[Information of (mainly) secondary relevance to the general subject matter of this Compilation is scattered thruout the Report. The Totals exclude those portions dealing with Industrial data.]

This Report is one of a series of descriptions of research conducted by the Energy Systems and Policy Research Group at the University of Wisconsin-Madison. The overall goal of the project is the development of quantitative policy analysis tools and the analysis of policy alternatives related to the energy futures of Wisconsin.

A comprehensive regional energy model (The WISE Model) was developed as part of the project effort. In response to the specific need for electricity demand forecasts (prior to any proposed installation of additional electrical generating capacity), the model has been used to provide such forecasts thru the year 2000 under a wide range of assumptions that include: state population; the nature of economic growth; consumer preferences; and energy conservation measures. The model is structured to permit the study of the effects of specific assumptions about these causal factors, as contrasted to the conventional energy trend projection techniques which tend to mask discrete effects.

The cases shown in this report are not absolute predictions but rather are intended to provide insight into possible electricity futures for Wisconsin. A problem encountered in attempting to identify specific factors related to electricity consumption, and then using those factors to predict future demands, is that future technology advances or policies could result in massive changes in electricity demands. For example, a significant penetration of solar energy systems into the heating and cooling market could markedly affect the electricity requirements in the time period covered by these forecasts. [The divergence of the results of this study merely reflects the divergence of assumptions used in obtaining them.]

None of the energy futures derived by these studies should be considered as a "best" forecast but rather should be looked upon as providing an indication of the response of the energy system to changes in the factors responsible for electricity demands and as drawing some tentative boundaries on what the future may hold.

TITLE: ELECTRIC POWER SYSTEM PLANNING in the COMMONWEALTH EDISON COMPANY

SOURCE: Proceedings of Conference on "Energy Systems Forecasting, Planning and Pricing"; University of Wisconsin-Madison; 9/23-10/3, 1974
AUTHOR(S): E.L.Michelson
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 2/75
OTHER IDENTIFIERS: pp 181-201; edited by C.J.Cicchetti & W.K.Foell

DATA USE RESTRICTIONS:

TOTAL:[PAGES 7 ;REFERENCES ;GRAPHS 2 ;TABLES 4] *
DOCUMENT CLASSIFICATION(S): 35/17,19,45,55,57

ABSTRACT: *[This Paper contains material of secondary relevance to the subject matter of this Compilation, mainly in its Appendix 1. The Total(s) are for the relevant content.]

From Commonwealth Edison studies - which correlate with other similar studies - it has been concluded that for a system with an annual load factor of 55 to 60% the ideal mix of units is: Base Load (50 to 55%); Cycling (25 to 30%); Peaking (15 to 20%). [A range of values is given because of the uncertainties in the many variables involved.]

As a rough check of the relationship between costs for base load and peaking capacity, tabulated values are given which show the KWH cost for these types of units for operating 600, 1500 and 6000 hours per year. While the unit cost figures are "out-of-date", the comparative results are still valid; they show that "peakers" are economical if they operate at a low annual capacity factor.

Appendix 1 of this Paper discusses Load Forecasting Methodology studies to determine whether summer peak loads should be analyzed in total, or reduced into meaningful segments. Investigation of factors causing these peaks indicated that the load was composed of 2 major components, namely a base load which changed with economic conditions and a heat sensitive component which varied with weather. The C.E. base component has been increasing at a rate of about 6% annually and represents about 2/3 of the summer peak; the remaining third was growing at a much more rapid pace. C.E. developed a technique to separate the load components and to analyze and forecast each separately with different forecast models. These models use estimating equations based upon the statistical method of correlation, discovering and measuring the relationship of various factors and expressing it in a brief equation.

In these models use is made of historical data for peak load, output, a computed year and day number, monthly Federal Reserve Board Index of Industrial Production (seasonally and non-seasonally adjusted) and significant weather data. These data were collected for every day since 1959 and put on magnetic tape. A computer program was developed to extract the data for any mix of days and to use it in a multiple regression program.

TITLE: SHORT TERM LOAD FORECASTING (A PAPER FROM "SYSTEMS ENGINEERING for POWER: STATUS and PROSPECTS")

SOURCE: Proceedings of an Engineering Foundation Conference sponsored by ERDA & EPRI; Henniker, New Hampshire; 8/17-22, 1975
AUTHOR(S): F.D.Galiana
PREPARED BY AUTHOR(S) AND/OR: University of Michigan

DATE OF ISSUANCE: 10/75
OTHER IDENTIFIERS: pp 105-115 (includes discussion); CONF-750867 (applies to entire collection of papers)
DATA USE RESTRICTIONS:

TOTAL: [PAGES 11 ;REFERENCES 26 ;GRAPHS ;TABLES] *
DOCUMENT CLASSIFICATION(S): 35/10, 45

ABSTRACT: *[Contains material of (mainly) secondary relevance to the subject matter of this Compilation. Some of the References are rather general in character.]

This Paper summarizes the "state-of-the art" (up to June 1975) in the field of short-term load forecasting in electric power systems. The prediction times considered here are of the order of minutes up to several weeks but many of the forecasting techniques are applicable to longer terms, of months and even years. A classification and qualitative comparison of the principal techniques used in the field is made according to: the type of model used, its application, the identification of model maintenance requirements (i.e., sensitivity to load behavior changes), forecasting requirements, data needs, claimed accuracy and other criteria. Some operating experiences are described and the author's evaluation of the mehtods available are presented. Fianlly, various recommendations for further research and development in short-term load forecasting are put forward.

The Paper summarizes some of the published accuracy results. For example, where considerable operating experience has been gained, peak prediction errors during 1973 and 1974 averaged around 2% and showed an improvement of 1.4% over operator forecasts. In the time series models, one investigator obtained an average error varying from 2% for a one-hour prediction to 4% for a 24-hour prediction. In the dynamic models, another investigator found average errors ranging from 1% for a one-hour prediction to 2.5% for a 24-hour prediction, with perfect weather information.

TITLE: ESTIMATING FUTURE ELECTRICITY DEMAND in an ERA of INCREASING ENERGY SCARCITY (CONF 751101-71)

SOURCE: ORNL

AUTHOR(S): W.S.Chern; et al
PREPARED BY AUTHOR(S) AND/OR: ORNL (Analysis and Evaluation Department, Energy Division)
DATE OF ISSUANCE: 11/75
OTHER IDENTIFIERS: For presentation at American Nuclear Society Meeting; San Francisco, California; 11/16-11/21, 1975
DATA USE RESTRICTIONS:

TOTAL:[PAGES 24 ;REFERENCES 18 ;GRAPHS 1 ;TABLES 6]
DOCUMENT CLASSIFICATION(S): 35/9, 10, 13, 16, 21, 47

ABSTRACT: *[Material of direct and (mainly) secondary relevance, to the subject matter of this Compilation, is scattered thruout this Paper. The Total(s) are for the entire Paper.]

This Paper compares forecasts for electricity use in the residential, commercial and industrial sectors (by using trend extrapolation and by an econometric model). The principal merit of the model is that it relates future electricity demand to changes in individual causal factors, whereas the trend method simply extends past history. Thus the detailed knowledge of the demand structure, which is part of the econometric model, provides an analytical framework for forecasting demand during periods of abrupt changes in the causal factors. If future prices of electricity (and other substitutes) fall into the assumed range of this Paper and if future levels of income, population and other independent variables are consistent with the assumptions, then the econometric model predicts that total electricity demand in the USA will increase 3.8 to 4.1% per year during the period 1973-85. On the other hand, trend extrapolation yields a (forecasted) annual growth rate of 6.9% for this period.

Forecasts made with econometric models are probabilistic statements since there may be errors related to estimates of explanatory variables and/or errors due to future structural change. The authors did a sensitivity analysis by specifying three sets of assumptions regarding future prices of various fuels; they found that the forecasts do vary, depending upon the assumptions used. Therefore, the validity of the forecasts depends upon the accuracy of these assumptions. Furthermore, there exists the possibility of a structural change due to the possible shortages of some energy sources since such shortages may result in greater interfuel substitution than their model could predict, based solely on the market mechanism. While the model cannot adequately measure the consequences of these potential shortages, these impacts can be evaluated separately.

TITLE: ELECTRICITY DEMAND: "PROJECT INDEPENDENCE"and the CLEAN AIR ACT

SOURCE: ORNL (Energy Division)

AUTHOR(S): L.D.Chapman; et al
PREPARED BY AUTHOR(S) AND/OR: ORNL (for NSF/RANN)

DATE OF ISSUANCE: 11/75
OTHER IDENTIFIERS: ORNL-NSF-EP-89 (may be ordered from NTIS by this number); Environmental Program
DATA USE RESTRICTIONS:

TOTAL:[PAGES 12 ;REFERENCES 9 ;GRAPHS ;TABLES 2] *
DOCUMENT CLASSIFICATION(S): 35/9, 10, 17, 18, 21, 34, 47

ABSTRACT: *[Material of (mainly) secondary relevance to the subject matter of this Compilation is scattered thruout this Study. The Total(s) are for the relevant data.]

This document was prepared for the Task Force on Conservation and Fuel Supply of the National Power Survey (NPS).

Forecasting electricity demand and capacity requirements is stated to be an unresolved methodological problem. Methods in current use can be described as being either exponential growth or demand analysis. In the past, the NPS used 10-year, short-run forecasts which are summaries of utility planned expansion programs. [These summaries are prepared by the 9 regional National Electric Reliability Councils (NERC).] This forecast essentially extrapolates the experience of the post World War II era and predicts a doubling in total generation every 9 or 10 years.

Forecasting by demand analysis employs independent projections of economic factors influencing demand growth and statistical estimates of the magnitudes of the relationships between these factors and the quantity of electricity demanded. The basic model relates the quantity of electricity demanded to a set of explanatory variables, including: the number of customers; income per capita; the prices of electricity and substitute fuels and electrical equipment. [These variables are expressed as natural logarithms in a linear regression framework.] The data used to estimate the model are annual observations for the years 1963 to 1972 for each of the contiguous states in the United States plus separate models for residential, commercial and industrial customers. Since all variables are expressed in logarithms, the coefficient for a particular explanatory variable (such as income) is an estimate of the "short-run" elasticity of the demand for electricity with respect to that variable.

Coefficients are included for the (estimated) demand models for electricity use for the 3 classes of customers. NERC and demand analysis projections are compared for 1974 thru 1980. Estimated "long-run" elasticities of demand are tabulated for the above explanatory variables.

TITLE: LOAD - FORECASTING TECHNIQUES EVOLVE to MEET NEED

SOURCE: Electrical World, 2/1/76 (pp 36-37) and 2/15/76 (pp 47)

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: E.W.

DATE OF ISSUANCE: 2/76
OTHER IDENTIFIERS: Transmission/Distribution (Engineer's Forum)

DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL: [PAGES 3 ;REFERENCES 1 ;GRAPHS 1 ;TABLES] *
DOCUMENT CLASSIFICATION(S): 35/14, 21, 55

ABSTRACT: *[Material is (mainly) of secondary relevance to the subject matter of this Compilation.]

These articles mainly consist of replies to the question: How can utilities achieve better performance in predicting future peaks than they have registered in recent years? The responses indicated that a growing number of utilities are working with econometric models, which attempt to describe the interplay of electricity usage with various other economic statistics. [This marks a rather abrupt departure from traditional methods of forecasting.]

One utility states that they can no longer accurately forecast loads, so they concentrate on finding the range of probable load-growth rates. Another says its forecasting methodology is structured on a philosophy (of several described guidelines) rather than on a single technique. Still another bases its forecasts (of energy use and peak demands) on economic and demographic variables which also account for the impact of conservation and rising energy prices; the variables are discussed, in summary fashion. The influence of temperature, population and economic factors are emphasized in other replies.

TITLE: PROCEEDINGS on FORECASTING METHODOLOGY for TIME-OF-DAY and SEASONAL ELECTRIC UTILITY LOADS

SOURCE: EPRI's "Energy Demand and Conservation Program"

AUTHOR(S): J.W.Boyd (Editor); W.G.Michaelson, et al
PREPARED BY AUTHOR(S) AND/OR: EPRI (Palo Alto, California) + FEA + various utilities and universities
DATE OF ISSUANCE: 3/76; Workshop held on 12/4 & 12/5, 1975
OTHER IDENTIFIERS: EPRI Workshop Report SR-31; available from NTIS as PB-251 444
DATA USE RESTRICTIONS:

TOTAL:[PAGES 259;REFERENCES 97 ;GRAPHS 2 ;TABLES 3] *
DOCUMENT CLASSIFICATION(S): 35/5,9,10,14,16,17,21,23,34,36,37,45,47,50,55

ABSTRACT: *[This rather extensive collection of Workshop Papers includes material of direct and (mainly) secondary relevance to the subject matter of this Compilation. All References are included in the Total(s), because in the main they are of (at least) general interest; also all Pages are included since relevant material is scattered thruout these Proceedings. The Paper: "Estimation of the Residential Demand Cycle for Electricity" by R.Koenker & W.Hendricks is particularly pertinent.]

The intent of the Workshop was to develop information on the current state-of-the-art of seasonal and time-of-day forecasting and to explore new techniques for handling long-run (conditional) forecasting problems. Topics discussed include: model selection, short-term forecasting, model identification in peak power demand forecasting, intermediate term forecasting of system loads using a special form of time series analysis, load forecasting methodologies in the electric utility industry, estimation of the residential demand cycle for electricity, recent developments in forecasting techniques and strategy, time-series modeling and forecasting, industrial and commercial rate structures and econometric estimation of the demand for electricity.

The EPRI has a major responsibility for forecasting energy consumption patterns over a 10- to 25-year period. This long-run emphasis is required for such forecasts to be relevant inputs to EPRI's technological Research and Development planning program. While EPRI's research efforts are oriented primarily to the R&D planning process, it is expected that methodologies developed to cope with these problems will be useful to the individual utilities' planning efforts.

In contrast to data on annual consumption, it is stated that it has not been possible to find a body of theoretical or empirical literature that could be readily adapted to the problem of forecasting the shapes of future load curves. It was found that the major part of the literature on forecasting demand concentrated on short-run peak loads rather than on developing a parametric characterization of the entire time-of-day or seasonal load curve. Of particular concern is the fact that time-of-day and seasonal utility load curves have shown a great deal of variation

from what appear to be basic underlying patterns dictated by weather and lifestyle; an important source of such variations are technological innovations (recent and future).

In addition to technological change, the long-run effects of levels of income and output and energy prices also create the possibility of significant changes. As an example, will higher electricity rates induce people in hot climates to have central and room air conditioners turned-on later in the day and turned-off earlier than had previously been the case? Will higher levels of income offset such an effect? Long-run forecasting must also take account of the possibility of load management schemes such as peak-load pricing and centrally controlled load management thru (for example) ripple control.

The Koenker and Hendricks paper notes that, unlike most commodities which are consumed at discrete points of time, electricity is used as a continuous flow. Numerous studies of the demand for electricity have sought to explain and to forecast the integral of this demand flow over some period, usually a year. Interest is now turning to the problem of understanding and forecasting the shape of the intrinsic demand cycle because of the technological fact that the cost of generating the power to satisfy a given demand integral is highly dependent on the path of the integrand.

This Paper presents a statistical model of the cycle of residential consumer's demand for electricity. The parameters chosen for the statistical model assume that the daily demand cycle for electricity can be well approximated by a periodic cubic spline - a class of piecewise cubic polyomials. [This form has a convenient feature in that it allows a representation which is linear as regards the parameters.] The parameters of the spline function which define the shape and height of the daily demand cycle are in turn taken to be linear functions of certain economic and demographic characteristics of consumers, namely: (a) mean family income; (b) index of stock of electrical appliances; (c) mean number of persons per housing unit; (d) proportion of housing units with air conditioning; (e) estimated mean age of houses; (f) mean number of rooms per housing unit.

The data on electricity consumption used in this paper were provided by Commonwealth Edison. For many years Commonwealth has metered hourly electricity consumption at selected (combined) "load sites" thruout Chicago, Ill. and the surrounding area, with each site containing from about 10 to about 350 customers. From approximately 100 load sites, 40 sites were selected for analysis. [These 40 sites represent nonspace heating residential customers, exclusively.] While such data is gathered continuously, the authors were primarily interested in electricity consumption during peak periods. They limited their analysis to cover the week in which the system peak occurred: Aug. 25-31, 1973; the weekend days were also excluded because they are "off-peak" in almost any system. These data are expressed as hourly usage per customer (at each site) by dividing the number of KW used by the number of "non-zero-demand" customers.

TITLE: FORECASTING ENERGY USE: THE RESIDENTIAL SECTOR

SOURCE: EPRI Journal, pp 6-13

AUTHOR(S): J.W.Boyd
PREPARED BY AUTHOR(S) AND/OR: EPRI (Palo Alto, California)

DATE OF ISSUANCE: 4/76
OTHER IDENTIFIERS:

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TOTAL:[PAGES 8 ;REFERENCES 10 ;GRAPHS 2 ;TABLES] *
DOCUMENT CLASSIFICATION(S): 35/5,10,17,21,47,52

ABSTRACT: *[Contains material of direct and (mainly) secondary relevance to the subject matter of this Compilation.]

EPRI's interest in energy demand forecasting is stated to be based primarily on the need to set long-term R&D priorities. The focus is on the allocation of research funds among new technological alternatives, such as coal gasification, storage batteries, solar generators, load management devices and "fast breeder" reactors. To deal with its own allocation problem, EPRI is producing forecasting models; this effort may also provide improved forecasting methods for the planning activities of individual utilities. A further by-product may be better forecasting tools available to the public at large.

Evolving technologies for energy use, increasing energy prices and rising personal income will critically affect both the need for electricity and the methods for providing same. Changing family characteristics, such as fewer children in each family and more women in the labor force, will affect the nature and extent of residential energy demand. Suggestions for dealing with these and other issues (in an economic forecasting framework) is the topic of this Article.

The Article comments on: (1) energy consumption growth, in general; (2) the influence on demand of "block" type rate structures; (3) models and modeling for forecasting demand; (4) time-of-day and seasonal forecasting; (5) changing patterns of electric use, as illustrated by HVAC applications.

Because of national policy interests, such as "energy independence", much of the early research in residential energy demand forecasting had to do with annual electricity use aggregated to the state or national level. [Most of the studies have related to economic-econometric structures and further development in this area is underway.] Problem areas remain, such as: data limitations, inherent difficulties with economic models based purely on time-series data and the inability of models-based on overly aggregated data - to accurately capture consumer behavior. Future research efforts must fill some of these gaps by concentrating more on household data, specific household appliance groups, time-series load forecasting and additional cross-section analysis.

TITLE: LONG-RANGE FORECASTING PROPERTIES of STATE-of-the ART MODELS of DEMAND for ELECTRIC ENERGY (Volume II: Annotated Bibliography) *

SOURCE: Charles River Associates, Inc. (Cambridge, Massachusetts)

AUTHOR(S): W.H.Hieronymus (Principal Investigator)
PREPARED BY AUTHOR(S) AND/OR: C.R.A. (for EPRI)

DATE OF ISSUANCE: 12/76
OTHER IDENTIFIERS: EPRI EA-221; Research Project 333 (J.Boyd, Project Manager)
DATA USE RESTRICTIONS:

TOTAL: [PAGES 42 ;REFERENCES 87 ;GRAPHS ;TABLES] **
DOCUMENT CLASSIFICATION(S): 35/10,13,16,23

ABSTRACT: *[Note: Vol. I (same Title) evaluates the long-range forecasting effectiveness of 8 econometric models believed to be of potential use in developing improved models for long-range forecasting at rather aggregated levels. The 90 references of Volume I are of general interest but nearly all of these are summarized in Volume II.]

**[Contains material of (mainly) secondary relevance to the subject matter of this Compilation. Total(s) are for the entire Bibliography. Note: 52 of the references have summaries of varying depth; the remaining 35 are not summarized.]

This Bibliography has been collected and annotated so as to inform load forecasters, analysts and other researchers of the content of extant research on electricity demand. The intent is to survey the literature rather than to review individual studies in depth; annotations are brief, outlining only major elements of methodology and major conclusions.

Three major selection criteria were (rather uniformly) employed. First, the bibliography focuses on studies which are not explicitly "short-run" (i.e., less than five years). Second, it was decided to exclude large-scale energy models. [Note: A number of energy models include an electricity sector but these electricity consumption sub-models tend to be highly summary in nature and not well suited to the needs of the practicing forecaster.] Third, the bibliography is largely limited to published materials which are available to all electricity demand researchers, i.e., proprietary models and forecasting studies conducted by individual utilities or state public utility commissions were generally not reviewed.

In the period since the beginning of the "energy crisis", research related to the development of long-term electricity demand models has mushroomed. This document includes a few studies published in 1975 and 1976 but the majority of such research is either incomplete or only recently available. This listing does not exhaustively survey this most recent literature. The reader is cautioned that ongoing and recent research will soon advance the state of the art of electric energy and load forecasting beyond that represented by the studies listed herein.

TITLE: SHORT-TERM FORECASTS GAIN in ACCURACY

SOURCE: Electrical World, 1/15/77, pp 64-65

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: E.W.

DATE OF ISSUANCE: 1/77
OTHER IDENTIFIERS: System Engineering

DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL: [PAGES 2 ;REFERENCES 1 ;GRAPHS ;TABLES 1] *
DOCUMENT CLASSIFICATION(S): 35/45, 50

ABSTRACT: *[Contains material of (mainly) secondary relevance to the subject matter of this Compilation.]

The main problem to be solved by an electric power system is to supply peak load and one of the major vexations of any electric utility is the forecasting of this peak demand. The historical load-demand forecasting procedures can be classified as conventional, probabilistic and stochastic.

Conventional methods use two basic approaches. One is direct extrapolation of the load-demand curve. The other makes use of the correlation between electricity use and such economic factors as gross national product, population growth and consumption per unit of production.

Probabalistic models have been developed for system peak-demand forecasts which use past weather/load data to determine "weather-sensitive" and "non-weather-sensitive" load models. Polynomial trend curves are fitted to the non-weather-sensitive demand and extrapolated to obtain the mean and the variance of the weather component. Then these two forecasts are combined to give peak-demand forecasts and their probability limits.

Stochastic methods involve the development of models that have as their output the evolving electrical demand, rather than a trend line.

The recently developed Box-Jenkins (B-J) method of forecasting is one that is well-suited for handling complex time series in which the basic pattern of data is not readily apparent. Other methods of forecasting assume, or are limited to, specific kinds of patterns in the data but in the B-J method there is initially no need to assume a fixed pattern.

The Article concludes that regression techniques are "ideal" for intermediate to long-term forecasting but cannot determine short-term trends, cycles or seasonal patterns. The B-J technique is considered the most accurate forecasting tool for the short term. Since the B-J technique is ideal for determining seasonality patterns in a time series, an hourly forecast may be used for any continuing load research.

TITLE: PREDICTING BUILDING ENERGY REQUIREMENTS (The Computer Dilemma)

SOURCE: Heating/Piping/Air Conditioning, pp 44-50

AUTHOR(S): J.M.Ayres
PREPARED BY AUTHOR(S) AND/OR: Ayres & Hayakawa Energy Management

DATE OF ISSUANCE: 2/77
OTHER IDENTIFIERS: Based on a Paper presented at the ERDA-Wide Energy Conservation Symposium held at Albuquerque, N.M.; 9/16-9/18, 1975
DATA USE RESTRICTIONS: Copyright by Reinhold Publishing Co., Inc.

TOTAL:[PAGES 7 ;REFERENCES 6 ;GRAPHS 6 ;TABLES 5] *
DOCUMENT CLASSIFICATION(S): 35/3, 9, 10, 11, 15, 30, 37, 44, 57

ABSTRACT: *[Contains material of (mainly) secondary relevance to the subject matter of this Compilation.]

Analysis of alternate energy conservation strategies for designing new buildings and retrofitting existing ones requires accurate calculations of (for example, monthly) energy loads that must be checked against appropriate utility rate schedules to obtain annual energy costs. Methodologies for calculating thermal performance of buildings, and their (associated) energy requirements, have developed rapidly in recent years.

It is now accepted that the rational way to calculate energy requirements is to employ computers to conduct hour-by-hour calculations of all building loads over a full year of weather data. HVAC systems respond to these dynamic loads and try to maintain temperatures dictated by system controls and equipment. To analyze the performance of these systems and their energy consuming components, they must be mathematically modeled or simulated and their hourly energy requirements calculated. These loads must then be integrated with other non-HVAC loads (such as "base" electric, cooking, domestic hot water, process, etc.) so as to arrive at total building demand and consumption loads.

The Article reports on the summarized results of its study of energy use prediction by computer programs. Four high-rise (California) residential buildings were first analyzed to establish the characteristics of "typical" rectangular and circular building models. Correlations were then computed for HDD, CDD, heating peak load and cooling peak load, all vs annual consumption; the correlations are shown plotted so as to indicate the effects of building shape and amount of glass area. The results of these correlations was said to be inconclusive altho they provided additional insight into the impact of the weather in the energy consumption of these particular models.

Four of the most widely used (commercial) computing programs were compared by being used to determine the annual and monthly energy uses for a 4 and a 12 story office building. Yearly energy consumptions (per sq. ft.) are shown for the 4 programs; monthly electrical uses (in KWH) are also plotted. The comparative results varied appreciably.

TITLE: LOAD FORECASTING - MODELING with JUDGMENT

SOURCE: EPRI Journal, pp 12-17

AUTHOR(S): A.Lawrence
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 8/77
OTHER IDENTIFIERS: An EPRI "program" article

DATA USE RESTRICTIONS: Copyright by Electric Power Research Institute, Inc. Permission to reprint is granted by EPRI.
TOTAL:[PAGES 6 ;REFERENCES 1 ;GRAPHS 1 ;TABLES 1] *
DOCUMENT CLASSIFICATION(S): 35/10, 11, 14, 17, 36, 37, 47, 57

ABSTRACT: *[Contains material of secondary relevance to the subject matter of this Compilation.]

Load forecasts have many different uses. The intended use of a forecast determines its time span and its level of detail. Generally, the longer the range of the forecast, the greater the need for detail because of the fact that as more and more factors are subject to change, the further one needs to project into the future. For short-run forecasts, these complicating factors can be ignored in favor of factors that have marked short-run variation, such as weather.

The Paper discusses the use of forecasts, as related to: (1) the promotion of conservation, thru the efficient operation of the power supply system; (2) measures for controlling the load curve; (3) determining the impact of new energy-using devices on electricity loads; (4) developing "models" of many behavioral and technological factors, such as rising family income and changing demographic patterns. The currently used methods of load forecasting are summarized, as are the methods being developed.

As to forecasting residential loads, the Paper states that the residential load profile (typically) has two daily peaks - in the morning and in the late afternoon or early evening. Winter heating and lighting loads shift the evening peak to a few hours later and flatten the night valley somewhat. Summer air conditioning advances the evening peak to the afternoon and partially fills the daytime valley.

Individual household load data can be combined with weather data plus survey data on household characteristics, so as to produce high-quality load projections. The household characteristics include an enumeration of appliances, type of dwelling and the demographic and economic characteristics of the family. When combined with "models" of appliance choice, these load forecasting models aid in evaluating the impact of changes in the efficiency or quantity of electrical appliances. The models can be extended to evaluate the load impact of new electrical devices. The reshaping of the load pattern resulting from secular changes in demographic and economic characteristics can also be estimated.

TITLE: HOW ELECTRIC LIVING AFFECTS the LOAD CURVE

SOURCE: Electrical World, 5/18/53, pp 155-164

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: E.W.

DATE OF ISSUANCE: 5/53
OTHER IDENTIFIERS: Load Studies (by 8 electrical utilities)

DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL: [PAGES 10 ; REFERENCES 8 ; GRAPHS 15 ; TABLES 6] *
DOCUMENT CLASSIFICATION(S): 36/1,2,4,6,8,12,13,30,37,47,52,55

ABSTRACT: *[Contains material of direct and (mainly) secondary relevance to the subject matter of this Compilation.]

The Article states that load balancing (thru the promotion of selected "revenue-building" appliances) is an answer to one of the most important problems facing electric utilities. The Article presents 8 sample studies to support this contention, as noted below.

Detroit Edison, as the result of a series of surveys and tests, singled-out ranges, dryers, water heaters and freezers for promotion. Plotted values show the (half-hourly) residential load plus (half-hourly) major appliance loads, before and after they were "reshaped" by the load balancing program.

Atlantic City Electric Co. studied a 20 home, all-electric, development to determine: the relationship of heating load to demand, the diversity of heating loads and the loading of distribution transformers. The homes were heated entirely by electric radiant glass panels; they are of frame construction and range in size from 5,825 to 7,100 cubic feet. All are insulated and equipped with storm sash. Average radiant panel load was 6.6 KW per residence.

Union Electric Co. metered the electric space heating installations of 7 of its customers. Houses chosen were "well insulated" and were 4 or 5 room, single family, varying from 5,768 to 9,607 cubic feet in size. Three homes had basements and 6 had storm windows. The (nameplate) heating load ranged from 5.0 to 9.2 KW, averaging about 1 KW per 1,000 cubic feet; theoretical load, based on the calculated heat losses, averaged about 22% higher than the actual load. For a period which included some 4,760 degree days, the average space heating usage was 12,520 KWH; other uses averaged about 6,013 KWH per year.

Duquesne Light Co. studies ("rural") residential customers whose loads included both electric ranges and electric hot water heaters. Controlled water heaters were found to use from about 270 to 315 KWH per month; un-

controlled heaters used about 325 KWH per month; ranges used from about 95 to 115 KWH per month.

West Penn Power Co. studied a circuit (serving 1,431 customers with 213 water heaters and 419 ranges) during a period of 3 weeks. Data was obtained for various modes of operation, either uncontrolled or time-clock controlled, to show how they would affect the feeder loads. Average KWH usage per customer per month (for tank capacities of somewhat over 60 gallons) ranged from about 250 to 325.

Duquesne Light Co. reported on another group of 60 electric clothes dryer customers, of whom 49 were metered and 41 were used for analysis of the collected data. [All except one dryer was rated between 3.9 and 4.9 KW, at 220 volts.] Annual KWH use per person (by family size) was reported as: 417 KWH (one person in "family"); 193 (2); 223 (3); 241 (4); 180 (5); 153 (6); 149 (7.7, average for over 6 in a family).

Portland General Electric Co. studied 7 homes in Portland, Ore. The results seem to confirm an earlier assumption that a severe winter would tend to fill up the "valleys" in the load curve without unduly increasing the demand; there is a greater use of energy in the hours after midnight.

Dallas Power & Light metered 14 central air conditioning installations (rated at over 2 HP) and found that their diversified maximum demand held steady at 5.6 KW from 3 to 6 p.m. Additionally 14 electric ranges were found to have a diversified maximum demand peaking at 0.62 KW at 6:00 p.m. Annual KWH for the AC units averaged 8,700; annual KWH for the ranges averaged 1,300.

TITLE: CREATIVE ELECTRIC LOAD MANAGEMENT

SOURCE: IEEE Spectrum, 2/75, pp 46-50

AUTHOR(S): T.Laaspere & A.O.Converse
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 2/75
OTHER IDENTIFIERS: NSF-supported study by Dartmouth College, et al

DATA USE RESTRICTIONS: Copyright by IEEE

TOTAL: [PAGES 5 ;REFERENCES 4 ;GRAPHS 1 ;TABLES 1] *
DOCUMENT CLASSIFICATION(S): 36/39, 45, 56

ABSTRACT: *[Information of (mainly) secondary relevance to the general subject matter of this Compilation is contained in this Paper.]

In the existing transition, between an era of abundance of relatively inexpensive electric energy and one in which energy of all types is relatively scarce and expensive, increasing emphasis is being placed on techniques which improve the efficiency of generation and distribution and usage of electricity. Such techniques are the basis of what is called load management or the programming of certain load segments, such as electric water heaters, for the purpose of smoothing out undesired "peaks" and "valleys" in the demand for electricity.

Load management techniques become attractive economically in order to increase the utilization of base-load generation capacity. In addition, with a significant portion of the load under remote control, it may be possible to reduce the requirements for "spinning reserve", since load reduction inherently increases this reserve. Remote load control also increases system security.

One basic requirement for load management is the existence of a deferrable load, such as an electric water heater. [How long such a load can be disconnected from the supply voltage without real inconvenience to the customer depends on a number of factors, a very important one being the energy storage capacity of the load.] In the USA, household water heaters presently represent essentially the only load segment having a substantial energy storage capacity. Since the average diversified demand of a water heater during peak hours is about one KW, a utility with 200,000 water heaters under control could thus reduce its load during the rush hour by about 200 megawatts.

The Paper summarizes new techniques that are being investigated (and field tested) for load management purposes. These "tools" include: electricity rate options, clock-activated switches and radio and (power-line frequency) ripple control systems.

TITLE: FIRST YEAR REPORT: VERMONT ELECTRIC UTILITY LOAD MANAGEMENT PROGRAM

SOURCE: Vermont Public Service Board (Coordinator); et al

AUTHOR(S): R.V.deGrasse, W.A.Gilbert, A.O.Converse, W.R.Veno; et al
PREPARED BY AUTHOR(S) AND/OR: V.P.S.B. (R.V.deGrasse, Deputy Commissioner)

DATE OF ISSUANCE: 2/75 *
OTHER IDENTIFIERS: Work sponsored by NSF/RANN Program

DATA USE RESTRICTIONS: Check with V.P.S.B. (Montpelier, Vermont)

TOTAL: [PAGES 128 ; REFERENCES 21 ; GRAPHS 35 ; TABLES 8] **
DOCUMENT CLASSIFICATION(S): 36/5, 11, 28, 31, 35, 38, 45, 55

ABSTRACT: *[This date is assigned to the overall report; portions are variously dated from 8/73 thru 10/74.]

**[This rather lengthy (progress) Report is divided into 9 Subreports and 3 Appendices. The material is of (mainly) secondary relevance to the subject matter of this Compilation and is primarily found in Subreports DVE-1, -3, -4, -6, -7; the Totals cover only the relevant material.]

Report DVE-1 (by Messrs Veno and Converse) is entitled: "On the Importance of Residential Electric Space Heating in Determining the Future Electricity Usage in the Central Vermont Region". This is the first report of a continuing effort to forecast the electrical energy consumption and peak demand requirements in Vermont. The problem of forecasting the energy and maximum power requirements is converted into the problem of forecasting the number of customers in each class, the per customer energy requirement of each class and the load factor of each class. In this report only the energy requirements are treated. The forecasts of customers and per customer energy requirements are generally based on the exponential growth observed over the past 7 years, the one exception being that the number of new residential electric heating customers is constrained so that it never exceeds the number of new residential customers.

Report DVE-3 (by W.P. Heim) is entitled: "Optimal Residential Insulation in Vermont"; however, DVE-3 is noted as being superseded - in large part - by a companion Report DVE-7 (also by W.P. Heim), "Insulation Standards for Vermont Residences". These reports include: (1) data on savings in electricity use for various combinations of insulation and (2) energy consumption factors vs HDD, for houses with and without their room temperatures being individually controlled.

Report DVE-4 (by Veno) is entitled: "An Examination of the Dynamics of Electric Storage Heating Systems in the Central Vermont Region". [DVE-4 is expanded upon by DVE-6 (also by Veno), "Storage Heating Evaluation".] Report DVE-4 deals with storage radiator heating, a concept which is new to USA practice; in fact, the Central Vermont Public Service Corp. is the first electric utility in the USA to start evaluating such technology on a test basis. The technique employed in storage radiator heating consists of the heating of electric coils imbedded in high heat capacity bricks, which are located in an insulated enclosure. Heat is then drawn from the bricks, as required by the house, using a (room) thermostat-controlled fan. The energy demand for charging the storage units is on the system during the off-peak daily cycle, resulting in a reduction in the peak daily demand and an improved load factor. [Note: the energy received by the storage units during this charging period must be adequate to meet the heating requirements thruout the remainder of the day.]

Report DVE-6 describes the model which is used to determine the impact of storage heating on a winter-peaking system. Based on a comparison of the system capacity savings with the storage heat costs, it is concluded that storage heating is generally economically advantageous in terms of both initial and equivalent annual costs.

Other parts of this document deal with: (1) European approaches to managing the electrical load; (2) a marginal-cost approach to experimental rate design for an electric utility; (3) technical alternatives for load management,with implications for rate structures.

TITLE: LOAD-MANAGEMENT STUDIES GET UNDER WAY

SOURCE: Electrical World, 8/1/75, pp 70-71

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: E.W.

DATE OF ISSUANCE: 8/75
OTHER IDENTIFIERS: Energy Marketing

DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL:[PAGES 2 ;REFERENCES ;GRAPHS ;TABLES 1]*
DOCUMENT CLASSIFICATION(S): 36/5, 13, 16, 38, 39

ABSTRACT: *[Contains material of secondary relevance to the subject matter of this Compilation.]

FEA has funded 7 demonstration projects in fiscal-year 1975 to learn more about (and to try to measure) the effect that rate changes and load management may have on utility systems, as well as customer reaction to such changes. The customer groups include residential, commercial and industrial classes. The demonstration projects involve air conditioning, water heating, space heating and use of solar energy. [In FY 1976, FEA expects to continue funding these projects, along with other projects not yet chosen.]

Most of the demonstrations will involve the collection of electrical usage data, on both a KWH and KW basis.

TITLE: CURTAILABLE SERVICE RATES CAN CUT PEAKS

SOURCE: Electrical World, 10/1/75, pp 68-69

AUTHOR(S): E.V.Sherry
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 10/75
OTHER IDENTIFIERS: Energy Marketing

DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL: [PAGES 2 ;REFERENCES 1 ;GRAPHS 1 ;TABLES 1] *
DOCUMENT CLASSIFICATION(S): 36/5, 19, 55

ABSTRACT: *[Contains material of (mainly) secondary relevance to the subject matter of this Compilation.]

Recently the use, availability and desirability of interruptible rates as a load-management tool has received much attention. Despite the fact that this form of service has been used for decades, it is not well publicized or understood.

Curtailable power is electricity service of lower reliability. But only if its limitations are clearly defined is this service acceptable to customers, while still of value to the utility. It is acceptable to customers only so long as the utility is maintaining a high degree of reliability for its firm service.

Unlike interruptible gas, the users of interruptible electricity do not normally have an alternate source of power and must, therefore, curtail their production to satisfy utility supply conditions. Also most curtailable-load rate schedules are based on seasonal variations in demand and on "spinning-reserve" requirements of the utility and not, for example, on the availability of water for generation. It therefore aids clarity and avoids unsatisfactory comparisons if the term "interruptible" is limited to hydroelectric and standby situations.

Utilities offer curtailable service to improve system load factor. With a typical utility load factor of 62%, the top 5% of demand occurs during only about 200 hours of the year. Since curtailable-type customer loads typically have a high load factor, they can add to all but the peak hours of the load-duration curve and thus improve the overall load factor and use of utility equipment. A second reason for utilities to encourage curtailable service is to improve the system capacity factor - the percentage ratio of average load to system capacity.

The Article defines - and clearly distinguishes between - "spinning-reserve service", "peak-shaving service" and "interruptible service". Altho the primary emphasis is in curtailing industrial service, it is implied that such curtailment is actually a byproduct of "firm service" to the nonindustrial customers.

TITLE: INTERIM REPORT: ELECTRIC LOAD MANAGEMENT PROJECT

SOURCE: Vermont Public Service Board (Coordinator); et al

AUTHOR(S): W.R.Veno, W.P.Heim, T.Laaspere, A.O.Converse, G.Laber; et al
PREPARED BY AUTHOR(S) AND/OR: V.P.S.B. (J.C.Romano, Energy Systems Analyst)
DATE OF ISSUANCE: 11/75 *
OTHER IDENTIFIERS: Work sponsored by NSF/RANN

DATA USE RESTRICTIONS: Check with V.P.S.B. (Montpelier, Vermont)

TOTAL: [PAGES 50 ;REFERENCES 25 ;GRAPHS 11 ;TABLES 4] **
DOCUMENT CLASSIFICATION(S): 36/4, 5, 19, 28, 31, 37, 38, 55, 56

ABSTRACT: *[This date is assigned to the overall report; portions are variously dated from 1/75 thru 10/75.]

**[This (interim) Report is divided into five sections, the last and longest of which is made up of 7 Appendices. The material is of (mainly) secondary relevance to the subject matter of this Compilation; the Total(s) apply to the relevant material.]

Electrical system costs can be reduced by providing the electricity from efficient base load plants operating at high load factors, rather than from peaking-type plants operating at less efficiency and lower load factors. Therefore, the system can operate more efficiently if the load shape can be flattened; manipulation of the load shape is termed load management. [Note: load management has a close relationship to, but should not be confused with, the separate issues of curtailment of use or non-wasteful use.]

Load Management has been used to a limited extent in the USA for many years; in Europe, higher costs and prices have supported methods of reducing costs there through sophisticated controls and load management techniques. Therefore, initial work on this particular Project consisted of a study of European methods of control and other load management techniques. A similar survey was also made in the USA. Load control and load limiting devices for residential customers were later added to the program studies.

The Report states that about 24,000 electric water heaters (or about 30% of the residential customers) are presently on time-clock control at Central Vermont Public Service Corp. and provide much potential for flattening the daily load shapes thruout the year. In addition several appliances have been identified as suitable for load management. These are the clothes washer, the dryer and the dishwasher - which are all deferrable loads - and the freezer, which is a storage appliance. [Note: the frost-free portion of a refrigerator may become a future deferrable load.]

A study was undertaken to determine the importance of residential electric space heating on future electricity usage. Included in this study is an optimization of the use of thermal insulation and an evaluation of storage heating in an electrical load management environment. Computer models were divised to aid in the evaluation.

The appendices of this Report contain background information and/or report progress in the following areas: (1) Storage heating evaluation; (2) Insulation standards for Vermont; (3) Creative electric load management; (4) Assessing the economic implications of load management in electric utilities; (5) Testimony on load management techniques; (6) Review of load management techniques; (7) Rate schedules.

TITLE: SURVEY SCRUTINIZES LOAD MANAGEMENT

SOURCE: Electrical World, 7/15/76, pp 76-77

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: E.W.

DATE OF ISSUANCE: 7/76
OTHER IDENTIFIERS: System Engineering

DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL:[PAGES 2 ;REFERENCES 1 ;GRAPHS 2 ;TABLES 1] *
DOCUMENT CLASSIFICATION(S): 36/9, 19, 37, 47

ABSTRACT: *[Contains material of secondary relevance to the subject matter of this Compilation.]

This Article summarizes an EEI-sponsored progress report on a study of Load Management. Among the conclusions reached are: (A) a warning that the benefits expected to result from achieving higher annual load factors may not always be sufficient to offset the costs of load-management programs.; (B) The previous low cost of electricity, a result of systems optimized to supply existing load profiles, had kept the economic incentive to manage loads relatively small; (C) Annual load factors, for individual utility systems, range from about 50 to almost 80% but daily load factors range from about 75 to 90%; (D) In most cases, today's average annual load factors provide necessary off-peak valleys during which generating unit maintenance can be performed; (E) Load management may have an adverse effect on the utilization of existing generating capacity; (F) In an analysis of an existing system configuration, an increase in system annual load factor resulted in a higher average fuel cost per KWH, because of the need to operate higher-cost generation for longer periods; (G) The greatest potential for load shifting, using load-management programs, appears to be in the residential class which (typically) contributes about 30% of peak load; (H) Some opportunities for load shifting may be available for commercial customers but this may result in inconveniencing work forces, customers and other businesses.

TITLE: COOLING-DEMAND CONTROLS LOOK GOOD

SOURCE: Electrical World, 7/15/76, pp 96-98

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: E.W.

DATE OF ISSUANCE: 7/76
OTHER IDENTIFIERS: Energy Marketing

DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL: [PAGES 3 ;REFERENCES ;GRAPHS 4 ;TABLES 1] *
DOCUMENT CLASSIFICATION(S): 36/1, 45, 55

ABSTRACT: *[Contains material of secondary relevance to the subject matter of this Compilation.]

The Article summarizes tests by several utilities which examine and quantify attempts to reduce system peak load, mainly by controlling residential air conditioning. One utility used a power line "ripple" system to control air conditioning (and water heaters) for 200 customers between 2 and 6 pm each weekday. Another utilized radio-controlled equipment for shutting off air conditioning compressors for 7 out of each 28 minutes. A third developed an outdoor-thermostat which starts and stops a simple cycle timer so that the compressor's control is periodically removed from the (usual) indoor-thermostat. Still other utilities used radio-control, along with monetary incentives for customer participation in the tests.

In general, the control tests show that (peak) KW demand can be substantially reduced but (so far) there appears to be no significant reduction in KWH usage. However, further tests are said to be needed to evaluate such factors as the full effects of outdoor temperature variations.

TITLE: DEMAND CONTROLLER SHAVES WINTER PEAK

SOURCE: Electrical World, 10/1/76, pp 92-93

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: E.W.

DATE OF ISSUANCE: 10/76
OTHER IDENTIFIERS: Energy Marketing

DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL:[PAGES 2 ;REFERENCES 2 ;GRAPHS 1 ;TABLES 2] *
DOCUMENT CLASSIFICATION(S): 36/39, 45, 47, 52, 55

ABSTRACT: *[Contains material of (mainly) secondary relevance to the subject matter of this Compilation.]

According to a study by the Potomac Edison Co., a "winter-peaking" utility, use of a demand controller to curtail operation of a residential electric-heating system, water heater and dryer (when the outside temperature is 24°F or lower) defers a minimum of 8 KW per customer from the morning and evening peaks. During the curtailment periods, the temperature in a house drops about 6-7° F, but this poses no customer-comfort problems. Less than 4 KWH per customer per deferment is lost by shedding these loads.

The installations consisted of a load-control unit, a contactor with a normally closed 24-v coil for controlling the water-heater and dryer circuits, an outdoor-temperature sensor, high-low thermometers and recording thermometers to record inside temperature drop, and a magnetic-tape meter. There was also a portable device used to read and set the time-of-day calendar of the load controller.

TITLE: ELECTRICAL ENERGY LOAD MANAGEMENT DEMONSTRATION PROJECT (Final Report) *

SOURCE:

AUTHOR(S): Arizona Solar Energy Research Commission
PREPARED BY AUTHOR(S) AND/OR: (plus) Arizona Public Service Co., Dynamic Science, Inc. and Arizona Corporation Commission
DATE OF ISSUANCE: 2/14/77
OTHER IDENTIFIERS: Prepared in cooperation with FEA's Office of Conservation and Environment
DATA USE RESTRICTIONS: Check with FEA as to availability

TOTAL: [PAGES 22 ; REFERENCES ; GRAPHS 5 ; TABLES 3] **
DOCUMENT CLASSIFICATION(S): 36/4, 5, 17, 37, 55

ABSTRACT: *[This document had not yet been made available for general use at the time this Abstract was prepared.]
**[This Report - which includes 4 seperately bound Appendices - contains information of direct and (mainly) secondary relevance to the subject matter of this Compilation. The Total(s) apply to the relevant material.]

This Project involves a program to examine and evaluate certain customer load-shaping techniques, which could lead to more efficient uses of electrical energy. The general objective was to demonstrate and evaluate these conceptual techniques for possible integration into a load management system. These concepts included: pricing incentives, application of load shaping appliances and supervisory load control.

Individual project objectives were expressed in terms of proposed tasks to fulfill the overall objective, as noted below.
(A) Develop and test rate forms which give the residential consumer incentives to defer electrical loads to off-peak periods, while still maintaining a reasonable level-of-service and rate-of-return.
(B) Identify and select load-shaping appliances and applications (giving consideration to cost benefit analysis, system load impacts, practicality and near and mid-term applicability) and recommend implementation on the basis of benefits to the utility, customers and State.
(C) Establish and demonstrate the economic and energy management benefits of positive load-shaping approaches, by utilizing supervisory load-shaping control.

All of the demonstrations were completed to a "proof-of-concept" stage. The pricing experiment results indicated a (probable) significant response to "time-of-day" pricing but they were not sufficient to establish the magnitude with any degree of reliability. [Except for the pricing demonstration, completion of the projects was affected by delayed hardware deliveries, operational failures and relatively cool weather.]

TITLE: LOAD MANAGEMENT

SOURCE: EPRI Journal, pp 6-11

AUTHOR(S): EPRI Journal Staff
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 5/77
OTHER IDENTIFIERS: An EPRI "state-of-the-art" feature

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TOTAL:[PAGES 6 ;REFERENCES ;GRAPHS 7 ;TABLES] *
DOCUMENT CLASSIFICATION(S): 36/5, 11, 14, 17, 21, 55

ABSTRACT: *[Contains material of secondary relevance to the subject matter of this Compilation.]

Load management deals with customer loads - by category or in total - as seen from the utility's side of the electric meter. Load management covers a user's own efforts to shift or reduce his pattern of electricity use, under the stimulation of rate incentives. It includes the use of instruments - from clock controlled relays to entire computer systems - that restrict demand at traditional peak hours, or during weather-caused peak periods. Energy storage devices that consumers may install are part of their own load management, as are shifts in operating routine that have the same effect without instruments. [Load management does not deal with utility system interconnections or with utility energy storage; these are modes of supply management.] It is noted that load management is likely to become commonplace, though not solely for the intended reason of shifting peak demand to save costs. It will also come about because of increasing recognition that the cost of electric service varies with the time of day, as well as with the season of the year. Methods are being developed - and agreed upon - for calculating those costs and building equitable rates on them. This is the result of regulatory concern on behalf of ratepayers faced with steeply rising charges. Such time-of-use pricing will cause peaks to shift, load factors to rise somewhat and the benefits of load management to be experienced.

The biggest group of peak electric loads that can be shifted are in the residential category, namely the water/space heating and air conditioning loads. They can now be managed only by controllers that cycle them "off" for brief periods (on a timed or rotating basis) to cut coincident loads and thus the system peak. Tomorrow such loads can be leveled by energy-conserving housing design, which includes consideration of at least the following: siting (i.e. orientation, exposure and landscaping); house construction (i.e. caulking, attic ventilation, insulation and glazing, etc.); use of heat pumps; use of thermal storage; changing to more efficient appliances and lighting. [Careful planning of these items will reduce the peak electricity use of an all-electric home from today's 8 to 10 KW to 3 to 4 KW.]

TITLE: AN EXAMINATION of the INTEGRATED EFFECTS of ADOPTING VARIOUS ENERGY CONSERVATION and LOAD LEVELING POLICIES for the METROPOLITAN AREA of NEW YORK CITY (Final Report) *

SOURCE:

AUTHOR(S):

PREPARED BY AUTHOR(S) AND/OR: Staff of New York State Department of Public Service (plus) its Contractors

DATE OF ISSUANCE: 6/77

OTHER IDENTIFIERS: Prepared in cooperation with FEA's Office of Conservation and Environment

DATA USE RESTRICTIONS: Check with FEA as to availability

TOTAL: [PAGES 25 ;REFERENCES ;GRAPHS 3 ;TABLES 6] **

DOCUMENT CLASSIFICATION(S): 36/1,3,4,11,13,38,40,45,47

ABSTRACT: *[This document had not yet been made available for general use at the time this Abstract was prepared.]
**[This Report is in two volumes; Volume II contains detailed data and individual reports which have been summarized in Volume I. The Report includes information of (mainly) secondary relevance to the subject matter of this Compilation; the Total(s) apply to the relevant material.]

This document summarizes an investigation of the major aspects that would be likely to influence an electrical load management program, as applied to the metropolitan area of New York City.

The following facts were considered in developing the residential aspect of the load management program:
(1) The residential summer peak exceeds the winter peak by 50%.
(2) About 15% of the residential load consists of "rent-included" apartments; these show little interest in energy use, conservation or load management, primarily because they do not directly receive or pay electric bills.
(3) Only about 1/8 of the "non-rent-included" customers have an average use of over 500 KWH/month.
(4) Sixty percent of the coincident residential load (at the summer peak) is room air conditioning; 20% is refrigerators and freezers; 5% is central air conditioners; 5% is from stoves and ovens; less than 2% is from dishwashers, clothes washers and dryers combined; less than 1% is from electric water heaters.
(5) The residential use of electricity in the Consolidated Edison territory differs from that of most other utilities. The average monthly use per residence is only 250 KWH per month, due to the high ratio of apartments to private homes which in turn results in many small loads and few large loads relative to the total residential load.
(6) The heavy usage by those appliances where the FEA residential standards will reduce consumption the most (namely refrigeration, room air conditioning and television) would indicate a greater than national average impact from imposition of those standards on the Consolidated Edison district.

TITLE: ELECTRIC LOAD PROFILES for ANALYZING TOTAL ENERGY and PRIME MOVER APPLICATIONS*

SOURCE: Northern Natural Gas Company (Omaha, Neb.)

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: Energy Economics Section of N.N.G.Co.

DATE OF ISSUANCE: 6/68
OTHER IDENTIFIERS:

DATA USE RESTRICTIONS: Detailed use may be controlled by AGA.

TOTAL: [PAGES 39 ;REFERENCES ;GRAPHS 16 ;TABLES] **
DOCUMENT CLASSIFICATION(S): 37/4,9,13,15,19,32,44,45,48,53,55

ABSTRACT* [Note: Many of the Profiles have been reproduced in several other reports, either uncredited or credited to GATE.]

**[Data is relevant (in the main) to the subject matter of this Compilation. The Total(s) are for the entire Book.]

This Book contains a series of electric load profiles for various commercial buildings and industrial activities in the Northern Plains area. It is stated that in most cases the buildings or installations are typical for that class of operation; e.g., office building, motel, hotel, school, etc. The profiles show the electrical energy use pattern for a building type throughout a "typical" 24 hour period and may be used in projecting the electrical energy requirements for similar building types.

The Book's profiles and associated data sheets provide much of the basic load information needed to make a T.E. system feasibility analysis. For example, when sizing a T.E. plant it is essential to assure that the number and capacity of the generators will adequately supply the KW demand of all the building's electrical loads and at the same time provide for good fuel economy; the hourly electric load profile can be utilized in making this selection of generators. The expected peak demand can also be calculated for a new building by projecting information from a similar building type, using the ratio of recorded peak demand to total connected electrical load. [This estimated peak demand multiplied by the load factor gives an hourly average base load which is needed to calculate annual KWH usage.]

Electrical load profiles and data sheets are presented for 16 installations covering 10 classes of commercial buildings. The data on each sheet indicates the total connected electrical load and the measured peak demand in KW per 1,000 square feet of usable building space. [Expressing such data on a unit basis allows one to estimate the connected load and peak demand for similar building types.]

Data for the load profiles were obtained by metering actual buildings, at the incoming power electrical service, with a four current element recording AC watt-meter. Each facility was metered and data recorded for a period of about two weeks.

The total connected electrical load is considered as being subdivided into: (1) lighting; (2) motors, including air handling and appliances; (3) motors, for air conditioning and heating; (4) "others", such as kitchen equipment or special equipment. [Small miscellaneous loads, such as counter displays connected to wall electrical outlets, are included in the lighting classification.] In computing the KW of connected load per 1,000 square feet, the elevators and heating and air conditioning electrical loads were excluded since such loads vary widely and are not accurately expressable on a per square foot basis; these loads are estimated separately and then added to the building's normal load when evaluating total connected electrical load.

The Book defines recorded peak demand as the maximum recorded peak having a duration greater than the one second required for instantaneous surges but normally less than 5 minutes; this demand is almost always greater than the 15 or 30 minute utility meter billing demand. Elevator KW demand must be considered separately in the recorded peak demand calculations since the type of elevator used in a proposed building would influence the magnitude of these peaks. Similarly, due to wide differences in the electrical power requirements for electric and absorption type air-conditioning systems, the total air-conditioning motor loads are not included in the normal peak KW demand. [When determining the total energy peak demand for a customer, the demands for the proposed elevators and air conditioning systems should be added to the normal peak.]

A daily load factor is computed using data from the hourly load profile curve. Average hourly readings for each hour of the day were divided by the recorded peak demand; the average of these ratios for the 24 hour period is defined as the daily load factor. Daily load factors for both normal and reduced operation were calculated in this manner. An annual load factor was determined from the following:

$$\frac{\text{Annual KWH Usage (Taken from Power Bills)}}{\text{Maximum Utility Meter Demand x 8,760 Hrs./Year}}$$

[It should be noted the maximum utility meter demand is fully diversified and includes air conditioning and elevator loads.]

To illustrate the use of the data tabulated and plotted in the Book, an electrical load profile was developed for a 100,000 square foot, 2 story office building. The example begins with a base load calculation and then adds the required air conditioning and elevator loads to obtain the total projected load.

TITLE: ENERGY SYSTEMS REVIEW

SOURCE: ASHRAE Journal, 7/70, pp 49-54

AUTHOR(S): H.H.Phipps
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 7/70
OTHER IDENTIFIERS: Presented (2/20/70) at 19th Annual Air-Conditioning Conference, University of Florida at Gainesville
DATA USE RESTRICTIONS: Copyright by ASHRAE

TOTAL: [PAGES 6 ; REFERENCES 1 ; GRAPHS 7 ; TABLES] *
DOCUMENT CLASSIFICATION(S): 37/3, 4, 25, 45, 53

ABSTRACT: *[Contains material of (mainly) secondary relevance to the subject matter of this Compilation.]

The point is made that since most facilities do not have provisions for storing energy, it is necessary to make an hour-by-hour analysis of the various energy requirements of the facility being analyzed.

An example of the need for such analysis may be demonstrated by the cooking load. Generally, it has been assumed that the use of electric cooking imposed impractical demands upon a T.E. plant; however, this depends upon the type of installation involved. With the amount of cooking to be expected in a senior citizens' project (plus the larger number of hours over which usage is spread) this need not impose such a severe limitation. On the other hand, electric cooking in some situations (such as a military housing installation) is an entirely different story. Younger, more active families obviously do more cooking and the peaks are more pronounced.

In the same manner that hourly loads are developed for cooking, similar data must be determined for other apartment usages, such as lighting, small appliances, refrigerators and television. When all of these hourly loads are added together the result could be an electrical load profile for an apartment building where, typical of all residential-type installations, we find the peak usage hour occuring somewhere around 7 p.m.

While an analysis is somewhat complex, it is possible to predict energy usages with a high degree of accuracy. Such an approach was used in projecting the energy usages of a large apartment building equipped with a conventional purchased power system. [Projected energy usage was summarized on a monthly basis.] Two years later when the building was completed, it reached its predicted level of occupancy in the month of July and was billed for 429,800 KWH as opposed to the 429,155 predicted. Actual usage from July through Feb. exceeded the projection by 8.5%. Upon investigation it was determined that, either in design or installation, an error had been made in the air-conditioning zoning. As a result, during mild weather the heating system and the air-conditioning system were opposing each other and this caused the additional usage.

TITLE: THE UTILITY LOOKS at LOAD PROFILES of ALL-ELECTRIC BUILDINGS

SOURCE: National Electrical Heating & Comfort Systems Exposition; Atlantic City, N.J.; 3/14-3/16, 1972
AUTHOR(S): W.R.New
PREPARED BY AUTHOR(S) AND/OR: TVA

DATE OF ISSUANCE: 1972
OTHER IDENTIFIERS: Session on Load Study and Economics of Electric Space Heating
DATA USE RESTRICTIONS:

TOTAL:[PAGES 19 ;REFERENCES ;GRAPHS 2 ;TABLES 12] *
DOCUMENT CLASSIFICATION(S): 37/3,6,7,9,19,22,36,44,45,55,57

ABSTRACT: *[Contains material of (mainly) direct and secondary relevance to the subject matter of this Compilation.]

This paper presents: (A) hourly load profile data - on the days of the summer and winter peaks - for 10 commercial buildings located in the city of Chattanooga, Tenn.; (B) background information on these buildings; and (C) draws conclusions from the data relative to the characteristics of the individual buildings, reasons for differences among the buildings and the effect of such buildings upon the system.

Of the 10, 3 are office buildings with 2 being all-electric and the other having gas heat. Four are department stores, 3 being all-electric and 1 with gas heat. One all-electric motel was included; the remaining 2 buildings are all-electric apartment buildings, 1 with resistance heat and 1 with heat pumps. [Note: The normal HDD (base 65 degrees) at Chattanooga are 3,248. There is also a large cooling and air-conditioning load in summer.]

Summary of Major Findings:

1. Five of the buildings had summer peaks; they included an all-electric office and 2 store buildings plus a gas-heated office and a store. Five all-electric buildings peaked in winter-an office building, a store, a motel and 2 apartment buildings.

2. There was little difference between the gas-heated and all-electric office and store buildings, as regards their average monthly and annual load factors; for example, the range of average monthly load factors was 53-62% for the gas-heated and 56-71% for the all-electric. The 2 apartment buildings and the motel had significantly lower load factors than the aforementioned; respectively, their monthly ranges were 46-51% and 50%.

3. The 2 department stores (which derived electric heat primarily thru their lighting installations) peaked every month during the year on warm days when air conditioning was used. The all-electric building had only 1 month with a peak caused by heating and the gas-heated bank had only 3 (non) air-conditioning peaks.

4. The all-electric office buildings had considerable diversity in the winter months (68-84%). Gas-heated buildings of these types had more winter diversity (29-62%). The apartment buildings (at 91-94%) and the motel (at 100%) had little.

5. In summer, all-electric office and store buildings had more diversity (74-95%) than gas-heated buildings (92-98%) of the same types. By contrast, the 2 apartment buildings (at 71-73%) and the motel (at 72%) had more diversity than the store and office buildings.

6. From the preceding "findings", one might conclude that a mixture of all-electric buildings is beneficial in terms of seasonal load leveling.

7. Older, thick masonry buildings can be economically converted to all-electric operation (from the standpoint of the customer), both as to operating costs and the cost of heaters necessary to supplement the other heat inputs from lighting, equipment and people.

TITLE: THE ELECTRIC UTILITY LOOKS at the DOMESTIC APPLIANCE & ELECTRIC HEAT LOAD

SOURCE: IEEE Industry and General Applications Group Annual Meeting; Chicago, Illinois; 10/3-10/6, 1966
AUTHOR(S): W.R.New
PREPARED BY AUTHOR(S) AND/OR: TVA

DATE OF ISSUANCE: 1966
OTHER IDENTIFIERS:

DATA USE RESTRICTIONS:

TOTAL:[PAGES 7 ;REFERENCES 3 ;GRAPHS ;TABLES 3] *
DOCUMENT CLASSIFICATION(S): 38/4, 14, 19, 21, 55, 56

ABSTRACT: *[Contains material of direct and (mainly) secondary relevance to the subject matter of this Compilation.]

An electric utility is usually interested in the use of domestic appliances from two viewpoints. The first of these is that of the consumer who is concerned as to the original cost of the appliance and its performance, maintenance and cost of operation. Regardless of the level of power use or the load characteristics of appliances, whether they are (or are not) purchased is affected by: income level; "competition" with automobiles, boats, vacation trips, etc.; their performance and durability and instruction in their best use. [Often there is little relationship between the cost of the appliance and its power use. For example, the electric shaver usually costs more than an electric iron.] The second viewpoint is that of the utility, which is interested in the facilities required to serve the total residential load and the cost of providing power to the consumer. The primary purpose of this Paper is tc present information, on the effect of growing saturations of appliances and electric heating in the TVA area, on utility system loads and to pcint out some conclusions which may be helpful to others. [Tabulated data is included to show contributions of selected appliances to total residential average use in the TVA area.]

The Paper points out that for the past 20 years, the electric water heater has contributed more than any other appliance to both total and average residential electric use. It has maintained this leading position for three reasons: it uses a great deal of electricity; the saturations of water heaters have been rising rapidly; the average KWH used has been rising from year to year. Of course, use increases with saturations of clothes washers and dishwashers. Additionally, a water heater will use about 75 KWH per month (just to maintain a temperature setting) even if no water is drawn.

The Paper includes data on the KWH use (of hot water) for various purposes and for 4 hot-water heater types (i.e., "average" and "high" use conventional and "average" and "high" use quick-recovery). The TVA-area's appliance average annual KWH are listed (for fiscal 1951, 1956, 1961 and 1966) for ranges, water heaters, electric (space) heating, room air conditioners, televisions, washers, dryers and miscellaneous appliances. Tabulated data is given on the load characteristics of residential appliances installed in a "low-rent" housing project having about 400 units; the data covers average monthly KWH per unit, average KW per unit and monthly load factors.

TITLE: "PROJECT INDEPENDENCE"BLUEPRINT: TASK FORCE REPORT - RESIDENTIAL and COMMERCIAL ENERGY USE PATTERNS (1970-1990); VOLUME I

SOURCE: FEA / CEQ

AUTHOR(S): Arthur D. Little, Inc. *
PREPARED BY AUTHOR(S) AND/OR: FEA

DATE OF ISSUANCE: 11/74
OTHER IDENTIFIERS: FEA/N-74/549; available from NTIS as PB-248 508

DATA USE RESTRICTIONS:

TOTAL:[PAGES 87 ;REFERENCES 27 ;GRAPHS 9 ;TABLES 28] **
DOCUMENT CLASSIFICATION(S): 38/4,9,10,11,14,17,18,23,47,50,52,56

ABSTRACT: *[Report was prepared by the "Interagency Task Force on Energy Conservation" under the direction of "Council on Environmental Quality". The Report is one of three technical analyses on Project Independence and Energy Conservation but Volumes II and III are not really relevant to this Compilation.]

**[Material of direct and secondary relevance to the subject matter of this Compilation is scattered thruout this rather lengthy Report. Sections III, IV and VI contain most of the pertinent data. The Total(s) refer to the relevant data.]

The purpose of this Report has been to lay a rational foundation for energy policy in the residential and commercial sectors of the USA economy. It explains in detail the present levels of consumption in these sectors, the projected growth of the consumption - generally between 1970 and 1990 - under several energy price assumptions and the potential for reducing this growth by various means. Among its several findings, observations and recommendations (which are of paramount importance for energy policy consideration) are the following:
(A) Of the energy presently consumed in the combined sectors, 75% is attributable to residential use.
(B) Of the energy consumed in the combined sectors, 70% is used for space heating.
(C) Under the economic and demographic scenario provided by CEQ/FEA, which may be considered as amenable to high levels of energy consumption, growth in the combined sectors is projected at the rate of 2.3% per year (3.2% if the fuel used in electric generation and transmission is included). [Several factors combine to produce this projected slowdown in growth relative to historical rates of 3.5 to 4.0%. These include: decrease in household size, slowdown in the rate of household formations, higher rates of construction in warmer areas of the country, fewer detached single-family homes, better construction standards and increasing consciousness of energy saving techniques.]

(D) Growth rates will differ significantly among sectors, regions, fuels and end uses. Commercial use will increase more rapidly than residential (4.1%/year vs 1.6%/year); electricity use will experience greater growth than oil or gas (5.2% vs 2.2% vs 1.5%, respectively); growth in the South and West (2.8% and 2.3%) will continue to be more rapid than for the Northeast and Northcentral regions (2.0% and 2.1%). Energy consumption for air conditioning and appliances will continue to grow, with relatively less energy used for space heating, water heating and cooking.

(E) Specified increases in energy costs will not have a major effect on dampening growth in the combined sectors.

(F) There is tremendous potential for energy conservation in the two sectors. Universal application of economically practicable technology, which is currently available, would reduce the growth rate in the combined sectors to under 1% per year. However, such potential will not be achieved without significant changes in consumer behavior patterns and the level of information available to "decision makers".

(G) Various policies may have substantially different effects depending on the individual building to which they are applied. Such policies need to account for the differing characteristics of energy loads, by structure type and region of USA.

(H) The extent of information for effectively evaluating policy options is severely lacking on the national, regional, local and unit levels.

The unit demands published thruout this report are weighted averages. For example, while the average unit demands that are cited are valid for measuring the energy used in the region for household heating, they are not valid for analyzing use patterns and technological changes possible in a given house. Average annual energy consumption estimates for appliances were developed from EEI, AGA and other industry data, which were reduced slightly to allow for the fact that the appliances in service represent both units made recently and those made some years ago; for the most part the older units are smaller and consume less energy. The unit demands for heating, cooling and lighting were developed by analyzing specific buildings typical of those being constructed in 1970. Adjustments were made to reflect changes in construction standards, the existence of non-centrally heated homes and variations in fuel distributions within the Census regions.

The Report includes major sections devoted to: residential/commercial building inventory (as of 1970) and its projected changes thru 1990; unit demands for heating/cooling for commercial/residential uses; a discussion of residential hot water heating and appliance (energy) loads; the technical potential for energy conservation; the price (and cross price) elasticity of energy demand; comparisons of "model" vs "field" data.

TITLE: MAGNETIC-TAPE RECORDING METERS IMPROVE LOAD SURVEY ACCURACY

SOURCE: Electrical World, 11/14/63, pp 98-100

AUTHOR(S): F.G.Hammer & J.W.Crawford
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 11/63
OTHER IDENTIFIERS:

DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL: [PAGES 3 ;REFERENCES ;GRAPHS 6 ;TABLES] *
DOCUMENT CLASSIFICATION(S): 39/13,37,38,52

ABSTRACT: *[Contains material of direct relevance to the subject matter of this Compilation.]

Beginning in 1957, chart-type meters were being replaced with meters which record the hourly KWH consumption on magnetic tape. Using a load survey "translator", the record is transferred to computer cards with no intervening manual stage other than loading the tape into the translator. Once the use of magnetic tape recording meters became established the amount of data grew rapidly, and diversified demand curves for residential load classifications were begun.

A total of 2,062 field tests (combined into more than 400 different groupings) were used in deriving a variety of diversified demand curves. Tests made from 1957 through 1961 were grouped as if they were in the same year. Tests made during the 13 weeks of a season were grouped as if they were the same week. To take care of the probability that a test did not coincide with the peak load week, all recorded demand values were (arbitrarily) increased by 15%.

Average diversified demand curves for various classes of residential load were calculated for both the winter and summer seasons. Demands for residential load classes, including air conditioning, are shown and the effect of high-recovery water heaters is indicated.

A Nomograph was constructed for determining the diversified KW demand from the monthly KWH usage and the number of customers in the group. The Nomograph (and the formula on which it is based) is reproduced in the Article.

TITLE: TRANSDUCERS ANSWER METERING CHALLENGE

SOURCE: Electrical World, 9/15/70, pp 72-73

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: E.W.

DATE OF ISSUANCE: 9/70
OTHER IDENTIFIERS: Transmission/Distribution

DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL:[PAGES 2 ;REFERENCES 2 ;GRAPHS 1 ;TABLES 1] *
DOCUMENT CLASSIFICATION(S): 39/7, 13, 55

ABSTRACT: *[Contains material of secondary relevance to the subject matter of this Compilation.]

Metering the largest entertainment complex of its kind in the world would be a challenge to any utility. The John F. Kennedy Center for the Performing Arts in Washington, D.C. posed exactly this challenge. The Potomac Electric Power Co. solved the problem by installing demand transducers to totalize the individual demands from the 27 load centers distributed throughout the complex. [A thermal "watt-demand transducer" is essentially a thermal converter that generates a direct electromotive force which is proportional to the power flowing in the measured circuit.]

Total coincident demand is actually determined by totalizing the outputs of transducers connected to each of 27 watthour meters. The sum of these outputs drives a recording potentiometer to get total demand. In this scheme a three-element, 3-phase, four-wire transducer connected to each meter generates an emf proportional to the load measured by the meter itself. The outputs of all the transducers are connected in series to drive the recording potentiometer, thereby recording the summation of the emfs which represents total coincident demand.

TITLE: NEW MAGNETIC TAPE SYSTEM for DEMAND BILLING, SUBSTATION MONITORING and LOAD SURVEY WORK

SOURCE: 1970 Proceedings of the American Power Conference, pp 1012-1019

AUTHOR(S): H.E.Campbell & C.E.Gambell
PREPARED BY AUTHOR(S) AND/OR: General Electric Company

DATE OF ISSUANCE: 1970
OTHER IDENTIFIERS:

DATA USE RESTRICTIONS: "PULSCRIPT" (Magnetic Tape System) is a registered trademark

TOTAL: [PAGES 8 ; REFERENCES 1 ; GRAPHS 3 ; TABLES 1] *
DOCUMENT CLASSIFICATION(S): 39/5, 10, 19

ABSTRACT: *[Contains material of secondary relevance to the subject matter of this Compilation.]

An electric utility is faced with the necessity of measuring and recording quantities pertinent to billing requirements and/or system surveying needs. Graphic meters and "printometers" have been developed over the years to measure these quantities and they are still used to some extent. However, these types of meters do not lend themselves to automatic means of reading the charts and tapes. Therefore, it has been difficult to use these types of meters for sophisticated billing and load survey work.

The magnetic tape recording system offers data recording on magnetic tapes, suitable for processing by modern computers. Among the quantities which may be directly measured are: KWH, KW, kilovarhours, kilovars, volt-square-hours and ampere-square-hours. This technique opens up a whole new field of measuring quantities that can be used for billing procedures and load survey work. In addition, the use of imaginative programming makes it possible to compute results not directly recorded, e.g.: diversity, load factor, power factor, average volts and amperes, kilovoltamperehours, kilovoltamperes and kilovars.

The magnetic tape system developed for demand billing has made available a very flexible system, not only for demand billing but also for load survey work. Once a magnetic tape system becomes available to a utility, then its engineers have an opportunity to do a better job of system analysis because of the ease of collecting and digesting load information. [The economics of using the magnetic tape system will vary from utility to utility.]

TITLE: TEST-METERING SUPPORTS RATE STUDIES

SOURCE: Electrical World, 8/1/74, pp 62-64

AUTHOR(S): B.C.Thomas
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 8/74
OTHER IDENTIFIERS: Energy Marketing

DATA USE RESTRICTIONS: Copyright by Mc-Graw-Hill, Inc.

TOTAL: [PAGES 3 ;REFERENCES 2 ;GRAPHS 1 ;TABLES 1] *
DOCUMENT CLASSIFICATION(S): 39/5, 13, 19, 52

ABSTRACT: *[This Paper contains material of (mainly) secondary relevance to the subject matter of this Compilation.]

Load research is becoming a very significant part of utility rate considerations. Increasingly, regulatory commissions are requiring detailed documentation of rate schedule increase data. This Paper is primarily concerned with the measurement of total electric demand in a given dwelling unit.

The main target of the study was the collection of objective, reliable and conslusive "class-demand" data for a cost-of-service analysis which, in turn, could be used to support residential rate design. Each housing unit in the sample was viewed as a self-contained electricity-consuming system and the electric energy input to each of these systems was monitored with a 2 channel cassette tape recorder. This article explores the rationale for using this method, instead of the specific-component metering concept.

A "sample" basic report is summarized in a tabular form, along with KW demand load profiles that were developed for an average weekday and average weekend. The tabulated data included: daily and monthly demands; daily KWH; maximum AM and PM demands and the times of their occurrence; average demand; % load factor.

TITLE: THE CORAL SPRINGS UNDERGROUND DISTRIBUTION LABORATORY: II - GENERAL RESULTS and DATA ANALYSIS

SOURCE: Transmission and Distribution Systems, Westinghouse Electric Corporation
AUTHOR(S): R.H.Stevens; et al
PREPARED BY AUTHOR(S) AND/OR: T & DS/WEC

DATE OF ISSUANCE: 1974
OTHER IDENTIFIERS: Presented at IEEE Underground Transmission and Distribution Conference; Dallas, Texas; 4/1-4/5, 1974
DATA USE RESTRICTIONS:

TOTAL: [PAGES 6 ;REFERENCES 7 ;GRAPHS 8 ;TABLES 2] *
DOCUMENT CLASSIFICATION(S): 39/10, 13, 19, 37, 38, 45, 50, 57

ABSTRACT: *[Contains material of direct and (mainly) secondary relevance to the subject matter of this Compilation.]

This Paper evaluates the design, installation and operation of an instrumented underground distribution system in Coral Springs, Fla. The instrumentation provides field test data consisting of transformer loads and temperatures, and environmental conditions. The objective of the Laboratory was to provide a field test installation for economic and technical evaluation of new systems and equipment under actual service conditions. The instrumented subdivision consists of 70 single-family sites, an area large enough to test and evaluate a broad range of equipment and system concepts, yet small enough to keep the extent of use of developmental equipment within acceptable limits.

Results of equipment and system evaluations in the Distribution Laboratory are discussed. Load characteristics were analyzed, using multiple linear regression techniques. The statistical models of the load characteristics include the effects of environmental parameters.

Curves are shown which relate: (1) monthly peak (KW) to average transformer loads; (2) monthly peak (KW) to number of customers; (3) coincidence factor vs number of customers; (4) transformer load characteristics, as a function of ambient temperature and humidity; (5) transformer load (KW) profiles for a 24 hour period during the summer and the winter "peak" period.

TITLE: NEW METERING SYSTEM REDUCES COSTS

SOURCE: Electrical World, 5/1/76, pp 36-37

AUTHOR(S): D.L.Murdock & W.F.Steele
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 5/76
OTHER IDENTIFIERS: Transmission/Distribution

DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL: [PAGES 2 ;REFERENCES 1 ;GRAPHS ;TABLES 2] *
DOCUMENT CLASSIFICATION(S): 39/10, 19, 55

ABSTRACT: *[Contains material of secondary relevance to the subject matter of this Compilation.]

Due to rapidly rising costs, customers and the regulatory commissions are now asking utilities for much more detailed information concerning load data. Central Iowa Power Cooperative (Cipco) is meeting these requests by using magnetic-tape recorders in conjunction with a low-cost minicomputer as the basis for a complete load-information system. Data from the system also enable Cipco's management to analyze and plan intelligently for future growth.

Meters are required at all load points to determine the system load. The conversion of these metering units to magnetic-tape installations permits the establishment of data files containing KW and power-factor information at 15-minute intervals, for each substation on the system.

The new equipment provides significant benefits, including: (1) elimination of most of the monthly expense involved in maintaining a variety of older, less reliable recorders; (2) the ability to determine accurate values of 60-minute coincident demand from a large number of delivery points; (3) capability of obtaining widespread load-duration curves on daily, weekly and monthly basis; (4) availability of comparative load data on almost any desired time basis, 15 minutes and up; (5) increased flexibility in analyzing the accumulated recorded data.

TITLE: SURVEY FINDS MASTER METERS on UPSWING

SOURCE: Electrical World, 3/1/71, pp 44-45

AUTHOR(S): M.C.Neuhoff
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 3/71
OTHER IDENTIFIERS: Transmission/Distribution

DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL:[PAGES 2 ;REFERENCES ;GRAPHS 2 ;TABLES 1] *
DOCUMENT CLASSIFICATION(S): 40/3, 5, 6, 13, 29, 55

ABSTRACT: *[Contains material of secondary relevance to the subject matter of this Compilation.]

A comparison of surveys conducted in 1964 and 1969-70 indicates that there has been a significant swing to master metering of new apartment buildings. [Conversion of existing buildings to master metering remains a minor factor.] An additional finding is that units in mobile-home parks are almost always individually metered. Master metering of new apartment buildings is currently a significant factor in more than half of the utilities - 19 out of 37 - on which information was developed in the 1969-70 survey; figures ranged up to 90% or more for several utilities. Among utilities serving large metropolitan areas, almost all master-metered units were in high-rise buildings. In others, master-metered apartments were concentrated in garden-type buildings.

The decision to master-meter is usually beyond the control of the utility. In 26 of 38 utilities reporting, this decision is made by the building owner; in eight cases, the decision is made solely by the utility; in four others, it is made jointly by the utility and the building owner.

Many utilities' rate structures encourage master metering. On the other hand, the 1969-70 survey found that many others, through their rate structures, strongly discourage this practice. Almost invariably, where the data were provided, utilities generate more revenue from individually metered apartments than they do from master-metered units. These figures varied from $38 annually for master-metered installations and $60 for individually metered apartments at one company to $100 and $225, respectively, at another.

In 5 utilities reporting, the number of KWH used per apartment is significantly higher for master-metered units than it is for individually metered units. [This can be due to many factors. First, the master-metered tenant may be less careful about the amount of electricity he uses, since he is paying a "flat rate" for electricity in his rent. Second, master-metered apartments are more likely to be all electric and thus have a higher rate of consumption.]

TITLE: THE ENERGY CONSERVATION IMPLICATIONS of MASTER METERING of ELECTRIC SERVICE in APARTMENTS

SOURCE: Proceedings of 2nd Annual Conference on Energy; held at Rolla, Missouri; 10/7-10/9, 1975
AUTHOR(S): G.E.Gross
PREPARED BY AUTHOR(S) AND/OR: Midwest Research Institute; Kansas City, Missouri
DATE OF ISSUANCE: 10/75
OTHER IDENTIFIERS: MRI 1206 (Reprint)

DATA USE RESTRICTIONS:

TOTAL:[PAGES 14 ;REFERENCES 5 ;GRAPHS 1 ;TABLES 4] *
DOCUMENT CLASSIFICATION(S): 40/3, 11, 38, 47, 55

ABSTRACT: *[Information of direct or secondary relevance to the general subject matter of this compilation are scattered thruout this paper. The Totals are for the entire paper.]

The practice of master metering often allows the sale of electricity to a building or complex at wholesale rates which are usually justified by the utility company by the requirement for only one meter, one reading and one bill for the sale of a large quantity of electricity. Additionally, the electrical wiring is appreciably simplified by this practice.

The purpose of this reprint is to compare the electric energy consumption in apartments which receive electricity thru master meters with those which receive electricity through individual meters. The report shows the extent of residential master metering in 10 major U.S. cities and discusses the factors which influence the choice of master metering.

Data taken from over 100 apartment buildings or complexes and from over 50 major electric power companies are used as the basis for the reported results. [Contractors estimates of the costs to convert building service from master to individual meter and some bases for these costs are presented.] The energy conservation potential which might be realized through nationwide elimination of master metering is discussed.

Summary of Major Findings:

1. The annual KWH consumption for a number of apartment buildings and complexes indicates that the ratio of the consumption by master metered customers to that of individually metered customers ranges from 1.08 to 2.69.
2. The average ratio of master to individually metered consumptions for this same group of apartments is 1.35, with a standard deviation of 0.07. There is thus only one chance in 20 that the "waste" by master metered users is less than 20%.
3. The extent of master metering of multi-family housing ranges from 18 to 77% in individual cities. For the combined population of the target cities it was found that 29.5% of all such housing was master metered.

TITLE: ENERGY CONSERVATION IMPLICATIONS of MASTER METERING: FINAL REPORT (VOLUMES I & II) *

SOURCE: Midwest Research Institute (Kansas City, Missouri)

AUTHOR(S): G.E.Gross; et al
PREPARED BY AUTHOR(S) AND/OR: M.R.I. (for FEA)

DATE OF ISSUANCE: 10/75
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TOTAL:[PAGES 130 ;REFERENCES 17 ;GRAPHS 23 ;TABLES 21] **
DOCUMENT CLASSIFICATION(S): 40/3,5,11,13,17,21,23,44,55

ABSTRACT: *[Volume II contains 7 appendices, which provide detailed support data for Volume I.]

**[Material of direct and secondary relevance to the subject matter of this Compilation is scattered thruout both Volumes of this rather comprehensive Report. The Total(s) are for the relevant material.]

This Report (and its appendices) is concerned with a study of master metering of electrical service in apartment and office buildings. The primary objectives were to determine: (1) the difference between electrical usage by tenants with master metered electric service and those who must pay individual electric bills; (2) the extent and trends of such master metering; (3) the economic and other factors which influence the initial selection of, or later conversion to, master or individual metering. Another objective was to provide and evaluate policy alternatives which could control the practice of master metering.

The Report recognizes important differences in the potential effects of the choice between master and individual metering of electricity in apartments and offices. For example, in apartments, the electric bill can be seen as a significant part of operating expense but in an office operation this utility charge is generally small in comparison to other costs and is further diminished by its use as a tax deduction. Also, in apartments the lighting and heating/cooling standards can (generally) be lowered with no penalty other than family complaints whereas in offices these standards are affected by company policies aimed at client comfort, employee productivity and "company image" - three factors which might outweigh electricity cost and energy conservation goals.

It was found that residential customers, whose electrical service comes through master meters, consume about 35% more KWH than those who receive service through an individual meter and pay directly for the energy they use. These master metered customers number about 4,433,000 (about 1/3 of all USA family dwelling units found in buildings of 3 or more dwelling

units each) and they will consume an estimated 26 billion KWH in 1975. Had this 1/3 used energy like the individually metered customers, they would have consumed only about 19 billion KWH. [The potential saving here is about 1% of the expected total residential consumption for 1975.]

Recent activities relating to energy costs, the "energy crisis" and the variable housing market were noted as producing highly erratic fluctuations in the extent of master metering in apartments. Prior to 1970 there was a slight trend toward master-metering in all types of new apartments; after 1970 nearly all new high-rise apartment buildings (4 or more stories) were master metered while newly constructed garden apartments showed a slight trend toward individual metering. Records of conversions to (or from) master metering show no clear net trend, except in garden apartments where there is a slight trend away from master metering.

The study of master metering in office buildings provides much less information than does the residential case. High-rise office buildings tend to be master metered and most single-story office buildings tend to be individually metered. The many differences in performance and operation of these two classes of buildings precludes meaningful comparison of their energy consumptions. Furthermore, requirements for flexibility in rental space causes building owners and managers to avoid individual metering. A comparison of 2 office buildings (in Kansas City, Mo.), which were similar except for metering practice, indicates a possible excess consumption of 10% by the master metered tenants. [Since other pairs were unavailable for study, no statistical value should be placed on this result.] If one were to assume that these buildings were typical of all office buildings, the potential for conservation by elimination of master metering in office buildings could amount to about 2.5 billion KWH per year. However, the uncertainty in this result (and the arguments against individual metering of office buildings) suggest that the residential sector offers the largest and most accessible opportunity for energy conservation through elimination of master metering.

The volume containing the 7 appendices includes the following: (A) examples of electricity rate structures; (B) names and addresses of information sources used in this study; (C) responses from 47 state public service commissions as to their stand on master metering; (D) comparison of electricity consumption for master-metered and individually metered apartments; (E) extent of master metering from the 1970 Census; (F) reports and information on load and consumption studies; (G) "comments" by utility and real estate management.

TITLE: APPLICATION of the INTEGRATED UTILITIES CONCEPT to COMMUNITY-SIZE DEVELOPMENTS

SOURCE: Proceedings of 9th IECEC (held at San Francisco, Calif.; Aug. 26-30, 1974); pp 493-498
AUTHOR(S): T.E.Redding
PREPARED BY AUTHOR(S) AND/OR: NASA-JSC

DATE OF ISSUANCE: 8/74
OTHER IDENTIFIERS: Paper No. 749016

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TOTAL: [PAGES 6 ;REFERENCES 2 ;GRAPHS 3 ;TABLES 3] *
DOCUMENT CLASSIFICATION(S): 41/7, 11, 37, 45

ABSTRACT: *[Information of secondary relevance to the general subject matter of this Compilation is scattered thruout this Report. The Total(s) are for the entire Paper.]

NASA-JSC, along with other government agencies, is conducting a project entitled "MIUS" sponsored by HUD. The MIUS concept combines the utility services of electrical power, heating/cooling, water supply and waste-water treatment and solid waste management into a single, local plant - while conserving energy. Th cbjective of the MIUS project is to demonstrate the technical and economic feasibility of this concept.

As a part of the conceptual design study efforts, NASA has investigated the application of the MIUS concept to a community model. The model is based upon a 20-year growth pattern to 110,000 people. The complete community consists of a central business district with 7 surrounding villages. Two different MIUS installation options are defined. Each option is evaluated relative to a conventional utilities system approach. Compared to the conventional system, MIUS energy savings were estimated to be 38%, water savings 17%, effluent reduction 17% and solid waste load reduction 80%.

The Paper includes a summary of the design (peak) power, heating, ventilation and air conditioning, water and solid waste loads for MIUS designs; these loads were derived by summing individual building loads. A total community electrical power profile was developed on an hourly basis. Electric power requirements are tabulated for a "village complex", "village center", "neighborhood" and "central business district".

TITLE: TECHNOLOGY SURVEY of ELECTRICAL POWER GENERATION and DISTRIBUTION for MIUS APPLICATION (JSC-08661)

SOURCE: NASA-JSC

AUTHOR(S): W.L.Gill & T.E.Redding
PREPARED BY AUTHOR(S) AND/OR: NASA-JSC

DATE OF ISSUANCE: 7/75
OTHER IDENTIFIERS: NASA TM X-58127; may be ordered from NTIS as N75-31573
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TOTAL:[PAGES 12 ;REFERENCES 4 ;GRAPHS 1 ;TABLES 2] *
DOCUMENT CLASSIFICATION(S): 41/4, 15, 19, 22, 36, 37, 42, 45

ABSTRACT: *[Contains material of secondary relevance to the subject matter of this Compilation. The Total(s) reflect the pertinent material.]
This Report describes candidate electrical generation power systems which have a potentiality for use with the MIUS program. The candidates are divided into "conventional" and "other" (newer and developing) types. Conventional power systems include the Rankine, Brayton and binary cycle systems and reciprocating internal combustion engines plus their electric generators. [Heat-recovery equipment associated with conventional power systems and major supporting equipment are also discussed.] The other possibilities include electrochemical, nuclear energy sources, thermoelectricity, solar energy, magnetohydrodynamics, hydroelectric power, tidal power, geothermal power and wind power.

Power distribution is discussed (briefly) under the general heading of Loading. It is claimed that "the overriding consideration in selecting systems is the peakload". The Survey further states that there are several ways to obtain estimates of peakloading for households; from the National Electrical Code or National Association of Home Builders data or by using so-called standardized or derived curve methods. In some instances, for normal dwellings, the peak may be only 10% larger than average and in others the peak may be as much as 70% larger. Load factor considerations (based on size, cost, location, etc.) will be among the predominant factors affecting MIUS operations.

In discussing electrical load profiles, the Survey recognizes the fact that for a given population sector the profile varies as a function of the requirements of that group. In a large grid, the effects of individual household appliance usage tends to be relatively small; as system size is reduced, fluctuating power requirements present more of a problem. The power generation and distribution system must be chosen to minimize voltage variation effects. Attention must also be focused on decreasing peakload requirements. The MIUS concept can alleviate some loading problems by allowing some internal loads to be activated during non-peak periods.

TITLE: DESIGN TECHNIQUES for MODULAR INTEGRATED UTILITY SYSTEMS

SOURCE: NASA-JSC

AUTHOR(S): B.M.Wolfer
PREPARED BY AUTHOR(S) AND/OR: NASA-JSC

DATE OF ISSUANCE: 2/77
OTHER IDENTIFIERS: NASA TMX - 58189; JSC-10747; available from NTIS

DATA USE RESTRICTIONS:

TOTAL:[PAGES 20 ;REFERENCES 6 ;GRAPHS 5 ;TABLES 1] *
DOCUMENT CLASSIFICATION(S): 41/15, 21, 34, 37, 38, 39, 55

ABSTRACT: *[Contains scattered material of (mainly) secondary relevance to the subject matter of this Compilation. The Total(s) are for the relevant material.]

This Report describes certain techniques which have been developed for the design of a MIUS and gives some results of design studies that have been performed. Comparative calculations are included for the energy required by a "conventional" utility system designed to provide the same services as a MIUS. [The MIUS system is to supply electricity, heating and air-conditioning, solid waste disposal and water treatment in a single integrated plant; it is intended to provide an alternative utility system which will conserve fossil fuels and water, minimize impact on the environment and (yet) be cost competitive.]

The electrical loads for each building being served by the MIUS are developed by using published information, generally derived from metered data. The load profiles are an hour-by-hour demand in KW, in two parts. The first part is made up of the loads in the environmentally conditioned spaces which in turn affect the heating and cooling loads; for example, in an apartment building these loads include: lighting; small appliances; air handler motors; refrigerators; electric ranges, etc. The second part is the auxiliary loads which consume electricity but do not affect heating and cooling loads; the principal contribution to this load is the equipment associated with the MIUS plant itself.

The energy requirements section of the Report determines the hourly, daily, seasonal and annual requirements for the MIUS complex. Load information from the HVAC loads section, heat recovery and fuel requirement data from the solid waste section and waste heat data from the power generation section are used to determine energy utilization and requirements for HVAC equipment, boilers, cooling towers, etc. [Thermal storage is considered an optional feature.] The power generation section calculates the energy requirements of specific prime mover systems, to provide electrical power as defined by the energy requirements section.

TITLE: INVESTIGATION of STORAGE SYSTEM DESIGNS and TECHNIQUES for OPTIMIZING ENERGY CONSERVATION in INTEGRATED UTILITY SYSTEMS (APPLICATION OF ENERGY STORAGE to IUS): FINAL REPORT

SOURCE: Battelle Columbus Laboratories

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: B.C.L. (for NASA-JSC)

DATE OF ISSUANCE: 3/10/76
OTHER IDENTIFIERS: Volume II (of 3 volumes); NAS9-14628, T-1139,3

DATA USE RESTRICTIONS: Check with NASA-JSC

TOTAL: [PAGES 19 ; REFERENCES 3 ; GRAPHS 3 ; TABLES 14] *
DOCUMENT CLASSIFICATION(S): 41/1,3,7,11,14,22,28,36,37,50,57

ABSTRACT: *[Information of direct and (mainly) secondary relevance to the subject matter of this Compilation is scattered thruout this Report. The Total(s) are for the relevant material.]

The primary objective of this investigation was the development of a framework for evaluating various alternative energy storage concepts. [Note: the basic technique should be adaptable to other areas which require the evaluation of alternative schemes.] This investigation had to do with the selection of the various criteria for assessing these energy storage systems, establishment of a "scoring system" and assignment of weighting factors for each criterion. The framework developed provides a means of summarizing the relative merits and shortcomings of the alternative schemes in a concise manner. The procedure devised basically involves the assignment of "weights" to each of the selected criteria according to their relative importance. The various alternatives are then evaluated against each of the assessment criteria and a "raw score" is assigned. The raw scores are multiplied by the assigned weights and the weighted scores are then summed for each alternative. The total weighted scores, for the various alternatives, may then be compared and a relative ranking determined.

The Report contains tabulated and graphical data showing the energy use profiles (for summer and winter "design" days) for a 1000-unit apartment and for a "village complex"; the hourly demand values cover: (1) domestic hot-water; (2) space heating/air-conditioning; (3) auxiliary electrical uses; (4) domestic electric uses. A "typical" load profile for integrated utility systems is also pictured to show the times when energy is stored and withdrawn from storage. [Note: In addition to the above "design" days, the Report also developed profiles for "average" summer, fall, winter and spring days.]

TITLE: INITIAL COMPARISONS of MODULAR-SIZED INTEGRATED UTILITY SYSTEMS and CONVENTIONAL SYSTEMS for SEVERAL BUILDING TYPES (JSC-09076)

SOURCE: NASA-JSC

AUTHOR(S): H.E.Benson & L.G.Monford, Jr.
PREPARED BY AUTHOR(S) AND/OR: NASA-JSC

DATE OF ISSUANCE: 4/76
OTHER IDENTIFIERS: NASA TM X-58140; may be ordered from NTIS as N76-24082
DATA USE RESTRICTIONS:

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DOCUMENT CLASSIFICATION(S): 41/3,7,10,14,22,30,42,44,48,49,57

ABSTRACT: *[Information of direct and secondary relevance to the general subject matter of this Compilation is scattered thruout the Report; the Total(s) cover the relevant material.]

The results of 6 MIUS conceptual design studies are reviewed in this Report; the studies were applied to a: garden apartment complex, high-rise office building, high-rise apartment building, shopping center, high school and hospital. The main purposes of the studies were to determine the performance of a MIUS (assumed) used in the facilities cited and to compare this performance with that of a conventional utility system. [All studies used Houston, Tex. weather data as the environmental conditioning base.] The size and location of the garden apartments design were varied to examine their effects on performance. In parallel with the design study, new construction was surveyed to determine where a MIUS could be applied for the largest market potential. Finally, the environmental effects of the design were established.

To ensure accurate data on the kinds and amounts of services required by each of the 6 building types, the architectural support contractor performed surveys of Houston buildings already constructed, under construction or being considered for construction. As a result of this survey, typical plans of each building type to be studied were chosen. These buildings varied in size and in services provided but served their purpose as elemental building blocks of a new community that was planned for study of an MIUS application. NASA-JSC subsystems engineering study groups concurrently determined the scope of service required by the various types of buildings by means of a literature review, surveys and interviews with apartment owners and utilities or from other applicable sources. The combined results of the construction and service requirements surveys served to identify the service demands (or "loads") for each service, in each building type, for a specific location. Operational characteristics of the subsystems were further determined under various load conditions. The provision by the MIUS and by conventional systems of identical services to the simulated buildings was then analyzed for comparison purposes.

TITLE: MIUS COMMUNITY CONCEPTUAL DESIGN STUDY (JSC-10650)

SOURCE: NASA-JSC

AUTHOR(S): B.E.Fulbright
PREPARED BY AUTHOR(S) AND/OR: NASA-JSC

DATE OF ISSUANCE: 6/76
OTHER IDENTIFIERS: NASA TM X-58174; may be ordered from NTIS by this number
DATA USE RESTRICTIONS:

TOTAL:[PAGES 76 ;REFERENCES 17 ;GRAPHS 61 ;TABLES 17] *
DOCUMENT CLASSIFICATION(S): 41/3,7,10,11,17,37,42,43,44,48,57

ABSTRACT: *[Information of direct or secondary relevance to the general subject matter of this Compilation is scattered thruout this rather lengthy Report; the Total(s) cover the relevant material.]

It should be noted that this is a Design Study for a large, hypothetical community development. Naturally, there is almost certainly a degree of inapplicability to the design for a real community. Thus, the assumed location may place significant constraints on the actual topography. Also, the assumed optimal utility distribution may have to be considerably compromised in a "real-life" situation.

This Study was undertaken to determine the applicability of the MIUS concept to an assumed "satellite community" of 100,000 persons. [Two MIUS design options were considered, one containing 8 MIUS-unit facilities and the other with 29 MIUS-unit facilities.] A conceptual design description and a system specification for an MIUS-supplied community have resulted from this Study. Parametric evaluations of the size and type of facilities to be included in the community have been made. Energy conservation devices were considered, cost analyses were performed and costs were compared for the MIUS and the conventionally supplied community. The analysis indicated that considerable resource savings could be obtained by using MIUS. The Report includes (idealized) electrical load and occupancy profile data for its townhouses, garden apartments, elementary/middle/high schools, local and regional shopping centers, recreational building, medium and high-rise apartments, office buildings, a community college, inn (or motel) and high-use hotel, and a hospital. [The basis for these profiles is from cited references plus certain NASA-JSC studies plus data collected by engineering consultants.]

[The electrical load for an MIUS is a function of the particular option considered.] Some electrical loads within the community are not associated with a particular building type; e.g., the electrical loads for the sewage treatment and solid-waste disposal systems, the water treatment plant and the water distribution system. Additional information regarding the development of the data for such loads is included in the section of the Report entitled "The MIUS Design Options I and II."

TITLE: MIUS SYSTEMS ANALYSIS: INITIAL COMPARISONS of MODULAR-SIZED INTEGRATED UTILITY SYSTEMS and CONVENTIONAL SYSTEMS + Addendum I

SOURCE: ORNL

AUTHOR(S): G.Samuels; et al **
PREPARED BY AUTHOR(S) AND/OR: ORNL

DATE OF ISSUANCE: 6/76; plus "errata" dated 9/21/76
OTHER IDENTIFIERS: ORNL/HUD/MIUS-6; may be ordered from NTIS by this number
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DOCUMENT CLASSIFICATION(S): 41/1,3,4,10,13,17,22,25,28,35,42,56,57

ABSTRACT: *[Most of the Report has direct or secondary relevance to the general subject matter of this Compilation; however, Section 4 + Appendices C, D, G and K are omitted from these Totals since they are essentially unrelated to this Compilation.]

**[Addendum I was authored by G. Samuels. It is entitled: "Further Comparisons of Modular-Sized Integrated Utility Systems and Conventional Systems - Sensitivity to Climate.]

This preliminary Analysis presents the results of an "initial comparison" of the economics, fuel requirements and environmental impacts of MIUS and conventional energy systems. [No final conclusions were reached because the results were only intended to help determine the requirements for additional modeling and analyses of Utility system performances and costs.]

The primary analytical effort was on determining the costs and energy requirements associated with several methods of supplying electricity, domestic hot water and space heating (and other air conditioning services) to garden and high-rise apartments. In this preliminary study, no associated commercial or industrial installations were considered.

Eleven cases (9 garden and 2 high-rise) were modeled. Four of the "garden" and one of the "high-rise" models obtained their electricity from on-site T.E. plants; the other 6 models were supplied from off-site sources. [There were variations in how space heating, air cooling and domestic hot water was assumed to be supplied; for example, space heating was either "district" or heat pumps or electric resistance or by gas.]

All models were evaluated on the basis of early 1972 marginal cost and fuel energy requirements. Two of the evaluations and comparisons are preliminary and approximate (being based on present country-wide average marginal cost figures) and are related to a single, fairly average, United States climate; they are, however, considered adequate for program planning purposes.

This Study chiefly compares energy systems that would be applicable to the residential portion of housing complexes on the outskirts of a large city; schools, offices, stores, and other buildings that would be associated with a large community, are not covered. Two general cases have been considered: (1) a complex consisting entirely of two-story garden apartments, with 12 (900 square foot floor area) dwellings per building and (2) a complex consisting exclusively of ten-story high-rise apartments containing 130 (800 square foot) units per building. The buildings would be arranged in clusters to form a large complex of several thousand dwelling units. Ample allowances were made for automobile parking, playgrounds and landscaped areas but detailed attention was not devoted to building designs and the location of the complexes.

The Philadelphia, Pa. area was selected as having climatic conditions which make it representative of many portions of the United States. [Addendum I extends the Study to other cities representing a broader range of climates and conditions.]

It was assumed that an apartment would have a gas-fueled cooking range and be air-conditioned during the summer. Equipment will be provided to permit an occupant to switch between heating and cooling in the spring and fall seasons, independent of other occupants. The cooling season was assumed to extend from May 22 to Sept. 24; during the early spring or late fall it is assumed that outside air ventilation can meet the cooling requirements. The domestic hot water source was varied from model to model.

Appendix H lists estimates of the electricity usage of various auxiliaries in the systems such as fan-coil blowers, hot-water pumps, chilled-water pumps and cooling-tower fans and pumps. [Elevators, corridor lights (and similar "common elements") have been prorated to the individual high-rise apartments.]

Appendix I gives information for the Report's estimate of domestic hot-water usage. The monthly energy usage is proportioned on the basis of past experience, with allowance for the fact that the (unheated) water temperature is higher in the summer and thus means less energy is needed to heat a specified quantity.

Appendix J has data on estimates of the peak and average electrical loads per apartment. These estimates were based on "typical" appliance usage and were then compared with similar data from two other sources (one being appreciably higher and the other appreciably lower).

TITLE: MIUS SYSTEMS ANALYSIS: COMPARISON of MIUS and CONVENTIONAL SYSTEMS for an EXISTING DEVELOPMENT

SOURCE: ORNL

AUTHOR(S): E.C.Hise; et al
PREPARED BY AUTHOR(S) AND/OR: ORNL

DATE OF ISSUANCE: 6/76
OTHER IDENTIFIERS: ORNL/HUD/MIUS-20; may be ordered from NTIS by this number.
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TOTAL:[PAGES 75 ;REFERENCES 22 ;GRAPHS 4 ;TABLES 27] *
DOCUMENT CLASSIFICATION(S): 41/9,10,13,17,22,25,28,42,57

ABSTRACT: *[Information of direct or secondary relevance to the general subject matter of this Compilation is scattered thruout the Report; Sections 2, 3 and 6 + Appendices A and C contain most of the data reflected in these Totals.]

This Study was directed toward the procedures related to applying the MIUS concept to an existing housing-commercial development (Walden) that is located near Chicago, Illinois. The postulated MIUS would supply electricity, district heating and cooling, liquid waste treatment and solid waste disposal.

This Report consists of 6 Chapters and 4 Appendices. [Chapt. 1 is an Introduction.] The second Chapter describes the Walden site and its buildings and also presents those estimated heating and cooling requirements, electrical requirements and waste productions which are the same, whether the site is Walden or the postulated "Live Model". In Chapt. 3, the conventional utility system serving the development is described; data is presented on electrical loads and heating and cooling, along with descriptions of how Walden handles its solid and liquid wastes. Chapt. 4 looks at the Live Model and estimates fuel energy savings with (and without) incineration with heat recovery; capital and operating costs for the MIUS installation are also presented; onsite treatment of liquid wastes is analyzed. Chapt. 5 discusses selected environmental impacts of the Live Model and compares them with impacts from conventional systems. Chapter 6 presents the summary and conclusion of the Live Model study. Appendix A describes the computational procedures used in the study and the input data sources. Appendix B shows how the cost of electricity from a utility grid was estimated. Appendix C looks at alternatives that could be used in the Live Model and also analyzes the effect of varying fuel costs. Appendix D gives technical data related to atmospheric dispersion of pollutants from the power plants and incinerators.

TITLE: MIUS SYSTEMS ANALYSIS: THE EFFECTS of THERMAL ENERGY STORAGE and SOLID WASTE INCINERATION OPTIONS on MIUS COST and FUEL CONSUMPTION

SOURCE: ORNL

AUTHOR(S): C.L.Segaser & W.R.Mixon
PREPARED BY AUTHOR(S) AND/OR: ORNL

DATE OF ISSUANCE: 7/76
OTHER IDENTIFIERS: ORNL/HUD/MIUS-26; may be ordered from NTIS by this number
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TOTAL: [PAGES 13 ; REFERENCES 9 ; GRAPHS 5 ; TABLES 3] *
DOCUMENT CLASSIFICATION(S): 41/3,10,11,15,17,21,30,34,36,37,57

ABSTRACT: *[Information of direct or secondary relevance to the subject matter of this Compilation is scattered thruout this Report, with most of it in Section 4. The Totals are for the relevant material.]

This Report presents the results of a parametric system analysis, using the ORNL 1973 MIUS hourly comparative energy computer program, to evaluate the effects of a sensible-heat TES device on fuel consumption in a hypothetical MIUS model. An economic evaluation is included for cases, with and without solid waste incineration and heat recovery, covering a range of storage capacities and fuel costs. The analysis indicates that a significant saving in fuel consumption can accrue from the storage of excess waste heat for subsequent use during periods when the available heat from the engine-generators is not adequate to satisfy the demand. [Note: the program was applied to a 720-unit garden apartment complex assumed located in the Philadelphia, Pa. climate.]

The development of anticipated electrical and thermal load profiles is a basic step in planning a MIUS or T.E. system, since the design and ultimate economic feasibility of the system depends on the magnitude and character of these loads. These load profiles depend on: climatological conditions; structure or building design; occupancy; method of operating lighting, heating and/or cooling; power equipment usage. The profiles can vary noticeably on an hourly/daily/seasonal basis.

Three major categories of data are required in order to develop the profiles, namely: local weather; building construction and design; building operating data. Building construction and design data will include: inside design temperatures; structure orientation with respect to the sun; heat-transfer characteristics of the building; areas of all exposed surfaces. Building operating data includes all parameters that vary with time and appreciably contribute to electrical and thermal loads, for example: building occupancy; illumination level; power-equipment operations (elevators, office machines, computers, tools and air-conditioning and air-handling machinery); domestic appliances; building thermal-lag, heat-storage and air-leakage characteristics.

TITLE: TECHNOLOGY ASSESSMENT of MODULAR INTEGRATED UTILITY SYSTEMS (Volume 2 of ORNL/HUD/MIUS-24) *

SOURCE: ORNL

AUTHOR(S): W.R.Mixon; et al
PREPARED BY AUTHOR(S) AND/OR: ORNL

DATE OF ISSUANCE: 12/76
OTHER IDENTIFIERS: ORNL/HUD/MIUS-25; may be ordered from NTIS by this number. Contract No. W-7405-eng-26.
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TOTAL: [PAGES 45 ;REFERENCES 23 ;GRAPHS 16 ;TABLES 20] **
DOCUMENT CLASSIFICATION(S): 41/4,10,13,14,17,21,37,38,42,55,56,57

ABSTRACT: *[Volume 1, Summary Report, has only slight relevance to the subject matter of this Compilation.]
**[Material of direct and (mainly) secondary relevance to the subject matter of this Compilation is scattered thruout this volume of almost 600 pages. The Totals (refer) to the relevant material, as found in Sections 3.3, 3.4, 3.8, 3.9 and 6.9 of Volume 2.]

This Technology Assessment is one of a series of publications developed in the MIUS program, under the direction of HUD. The assessment is a systematic study that places the technology within the total social framework, identifies impacts in all sectors and establishes cause/effect relationships to aid decision makers in balancing "good" and "bad" impacts. However, the assessment does not focus on technology but rather on the consequences of its application; the primary objective was to identify and evaluate the consequences of a widespread utilization of MIUS to the year 2000.

ORNL/HUD/MIUS-25 contains detailed data and analyses, in several sections. [Section 1 is identified as ORNL/HUD/MIUS-24. See * note, above.] Section 2 introduces the MIUS program and its concepts and the objectives, scope and approach of this assessment. Section 3 describes the types of MIUS and "conventional" subsystems - considered most likely to exist in the period 1975 to 2000 - and documents their projected costs, physical features, operating characteristics and the systems analyses used to determine the direct effects of MIUS operation. In Section 4, the societal characteristics are identified and discussed that may significantly affect - or be affected by - the development and application of MIUS. Major topics include: national goals and policies; market analysis; demands for and availability of fuel and other resources; institutional and legal factors; characteristics of home builders and developments; psychological and social factors. Section 5 is primarily for identification of the possible impacts of MIUS use on all sectors and interest groups of society; as a first step, the relevant characteristics of each subsystem were listed, operational aspects were defined and possible effects were identified and subjected to a preliminary evaluation. Sec-

tion 6 is an extension and integration of previous sections in which the influences and impacts on society from the application of MIUS are analyzed; several methods of impact analysis were used (with varying levels of measurement) in order to group as many impacts as possible into sets having a common basis for comparison. Impact categories considered included: economic; institutional; demographic; environmental; psychological/social; resources; national goals/policies. [Note: Since this Report compares MIUS and conventional systems, the characteristics deemed necessary to define MIUS were also determined for the analogous conventional systems.]

Electric system load patterns are briefly discussed (in Section 3.3), as part of a general discussion on the technology of conventional electric utilities. The limited data presented is highly aggregated at the national or utility-wide level.

Section 3.4 deals with heating and cooling applications applicable to MIUS and conventional utilities. [Conventional systems are considered to include district systems similar to MIUS, having central equipment within each apartment building and individual systems within each residence; however, no clear distinction is drawn between MIUS and conventional heating/cooling technologies, since a MIUS installation could serve low-density parts of a development with individual systems such as heat pumps and a conventional district system using centrally located boilers and chillers could be used to serve medium- or high-density housing.] Data is included for the power requirements of cooling-tower fans and pumps for a range of sizes of centrifugal and absorption-chiller systems.

Section 3.8 covers "consumer thermal and electrical requirements". It includes background data on domestic electric loads, as well as (reference literature) summaries concerned with the electricity demand and use of the various major household "appliances". Other topics touched upon: energy sales per residential customer; monthly variation in electrical energy use; domestic hot-water requirements; peak hourly/daily demands of commercial and institutional buildings; daily and monthly variation of electrical use in apartments; energy consumption vs style of house; building and site auxiliary electrical loads.

In Section 3.9, (specific) hypothetical models are developed to calculate the annual electrical (and other) energy uses for garden-apartment complexes assumed located in various climate regions of the USA. The effects of variations in a number of significant parameters are covered.

Section 6.9 discusses the impact of MIUS on conventional utilities. Data from the Philadelphia Electric Company (on residential load characteristics) is cited.

TITLE: PRELIMINARY DESIGN STUDY of a BASELINE MIUS SYSTEM

SOURCE: NASA-JSC

AUTHOR(S): B.M.Wolfer, et al (JSC); E.H.White (Clovis Heimsath Assoc.);
PREPARED BY AUTHOR(S) AND/OR: NASA-JSC R.Monzingo (Boeing Co.)

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DOCUMENT CLASSIFICATION(S): 41/3,10,13,17,22,30,37,42,43,56,57

ABSTRACT: *[The Study contains material of direct and (mainly) secondary relevance to the subject matter of this Compilation. The Total(s) apply to the relevant material.]

This conceptual design study for a high-density, 496-unit apartment complex in a median climate (Washington, D.C.) was performed to determine whether a MIUS would be cost competitive with conventional utilities and whether implementation of the MIUS would result in use of less fuel. Detailed cost analyses were performed and comparisons were made of design and operating variations for various climatic conditions; in addition, size-variation effects were investigated by using 300- and 1000-unit apartment complexes for comparison. [Note: The MIUS design presented in this report is said to be insufficiently detailed for (actual) implementation.]

The stated objectives of this Study were to: (1) define and cost a "baseline MIUS" system for an apartment complex, consisting of a mix of high-rise and garden apartments in a median climate; (2) investigate the deviations from the "baseline" for variations in location (climate) and size; (3) develop a preliminary performance specification; (4) assess the environmental impact of the system.

The Report includes: hour-by-hour occupancy and (KW) electrical demand profiles for the 496-unit apartment complex; average daily domestic water demands by building type; a summary-type discussion of the various major utility loads.

TITLE: ABSTRACTED REPORTS and ARTICLES of the HUD MODULAR INTEGRATED UTILITY SYSTEMS (MIUS) PROGRAM

SOURCE: NBS

AUTHOR(S): J.D.Ryan & B.Reznek
PREPARED BY AUTHOR(S) AND/OR: NBS

DATE OF ISSUANCE: 8/77
OTHER IDENTIFIERS: Work supported by HUD; NBS Special Publication No. 489; available from GPO as: SD Catalog No. C13.10:489
DATA USE RESTRICTIONS:

TOTAL: [PAGES ;REFERENCES ;GRAPHS ;TABLES] *
DOCUMENT CLASSIFICATION(S): 41/23

ABSTRACT: *[These Total(s) are not considered significant for this type of publication. Information relevant to this Compilation is (generally) found as "secondary" material in a minor % of the Abstracts; such pertinent reports/articles are seperately abstracted as part of this Compilation.]

This document provides a listing of reference material relating mainly to the HUD-MIUS Program; reports from 1970 through June 1976 are included. The entry for each report contains an abstract and other pertinent information, including procurement sources and procedures. The reports are classified into 3 publication/availability categories, namely: government publications (Published Reports), non-government publications and articles (Outside Publications) and unpublished reports and data (Open-File Reports). These reports are indexed, by subject matter, into 15 classifications covering 4 general areas: Program and Concept Description and Evaluation; Systems Analysis; Technology Evaluation; Hardware Evaluation and Testing.

This list of abstracted reports and articles also surveys data related to HUD-sponsored activities in the MIUS-related area of T.E. Systems. Included are all formal publications and selected unpublished reports which are accessible in the files of agencies participating in the MIUS Program. Significant articles and reports concerning MIUS, which were published outside the Program, are also included. [Agency press releases, newspaper articles and items in periodical publications are generally excluded, if they are not a direct part of the HUD-MIUS Program.]

Note: Additional reference material, issued since the publication of NBS SP-489, will be abstracted in a revision of NBS SP-489. This update of HUD-MIUS literature should be available by mid-1978 and will include some items which are abstracted elsewhere (in this Compilation), as well as a few "new" items which are somewhat relevant to the subject matter of this Compilation.

TITLE: ELECTRICAL POWER CONSUMPTION for MUNICIPAL WASTEWATER TREATMENT

SOURCE: EPA (National Environmental Research Center; Advanced Waste Treatment Research Laboratory)
AUTHOR(S): R.Smith
PREPARED BY AUTHOR(S) AND/OR: EPA

DATE OF ISSUANCE: 7/73
OTHER IDENTIFIERS: EPA-R2-73-281; NTIS PB-223360

DATA USE RESTRICTIONS:

TOTAL:[PAGES 21 ;REFERENCES 12 ;GRAPHS 3 ;TABLES 10]*
DOCUMENT CLASSIFICATION(S): 42/9,13,15,23,38

ABSTRACT: *[Information of direct and secondary relevance to the subject matter of this Compilation is scattered thruout this Report. The Total(s) are for the relevant material, although some of the References are rather general in content.]

This Report contains estimates of electrical usage for most of the conventional and advanced processes used to treat municipal wastewater. [Much of the information was taken from literature made available by equipment manufacturers but some came from reports related to EPA-sponsored research projects.]

The first part of the report is devoted to detailed consumption calculations for individual conventional processes; these estimates are then summed for primary, trickling filter and activated sludge plants. The second part of the report presents detailed computations of the consumption for the advanced or tertiary processes, to be used downstream of secondary processes. [Estimates of electrical power usage made at Lake Tahoe, Calif. were the principal source of this information.] These estimates were then summed for various alternative tertiary treatment trains. Finally, the electricity used in treatment plants is related to other uses, such as the typical residential use of electrical power.

Electricity usage in municipal wastewater treatment is about 1% of the average residential consumption of electrical power, when the distribution of treatment schemes given in the 1968 Inventory of Municipal Waste Facilities is used as a basis. If all communities were served by activated sludge plants, the power used would be about twice this amount, or equivalent to about 15 watts per household. The power consumed by tertiary treatment depends on the processes used, but for the Lake Tahoe system of tertiary treatment it is about 40-50% greater than that for conventional activated sludge treatment plants.

TITLE: ENERGY COST for the ALL-ELECTRIC BUILDING

SOURCE: Air Conditioning, Heating and Ventilating, 10/67, pp 72-74

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: Air Conditioning, Heating and Ventilating

DATE OF ISSUANCE: 10/67
OTHER IDENTIFIERS: A.C.H. & V. now called"Building Systems Design"

DATA USE RESTRICTIONS: Copyright by BSD, Inc.

TOTAL:[PAGES 3 ;REFERENCES 1 ;GRAPHS 2 ;TABLES 1] *
DOCUMENT CLASSIFICATION(S): 44/1, 6, 21, 28, 32, 37, 56

ABSTRACT: *[Information of (mainly) secondary relevance to the general subject matter of this Compilation is contained in this Paper.]

For 10 years the Los Angeles Department of Water and Power has been measuring (KW) demands and (KWH) consumption of electric air conditioning compressors in large office buildings. These tests, on central systems of 500 tons and over, covered periods of 2 years or more and used graphic-recording, 15-minute demand meters in series with the compressors.

Previously it was generally believed that there were 1200 to 1400 hours use of plant capacity per year with demands running close to 100% each month. The tests disclosed that older office buildings, with little glass area and moderate lighting levels, operate at 1800 to 2000 hours use of plant capacity per year whereas newer office buildings (with 45% and greater glass areas, utilizing average lighting levels of 80 foot-candles or better) operate at 2000 to 2400 hours use. KW demands, depending on season and system design characteristics, vary from 45 to 95% of capacity. It was also found that 35 to 40% of energy for cooling is used in the so-called heating period between Nov. and Apr.

The Paper contains a month-by-month tabulation which gives the annual electrical energy use for a 300,000 square foot (all electric) office building. The tabulation is divided into: base loads (lighting, air handling, pumps, elevators, receptacles and miscellaneous): air-conditioning compressors; resistance space heaters; domestic water heating. Related data on demands and cost are included in the Table. [Representative hourly demand profiles are also shown which indicate the proportionate amounts taken up by the base loads, etc.]

TITLE: ENERGY CONSUMPTION and COST in TWO LARGE AIR-CONDITIONED BUILDINGS

SOURCE: Building Research Station; Ministry of Public Buildings and Works

AUTHOR(S): N.O.Milbank
PREPARED BY AUTHOR(S) AND/OR: BRS/MPBW

DATE OF ISSUANCE: 4/68
OTHER IDENTIFIERS: Current Paper (CP 40/68) *

DATA USE RESTRICTIONS: Crown Copyright (British)

TOTAL:[PAGES 17 ;REFERENCES 6 ;GRAPHS 11 ;TABLES 4] **
DOCUMENT CLASSIFICATION(S): 44/1,9,13,15,17,21,22,32,43,57

ABSTRACT:*[Copy may be available. Request from: The Publications Officer; Building Research Station; Bucknalls Lane; Garston, Watford, Herts.]

**[Information of direct or secondary relevance to the subject matter of this Compilation is scattered thruout this Report. The Total(s) are for the entire Paper.]

The research program at the Building Research Station includes a study of the utility services in air-conditioned office buildings and how they are controlled by the design of the building, its usage and the environment provided. This Paper is an interim report on this work, providing information on the quantity and cost of energy consumption in 2 office buildings for a period of 12 months. Energy balances are presented which show how the use of oil and electricity is related to the design and use of the buildings and the prevailing weather conditions. The cost of energy is shown to have 4 significant parts, namely, heating, cooling, distribution and lighting. For each of these four, a further division is made to show the proportion of cost which arises from energy used and that which is determined by the capacity of the plant (i.e., maximum demand and connected load charges), a breakdown which is useful when considering the savings which may be possible by changes in design.

The 2 buildings, which are in normal commercial use, differ considerably in shape and methods of lighting and air conditioning but have similar thermal response characteristics to energy input. The principal features of the buildings are given, as are details of the major plant items which concern this Report. This paper contains only a brief description of the air-conditioning systems used, since they are conventional for their type.

The analysis of energy gains and losses has been made in 3 stages. Half-hour balances have been used to study the interaction of building and plant and also to establish the validity of the theory used for analysis. Consecutive half-hour results have then been brought together for 12 hour periods, which is the usual daily plant operating time. The same method has then been applied to the weekly results for a complete year. The results show that energy balances can be established for air-conditioned buildings of the type studied. The analysis is expected to lead to a method of obtaining reliable estimates for energy consumption and cost so that the architect and the building owner may become more aware of the implications of their design decisions.

The Paper includes tabulated data on occupancy, lighting, electricity demands and usage, fuel oil consumption and costs. Plots are shown for: complete energy balances; cumulative energy gains (from occupants, solar heating, lighting, etc.) vs time of day; energy losses and gains for weekly periods; cumulative electrical power consumptions and maximum demands.

TITLE: INVESTIGATION of MAINTENANCE and ENERGY COSTS for SERVICES in OFFICE BUILDINGS

SOURCE: Building Research Establishment; Department of the Environment

AUTHOR(S): N.O.Milbank; et al
PREPARED BY AUTHOR(S) AND/OR: BRE/DE

DATE OF ISSUANCE: 10/71
OTHER IDENTIFIERS: Current Paper (CP 38/71) *

DATA USE RESTRICTIONS: Crown Copyright (British)

TOTAL: [PAGES 10 ;REFERENCES 14 ;GRAPHS 13 ;TABLES 5] **
DOCUMENT CLASSIFICATION(S): 44/9,13,17,20,22,25,32

ABSTRACT: *[Reprinted from "Journal of the Institution of Heating and Ventilating Engineers"; October 1971, pp. 145-154.]

**[Information of (mainly) secondary relevance to the subject matter of this Compilation is scattered thruout this Report. The Total(s) are for the entire Paper.]

This survey of 25 commercial office buildings shows that broad estimates of maintenance and energy costs can be made in terms of floor area. However, somewhat better estimates are shown to result by also allowing for the capacity of the installed plant. [This latter approach is of benefit to the designers, if they are examining the "cost-in-use" of alternative design solutions.] Maintenance costs are given for heating/cooling, distribution of water and air, lighting, elevators and plumbing/drainage. Electricity contributes most to energy costs; its consumption can be estimated from the hours of equivalent full load operation for fans, pumps, lighting and refrigeration. Fuel-oil usage was found to be more difficult to predict but is only a small part of the total energy bill.

The pattern of operating costs for services in this sample of office buildings is surprisingly consistent. Lighting, elevators and heating and cooling distribution are the main areas of maintenance expenditure but lights, pumps and fans are most important for energy costs.

The Survey has only examined operating costs as they relate to building size, plant capacity and hours of use. The sample is too small to show the influence of the age of the plant or of the standards of maintenance. Notwithstanding these limitations, it is stated that this new data can be used by designers to make more informed estimates of operating costs which will give better design decisions based on the concept of costs-in-use. This view is encouraged by the fact that the few references to cost in existing publications are in general agreement with these findings. [The Paper includes a variety of cost data for the major building utility elements. There is a tabulation of the average annual electricity usage for lights, fans, etc., based on square footage. The concept of "annual hours of equivalent full load operation" is explained.]

TITLE: ENERGY CONSUMPTION in TALL OFFICE BUILDINGS

SOURCE: Building Research Establishment; Department of the Environment

AUTHOR(S): N.O.Milbank
PREPARED BY AUTHOR(S) AND/OR: BRE/DE

DATE OF ISSUANCE: 7/74
OTHER IDENTIFIERS: PD 67/74 *

DATA USE RESTRICTIONS: Copyright by BRE/DE (British)

TOTAL: [PAGES 20 ;REFERENCES 13 ;GRAPHS 4 ;TABLES 2] **
DOCUMENT CLASSIFICATION(S): 44/1, 9, 11, 15, 22, 32

ABSTRACT: *[Paper may be available as part of Proceedings of a Conference on "Tall Buildings and People" organized by Institution of Structural Engineers; held at Oxford, Sept. 17-19, 1974.]

**[Information of direct or secondary relevance to the subject matter of this Compilation is scattered thruout this Report. The Total(s) are for the entire Paper.]

Energy consumption in buildings is primarily determined by the specified Standards for lighting, ventilation and internal temperatures. From this viewpoint the building height is not as important as its depth. The Paper shows that shallow buildings (of up to 14 meters in overall depth) can be designed to make adequate use of daylight and natural ventilation, provided the ambient traffic noise is not serious. When air-conditioning is used, either as an alternative to natural ventilation or because of excessive noise levels, there are increased consumptions of electricity. In general, air-conditioned buildings use about 50% more primary energy than buildings with natural ventilation. When allowance is made for the efficiency of power stations, fuel processing and distribution losses (i.e., losses before energy reaches the building) there is little to choose between the basic energy requirements of air-conditioned buildings, whether they are designed as "deep-plan" structures with high levels of artificial lighting or as "shallow-plan" structures with natural lighting.

The Paper states that when buildings must be air-conditioned then, based on current design information, the deep-plan building may save around 7% energy relative to conventional designs. However, keeping in mind the many assumptions made in the calculations, it is doubtful whether this 7% value is sufficiently reliable to decide which building shape is the best; the decision could probably better be based on the shape which best suits the organizational needs of the building users. Questions of window area, sun shading and double-glazing are more important in the shallow buildings and even then they do not make a marked difference, say about $\pm$ 8%. [Of more significance is the way one compares heat and power requirements. When results are expressed in terms of primary energy, i.e. by accounting for the efficiency of processing, power stations and distribution losses, one gets a better indication of the energy resources required to maintain each individual building.]

There is a tabulation of the energy user for: refrigeration, fans and pumps, lights and boilers; building and equipment details are given for the various building shapes and internal environments that are examined.

TITLE: LIGHTING & THERMAL OPERATIONS: BUILDING ENERGY REPORTS (CASE STUDIES)

SOURCE: FEA

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: FEA (Office of Buildings Programs)

DATE OF ISSUANCE: 1975 (Revised)
OTHER IDENTIFIERS: Conservation Paper No. 4; FEA-195-D; available as NTIS PB 245 047
DATA USE RESTRICTIONS:

TOTAL: [PAGES 21 ; REFERENCES 19 ; GRAPHS ; TABLES 19] *
DOCUMENT CLASSIFICATION(S): 44/9, 11, 19, 32, 43

ABSTRACT: *[Contains material of relevance to the subject matter of this Compilation.]

These Case Studies provide energy conservation program results for 19 office buildings, located thruout the USA. The buildings had reported floor areas ranging from about 97,300 (for 6 floors) to 1,844,000 square feet (for 7 floors) and had from 2 to 41 floors. Electricity use in 1974 ranged from 8.5 KWH/square foot/year (for a 148,000 sq. ft., 7 floor building in Portland, Ore. which was built in 1919) to 21.0 KWH/square foot/year (for a 569,000 sq. ft., 18 floor building in Los Angeles, Calif. which was built in 1969). [The 1974 values (of KWH consumed) represent savings of from 15 to 42% over 1973.]

Data is also listed which compares the 1973 and 1974 values for: (a) illumination levels; (b) summer and winter thermostat settings; (c) building occupancy - in hours - for tenant workers and custodians; (d) ventilating fan operation - in hours.

TITLE: EFFECT of DEMAND INTERVAL UPON INDICATED PEAK DEMAND

SOURCE: AIEE Winter General Meeting; New York, N.Y.; 1/28-2/2, 1962

AUTHOR(S): R.H.Sarikas
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 1962
OTHER IDENTIFIERS: Paper (CP)62-114; AIEE Transmission and Distribution Committee
DATA USE RESTRICTIONS: All rights reserved by AIEE

TOTAL:[PAGES 7 ;REFERENCES 4 ;GRAPHS 2 ;TABLES 7] *
DOCUMENT CLASSIFICATION(S): 45/9, 13, 15, 19, 34, 37, 38, 39, 47, 52, 55

ABSTRACT: *[Contains material of (mainly) direct and secondary relevance to the subject matter of this Compilation.]

The peak demand imposed upon electrical equipment and distribution systems is the usual basis for design and operation. The factor that is often neglected is the duration or time interval of such demands. Data given in the paper provides a comparison of the peak demand of various classes of load for demand intervals of 15 minutes, half-hour and longer intervals. Also, the size of the demand interval affects the magnitude of the coincidence (and its reciprocal, diversity) factors used in determining the coincident demand of a group.

The data presented in this Paper furnishes a comparison of the peak demand (during the period 1952-59) for various demand intervals and classes of load served by the Illinois Power Co. system. [The demands were metered by graphic charts installed on the primary of distribution transformers serving the customers in the test groups.] An important use of the data is in correlating published load tests in which the investigators have used instruments with different demand intervals; this is especially true with regard to transformer load estimating schemes based upon relationships between KWH and KW. It is believed that the residential load figures given in this report are representative of many utilities since the annual KWH consumption and appliance saturation of Illinois Power Company residential customers was very nearly equal to the national average.

The tests covered urban residential and commercial customers (summer and winter) and rural residential plus farm customers. The indicated peak demand was found to depend to some extent upon the magnitude of the demand interval. The data provided permits an estimate of the effect of using different demand intervals. In the case of distribution transformers, serving a small number of residential customers, the 15-minute and hourly demands will differ by nearly 15%; this difference is greatly reduced if a large number of customers is served, such as is found on a distribution primary circuit. Groups of commercial customers have nearly equal 15-minute and hourly demands.

TITLE: PEAK SHAVING SLICES HIGH DEMAND

SOURCE: Electrical World, 1/15/76, pp 46-47

AUTHOR(S): C.F.Jack
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 1/76
OTHER IDENTIFIERS: System Engineering

DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL: [PAGES 2 ;REFERENCES ;GRAPHS 1 ;TABLES] *
DOCUMENT CLASSIFICATION(S): 45/13, 36, 55

ABSTRACT: *[Contains material of secondary relevance to the subject matter of this Compilation.]

Buckeye Power, Inc. (an Ohio generation-transmission cooperative) avoids high demand charges by shaving its peak with a computerized system that automatically cuts off power to residential water heaters at times of heavy demand. The system monitors total KW demand, calculates whether a new peak for the year is imminent and, if it is, triggers radio-controlled switches installed at customer water heaters.

Buckeye needs to operate the system only about 12 times a year to lop the most severe peaks from its load curve. Buckeye's load correlates strongly with ambient temperature, especially during winter, because its member co-ops serve many electric-heat customers. Thus, the system has, to date, operated only on the coldest days of the year. [On the coldest (peak) day the system deferred water-heater load at 10,000 households.]

TITLE: CONNECTICUT PEAK LOAD PRICING TEST
(Final Report)*

SOURCE:

AUTHOR(S): Conn. Public Utilities Control Authority;
PREPARED BY AUTHOR(S) AND/OR: Conn. Department of Planning and Energy Policy; Conn. Office of Consumer Counsel; Northeast Utilities Service Co.
DATE OF ISSUANCE: 5/77
OTHER IDENTIFIERS: Prepared in cooperation with FEA's Office of Conservation and Environment
DATA USE RESTRICTIONS: Check with FEA as to availability

TOTAL:[PAGES 27 ;REFERENCES ;GRAPHS 28 ;TABLES 7] **
DOCUMENT CLASSIFICATION(S): 45/5,11,19,21,36,37,38,39,47,52,55,57

ABSTRACT: *[This document had not yet been made available for general use at the time this Abstract was prepared.]
**[This Report contains information of direct and (mainly) secondary relevance to the subject matter of this Compilation. The Total(s) apply to the relevant material.]

The purpose of the test was to determine the response of Connecticut Light and Power Co. customers to a time- and price-differentiated rate structure, based on the innovative concept of peak load pricing. The test covered the period 10/16/75 thru 10/15/76.

The customers to be tested were drawn from a sample whose electricity use had been recorded (for a year prior to the subject test) as part of a previous CL&P residential-class load test. Those sample customers were assigned to 5 strata according to their total annual KWH consumption, as follows: 0-6,300; 6,301-9,400; 9,401-13,500; 13,501-23,000; over 23,000. Fifty customers, in each of the strata, were selected at random; their load test data have been used for the Peak Load Pricing Test (P.L.P.T.) to compare the use of the sample customers before and after the introduction of a time- and price-differentiated rate structure.

Because one of the primary objectives of the P.L.P.T. was to determine customer reaction to the experimental rate structure, an opinion research firm interviewed the sample customers prior to the test. Interviewers informed the test customers about the rate and ways to use it to best advantage and administered a questionnaire about demographic and appliance characteristics and attitudes concerning electricity use; 199 customers (out of the 228 interviewed) agreed to participate and 184 completed the test. [A control group on the regular CL&P rate was selected on the same basis as the test group and their use was monitored by similar recording devices. These two groups were affected by equivalent weather and economic conditions, thus allowing direct comparisons to be made.]

Certain detailed conclusions from the data are summarized below.
(1) Distribution of consumption by rate periods: the portion of the P.L.P.T.

group's total electricity usage in the "peak" hours was 10%, in contrast to 13% for the control group. In the "off-peak" period the percentage of usage by the test group was notably higher than that of the control group, 42.4 vs 37.4. In the "intermediate" period, the test group consumed 47.6% of its total usage and the control group 49.6%. [This evidence, and the responses to the customer survey, confirm that the test rate induced customers to shift the use of appliances out of the peak hours and (to a lesser extent) out of the intermediate hours into the off-peak hours.]

(2) Load shapes: the test group peak for an average Jan. day occurred in the hours ending at 10 and 11 p.m. whereas the control group peak occurred in the hour ending at 7 p.m., nearly coincident with the time of the system evening peak. In response to the lower prices in effect until 8 a.m., the test group displayed early morning loads in the winter which were considerably higher than those of the control group. In the summer the test group reduced its load during the system peak hours (10 a.m. to 12 noon and 1 to 3 p.m.), in contrast to the control group whose load remained relatively constant thru those hours.

(3) Load factor: the annual load factor of the test group (based on its load coincident with the Jan. evening system peak) was 0.597, in contrast to 0.524 for the control group. In all months of the year, the test group load factor (based on its load coincident with the system peak of that month) was higher than that of the control group; the difference was greater in the warm months than in the cold months.

(4) Test group peaks: the monthly peaks of the test group were lower than those of the control group in all highly weather-sensitive months.

(5) Diversity: there was no conclusive evidence as to whether the test rate had the effect of encouraging a greater coincident use of appliances among the test group customers, thereby reducing the diversity of appliance use found with non-time-differentiated rate structures.

(6) Reduction in use: the average test group customer used 5% less electricity than did the average control group customer. [Because of statistical differences between the test group sample and the control group sample, it is not clear what portion of the difference is directly attributable to the rate.]

(7) Customer response on days of extreme temperature: the proportions of total daily consumption in the four peak hours on the days of the Jan. evening system peak and of the June system peak (which are the days of extreme temperatures) were nearly equal to the corresponding proportions on average Jan. and June weekdays, respectively; this result shows that the test customers responded similarly to the pricing "signals" on extremely hot and cold days, as on days of normal seasonal weather.

(8) Customer attitudes: in general, the response to a time-of-day rate schedule was strongly favorable. The customer survey revealed that test customers responded to the test rate structure by changes in household schedules rather than by changes in activities. [Note: The test sample generally found it easier to control the use of the air conditioner, than that of the electric heating system, to respond to the rate.]

TITLE: RESIDENTIAL LOADS - OLD and NEW

SOURCE: Electrical World, 5/22/48, pp 114-117

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: E.W.

DATE OF ISSUANCE: 5/48
OTHER IDENTIFIERS:

DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL: [PAGES 4 ; REFERENCES 4 ; GRAPHS 5 ; TABLES 3] *
DOCUMENT CLASSIFICATION(S): 47/4, 19, 21, 37, 38, 52, 55

ABSTRACT: *[This Paper contains material of (mainly) secondary relevance to the subject matter of this Compilation.]

Individual applications are the building blocks that compose electric system loads. In all load problems - engineering, rate, sales, etc. - the loads of these individual applications are the primary elements. The more that is known about them, the more desirable the over-all load that can be built with them. Their preponderant majority in the total number makes residential customers and their load characteristics a matter of vital concern to utility management. Whether a utility does, or does not, promote residential uses of electricity seems to make no difference; its load and energy sales in that customer class will tend to increase.

The Paper tabulates the load characteristics of domestic appliances (and other uses) in urban communities in the middle eastern section of the USA. These characteristics are: annual use, non-coincident 30 minute maximum demand, diversified 30 minute maximum demand, diversity factor and coincidence factor. It is pointed out that for any particular utility the figures may be quite different from those in the tables. Thus it is best to determine load characteristics of applications and of customer groups by local research. Next best is to find applicable data in reports of researches made under conditions of climate, living habits, economic levels, etc., as nearly like the local scene as possible.

Characteristic (winter weekday) load profiles are shown for: (1) lighting plus small appliances; (2) refrigerators; (3) ranges; (4) controlled water heaters; (5) uncontrolled water heaters. These profiles are normalized in terms of the % of diversified maximum demand.

Additional data is tabulated for both unit and central furnace electric heating installations and for the heating load demands and load factors for an "average" 10,000 cubic foot house in Chattanooga, Tenn.

TITLE: HOW to SAVE TRANSFORMER CAPACITY

SOURCE: Electrical World, 4/22/57, pp 53-56

AUTHOR(S): R.W.Baker
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 4/57
OTHER IDENTIFIERS: Distribution-Operation

DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL: [PAGES 4 ;REFERENCES 3 ;GRAPHS 5 ;TABLES 5]*
DOCUMENT CLASSIFICATION(S): 47/13, 15, 17, 52, 55

ABSTRACT: *[Contains material of direct relevance to the subject matter of this Compilation.]

An economic study has produced a set of curves that are providing the Georgia Power Co. with a more economical basis for designing distribution transformer and secondary capacity. The curves plot coincident diversified demand against the number of customers, for 5 types of residential loads.

The study was made from demand charts taken for a week (or more) during the summer of 1954 on 232 residential customers selected from the entire KWH usage range and service area. The charts were made with 30 minute interval, integrating-type recording demand meters. [The weekly KWH ranged from about 35 to 159, with an average of about 90.]

Conclusions from this Study are:
1. For most customer types, older values for diversified demand are greater than present-day values.
2. Diversity between customer types is more pronounced than previously considered possible.
3. Transformer capacity installed for each new customer will be less, through application of demand data and transformer loading schedules.
4. Application of the Study's results to distribution design, for customers with high-wattage clothes dryers, would provide adequate service.

TITLE: RESIDENTIAL GROWTH NOT SET by EXISTING LOADS

SOURCE: Electrical World, 7/24/67, pp 58-60

AUTHOR(S): E.McCollom
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 7/67
OTHER IDENTIFIERS:

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TOTAL: [PAGES 3 ;REFERENCES 2 ;GRAPHS 5 ;TABLES] *
DOCUMENT CLASSIFICATION(S): 47/13, 14, 35, 38, 52, 55

ABSTRACT: *[Contains material of (mainly) secondary relevance to the subject matter of this Compilation.]

Analysis of loads and load growth rates among representative residential customers since 1960 led Oklahoma Gas & Electric Co. to conclude that:
1. Residential load growth in the O.G.&E. area is not proportional to load. Compound annual growth rates, which have been useful in projecting loads on systems where customers are being added each year, are not applicable for small groups of residential customers where the number of customers is constant.
2. Residential load growth is independent of the size or age of the house. Average annual load increase was found to be 0.5 KVA per house, with this average rate continuing until all major electric appliances are installed; from this point on the growth rate is slight, reflecting the addition of smaller appliances and the lack of new major appliances that could increase demand significantly.
3. Altho it is not considered practicable to attempt to predict load growth among residential customers within close limits because of the many variables involved, use of a uniform incremental annual KVA increase will nonetheless prove more accurage in projecting loads than would application of compound annual growth rates currently in use.

Study of residential load growth was undertaken because single-family dwellings comprise the largest block of customers in O.G.&E.'s area. [There lies within residential distribution system design a very significant likelihood for cost reduction through economic tailoring of the system to meet initial and future loads.] Earlier investigations of load characteristics, leading to faulty conclusions, were limited in scope by the expense of setting special meters and the limited time meters were left in place. Much was learned about residential loads, but very little about load growth.

TITLE: EXPLORING the NATURE of RESIDENTIAL LOAD

SOURCE: Electrical World, 1/26/70, pp 38-39

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: E.W.

DATE OF ISSUANCE: 1/70
OTHER IDENTIFIERS: Transmission/Distribution. (Data supplied by Tampa Electric Company; Tampa, Florida).
DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL:[PAGES 2 ;REFERENCES 1 ;GRAPHS 7 ;TABLES] *
DOCUMENT CLASSIFICATION(S): 47/13, 27, 38, 52, 55, 57

ABSTRACT: *[Contains material of direct relevance to the subject matter of this Compilation.]

To get accurate data for development of a transformer load management program, Tampa Electric Co. conducted a comprehensive survey of residential loads. Five real estate subdivisions (each representing a different category of load) were metered, using magnetic tape and indicating-demand meters. The data from the survey was also used: to develop diversity curves and transformer selection curves for field engineers; to determine the effect of weather on loading; to aid in locating overloaded distribution equipment; etc.

Magnetic tape meters were installed at 100 of 300 locations surveyed, and also at each of 90 heat pump customers. The survey was started late in 1965 and was completed in the spring of 1969.

The subdivisions selected as test sites each contained predominately one particular class of house, and ranged in electrical usage from below average to very high. The subdivisions were relatively stable in terms of customers.

Heat-pump homes metered included only those with the popular air-to-air type pump. Thirty each of 2-ton, 3-ton and 5-ton heat-pump homes were metered.

A recording meter was installed on the incoming feeder of each subdivision for the measurement of diversified demand and average usage and as a check on meter accuracy. Smaller groups of houses were also metered, so that a statistical sample could be obtained for the entire group.

Samples of plotted data (from the comprehensive survey) are reproduced in this Article.

TITLE: RESIDENTIAL DEMAND FOR ELECTRICITY

SOURCE: The Quarterly Review of Economics and Business; Vol. 11, No. 1 (Spring 1971); pp 7-22
AUTHOR(S): J.W.Wilson
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 1971
OTHER IDENTIFIERS:

DATA USE RESTRICTIONS: Copyright by Board of Trustees of the University of Illinois
TOTAL: [PAGES 16 ; REFERENCES 25 ; GRAPHS 2 ; TABLES 2] *
DOCUMENT CLASSIFICATION(S): 47/5,14,18,21,35,50,52,57

ABSTRACT: *[Information of direct or secondary relevance to the general subject matter of this Compilation are scattered thruout this paper. The Total(s) are for the entire paper, although most of the References are rather general in character.]

The principle objective of this Article is to estimate and evaluate intermarket variations in the quantity of electricity demanded by households in response to corresponding variations in power rates. Other possible determinants of electricity consumption (such as personal income, the price of natural gas and climatic conditions) were also considered. [Multiple regression of cross-section data is the primary statistical technique employed.]

Section I of the Article is a summary and evaluation of the conclusions of the best known empirical study on the demand for electricity. Statistically derived results, indicating that previous analysis of electric power demand have led to erroneous conclusions, are presented and interpreted in Section II. The empirical analysis is continued in Section III, where the author examines the impact of residential rates on electricity consumption for specific household uses. In Section IV, the substantive findings in Sections II and III are related to some persistent policy questions.

The major conclusions of this Study relate to "long run" changes. They are as follows: (1) the price of electricity is the primary determinant of the volume of electric power consumed by residential buyers; (2) residential demand for electricity is price elastic: (3) the cross-elasticity of residential demand for electricity (with respect to the price of natural gas) is substantial. These conclusions remain basically the same, whether they are concerned with aggregate demand or specific appliances.

TITLE: PATTERNS of ENERGY CONSUMPTION in the UNITED STATES

SOURCE: Stanford Research Institute (Menlo Park, Calif.)

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: SRI (for Office of Science and Technology, Executive Office of the President)
DATE OF ISSUANCE: 1/72
OTHER IDENTIFIERS: GPO Stock No. 4106-0034

DATA USE RESTRICTIONS:

TOTAL:[PAGES 28 ;REFERENCES 13 ;GRAPHS ;TABLES 25] *
DOCUMENT CLASSIFICATION(S): 47/1,4,8,12,14,21,22,24,25,33,51,56

ABSTRACT: *[Information of direct or secondary relevance to the general subject matter of this Compilation is scattered thruout the Report. The Totals are for the relevant material.]

The Report's tabulations of the residential consumption of electrical energy, by functional use, are based on the estimated number of appliances in use and their unit consumption. The number of units for individual years was usually based on Census data for 1960; to determine the appliances in service for each year, a % of domestic sales was added to the total in service at the end of the previous year. [Those not added to the previous year total were taken to be replacements.]

Unit consumption for individual years was calculated using straight-line interpolation between 1961 and 1969; for those years, EEI estimates of typical annual consumption of selected electrical appliances are available. [Unit consumption for gas appliances was estimated using straight-line interpolation between 1962 and 1969, for which years AGA estimates are available.]

Electricity consumption was found to be more diversified than for other "fuels"; no individual end use accounted for as much as 20% of total residential electrical consumption. For example, electricity, as an energy source for space heating, has grown rapidly and electric heat is estimated to account for 20% of the installations in all new homes. In 1968, 3.4 million homes were electrically heated compared with 0.7 million in 1960; this represents an annual growth rate in excess of 20%. [Altho 509,000 households acquired electric heat in 1969, only 449,000 were actually added to the 1968 total which means that 60,000 households must have changed from electric heat to another fuel, probably natural gas.]

In 1968, only 8% of all households were without a gas or electric water heater, compared with 26% in 1960. [Estimates of total water heater installations were based on saturation data. Of all water heaters in use, gas water heaters were estimated to have accounted for three-fourths.] The per unit annual energy consumption for gas and electric water heaters is tabulated for the period 1960-68. The increased per unit consumption during this period, for both gas and electric water heaters, may be explained by the fact that households are using more hot water, mainly because of the greater use of dishwashers and automatic washing machines.

In 1960, about 96% of all households were equipped with gas or electric ranges. Electric ranges increased their share from 33% in 1960 to almost 40% in 1968. A tabulation shows that the average (per unit) annual consumption of electric ranges (and ovens) decreased over the nine-year period by some 45 KWH per year, despite added features such as self-cleaning ovens, built-in clocks and automatic timers; the per unit energy consumption of gas ranges is reported to have remained stable. [One important development is microwave cooking. Studies by the AGA show that microwave ovens use an average 96.5% fewer BTU than gas ovens and 71.4% fewer BTU than electric ovens.]

The estimated saturation of households with refrigerators was 96% in 1969. The unit annual consumption of electric refrigerators was calculated using averages as reported by EEI. An increase in the (tabulated) consumption between 1961 and 1969 may be attributed to increased size and to added "automatic" features such as temperature control, ice cube makers and defrosting. In 1968, the most popular models of new frost-free refrigerator/freezers ranged from 13.5 cu. ft. to 17.0 cu. ft. of capacity, with electric energy consumption ranging from about 900 KWH/year to 2000 KWH/year.

Clothes dryers are somewhat of a luxury item and it is estimated that only 40% of all households were equipped with them in 1969. [The ratio of electric to gas dryers in use has remained relatively stable at about 2 to 1.] Despite a greater average utilization of dryers, the unit yearly consumption of gas dryers has declined slightly, from about 9.3 million BTU in 1960 to about 9.0 million in 1968; the reason for the decline is the gradual replacement of gas pilots (which account for nearly 50% of the total energy consumption in gas dryers) with electric pilots. Electrical dryers used (on average) from 960 to 990 KWH per year during the same time period.

The unit electricity consumption of electric food freezers was calculated using EEI estimates for 1961 and 1969. In 1961, the annual consumption was about 915 KWH per unit. In 1969 the average increased to about 1,195 for a unit comparable to the 1961 model; "frost-free" models, however, averaged about 1,761 KWH.

Almost all households had one television set and a substantial number had two or more. The average annual energy consumption of monochrome television sets increased from about 345 to 360 KWH during 1960-68; that for color sets increased from about 450 to 490 KWH. [Larger picture tubes and features such as "instant-on pictures" have increased the average energy consumption per set over the years, despite the fact that the average use per set declined because of the extra sets in many households.]

One of the most rapidly growing uses of energy in households is for air conditioning; in 1968, almost 25 million air-conditioning units were in operation. [All room air conditioners were assumed to operate in residences, since sales records do not show how many are used in small commercial establishments.] The average annual energy consumption for electric room air conditioners increased from about 1,250 KWH (1960) to 1,375 KWH (1968). [Increases are apparently the result of a larger unit size of 1,600 watts in 1969 compared with 1,300 watts in 1961; data for intermediate years were interpolated.] Central air-conditioning units, both electric and gas, have been assumed to average 3 tons of refrigeration. Electric units were estimated to consume 3,600 KWH per year on the average and gas to use an average 20 million BTU/year.

Other large appliances include dishwashers and washing machines. The average yearly residential use for dishwashers was about 338 KWH (1960) and about 360 KWH (1968). The corresponding values for washing machines was about 65 (1960) and 98 (1968). Despite this relatively low level of energy consumption, these appliances are included because both consume large quantities of hot water and the energy consumption for heating this water is included in that for water heating. [Thus dishwashers and washing machines are substantial consumers of energy, if this "indirect" use of energy is included.] Dishwashers, particularly, will increase in relative significance since only (an estimated) 20% of the households had them in 1969.

The remaining electric energy used in households was for lighting and miscellaneous small appliances. At the time this Report was prepared, little detail was available on lamps and estimates on the consumption of electricity by small appliances was said to be "controversial".

TITLE: RESIDENTIAL DEMAND for ELECTRICITY: ECONOMETRIC ESTIMATES for CALIFORNIA and the UNITED STATES

SOURCE: The Rand Corporation; Santa Monica, Calif.

AUTHOR(S): K.P.Anderson
PREPARED BY AUTHOR(S) AND/OR: The Rand Corp. (for NSF)

DATE OF ISSUANCE: 1/72
OTHER IDENTIFIERS: Report R-905-NSF. Available from NTIS as PB-236251

DATA USE RESTRICTIONS:

TOTAL: [PAGES 47 ;REFERENCES 10 ;GRAPHS ;TABLES 9] *
DOCUMENT CLASSIFICATION(S): 47/6,14,21,22,38,50,52

ABSTRACT: *[Information of (mainly) secondary relevance to the general subject matter of this Compilation is contained in this Report.]

Least-squares regression techniques were applied to a 50-state sample (of 1969 data) and to a 1947-1969 sample (for California), in order to identify and assess the quantitative impacts of significant residential electricity demand-determining factors. In the 50-state case, the chosen explanatory variables are: electricity and gas costs, average household income, average number of persons per household, fraction of population living in non-metropolitan areas, average Jan. and July temperatures and (in a special case) the number of all-electric customers per 100 utility customers. In the California case, the chosen explanatory variables are: electricity and gas costs, average per capita income and time (which is used to account for the effects of such time-related phenomena as the introduction and diffusion of new types of appliances).

The 50-state results yield statistically significant evidence that residential demand is influenced by all the explanatory variables, except the cost of gas and average Jan. temperature. Also, the saturation of all-electric homes has an important influence upon demand although one must reject the hypothesis that variations in such saturation can account for all the influence exerted by energy costs and income upon demand; however, it is found that this saturation is significantly related to energy costs and the average number of persons per household. The California results indicate that time-related phenomena accounted for a substantial portion of the growth in average demand per residential customer between 1947 and 1969.

The author states that whether the equations he has cited are better predictions than those previously available is best left to the judgment of the reader. Since it is not possible to predict with certainty that one estimate will be better than another, one is often right for the wrong reasons and "naive" trend extrapolation may just happen to turn out a better prediction than a carefully built model. This sort of result is most likely to occur when future conditions resemble those of the past and is least likely when important changes in underlying determinants occur.

TITLE: RESIDENTIAL ENERGY CONSUMPTION: MULTI-FAMILY HOUSING DATA ACQUISITION

SOURCE: Hittman Associates, Inc.

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: Hittman Associates, Inc.

DATE OF ISSUANCE: 10/72
OTHER IDENTIFIERS: HUD-HAI-3; HUD-PDR-29-5; NTIS PB 216-440

DATA USE RESTRICTIONS:

TOTAL:[PAGES 17 ;REFERENCES 32 ;GRAPHS 4 ;TABLES 8] *
DOCUMENT CLASSIFICATION(S): 47/3,4,11,22,23,30,33,38,40,57

ABSTRACT: *[Information of direct and secondary relevance to the subject matter of this Compilation is scattered thruout this Report. The Total(s) are for the relevant material, although some of the References are rather general in content.]

This program (which is partly summarized in this Report) identifies means for obtaining greater efficiencies in the utilization of energy in residences, in order to obtain lower per capita consumption without modification of existing life styles. The project objectives are two-fold:
(1) To identify and quantify the total energy balance in single-family and multi-family dwellings in the Baltimore/Washington area, including all sources of heat gain and loss from the structures due to "weather" and internal sources and the effect of air infiltration on the structure and on the energy balance of the structure.
(2) To evaluate various technical innovations that tend to minimize residential energy utilization by looking at all of the various household appliances and identifying those that are the largest energy consumers. Additionally, to examine innovations that will either reduce the energy consumption of the appliances or to find a way to reuse the discharged heat energy within the structure to further reduce the total (cooling) energy requirement of the structure.

The Report lists the design parameters for the (defined) "characteristic" town houses, low-rise apartments and high-use apartments which were examined as part of this study. Data is also shown for: (1) the appliances installed in each of the three characteristic residences; (2) appliance % saturation values; (3) estimated annual KWH/square foot, as a function of average apartment size and the number of apartments on a single electric meter; (4) estimated annual KWH for all-electric apartments, divided into base load, cooling, cooking, water heating and space heating; (5) % base load taken by lights, specified appliances and "miscellaneous"; (6) comparisons of estimated energy consumption values for characteristic single- and multi-family dwellings.

TITLE: ENERGY UTILIZATION in a RESIDENTIAL COMMUNITY

SOURCE: Princeton University/Center for Environmental Studies

AUTHOR(S):R.A.Grot & R.H.Socolow
PREPARED BY AUTHOR(S) AND/OR:Princeton University/C.E.S.

DATE OF ISSUANCE: 2/20/1973 (for Paper W-7) *
OTHER IDENTIFIERS:Working Paper W-7 (sponsored by NSF/RANN) *

DATA USE RESTRICTIONS:MIT Copyright (for second version) *

TOTAL:[PAGES 27 ;REFERENCES 1 ;GRAPHS 2 ;TABLES 5] **
DOCUMENT CLASSIFICATION(S): 47/3,4,7,14,16,22,30,52,57

ABSTRACT: **[Information of (mainly) secondary relevance to the subject matter of this Compilation is scattered thruout this Report.]

Twin Rivers, New Jersey, a relatively large Planned Unit Development, is also being used as a "laboratory" to investigate energy usage in residential communities. This development possesses an example of almost every generic type of housing: there are 168 single-family detached homes, 1626 townhouses, 942 garden apartments and (plans for) 2 high-rise apartment complexes. The consumption of gas and electricity is monitored and correlations are being established with weather data, housing type, architectural design, mechanical subsystems and the demographic characteristics of the residents. In parallel with this investigation, an extensive study is underway of the consequences for energy utilization of "decision-making" by the builder, architects, contractors and public and utility officials.

The current price range of the dwelling units is $32,000 to $41,000. The townhouses and condominium and garden apartments are of masonry bearing-wall construction, with wood framing for floors and roof. The single family dwellings are conventional wood frame. The construction (nominally) meets the various applicable codes, ordinances and Federal Housing Administration standards. With the exception of 43 "town-center" apartments, all constructed units have gas space heating. There is electric central air conditioning thruout. The dwellings of the first two construction stages have electric hot water heaters, electric ranges and electric dryers; the corresponding appliances of the third of the (planned four) stages are gas. Thermopane windows and patio doors are optional and these have been adopted by approximately half of the residents. The town is particularly suited to be a "laboratory" because there are a relatively few basic units all containing identical major appliances, except for standardized options.

The Report tabulates data for average (winter) gas consumption, for a statistical sample of various sizes and types of townhouses. A summary of the heat losses (via walls, doors, ceiling, basement and windows) is included for a 3-bedroom, 2-level townhouse. Among other preliminary observations, it is stated that the average winter gas usage is quite closely proportional to the townhouse width in the two-floor townhouses, but not in the split-levels; in fact, the 3-bedroom splits use slightly more gas than their 4-bedroom counterparts.

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*Note: Another version of this paper (having the same title but with some relatively minor changes in format and content) was included as Chapter 36, pp 483-498, of an NSF/RANN Symposium on "Energy Demand, Conservation and Institutional Problems", held at Massachusetts Institute of Technology on Feb. 12-14, 1973. This version had 3 references.

TITLE: RESIDENTIAL DEMAND for ELECTRICITY *

SOURCE: NSF/RANN Symposium on "Energy Demand, Conservation and Institutional Problems";held at Mass. Institute of Tech., 2/12-2/14, 1973
AUTHOR(S): J.Tansil & J.C.Moyers
PREPARED BY AUTHOR(S) AND/OR: ORNL

DATE OF ISSUANCE: 2/73
OTHER IDENTIFIERS: Chapter 28, pp 375-385 of Proceedings

DATA USE RESTRICTIONS: MIT Copyright on Symposium Proceedings

TOTAL:[PAGES 11 ;REFERENCES 20 ;GRAPHS 3 ;TABLES 3]**
DOCUMENT CLASSIFICATION(S): 47/1,4,11,14,16,21,25,27,28,31,52

ABSTRACT: **[Information of direct or (mainly) secondary relevance to the subject matter of this Compilation is scattered thruout this Paper. The Total(s) are for the entire Paper.]

This Paper examines the growth of residential electricity use (for 1950 to 1970) from the standpoint of increases in: the number of households; appliance saturations; average annual electricity usage per appliance. Growth patterns are defined which illustrate the factors accounting for the increase from 1800 KWH per household in 1950 to 7000 in 1970. Space heating, water heating and air conditioning are noted as having relatively small saturations, large average annual consumptions and the greatest growth potentials for contributing to the residential load. Energy conservation is stressed thru: (1) the importance of thermal insulation, (2) use of more efficient room air conditioners and (3) the substitution of heat pumps for electric resistance heating. The number of households, appliance saturations and average annual electricity use per appliance are projected to 1990 to obtain the total electricity consumption per appliance. The sum of the disaggregated projections is compared to other (independent) forecasts which were based on extrapolation and econometric methods.

The Article tabulates % saturation and (average) KWH/household/year, for a list of end uses which includes all major appliances plus air-conditioning (whether "room" or "central") and lighting and space heating. The tabulation covers both past and future values for 1950, 1960, 1970, 1980 and 1990. Predictions, for total USA residential demand, are plotted from 5 data sources; these show a value "spread" of about 2.5 by the year 1990.

*Note: This paper is mainly composed of information from ORNL-NSF-EP-51: "Residential Consumption of Electricity; 1950-1970" by J.Tansil, which is abstracted elsewhere.

TITLE: RESIDENTIAL ENERGY CONSUMPTION: SINGLE FAMILY HOUSING (FINAL REPORT)

SOURCE: Hittman Associates, Inc.

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: Hittman Associates, Inc.

DATE OF ISSUANCE: 3/73
OTHER IDENTIFIERS: HUD-HAI-2; HUD-PDR-29-2; NTIS PB 222-812

DATA USE RESTRICTIONS:

TOTAL:[PAGES 22 ;REFERENCES 15 ;GRAPHS 9 ;TABLES 3] *
DOCUMENT CLASSIFICATION(S): 47/1,4,6,10,11,23,28,30,33,34,37,43

ABSTRACT: *[Information of direct and secondary relevance to the subject matter of this Compilation is scattered thruout this Report. The Total(s) are for the relevant material, although some of the References are rather general in content.]

The Report describes the detailed quantitative thermal analyses that were performed on typical single-family residences in the Baltimore/Washington area. Thermal modeling techniques were adapted to identify the energy profile of a typical residence and to evaluate concepts whereby the energy consumption could be minimized. [As a reference for these analyses, a "Characteristic" house was synthesized to represent current trends in construction and the use of energy-consuming appliances.] In defining the consumption of internal energy and the associated evaluation of conservation concepts, the house was divided into three areas: the structure, the internal load and the comfort control components. Note: with respect to the heating and cooling requirements, it was found that infiltrated air was the greatest load component in both cases.

During the Heating season, the internal load is noted as contributing 16% of the heating requirement but in the cooling season this load added 35% to the cooling requirement. Analysis of the internal load showed the heat gain from the occupants was 25% of the load, the lights 19% and appliances 56%. The heating and cooling components accounted for 40 and 15%, respectively, of the primary energy consumption attributed to the Characteristic house; the remainder was internal load.

In addition to estimates of the energy savings to be expected from various conservation techniques, the Report contains data on: (1) ranges of values for major structural parameters of single-family dwellings in the northeast region of USA; (2) annual electrical heating requirements; (3) electrical appliance saturation data; (4) electricy energy use patterns for "all-electric" and "minimum-energy" houses; (5) 24-hour load profiles, due to appliances and lights; (6) 24-hour occupancy profile; (7) annual heating/cooling load profiles.

TITLE: RESIDENTIAL CONSUMPTION of ELECTRICITY (1950-1970)

SOURCE: ORNL

AUTHOR(S): J.Tansil
PREPARED BY AUTHOR(S) AND/OR: ORNL

DATE OF ISSUANCE: 7/73
OTHER IDENTIFIERS: ORNL-NSF-EP-51; NSF Environmental Program

DATA USE RESTRICTIONS:

TOTAL: [PAGES 34 ;REFERENCES 49 ;GRAPHS 5 ;TABLES 17]* 52,56,57
DOCUMENT CLASSIFICATION(S): 47/1,4,11,14,16,17,21,23,25,27,28,31,33,50,

ABSTRACT: *[Contains information of (mainly) direct relevance to the subject matter of this Compilation.]

This Report examines the growth of residential electricity use (between 1950 and 1970) on the basis of increases in the number of households, number of appliances and the average annual electricity consumption per appliance. Increased electricity use per household accounted for 73% of the growth while 27% of the growth was due to an increase in the number of households. Consumption patterns are defined which illustrate the factors accounting for the increase from 1800 KWH per household in 1950 to 7000 per household in 1970. It is noted that the greatest potential for more efficient energy use occurs through insulating houses better, shifting from electric resistance heating to heat pumps, using more efficient air conditioners, substituting fluorescent for incandescent lighting and by improving insulation for refrigerators, freezers and water heaters.

The number of households, number of appliances and average annual electricity use per appliance are projected to 1990 to obtain the total electricity consumption per appliance. The sum of the disaggregated projections is compared to other independent projections based on extrapolation and econometric methods.

This Report contains considerable detailed data (for 1950, 1960 and 1970 plus - as appropriate - % growth values for 1950-60, 1960-70 and 1950-70) compiled from its source references. This data includes the underdescribed.

(A) A tabulation of Residential electricity sold, number of wired households and related demographic information.

(B) A plotting of 20 year trends of major economic factors which help to determine Residential electricity use. These factors are arranged to show the effects of both current prices and "constant" (deflated) dollars; they are listed as: per capita disposable income, residential electricity price and household appliance consumer price index.

(C) Saturation percentages of the major household "users" of electricity and their average annual (KWH/household) consumption. Data is included for all major appliances plus air-conditioning ("room" and "central") plus lighting and space heating.

(D) Statistics on electric space heating, arranged by USA geographical regions. In addition to the values for average annual use there are values for average annual HDD.

(E) Information on the usage patterns of electric air conditioners of various types.

(F) Information related to the statistics, usage patterns and electrical consumption of all major appliances.

(G) Data on the use of electricity for lighting, water heating and miscellaneous appliances.

(H) Projections of appliance saturations and average annual electrical use per (appliance) household.

National average (annual) electricity consumption per appliance was computed from appliance saturations, electricity use per appliance per household and number of households. Increases were noted as due to: fuel shifts to electricity (from coal, oil and wood) for space heating, water heating and cooking; new uses of energy in the home, primarily air conditioning and clothes drying and television; bigger, more powerful, appliances. These causal factors were related to increased per capita income, cheaper electrical appliances and lower electricity prices.

TITLE: THE RESIDENTIAL DEMAND for ELECTRICITY in NEW ENGLAND

SOURCE: Massachusetts Institute of Technology, Department of Urban Studies and Planning + Energy Laboratory
AUTHOR(S): P.F.Levy
PREPARED BY AUTHOR(S) AND/OR: M.I.T.

DATE OF ISSUANCE: 11/73
OTHER IDENTIFIERS: Report #MIT-EL 73-017, for NSF; may be ordered from NTIS as PB 227 172. (Thesis for Master of City Planning.)
DATA USE RESTRICTIONS:

TOTAL: [PAGES 122 ; REFERENCES 29 ; GRAPHS ; TABLES 12] *
DOCUMENT CLASSIFICATION(S): 47/14,16,18,21,23,52,57

ABSTRACT: *[Information of direct and (mainly) secondary relevance to the subject matter of this Compilation is scattered thruout this Report. The Total(s) are for the entire Report, although many of the References are of general (rather than specific) interest.]

The Residential demand for electricity is here investigated on the regional level. A survey of the literature is included which covers past econometric work in the field of electrical energy demand. An econometric model is presented, using a 1970 cross-section of 67 New England electric utilities (and their service areas) as the data base. The special nature of the market for electricity, characterized by decreasing block rate structures, requires that both a supply price equation and a demand equation be estimated. A suitable technique, two-stage least squares, is used to obtain consistent coefficients from which elasticities of demand are obtained. The structural supply and demand equations were also estimated using ordinary least squares procedures. The coefficients derived in this manner are not significantly different from those obtained using the two-stage technique, an unexpected result considering the simultaneity of the demand and supply price equations.

Residential electrical demand is found to be significantly correlated with its average price, family income, family size, HDD and the ownership - public or private - of the electric utility. Price and income are found to be the most important determinants of demand. The cross-elasticities of demand with respect to the average prices of natural gas and fuel oil are (unexpectedly) negative.

The supply price correlates with the quantity of electricity consumed, utility operation and maintenance costs, total number of customers, degree of urbanization and the ownership of the utility.

Three methods are investigated for obtaining the total elasticities of demand from the reduced-form of the demand equation. These elasticities, contrasting with the direct elasticities derived from the structural equations, are shown for comparative purposes.

TITLE: RESIDENTIAL ENERGY CONSUMPTION: MULTI-FAMILY HOUSING (FINAL REPORT)

SOURCE: Hittman Associates, Inc.

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: Hittman Associates, Inc.

DATE OF ISSUANCE: 6/74
OTHER IDENTIFIERS: HUD-HAI-4; HUD-PDR-29-18(2)

DATA USE RESTRICTIONS:

TOTAL:[PAGES 25 ;REFERENCES 39 ;GRAPHS 2 ;TABLES 3] *
DOCUMENT CLASSIFICATION(S): 47/1,3,4,10,11,22,23,28,30,33,34,37,43

ABSTRACT: *[Information of direct and secondary relevance to the subject matter of this Compilation is scattered thruout this Report. The Total(s) are for the relevant material, although some of the References are rather general in content.]

This Report analyzes the consumption of energy within multifamily residences so as to define their patterns and also evaluate modifications whereby consumption could be reduced. [The types of multi-family residences included in this study were townhouses and low-rise and high-rise apartments.] Major emphases were placed on energy for heating and cooling and on modifications that would reduce the requirements for same.

To identify the current trends in multi-family housing in the Baltimore/Washington area, a large data base was developed from information obtained from national and municipal government agencies, gas and electric utilities, trade and industrial sources, and by supplementary field observations. Parameters were then identified for the design, construction, internal loads and comfort control systems for the following "characteristic" structures: (A) Townhouse, a 2-story structure containing 8 apartments in line; (B) Low Rise, a 3-story structure containing 24 apartments; (C) High Rise, a 10-story structure containing 196 apartments. [In defining these parameters, quality materials/components/workmanship were assumed, consistent with current practice and standards. All apartments were air-conditioned. Since the apartments could be considered "typical" of those occupied by middle-income residents, the kinds and use-rate of appliances and life-style patterns were assumed accordingly.]

The Report includes the following data for each of the above 3 characteristic structures: (1) ranges of heating/cooling loads, as between individual units; (2) % of heating/cooling loads attributed to air infiltration; (3) primary energy consumption per apartment and per square foot and per occupant; (4) 1970 appliance saturation values; (5) annual electrical consumption for lights, appliances, space cooling and "miscellaneous"; (6) daily internal load profiles - as a fraction of maximum load - for appliances, lights and occupants.

TITLE: ENERGY REQUIREMENTS of RESIDENTIAL HOMES

SOURCE: Proceedings of the Conference on Improving Efficiency in HVAC Equipment and Components (for Residential and Small Commercial Buildings), pp 202-213

AUTHOR(S): D.R.Tree & J.F.Hamilton
PREPARED BY AUTHOR(S) AND/OR: Ray W. Herrick Laboratories, Dept of Mechanical Engineering, Purdue University

DATE OF ISSUANCE: 10/7 & 10/8, 1974
OTHER IDENTIFIERS: Conference co-sponsored by FEA, ASHRAE, NBS, Ray W. Herrick Labs
DATA USE RESTRICTIONS:

TOTAL:[PAGES 12 ;REFERENCES 5 ;GRAPHS 12 ;TABLES 5] *
DOCUMENT CLASSIFICATION(S): 47/1, 8, 12, 22, 24, 28, 30

ABSTRACT: *[Contains material of relevance to this Compilation.]

As part of this study, 4 houses were designed, built and instrumented to evaluate the comfort provided by and the operating characteristics of 4 different heating and air-conditioning plants. The energy inputs to each house (including those to the heating and cooling equipment and to some of the major appliances) were measured. Thruout the project each house was occupied by a family especially selected (from 67 applications) to participate in this research project. These homes were located in a northern, midwest city.

All 4 houses were 3 bedroom, brick exterior ranch-style, with approximately 1145 sq. ft. of living area. Each house has a full basement. Identical construction procedures were followed for all the homes. In general, the homes were built as similar as possible (except for intentional variations in insulation thickness) without making the exterior appearance identical. The overall construction procedures were the same as used in ordinary practice, in hopes that the homes might well represent "typical" dwellings.

The above-mentioned heating and cooling equipment consisted of: (a) gas heating/cooling; (b) gas heating/electric cooling; (c) heat pump, for heating/cooling; (d) electric heating/cooling. [The comfort conditioning systems were installed according to manufacturer's specification and are considered "typical" for the northern part of the USA.]

The Paper includes "bar" graphs of the electricity and/or gas used by range/ovens and by clothes dryers, in each of the 4 test homes. [The values are presented as BTU/hour, with an electricity equivalent of 3413 BTU/KWH, and are weekly averages during the test year.] Two of the houses used gas for these appliances (except for their electric auxiliaries) and the other two used electricity. There is also some data given for: (a) energy use by refrigerators; (b) operating minutes per week for washers and dryers; (c) number of times dryers were used per week.

TITLE: GROWTH of RESIDENTIAL CONSUMPTION of ELECTRICITY: DISTRIBUTION AMONG HOUSEHOLDS at VARIOUS CONSUMPTION LEVELS

SOURCE: Land Economics (Quarterly), pp 149-157

AUTHOR(S): W.Lockeretz
PREPARED BY AUTHOR(S) AND/OR: University of Wisconsin

DATE OF ISSUANCE: 5/75
OTHER IDENTIFIERS: Volume LI, Number 2

DATA USE RESTRICTIONS:

TOTAL: [PAGES 9 ;REFERENCES 20 ;GRAPHS 4 ;TABLES]*
DOCUMENT CLASSIFICATION(S): 47/23, 34, 50, 52, 55

ABSTRACT: *[This Paper contains information of direct (mainly) and secondary relevance to the subject matter of this Compilation. The Total of all References is shown, although some are rather general in nature.]

This Paper examines how households consuming different amounts of electricity have shared in the overall growth in residential consumption; an important question in determining whether the benefits of a continuing increase in consumption outweigh the mounting difficulties of providing the additional supply.

This work analyzes the use of residential electricity in the Missouri service area of the Union Electric Company, or approximately 580,000 households. Consumption per household rose by 37.5% between 1968 and 1973 and the number of households increased by 7.7% in the same period, yielding an overall increase in consumption of 48.1% or an average of 8.2% annually.

The basic data used in the study consisted of the monthly frequency distributions of residential consumption for the years 1968 through 1973. Each such distribution gives the fraction of households in each consumption interval; the intervals ranged "in width" from 10 KWH (for consumption up to 100 KWH per month) up to 100 KWH (for consumption above 1000 KWH per month). For example, a household with a base load consumption of 510 KWH in 1968 was in the top 20% of households and one would expect that, on the average, this household would have a base load consumption of 670 KWH in 1973, which corresponds to the top 20% of households in that year.

TITLE: RESIDENTIAL DEMAND FOR ELECTRICITY: A CONSUMER PANEL APPROACH

SOURCE: Southern Economic Journal, pp 212-217

AUTHOR(S): R.P.Wilder & J.F.Willenborg
PREPARED BY AUTHOR(S) AND/OR: University of South Carolina

DATE OF ISSUANCE: 10/75
OTHER IDENTIFIERS: Volume 42, Number 2

DATA USE RESTRICTIONS:

TOTAL:[PAGES 6 ;REFERENCES 6 ;GRAPHS ;TABLES 5] *
DOCUMENT CLASSIFICATION(S): 47/10, 13, 14, 16, 17, 18, 21, 52

ABSTRACT: *[This Paper contains information of direct and (mainly) secondary relevance to the subject matter of this Compilation.]

Previous studies of the demand for electricity have been handicapped by the unavailability of microlevel data, at least in the "open" literature. Prior investigators have generally used a state, a city or an SMSA as the unit of observation but because of the level of data aggregation, their studies offer only limited insight into the household level determinants of demand for electricity.

This study makes use of cross-sectional, household-level data for a single metropolitan area in estimating the price and income elasticity of demand for electricity. Relationships between electricity consumption and price, family income, stock of electrical appliances and size of residence are explored. The results are said to have implications both for energy policy and for the rate-making activity of utility regulatory commissions.

The "model" selected by the authors includes both a demand equation and a price equation, which are estimated simultaneously to provide the elasticity estimates. In specifying the demand equation, it is noted that the residential demand for electricity is a derived demand, which is based on the primary demand for appliances and other electrical devices in the household. In general, household electricity use depends on the following: (a) the stock of electrical appliances; (b) the size of the residence; (c) the intensity with which appliances and electric service are used. [Changes in income and price affect use in the shortrun by changing the intensity of use of existing stocks of appliances; in the longrun households can also make adjustments to the appliance stock and size of residence primarily in response to changes in income.]

It was concluded that altho electricity is frequently thought of as a necessity rather than a luxury, its income elasticity is relatively high (but less than unity) for the middle and upper income class households studied. Even without population growth, growth in per capita income would tend to perpetuate the strong rate of increase in the residential demand for electricity; e.g., if gross family income grows by 6% per year, this demand would grow by about 2% per year from the income effect alone, everything else being equal. The size of residence also has a strong effect on the demand and the size of residence is closely related to income.

The reported estimates of price elasticity, as well as those of most other recent studies, suggest that it is in the vicinity of -1.0. This finding contrasts with the view expressed (by utilities) in many regulatory proceedings that total revenues should increase by the same percentage as average rates, which would imply a price elasticity of zero.

TITLE: ELECTRIC SCHOOL HEATING - OPERATING RESULT DATA (Northern Pike School and Others)

SOURCE: American Institute of Electrical Engineers

AUTHOR(S): W.G.Potter & J.P.Gallagher
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 1959
OTHER IDENTIFIERS: Paper No. (DP)59-1001; AIEE Summer and Pacific General Meeting; Seattle, Washington; 6/21-6/26, 1959
DATA USE RESTRICTIONS:

TOTAL:[PAGES 21 ;REFERENCES 2 ;GRAPHS 4 ;TABLES 4] *
DOCUMENT CLASSIFICATION(S): 48/13, 21, 28, 36

ABSTRACT: *[Contains material of direct and (mainly) secondary relevance to the subject matter of this Compilation.]

In order to obtain data under various operating conditions, a study was made at the Northern Pike Elementary School, Monroeville, Pa., during the 1958-1959 winter. [Data is also included in the Paper on 6 other schools, varying in size from a small elementary school to a large high school with an electrically heated swimming pool.] The study was to determine: (1) Heating energy consumption (KWH); (2) Heating and total demands established (KW); (3) Heating load diversity; (4) Heating operating cost; (5) Operating results using an electric room-temperature system.

The following conclusions were reached:
1. Buildings built with insulation and controls specifically for the use of electric heating ordinarily enjoy a very low "heat factor" (and hence have operating costs that are frequently well below original estimates). Those with less insulation than economically justified may result in disappointing operating costs. Buildings built in the conventional manner (with an electric-heating system sized and designed to simply replace a steam or hot water system) are invariably unsatisfactory and result in disappointingly high operating costs.

2. All electrically heated buildings (on a demand rate schedule) should be equipped with a recording demand meter in order to provide quick evidence of equipment or operating personnel irregularities that might cause excessive demand or consumption.

3. Total building demand can be successfully limited by accurate scheduling of (zone) time clock warm-up periods, whenever night temperature setback operation is used. [Note: The integral, electric room-temperature control system tested was completely successful in maintaining room comfort level under all occupancy and weather conditions.]

TITLE: METERED DATA-SCHOOLS

SOURCE: Florida Power Corporation (St. Petersburg, Florida)

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: F.P.C.'s Competitive Research Dept.

DATE OF ISSUANCE: 4/2/70
OTHER IDENTIFIERS: Bulletin #167

DATA USE RESTRICTIONS:

TOTAL: [PAGES 1 ;REFERENCES ;GRAPHS ;TABLES 1] *
DOCUMENT CLASSIFICATION(S): 48/13, 43, 55

ABSTRACT: *[Contains material of direct relevance to the subject matter of this Compilation.]

Tabulated data is presented for 4 Senior High Schools (2 all-electric), 6 Junior High Schools (2 all-electric), 6 Elementary Schools (2 all-electric) and 3 "others" (1 all-electric). The respective (average) daily attendance ranges were about: 1100 to 1800, 860 to 1490, 280 to 770 and 185 to 780.

Annual KWH values are listed as are demand values, where available. KWH values are also given in terms of square footage per classroom and on a per student basis. Data is included as to the size of the school, number of classrooms and student capacity.

TITLE: TOTAL ENERGY: A TECHNICAL REPORT FROM EFL

SOURCE: Educational Facilities Laboratories, Inc.

AUTHOR(S): N.Kurtz; et al
PREPARED BY AUTHOR(S) AND/OR: EFL

DATE OF ISSUANCE: 5/70 (3rd printing)
OTHER IDENTIFIERS: Technical Report No. 2. (Based on a research project conducted for EFL by F.S.Dubin Associates, Consulting Engineers).
DATA USE RESTRICTIONS:

TOTAL: [PAGES 15 ;REFERENCES ;GRAPHS 17 ;TABLES 6]*
DOCUMENT CLASSIFICATION(S): 48/13, 15, 17, 22, 42, 53

ABSTRACT:*[Information of (mainly) secondary relevance to this Compilation is scattered thruout this Report. The Total(s) are for the relevant material.]

This Report deals with a "total energy" (T.E.) approach to on-site power generation providing school buildings with heating in winter and cooling in summer, as well as light and power all year round. [EFL's goal in supporting this study was to determine objectively its implications and advisability for American schools and colleges.]

Evening classes, multifunction buildings, (probable) year-round air conditioning and the increased use of electronic teaching aids all add up to one indispensable fact: the energy requirements - for light and power, heating and cooling - of the modern educational institution are markedly different from those of the pre-1950 school.

Dealing with both initial and operating costs of mechanical and electrical systems, this Report presents design alternatives measured on the basis of long-range engineering economics. The report examines (and advocates) higher initial investments when balanced by greater long-range operating economies.

The fundamental approach used in this report to evaluate the feasibility of T.E. was to compare two sets of hypothetically equivalent schools or colleges, one set with a conventionally powered heating and air-conditioning plant and the other with a T.E. plant. Pairs of schools identical in respect to program, size, layout, construction, location, hours of occupancy and energy requirements were then compared.

TITLE: SCHOOL ENERGY SYSTEMS: AN ANALYSIS of GAS and ELECTRIC HEATING in NORTHERN PLAINS SCHOOLS

SOURCE: Northern Natural Gas Company (Omaha, Neb.)

AUTHOR(S): G.R.Schmieding
PREPARED BY AUTHOR(S) AND/OR: Market Development Department of N.N.G.Co.

DATE OF ISSUANCE: 10/70
OTHER IDENTIFIERS:

DATA USE RESTRICTIONS: Detailed use may be controlled by AGA

TOTAL: [PAGES 17 ;REFERENCES 2 ;GRAPHS 3 ;TABLES 6] *
DOCUMENT CLASSIFICATION(S): 48/10, 14, 17, 22, 28, 30, 32, 42, 55, 47

ABSTRACT: *[Information of direct or secondary relevance to the general subject matter of this compilation is scattered thruout the Report. The Totals are for the relevant material.]

The major purpose of this Report is to present representative, factual information about the energy costs of both natural gas-heated and electrically heated schools in the Northern Plains region of the USA. Schools cannot be expected to consume the same amount of energy (due to differences in building construction, operating hours, equipment and weather conditions) but this Report serves as a reference point for energy requirements, based on the historical experience of other schools. In addition to information on operating costs, construction costs and system performance and environmental pollution are among the other factors which are discussed. A final purpose is to illustrate (for school administrators, architects and engineers) the extent to which the energy consumption and cost of proposed school buildings can be predicted during the planning stage with the aid of computer programs available thru the gas utilities of the Northern Plains.

The major data came from a survey of 136 public schools including 113 with "conventional" energy systems and 23 with "all-electric" energy systems. The conventional schools used natural gas for space and water heating, purchased electricity for light and power and a combination of gas and electricity for kitchen and air conditioning purposes. The other schools purchased electricity for all energy using purposes. The survey was conducted by means of personal interviews, correspondence and telephone interviews. For each school, energy consumption and cost was obtained in total and (where possible) for heating and other functions, during a 12-month period. Additional information included: average climatic conditions; the date and cost of construction; size and student capacity; the operating schedule; and, frequently, the opinions of school administrators and operating personnel on energy system performance.

Tabulated data is used to summarize the (available) maximum monthly demand and maximum KWH use for elementary, junior and senior high schools of both the conventional and all-electric types. Additionally, annual KWH consumption is listed on both an overall and "per square foot" basis; annual (total $) electricity costs are provided,as are the unit costs (¢/KWH).

The appendices contain detailed statistical tables summarizing the survey findings. For each individual school the tables list: (1) its physical description; (2) heating consumption and costs; (3) electric light and power usage and costs; (4) composite energy consumption and costs; (5) construction cost; (6) definition of technical terms; (7) an example of the method of calculating utility fuel bills.

TITLE: THE ECONOMY of ENERGY CONSERVATION in EDUCATIONAL FACILITIES

SOURCE: Educational Facilities Laboratories, Inc.

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: EFL (New York, N.Y.)

DATE OF ISSUANCE: 7/73; reprinted 9/74
OTHER IDENTIFIERS:

DATA USE RESTRICTIONS: Copyright by EFL, Inc.

TOTAL:[PAGES 81 ;REFERENCES 14 ;GRAPHS 3 ;TABLES] *
DOCUMENT CLASSIFICATION(S): 48/11, 17, 42

ABSTRACT: *[Information of (mainly) secondary relevance to this Compilation is scattered thruout this Report. The Total(s) are for the entire Report, although some of the References are rather general in character.]

The Report states that school boards continuing energy-wasting practices can expect soaring operating costs. [According to a panel consulted by EFL, one can expect a roughly three-fold multiplication of energy costs over the next decade.] Yet, there is nothing to prevent school boards and administrators from trying to obtain the most for the public's money. It is pointed out that: "In any given year, a mere 5% reduction in the energy costs for existing buildings would add up to a greater total saving than a 50% saving in new school buildings."

The opinion is expressed that in new construction one should design for 40% less energy consumption than in conventionally designed and operated buildings. [About half of this reduction would not reduce capital costs but would reduce long-term owning costs; a minor proportion of this energy conservation design, say 10%, would raise even long-term costs.] In existing buildings, one should aim for 30% less energy consumption and about two-thirds of the realized savings would bring long-term economy.

TITLE: ENERGY CONSERVATION and the BUILDING SHELL

SOURCE: Building Systems Information Clearinghouse (of) Educational Facilities Laboratories, Inc.
AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: BSIC/EFL (Menlo Park, California)

DATE OF ISSUANCE: 7/74
OTHER IDENTIFIERS: BSIC/EFL Energy Workbook (Section 1)

DATA USE RESTRICTIONS: Copyright by EFL, Inc.

TOTAL: [PAGES 31 ;REFERENCES 4 ;GRAPHS 5 ;TABLES 10]*
DOCUMENT CLASSIFICATION(S): 48/11, 22, 42

ABSTRACT: *[Contains material of (mainly) secondary relevance to the subject matter of this Compilation.]

Planners/designers, manufacturers of equipment and owners - which includes the administrators - "must" take the lead in developing and using energy conservative practices in the design, building, equipping and use of school buildings because the facilities they plan and operate are high consumers of energy and because they are most directly answerable to the public.

The basic purposes of this Workbook are to:
A. Show how the building shell affects the school's energy consumption.
B. Identify energy conserving ideas for use in the design (or redesign) of the shell and to give examples showing how such ideas may be applied to new construction and modernization projects.
C. Provide a simple method for determining, during the preliminary stages of the design process, the effects of these ideas.
D. Identify sources of additional information to assist design professionals in making a more complete analysis of the effect of the building shell on energy consumption.

To illustrate how these ideas may be applied to design projects, two examples are presented - one a modernization project and the other a new school design project. Electrical usage data plays only a minor role in the examples.

TITLE: RESEARCH, DESIGN, CONSTRUCTION and EVALUATION of a LOW ENERGY UTILIZATION SCHOOL (Phase 1: Interim Report)*

SOURCE: NSF/Board of Education, New York City

AUTHOR(S): R.G.Stein; et al
PREPARED BY AUTHOR(S) AND/OR: Prepared for Board of Education by Richard G. Stein and Associates, Architects (New York, N.Y.)
DATE OF ISSUANCE: 8/15/74
OTHER IDENTIFIERS: NSF-RA-N-74-117; GPO Stock No. 3800-00194; NSF-RANN Grant No. GI-39612
DATA USE RESTRICTIONS:

TOTAL:[PAGES 100;REFERENCES 15 ;GRAPHS 20 ;TABLES 35] **
DOCUMENT CLASSIFICATION(S): 48/1,6,11,22,28,38,39,42,43,50,57

ABSTRACT: *[There are two other Reports associated with this School Study. One of these is a "phase 2" Report, identified as NSF/RA-770032 and is available from NTIS as PB-269407; it is abstracted elsewhere in this Compilation. The other is an "Energy Conservation Operation Manual", identified as NSF/RA 770033 and is available from NTIS as PB-268555; this Manual is essentially an appendix to NSF/RA-770032 and is not seperately abstracted as part of this Compilation.]
**[Information of direct or secondary relevance to the general subject matter of this Compilation is scattered thruout this rather lengthy Report. Because of the overlapping nature of the data, the Total(s) for the relevant material are approximated.]

The Report states that substantial energy savings can be achieved in schools. This statement is based on a re-examination of the educational determinants that have influenced energy consumption in the past and on a review of the technical performance of the building components. [Since educational buildings represent 7% of the building area in USA, these savings are potentially considerable.]

New York City (NYC) has a comparatively well-run school system, with an annual average use per 1,000 sq. ft. of 7.32×10^7 BTU for heating and 5.27×10^7 (equivalent) BTU for the "source generation" of electricity. This is only 2/3 to 1/2 of the fuel and electricity used in other schools, whose energy records were gathered for this and other studies. Nevertheless, they also represent a spread with a standard deviation of 30 and 35% of the mean. The Report concludes that, by use of the recommended new standards, schools can be designed to operate with no educational penalty at savings of 25 to 50% below the already carefully monitored NYC level.

Among the energy aspects examined in this Study was that of electricity use in both coal and oil-heated buildings. In the oil-heated schools the average annual consumption was 3861 KWH per 1,000 sq. ft. of gross building floor area; in the coal-heated schools the corresponding value was 3,110 KWH. [These figures were also compared with data from other sources, as noted below.]

Thirty-one "all-electric" schools in a zone in the Northeast USA (having 4500-6000 annual HDD) offered the underdescribed data, though direct comparisons with NYC schools are somewhat difficult for the following reasons: (a) Records for the all-electric schools only show energy consumption at "point of use"; (b) Some of the 31 schools are air-conditioned; (c) These schools are generally built to NEMA standards (10 of the 31 are double-glazed, for example).

The average electricity usage for the 31 all-electric schools was 15,700 KWH/1000 sq. ft./year. In order to make some comparison with the NYC schools the following assumptions were made: (1) Air-conditioning represents about 10% of the annual electric usage; (2) The electricity used for non-space conditioning functions will be similar for all the schools. This results in a total annual use of 14,130 KWH/1,000 sq. ft. without air-conditioning, of which 3861 is assumed to be for non-heating functions and 10,269 for heating.

Another Report (prepared by the Minnesota Energy Project and dated 15 Feb. 1974) cited an annual heating fuel consumption of 15.8×10^6 BTU/student and an electric consumption of 613 KWH/student. This compares with 7.5×10^6 BTU/student and 289 KWH/student in the NYC school system.

It was found that the consumption of energy varied substantially from school to school. Annual oil use showed a mean of 519 gallons per 1,000 sq. ft., with a standard deviation of 154. Electricity showed a mean of 3637 KWH/1,000 sq. ft./year, with a standard deviation of 1403. [Note: The mean figures are unweighted averages.] A substantial portion of this variation is due to differences in scheduling; some portions, however, were clearly attributable to: types of construction and mechanical systems, patterns of operation, etc.

Another finding was that the environmental conditions within teaching spaces vary from building to building and within individual buildings. Such conditions were frequently unrelated to the specific activities which were taking place within the space. To a large degree, this is due to the lack of flexibility of the systems. The mechanical systems are designed to meet the most critical criteria, which are rarely applicable; also mechanically supplied services frequently overlap natural ones. It was found also that mechanically supplied services were frequently provided in unoccupied areas and were often delivered at a level much higher than desired. [In general, the "complicated/sophisticated" systems functioned much less effectively than the "simpler/common" ones. Buildings that relied entirely on mechanical delivery systems for their interior conditions appeared to have the greatest number of problems with control systems and to have the widest temperature variations and to consume the most fuel.]

TITLE: CASE STUDIES of ENERGY USE: ELEMENTARY and SECONDARY SCHOOLS

SOURCE: Building Systems Information Clearinghouse (of) Educational Facilities Laboratories, Inc.
AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: BSIC/EFL (Menlo Park, California)

DATE OF ISSUANCE: 10/74
OTHER IDENTIFIERS: BSIC/EFL Energy Workbook

DATA USE RESTRICTIONS: Copyright by EFL, Inc.

TOTAL: [PAGES 22 ; REFERENCES 8 ; GRAPHS 1 ; TABLES 20] *
DOCUMENT CLASSIFICATION(S): 48/7, 15, 22, 42

ABSTRACT: *[Information of direct and secondary relevance to this Compilation is scattered thruout these Case Studies. The Total(s) are for the entire report.]

While investigating the responses of various school districts to the current energy situation, BSIC arrived at some conclusions and the possibility of coping with the situation by rational procedures. These conclusions may be classified as: (1) The problems of analysis using existing tools. (2) The need for design and operation energy use guidelines. (3) The need for more complete energy use studies. [The Workbook discusses the preceding in some detail.]

The Report presents the annual energy consumptions of the school plants which it discusses. In order to compare their energy uses, all of the fuel and electricity consumed in the plants has been reduced to two comparative measures, namely: Btu's of energy consumed per year and Btu's of energy consumed per square foot per year. [As far as BSIC could tell, the only guideline for energy consumption was GSA's tentatively suggested 55,000 Btu/sq. ft./year for office buildings. Although this figure is for a different building type and operating usage, it does provide a "ball-park" measure of building efficiency which can be applied to schools.]

It is noted that even in the studies with the most complete metering and observation of energy use, significant gaps may appear in the data. For example, in very few of the studies BSIC has seen it is possible to obtain the amount of electricity consumed by the lighting system of a school. Estimates can be made, but data is rare. [It is stated that "perhaps a new design methodology for electrical distribution, involving the routine installation of devices to monitor power flow will evolve."] Altho large commercial buildings are routinely equipped with sophisticated control and monitor consoles for their operating systems, school plants in which all energy flow is monitored and controlled by central stations (or computers) are rare.

TITLE: ENERGY AUDIT and ENERGY USE ANALYSIS for ST. LOUIS COMMUNITY COLLEGE DISTRICT

SOURCE:

AUTHOR(S): C.J.R.McClure; et al
PREPARED BY AUTHOR(S) AND/OR: Charles J.R.McClure and Associates, Inc. St. Louis, Missouri
DATE OF ISSUANCE: 10/15/76
OTHER IDENTIFIERS: Prepared for St. Louis Community College District; Contract No. C-23
DATA USE RESTRICTIONS: Check with St. Louis C.C. District

TOTAL: [PAGES 25 ;REFERENCES ;GRAPHS 13 ;TABLES 7] *
DOCUMENT CLASSIFICATION(S): 48/1, 11, 17, 28, 32, 37, 42

ABSTRACT: *[Contains material of direct and (mainly) secondary relevance to the subject matter of this Compilation. The Totals apply to the relevant material.]

This Report concerns itself with a detailed analysis of the ways in which energy is used at three campuses of the District and at the District Office. The resulting information is used to direct further efforts at achieving lasting reductions in the consumption of electricity and fuel in the District's physical plant. [Such reports have been issued on a continuing basis, since 1973, as a part of a successful energy conservation program.] In the process of developing information and assessing performance, generalized conclusions were drawn concerning plant operations; these conclusions are stated and discussed.

The average daily consumption of electricity is plotted for each of the 3 campuses and for the District Office. These load profiles cover metered values for 1972-1975, plus values for a "simulated normal year". [Note: One of the campuses started using computerized demand limiting in Feb. 1975.]

Electrical energy usage is tabulated in KWH/year (and as a % of the total consumption) for: refrigeration chillers; cooling system auxiliaries, such as pumps and cooling towers; air-handling equipment; heating system auxiliaries, such as pumps and boilers; lighting for interiors; "other", outside lighting, etc. [Average electrical rates are also specified, in ¢ per KWH.]

TITLE: RESEARCH, DESIGN, CONSTRUCTION and EVALUATION of a LOW ENERGY UTILIZATION SCHOOL (Phase 2: Report)*

SOURCE: NSF/Board of Education, New York City

AUTHOR(S): R.G.Stein; et al
PREPARED BY AUTHOR(S) AND/OR: Prepared for Board of Education by Richard G. Stein and Partners, Architects (New York, N.Y.)
DATE OF ISSUANCE: 3/31/77
OTHER IDENTIFIERS: NSF/RA-770032; NTIS PB-269407; NSF-RANN Grant No. AER 73.0357 A02
DATA USE RESTRICTIONS:

TOTAL:[PAGES 18 ;REFERENCES 3 ;GRAPHS ;TABLES 2] **
DOCUMENT CLASSIFICATION(S): 48/11, 15, 17, 22, 28, 32, 38, 42

ABSTRACT: *[There are two other Reports associated with this School Study. One of these is a "phase 1 Report, identified as NSF-RA-N-74-117 and is available from GPO as Stock No. 3800-00194; it is abstracted elsewhere in this Compilation. The other is an "Energy Conservation Operation Manual", identified as NSF/RA 770033 and is available from NTIS as PB-268555; this Manual is essentially an appendix to NSF/RA-770032 and is not seperately abstracted as part of this Compilation.]
**[Information of (mainly) secondary relevance to this Compilation is scattered thruout this Report, whose Appendices include several background reports of general interest. The Total(s) apply only to the relevant material.]

This Report describes a series of pilot programs designed (and in some cases carried out) for New York City school buildings and using minimum cost means for conserve energy. These programs include: the development of an Energy Conservation Operation Manual for operating personnel; the development of a lighting program which includes the evaluation of high-efficiency commercially available light fixtures and the design, construction and testing of fluorescent adaptors for use in buildings presently lighted with incandescent fixtures; and the effects of modifications to ventilation systems. [All programs, except replacement of lighting fixtures, are said to have "payback times" of less than a year.]

Data is tabulated for a number of tests of alternative lighting configurations for a "typical" classroom, which had a ceiling height of 13 feet and a floor area of 590 sq. ft. The KWH/year (equivalent) usage of these alternatives was found to vary from about 350 to about 1800. [It is noted that lighting accounted for about 60% of the total school system electrical consumption.]

Summary data is listed for 3 junior high schools ("oil-heated") and 1 senior high school ("coal-heated"); the summary includes a general description plus details of the heating and ventilating and lighting systems. Electrical consumption was from 2.64 to 4.14 KWH/sq.ft./year.

TITLE: SHOPPING CENTER LOAD ANALYSIS by TENANT CLASSIFICATION

SOURCE: Total Energy, 6/67, pp 6

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: T.E. Magazine

DATE OF ISSUANCE: 6/67
OTHER IDENTIFIERS: Vol. 4, No. 6

DATA USE RESTRICTIONS: Unknown; T.E. is no longer published.

TOTAL: [PAGES 1 ;REFERENCES ;GRAPHS ;TABLES 1] *
DOCUMENT CLASSIFICATION(S): 49/1, 13

ABSTRACT: *[Data is relevant to the subject matter of this Compilation.]

This is a sampling of electrical and air-conditioning load values, derived from shopping centers in the Alabama-Mississippi-Georgia-Florida area. [The electrical values are stated to be "typical" and the air-conditioning values as (maybe) requiring adjustment to local conditions, if used for estimating.]

The data tabulated is: size of the business area (in sq. ft.); hours open per month; demand (in KW); energy usage (KWH per month); air-conditioning load (in tons of refrigeration). A total of 39 types of stores are listed. A separate listing is given for the mall (i.e., "common") areas.

TITLE: DATA AGGREGATION and INFORMATION LOSS

SOURCE: The American Economic Review, Vol. LVIII, No. 4, pp 773-787

AUTHOR(S): G.H.Orcutt; et al
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 9/68
OTHER IDENTIFIERS:

DATA USE RESTRICTIONS: Copyright by American Economic Association

TOTAL:[PAGES 15 ;REFERENCES 12 ;GRAPHS ;TABLES 2] *
DOCUMENT CLASSIFICATION(S): 50/10, 17

ABSTRACT: *[Contains material of general interest to the subject matter of this Compilation.]

To the researcher or policy maker interested in the economic performance and development of a small area or region, the rather limited availability of suitable time series data in the area of specific interest is an obvious handicap. If one is interested in the prediction and control of national aggregates the handicap is not so obvious and, in consequence, more serious.

Aggregation of data (for purposes of research and analysis) may sometimes be very much in order. But aggregation before analysis discards information and the researcher should have something to say about the tolerability of such loss. The purpose of this Paper is to demonstrate that the loss of effective estimation and testing power, incurred through aggregation carried all the way up to the national level, can be extremely great.

The approach underlying this study was to construct a microanalytic model of the USA economy, which was as realistic for a small model as insight permitted. This primary model (and several variants of it) were then used to produce large numbers of "histories" and an effort was made to estimate the underlying structure of the generating models by conventional estimating techniques. By carrying out estimation on data at three levels of aggregation (including the national level) it was possible to evaluate how the degree of aggregation influences the efficiency of conventional estimation techniques.

TITLE: SAMPLING, STATISTICS, DATA PROCESSING and ANALYSIS

SOURCE: AEIC Load Research Seminar

AUTHOR(S): R.E.Ashburn (of AEIC's LRC)
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 2/27/75
OTHER IDENTIFIERS: Presented to NARUC Executive Committee (et al) at a Washington, D.C. meeting on 2/27/75
DATA USE RESTRICTIONS:

TOTAL: [PAGES 16 ;REFERENCES ;GRAPHS 2 ;TABLES 3] *
DOCUMENT CLASSIFICATION(S): 50/10, 34, 39, 55

ABSTRACT: *[This "informal" paper contains material of direct or secondary relevance to the subject matter of this Compilation. It parallels certain information in "printed" (but unpublished) notes used as part of AEIC's industry Seminars, conducted by the LRC from time-to-time.]

The Paper states that a "perfect" sample (small in size, low in sampling costs and perfectly representative of the group sampled) can only be approximated. However, present sampling theory can produce highly satisfactory and defensible load research results when coupled with: thorough planning; a comprehensive knowledge of the characteristics of the utility customers; cooperation between customers and the utility; an adequate stock of reliable test meters.

System load analysis, demand allocations, new rate designs, load management and forecasting procedures all call for extensive load data for all types and sizes of customers and appliances. The author states that there is no real substitute for test metering on a sample basis to get this information.

Sampling theory essentially reduces to two basic concepts which underlie all the statistics used in load research. They are: (1) any "population" (such as the electric space heating customer) has certain load characteristics and (2) variations within the population are definitely limited since someone has to be the largest and someone has to be the smallest. [These two facts make it possible to select a relatively small, unbiased, random sample that can acceptably reflect the load characteristics of the entire population (class of business, type of appliance, etc.) from which it is drawn.]

The Paper summarizes the following: (a) factors to be considered in determining sample size; (b) decision as to whether the sample should be random or stratified; (c) optimum sample size and the expected accuracy at the desired confidence level; (d) data processing requirements; (e) role of statistics in load research; (f) data compilation and analysis formats. [Some sample results are included to illustrate "typical" load analysis studies.]

TITLE: A STATISTICAL ANALYSIS of the MONTHLY CONSUMPTION of GAS and ELECTRICITY in the HOME

SOURCE: Princeton University/Center for Environmental Studies

AUTHOR(S): L.S.Mayer & J.A.Robinson
PREPARED BY AUTHOR(S) AND/OR: Princeton University/C.E.S.

DATE OF ISSUANCE: 4/75
OTHER IDENTIFIERS: C.E.S. Report No. 18 (Sponsored by NSF/RANN)

DATA USE RESTRICTIONS:

TOTAL:[PAGES 50 ;REFERENCES ;GRAPHS 13 ;TABLES 5] *
DOCUMENT CLASSIFICATION(S): 50/3,10,21,22,30,34,47,55,57

ABSTRACT: *[Information of direct and secondary relevance to the subject matter of this Compilation is scattered thruout this Report. The Total(s) reflect only the relevant data.]

This Report examines the macroconsumption of energy in residential housing, as indicated by monthly readings of the gas and electricity meters. The consumption processes for both gas and electricity are shown to be "well-behaved" over months, and are also shown to have variance trends proportional to the mean trends. Specified characteristics of the housing units are used to predict macroconsumption; thus the number of bedrooms and whether the unit is an "end" unit are shown to be significant predictors of gas macroconsumption while the number of bedrooms, number of occupants and whether the house has a "central vacuum system" are similar predictors of (summer) electricity usage.

No significant decrease in (winter) electricity use after the "energy crisis" was detected using classical methods, but a 6% decrease was detected by a modified type of analysis which is unaffected by "extremes" in the test data. C.E.S. could not assess whether there is a decrease in summer electricity use after the energy crisis because it had not found a suitable method for adjusting such consumption for weather conditions.

Winter gas and summer electricity consumption are compared to determine if people who are high gas consumers in the winter tend to be high electricity consumers in the summer but no such relationship appears; neither is the converse situation supported by the data. Even after controlling for the characteristics of the house, no relationship appears between summer electricity consumption and winter gas consumption.

In addition to its statistical tabulations, the Report contains a number of graphs related to both gas and electricity usage, as follows:
(1) Overall mean trend for monthly electrical consumption in townhouses, apartments and "split levels".
(2) Overall variance trend (in KWH-squared) for monthly electrical consumption in townhouses, apartments and "split levels".
(3) Median and midspread trends for monthly electrical consumption.

Twin Rivers, N.J. is stated to be an excellent environment for a statistical analysis of macroconsumption in that altho the data is aggregated, it is not confounded by many sources of variation which would be found in a cross section of housing units in the USA. It is a planned unit development, representative of much conventional residential housing being built at this time. It contains residences of several types, including 168 detached houses, 1,626 townhouses and 942 garden apartments. The townhouses - which are the focus of this study - are of masonry bearing-wall construction, with wood framing floors and roof.

TITLE: STATISTICAL YEARBOOK of the ELECTRIC UTILITY INDUSTRY

SOURCE: EEI

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: Statistical Committee of EEI

DATE OF ISSUANCE: 1976 *
OTHER IDENTIFIERS: Number 43; Publication 76-51

DATA USE RESTRICTIONS:

TOTAL: [PAGES ;REFERENCES ;GRAPHS ;TABLES] **
DOCUMENT CLASSIFICATION(S): 50/5, 17, 23, 26, 55

ABSTRACT: *[These Yearbooks are normally issued towards the end of the year following the issue date. This is the date of most recent issuance at the time this sheet was prepared.]

**[Information of (mainly) secondary relevance to the subject matter of this Compilation is scattered thruout the Yearbook. The Total(s) are not too significant for a Publication of this type.]

The Yearbook is primarily concerned with the listing of data for generating capacity, revenues, costs and customers. Generally aggregation of the statistics is by type of utility (i.e., "investor owned," "cooperative," "municipal," etc.) or by type of prime mover or by states (of the USA) or by type of fuel.

Tabulations are included to show:
(A) the number of customers classified as residential, "small" and "large" commercial and industrial, street and highway lighting, public buildings, etc.;
(B) average KWH use and average annual bill (per customer);
(C) fuel statistics;
(D) cost trends.

TITLE: STATISTICAL STUDY COMPARES ENERGY NEEDS

SOURCE: Electrical World, 5/1/77, pp 86-87

AUTHOR(S): G.B.Drennan & K.B.Powell
PREPARED BY AUTHOR(S) AND/OR: Study was initiated by the Utah Chapter of ASHRAE in 1973
DATE OF ISSUANCE: 5/77
OTHER IDENTIFIERS: Energy Marketing

DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL:[PAGES 2 ;REFERENCES 1 ;GRAPHS ;TABLES 2] *
DOCUMENT CLASSIFICATION(S): 50/2, 4, 6, 14, 22

ABSTRACT: *[Contains material of (mainly) secondary relevance to the subject matter of this Compilation.]

The study was made using a statistical sample of a large number of homes. The data are broken into two groups, those with central electric-refrigeration air conditioning and those without. Only homes with electric-refrigeration air conditioning were used in the study because there were too few homes in the sample with gas air conditioning for statistical validity.

Information is tabulated for centrally air conditioned homes that are heated by gas or by electric resistance elements or by electric heat pumps; similar tabulations are shown for homes that do not have central air conditioning and which are simply gas or electric heated.

The tabulated (averaged) data covers: (a) age and size of homes; (b) number of occupants; (c) number and type of major appliances; (d) electricity/gas used per year; (e) equivalent annual energy use; (f) energy per sq. ft.

TITLE: STATISTICS of PUBLICLY OWNED ELECTRIC UTILITIES in the UNITED STATES (1975)

SOURCE: FPC

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: FPC (Office of Accounting and Finance)

DATE OF ISSUANCE: 1977 *
OTHER IDENTIFIERS: FPC Report No. S-261; available as GPO#0-15-00000-3634
DATA USE RESTRICTIONS:

TOTAL: [PAGES ;REFERENCES ;GRAPHS ;TABLES] **
DOCUMENT CLASSIFICATION(S): 50/5, 9, 17, 47, 55

ABSTRACT: *[These statistics are updated from time-to-time. The 1975 statistical tabulations were the latest available at the time this sheet was prepared.]

**[Not considered particularly pertinent to this form of Publication.]

This publication presents financial and operating information on publically owned electric utilities operating in the USA. The statistics are compiled from annual reports which the utilities file with the FPC. [The term "publicly owned electric utilities" refers to electric utilities operated by defined "municipalities" and federal power agencies.]

Included in the report is a "line-item" summary for (essentially) all reporting municipals and for all Federal projects. The summary covers the balance sheet, income account, electric operating revenues, electric utility plant, electric operation and maintenance expenses plus the electric energy account and physical characteristics of the generating stations.

Data is graphed (for 1966 thru 1975) which shows: (1) residential customer revenues, KWH sales, number of customers, sales per customer, revenue per customer, ¢ revenue per KWH; (2) commercial/industrial customer revenues, etc., as for (1); (3) operating expenses, divided into major categories, as a % of operating revenues.

TITLE: SUMMARY REPORT on the COMMERCIAL MARKETS for TOTAL ENERGY (to GATE, Inc.)

SOURCE: Battelle Memorial Institute (Columbus Laboratories)

AUTHOR(S): H.W.Nelson; et al
PREPARED BY AUTHOR(S) AND/OR: BMI/CL

DATE OF ISSUANCE: 4/67
OTHER IDENTIFIERS: AGA Library Call No. 621.43, NY

DATA USE RESTRICTIONS: Copyrighted by GATE but AGA is now copyright holder. Originally stamped "Confidential" but current status is not known.
TOTAL: [PAGES 24 ;REFERENCES 7 ;GRAPHS 5 ;TABLES 3] *
DOCUMENT CLASSIFICATION(S): 53/7, 13, 19, 21, 22, 44, 45, 48, 49

ABSTRACT: *[Information of direct or secondary relevance to the general subject matter of this Compilation is scattered thruout the Report; the Total(s)cover the relevant material.]

As used in this Report, T.E. is defined as the concept under which all of the electricity required by a given establishment is produced "on-site" by natural-gas fueled engines or turbines, with the recovery of the equipment's heat for comfort conditioning and other uses. Other concepts, such as Partial Energy or conventional on-site generation, have not been considered. This report is concerned only with the commercial potential market for T.E.

This Study was conducted in three steps. First, the number of buildings (both new and existing) in each of 8 categories was determined. [Many sources were used in developing these data, with government statistics forming the principal basis.] Next, the electrical demand and usage for each type of building was derived from "questionnaire survey" data submitted by the GATE members on over 250 buildings. Lastly, a formula using average electrical and gas rates in each of the states was applied to each of the size ranges of the various building categories so as to determine the number of economically feasible T.E. buildings within that state.

Although other useful information could be derived by analysis of the above-mentioned questionnaire data, of prime interest were the development of average or generalized values for the load factors for the several classes of buildings and determination of average values of KW of peak billing demand per unit area, for each class of buildings.

The average values for load factors derived from the questionnaire data is tabulated, both on the basis of all of the buildings reported and on those with gas air conditioning. [The size of the sample for each class of building is indicated.] Data is included for motels, hotels, apartments, schools (below college level), hospitals, office buildings and shopping centers. For all buildings the reported average values ranged from about 21 to 53%.

Values of the average peak billing demand per unit area for different classes of buildings are useful criteria for use in estimating. Calculation of these values from the questionnaire data also showed a wide variation within each category, as for load factors. Tabulations show values in KW per 1,000 square feet of building area for the several categories of buildings; also shown are the average values for all buildings in each category, those for buildings having gas air conditioning and the sample size. Data is included for the same categories as in the preceding paragraph; for all buildings these KW demands varied from 1.71 (apartment houses) to 6.57 (shopping centers).

TITLE: TOTAL ENERGY and PRIME MOVER MARKETING GUIDELINES

SOURCE: Northern Natural Gas Company (Omaha, Neb.)

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: Energy Economics Section of N.N.G.Co.

DATE OF ISSUANCE: 2/68
OTHER IDENTIFIERS:

DATA USE RESTRICTIONS: Detailed use may be controlled by AGA

TOTAL: [PAGES 20 ;REFERENCES 2 ;GRAPHS 2 ;TABLES 6] *
DOCUMENT CLASSIFICATION(S): 53/7, 13, 17, 55

ABSTRACT: *[Information of direct or secondary relevance to the general subject matter of this Compilation is scattered thruout these Guidelines; the Total(s) cover the relevant material.]

This Study is designed to assist Utilities in identifying and analyzing the local market potential for T.E. and prime movers. It provides a structured procedure for: (1) identifying potential customers; (2) calculating preliminary feasibility; (3) assessing the local market potential for T.E. and prime movers. A "Market Identification Kit" and "Prime Mover Nomograph" was prepared, with the objective of systemizing the search and analysis for T.E. and prime mover prospects.

Electrical load demands and usage are two of the factors considered in these Guidelines.

TITLE: THE GATE TOTAL ENERGY TRAINING PROGRAM: MODULES I, II, III, IV *

SOURCE: GATE, Inc.

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: David Sage, Inc. (New York, N.Y.)

DATE OF ISSUANCE: 1968 (Copyright date)
OTHER IDENTIFIERS: AGA Catalog No. S11016 **

DATA USE RESTRICTIONS: Copyright by GATE, Inc. (Check with AGA)

TOTAL: [PAGES 48 ;REFERENCES 3 ;GRAPHS 3 ;TABLES 5] ***
DOCUMENT CLASSIFICATION(S): 53/7,10,13,15,17,21,22,26,30,34,35,37

ABSTRACT: *[Module I: On-site Fundamentals (consists of 3 pamphlets); Module II: Electrical Requirements (consists of 7 pamphlets); Module III: Equipment Selection (consists of 14 pamphlets); Module IV: Financial Analysis (consists of 10 pamphlets).]

**[Check with AGA as to current availability (for purchase).]

***[Material of direct and secondary relevance to the subject matter of this Compilation is scattered thruout this relatively lengthy Program but most of the relevant data is to be found in Module II and in the first pamphlets of Modules I and III. The Total(s) refer only to the relevant material in all 4 Modules.]

Reliable T.E. feasibility analysis is stated as requiring accurate energy consumption estimating plus correct costing. Such costing of energy usage dictates the correct application of gas and electric rate schedules. For example, in some utility areas, different schedules apply to different types of consumption (even) in the same building; often such rates are seasonal, or apply only during certain hours of the day. The first practical task of feasibility analysis is a study of applicable gas and electric rate structures so that one can readily find the rates applying to any existing or proposed building and the average unit energy cost at any level of consumption.

The first requirement of a T.E. energy system is to meet the electrical requirements of the building(s). The second is that the system must yield a favorable owning and operating cost compared to the traditional system. Undersizing the system may defeat the first objective, oversizing may defeat the second.

System design, equipment selection and energy consumption calculations should be based on the most accurate electrical demand curves obtainable. [Often demand curves must be projected for buildings that are not yet built.] Analysts may use a variety of methods, factors and "rules of thumb" to estimate electrical demand. Some construct the curves by

considering the size and operating schedule of each individual electrical load to be included in the proposed building; others use curves of a similar (existing) building - generally obtained from metered data - and modify them for a particular project. Interest has also been shown in analyzing data from existing buildings to develop a set of "standard curves" for each building type, which are expressed as a % of maximum demand and are converted to KW demand once the maximum demand for a particular building of that type is determined; this method assumes that buildings of the same type will have similar electrical demand patterns. All three methods produce the same results, namely an estimated electrical demand curve for the proposed building. The degree of validity of the resulting curves will tend to differ, depending on both the method and the accuracy of the data employed, as is noted below.

The Derived Curve Method has the highest potential validity; the level of validity will depend on how accurately the individual loads and schedules can be (or are) determined. The Metered Curve Method has the next highest validity potential; the level of validity will depend on the degree of similarity between the metered and proposed projects and the extent to which the variables can be isolated and their effects compensated for. The Standardized Curve Method has the lowest potential validity; the actual level of validity will depend on the degree of similarity between the buildings which were considered in preparing the original standardized curve, the degree of similarity between the proposed building and the previously mentioned buildings and the extent to which the variables can be isolated and their effects compensated for. The "ease of application" of the methods is exactly in reverse of the preceding order. Thus, the Standardized Curve Method - which involves the greatest degree of generalization concerning the proposed building - will produce an estimated demand curve in a considerably shorter period of time than the Derived Curve Method, which requires detailed knowledge about the proposed building. [The method actually used will depend on both the availability of data and the intended function of the resulting demand curves.]

The Modules include data on: the characteristics of electric motor loads; (outlined) procedures for applying the various methods for analyzing electrical demands; an example of determining a "standardized % of maximum demand" vs "time-of-day" profile, plus a variation analysis to account for differences between the standard and a proposed (motel); tabulated summaries of electrical usage by building type (for schools, apartment houses, hotels, motels, hospitals, office buildings and shopping centers) for a range of building sizes and USA geographic regions.

TITLE: TOTAL ENERGY HANDBOOK

SOURCE: Caterpillar Tractor Company, (Peoria, Illinois)

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: Caterpillar Tractor Co., Marketing Dept., Industrial Div.

DATE OF ISSUANCE: 8/69
OTHER IDENTIFIERS:

DATA USE RESTRICTIONS: Copyright by C.T.Company

TOTAL: [PAGES 2 ;REFERENCES ;GRAPHS 1 ;TABLES 1] *
DOCUMENT CLASSIFICATION(S): 53/5, 15, 26, 35, 37

ABSTRACT: *[These Totals refer only to these pages of the Handbook that are relevant to the general subject matter of this Compilation, specifically the Chapter on "Load Analysis".]

The Handbook, among other things, summarizes the electrical loads aspect of T.E. plants. It states that a load analysis for a plant or facility must encompass a study of the energy requirements for each of the major services, namely: air conditioning; heating; and electric power and lighting. Complete treatment of all 3 areas is considered to be beyond the scope of this publication. The material offered is an attempt to provide some of the more useful data for the convenience and use of those engaged in the preparation of load analyses and economic studies for on-site power applications.

The first step in making an analysis of the electric load is to develop and plot a family of load profile charts. A minimum would consist of one chart for a "representative" 24-hour period and one for a "representative" 12-month period. In some instances, an additional set of charts should be made to reflect the possible increase in power consumption and demand resulting from anticipated growth. Such charts provide a basis for the selection of power generating equipment as well as data for feasibility and economic studies.

The Handbook has a Table of normalized load and power consumption estimating data (typically in watts/sq. ft. and KWH/sq. ft./year, respectively). The data covers schools, shopping centers, office buildings, hotels/motels, hospitals and apartment houses; each category has a partial demand break-down for various regions of the buildings.

TITLE: AN INTEGRATED UTILITY SYSTEM CONCEPT

SOURCE: International Research and Technology Corporation

AUTHOR(S): R.U.Ayres; et al
PREPARED BY AUTHOR(S) AND/OR: I.R.&T. Corp. (Washington, D.C.)

DATE OF ISSUANCE: 4/13/70
OTHER IDENTIFIERS: IRT-N-95

DATA USE RESTRICTIONS: May contain proprietary information; check with I.R.T. Corp.
TOTAL: [PAGES 14 ;REFERENCES 9 ;GRAPHS 3 ;TABLES 6] *
DOCUMENT CLASSIFICATION(S): 53/4, 13, 33, 42, 45, 47, 56

ABSTRACT: *[Information of direct or secondary relevance to the subject matter of this Compilation is scattered thruout this Report; the Total(s) cover the relevant material.]

The Utility Systems comprise a substantial portion of the total cost of housing projects and certain commercial construction projects. The Report analyzes 4 subsystems to replace the conventional utility systems. These four subsystems are: (1) Energy; (2) Water purification and recirculation; (3) Refuse and sewage disposal; (4) Fire protection. An integrated utility package is expected to yield significant savings in construction cost as well as operation and, at the same time, residuals discharged to the environment will be reduced.

The Report does not seek to develop specific components for any of these systems. Rather than a detailed design of hardware, the basic problem is said to be to determine requirements and to select, match and modify existing "off-the-shelf" equipment and "state-of-the-art" technology in order to find the most feasible combinations and configurations for integrated utility systems.

Estimated average daily requirements are tabulated for electrical power and heating and cooling for single dwelling units and for complexes of 20, 50, 150 and 400 units. The tabulation shows: peak power demand in KW; average daily electrical usage in KWH; average daily heating and cooling and hot-water loads, for "peak months", in BTU.

Electrical consumption, based primarily on appliance characteristics and certain lighting assumptions, is determined for a 1200 square foot detached house with 4 occupants.

TITLE: TOTAL ENERGY; CHAPTER 12-"ECONOMIC ASSESSMENT of TOTAL ENERGY"

SOURCE: Pergamon Press

AUTHOR(S): R.M.E.Diamant
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 1970
OTHER IDENTIFIERS: First Edition

DATA USE RESTRICTIONS: Copyright by Pergamon Press Ltd.

TOTAL:[PAGES 13 ;REFERENCES 1 ;GRAPHS 2 ;TABLES 4]*
DOCUMENT CLASSIFICATION(S): 53/7, 13, 17, 55

ABSTRACT:*[Total(s) apply only to Chapter 12, which is ascribed to: The Energy Economics Section, Market Development Dept., Northern Natural Gas Co.; Omaha, Neb. The information is of secondary relevance to the subject matter of this Compilation.]

Essentially, Chapter 12 is adapted from a Northern Natural Gas Co. Report entitled: "Total Energy and Prime Mover Marketing Guidelines", dated February, 1968. [The N.N.G. Report is abstracted elsewhere in this Compilation.]

TITLE: (GATE) ENERGY PARAMETER HANDBOOK

SOURCE: GATE Information Center (of Southwest Research Institute)

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: Energy Parameter Handbook Committee

DATE OF ISSUANCE: 6/71
OTHER IDENTIFIERS: (E-CUBE) input data

DATA USE RESTRICTIONS: Handbook designed to supplement the GATE (E-CUBE) Computer Program; check with AGA
TOTAL: [PAGES 50 ;REFERENCES ;GRAPHS 21 ;TABLES 18] *
DOCUMENT CLASSIFICATION(S): 53/7, 15, 21, 22, 26

ABSTRACT: *[Information of direct or secondary relevance to the general subject matter of this Compilation is scattered thruout the Handbook; the Total(s) cover the relevant material.]

The Handbook provides parameters for use in evaluating the overall energy requirements of diverse types and classes of buildings, particularly where the design concept has not been fully developed and only limited data appear available. It represents an effort to cover the subject simply and comprehensively so that the accumulated information will provide the required input data for E-Cube with a reasonable degree of accuracy, particularly for the inexperienced user of the program. Readers are advised that altho the data supplied in this Manual was carefully developed from the best information available, no warranty can be made as to its accuracy. [As a building design progresses and more "unknowns" become known, followup studies can be developed to refine the design.] The information and data (used in compiling the Handbook) were contributed by experts in the field and represent a composite evaluation of the requirements of numerous existing buildings and facilities, based upon actual operating experience.

The text is arranged so that each particular type of building application is sectionalized, providing an easy means of locating the required input data. Most of the parameters are expressed in either tabular or chart form, not only for convenience in filling out the computer input sheets but also because this format shows the consultant and/or owner the effect of changing various factors, such as % area of glass, insulation, etc. With this arrangement, there is some intentional repetition of the presented material, which allows one to keep abreast of the rapid changes resulting from design progress and new development and also permits future additions from sources not available at the time of publications.

Each section of the Handbook is based upon a specified set of design conditions. [The design parameters change from one section to the next because of differences in geographic location of the section authors.] If the design conditions of the section in use differ from those of the location being analyzed, adjustments must be made.

TITLE: A FEASIBILITY STUDY OF TOTAL ENERGY SYSTEMS for "BREAKTHROUGH" HOUSING SITES

SOURCE: NBS

AUTHOR(S): P.R.Achenbach; et al
PREPARED BY AUTHOR(S) AND/OR: NBS

DATE OF ISSUANCE: 8/12/71
OTHER IDENTIFIERS: NBS Report 10402

DATA USE RESTRICTIONS:

TOTAL:[PAGES 48 ;REFERENCES 7 ;GRAPHS 4 ;TABLES 14]*
DOCUMENT CLASSIFICATION(S): 53/1, 13, 28, 30, 31, 56

ABSTRACT: *[This Report contains information of direct and (mainly) secondary relevance to the subject matter of this Compilation. The relevant material is (primarily) in Section 4.3 but the Total(s) are for the entire Report.]

The Report includes calculations for the expected loads for space heating/cooling, domestic water heating and miscellaneous electrical uses at each of the 6 BREAKTHROUGH sites. This information was needed to determine the: approximate size of the T.E. plants; applicable energy rate schedules; availability of appropriate system components; differentials in first costs; space needed for the T.E. on-site plant. The materials to be used in the exterior envelopes, amount of window area and area of the exposed walls were not sufficiently detailed to permit a good calculation of the heating and cooling loads; therefore, these loads for the dwelling units were approximated by assuming that the constructions would meet the heat transmission factors and window areas cited in the Report's evaluation criteria.

All dwelling units were assumed to be 1,050 square feet, with 8 foot ceilings. Exterior wall, roof and floor "U" values were assumed as: 0.2, 0.1 and 0.1 BTU/hour-sq. ft. - °F, respectively. [Corresponding window "U" values were 1.1 for single family detached and 0.55 for other dwelling types.] The units were of 6 types, 4 of which were in various locations in a multiple-family high-rise building with the other 2 being in multiple-family low rise or single-family detached buildings.

The Report contains calculated heating and cooling loads (for the 6 dwelling types) on a month-by-month basis, under assumed winter and summer outdoor temperatures of zero and 94°F; an indoor temperature of 75°F was assumed.

Electricity and domestic hot-water usage profiles were developed, using data from referenced literature; the effects of diversity were included. Monthly values are also shown for: KWH of miscellaneous electrical usage; KW electricity demand; hot-water KWH and KW, using equivalent heating values for non-electric installations.

TITLE: THE APPLICATION of TOTAL ENERGY SYSTEMS to HOUSING DEVELOPMENTS

SOURCE: Proceedings of the Joint RILEM-ASTM-CIB Symposium, May 2-5, 1972, Philadelphia, Penna.
AUTHOR(S): P.R.Achenbach & J.B.Coble
PREPARED BY AUTHOR(S) AND/OR: NBS

DATE OF ISSUANCE: 3/72
OTHER IDENTIFIERS: NBS Special Publication 361, Vol. 1, pp 419-430

DATA USE RESTRICTIONS:

TOTAL:[PAGES 12 ;REFERENCES 5 ;GRAPHS 2 ;TABLES 1] *
DOCUMENT CLASSIFICATION(S): 53/11, 15, 37, 42, 56, 57

ABSTRACT: *[Information of (mainly) secondary relevance to the general subject matter of this Compilation is scattered thruout these "guidelines". The Total(s) are for the entire Paper.]

A pilot investigation of the performance of a T.E. system was undertaken by NBS to evaluate the potential for decreasing the fuel required to provide the utility services to an apartment complex of 500 units (in Jersey City, N.J.) and for better control of noise and air pollution. The selection of the site followed a feasibility study of 11 sites distributed over the USA and the preparation of a performance specification which covered: the design conditions; the requirements for reliability, stability and safety of the system; the environmental quality that must be attained. The pilot T.E. plant is being extensively instrumented to determine: thermal efficiency; daily and seasonal utility load patterns; reliability of the utility services; level of noise and pollution control; maintenance and repair requirements; owning and operating costs; the occupant response to his environment.

These studies will be carried out during the "cold", "hot" and "mild" weather seasons of the year. Measurements of the use of chilled and hot water and electrical energy will also be made in these dwelling units, as practical. It is anticipated that the field studies in Jersey City will develop authoritative and useful information on most of the important aspects of T.E. systems.

TITLE: A CRITICAL LOOK at TOTAL ENERGY SYSTEMS and EQUIPMENT

SOURCE: Proceedings of 7th IECEC held at San Diego, Calif.; 9/25-9/29, 1972; pp 1263-1268
AUTHOR(S): M.G.Gamze
PREPARED BY AUTHOR(S) AND/OR: Gamze-Korobkin-Caloger, Inc. (consulting Engineers; Chicago, Ill.)
DATE OF ISSUANCE: 9/72
OTHER IDENTIFIERS: Paper No. 729192

DATA USE RESTRICTIONS:

TOTAL: [PAGES 6 ;REFERENCES ;GRAPHS 1 ;TABLES 1] *
DOCUMENT CLASSIFICATION(S): 53/7, 22, 37

ABSTRACT: *[Information of (mainly) secondary relevance to the general subject matter of this Compilation is scattered thruout this Report.]

The Report defines the T.E. concept, reviews its history and describes the problems involved in designing and installing T.E. systems. The basic problem is that such systems generally have to be "custom-designed" around components that are not always totally suited for such applications. This necessitates extensive engineering if one is to end up with a dependable installation plus rigorous maintenance procedures to insure system reliability after the job has been placed in operation.

In addition the author presents a detailed listing of the problems plus specific recommendations to improve upon existing hardware and to develop new hardware, in order to make the T.E. concept a viable one which will permit realization of its potential for conserving fossil fuels and reducing pollution.

The Report includes (unidentified) "typical" thermal and electrical load profiles for a motel. There is also a summary-type list of the institutional and technical problems that have been associated with T.E. plus a list of areas which are considered to need substantial research and development.

TITLE: SAWYER'S GAS TURBINE ENGINEERING HANDBOOK; VOLUME II: APPLICATION

SOURCE: Gas Turbine Publications, Inc.

AUTHOR(S): J.T.Shore (Author, Chapter 14) & J.W.Sawyer (Editor)
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 1972
OTHER IDENTIFIERS: 2nd Edition; pp 177-195, Chapter 14: "Total Energy"

DATA USE RESTRICTIONS: Copyright by G.T.P., Inc.

TOTAL: [PAGES 5 ;REFERENCES 2 ;GRAPHS 1 ;TABLES]*
DOCUMENT CLASSIFICATION(S): 53/15, 17, 37

ABSTRACT: *[Chapter 14 contains data of secondary relevance to the subject matter of this Compilation; the Totals are for the relevant material.]

The author states that gas turbine prime-movers provide a practical solution to the need for a completely independent electrical system to overcome the multitude of complex problems experienced during power "blackouts". He also advocates that consideration be given to the T.E. concept on any project requiring energy in a variety of mechanical and electrical forms.

The selection and application of generators is outlined. Topics summarized include: (1) determining generator capacity; (2) ability to start large motors; (3) flicker frequency and its effect on lighting applications; (4) number of units to be installed; (5) voltage regulation; (6) parallel operation; (7) switching and protective devices.

Chapter 14 also discusses the primary parameters concerned with the selection and installation requirements of T.E. systems and the economic justification of such systems. The importance of developing (acceptably accurate) electrical and thermal load profiles is stressed. It is recommended that these profiles be developed on a daily, weekly, monthly and yearly time base; prior to developing the profiles one has to obtain climatological, construction and operational data which are pertinent to the project being designed. Once the load profiles are established, the next step (for the system designer) is to analyze the electrical loads and determine the frequency and voltage characteristics that will have to be supplied by the gas turbine/generator modules. [The details of gas turbine selection and use are also covered in Chapter 14.]

TITLE: ECONOMIC EVALUATION of TOTAL ENERGY: TECHNICAL REPORT; HUD-DSC-1
[Note: See also the auxiliary report of same title, plus sub-title "Guidelines", HUD-DSC-2.]
SOURCE: Decision Sciences Corporation

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: DSC

DATE OF ISSUANCE: 7/12/73
OTHER IDENTIFIERS: PB 228 893; may be ordered from NTIS by this number

DATA USE RESTRICTIONS:

TOTAL:[PAGES 66 ;REFERENCES 33 ;GRAPHS 37 ;TABLES 8] *
DOCUMENT CLASSIFICATION(S): 53/7, 10, 15, 17, 22, 30, 37, 43

ABSTRACT: *[These Totals refer only to Sections II-D + II-E + II-H + IV-D + VII-A + VII-D1 + VII-E, since they are the ones which contain material of same relevance to the general subject matter of this Compilation.]

The Department of Housing and Urban Development (HUD), in its efforts to provide decent housing and living environments at reasonable cost, is evaluating the performance of T.E. systems in a residential/commercial setting. [Total energy systems are onsite power generation systems with heat recovery. By generating electricity on the premises, it is possible to recover normally wasted heat so as to provide space heating, cooling and domestic water heating.] The objective of this Study was to develop economic evaluation guidelines which could be used by the private and public sectors as a "screening tool" to determine the applicability of T.E. systems for residential developments.

Computer simulation analysis was used to evaluate the economic feasibility of T.E. for residential projects in the continental USA. Altho many factors influence economic feasibility, the most significant are: (A) Relationships between the costs of fuel and purchased power; (B) Project size; (C) Relationships between annual heating and cooling loads; (D) Incremental maintenance costs (parts and labor) for T.E.; (E) Energy system designs for both conventional and T.E.

Section II-D covers Energy Use Profiles, including electrical load and occupancy profiles. For example, the demand for energy in an apartment complex is considered in terms of: space heating/cooling; electricity for lighting, appliances, elevators, etc.; domestic hot water; cooling.

Sections II-E and II-H (respectively) deal with Project and Building Characteristics and Regionalized Electricity Costs. Section IV-D discusses Thermal Balance/Waste Heat Utilization. [References are listed in Section VII-A.] Section VII-D1 looks into Historic and Current Electricity Prices.

TITLE: ECONOMIC EVALUATION of TOTAL ENERGY:GUIDELINES; HUD-DSC-2

SOURCE: Decision Sciences Corporation

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: DSC (for HUD)

DATE OF ISSUANCE: 7/73
OTHER IDENTIFIERS: PB 228 683; may be ordered from NTIS by this number

DATA USE RESTRICTIONS:

TOTAL:[PAGES 8 ;REFERENCES ;GRAPHS 4 ;TABLES 2] *
DOCUMENT CLASSIFICATION(S): 53/17

ABSTRACT: *[Information of (mainly) secondary relevance to the subject matter of this Compilation is scattered thruout these Guidelines; the Total(s) cover the relevant material.]

One of the major factors inhibiting the greater application of T.E. systems is the technical complexity of evaluating such systems as an alternative to purchase of conventional utility services. There has been insufficient information available for architects, bankers, builders, developers, consumers (and others) to make even preliminary decisions concerning the feasibility (economic advantages) of T.E. The purpose of these Guidelines is to provide a preliminary "screening" technique which can be used by the private and public sectors to help in determining the economic applicability of T.E. systems for residential developments.

The guidelines were designed to make a quick, easy, low-cost determination of whether or not a complete engineering feasibility study is needed. A complete feasibility study, which requires the attention of competent engineering consultants experienced with T.E. systems, would still be needed if justified by the preliminary study.

The Guidelines contain information on regionalized electrical costs.

Note: See also the main report of same title, except for omission of "Guidelines"; (HUD-DSC-1).

TITLE: A SELECTIVE TOTAL ENERGY SYSTEM for a RESIDENTIAL COMPLEX

SOURCE: Proceedings of 8th IECEC (held at Philadelphia, Penna.; August 13-16, 1973); pp 389-395
AUTHOR(S): W.E.Mayo & J.C.Purcupile
PREPARED BY AUTHOR(S) AND/OR: National Science Foundation and Lear-Siegler, Inc.
DATE OF ISSUANCE: 8/73
OTHER IDENTIFIERS: Paper No. 739099

DATA USE RESTRICTIONS: Copyright by American Institute of Aeronautics and Astronautics
TOTAL:[PAGES 7 ;REFERENCES 8 ;GRAPHS 2 ;TABLES 3] *
DOCUMENT CLASSIFICATION(S): 53/11, 13, 29, 45

ABSTRACT: *[Information of secondary relevance to the general subject matter of this Compilation is scattered thruout this Report. The Total(s) are for the entire Paper.]

A modular integrated utilities package is being investigated as a possibility for relatively small, out-of-the-way communities. One of the principal components of this package is a Selective T.E. System which will supply all of the thermal needs of the complex but only a portion of the electrical needs. The remainder of the electric energy requirements would come from a central utilities grid. [This concept differs from the classic T.E. System in that the complex is not divorced from a dependence upon the public utility for electric energy.] As long as a balance between electric and thermal demand exists, the Selective T.E. plant supplies both electricity and heat. But whenever the electric demand exceeds the thermal demand - which can very often be the case - the electric grid of the public utility automatically takes over and supplies what is needed. The Paper identifies and characterizes those parameters limiting the potential energy savings of such a system, along with the development of tentative guidelines for future systems.

It is pointed out that since the USA's average electric generation efficiency in 1970 was 32.5%, an adjustment for transmission and distribution losses brings the overall system efficiency down to about 29.5%. These are yearly average figures and do not reflect seasonal variations. During the summer, the use of peak shaving units and older, less efficient units (along with the changing load characteristics) reduce the overall system efficiency to something of the order of 26%.

A mobile home park was chosen as the vehicle for this initial study. The study used reference data for estimating purposes. In addition, electrical measurements were made (at an actual 50 home site) during Jan.-Mar. of 1973. From these measurements, "typical" hourly peak KW electrical demands were plotted and monthly energy needs (for heating, cooling and miscellaneous) were tabulated.

TITLE: ASSESSMENT of TOTAL ENERGY SYSTEMS for the DEPARTMENT of DEFENSE - VOLUME 2 *

SOURCE:

AUTHOR(S): R.L.Goen; et al
PREPARED BY AUTHOR(S) AND/OR: Stanford Research Institute; Menlo Park, California
DATE OF ISSUANCE: 11/73
OTHER IDENTIFIERS: A Final Report prepared for Defense Advanced Research Projects Agency. SRI Project EGU-2513. Available from NTIS as AD-781817
DATA USE RESTRICTIONS:

TOTAL:[PAGES 33 ;REFERENCES 5 ;GRAPHS 2 ;TABLES 21] **
DOCUMENT CLASSIFICATION(S): 53/1,13,14,15,22,28,37,40,42,45,47,56,57

ABSTRACT: *[This Volume contains Appendices for Volume I; the material in Volume I is not particularly relevant to this Compilation.]
**[Contains material of direct and (mainly) secondary relevance to the subject matter of this Compilation. The Totals apply to the relevant material, which is primarily in Appendix B: "Energy Load Data for Military Installations".]

The primary purpose of this document is to assess the potential applicability of various types of T.E. systems to military installations. This Volume contains: (1) engineering performance characteristics and costs of the fuel system elements; (2) energy consumption data for military bases and derivation of the associated load profiles used in the study; (3) descriptions of the fuel usage "model" and summaries of consumption and total system costs for the various cases studied; (4) characteristics and costs of geothermal systems; and (5) descriptions of solar energy systems. [Altho primary emphasis was directed toward military bases of the U.S. Army and Air Force, those of the Navy were also considered. Generally, the collected data was based on fiscal 1972, the last full year compiled at the time of the field investigation.]

Two primary sources for utility data were utilized, namely the annual reports by the headquarters of each of the three services and interviews with base engineering and utility personnel at several military installations. This second source provided the monthly, daily and hourly information on utility consumption and utility services that was necessary both for correlation to the annual data and for the development of utility load factors used in the analysis of the T.E. concept. [Note: Even though considerable utility data were available within the files of the base utility offices (in some cases disaggregated to 15-minute electrical consumption and peak loads) the biggest problem encountered was that of centralized metering.] ***

Hour-by-hour thermal, electric and air conditioning loads were derived for 5 "representative" days of the year, viz: high heating; moderate heating; mild spring or fall day, with no heating or cooling requirement; moderate air-conditioning; high air-conditioning. Each of the 5 days represented a specified number of days of the year, varying with the climate. Three climates were included: Northcentral, Southeast and Southwest.

Data is included for: (a) family "density" per housing unit; (b) size of housing unit; (c) hourly energy loads by type of day; (d) KWH and KW per person and per housing unit; (e) annual electricity use vs peak demand; (f) "typical" peak electric demands for the 5 "representative" days, as a % of peak demand for the year; (g) hourly electrical demands, as a % of daily peak demand for 3 levels of heating demands; (h) KWH/sq. ft. and BTU/sq. ft.; (i) % of electricity used for air conditioning; (j) energy used for hot-water heating; (k) hourly heating and air-conditioning loads.

***Most of the bases had single electrical and gas meters "at the gate" only, without submetering or separate metering of even major component functions on the base. In effect, this meant that energy consumption and peaking data for electrical, heating and cooling requirements (associated with troop housing, family housing, administrative/industrial functions, hospitals, water supply, sewage treatment, etc.) were for the most part aggregated into single meter recordings. Where multiple metering did occur, such was mainly used to separate family housing from other base functions.

TITLE: ECONOMIC GUIDELINES for TOTAL ENERGY SYSTEMS

SOURCE: ASHRAE Transactions, Vol. 80-Part 2, pp 212-223

AUTHOR(S): J.L.Oplinger; et al
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 1974
OTHER IDENTIFIERS: Paper No. 2318

DATA USE RESTRICTIONS: Copyright by ASHRAE

TOTAL: [PAGES 12 ;REFERENCES 12 ;GRAPHS 8 ;TABLES] *
DOCUMENT CLASSIFICATION(S): 53/10, 17, 37, 57

ABSTRACT: *[Information of (mainly) secondary relevance to the general subject matter of this Compilation is scattered thruout this Report.]

The purpose of the study was to provide easily usable guidelines for evaluating T.E. system opportunities over a wide range of conditions. The basic evaluation procedure consists of the following steps: (1) identify climatic region, (2) determine purchased electricity cost: (3) determine total energy fuel costs; (4) calculate total energy annual operating cost savings; (5) calculate rate of return on incremental investment.

The Report says that by simulating the performance of residential T.E. systems in a number of climatic regions, it was possible to evaluate waste heat utilization accurately and identify regional variations of economic feasibility. [The simulation results indicate that T.E. economic feasibility has a significant regional variation.] Cooling load variation has a more significant effect than heating load variation: a number of factors account for this behavior, one being the fact that cooling load affects both the electric equipment and the utilization of waste heat. A regionalization, based primarily on cooling load variations, was developed to model geographic variations of feasibility, as determined by computer simulation.

A complete discussion of the simulation analysis approach, including a detailed description of the synthesis of electric and thermal load profiles, is not given (but is referenced). Briefly, thermal load profiles were computed by utilizing historical hourly weather data, revised HUD insulation standards and commercially available load programs. Electric load profiles were synthesized, based on actual metered data obtained from a cross section of multi-family residential developments. The operating cost savings curves are based on the comparison of optimum conventional and total energy systems.

This work has shown that it is possible to obtain a general estimate of T.E. economic feasibility in response to critical factors of electricity and fuel cost, project size, climate, etc.

TITLE: A CONSULTANT'S APPROACH to TOTAL ENERGY

SOURCE: Electronics & Power, 29 May 1975, pp 614-618

AUTHOR(S): K.W.Sutton
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 5/75
OTHER IDENTIFIERS: Journal of the Institution of Electrical Engineers (Great Britain)
DATA USE RESTRICTIONS: Crown Copyright

TOTAL: [PAGES 5 ;REFERENCES 2 ;GRAPHS 1 ;TABLES] *
DOCUMENT CLASSIFICATION(S): 53/1, 10, 17, 19, 22, 28, 32, 37, 44

ABSTRACT: *[Contains material of direct and (mainly) secondary relevance to the subject matter of this Compilation.]

This Article focuses attention on the possible use of T.E. systems, as a means of reducing the overall energy use by commercial and industrial customers, and outlines the basic considerations that are involved in the preliminary (feasibility) analysis of such systems.

It is stated that it is possible to carry out an initial study quickly and with reasonable accuracy, provided the technique employed is used with great caution and the result is only used to decide whether a detailed study should be carried out. The primary variables which have the greatest effect on feasibility are: (1) the cost of purchased electricity; (2) availability and price of suitable prime-mover fuels; (3) the load factor; (4) availability of capital and the rate of return on the client's capital.

On an existing site, hourly steam and electrical demands (as well as annual fuel and electrical-power costs) are often available; therefore the assessment of loads can be made reasonably accurately. In the case of new premises, however, these hourly load profiles can only be good estimates and are an obvious weakness in the study. Calculation of energy requirements for a building involves two principal steps: first, the determination of the heating, cooling and electrical load imposed on the system and, secondly, the calculation of the energy input required by the system to satisfy that load.

A yearly load profile - in KWH per week - is shown for a 16,000 square meter office building; this profile is made up of 3 components, namely: (a) boiler and utility system (zone) pumps; (b) lighting and office power; (c) air conditioning equipment, including pumps. The corresponding profile is also shown for maximum KW demand.

TITLE: TOTAL ENERGY SYSTEM DESIGN PRIMER (PART I)

SOURCE: Gamze-Korobkin-Caloger, Inc. + Proceedings of 10th IECEC (held at University of Delaware) 8/18-8/22, 1975); pp 456-460
AUTHOR(S): M.G.Gamze
PREPARED BY AUTHOR(S) AND/OR: G-K-C, Inc. (Consulting Engineers; Chicago, Illinois)
DATE OF ISSUANCE: 8/73 and 8/75 *
OTHER IDENTIFIERS: 10th IECEC, Paper No. 759072; marked "Part I-Continuation" *
DATA USE RESTRICTIONS: 1975 IECEC Proceedings Copyright by IEEE

TOTAL: [PAGES 34 ; REFERENCES 2 ; GRAPHS 17 ; TABLES] **
DOCUMENT CLASSIFICATION(S): 53/1,3,7,12,13,15,25,28,32,33,37,44

ABSTRACT: *[G-K-C Paper is marked: "Presented in two sections at 8th IECEC, Aug. 1973, University of Pennsylvania and at 10th IECEC, Aug. 1975, University of Delaware". However nothing appears in the 1973 IECEC under above Title.]

**[Information of direct or secondary relevance to the subject matter of this Compilation is scattered thruout the two sources. The Total(s) are for both sources, other than for data identical to the two.]

The author discusses the impact of the heating, cooling and electrical requirements as they relate to both the building design and the T.E. plant. Since the T.E. plant is intended to serve a limited group of users, the user systems influence the size and component make-up and operating economics of such plants. Altho conventional utility systems can be considered as essentially unlimited power sources, a T.E. system is a user-limited source.

The first phase of the design process is a preliminary selection of equipment based on thermal loads which, in conjunction with occupancy characteristics, determine the electrical loads to be supplied by the prime mover(s). In the final design, the process is reversed and the electrical equipment is selected first: the heating/cooling plant is then chosen since the amount and temperature of prime mover waste heat affects such selection. [In this Paper real buildings are used as models.]

It is pointed out that the overall HVAC system of the models represent substantial portions of the site electrical load. Therefore, it is imperative that the T.E. plant designer begin by computing these loads in order to rationally approach a synthesized electrical load demand that can be used in further computations, i.e. load data obtained from the building's designers should not be used without checking. [Note: a 1968-72 utility survey, on 25 large-tonnage refrigeration plants in the Chicago area, discovered that the actual cooling load was from 50 to 65% of the designer's cooling load.]

The Paper contains (unidentified) electrical, 24 hour, demand profiles for: apartment buildings of various types, some having electric ranges and some having gas; office buildings of 2 designs; "old" and "new" hospitals. Additionally, data is included on the range of demands to be expected for: lights, receptacles and cooking, pumps, fans and fan-coils (for apartment buildings); lights, patient equipment, fans and pumps (for hospitals); lights, fans and pumps (for office buildings); central HVAC plants.

From looking at the models, load matching of various types of buildings may prove feasible. For example,office building use occurs fairly much in the mid-day valley of the apartment building usage. Therefore, if you have a preponderance of apartment buildings with some office space, it is possible to get a relatively stable electrical loading from approximately 7:00 a.m. to 10:00 p.m. thus making a T.E. plant relatively worthwhile.

TITLE: PROCEDURES for FEASIBILITY ANALYSIS and PRELIMINARY DESIGN of TOTAL ENERGY SYSTEMS

SOURCE: Booz-Allen and Hamilton, Inc.

AUTHOR(S): D.Wulfinghoff & D.Malm
PREPARED BY AUTHOR(S) AND/OR: B.-A. & H., Inc.

DATE OF ISSUANCE: 7/75 (Revised 9/75)
OTHER IDENTIFIERS: Report No. BA 9005-454. Prepared for: Naval Civil Eng. Lab. and Army Construction Eng. Research Lab.
DATA USE RESTRICTIONS:

TOTAL:[PAGES 9 ;REFERENCES 35 ;GRAPHS ;TABLES] *
DOCUMENT CLASSIFICATION(S): 53/10, 11, 15, 17, 21, 23, 34, 55

ABSTRACT: *[Material of secondary relevance to the subject matter of this Compilation is scattered throughout the Report, primarily in Chapter V. The Total(s) cover the relevant material except that all References are included, even though some are rather general in their subject matter.] Under the general heading of "Load Analysis", Chapter V of this Report states that after the candidate site (or sites) for a prospective T.E. heat recovery system have been identified it becomes necessary to analyze the site's energy loads to establish their time profiles. The distribution of such energy loads is a major part of the information needed for defining an optimum equipment configuration and for doing the detailed analysis of their performance. [The process of defining the equipment configuration is covered, as are the procedures for detailed technical performance analyses.] The initial load analysis is very similar to one done as part of a conventional HVAC design. The major differences is that a heat recovery system analysis must address the time dependence of the loads in greater detail.

Chapter V also discusses details of load analysis, namely: the required outputs, selection of the analysis method and the required input data. The "outputs" are the magnitude and time characteristics of the mechanical and electric loads. The "methods" discussed are: (1) the actual metering of the loads; (2) manual computations, based on occupancy and usage of a facility so as to determine the individual components of electric load as a function of time; (3) use of computer programs to provide load data for building structures having common-place HVAC loads. The "inputs" include factors related to: (a) location of the buildings and their constructional details; (b) environmental conditions; (c) occupancy patterns and other demographic parameters; (d) ratings of installed electric lights, motors and other heat-releasing equipment; (e) details of the space conditioning equipment.

The Report states that data are most commonly acquired from the following sources: (1) Architectural, mechanical and electrical plans; (2) System specifications; (3) Designer's HVAC calculations; (4) Operating logs; (5) Utilities bills and records; (6) Discussions with personnel responsible for the operation and maintenance of the facility; (7) Standard reference values for structures and components of similar type.

TITLE: NEW ENERGY TECHNOLOGIES for BUILDINGS: INSTITUTIONAL PROBLEMS and SOLUTIONS

SOURCE: Ballinger Publishing Company

AUTHOR(S): R. Schoen; et al
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 1975
OTHER IDENTIFIERS: First Printing

DATA USE RESTRICTIONS: Copyright by the Ford Foundation

TOTAL: [PAGES 13 ; REFERENCES 12 ; GRAPHS ; TABLES] *
DOCUMENT CLASSIFICATION(S): 53/17

ABSTRACT: *[Chapter 2 contains information on Total Energy which has some secondary relevance to the subject matter of this Compilation; the Total(s) reflect this.]

The author states that sometimes a building owner might prefer - if there was evidence to justify such a decision - to incorporate a T.E. system as an insurance policy against "brownouts" and "blackouts". Given the present rapidly changing set of circumstances, concerning oil and gas cost and availability, it does not appear possible to determine whether it is more cost effective to add central generation capacity or T.E. systems. A complex set of factors must be included in any economic analysis; these include:
(1) A detailed load profile of a building which reflects design, usage and environment - including patterns of weather and climate;
(2) Local utility rate structures and the prevailing costs of energy;
(3) Energy availability, in terms of the type of energy and the expected rate of growth of supply for the local utilities;
(4) Air quality standards prevailing in the utility service territory and the relative impact on air quality in a particular region from the addition of T.E. systems vs. large central generating facilities.

Due to the preceding economic factors, it was concluded that new incentives must be created to encourage the use of T.E. systems. For example, energy performance standards might be required for buildings, including an evaluation of the total amount of fossil fuels that a building could consume. Other incentives could include setting-up preferential rates, to developers who can demonstrate that their buildings meet very stringent overall energy-use requirements, and establishing preferred tax writeoffs for owners of high energy conservation buildings. A related approach would be the establishment of zoning ordinances which would give preference to projects with a high degree of energy conservation and limit the rate of growth of new commercial floorspace to correspond to the rate of growth in available electrical energy.

TITLE: TOTAL ENERGY and TOTAL UTILITY SYSTEMS for CONSERVATION of RESOURCES

SOURCE: Construction Engineering Research Laboratory

AUTHOR(S): D.C.Hittle
PREPARED BY AUTHOR(S) AND/OR: C.E.R.L. plus Battelle Memorial Laboratories

DATE OF ISSUANCE: 3/76
OTHER IDENTIFIERS: Interim Report E-61, for period 7/73 thru 6/74

DATA USE RESTRICTIONS:

TOTAL: [PAGES 30 ; REFERENCES 7 ; GRAPHS 1 ; TABLES] *
DOCUMENT CLASSIFICATION(S): 53/10,15,17,37

ABSTRACT: *[Information of (mainly) secondary relevance to the subject matter of this Compilation is scattered thruout this Report. The Total(s) are for the entire Report.]

The Report concludes that a universally applicable and proven design method for T.E./utility systems does not exist. The construction of these complex systems (at Army installations) without prior development of good design methods is likely to result in a random pattern of success and failure. In theory, design methods and criteria could ultimately evolve from field data taken at future sites but this approach has two disadvantages. First, the construction of test or demonstration systems will be quite costly if many systems fail to be economically competitive or energy -conservative. A second major disadvantage is the time that would be required to obtain funding for, and construct, demonstration facilities. The development of design criteria would be delayed for several years if this approach were pursued.

The work described in this report proposes a simulation technique as an alternative to the costly approach of "trial-and-error" design and construction. Key features of the proposed model include: (1) A submodel to predict building energy load profiles; (2) An equipment performance submodel to calculate hourly equipment performance and fuel or energy consumption; (3) An economic submodel for determining life-cycle costs.

The Report contains "hypothetical" 24-hour load profiles for the electrical and thermal energy demands of schools, street lights, family dwellings, barracks, cold-storage buildings, office buildings and recreation centers. Appendix B (briefly) discusses electric utility projection methods, heating and cooling forecasts, and some of the more widely used energy analysis (computer) models.

TITLE: TOTAL INTEGRATED ENERGY SYSTEM FEASIBILITY ANALYSIS for the DOWNTOWN REDEVELOPMENT PROJECT (in) PASADENA, CALIFORNIA

SOURCE:

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: City of Pasadena; Pasadena Development Agency; Levine & McCann; Genge Community Consultants
DATE OF ISSUANCE: 4/77
OTHER IDENTIFIERS: Prepared for ERDA's Division of Building and Community Systems, Office of Conservation
DATA USE RESTRICTIONS:

TOTAL: [PAGES 50 ;REFERENCES 4 ;GRAPHS 53 ;TABLES] *
DOCUMENT CLASSIFICATION(S): 53/1,9,12,20,30,32,34,37,43,44,49,55,56,57

ABSTRACT: *[Contains material of direct and (mainly) secondary relevance to the subject matter of this Compilation. The Totals apply to the relevant material, which is mainly in the Appendices.]

The purpose of this Study to determine the most desirable method of serving the energy needs of a commercial development to be constructed in Pasadena, California. The methods studied were the Total Integrated Energy System (TIES) concept, in several configurations. The TIES concept differs from T.E. in that the electric power output of the "local power generation plant" goes directly into the utility company distribution grid, rather than to the user; the user is served power from the grid, as with a conventional system, but also receives heating and cooling media (produced from power generation by-product heat) from the TIES plant. [Note: The Report concludes that none of the TIES configurations analyzed proved financially feasible and explains why. Other conclusions and recommendations are presented.]

Appendix "A" deals with factors used in load calculations, such as weather and the details of commercial building construction. Appendices "B" and "C" deal with factors used to develop tenant area allocations and electrical loads, plus data on: lighting loads (watts/sq. ft.), occupancy (sq. ft./person), hot water usage (gal./hour) and ventilation requirements.

Appendix "D" discusses the electrical loads and load profiles for a variety of commercial establishments, including department stores, shopping centers, restaurants and office buildings. Data values are given for various major connected loads (in KW) and for lighting (in watts/sq. ft.); these values cover such loads as: elevators/escalators, cooking equipment, supply/exhaust fans, water heating, lights and "miscellaneous small loads". A large number of occupancy and connected load profiles are reproduced (from other sources) as part of this Appendix. These daily profiles - which cover weekdays, weekends (and holidays, in some instances) - are stated in terms of "% connected load" or "% design occupancy" or "% daily peak".

TITLE: TEM BOOSTS BUILDING'S ENERGY EFFICIENCY

SOURCE: Electrical World, 9/15/75, pp 116-117

AUTHOR(S): N.K.Khosia
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 9/75
OTHER IDENTIFIERS: Energy Marketing

DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL: [PAGES 2 ;REFERENCES 1 ;GRAPHS 2 ;TABLES]
DOCUMENT CLASSIFICATION(S): 54/7, 13

ABSTRACT: *[Contains material of secondary relevance to the subject matter of this Compilation.]

In a direct response to FEA, and with its complete cooperation, the NEMA and NECA undertook a project to develop a practical approach to energy conservation in office buildings. The program is called TEM (Total Energy Management), which should not be confused with Total Energy (on-site power generation.)

TEM holds that all buildings comprise 3 basic systems, namely:

A. Energized systems, those which actually consume energy;
B. Nonenergized systems (such as walls, roof and windows) which do not consume energy but which impact on the amount of energy consumed;
C. Human systems, meaning the people who use the building, manage and operate it, or perform maintenance.

A limited amount of electrical usage data is included.

TITLE: TOTAL ENERGY MANAGEMENT: A PRACTICAL HANDBOOK on ENERGY CONSERVATION and MANAGEMENT (for USE of OWNERS and MANAGERS of OFFICE BUILDINGS and SMALL RETAIL STORES)
SOURCE: NECA & NEMA

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: (Developed by) NECA & NEMA; endorsed by FEA, et al
DATE OF ISSUANCE: 9/76
OTHER IDENTIFIERS: Index No. 2095 *

DATA USE RESTRICTIONS: Copyright by NECA

TOTAL:[PAGES 97 ;REFERENCES 54 ;GRAPHS 17 ;TABLES 4] **
DOCUMENT CLASSIFICATION(S): 54/9,11,20,23,32,44,49,56

ABSTRACT: *[An auxiliary report, "Total Energy Management Research Report," was published in 10/76 and identified as Index No. 2096.]

**[Information of direct or (mainly) secondary relevance to the subject matter of this Compilation is scattered thruout this Handbook. The Totals are for the entire Reference, even though much of the Bibliography is rather general in its subject matter.]

The vast majority of commercial buildings in the USA were completed before energy conservation started to command the urgency it does now. Significant attempts are now being made to modify such buildings so that their operation requires significantly less energy. These NECA/NEMA reports deal with one of these attempts, identified by the acronym TEM.

In essence TEM considers every building as a unique, complex system. To conserve energy one first must understand how: (1) the building consumes energy; (2) users' needs are met; (3) the systems' elements interrelate; (4) external environment affects it; etc. By understanding how a specific building consumes energy, one can make energy conservation improvements which can be integrated into the system so that it runs efficiently and therefore tends to use the least amount of energy to get the job done. The TEM approach involves literally hundreds of different options from which a building owner/manager can pick and choose to achieve energy savings. This gives him the flexibility he needs to conserve energy while also meeting the specific needs of his building and the people who use it.

It is noted that many of the specific concerns addressed by TEM are not new. What is new is the manner in which they are addressed and the methodology suggested for effective implementation. Perhaps most important, utilization of the TEM approach will enable building owners and managers to realize significant energy and energy cost savings without having to make any significant changes in the working environment each building must support.

The publication contains data pertinent to areas like the following: (a) suggested illumination levels; (b) guidelines for conserving hot and cold water; (c) options in the use of elevators and escalators. [Case histories are presented to summarize energy use in two office buildings before, and after, a list of enumerated conservation steps were taken.]

The primary objective of the auxiliary report was to evaluate the quality and effectiveness of the original ("Testing Edition") of the NECA/NEMA manual. The evaluation indicated that the basic approach of the manual was sound and that only minor revisions were needed; these revisions were incorporated in Index No. 2095.

TITLE: ENERGY MANAGEMENT (A SERIES OF REPORTS on BUILDING PROJECTS)

SOURCE: EEI Energy Management Program

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: EEI Conservation & Energy Management Division, (New York, N.Y.)
DATE OF ISSUANCE: *
OTHER IDENTIFIERS: Case Study Number (sequential)

DATA USE RESTRICTIONS:

TOTAL: [PAGES ;REFERENCES ;GRAPHS ;TABLES]**
DOCUMENT CLASSIFICATION(S): 54/1,3,7,9,11,13,15,28,44,48,49

ABSTRACT: *[Issued from time-to-time; sheets are undated but EEI's "Energy Information Materials" catalog gives a date and a Publication No. Case Study No. 1 was issued in 1973; latest Case Study - at time this sheet was prepared - was No. 20 (available 1/78).]
**[All Case Studies have a standardized 4 page format. Data is (mainly) relevant to the general subject matter of this Compilation, altho rather highly aggregated in nature.]

These case studies cover: office buildings of a range of sizes; apartment houses; schools (elementary and junior and senior high schools); hospital; department store; shopping malls; industrial training facility and a corporate office tower.

Each study contains a general description of the structure and its special features, supplemented by schematic layouts as necessary. A design summary is always included which gives: building areas/volumes; constructional details and their thermal conductivity properties; environmental design conditions, for heating/cooling (i.e., heat losses, normal DD, ventilation requirements, assumed indoor/outdoor temperatures and relative humidity); lighting levels and fixture types used; major connected electrical loads for heating/cooling, ventilation, lighting, water heating, cooking, etc. (as applicable to the particular structure.)

The following summarizes the size of the major buildings covered by these case studies:
(a) 7 office buildings (or building complexes), ranging from about 225,000 to 2,700,000 sq. ft.;
(b) 2 shopping malls, with total building areas of about 265,000 and 600,000 sq. ft.;
(c) 2 apartment developments of about 269,000 and 316,000 sq. ft.;
(d) 3 schools, ranging up to about 244,000 sq. ft.;
(e) a department store, with floor area of about 463,000 sq. ft.;
(f) a hospital, with floor area of about 138,000 sq. ft.;
(g) a corporation training center complex, totaling about one million sq. ft.

TITLE: THE ELECTRIC POWER BUSINESS

SOURCE: McGraw-Hill, Inc.

AUTHOR(S): E.Vennard
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 1970
OTHER IDENTIFIERS: Second Edition

DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc. Load chart data (in Chapt. 8) credited to LRC of AEIC

TOTAL: [PAGES 54 ;REFERENCES 3 ;GRAPHS 41 ;TABLES 2] *
DOCUMENT CLASSIFICATION(S): 55/5, 14, 19, 21, 35, 37, 47

ABSTRACT: *[Chapters 6: "Forecasting" and 7: "Getting New Business-Selling" and 8: "The Nature of Electrical Loads" contain information of direct or secondary relevance to the subject matter of this Compilation. The Total(s) apply only to Chapters 6, 7 and 8.]

Chapter 6 states that "every power company periodically makes the kinds of forecasts described (here) as part of its over-all planning." These forecasts are periodically reviewed and modified, as required, to meet changing conditions.

Chapters 6 and 7 include charts (or graphs) of the following: (1) a correlation between disposable personal income (in 1954 dollars) and residential KWH sales; (2) a correlation between personal income expenditures (in 1954 dollars) and KWH sales to "small" light and power customers: (3) "typical" daily residential load curves, based on 1968 "sales" data and on 1980 "target" data, as a build-up of the KWH usage for various household appliances and lighting; (4) annual residential load factors, for 1967 and 1980 (estimated).

Chapter 8 briefly discusses the principles of rate making, load factor, diversity and load characteristics. It includes a few examples of typical (daily) load profiles for such appliances as electric ranges and shows the effects of adding such demand curves.

TITLE: SELECTION of UTILITIES for SUBSIDIZED HOUSING in REGION IX

SOURCE: HUD's San Francisco Regional Office

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: HUD

DATE OF ISSUANCE: 12/72
OTHER IDENTIFIERS: A Region IX Handbook; HPMC-FHA 4500.6 (SF SUPP 1) *

DATA USE RESTRICTIONS:

TOTAL:[PAGES 25 ;REFERENCES 2 ;GRAPHS ;TABLES 12] **
DOCUMENT CLASSIFICATION(S): 55/13,14,15,17,22,25,26,28,40,47,56

ABSTRACT: *[This is the most recent update of HUD's Bulletin LR-11; if LR-11 is revised and reissued it will supersede this Reference. Note: LR-11 was originally issued in 6/63 as "Selection of Utilities for Low-Rent Housing" and revised in 4/72 (for HUD), by an EEA task group, as "Selection of Utilities (for) HUD Multi-family Housing".]

**[Information of direct and secondary relevance to the subject matter of this Compilation is scattered thruout this Handbook. Data pertaining directly to non-electric utilities has been excluded from the Total(s).]

This Handbook contains information which is intended to assist in selecting utilities and fuels for new subsidized housing developments constructed under the U.S. Housing Act of 1937, as amended. It is designed to make the experience of existing developments available to those concerned with the initial selection of utilities and fuels and with the purchase, distribution and use thereof in new subsidized housing developments. [Since the information in the Handbook is presented on the basis of national averages - which may not be (directly) applicable to a particular locality or housing development - the data contained therein should be considered as a guide only and should be adjusted to fit local conditions. Local experience and data from existing developments in the area should be used for such adjustments,as applicable.]

Among the general topics covered by the Handbook are: (a) Basic considerations in doing a comparative analysis of utility costs; (b) Estimating fuel and energy consumption (including electricity); (c) Determination of the initial cost, annual cost and service life of equipment and facilities; (d) Procedures for adjusting data, e.g. to satisfy local circumstances.

In connection with its discussion of electrical requirements, the Handbook has tabulated estimation data on: (1) the consumption in KWH/dwelling/month, for residences having up to 6 bedrooms and for both individual and master-metered conditions; (2) KW demands (monthly peak) for same units as (1); (3) consumption in KWH/dwelling/month for hot water heaters in various geographical regions of the USA; (4) usage, KWH/dwelling/month, for space heating as a function of HDD; (5) consumption, for non-dwelling purposes.

TITLE: OPTIMAL RATE STRUCTURES and the ELECTRIC UTILITY PROGRAM

SOURCE: NARUC

AUTHOR(S): J.E.Smith, Jr.
PREPARED BY AUTHOR(S) AND/OR: NARUC

DATE OF ISSUANCE: 10/8/74
OTHER IDENTIFIERS: Paper presented at 86th NARUC Annual Convention; Hershey, Pa.; Sept. 12-13, 1974
DATA USE RESTRICTIONS: Paper presented (for informational purposes) to the NARUC Executive Committee
TOTAL: [PAGES 10 ;REFERENCES 13 ;GRAPHS ;TABLES 4] *
DOCUMENT CLASSIFICATION(S): 55/4,5,13,14,16,17,18,21

ABSTRACT: *[Information relevant to the subject matter of this Compilation is mainly in Chapter 2 of this Paper; the Totals apply to the most relevant material.]

Chapter 2 deals with "The Demand for Electricity". The results of both the econometric and noneconometric approaches are summarized in this chapter.

The Paper summerizes the results of the efforts of a number of economists in attempting to measure the demand for electricity and its elasticity. It is stated that, due to both data and econometric problems, such efforts are only partially fruitful. One of the major problems has been that the customer data is not usually available on the desired cost basis. Another problem is that changing markets may also change the demand elasticity, rendering previous studies obsolete.

A noneconometric study was discussed which examined the demand for electricity. This Study indicated that personal consumption expenditures for household utility services over the last 30 years, as a % of total expenditures for all goods and services, have fluctuated around the 4% level. The small proportion of expenditures that goes for the purchase of electricity dramatizes that only substantial rate increases could significantly affect the total usage of power. The study also indicated that appliance ownership significantly determines the consumption of electricity. The size of the community and the percent of housing units which are one-family structures and/or owner-occupied deserves special attention in explaining differentials in appliance ownership and the levels of energy consumption by the average residential customers in the communities. Life style and income determine appliance ownership.

On the basis of multiple correlation studies prepared in the New York Office of Economic Research, it is stated that there is a closer correlation of average levels of power consumption with housing characteristics than with such factors as income or typical bills for 250 or 500 KW. The stockpile of appliances which the consumer has is directly related to the space he has; single family structures tend to have a lot of appliances and use a lot of electricity.

It is concluded that the degree of responsiveness of the demand for electricity to changes in the price of electricity has been difficult to quantify. Various studies have found the demand for electricity to be a function of some and/or all of the following variables: price of electricity, price of alternative fuels, income, population, life style and stocks of appliances. There is (currently) disagreement among economists about the demand for electricity, altho additional research is likely to result in obtaining improved knowledge of the demand. For "policy-making" purposes, one could (probably) accept the following statement: The demand for electricity would appear to be somewhat responsive to price in the long run; short run responsiveness is likely to be limited, for consumers of electricity appear to be locked into certain life styles which will take time to change.

TITLE: PUBLIC SERVICE COMMISSION of MARYLAND CASE NO. 6808 (An investigation by the Commission, on its own motion, of electric utility rate structures and the changes, if any, that should be made....)
SOURCE: PSC of Maryland

AUTHOR(S): *
PREPARED BY AUTHOR(S) AND/OR: PSC of Maryland (Baltimore, Md.)

DATE OF ISSUANCE: Case instituted by PSC Order No. 61081 dated (11/27/74)
OTHER IDENTIFIERS:

DATA USE RESTRICTIONS: Case documentation is a matter of "public record"; it is available for inspection at PSC of Maryland
TOTAL: [PAGES ;REFERENCES ;GRAPHS ;TABLES] **
DOCUMENT CLASSIFICATION(S): 55/5,11,13,14,19,21,28,30,36,37,38,52,56

ABSTRACT: *[The extensive case records of this investigation cover supporting documentation and testimony by interested persons and groups, including - by PSC order - all Maryland electric utilities with annual revenues in excess of $25,000,000.]
**[Contains material of direct and (mainly) secondary relevance to the subject matter of this Compilation. The extensive and varied documentation does not lend itself to providing meaningful Total(s).]

The purpose of this investigation is to provide the PSC with recommendations related to electric utility rate structures, as stemming from Case No. 6808. As of the time this sheet was prepared, a (proposed) order of the hearing examiner had been issued which summarizes the voluminous testimony and orders the steps to be taken by each of the four major Maryland utilities in order to implement the "findings" resulting from said testimony. These steps include: (1) submission of plans for experimental sample testing of 800 large residential consumers for "time-of-day" usage; (2) reporting on the practicality of "end-use" tariffs for air-conditioning usage by large residential users, as well as by office buildings and shopping centers; (3) a study of existing seasonal "rate differentials" to see if changes are warranted; (4) reporting on the establishment of a provision for "off-peak" discounts for large commercial and industrial customers; (5) filing a summary of plans for "load management", as deemed practical in reducing future needs for new utility facilities.

A significant amount of load usage data was submitted as part of the numerous "exhibits" in this case. [Representative data is summarized below, identified as to the utility which supplied the exhibits.]

The Potomac Edison Co. supplied: (1) monthly and annual system load factors for 1961 thru 1974, expressed as a % of its capacity; (2) the number of residential customers, in each rate class, and the average annual KWH used per customer, for 1973 and 1974; (3) annual KWH used by various major consumption categories in a 2500 sq. ft. home having maximum insulation, for typical high-use customers operating under "normal"

and under "conservation" conditions; (4) effects of compulsory reductions in settings of space-heating and water-heating thermostats, for typical high-use residential customers; (5) same reductions as for (4), plus implementation of a "conservation" step prohibiting air-conditioning; (6) Census tract data (family income, monthly rent or cost of home, etc.) for the utilities' service area; (7) distribution of monthly KWH usage for non water-heating customers, by income grouping.

The Potomac Electric Power Co. supplied: (1) estimated annual KWH usage plus saturation data, for major appliances; (2) KWH monthly and annual consumption of "large" and "small" residential users, for 1973 and 1974; (3) dwelling size and number of persons per dwelling unit, from 1970 Census data; (4) utility data (as of 12/31/74) for the number of customers having electric water-heating and space-heating, and for those with all-electric homes; (5) residential load survey results (Jan. 1974), in 9 grouped annual KWH ranges extending from 0-340 to "in excess of" 2200, which included the monthly KWH per customer and the group maximum non-coincident KW demand per customer; (6) residential electric customer load profiles for the days of system peak demands, 8/30/73 and 1/14/74.

TITLE: STATE of NEW YORK PUBLIC SERVICE COMISSION CASE NO. 26806 (Proceedings on motion of the Commission as to rate design for electric corporations)
SOURCE: PSC of New York

AUTHOR(S): *
PREPARED BY AUTHOR(S) AND/OR: PSC of New York (Albany, N.Y.)

DATE OF ISSUANCE: Case initiated by Commission's order of 1/29/75
OTHER IDENTIFIERS:

DATA USE RESTRICTIONS: Case documentation is available at Commission's offices in Albany and New York City + 18 libraries thruout state
TOTAL: [PAGES ;REFERENCES ;GRAPHS ;TABLES] **
DOCUMENT CLASSIFICATION(S): 55/5, 18, 36, 38, 39, 45, 52

ABSTRACT: *[The extensive case records cover supporting documentation by the designated parties to the Proceedings, including: seven electric utilities, the Environmental Defense Fund and the Commission's Staff.]

**[Contains material of direct and (mainly) secondary relevance to the subject matter of this Compilation. The extensive and varied documentation does not lend to providing meaningful Total(s).]

The broad areas of inquiry suggested by the PSC order included, among other things, issues related to: (1) peak responsibility pricing; (2) determination of incremental costs; (3) time-of-day metering; (4) the development of load data; (5) load management techniques to reduce "needle" peaks.

The 7 electric utility parties to this proceeding were directed to file with the PSC a statement of their views, with as much specificity as possible. The companies were asked to indicate, among other things: (1) their proposals for developing a methodology for measuring incremental costs as a possible basis for pricing; (2) how they propose to develop measures of peak cost responsibility; (3) the load data they now have available, and are collecting, and how these data might be employed as a basis for pricing; (4) the customers or categories of customers whose meters permit usage measurement according to the time-of-day; (5) what alternative methods of embodying peak responsibility principles they propose to consider employing and how they would propose to have them developed and considered; (6) their proposals for the collection of such additional data as may be required for resolving the issues raised by the 1/29/75 order.

Other areas of concern dealt with by Case 26806 were: (1) the measurement of the price elasticity of the various categories of electrical demand and the extent to which these varying elasticities should be reflected in rates; (2) exploring the use of interruptible service and other load management techniques.

TITLE: STAFF REPORT on ELECTRIC UTILITY RATE STRUCTURES (An investigation by the Commission's own motion into electric utility rate structures, and the changes, if any, that should be made....) *
SOURCE: California Public Utilities Commission

AUTHOR(S): D.L.Houck; et al
PREPARED BY AUTHOR(S) AND/OR: Utilities Division, Electric Branch of C.P.U.C. (San Francisco, California)
DATE OF ISSUANCE: 3/28/75
OTHER IDENTIFIERS: C.P.U.C. Case No. 9804

DATA USE RESTRICTIONS: Case documentation is a matter of "public record" and should be available for inspection at California PUC
TOTAL: [PAGES 13 ;REFERENCES ;GRAPHS ;TABLES 5] **
DOCUMENT CLASSIFICATION(S): 55/5,13,14,21,37,38,50,52

ABSTRACT: *[This Report is one of the "exhibits" in the voluminous records of this case.]

**[Information of (mainly) secondary relevance to the subject matter of this Compilation is scattered thruout this Report; the Total(s) apply to the relevant material.]

The purpose of this Report is to provide, for the consideration of the C.P.U.C., the staff's recommendations on electric utility rate structures in connection with Case No. 9804. The staff reviewed the extensive data filed by the respondent electric utilities, as required by the Commission. Where appropriate, this report summarizes data from the utility filings and, in certain instances, selectively utilizes the data for illustrative purposes or in developing an example. The staff also has independently developed certain examples as illustrative of the effect of the various alternatives being investigated. A staff conclusion is set forth for each alternative.

It was indicated that a number of issues have been raised by the utilities relating to acquiring the necessary data and the associated costs of a program examining: "discount prices for consumers who achieve a decrease in their consumption of electricity compared to a like period in the preceding year". In addition, information is lacking on the continuing effect on electricity consumption by the use of discount rates. Therefore, the staff recommended that all 3 major electric (respondent) utilities should be required to file a limited tariff to test the effect of this alternative. [It was suggested that a small group of customers could be established by random sampling techniques. This approach would permit development of statistical usage data, in order to determine the desirability of widespread application of discount rates. It would also allow the utilities to perfect methods of collecting and utilizing consumption data in connection with furnishing such discount rates, as well as providing information on the additional costs involved in such a program.]

The Report said that there appears to be some divergence of opinion between the 3 major electric utilities on the amount of correlation between income and electricity consumption. One utility submitted a 218-page study analyzing the consumption of gas and electricity by "low income" users in its service area; it concluded that "usage and income do not correlate to any significant degree, nor for that matter does usage and any quantifiable variable on a cross-sectional basis." A second utility stated that analyses for its service area show that "income level and size of household have a definite effect on the use of electricity, but that the effect of household size is greater than income level." The third utility included a chart which indicates definite correlation between income and age; they also found a correlation between family size and electricity consumption. [The Los Angeles Department of Water and Power indicates that the 2.6% of its domestic customers using less than 50 KWH/month consists mainly of "vacancies" and people on vacation. However, the 30% that use between 50 and 200 KWH/month are either apartment dwellers or homes in lower income areas.] There does seem to be agreement on the fact that many low use bills have nothing to do with income level.

The Report includes (summer and winter) "peak day" system load curves for 3 major utilities. It also has a Table of the number of customers contained within various demand ranges. [Various types of cost information form the bulk of the data.]

TITLE: ELECTRICAL WORLD DIRECTORY of ELECTRIC UTILITIES

SOURCE: McGraw-Hill, Inc.

AUTHOR(S): J.E.Slater (Publisher); E.S.Macdonald (Manager)
PREPARED BY AUTHOR(S) AND/OR: Editorial and Research Staff of "Electrical World"
DATE OF ISSUANCE: 1976
OTHER IDENTIFIERS: 85th (annual) Edition, 1976-1977

DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL: [PAGES ;REFERENCES ;GRAPHS ;TABLES] *
DOCUMENT CLASSIFICATION(S): 55/23, 26

ABSTRACT: *[Contains material of secondary relevance to the subject matter of this Compilation. These Total(s) are not considered pertinent to this form of publication.]

This Directory contains the following information:
(1) Names, mailing addresses and phone numbers of all electric utilities for each state and Canada, classified as to type (e.g., wholesale generating companies).
(2) Names and titles of executive and operating personnel.
(3) Cities served (over 1,000 population).
(4) Equipment and system characteristics (generation, transmission and distribution).
(5) Number of customers by residential, industrial, commercial and rural classifications.
(6) Power purchased and power sales in KWH.
(7) Major interties, by company, with maximum tie KVA and voltages.
(8) Average KWH rate and use.
(9) System heat rate in BTU/KWH of net generation, unit heat rate under 10,000 BTU.

Note: much of the technical data on systems published here is presented on different bases, because of the diversity of methods employed by the different systems. This information, therefore, is stated to be for reference purposes only and is to be regarded as unofficial.

TITLE: BULLETIN of NATIONAL ASSOCIATION of REGULATORY UTILITY COMMISSIONERS

SOURCE: NARUC (Washington, D.C.)

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: NARUC

DATE OF ISSUANCE: Generally on a weekly basis
OTHER IDENTIFIERS: *

DATA USE RESTRICTIONS:

TOTAL: [PAGES ;REFERENCES ;GRAPHS ;TABLES] **
DOCUMENT CLASSIFICATION(S): 55/26

ABSTRACT: *[Individual issues are dated and assigned a number - year, e.g. NARUC No. 46-1974.]

**[Not considered pertinent to this form of publication.]

These Bulletins contain matters of general interest that could be helpful in finding data sources on electrical usage. For example, they contain the names, addresses and phone numbers of the members of the various state public utility regulatory agencies. [Note: any material submitted to such regulatory groups, e.g., in connection with rate cases, becomes a matter of public record.]

The Bulletin reports important regulatory agency and court decisions and other items of significance affecting the regulation of all utilities and public carriers. It also reports the status of legislation of regulatory interest.

Information on the various NARUC publications is summarized in these Bulletins, from time to time; such publications include the Annual Convention Proceedings.

TITLE: WATER HEATER DIVERSITY and DAILY LOAD CURVES

SOURCE: Electrical World, 11/23/46, pp 68-72

AUTHOR(S): H.G.Knaf
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 11/46
OTHER IDENTIFIERS:

DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL: [PAGES 5 ;REFERENCES 2 ;GRAPHS 12 ;TABLES] *
DOCUMENT CLASSIFICATION(S): 56/14, 21, 37, 50, 57

ABSTRACT: *[This Paper contains material of limited (direct) relevance to the subject matter of this Compilation.]

This Paper discusses the possibility of a proportional adjustment of the various daily water-heater load curves to a common daily KWH amount. Such an adjustment can only give approximate results but, with a fairly large number of available tests, a certain cancellation of error can be expected, particularly when the chosen representative KWH value falls between the high and low limits.

The choice of a representative daily energy use requires some consideration. After examining available data, the figure of 3,600 KWH/year was chosen to represent the use of an average size family of medium circumstances, living in a zone of medium climate and doing most of its laundering at home. From a number of investigations, it has also been established that water-heater use exhibits a seasonal variation of about plus and minus 10% from normal. The drop in summer use can be explained by two factors: higher intake water temperature, which more than cancels the larger hot water use in summer, and summer vacations. With the aforementioned 10% deviation, average summer use is taken to be about 9 KWH/day and average winter use is about 11 KWH/day.

The coordination on a unified basis of a fairly large number of water heater tests (including a wide range of element ratings) has resulted in the establishment of a general diversity pattern for uncontrolled operation. The main feature of this pattern is that the maximum demands for heaters with higher element ratings tend to approach those of lower rating, as the number of heaters increases. In fact, the diversified demands fall within a narrow range as the number in a group approaches a thousand.

TITLE: TEST METER DATA; RESIDENTIAL WATER HEATING COMPARISON; ELECTRIC vs GAS

SOURCE: Florida Power Corporation (St. Petersburg, Florida)

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: F.P.C.'s Competitive Research Dept.

DATE OF ISSUANCE: 4/1/70
OTHER IDENTIFIERS: Bulletin #166

DATA USE RESTRICTIONS:

TOTAL: [PAGES 2 ;REFERENCES ;GRAPHS ;TABLES 1] *
DOCUMENT CLASSIFICATION(S): 56/4, 14, 17, 22, 55

ABSTRACT: *[Contains material of (mainly) direct relevance to the subject matter of this Compilation.]

Information is tabulated which shows the results of a "first season" study of gas and electric water heaters. There were 4 test installations involved, 2 are gas and 2 are electric. The method of test was to measure the (top of the tank) outlet water temperature from the heater, obtaining an average delivered water temperature over a period of several days. A water meter on the cold water side of the heater measured the gallons used; on the electric units a KWH meter was used to measure consumption while a cubic foot meter was used on the gas installations. All energy figures were converted to BTU by using 3,412 BTU per KWH for electric heaters and 1,050 BTU per cubic foot for gas. [Four different average outlet temperatures were obtained from the residences under study, ranging from 162°F for an electric down to 114°F for a gas unit.]

The data includes descriptive and numerical information on: the water heaters; family and apartment characteristics; appliances; the performance of the heaters tested, both as to their thermal and economic characteristics.

It was found that during the non-heating months electric water heating is far cheaper than gas water heating. However, in the winter (or heating months) electric water heating is sometimes (somewhat) cheaper and sometimes (somewhat) more expensive.

TITLE: RESIDENTIAL WATER HEATING: FUEL CONSERVATION, ECONOMICS and PUBLIC POLICY

SOURCE: The Rand Corporation (Santa Monica, Calif.)

AUTHOR(S): J.J.Mutch
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 5/74
OTHER IDENTIFIERS: Report #R-1498-NSF (prepared for NSF)

DATA USE RESTRICTIONS: Published by The Rand Corporation

TOTAL:[PAGES 15 ;REFERENCES 24 ;GRAPHS ;TABLES 5] *
DOCUMENT CLASSIFICATION(S): 56/4, 6, 11, 22, 23, 31, 35, 36, 47

ABSTRACT: *[Information of direct and (mainly) secondary relevance to the subject matter of this Compilation is scattered thruout this Report. The Total(s) are for the relevant material, although some of the References are rather general in content.]

Water-heating is one of the largest and, at the same time, least apparent uses of energy in the home. It accounts for about 15% of the residential consumption and 3% of energy for all uses in the USA. The energy used is often overshadowed and hidden in monthly utility costs by space heating, air conditioning, lighting, cooking and other more obvious uses.

The purpose of this study is to examine (possible) ways for reducing the amount of fossil-fuel based energy needed for residential hot water. Two categories of alternatives are considered: first, those that reduce thermal losses and second, those that reduce the non-renewable energy requirements of the system. First category alternatives include the application of thicker tank insulation, lowering the temperature at which water is maintained in the tank, insulating exposed plumbing and installing a "timer" to automatically shut down the heater during periods when little or no hot water is needed. At present, the most attractive second category alternative is said to be the use of solar technology. [The author states that combination solar-electric water heaters, which use an electric booster to provide hot water during periods of extended cloudiness, may now be competitive with all-electric systems in areas of the USA where solar conditions are favorable and electricity is relatively expensive.]

Appendix C of this Report contains selected 1970 data pertaining to the use of "fuel" - including electricity - for residential water heating, for 9 different regions of the USA. Projections are also tabulated, for 1990 regional estimates, of the fuel to be consumed for heating water; the projections are made for 4 different levels of assumed fuel prices and are based on estimated unit consumption values. Projected 1990 levels of electric water-heater saturation range from 4 to 88%, the low value being for the highest price in the west-south-central region.

TITLE: THE POTENTIAL for ENERGY SAVINGS THROUGH REDUCTIONS in HOT WATER CONSUMPTION

SOURCE: FEA

AUTHOR(S): J.G.Muller
PREPARED BY AUTHOR(S) AND/OR: FEA

DATE OF ISSUANCE: 4/75 + Addendum dated 11/19/75
OTHER IDENTIFIERS: Conference on Water Conservation and Sewage Flow Reduction with Water Saving Devices; available from NTIS as PB-344068
DATA USE RESTRICTIONS:

TOTAL: [PAGES 12 ;REFERENCES 9 ;GRAPHS ;TABLES 4] *
DOCUMENT CLASSIFICATION(S): 56/8, 11, 14, 31

ABSTRACT: *[Information of direct and (mainly) secondary relevance to the subject matter of this Compilation is scattered thruout the Report. The Total(s) are for the relevant material.]

This Report investigates USA's patterns of heated water use. It estimates the energy savings from various methods of using hot water, evaluates the economic, social and institutional problems involved in its use and makes recommendations for legislation concerning hot water consumption. This study also outlines some of the many possible techniques for conserving hot water, noting that implementation, in some cases, requires changes in building codes and/or new legislation. [The report also estimates energy savings from the more promising energy conservation measures proposed.] The topics discussed in this report include: (a) use patterns of heated water; (b) water heaters: their efficiency, how heat loss can be reduced, reduction of tank size and complete electricity/gas shut-off for periods when the home is unoccupied; (c) how piping heat losses can be reduced by insulation, reduced pipe size, lower heater thermostat setting and by combining hydronic space heating systems with domestic hot water systems; (d) how hot water use for showers can be reduced; and (e) how appliance efficiency can be improved.

The paper includes quantitative information on: (1) how water is used by a "typical" family of four; (2) approximate temperatures of heated water for various uses; (3) the estimated disposition of the annual energy input to various types of residential water heaters; (4) tank insulation; (5) piping losses; (6) heat recovery techniques; (7) the specifications and performances of shower heads and washing machines.

TITLE: MANAGE LOADS to REDUCE CAPACITY NEEDS

SOURCE: Electrical World, 11/15/75, pp 92-94

AUTHOR(S): B.F.Hastings
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 11/75
OTHER IDENTIFIERS: System Engineering

DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL:[PAGES 3 ;REFERENCES 1 ;GRAPHS 2 ;TABLES 2] *
DOCUMENT CLASSIFICATION(S): 56/36, 39, 45, 55

ABSTRACT:*[Contains material of secondary relevance to the subject matter of this Compilation.]

This article reports in Detroit Edison Co.'s seven years of experience in operating a system that flattens demand by (remotely) controlling water heaters. The system produces significant savings and provides better service than does time-clock control of heaters. This form of peak-shaving has proved to be a useful tool even in periods when reserve margin has been relatively high. Its benefits will assume still greater significance if construction cutbacks lower the reserve.

This load-management system, North America's first large-scale installation for controlling water heaters and distribution voltage regulators by radio, has several uses. It augments system reserves on a seasonal basis. It improves system reliability by increasing daily and weekly operating reserves. It helps minimize consumption of costly oil and natural gas. Another benefit is that it improves service to water-heater customers. [Formerly, time-clock controls at each customer's home switched heaters off every day, regardless of whether load control was actually needed. Any outage required resetting of these clocks.]

About 203,000 water-heater customers subscribe to the controlled-service rate. A customer who does so can reduce his energy charges by about 35%. The controlled-use customers are divided into 10 groups, to provide flexible control of the amount of load to be dropped.

Sophisticated analyses (of load patterns, equipment availability, reserve commitments and of the effects on external transactions) must be made to obtain maximum benefits involving more than the application of peak-shaving.

TITLE: WATER HEATER TEST DATA (Average Group KWH)

SOURCE: Florida Power Corporation (St. Petersburg, Florida)

AUTHOR(S):
PREPARED BY AUTHOR(S) AND/OR: F.P.C. (Energy Conservation Research)

DATE OF ISSUANCE: 12/20/76
OTHER IDENTIFIERS: Technical Information No. 37

DATA USE RESTRICTIONS:

TOTAL:[PAGES 4 ;REFERENCES ;GRAPHS 2 ;TABLES 2] *
DOCUMENT CLASSIFICATION(S): 56/4, 14, 50, 55

ABSTRACT: *[Contains material of direct relevance to the subject matter of this Compilation.]

This information Bulletin summarizes KWH usage data obtained from about 265 randomly-selected residential water heaters, metered in 1974. [Note: 146 of these test meters provided "good" test data for use in the tabulated results.] The distribution of the meters by size of household (classified in groups of 1, 2, 3, 4 and 5 or more) approximated the distribution of family sizes in the F.P. Corp. service area. Also, the saturation of water heaters was 100% for all sample groups; additionally, the test sample's saturation of the major (hot water using) appliances was about 80% (for washing machines) and about 37% (for dishwashers), as compared to the F.C. Corp. service area respective saturation values of 68% and 32%.

Average KWH use per month, as a function of family size, was: 96 (1 person); 157 (2); 256 (3); 354 (4); 384 (5 or more); 208 (weighted average of all sizes). The average KW demand, at the monthly system peak, ranged from 0.28 to 0.51 (for Mar. thru Oct.). This data is also plotted as: % of test group using more than (x), KWH, vs (x), KWH per month.

An appliance saturation survey is included, as a function of family size. In addition to the 3 appliances noted above, saturations are tabulated for: central and unit air conditioners, electric heating, ranges, clothes dryer, food freezers and refrigerators.

TITLE: ENERGY and COST ANALYSIS of RESIDENTIAL WATER HEATERS

SOURCE: ORNL (Energy Division)

AUTHOR(S): R.A.Hoskins & E.Hirst
PREPARED BY AUTHOR(S) AND/OR: ORNL (for FEA and ERDA)

DATE OF ISSUANCE: 6/77
OTHER IDENTIFIERS: ORNL/CON-10 (may be ordered from NTIS by this number).
Conservation/Division of Buildings and Community Systems
DATA USE RESTRICTIONS:

TOTAL: [PAGES 10 ; REFERENCES 5 ; GRAPHS ; TABLES 3] *
DOCUMENT CLASSIFICATION(S): 56/10, 11, 15, 17, 22, 31

ABSTRACT: *[Material of (mainly) secondary relevance to the subject matter of this Compilation is scattered thruout this Report. The Total(s) apply to the relevant data.]

The Report describes a detailed computer model for calculating energy flows in (residential) electric and gas water heaters. The model is used to evaluate the energy (and associated initial cost) impacts of alternative designs intended to reduce water heater fuel use.

The analysis shows that the largest loss in an electric water heater is by conduction thru the jacket walls, 14% of energy input. An additional 5% is lost thru the distribution pipe, assuming a 25 foot pipe; the remaining energy input is used to heat water. [In a gas water heater, conduction losses thru jacket and distribution pipe are 12% and 3%, respectively; 33% is lost up the flue (due to the main burner and pilot light operation). Consequently, only 52% of energy input to a gas water heater is used to heat water.]

Several energy-saving design changes are examined with the model, namely: increase in jacket insulation thickness; reduced jacket insulation thermal conductivity; reduced thermostat setting; adding insulation to the distribution line. Application of all these changes to an electric water heater would reduce electricity use 17% and increase initial cost 27%. Additional changes were examined for gas water heaters; implementing all these changes (except addition of an electric ignitor) would reduce gas use 27% and increase initial cost 26%. [These results show that there are significant opportunities for reducing water heater energy use, with only small initial cost increases.]

Water heater energy use estimates are also included from 4 of the References (for both gas and electric units). The values agree reasonably well with those from this Report. The usage is found to depend (mainly) on fuel type, usage rate and water temperature.

TITLE: METEOROLOGICAL DIVERSITY-LOAD DIVERSITY: A FRESH LOOK at an OLD PROBLEM

SOURCE: Proceedings of the 1972 American Power Conference, pp 1017-1024

AUTHOR(S): J.D.McQuigg; et al
PREPARED BY AUTHOR(S) AND/OR: University of Missouri; Columbus, Missouri

DATE OF ISSUANCE: 1972
OTHER IDENTIFIERS: Volume 34

DATA USE RESTRICTIONS:

TOTAL:[PAGES 8 ;REFERENCES 8 ;GRAPHS 1 ;TABLES 3] *
DOCUMENT CLASSIFICATION(S): 57/19, 34

ABSTRACT: *[Contains information of (mainly) secondary relevance to the general subject matter of this Compilation.]

The Paper describes a method which can be used to produce estimates of electric power load diversity, from samples of daily mean ambient temperature observations within a region served by a large interconnected power system. This technique has several advantages, chief of which is the comparative ease of locating homogenous samples of temperature data.

By relating the climatic component of load diversity to meteorological diversity it is possible to develop reasonably precise load diversity estimates on the basis of the available long series of weather data. Such a simplification of the problem, both conceptually and in terms of data requirements, should begin to make planning in this area both operationally feasible and more reliable.

The methods suggested, for obtaining potential meteorological and electric load diversity, are easy to compute and have rather nominal data requirements. The feasibility of obtaining such diversity potential information (together with the information which it could be made to contain in regard to electric power distribution plans) appear to commend the method for practical application.

TITLE: FORECAST METHOD REMOVES WEATHER BIAS

SOURCE: Electrical World, 2/1/75, pp 48-49

AUTHOR(S): D.A.Fajkus
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: 2/75
OTHER IDENTIFIERS: System Engineering

DATA USE RESTRICTIONS: Copyright by McGraw-Hill, Inc.

TOTAL: [PAGES 2 ;REFERENCES 1 ;GRAPHS 2 ;TABLES 1]*
DOCUMENT CLASSIFICATION(S): 57/13, 25, 45

ABSTRACT: *[Contains material of (mainly) secondary relevance to the subject matter of this Compilation.]

Extremes of temperature and humidity often mask underlying electrical load trends. This Article briefly summarizes one recently developed forecasting scheme which correlates peak system demand with the weather and allows modeling the effect of different weather conditions. This scheme develops a quantitative relationship between demand and a composite function of weather.

A plot of peak system demand against effective temperature gives the equation that represents the weather/demand relationship:

Peak demand = (38.3 x effective temperature) -2162.5.

[Note: For the purposes of this study, effective temperature is defined as that temperature at 50% relative humidity which is equivalent in comfort to the actual temperature and humidity.]

Sample data are plotted and tabulated to illustrate the forecast technique.

TITLE: WEATHER LOAD MODEL for ELECTRIC DEMAND and ENERGY FORECASTING

SOURCE: IEEE Transactions on Power Apparatus and Systems, Vol. PAS-94, No. 4, pp 1111-1116
AUTHOR(S): C.E.Asbury
PREPARED BY AUTHOR(S) AND/OR:

DATE OF ISSUANCE: July/August 1975
OTHER IDENTIFIERS: Paper No. T 73453-8 and Discussion

DATA USE RESTRICTIONS: Copyright by IEEE

TOTAL:[PAGES 6 ;REFERENCES 5 ;GRAPHS 3 ;TABLES 2]*
DOCUMENT CLASSIFICATION(S): 57/1, 10, 21, 25

ABSTRACT: *[Contains material of general interest to the subject matter of this Compilation.]

This Paper is concerned with a method of forecasting the (environmental) heat-sensitive portion of electrical demand and energy, utilizing a summer weather load model and taking into account the probability variation of weather factors. The heat sensitive part of the load is separated from the base load and historical data is used to determine the effect of weather on the system load. This method is based on regression analysis of available load and weather information and the establishment of system load characteristics based on either historical or survey information.

The method has been primarily used for forecasting demands and energy for an intermediate range of from 3 to 10 years. However, it is applicable for monthly and annual peak forecasting but probably not applicable for short terms, such as an hour-to-hour or day-to-day forecast. It may also be helpful in long term forecasting along with appropriate forecasts of future quantities of heat sensitive load on the system. [Separate weather load models are used for independently determining the heat sensitive portion of electric energy and demand.]

This method gave a simple tool to give reasonably accurate results for the determination of the effects of weather for the summer seasonal and monthly demands and energy for the systems studied. It is based on having available reasonably accurate information on the system load characteristics, especially the growth trend of air conditioning. Although this test had to do with load areas where humidity is normally high during high temperatures (and where the effects of bodies of water or wind direction may not be a factor) it is quite likely that the model may need to have other weather factors included - which can be done - and may need to take into effect still other weather factors, where they may be found to affect the load.

APPENDIXES FOLLOW

(A) ACRONYMS AND ALLIED INFORMATION

(B) GLOSSARY

(C) AVAILABILITY AND PROCUREMENT NOTES

ACRONYMS AND ALLIED INFORMATION

Current addresses, phone numbers and related information (for the non-government groups in this list) are generally to be found in the Volume entitled "1977 National Trade and Professional Associations of the United States and Canada and Labor Unions"; published (and periodically revised) by Columbia Books, Inc.; 734 15th St., N.W., Room 601; Washington, D.C. 20005.

For Government Agencies, check your Telephone Directory.

AEC - (U.S.) Atomic Energy Commission; now ERDA (5)

AEIC - Association (of) Edison Illuminating Companies; see LRC

AGA - American Gas Association

AIA - American Institute (of) Architects

AIEE - American Institute of Electrical Engineers; now part of IEEE

ANSI - American National Standards Institute

* ASHRAE - American Society (of) Heating, Refrigerating (and) Air-Conditioning Engineers (1)

* ASME - American Society (of) Mechanical Engineers

ATMES - Advanced Technology-Mix Energy Systems; an ERDA concept (5)

AWCS - All-Weather Comfort System

BLS - (U.S.) Bureau (of) Labor Statistics

BTU - British Thermal Unit

CDD - Cooling Degree Days

COP - Coefficient of Performance (of heat pumps)

CPI - Consumer Price Index; see PI

* EAPA - Energy Abstracts (for) Policy Analysis (2)

EEA - Electric Energy Association; "absorbed" by EEI

* EEI - Edison Electric Institute

EER - Energy Efficiency Ratio

EFLH - Equivalent Full-Load Hours

** EI - Engineering Index (Inc.) (3)

E/P - Earnings/Price (ratio)

** EPRI - Electric Power Research Institute

** ERDA - (U.S.) Energy Research (and) Development Administration; see AEC (5)

EUI - Energy Utilization Index

** FEA - Federal Energy Administration (5)

* FPC - (U.S.) Federal Power Commission (5)

GATE - Group (to) Advance Total Energy; "absorbed" by AGA

* GPO - (U.S.) Government Printing Office

GSA - (U.S.) General Services Administration

HDD - Heating Degree Days

* HUD - (U.S. Department of) Housing (and) Urban Development

HVAC - Heating, Ventilating (and) Air-Conditioning

IECEC - Intersociety Energy Conversion Engineering Conference

* IEEE - Institute (of) Electrical (and) Electronics Engineers

IERI - Illuminating Engineering Research Institute

IES - Illuminating Engineering Society

IUS - Integrated Utility System

JSC - (U.S. Lyndon B.) Johnson Space Center (of NASA); see NASA and USPO

KVA - Kilovolt - Ampere (6)

KWD - Kilowatt Demand (6)

KWH - Kilowatt Hour (6)

** LRC - Load Research Committee (of AEIC)

MIUS - Modular Integrated Utility Systems; a HUD concept

MPS - Minimum Property Standards

MWH - Megawatt Hour (6)

NARUC - National Association (of) Regulatory Utility Commissioners

* NASA - (U.S.) National Aeronautics (and) Space Administration; see JSC and USPO

* NBS - National Bureau (of) Standards (U.S. Department of Commerce)

NEC - National Electrical Code; see NFPA

* NECA - National Electrical Contractors Association

* NEMA - National Electrical Manufacturers Association

NFPA - National Fire Protection Association; see NEC

* NSF/RANN - National Science Foundation/Research Applied (to) National Needs

** NTIS - National Technical Information Service (an agency of the U.S. Department of Commerce)

O & M - Operating and Maintenance (costs)

*ORNL - Oak Ridge National Laboratory (Operated by Union Carbide Corporation for AEC and its successor ERDA) (5)

PI - Price Index; see CPI

PLC - Permissive Load Control

PUD - Public Utility District

QUAD - (short for) Quadrillion; equal to 10^{15}

REA - (U.S.) Rural Electrification Administration

SIC - Standard Industrial Classification (Code)

SMSA - Standard Metropolitan Statistical Area

T.E. - Total Energy

TEM - Total Energy Management; an NECA/NEMA concept

TES - Thermal Energy Storage

* TVA - (U.S.) Tennessee Valley Authority

UL - Underwriters' Laboratories

URD - Underground Residential Distribution

USPO - (U.S.) Urban Systems Project Office; see NASA and JSC

* WGA - Weekly Government Abstracts; see NTIS (4)

Notes: (1) The most likely U.S.A. sources of near future information in the general subject areas of this Compilation (including data from work in progress) have been judgmentally indicated by ** (for "primary") and * (for "secondary").

(2) EAPA (available through GPO) is a monthly abstract journal for the analysis and evaluation of energy research, conservation and policy. EAPA provides abstracting/indexing of selected, publicly available, literature.

(3) EI (operated in conjunction with the United Engineering Center; New York, N.Y.) supplies a transdisciplinary abstracting/indexing coverage of the world's engineering developments.

(4) WGA (Energy), available through NTIS, contains technical report summaries (in the various energy-related fields) of most unclassified federally-funded research, as it is completed and made available to the public.

(5) ERDA, FEA and FPC have recently been made part of the (U.S.) Department of Energy (DOE).

(6) These abbreviations are not in a "standardized" form since in this Compilation they have been regarded as part of a list of Acronyms.

GLOSSARY

This annotated Compilation (of which this Glossary is a part) necessarily deals with interrelated disciplines. The selection of Glossary items is judgemental and deliberately excludes overly technical explanations and standard quantifying terms, such as kilowatt, lumen, etc. It should be noted that there are a limited number of Economic, Statistical and Instrumentation entries only because of the many textbooks which specialize in these three areas and not because the areas are unimportant to an understanding of the literature abstracted herein.

Much of the following material can be found in more than one "source document", with variations in specificity and format. Although a few of the glossaries cite the source of certain of their definitions, it would be difficult to determine if even such sources were strictly original; in a high percentage of cases there was no claim as to "originality". While trying to simplify terminology, this document does include material that can be considered somewhat specialized but nevertheless should be informative to persons interested in the electrical loads usage fields.

Even though specific sources have not been listed for individual entries, general credit should be given to the following organizations who have issued glossaries containing items pertinent to many facets of this document, namely: AEIC, EEI, IEEE, FPC and HUD.

Accuracy: A measure of how well a given measurement agrees with a defined standard value. NOTE: Refer also to Precision, which is sometimes confused with Accuracy.

Active Demand: See "Demand, Active".

All-electric Residence: One in which electricity is the preponderant source of energy for lighting, air-conditioning (i.e., heating/cooling/ventilation, etc.) and general power needs.

Ampacity: (Commonly used to mean) "current-carrying capacity".

Analysis, Multiple Regression: See "Multiple Regression Analysis".

Analysis, Regression: See "Regression Analysis".

Annual Average Use: See "Use, Average".

Annual KWH Use, Average per Customer: Annual KWH sales to a service class divided by the corresponding annual average number of customers in said class; see also "Electric Bill, Annual Average (per Customer.)" NOTE: Service Classes are usually defined by a Public Service Commission or equivalent agency.

Annual Load Factor (%): [Annual KWH usage] ÷ [Max KWH utility meter demand x 8760] x 100. NOTE: usage ≈ electric bill totals; 8760 hours per year of 365 days.

Apparent Power: See "Power, Apparent"

Appliance, Major: One having relatively large electric use and/or demand; usually these devices are not readily moved, so tend to be more or less permanently installed. NOTE: Examples of such major appliances include ranges, deep-freezers, refrigerators and air-conditioning units.

Appliance, Minor: One having relatively small electrical use and/or demand; these devices are generally portable.

Appliance Saturation: The total appliances of a designated type divided by the total number of customers in a specified region containing the customers. NOTE: Statistical data on major appliances in use (and their "Saturation") are used in "Trend Forecasting" of electrical loads.

Availability, Operating: % of time an apparatus is ready to perform its intended service, whether operated or not. Availability (which has reliability/maintainability aspects) may be experssed as (available hours) ÷ (total hours), in the period under consideration. NOTE: See "Maintainability" and "Reliability".

Availability Factor: % of time that a plant (or other defined entity) is available (or used) for supplying electricity; the time period to which the Factor applies has to be specified.

Availability Factor, Overall: The product of the Availability and Reliability Factors. NOTE: See "Availability Factor" and "Reliability Factor".

Average Annual Electric Bill per Customer: See "Electric Bill, Annual Average (per Customer)".

Average Demand: See "Demand".

Average Number of Customers: See "Customers, Average Number of".

Base-Load: The minimum system load during a specified time period; alternately used to refer to that part of the load profile, over the same specified time period, which determines the minimum continuous capacity of the system or subsystem. NOTE: Sometimes defined as that portion of the peak load which is not directly related to weather variations.

Base-Load Plant: One which is normally designed and operated to supply base loads, which may be regarded as essentially constant loads; see "Base-Load".

Billing Demand: The demand value used in determining any demand-related charges associated with a specified rate schedule or with a contractural agreement to supply electricity.

Bills, Typical Electric: Refers to entries in the yearly reports, compiled by the FPC, which cover typical (averaged) net monthly bills for Residential/Commercial/Industrial Services for various KWH levels of use in a large number of USA cities.

Burden: See "Load".

Capability: The maximum load which can be supplied by a power source, distribution system or connected electrical apparatus under specified conditions and without damage to the equipment; see also "Capacity". NOTE: Normally, capability is stated in KVA or KW.

Capability Margin: The difference between the available capability of a system to supply electricity and the peak load requirements of the system. NOTE: This margin is supposed to be enough to allow for scheduled maintenance, emergency outages of a relatively limited nature, the (internal) electrical needs to guarantee proper system operation and unpredicted loads.

Capability, Net: The maximum KWH (per hour, usually) supply capability of a power source or system, under optimal operating conditions.

Capacity: The maximum load or output for which a system, subsystem, component, etc. is rated, either by the manufacturer or by the user; see also "Capability". NOTE: Capacity, Capability and Name-plate Rating are loosely synonymous.

Capacity Factor: Ratio of amount of electricity generated (or used) to the maximum amount that could have been generated (or used) if the equipment had operated continuously at its "Capacity" rating; both "amounts" are for the same specified time period. NOTE: Capacity Factor, Plant Factor and Plant Load Factor basically describe the same concept.

Capacity, Peaking: Generating equipment normally reserved for use only during periods of peak daily/weekly/seasonal loads. NOTE: Some equipment is used for both peak loads and base loads, dependent on local circumstances.

Capital Expenditures: See "Expenditures, Capital"

Characteristic Dwelling: See "Dwelling, Characteristic"

Charge, Demand: See "Demand Charge"

Class of Service: Such classification is commonly based on parameters like customer description, type of equipment to be supplied with power and the end-use of the energy supplied. NOTE: Commonly encountered are the Residential, Rural, Commercial and Industrial Classes. [Numerous special classes have been defined to suit specialized needs.]

Code, SIC: See "Standard Industrial Classification Code"

Coefficient of Performance: For cooling systems, the ratio of the rate of net heat removed to the rate of energy input; for heating systems, the ratio of the rate of net heat delivered to the rate of energy input. NOTE: COP is used to describe the performance of heat-pumps; consistent units are required in determining this ratio. [See "Heat Pump".]

Coefficient of Utilization (for a lighting installation): Total lumens at the working plane divided by the total lumen output of all the lamps seen by the plane.

Coefficient of Variation: A statistical term equal to the Standard Deviation divided by the Mean Value.

Coincidence Factor: Ratio of the overall maximum demand (of a specified Class, Sub-system, etc.) to the sum of the individual maximum non-coincident demands of the component elements of the same Class, Sub-system, etc. NOTE: Coincidence and Diversity Factors are mutually reciprocal; the Coincidence Factor never exceeds 1.0.

Coincident: Generally associated with the summation of two or more electrical demands which exist over the same time interval, however specified.

Coincident Demand: See "Demand, Coincident"

Coldness Index: The mean value of January temperatures for the population area in question; see also "Hotness Index".

Commercial: A general term covering electrical services for commercial purposes. National organizations, such as the AEIC, have defined various Divisions and Major Groups within the general term.

Confidence Interval: The data region bounded by the Confidence Limits. NOTE: As an example, a 95% Confidence Interval is one which has a probability of 0.95 correctness.

Confidence Limits: The statistically determined pair of high/low values which specifies the observed values or data in terms of an X% confidence that Y% of all the values will be included within said limits; Confidence Limits may be regarded as: (equal valued) + and - tolerances applied to the mean value. NOTE: See any standard statistical text for the mathematical formulation of these limits.

Connected Load: See "Load, Connected"

Cooling Degree Day (CDD): $\frac{[\text{Max°F} + \text{Min°F}]}{2}$ -65°F. NOTE: See also "HDD" and "DD".

Correlation Coefficient: A statistical measure of how well two or more variables change together. The correlation can be + or -, depending on whether the variables vary in the same (+) or opposite (-) direction. NOTE: Perfect correlation would result in either a +1.0 or a -1.0 coefficient.

Cross (Price) Elasticity: The % change in demand for a good, e.g. quantity of electricity, divided by the % change in the price of a substitute or competing energy source. The higher the cross-elasticity, the more substitutable are the competing goods. NOTE: See "Own (Price) Elasticity".

Cross-Section Data: Data based on observations where the time span is so short that the data can be considered time independent.

Curtailment (of Load): See "Interruptible Load"

Customer, Average Annual Electric Bill: See "Electric Bill, Annual Average (per Customer)".

Customer, Average Annual KWH use: See "Annual KWH Use, Average per Customer".

Customers, Average Number of: Arithmetic Average of month-end customers, taken during 12 consecutive months. NOTE: Adjustments are made for special cases where customers are not billed on a monthly basis.

Customer Saturation: Total number of customers (in a defined Class and Service area being supplied with electricity) divided by the total number of actual plus potential customers in the same Class and Service area.

Customer, Ultimate: Customers that do not resell the electricity which they buy.

Daily Load Factor (%): [Average Daily Demand] x 100 ÷ [Peak Demand]. NOTE: Demands are to be in consistent units.

Degree-day (DD): A unit for measuring the amount by which the outdoor mean (assumed to be the arithmetic average of maximum and minimum) daily drybulb temperature falls below (in the case of heating) or rises above (in the case of cooling) an assumed base, generally taken as 65°F. NOTE: As an example, one degree-day is counted for each degree above or below 65°F for each calendar day on which such excess or deficiency of temperature occurs; see "CDD" and "HDD".

Demand: The average rate of supply or use of electrical energy by a system (or specified portion thereof) during a specific, continuous time interval, e.g. 15 min. NOTE: Demand is also referred to as Average Demand. Demands are usually expressed in KW, KVA or other analogous units, including totalized KWH divided by the time (in hours) during which totalizing was done.

Demand, Active: Demand in terms of Real Power. Typically expressed (primarily) in terms of the highest 15-minute integrated KW demand during the month in question.

Demand, Annual System Maximum: The largest system demand, averaged over a relatively short specified time interval, during a calendar year.

Demand, Average: See "Demand"

Demand, Billing: See "Billing Demand"

Demand Charge: A specified costing factor (e.g., for a utility service) based on rate of use (e.g., during a 15 minute interval) which is intended to reflect the utility's investment in the generating/transmission/distribution equipment needed to supply its peak loads.

Demand, Coincident: A demand occurring at the same time as other demands in the same (specified) service area. NOTE: Coincident Demand is also used to refer to the sum of a set of individual coincident demands.

Demand, Contract: The Demand placed upon the supplier by a mutual agreement with the user of electricity.

Demand Curve: Any graphical plot of demand vs time, for the time interval in question.

Demand Curve (alternate meaning): From an economist's viewpoint, it is often represented as a graphical plot of price vs use (or demand).

Demand, Derived: A demand resulting from secondary demands. As an example, in the case of electricity - which, by itself, is of little use - the ultimate consumer demands conveniences such as light and heat, which in turn is what creates a demand for electricity.

Demand, Diversified: The sum or aggregation of the demands of a specified group of electrical users; generally the maximum of such sums (also known as the maximum aggregated coincident demand) is of most interest. NOTE: Diversity comes about because the demands (average, maximum, etc.) of the individual users are not simultaneous.

Demand, Economic: See "Economic Demand"

Demand Equations: Exemplified by equations which relate the average electricity used by a household in a specified time interval to such (explanatory) variables as price of electricity, type of residence, etc.

Demand Factor: Ratio of the maximum coincident demand on an electrical supply system (e.g., power plant or distribution substation) to the total connected load; both quantities are for the same time period, however specified.

Demand, Instantaneous: The demand load at any "instant". NOTE: As a practical matter, instantaneous refers to a relatively short time approximating a few "time-constants" of whatever instrument is indicating and/or recording such demands.

Demand, Integrated: Demands which have been integrated over a specified time period; it is the average of the continuous readings of the instantaneous demands during said period. NOTE: Integration is generally expressed in terms of KW (as determined from an integrating demand meter or by planimetering a load vs time curve, etc.).

Demand Interval: The specified period associated with the measurement of Demand. NOTE: Commonly used time intervals are "instantaneous" and 15, 30 and 60 minutes.

Demand, Law of: See "Law of Demand"

Demand Limiter: See "Load Limiter"

Demand Management: See "Load Management"

Demand, Maximum: The largest of the demands (averaged over same specified time interval, e.g. 15 minutes) during a specified time period such as daily, weekly, monthly or annual. NOTE: Generally the nature of the load is also specified, either as to customer type and/or appliance.

Demand Meters: See various types of "Meter, Demand"

Demand, Non-coincident: The sum of the randomly-occurring, individual maximum demands as determined during a relatively-long time interval such as a day, week or month. NOTE: Generally the user category is also specified, e.g. a particular major appliance, customer class, etc.

Demand, Reactive: Demand in terms of Reactive Power. Typically expressed (primarily) in terms of the highest 15-minute integrated KVA of lagging reactive demand during the month in question.

Design Days: Days for which selected weather parameters, related to electrical usage, depart from average conditions by a specified amount. The degree of such departure is commonly expressed in (statistical) standard deviation units; see "Standard Deviation." NOTE: As an example, two "standard deviations" (sometimes referred to as "2-Sigma") would include about 86% of the total days being considered.

Design Load: A calculated load (as used in HVAC practice) assumed to be placed upon a building during the most critical hour of both the heating and cooling seasons.

Deviation: Normally used in statistical terminology to refer to the differences between individual values in a set and the arithmetic mean of the set.

Deviation, Standard (σ): A statistical measure of the spread of a distribution of values or data; equivalent to the square root of the variance, see "Variance". NOTE: The standard deviation is in the same units as the data; see any standard statistical text for the mathematical formulation of σ.

Dispersion: See "Variance"

Diversified Demand: See "Demand, Diversified"

Diversity: A general characteristic to describe the fact that individual maximum electrical demands usually occur at non-coincident times; see "Diversity, Load".

Diversity Factor: Ratio of the sum of the individual maximum non-coincident demands of the component elements (of a specified Class, Subsystem, etc.) to the overall maximum demand (of the same Class, Subsystem, etc.) NOTE: Diversity and Coincidence Factors are mutually reciprocal; the Diversity Factor is never less than 1.0.

Diversity, Load: The difference between the sum of the peak values (of two or more individual loads) and the coincident or combined maximum load peak. NOTE: Load Diversity is usually measured in KW for a specified time period.

Diversity, Seasonal: Load diversity which occurs when annual peak loads are in different seasons of the yearly cycle. NOTE: The terminology generally refers to diversity between two or more electric systems but can also be applied to smaller units of the same system.

Duration Curve: A curve or histogram of quantities, plotted in descending order of size against time intervals of a specified time period. NOTE: the ordinate values may be expressed in absolute or in % form.

Dwelling, Characteristic: An idealized dwelling unit such as might be used for energy consumption analysis; see also "Typical Dwelling". NOTE: These model dwellings are generally characterized in terms of selected sets of structural and energy-use parameters, whose selection perforce reflects varying degrees of personal judgment.

Dwelling, Typical: A dwelling unit that is considered representative of a class of such units and which is characterized by averaging selected structural and energy-use parameters monitored from actual dwellings; see also "Characteristic Dwelling". NOTE: Proper use of this term should imply that the averaging procedures used are statistically sound and are based on a proper sample size.

Econometrics: Application of statistical techniques to the testing and quantifying of economic data and the solution of related economic problems. NOTE: Econometric techniques are now widely used in electrical load forecasting; see also, "Statistical Model Forecasting".

Economic Demand: A term used to express the economic relationships between quantities consumed and the factors which determine such consumption. NOTE: This term should not be confused with electrical demand, even though certain economic factors may strongly influence electrical demands.

Elasticity: As an economic concept, elasticity is used to measure the relative change in the magnitude of a dependent variable resulting from a change in one (or more) of its determining factors. NOTE: More precisely, elasticity equals the change in the logarithm of the magnitude of one quantity divided by the corresponding change in the logarithm of the other quantity. See "Elasticity of Demand."

Elasticity, Cross (Price): See "Cross (Price) Elasticity".

Elasticity of Demand: The % change in average consumption ascribed to a % change in any explanative variable, with all other such variables "frozen". NOTE: An example would be changes in KWH usage as a function of electricity costs.

Elasticity Estimate (economic): Represents the % change in "demand" connected with a 1% change in an ascribed causal factor; e.g., a commercial price elasticity estimate of -2.0 means that a 1.0% increase in the average price of commercial electricity would (eventually) cause the demand for such electricity to be 2.0% less than it might otherwise have been.

Elasticity, Income: See "Income Elasticity"

Elasticity, Own (Price): See "Own (Price) Elasticity"

Elasticity, Price: See "Price Elasticity"

Electric (System) Losses: Energy lost in transmitting, transforming and distributing electricity; the dissipated electric energy mainly appears as non-salvageable heat. NOTE: These losses may range up to as much as 10% of the energy delivered to the ultimate consumers.

Electric Bill, Annual Average (per Customer): Annual revenue from a Service Class (excluding any lost discounts, penalty charges, etc.) divided by the annual average number of customers in said class. NOTE: Service Classes are usually defined by a Public Service Commission or equivalent agency.

Endogenous Factor(s): Contributory factor(s) which stem from functional or structural causes within a specified economic system. NOTE: An example would be the effect on residential KWH use of such factors as the amount used per customer, the number of customers and their disposable income, etc.

Energy Charge: Electricity costs, generally expressed in dollars ($) per KWH.

Energy Efficiency Ratio: Ratio of the thermal energy added (or removed) to the electric energy used in carrying out the addition (or removal) process. NOTE: The ratio is commonly expressed as BTU/watt-hour and has been generally accepted as a reasonable approximation of the efficiency of heating/cooling equipment.

Energy, Off-peak: Electricity supplied during periods that the utility has historically found to be ones of relatively low-system demands. NOTE: There is a developing tendency to adjust rate schedules so as to "favor" such demands, with the object of improving the system Load Factor.

Energy, On-peak: Electricity supplied during periods that the utility has historically found to be ones of relatively high system demands. NOTE: There is a developing tendency to adjust rate schedules so as to "penalize" such demands, with the object of improving the system Load Factor.

Energy, Primary: Energy from the ultimate source (e.g., power plant) required to supply energy at its point-of-use. NOTE: allowing for average power plant (thermal) efficiencies and transmission/distribution losses one consumes about 11,500 BTU of primary energy for each KWH delivered to the "customer"; at 100% efficiency, KWH≙3413 BTU.

Energy Storage Density: Ratio of energy storage capacity (e.g. in KWH) to the gross volume of the storage facility.

Energy, Total: See "Total Energy"

Energy Utilization (or Use) Index: Sum of BTU (or energy in equivalent forms) demands per square foot of wall-to-wall (interior) areas. NOTE: EUI is also used as a measure of energy consumption, BTU per (gross) air-conditioned square feet per year; see also "Heat Factor".

Energy, Waste: Generated energy in excess of immediate needs and which cannot be economically stored for future use. NOTE: See "Waste Heat".

Environmental Concerns: A general term for the effects of system installation/operation upon the maintenance of environmental quality, as related to such factors as land/water use and environmental contamination.

Error, Statistical: The recognized, measurable, "error" resulting from the basic nature of any statistical sampling process that has been properly designed to give acceptable results without checking 100% of the population in question.

Estimate, Point: Use of sample data to compute a single best estimate of a population parameter. NOTE: Such statistical estimates, in themselves, give no clue as to the error involved in this type of estimation.

Estimate, Standard Error of: The standard deviation of the data values (conventionally measured vertically) from a trend or regression line; often referred to as Standard Error. NOTE: See "Deviation" and "Regression Analysis".

Exogenous Factor(s): Contributory factor(s) which originate from certain influences (e.g., accidental or technological) that are exterior to a specified economic system. NOTE: An example would be the effect on the average price of electricity of such factors as fuel costs, wage rates, the nature of the residential/commercial/industrial customer mix, etc.

Expenditures, Capital: Includes the costs of constructing new (additional) plant facilities plus expenditures for acquiring the existing plant facilities. NOTE: Sometimes referred to as Capital Outlay.

Factor, Annual Load: See "Load Factor, Annual"

Factor, Availability: See "Availability Factor"

Factor, Capacity: See "Capacity Factor"

Factor, Coincidence: See "Coincidence Factor"

Factor, Demand: See "Demand Factor"

Factor, Diversity: See "Diversity Factor"

Factor, Endogenous: See "Endogenous Factor"

Factor, Exogenous: See "Exogenous Factor"

Factor, Heat: See "Heat Factor"

Factor, Load: See "Load Factor"

Factor, Operation: See "Operation Factor"

Factor, Overall Availability: See "Availability Factor, Overall"

Factor, Power: See "Power Factor"

Factor, Reliability: See "Reliability Factor"

Factor, Utilization: See "Utilization Factor"

Forecasting, Statistical Model: Such forecasts are based on summing the estimated influences, e.g. on future electrical demand, of the major significant causal factors for which significant data is available. NOTE: See "Trend Forecasting".

Forecasting, Trend: Such forecasts are based on the extrapolation of historical trend lines into the future. The extrapolation procedure may be modified by explicity defined assumptions. NOTE: See "Statistical Model Forecasting".

Frequency Distribution: A diagrammatical method of summarizing data, constructed by dividing the range of observed values into equal intervals and then indicating the number (or frequency) of the observations in each interval. NOTE: An example would be a (bar-type) plot of the number of electrical customers (in a specified sample size) associated with a range of defined KWH levels which categorize the demand levels of such customers.

Fuel Utilization Efficiency: See "Heat Rate"

Heat Balance: Generally refers to calculations which account for all except quite minor thermal energy "inputs" and "outputs" into any defined system, including recovered heat. NOTE: in MIUS-type technologies, the Heat Balance refers specifically to the amount of heat for air-conditioning and other MIUS processes relative to the amount available as a recovered by-product from the various energy conversion processes; see "Overall Thermal Efficiency".

Heat Factor: A "least common denominator" scheme sometimes used for quantitatively comparing the electrical demands of variable size structures of a specified type. NOTE: This approximating factor has been expressed in terms of KWH per Degree Day per 1000 cubic feet

of (interior) building volume or BTU per Degree Day per square foot; compare to Energy Utilization Index.

Heat Pump: This terminology is loosely applied to refrigeration systems which increase, rather than decrease, the amount of heat in a given space; however, the prime advantage of heat pumps is that the same equipment can be used for both heating and cooling. NOTE: Standard reference texts (such as the ASHRAE "Guide and Data" volumes) should be consulted for detailed descriptions of these systems. [See "COP".]

Heat Rate: A quantitative measure of a generating plant's thermal efficiency, generally computed by dividing the total BTU content of the fuel (or equivalent heat released from a nuclear reactor) by the resulting KWH generated. NOTE: Heat Rate is commonly expressed in BTU per KWH.

Heat Waste: Heat rejected to relatively low-temperating "sinks" or heat lost due to the failure to salvage the energy potential of solid and liquid wastes. NOTE: See T.E. and MIUS.

Heat-rate, System: See "System Heat-rate"

Heating Degree Day (HDD): $65°F - \frac{[\max°F + \min°F]}{2}$ NOTE: See also "CDD" and "DD".

Histogram, Frequency: See "Frequency Distribution"

Homogeneous Populations: See "Populations, Homogeneous"

Hotness Index: The mean value of July temperatures for the population area in question; see also "Coldness Index".

Income Elasticity (of Demand): % of change in income divided by % change in quantity demanded.

Income, Real: Income that has been adjusted to reflect variations in specified price level(s).

Individual Metering: See "Metering, Individual"

Instantaneous Peak: The maximum demand at the "instant" of greatest load. NOTE: These peaks are usually determined from the readings of indicating or panel-type meters, therefore "instantaneous" actually refers to a short time interval related to the time-constant of the meter; see also "Maximum Demand".

Integrated Demand: See "Demand, Integrated"

Integrated Energy Curve: A plot of demand vs energy showing the amount of energy represented by the area under a load curve (or under a load-duration curve) above any of a series of specified demand values. NOTE: Such curves are also called peak % curves.

Interruptible Load: See "Load, Interruptible"

Interval, Demand: See "Demand Interval"

Interval Estimate: A statistical measure of the error involved in making an estimate; the wider the range of the estimate, the less reliable is the estimated correct value. NOTE: This estimate defines the range of values which can be expected to include the correct value a certain % of the time.

Law of Demand: A statement that an inverse relationship holds for price vs quantity demanded, assuming other things are equal. [The significant relevant factors maintained constant may include the number of buyers and their tastes, expectations and incomes plus the prices of related goods and the time during which constancy was assumed.]

Least Squares: A statistical method for determining the line which best

fits the general trend of the family of data observations. NOTE: An extension of this method, called multiple least squares, can be used for higher-order "fits".

Load: A measure of the electric power delivered to or received by a specified location of an electrical system or unit thereof; see "Demand".

Load, Base: See "Base-Load"

Load Characteristics: Refers to a collection of the significant parameters used to characterize an electrical service; such a collection can include:quantity supplied, demands, time of occurrence of these demands, load factor, diversity factor, coincidence factor, etc.

Load Check Sheet: any logical format for listing electrical loads and summarizing their characteristics, e.g. for estimating electrical demands.

Load, Connected: The sum of the ratings of the (electric) energy-using equipment capable of drawing power-as needed-from a specified system, sub-system, transformer, etc. NOTE: "Ratings" normal refer to Name-Plate Rating or Capacity.

Load Control, Permissive: PLC equipment is used to temporarily disconnect (some) deferrable loads whenever nondeferrable loads reach a predetermined power level. NOTE: Deferrable loads generally include domestic hot-water heating, corridor and stairwell heating/cooling, etc. Nondeferrable loads generally include lights, elevators, general heating/cooling, etc.

Load Curve: See "Load Profile"

Load, Design: See "Design Load"

Load Diversity: See "Diversity, Load"

Load Duration Curve: A plot of loads under specified conditions, arranged in order of load magnitude, vs the time intervals during which such loads equaled or exceeded the indicated magnitudes.

Load-duration Curve: A plot of variations in system demand, usually expressed as a % of maximum demand vs the number of hours that specified % values are equaled or exceeded. NOTE: The data is usually on an annual basis. Currently, the top 5% of the demand values occur during about 2.5% of the time.

Load Factor: Ratio of average load (or "demand") to the maximum (or "peak") load.Both quantities are for the same time period, however specified; may be multiplied by 100 and given in %. NOTE: This factor is often said to be the single most important factor characterizing the use pattern of a specified electrical consumer. [The electrical industry's current (average) system load factor is not much more than 0.60.]

Load Factor, Annual: See "Annual Load Factor (%)"

Load Factor, Daily: See "Daily Load Factor (%)"

Load, Interruptible: Loads which can be curtailed, either at the supplier's discretion or in accordance with a written agreement between supplier and user. NOTE: Curtailment is mainly in connection with Peak Load periods.

Load Limiter: A device programmed to operate loads (e.g., within a building) in such a manner or sequence that the Billing Demand tends to remain close to an optimized value.

Load Management: A phrase which embraces the use of one or more significant options available to the electric utilities (and/or their regulatory counterparts) for conserving electrical energy and improving the efficiency of its generation and distribution. NOTE: Such options could include logical rate-schedule adjustments, load-shaping schemes, equipment changes and end-use curtailment.

Load, Maximum Hourly: Reference is to the maximum hourly integrated load for a specified system or major portion thereof. NOTE: Usually stated in KWH per hour.

Load, Peak: The maximum (or average maximum) load produced or used within a stated time period by a specified electrical system or unit thereof. NOTE: The duration of the time period should be specified along with the time interval associated with the averaging process, if such is used.

Load Profile: Load (demand) of a system, sub-system, etc. plotted as ordinates vs time of day, month, etc. as abcissae; such profiles may also be expressed as a % of the maximum demand occurring during the specified period covered by the profile. NOTE: Integrated Demand (over specified, relatively-short intervals) is normally the demand used in such plots.

Load Profile (derived): A synthesized profile built-up from a detailed analysis of estimates of the peak loads, diversified demands and operating characteristics of the various loads under (planned) consideration.

Load Survey: Generally taken to mean the logical steps used in conducting and evaluating electrical load tests. Such steps would include: the selection of the loads to be studied and their proper sample size, collecting and analyzing the data from properly instrumented tests and presenting the summarized data and their conclusions in a useful format.

Load Survey Recorder: See "Recorder, Load Survey"

Losses, Electric (System): See "Electric (System) Losses"

Maintainability: A system design characteristic that allows the system to be held in (or restored to) a state of readiness responsive to demand; it contains the scheduled downtime element of Availability.

Master Metering: See "Metering, Master"

Maximum Demand: See "Demand, Maximum"

Mean Value: Sum of all observed values or data points divided by the total number of observations.

Meter, Cumulative Demand: An indicating demand meter which provides for displaying the accumulated totals of maximum demands during the period after the meter has been reset and before it is reset again.

Meter, Demand (Time Characteristic): The nominal time to reach 90% of the final indication, under a suddenly applied constant input.

Meter, Indicating Demand: A meter equipped with a suitable scale over which a friction-type pointer is advanced to indicate maximum demand. NOTE: Generally the demands are either integrated or lagged.

Meter, Integrated-demand: A meter which indicates and/or records the demand obtained by integrating over specified demand interval periods. In operation, the period during which demands are measured at specific intervals is blocked into discrete segments having a duration equal to the prescribed demand interval.

Meter, Lagged-demand: A meter whose response is shaped by a controlled time-lag, generally determined by mechanical or thermal means. Such meters are analogous to conventional indicating wattmeters except for their highly accentuated damping which is used to produce the desired time-lag.

Meter, Recording Demand: A meter which produces a permanent record of the demands measured during the period of the record. NOTE: The recording media include paper strip-chart, punched paper-tape and magnetic tape.

Metering, Individual: Measurement of utility use (e.g., electricity) on a per unit of occupancy basis. NOTE: See "Master Metering".

Metering, Master: Measurement of utility use (e.g., electricity) on a project, building, etc. basis; meter readings are (generally) proportionally distributed to the individual units. NOTE: See "Individual Metering".

MIUS: A utility system concept consisting of electric-power generation plus water processing, solid- and liquid- waste management and environmental conditioning subsystems. The MIUS includes the distribution networks for these services and the controlling and monitoring subsystems.

Multiple Regression Analysis: A statistical-based analysis procedure whose objective is the determination of a single equation to numerically describe the complex relationships assumed by the analyst to hold for the variables of the situation in question.

Name-Plate Rating: See "Capacity"

Needle Peak: See "Peak, Needle"

Non-coincident Demand: See "Demand, Non-coincident"

Occupancy Profile: A tabulation or plot of the total of persons within a defined space vs time, for a 24 hour day. NOTE: Values are normally plotted on an hourly basis and are variously expressed as an actual number or as a % of maximum occupancy or as "people" per specified floor area.

Off-Peak Energy: See "Energy, Off-Peak"

OGIVE: A plot or curve representing a cumulative frequency distribution. NOTE: See also "Histogram, Frequency".

On-Peak Energy: See "Energy, On-Peak"

Operating Availability: See "Availability, Operating"

Operation Factor: The ratio of the total time of actual operation to the total period of time under consideration.

Overall Thermal Efficiency: See "Thermal Efficiency, Overall"

Own (Price) Elasticity: The % change in demand for a good, e.g. electricity, divided by the % change in its own price. NOTE: See "Cross (Price) Elasticity".

Parameters: Statistically derived numerical factors relating to an entire population class; see "Statistics" and "Population".

Peak, Instantaneous: See "Instantaneous Peak"

Peak, Needle: A demand maximum of (relatively) short duration; such "peaks" are generally characterized as "undesirable".

Peak Load: See "Load, Peak"

Peak Shaving: See "Interruptible Load"

Peak, Summer: The greatest load on an electrical system or sub-system

during any specified continuous time interval in the summer (i.e., the nominal cooling) season.

Peak, System: See "System Peak"

Peak-Load Plant: See "Peaking Equipment"

Peak-Load Pricing: See "Pricing, Peak-Load"

Peak, Winter: The greatest load on an electrical system or sub-system during any specified continuous time interval in the winter (i.e., the nominal heating) season.

Peaking Capacity: See "Capacity, Peaking"

Peaking Equipment: Generating equipment available for use during maximum load periods to assist in meeting that portion of the Peak Load which is in excess of Base-Load.

Performance, Coefficient of: See "Coefficient of Performance"

Plant, Base-Load: See "Base-Load Plant"

Plant Factor: See "Capacity Factor"

Plant Load Factor: See "Capacity Factor"

Population: A term used to characterize a relatively large group (e.g., of persons or appliances) whose statistical properties are under investigation. NOTE: Since there is no standardized definition, an accurate definition of "population" is a necessary part of each statistical study.

Population, Homogeneous: A term applied to groups in which there is a fairly even spread of values over the entire range of the characteristic(s) under examination. NOTE: Residential electrical users could be considered quite homogeneous in their patterns of electric use compared (relatively) to the heterogeneous pattern of industrial users.

Power, Apparent: The sum of real and reactive power; Apparent Power is proportional to the KVA of the system.

Power Factor: The ratio of Real Power to Apparent Power, for any specified load and time. NOTE: Normally expressed as a % ratio of KW to KVA.

Power, Reactive: That portion of Apparent Power which does no work. Such power must nevertheless be supplied to all loads, other than those that are purely resistive. Commercially, Reactive Power is measured in Kilovars.

Power, Real: The energy or work-capable portion of Apparent Power. It is a measure of the rate of supply or use of electrical energy, usually measured in KW.

Power, Standby: Generally refers to any emergency power source, which automatically or manually replaces the regular power source in whole or in part. NOTE: Such power may be mandatory, e.g. in hospitals, or desirable, e.g. in parts of schools, office buildings, etc.

Precision: A measure of how well a measurement can be repeated, often expressed in terms of Standard Deviation. NOTE: Refer also to "Accuracy", which is sometimes confused with precision, and to "Standard Deviation".

Price Deflator: A defined price index which is used to reduce the (inflated) level of prices, of the same commodity or service, to those of an arbitrarily chosen base period.

Price Elasticity: [Change in the logarithm of a quantity] ÷ [Change in

logarithm of its price]. NOTE: an example would be the price elasticity of demand for electricity.

Price Elasticity (of Demand): A measure of the change in demand resulting from price changes; usually measured over relatively long time intervals because of the practical inability of the user to rapidly modify his demand patterns. [See also "Price Elasticity".] NOTE: Demand is said to be price inelastic if the price elasticity measure is less than unity.

Price, Real: Price of a good (e.g., electricity) in relation to the general price level. NOTE: increases in real prices may be considered as being those which exceed the overall inflation rate during the period in question. [See also "Real Income".]

Pricing, Peak-Load: As applied to electric utilities, this terminology generally refers to special rate schedules - normally as a function of season and/or time of day - which are pragmatically related to the utility's cost for providing electrical service during such peak periods.

Primary Energy: See "Energy, Primary"

Profile, Occupancy: See "Occupancy Profile"

Random Sample: A group selected from a given population in such fashion that each sample unit has an equal and independent chance of being included in the specified group. NOTE: Tables of Random Numbers are commonly used in making the selection.

Ratio, Energy Efficiency: See "Energy Efficiency Ratio"

Reactive Demand: See "Demand, Reactive"

Reactive Power: See "Power, Reactive"

Real Income: See "Income, Real"

Real Power: See "Power, Real"

Real Price: See "Price, Real"

Recorder, Load Survey: A system for recording integrated KW of demand, generally in a form suitable for translating the data for subsequent analysis by data processing equipment.

Reliability: A system (design) characteristic which is actually the probability that a system would perform as intended when called upon to do so.

Reliability Factor: % of time that a plant (or other defined entity) is unavailable for supplying electricity, excluding any scheduled maintenance; the time period to which it applies must be specified.

Regression Analysis: A statistical procedure - commonly making use of Least Squares or Multiple Least Squares - which is used to derive a relationship between a dependent variable and one or more independent variables. NOTE: An example of such analysis would be the derivation of an equation relating the demand for electricity to such factors as the price of energy, family income and HDD (or CDD).

Residence, All-electric: See "All-electric Residence"

Residential: A general term covering electrical services for residential purposes; single family and individual apartments in multi-apartment dwellings are Residential sub-classes.

Residual: The difference between the true value of a quantity, e.g. electrical demand, and its predicted value.

Revenue, Annual Average (per KWH sold): Annual income from the sale of electricity, excluding lost discounts and penalties, divided by the

related total of KWH sold during the specified annual period.

Sample, Random: See "Random Sample"

Sample, Test: See "Test Sample"

Sampling: A statistical procedure involving the selection of a relatively small number from a relatively large population in such manner that the conclusions reached from the small number can be logically generalized to the entire population. See "Population".

Sampling, Cluster: The statistical procedure for selecting groups randomly from a population, as contrasted with the similar selection of individual units. NOTE: The procedure is also referred to as Cluster Random Sampling.

Sampling, Stratified Random: A statistical procedure in which the overall population is first divided into subgroups related to selected facets of the study and in which these subgroups are, in turn, subjected to Random Sampling.

Saturation, Appliance: See "Appliance Saturation"

Saturation, Customer: See "Customer Saturation"

Scatterplot: Data plotted as individual points because the relationship between the variables is obscure and trend lines would be essentially meaningless.

Seasonal Diversity: See "Diversity, Seasonal"

Service, Class of: See "Class of Service"

Standard Deviation: See "Deviation, Standard"

Standard Error of Estimate: See "Estimate, Standard Error of"

Standard Industrial Classification Code: The SIC Code is a numerical system, devised by the U.S. Bureau of the Census, to designate various business activities according to product or service. The classification scheme makes it possible to categorize all establishments with a 2, 3 or 4 digit number according to the degree of descriptive detail needed.

Standby Power: See "Power, Standby"

Statistical Error: See "Error, Statistical"

Statistical Model Forecasting: See "Forecasting, Statistical Model"

Statistics: Generally used in referring to numbers calculated from sample results, e.g. load research results. NOTE: Statistics are commonly used to estimate parameters; see "Parameters".

Summer Peak: See "Peak, Summer"

System Heat-rate: Commonly expressed as the average BTU (of the fuel) required to generate a KWH. NOTE: Modified definitions are often used (e.g., for T.E. plants) to account for recovered "waste heat" as a supplemental credit to the electricity generated.

System Peak: The maximum electrical demand, essentially "instantaneous", placed upon a system or specified subsystem during the year in question. NOTE: Moderate and cold climate areas generally are winter-peaked; warm and hot climate areas generally are summer-peaked, primarily because of the widespread use of cooling equipment.

Test Sample: A collective group (e.g., customers) that has been chosen for such purposes as investigation of their electrical demands; the method of selecting the group should involve statistically valid procedures.

THERM: Equal to 100,000 BTU

Thermal Efficiency, Overall: A term used in T.E., IUS and MIUS situations where some of the normally wasted heat energy from power plants

is recycled for useful purposes. NOTE: OTE can be calculated as: (electrical output, or its heat equivalent) + (heat recovered, that would normally have been wasted) ÷ fuel-heat input.

Thermal Integrity Factor, Overall: See "Heat Factor"

Thermal Loads, Basic: Generally refers to the following categories: heat gains/losses into a building; gain from process heat sources; gain/loss by thermal induction through various parts of building shell; gain/loss through ventilation and infiltration air; gain due to direct use of electricity; sensible and latent heat gain from occupants ; gain from solar radiation; gain/loss due to maintaining humidity levels; gain from use of domestic hot water.

Time-Series Data: Data based on time-related observations where the time span is quite long, say years.

Ton (of Refrigeration): Equal to 12,000 BTU per hour. (Cooling or heating capacity).

Total Energy: On-site generation of electrical energy plus provisions for reclaiming significant portions of the (relatively low temperature) heat that would otherwise be wasted. NOTE: References should be consulted for details of the numerous variations in applying T.E. concepts.

Total Energy (alternate meaning): Energy required for lighting, heating, cooling and motor loads.

Trend Forecasting: See "Forecasting, Trend"

Typical Dwelling: See "Dwelling, Typical"

Ultimate Customer: See "Customer, Ultimate"

Use, Average: Generally refers to the (annual) KWH used divided by the (annual) average number of users in a defined Class of customers. NOTE: Commonly expressed in KWH.

Utility Rate Structure: Approved schedules of charges that a utility uses in billing, for "services rendered", its various defined Classes of customers.

Utilization Factor: The ratio of the maximum demand of a system (or defined sub-system) to its installed (i.e., rated) capacity.

Variance: A statistical measure of the dispersion (i.e., spread) of a distribution of observed values or data; see any standard statistical text for the mathematical formulation. NOTE: Variance is equal to the "Standard Deviation", squared.

Variation, Coefficient of: See "Coefficient of Variation"

Waste Energy: See "Energy, Waste"

Waste Heat: See "Heat, Waste"

Winter Peak: See "Peak, Winter"

AVAILABILITY AND PROCUREMENT NOTES

For the reader's convenience, information is summarized below as to the procedure for obtaining complete copies of references that are apparently part of the "open literature". [Note: the reader should also check the DATA USE RESTRICTIONS on the Abstract forms.]

Some reports should be available from GPO or NTIS, as indicated after OTHER IDENTIFIERS on the Abstract forms; the number following the acronym is to be used when inquiring about or ordering the report. [Note: NTIS can be called (or written) and requested to check as to the NTIS availability of a report for which one does not have an NTIS identification number.] GPO reports are available only while still "in-print"; once they are "out-of-print" they are generally obtainable thru NTIS. Inquiries as to availability, format, prices, deposit and coupon accounts, etc. should be sent to:

Superintendent of Documents
U.S.Government Printing Office
Washington, D. C. 20402 (USA)

or to:

National Technical Information Service
U.S.Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22161 (USA)

Other reports, articles, etc. may be requested-but may have to be purchased-from the publisher, subject to availability. Those which are unavailable from the original source can often be purchased at a nominal price through library lending/duplication services or from the Library of Congress Photoduplication Service; information about this latter source may be obtained from:

Photoduplication Service
Library of Congress
Washington, D. C. 20540 (USA)