BNL 50696 123/12-9-77

MASTER

dr. 1653

ENERGY MODELING AND DATA SUPPORT FOR THE ELECTRIC POWER RESEARCH INSTITUTE

ANNUAL REPORT
JULY 1977

ENERGY TECHNOLOGY ASSESSMENT GROUP
NATIONAL CENTER FOR ANALYSIS OF ENERGY SYSTEMS
BROOKHAVEN NATIONAL LABORATORY
ASSOCIATED UNIVERSITIES, INC.
UPTON, NEW YORK 11973

Prepared for the
ELECTRIC POWER RESEARCH INSTITUTE
UNDER EPRI PROJECT RP442-1

DISCLAIMER

BNL 50696
(Energy Conversion-Systems Modeling
and Performance Assessment - TID-4500)

ENERGY MODELING AND DATA SUPPORT FOR THE ELECTRIC POWER RESEARCH INSTITUTE

ANNUAL REPORT
JULY 1977

Contributors

H. Abilock	A. Hermelee
M. Beller	L.L. Juang
E.A. Cherniavsky	W. Marcuse

Prepared for the
ELECTRIC POWER RESEARCH INSTITUTE
UNDER EPRI PROJECT RP442-1
By the
ENERGY TECHNOLOGY ASSESSMENT GROUP
NATIONAL CENTER FOR ANALYSIS OF ENERGY SYSTEMS

BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK 11973

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

NOTICE

Printed in the United States of America
Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161
Price: Printed Copy $5.00; Microfiche $3.00
25

September 1977 240 copies

Abstract

Progress for the period from July 1, 1976 to June 30, 1977 is reviewed in this second annual report in support of the Energy Modeling and Data Support program for EPRI. Reference Energy Systems were formulated for the base year 1972 and projections developed for the years 1980, 1985, and 2000 for the area serviced by the New York Power Pool. In addition, Brookhaven, EPRI and the Tennessee Valley Authority have entered into a cooperative effort to develop demand projections for the area serviced by TVA. The RES and associated data will provide a baseline against which TVA can evaluate the effect of substituting alternate technologies and policies for one another. Development of the Dynamic Energy Systems Optimization Model is continuing, with effort this year directed toward better representation of the electrical sector within the model. The model has been reformulated such that the year is divided into three seasons and two daily divisions, thus allowing the model to choose whether a summer or winter peak will occur and better depict the yearly time dependence of demands.

THIS PAGE

WAS INTENTIONALLY

LEFT BLANK

TABLE OF CONTENTS

	Page No.
Abstract	iii
List of Tables	vi
List of Figures	ix
Introduction	1
Task 1 - Reference Energy Systems	3
Task 2 - Dynamic Model Development	29
Task 3 - Support Activities	37
References	38
Appendix A	A-1
Appendix B	B-1

LIST OF TABLES

Table No.	Title	Page No.
I	Percent Distribution of Housing	11
II	New York State Population and Households, 1972-2000	12
III	Residential Appliances-- Energy Use and Market Penetration	13
IV	New York State Commercial Inventory	15
V	Industrial Energy Consumption vs. GNP in the United States	20
VI	New York State Modal Transportation Projections	23
VII	Energy Intensiveness by Transport Mode for New York State	23
VIII	NYPP Electric Generation - By Central Station Power Plants	27
IX	Demand Type Characteristics	30
X	Final Demand Classification	31
XI	Regional Variation in Space Conditioning Demands	32
XIIa	Heating Degree Days	34
XIIb	Cooling Degree Days	35
XIII	Peak Fractions for Demand Types	36
A-1	Summary of Energy Demand and Fuel Mix, 1972 Region: New York State	A-2
A-2	Summary of Energy Demand and Fuel Mix, 1980 Region: New York State	A-3

LIST OF TABLES

Table No.	Title	Page No.
A-3	Summary of Energy Demand and Fuel Mix, 1985 Region: New York State	A-4
A-4	Summary of Energy Demand and Fuel Mix, 2000 Region: New York State	A-5
B-1	Residential Space Heat - Projected Regional Fuel Mix	B-2
B-2	Residential Water Heat - Projected Regional Fuel Mix	B-3
B-3	Residential Air Conditioning - Projected Regional Fuel Mix	B-4
B-4	Residential Cooking - Projected Regional Fuel Mix	B-5
B-5	Residential Appliances and Lighting - Projected Regional Fuel Mix	B-6
B-6	Commercial Space Heat - Projected Regional Fuel Mix	B-7
B-7	Commercial Water Heat - Projected Regional Fuel Mix	B-8
B-8	Commercial Cooking - Projected Regional Fuel Mix	B-9
B-9	Commercial Air Conditioning - Projected Regional Fuel Mix	B-10
B-10	Commercial Lighting and Appliances - Projected Regional Fuel Mix	B-11
B-11	Aluminum - Projected Regional Fuel Mix	B-12
B-12	Iron - Projected Regional Fuel Mix	B-13

LIST OF TABLES

Table No.	Title	Page No.
B-13	Steel - Projected Regional Fuel Mix	B-14
B-14	Industrial Process Heat - Projected Regional Fuel Mix	B-15
B-15	Industrial Electric Drive - Projected Regional Fuel Mix	B-16
B-16	Petrochemicals - Projected Regional Fuel Mix	B-17
B-17	Automobile - Projected Regional Fuel Mix	B-18
B-18	Truck and Bus - Projected Regional Fuel Mix	B-19
B-19	Railroads and Mass Transit - Projected Regional Fuel Mix	B-20
B-20	Air Transport - Projected Regional Fuel Mix	B-21
B-21	Ship Transport - Projected Regional Fuel Mix	B-22
B-22	Electric Utilities - Projected Regional Fuel Mix	B-23

LIST OF FIGURES

Figure No.	Title	Page No.
I	New York State Reference Energy System, Year 1972	4
II	New York State Reference Energy System, Year 1980	5
III	New York State Reference Energy System, Year 1985	6
IV	New York State Reference Energy System, Year 2000	7
V	Industrial Energy Consumption Relative to GNP, 1960-2000	18
VI	New York State Electricity Generation By Fuel	26

INTRODUCTION

This report outlines progress for the period from July 1, 1976 to June 30, 1977, and covers the second year of effort in the program. The major purpose of the program is to extend the use of energy models employed in various studies at the National Center for Analysis of Energy Systems at Brookhaven National Laboratory to programs of interest to the Electric Power Research Institute (EPRI).

Within this context, the Reference Energy System concept, usually employed on a national basis for the assessment of energy technologies, has been applied on a regional basis. In the initial phase of the program, Reference Energy Systems were developed for the nine census regions of the United States for the years 1972, 1980, 1985, and 2000. A topical report entitled Regional Reference Energy Systems, describing the methodology and results of this study, has been written and sent to EPRI for publication.

As a follow-up to the above regional analysis, Reference Energy Systems were developed for the years 1972, 1980, 1985, and 2000 for an electric utility region selected as mutually acceptable to EPRI and Brookhaven. The region serviced by the New York Power Pool was selected as an acceptable region to analyze, and results of the analysis are presented here.

In addition to the development of Reference Energy Systems for the area serviced by the New York Power Pool, EPRI, Brookhaven, and the Tennessee Valley Authority (TVA) have entered into a cooperative effort to model the area serviced by the TVA. The Tennessee Valley Authority is supplying the data necessary for Brookhaven to develop Reference Energy Systems for the years 1972, 1980, 1985, and 2000. Since funding for this study will not continue past June 30, 1977, Brookhaven has decided to continue the work on its own, and report the results to EPRI on an informal basis.

In the development of the Dynamic Energy Systems Optimization Model (DESOM) effort this year has been directed toward better representation of the electrical sector within the model. Matrix and report generator software and performance of sample assessments have been completed and will be discussed in a forthcoming topical report.

TASK 1 - REFERENCE ENERGY SYSTEMS

Reference Energy Systems have been developed for the area serviced by the New York Power Pool (NYPP) for the years 1972, 1980, 1985, and 2000 as shown in Figures I-IV. The area serviced by the NYPP coincides exactly with the political boundaries of New York State, thus facilitating the data-gathering effort required for the development of the New York State Reference Energy System. The Reference Energy System (RES) is a network representation of the technical activities required to supply various forms of energy to end-use activities. Technologies are defined for all operations involving specific fuels including resource extraction, refinement, conversion, transportation, distribution and utilization. Each of these activities is represented by a link in the network for which an efficiency is specified. The network is quantified for a given year with the level of energy demands and the energy flows through the supply activities that are required to serve these demands.

The Reference Energy System, usually employed on a national level, had been extended to a regional level in the initial phase of the program. The purpose of further disaggregating the RES to selected electric utility regions adds a new dimension to the information that can be obtained from this type of analysis. On a regional level, the RES can be used to assess the impact of introducing alternate technologies into a region. For example, the introduction of heat pumps to replace electric resistance, gas, or oil space heating can easily be analyzed within the Reference Energy System framework to evaluate the overall impact on fuel requirements. The sensitivity of electric utility capacity forecasts to shifts in technology can be assessed in a similar fashion.

The Reference Energy System is demand driven, that is, sectoral demands for energy are initially derived for each end-use category, such that:

Intermediate Energy Demand =
Unit Energy Demand x Basis x Market Penetration;

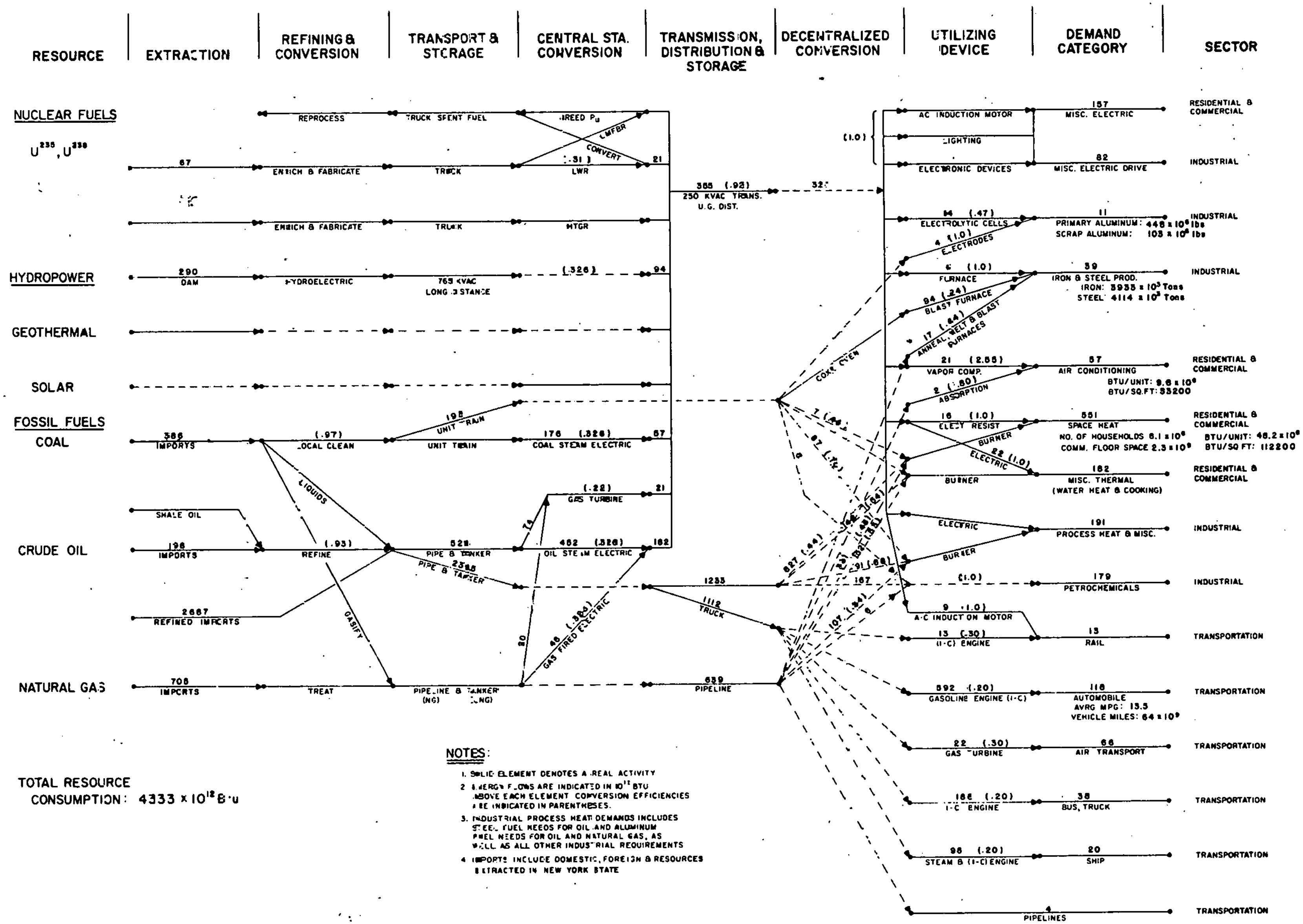

Figure I. New York State Reference Energy System, Year 1972

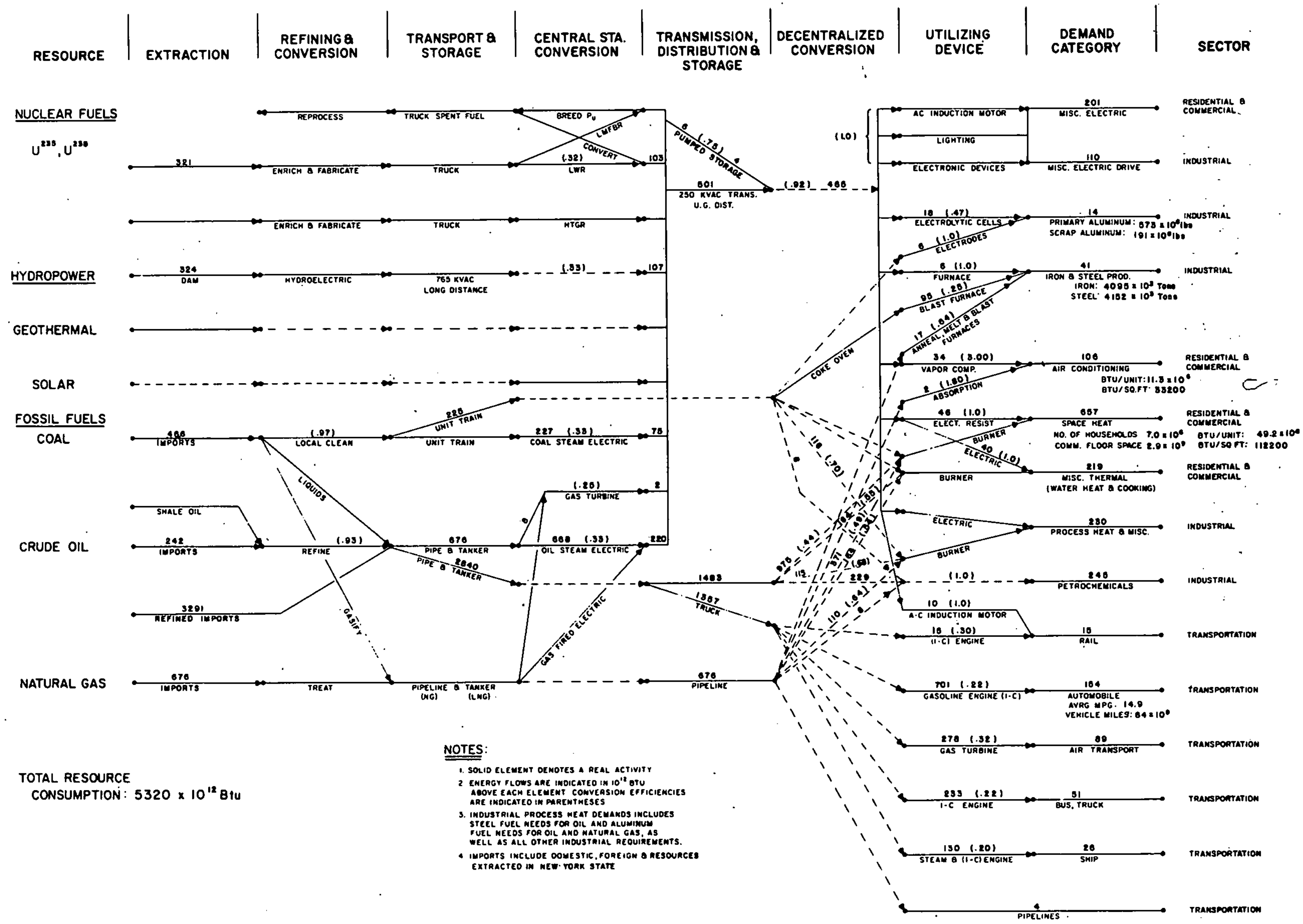

Figure II. New York State Reference Energy System, Year 1980

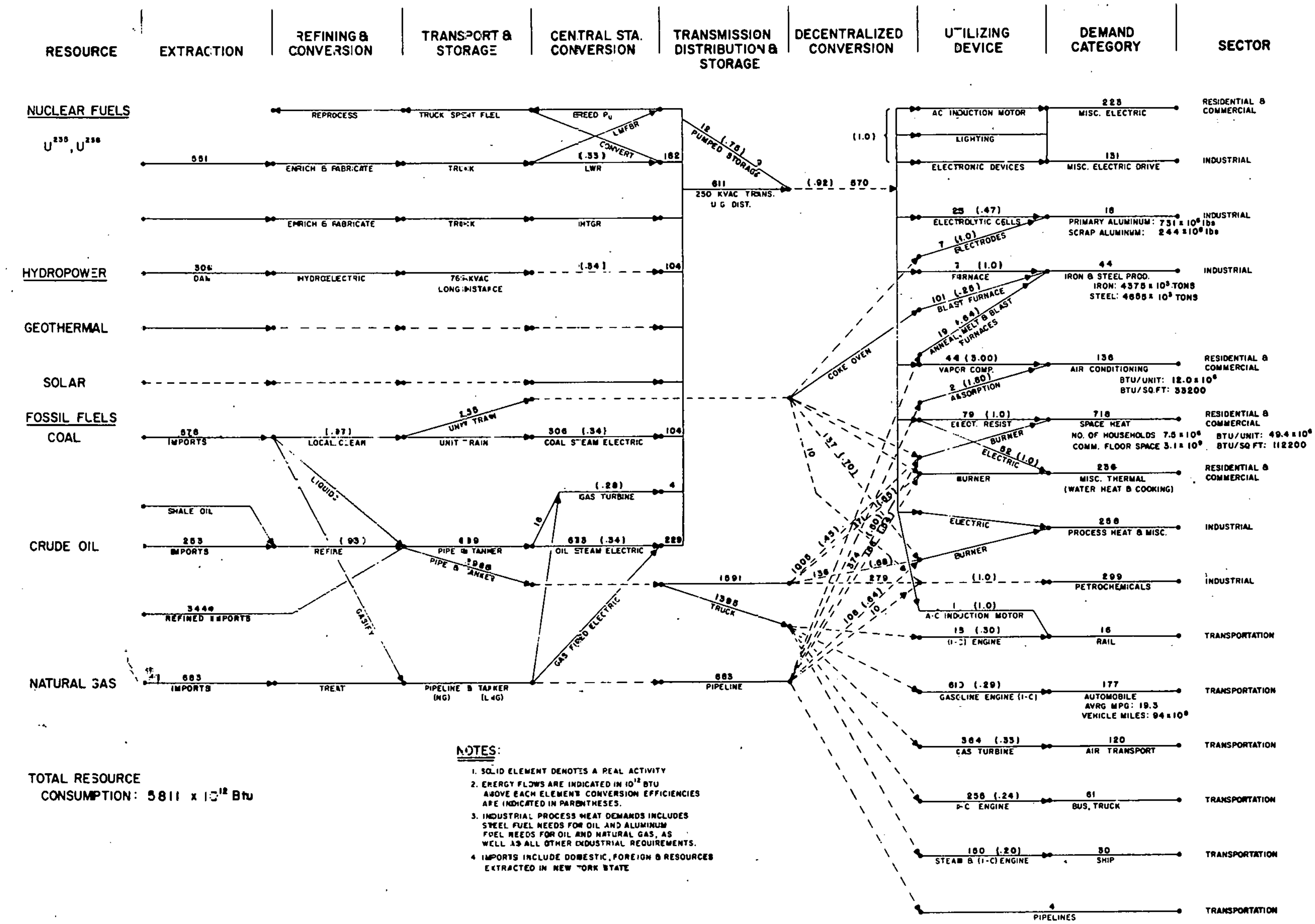

Figure III. New York State Reference Energy System, Year 1985

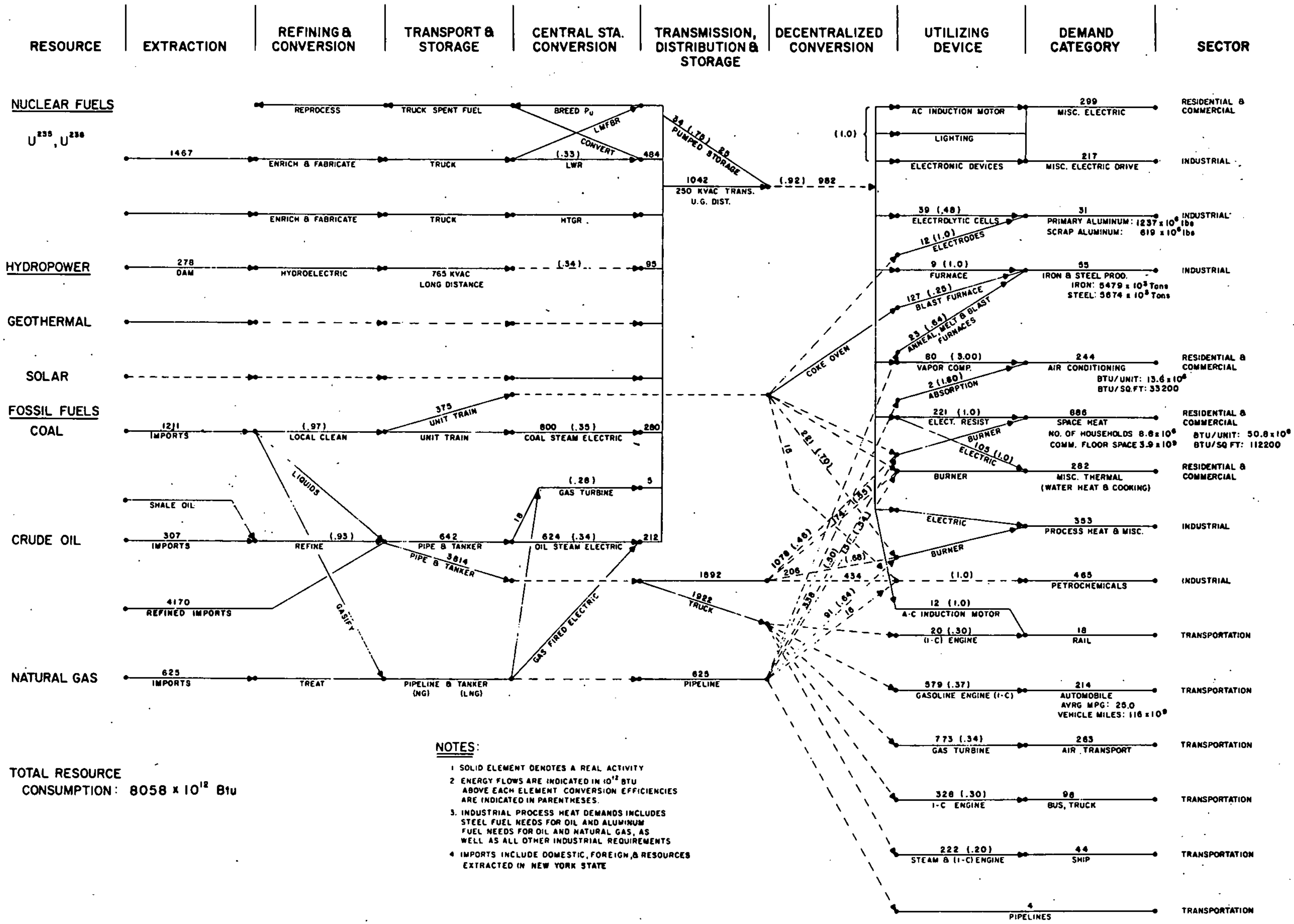

Figure IV. New York State Reference Energy System, Year 2000 where the basis represents number of households, vehicle-miles, tons of steel, etc. This parameter is projected using the best available information as specified in the Fuel Mix Tables (see Appendix B). The unit energy demands are derived using engineering parameters such as heat loss per household or embodied energy in a ton of steel. Intermediate energy demands include transmitted and distributed electricity, gasoline in an automobile, or oil in a home oil tank, for example. The supplies are then derived from a combination of available forecasts and a mix of alternate energy forms.

The values on the right hand side of the RES under the heading "Demand Category" represent the basic energy demand for the above set of end-use categories. These basic energy demands should be distinguished from the more commonly used fuel demands (intermediate energy forms) indicated above. Basic energy demand represents the net energy required to provide a given level of service, e.g., to maintain room temperature at 72^{o}F. It is derived from the various fuel requirements and the fuel efficiencies of utilizing devices. This is useful both conceptually, since it more closely represents the level of service rendered by energy use, and for projection purposes since it is directly related to underlying causative factors, e.g., number of households, vehicle-miles, etc.

"Fuel Mix Tables" are included in Appendix B for each end-use category containing a detailed description of (1) reference technologies utilized, (2) derivation of base case fuel demands and efficiencies, and (3) the basis of energy projections. Data sources referenced in deriving the base case and projected energy demands are noted in the tables. Values for fuel fraction (f_i), fuel demand (D_i), relative effectiveness (e_i), saturation (S), and basis of projection (B) for each demand category are included in the Fuel Mix Tables. The Basic Energy Demand (E) is independent of the fuel or energy form employed. It is computed in the Fuel Mix Tables as the intermediate energy form (as listed in Tables A-1 through A-4 of Appendix A) times the relative efficiency (e_i) summed over all fuels:

$$E = \sum_i D_i \times e_i$$

In general, a projection of Basic Energy Demand, as defined above, includes (1) any saturation effects that may be present (i.e., increased market penetration for air conditioning by 2000), (2) the effect of overall growth in households, vehicle-miles, tons of steel, etc., and (3) the effect of changes in the Unit Basic Energy Demand due to technological or conservation efforts. The fuel mix is then specified in terms of fuel fraction (f_i) for each reference year allowing for switches to alternative fuels. For example, a shift from natural gas to electricity in residential cooking is forecast.

The relative efficiencies (e_i) of the various fuels that satisfy the projected Basic Energy Demands are specified in the Fuel Mix Tables. It is more accurate to consider these efficiencies in terms of relative effectiveness since this both reflects the technical efficiency of an end-use device, and takes differences in utilization practices between fuels into account. Thus, the "efficiency" that is derived from 1972 data for residential space heating supplied by electricity has a value of 1.00 compared with 0.47 for gas; this reflects the improved insulation that is generally used with electric heat as well as the higher technical efficiency. The relative effectiveness is also employed to reflect differences between reference years. Existing construction practices are gradually improving the insulation levels of the overall fossil-heated housing stock; this is represented by increasing the efficiency factor, e_i.

The remainder of this section describes the underlying methodology for the development of each demand sector in the base case and projected RES's.

Residential Sector

The primary end-use demand in the Residential Sector is space heating, which consumed 67% of the energy used in that sector during 1972. Demand for energy in the Residential Sector is computed as follows:

$$\left[\text{FUEL DEMAND}\right]_i = \left[\sum_j (D_{ij} \times B_j)\right] \times S_i$$

where,

D_{ij} = Annual fuel demand for end use i and housing type j.

B_j = Number of households per housing type j

S_i = Market penetration of end-use i

i = end-use 1,..., end-use η

j = Housing type 1,..., housing type 5 (for space heating)

j = 1 (for other end-uses)

The housing stock is divided into five distinct housing types according to the 1970 census of housing:[2]

- Mobile Homes
- Single-family Detached
- Single-family Attached
- Multi-family Low Rise
- Multi-family High Rise

The most dramatic change in the housing stock occurs in mobile homes, which grow from 1% to 4% of the housing stock by 1985 (see Table I). The proportional increase in single-family detached homes and decrease in high rise apartment buildings projected to occur in New York State runs counter to the trend expected in the nation.[30] This is attributed, in part, to a shift away from the cities that is presently occurring in the Northeast.

Table I

PERCENT DISTRIBUTION OF HOUSING

HOUSING TYPE	1972	1980	1985	2000
Mobile Homes	1	3	4	4
Single-family Detached	38	40	41	44
Single-family Attached	24	21	19	16
Multi-family Low Rise	13	15	15	15
Multi-family High Rise	24	21	21	21

The basic energy demand for space heating in 1972 is escalated in proportion to the projected number of households and the housing mix. Household projections are derived from the declining persons per household ratio and the projected population. The population in New York State is projected to grow from 18.4 million to 22.4 million between 1972 and 2000 (see Table II) based on the Bureau of the Census, Series E population projections.(17)

Market penetration for room and central air conditioning units in 1972 were derived from 1970 census data and escalated such that most households are centrally air conditioned by the year 2000, reflecting almost a four-fold increase in electric power requirements for this end-use. In 1972, 30% of the housing units in New York State had at least one room air conditioning unit and 6% of the housing stock had central air conditioning. The coefficient of performance for air conditioning equipment is increased in future reference years from 2.0 and 2.50 for room and central units to 3.00 for both to reflect use of the more efficient devices on the market today. The basic demands derived for 1972 are escalated in proportion to the market saturation and the number of households projected in the reference years.

Table II

NEW YORK STATE POPULATION AND HOUSEHOLDS, 1972-2000

(Thousands)

	1972	1980	1985	2000
Population*	18,367.0	19,351.9	20,132.9	22,438.4
Number of Households	6,069	6,961	7,484	8,799

* Source: Bureau of the Census, Series E Population Projections, Reference 17

Water heating, cooking, and lighting are assumed to be available in all households in the reference years. "Appliances" include dishwashers, clothes dryers, televisions, freezers, clothes washers, refrigerators, small appliances, and new devices not yet in use. To allow for the introduction of new electrical devices not yet in use, it is assumed that these devices will consume as much energy in 2000 as small appliances per household did in 1970. Using the 1972 market penetration levels (Table III), unit energy demands, and number of households, the electricity required for residential water heating, cooking, appliances and lighting was computed for the base year. The basic energy demands derived for 1972 are escalated in proportion to the number of households and saturation levels projected in the reference years.(1) Shifts in residential cooking fuel are projected in proportion to the decreasing use of gas ranges and increasing use of electric ranges forecast. In 1972, 21% of the ranges in New York State were electric, compared with 65% forecast for 2000.

Commercial Sector

Those buildings not specifically incorporated in the Residential or Industrial Sectors are included in the Commercial Sector under

Table III

RESIDENTIAL APPLIANCES --
ENERGY USE AND MARKET PENETRATION

	Million Btu Per Household[1]	Percent Penetration			
		1972	1980	1985	2000
Refrigerator, Lighting, & Small Appliances	7.9	100	104	106	113
Dishwasher	1.2	24	45	59	99
Electric Dryer	3.2	22	33	39	59
Gas Dryer	8.8	10	10	10	10
Television	1.5	132	145	153	178
Food Freezer	4.6	17	24	29	42
Clothes Washer	0.3	57	60	62	67
New Uses[2]	1.6	0	29	46	100
Total	29.1	-	-	-	-
Average	-	44	50	53	64

(1) Source: Reference 1

(2) Assumes new residential electrical devices not yet in use will consume as much energy in 2000 as small appliances per household did in 1970.

the following building type definitions:

- Offices
- Retail
- Schools
- Hospitals
- Other

Commercial floor space in the Northeast as computed in the Project Independence Report[1] was regionalized to New York State based on the following variables for 1972:

- Offices - employment in government, services, finance, insurance and real estate
- Retail - employment in wholesale and retail trade
- Schools - school age population
- Hospitals - hospital beds
- Other - employment in wholesale and retail trade

Aggregate 1972 energy demand in the Commercial Sector is computed as the difference between total New York State energy demand in the Residential-Commercial Sector as reported by the Bureau of Mines[4] and energy demand in the Residential Sector (derived on a per household basis as previously described).

Demand for energy in 1972 disaggregated into Commercial water-heating, air conditioning, cooking, appliances and lighting is derived from energy demand per square foot calculations from Project Independence.[1] The Commercial space heating category then includes the remainder of the energy consumed in the Commercial Sector after all other end-use categories in the Commercial Sector have been accounted for.

The basic energy demand in each end-use category is escalated in proportion to projected commercial floor space in the reference years. Commercial floor space projections in the U.S. are based on projections of employment in wholesale and retail trade, finance, insurance, real estate, services, and civilian government.[17]

Floor space per employee in 2000 is assumed to be 10% above what it was in 1972. The New York State commercial inventory (see Table IV) is derived from the U.S. total on the basis of OBERS earnings projections in wholesale and retail trade, finance, insurance, real estate, services, and civilian government.(17) All commercial establishments are expected to be air-conditioned by the year 2000. Electricity is expected to supply an increasing share of the energy requirements for commercial space heat and water heat; gas and oil will be reduced proportionately.

Table IV

NEW YORK STATE COMMERCIAL INVENTORY

	1972	1980	1985	2000
Million Square Feet	2278	2854	3100	3904

Industrial Sector

The Industrial Sector has been disaggregated into several major energy intensive industries, including Aluminum, Iron, Steel, and Petrochemicals; remaining industrial energy requirements (excluding Petroleum Refining) are included in Industrial Process Heat and Industrial Electric Drive.

The Primary Metals Industry consumed the largest share of energy in the Industrial Sector, with iron and steel accounting for most of this consumption. The Btu value of the coal input to coke ovens for conversion of coal to coke and coke by-products accounts for almost 90% of the energy required by blast furnaces. The value of the efficiency for coal shown in the Fuel Mix Tables is based on a minimum theoretical requirement of 2860 Btu/lb for the reduction of iron ore and includes the efficiency of converting coal to coke. The principal uses of natural gas and fuel oil in the Steel Industry are in heating and annealing furnaces, and in open hearth furnaces, which are declining in number. Electric power is used in the Steel Industry for driving mills forges, process lines, and in the steel-making process itself. The quantity of electric power required in the steel-making process is highly dependent upon the type of furnace utilized (open hearth, basic oxygen, or electric furnace). From an ad hoc survey of several major steel producers in New York State, it has been estimated that at the present time, 80% of the steel is manufactured using the basic oxygen process, 10% using the electric furnace, and 10% in the open hearth. Production via the open hearth is projected to decrease to zero by the year 2000. The ratio of basic oxygen to electric furnace production is projected to remain constant over the reference years. Overall steel production in New York State is projected to remain proportional to U.S. production, adjusted by OBERS projected New York State earnings in primary metals as follows:(17) (30)

$$\left[\text{N.Y.S. PRODUCTION}\right]_t =$$

$$\left(\frac{\text{N.Y.S. PRODUCTION}}{\text{U.S. PRODUCTION}}\right)_{1972} \times ER_t \times \left(\text{U.S. PRODUCTION}\right)_t \qquad \text{(I)}$$

where, $\left[ER\right]_t =$

$$\left[\left(\frac{E_{N.Y.S.}}{E_{U.S.}}\right)_t \Big/ \left(\frac{E_{N.Y.S.}}{E_{U.S.}}\right)_{1970}\right] \qquad \text{(II)}$$

E = Earnings
ER = Earnings Ratio
t = Projection Year--1980, 1985, 2000

Electric power is the major form of energy used to produce primary aluminum and is required in the electrolysis of alumina. The electrolytic efficiency of this process is based on a minimum theoretical requirement of 13,300 Btu/lb. Secondary recovery from scrap is less energy intensive than primary production and is projected to represent a growing share of the market. This will increase from 19% of total production in 1972 to 33% by the year 2000, thus decreasing energy consumption per pound of aluminum produced. Aluminum production in New York State is projected to remain proportional to U.S. production, adjusted by OBERS projected New York State earnings in manufacturing (see equations I and II for additional detail).[17] [30]

Historically, the mix of raw materials supplying the Chemical Industry has shifted from coal to oil and gas. This trend is not expected to continue as coal becomes more readily available relative to oil and gas. The mix of resources supplying the Petrochemical Industry is projected to remain approximately constant over the reference years as shown in the Fuel Mix Table in Appendix B. The basic energy demand is escalated at a 4% growth rate through 1985 and 3% thereafter.

All energy used for fuel in the Industrial Sector which is not consumed in the Aluminum, Iron, Steel, Petrochemical, or Petroleum Refining Industries is included in Industrial Process Heat. Energy consumed in the Industrial Process Heat category is escalated at an annual growth rate of 2.3% per year through 1985 and 2.1% thereafter. This growth rate is derived from (1) the historical ratio of U.S. energy consumption in the industrial sector to gross national product (GNP), and (2) the ratio of New York State to U.S. earnings in manufacturing in the projected year divided by the ratio of New York State to U.S. earnings in 1970 (see equations I and II). Energy consumed in the Industrial Sector in the U.S. between 1960 and 1972 grew at 3.2% per year, whereas GNP grew at 4.1% per year over the same period (see Figure V). The ratio of industrial energy consumption to GNP (in constant dollars) has been declining over time and is projected

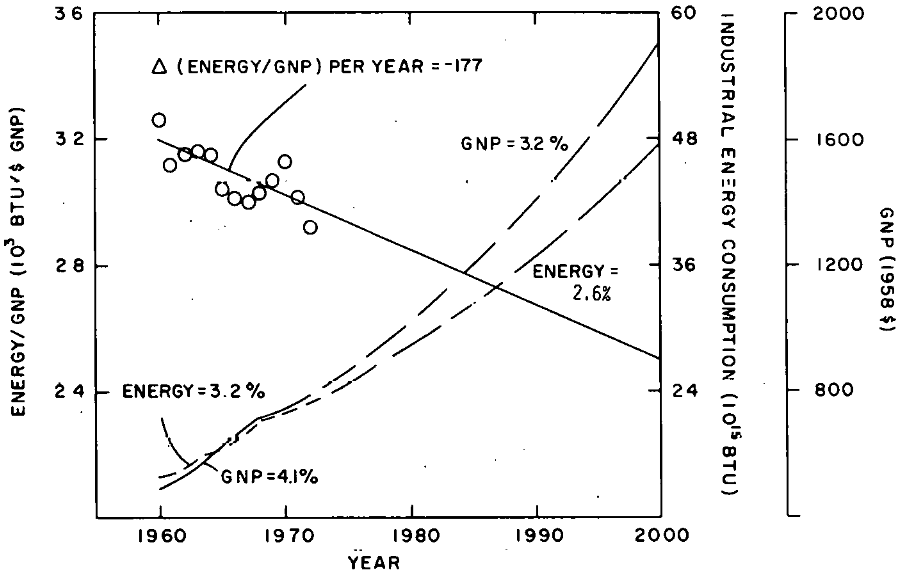

Figure V. Industrial Energy Consumption Relative to GNP, 1960-2000 to continue declining through 2000. A least squares fit to Energy-GNP data over the period 1960-1972 results in the following equation:

$$\left(\text{ENERGY/GNP}\right)_t = \left(\text{ENERGY/GNP}\right)_{1960} + M\left(t-1960\right) \qquad \text{(III)}$$

where, $\left(\text{ENERGY/GNP}\right)_{1960}$ = 32,042 Btu/$GNP

M = -177 Btu/$GNP per year

t = 1960,...,1972

Thus, if it is assumed that the ratio of industrial energy consumption to GNP continues to decline as it has since 1960, at the rate of 177 Btu per dollar of GNP per year, then the following equation can be used to project the ENERGY/GNP ratio in 1980, 1985 and 2000:

$$\left(\text{ENERGY/GNP}\right)_t = 32{,}042\ \text{Btu/\$GNP} - 177\ \frac{\text{Btu/\$GNP}}{\text{YEAR}}\left(t - 1960\right) \qquad \text{(IV)}$$

where, t = 1980,...,2000

If the growth in GNP over the 1972 to 2000 time period is projected to be 3.2% per year, then the level of energy consumption by industry in the U.S. in period "t" can be projected using the following equation:

$$\left(\text{ENERGY}\right)_t = \left(\text{ENERGY/GNP}\right)_t \times \left(\text{GNP}\right)_t \qquad \text{(V)}$$

Values of energy, GNP, and the energy/GNP ratio are listed in Table V for the years 1972, 1980, 1985, and 2000.

Table V

INDUSTRIAL ENERGY CONSUMPTION VS. GNP IN THE UNITED STATES

YEAR	INDUSTRIAL USE OF ENERGY (10^{15} Btu)	GNP (BILLIONS 1958$)	ENERGY/GNP (Btu/$)
1972	23.10	790.7	29,215
1980	28.98	1,017	28,500
1985	32.87	1,191	27,600
2000	47.75	1,910	25,000
Rate of Change Per Year	2.6%	3.2%	-177

Consumption of energy in the Industrial Process Heat category in New York State is projected to grow at 2.3% per year through 1985 and 2.1% thereafter. These growth rates were derived from a national growth rate of 2.6% by multiplying the national rate by the "earning ratio" in manufacturing from equation II.

All electricity used in the Industrial Sector and not consumed in the Aluminum, Iron, Steel, or Petrochemical Industries is included in Industrial Electric Drive.

The basic energy demand in Industrial Electric Drive is escalated at a 3.7% growth rate to 1985 and 3.4% thereafter. This is derived from an estimated annual U.S. growth in industrial electric demand of 4.2%, adjusted by projected New York State earnings in manufacturing (see equations I and II).

Transportation Sector

In 1972 the automobile consumed 53% of the energy in the Transportation Sector compared to 30% projected for 2000, reflecting improved automobile fuel economy and market saturation.

Projected energy demand by the automobile is computed as a function of vehicle-miles traveled (VMT) and fleet average fuel economy. A constant value of 10,200 miles per vehicle is multiplied by the projected number of vehicles in estimating total VMT's. The number of registered vehicles in the U.S. has historically been an increasing proportion of the driving age population, and this trend is expected to result in nine automobiles for each ten persons of driving age by 2000 (currently, there are two automobiles for each three persons in the U.S.).[30] In New York State at the present time, there is one auto for each two persons of driving age, considerably less than the national average. The number of automobiles in New York State is increased in proportion to the national total such that by 2000, 67% of the driving age population own automobiles. In projecting gasoline consumption, a composite fuel efficiency is derived for each reference year on the basis of mix of model years on the road, distribution of vehicle-miles with age of auto, and the fuel efficiency per model year. Fuel economy per model year is assumed to be 10% lower than that specified in the Energy Policy and Conservation Act because of typically observed nonoptimum engine performance in older model vehicles.[20] The fleet average fuel economy projected for 1980, 1985, and 2000 is 14.9 mpg, 19.3 mpg, and 25 mpg, respectively.

The Truck and Bus Category includes all gasoline and diesel fuel not consumed by automobiles; marine and aviation consumption of gasoline is included in Ship and Air Transport, respectively. Thus, gasoline and diesel fuel consumed by agricultural, construction, and miscellaneous equipment is included in the Truck and Bus Category. Trucks are by far the largest energy consumer in this category, with buses using less than 5% of the fuel consumed. Projected Truck and Bus energy consumption in New York State is computed as a function of U.S. truck ton-miles, truck vehicle-miles, bus passenger-miles, and the energy intensiveness of each transport mode. Historically, truck ton-miles in the U.S. have increased in proportion to GNP, and this trend is projected to continue through the year 2000 with GNP growing at a 3.2% growth rate (see Table VI). The fuel efficiency in nonfreight trucking is projected to increase from 9.3 mpg in 1972 to 14.0 mpg in 2000. Conversion of trucks from gasoline to diesel fuel is projected to result in a 14% reduction in the Btu's required per ton-mile by the year 2000, as shown in Table VII. New York State truck ton-miles projected to 1980, 1985, and 2000 are derived as a fraction of U.S. truck ton-miles using the following equation:

$$\left[\left(\text{TRUCK T-M}\right)_{NYS}\right]_t = \left[\frac{\left(\text{T\&B}_{\text{N.Y.S.}}\right)}{\left(\text{T\&B}_{\text{U.S.}}\right)}\right]_{1972} \times \left[\text{ER}\right]_t \times \left[\left(\text{TRUCK T-M}\right)_{\text{U.S.}}\right]_t \quad \text{(VI)}$$

where

$$\left[\text{ER}\right]_t = \left[\left(\frac{E_{\text{N.Y.S.}}}{E_{\text{U.S.}}}\right)_t \Bigg/ \left(\frac{E_{\text{N.Y.S.}}}{E_{\text{U.S.}}}\right)_{1970}\right] \quad \text{(VII)}$$

and T&B = Truck and Bus energy consumption
ER = Earnings ratio
E = Total earnings
t = 1980, 1985, and 2000

Nonfreight trucking vehicle-miles are regionalized in a similar fashion.

Projected energy consumption by Air Transportation in New York State is computed as a function of U.S. air passenger-miles, air ton-miles, and the energy intensiveness of each transport mode. The procedure is analogous to that used in the Truck and Bus Category. Projections of U.S. domestic (133 billion P-M in 1972) and international (34 billion P-M in 1972) air passenger-miles from the Air Transport Association of America[34] [35] are regionalized to New York State using equations VI and VII where Air Transport energy consumption is substituted for Truck and

Table VI

NEW YORK STATE MODAL TRANSPORTATION PROJECTIONS
(Billions)

	1972	1980	1985	2000
Passenger-Miles				
Air	22	30	40	86
Local Bus	3.8	4.3	4.6	6.7
Intercity Bus	1.5	1.5	1.5	1.6
Ton-Miles				
Air	1.1	1.6	2.7	5.4
Local Truck / Intercity Truck	18	25	29	45
Ship	160	213	246	365
Rail	18	21	22	28
Vehicle-Miles				
Nonfreight Trucking	9	12	14	21

Table VII

ENERGY INTENSIVENESS BY TRANSPORT MODE FOR NEW YORK STATE

	1972	1980	1985	2000
Btu/Passenger-Mile				
Air	8,698	7,918	7,431	7,431
Local Bus	1,704	1,704	1,704	1,704
Intercity Bus	1,160	1,160	1,160	1,160
Btu/Ton-Mile				
Air	26,162	25,306	24,771	24,771
Local Truck	7,139	6,854	6,497	6,140
Intercity Truck	2,604	2,500	2,370	2,240
Ship	567	567	567	567
Rail	709	709	709	709
Btu/Vehicle-Mile				
Nonfreight Trucking	13,402	12,126	11,328	8,935

Bus energy consumption (T&B) and air passenger-miles is substituted for truck ton-miles (TRUCK T-M). Btu per passenger-mile and Btu per ton-mile for air transport are derived from reference 29.

Railroad demands for diesel fuel and electricity in New York State during 1972 are based on Bureau of Mines data.(4) (11) Diesel fuel requirements in 1980, 1985 and 2000 are BNL estimates.(36) Shipping demand for residual oil in the reference years is a BNL estimate.(36)

Electric Utility Sector

The New York Power Pool incorporates the seven major investor-owned electric utility companies in New York State and the Power Authority of the State of New York in order to achieve optimum coordination in the planning and operation of their electric system and to provide a means whereby all parties may realize and share in the mutual benefits which can be obtained thereby. These inventor-owned utilities include:

- Central Hudson Gas & Electric Corporation
- Consolidated Edison Company of New York, Inc.
- Long Island Lighting Company
- New York State Electric & Gas Corporation
- Niagara Mohawk Power Corporation
- Orange and Rockland Utilities, Inc.
- Rochester Gas & Electric Corporation

The member system is part of a continental power system. For the purpose of maintaining an operationally reliable energy supply for the Nation, the Nation's electric utilities, both investor-owned and publicly owned, voluntarily established regional reliability councils which cover the entire Nation and parts of Canada. The responsibility of each of the regional reliability councils is to review the overall broad planning and operation of the electric power supply systems in its region. The regions have technical criteria to consider for overall reliability of the supply of energy. The member companies are in the Northeast Power Coordinating Council region, which also includes Ontario, New Brunswick and New England. The regional reliability councils have also formed the National Electric Reliability Council which coordinates the activities of the councils on a National basis.

Recent electric utility forecasts of future energy requirements have been reduced from what they were in the 1972 to 1973 time period. Higher energy prices, depressed economic conditions, and the "conservation ethic" have all been contributing factors to the low energy growth recently experienced. These factors have added a considerable degree of uncertainty to future projections. Traditionally, utilities have depended upon historical trends in forecasting future loads, but this method is rapidly being replaced by more sophisticated techniques using econometrics and detailed engineering analyses of demands. A systems approach using the latter technique is being applied in this study to project requirements for electric power. More specifically, demand for electric power is obtained from the summation of electric demands in 1980, 1985, and 2000 over all other demand categories, adjusted to include transmission and distribution losses.

The mix of capacity additions reported in the <u>1976 Report of Member Electric Systems of the New York Power Pool and the Empire State Electric Energy Research Corporation</u>[38] is derived from individual company forecasts. It projects a 1991 capacity mix of 36% nuclear, 13% coal, 35% oil, and 16% hydro, compared to a 1976 mix of 10% nuclear, 11% coal, 61% oil, and 18% hydro. As anticipated, nuclear capacity in the NYPP forecast rises rapidly to replace diminishing oil-fired generating facilities and to meet increasing demands (see Figure VI). The use of oil to generate electricity is expected to peak in 1985 according to NYPP estimates. Since 1976, essentially no natural gas has been consumed by central station generating facilities in New York State. Power plants burning natural gas have either been retired or converted to burn

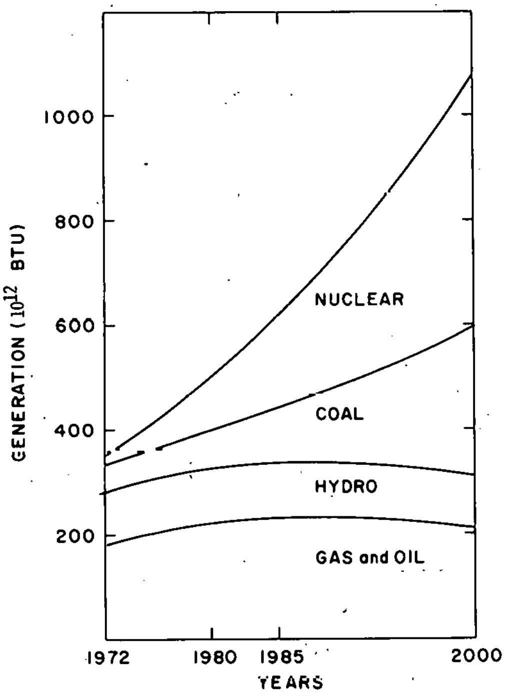

Figure VI. New York State Electricity Generation By Fuel oil. Conventional hydroelectric plants met more than one-fourth of the State's energy requirements in 1972, primarily through the Niagara Falls hydroelectric complex. With hydro capacity remaining at a fairly constant level over the next twenty-five years, it is expected to meet only about 10% of demand by 2000.

The fuel mix in each of the reference years through 1985 is proportional to that projected by the New York Power Pool.[38] Oil steam, gas turbine and hydroelectric capacity in 2000 is held constant at the 1991 levels projected by the NYPP. In addition to the four 1000 MW pumped storage units that the NYPP projects to be on line by 1991, two 1000 MW pumped storage units are projected to become operational between 1991 and 2000. Nuclear power is projected to satisfy 45% of demand in 2000, compared to 1976, when it satisfied only 17% of demand (see Table VIII). Coal is assumed to meet the demand for fuel remaining after all other energy forms are considered, resulting in about 35 million tons of coal being burned in the year 2000.

Table VIII

NYPP ELECTRIC GENERATION - BY CENTRAL STATION POWER PLANTS*

	1972	1980	1985	2000
Natural Gas	5	-	-	-
Oil-Steam	41	43	37	20
Gas Turbine	5	1	1	1
Coal-Steam	16	15	17	25
Hydro	27	21	16	9
Nuclear	6	20	29	45
Total	(356)	(507)	(623)	(1,076)

* Generation by Prime Mover in percent, total in 10^{12} Btu.

Using completely independent methodologies, it is interesting to compare the energy requirements presented in this study with those forecast by the electric utilities.[38] The 4.2% annual growth in electric demand projected to occur from 1980 to 1985 and the 3.7% annual growth projected in this study from 1985 to 2000 are very similar to the 4.0% and 3.8% growth rates projected by the NYPP over the same period. Electric utility energy requirements in 1980 are projected to be 507×10^{12} Btu compared to 450×10^{12} Btu projected by the NYPP. This difference is due to the negative energy growth experienced in New York State over the three year period from 1973 through 1975. The NYPP has held its post 1980 growth rates constant but reduced energy requirements in the remainder of this decade to compensate for this decrease in demand. Insufficient data in other energy sectors at the time this study was conducted prevented an accurate adjustment for the negative growth experienced from 1973 to 1975. In addition, it is not clear that this unusual pattern has passed, and a return to "normality" is imminent. If adjustments in the electric sector are made to compensate for the negative growth in demand, electric sector energy requirements fall within 2% of those forecast by the NYPP.

The purpose of the Reference Energy System, as previously noted, is <u>not</u> to forecast energy demand, but to serve as a baseline from which technology assessments can be performed in order to determine the impact of introducing new technologies, alternate conservation strategies, and fuel mixes in future years. Fluctuating demand patterns due to any number of regional or international economic problems will most likely occur again over the next twenty-five years. These demand perturbations may or may not balance one another out, but they will not have a significant impact upon the overall assessment of alternate technologies. In analyzing the impact of introducing new technologies or conservation strategies, a baseline projection (e.g., a RES) is used to compute the difference in energy consumption levels with and without the technological change. Thus, changes in specific fuel requirements, electric demands, or total resource consumption can be calculated as a result of given technological changes.

TASK 2 - DYNAMIC MODEL DEVELOPMENT

Under this task, attention is focused on development of the Dynamic Energy Systems Optimization Model (DESOM) with emphasis on tailoring it to address particular questions in the electrical sector, and on providing efficient software for running the model. In the first year, investigation of more efficient solution algorithms was undertaken in conjunction with the Stanford Systems Optimization Laboratory. At the same time, work began on development of efficient matrix and report generator software. That work has continued into this year, and will be described, along with the sample assessments, in a topical report. Efforts during this year also focused on better representation of the electrical sector within DESOM.

In order to model the electrical sector more realistically, a study was performed of a formulation in which the year is divided into three seasons (winter, summer, spring/fall) and two daily divisions (day, night). This more flexible approach allows the model to choose whether a summer or winter peak will occur and better depicts the yearly time dependence of demands. This is important since in the Sourcebook case, replication of the RES's yields a summer peak in 1972 and a winter peak in succeeding years.

Six basic demand types were defined: base load, intermediate load, daily off-peak, winter, summer, and fall/spring.

The demand types were characterized by the seasons and daily divisions in which they occurred, as follows*:

Table IX
DEMAND TYPE CHARACTERISTICS

		WD	WN	SD	SN	FD	FN
BL	Base load	4/24	4/24	3/24	3/24	5/24	5/24
IL	Intermediate load	4/12	0	3/12	0	5/12	0
DO	Daily off-peak	0	4/12	0	3/12	0	5/12
WH	Winter	1/2	1/2	0	0	0	0
SC	Summer	0	0	1/2	1/2	0	0
FS	Fall/spring	0	0	0	0	1/2	1/2
Fraction of year		4/24	4/24	3/24	3/24	5/24	5/24

It is assumed that the fraction of demand occurring in a given season/daily division demand type is proportional to the length of that season/daily division. Thus, 5/24 of a demand characterized as demand type base load will occur during a fall/spring day. Of course, a final demand, such as miscellaneous commercial electric, does not have to be characterized as a pure demand type: the load curve can be defined in as detailed a manner as desired by specifying the fractions of final demand that belong to each of the different demand types. To illustrate, the study employed 24 different final demands tabulated for the regional Reference Energy Systems (room and central air conditioning, and aluminum electrolysis and drive are disaggregated in the fuel mix tables). These demands

---

* W = Winter = 4 months (Jan., Feb., Mar., Dec.)
S = Summer = 3 months (1/2 June, July, Aug., 1/2 Sept.)
F = Fall/spring = 5 months (Apr., May, 1/2 June, 1/2 Sept., Oct., Nov.)
D = Day = 12 hours
N = Night = 12 hours

were characterized by the fraction belonging to each demand type, as shown in Tables X and XI. Regional variation in space conditioning demands is shown in Table XI.

Table X

FINAL DEMAND CLASSIFICATION

Sector*	Classification	BL**	IL
RES	Water Heat	1.00	
RES	Cooking	0.75	0.25
RES	Appliances & Light	0.75	0.25
COM	Water Heat	1.00	
COM	Cooking	0.75	0.25
COM	Miscellaneous Electric	0.75	0.25
IND	Aluminum Electrolysis	1.00	
IND	Aluminum Electric Drive	1.00	
IND	Iron	1.00	
IND	Steel	1.00	
IND	Process Heat	1.00	
IND	Electric Drive	1.00	
IND	Petrochemicals		
TRP	Automobiles		
TRP	Truck & Bus		
TRP	Rail & Transit		
TRP	Air Transport		
TRP	Pipelines		
TRP	Ship		

*RES = Residential
COM = Commercial
IND = Industrial
TRP = Transportation

**BL = Base Load
IL = Intermediate Load

Table XI

REGIONAL VARIATION IN SPACE CONDITIONING DEMANDS

	Residential & Commercial Space Heat			Residential & Commercial Air Conditioning (Room and Central)		
Region	WH	SC	FS	WH	SC	FS
1. New England (NE)	0.65	0.01	0.34		1.00	
2. Middle Atlantic (MA)	0.70		0.30		1.00	
3. East North Central (ENC)	0.67	0.01	0.32		0.95	0.05
4. West North Central (WNC)	0.69	0.01	0.30		0.90	0.10
5. South Atlantic (SA)	0.76		0.24		0.79	0.21
6. East South Central (ESC)	0.75		0.25		0.80	0.20
7. West South Central (WSC)	0.82		0.18		0.71	0.29
8. Mountain (MT)	0.64	0.01	0.35		0.93	0.07
9. Pacific (PAC)	0.64		0.36		1.00	

WH = Winter (Jan., Feb., Mar., Dec.)

SC = Summer (1/2 June, July, Aug., 1/2 Sept.)

FS = Fall/spring (Apr., May, 1/2 June, 1/2 Sept , Oct., Nov.)

The methodology for computing the fractions is as follows:

Climatological data by regions (approximately 10) in each state for a five-year period were weighted to the respective region's percent of the total state's population. Furthermore, the state's weighted degree-day demand was weighted within its region by the ratio of state to regional population. The basis was 68°. The results for each region are shown in Table XII.

Each of the demand types was also characterized by its "peak fraction," the amount contributing to the endogenous peak demand. This formulation is used in BESOM. The peak fractions were assumed to be the same as used in standard runs of BESOM (see Table XIII).

In each season/time-of-day period, (S)(D), the demand attributable to a particular demand type DT will be:

$$\text{elec (DT) (S)(D)} = \text{SUM (DC)} \left(\text{elec (DC)} * \text{f(DC) (DT)} * \text{t(DT) (S)(D)} \right)$$

where, SUM (DC) indicates that the sum is over the demand categories, elec (DC) is the total demand in the demand category DC, f(DC) (DT) is the fraction of demand in category DC that is of type DT (see Tables X and XI), and t(DT) (S)(D) is the fraction of demand type DT that occurs in time period (S)(D), as in Table IX. The capacity required in that time period is a function of the height of the peak:

$$\frac{(1 + u)}{\ell\text{(S)(D)}} * \text{SUM (DT)} \left(\frac{\text{elec (DT) (S)(D)}}{1 + \text{pf(DT)}} * (1 + (\text{pf(DT)}/\text{LFP})/\text{d(DT)}) \right)$$

u   is the reserve margin requirement.

ℓ(S)(D)   is the fraction of the year represented by the time period (S)(D) (see Table IX).

pf(DT)   is the endogenous peak fraction for DT.

LFP   is the load factor of peak demand (taken as 0.1 in the model).

d(DT)   is the duration of demand DT as a fraction of the year, e.g. for intermediate load d(IL) = 1/2. In general,

$$\text{d(DT)} = \text{SUM (S)(D)} \left([\text{for t(DT) (S)(D)} > 0] \ \text{fraction of year (S)(D)} \right) \text{(see Table IX)}.$$

Table XIIa

HEATING DEGREE DAYS

68° BASE

Month \ Region*	NE	MA	ENC	WNC	SA	ESC	WSC	MT	PAC
Jan.	1,239	1,064	1,304	1,457	624	752	629	1,119	578
Feb.	1,124	986	1,140	1,181	605	671	498	868	431
Mar.	995	827	960	933	437	456	260	731	426
Apr.	680	517	615	542	220	237	77	550	327
May	334	196	280	213				249	193
June	37								45
July									
Aug.									
Sept.	128	1	123	138				107	
Oct.	460	321	404	399	105	133		401	187
Nov.	763	626	777	853	389	479	353	782	389
Dec.	1,088	916	1,136	1,282	583	696	587	1,058	564
Total	6,849	5,454	6,739	6,997	2,964	3,422	2,404	5,865	3,139

*Regions are as in Table X.

Table XIIb

COOLING DEGREE DAYS

68^{o} BASE

Region* / Month	NE	MA	ENC	WNC	SA	ESC	WSC	MT	PAC
Jan.									
Feb.									
Mar.									
Apr.									
May					25	15	159		
June		94	34	105	222	240	352	68	
July	156	272	153	227	320	336	445	238	72
Aug.	120	245	124	173	315	318	405	185	74
Sept.					180	156	232		1
Oct.							6		
Nov.									
Dec.									
Total	276	611	311	506	1,061	1,066	1,599	491	149

*Regions are as in Table X.

This formulation is equivalent to the one now used in BESOM but allows much greater flexibility and avoids the conceptual problems posed by a formulation in which it is known exactly which central station plant meets what demand.

The new formulation was tested, for 1972, using a reserve margin of 20%. The results were that in every region the peak demand occurred during the summer day. Total capacity required was 408.6 GWe as opposed to the Sourcebook total of 399.5. If a reserve margin factor of 18% had been used, the result would have been 401.8, or an error of 0.6%. It was concluded that the formulation and demand type characterization of demand categories were valid.

Table XIII

PEAK FRACTIONS FOR DEMAND TYPES

Demand Types (DT)		Peak Fraction
BL	Base load	0.05
IL	Intermediate load	0.10
DO	Daily off-peak	0.00
WH	Winter	0.00
SC	Summer	0.20
FS	Fall/spring	0.00

TASK 3 - SUPPORT ACTIVITIES

Under this task, support was provided to EPRI through model and data transfers, and telephone consultations on modeling and data questions.

At the request of R. Michelson, assistance was provided to Dennis Fromholzer to answer questions about the structure and input parameters for BESOM and DESOM.

Several case runs of the old version of DESOM were transferred to EPRI on tape, including a base case Sourcebook scenario and a full technology run. Although these did not represent the improved formulation being developed for EPRI, the runs were requested by Systems Control, Inc., which was performing an assessment of DESOM for J. Karaganis.

EPRI personnel also requested BESOM's report writing capability. In response, the report writing Fortran program was made IBM-compatible, and a tape was sent to EPRI which included this program, standard data files needed for the report generator, and three problem files consisting of base cases for 1985, 1990, and 2000.

REFERENCES

1. Project Independence Task Force Report, Residential and Commercial Energy Use Patterns 1970-1990, Federal Energy Administration, Washington, D.C., November 1974.

2. Bureau of the Census, Census of Housing, 1970--Detailed Housing Characteristics, U.S. Department of Commerce, Washington, D.C., 1972.

3. Tansil, J., Residential Consumption of Electricity, 1950-1970, Oak Ridge National Laboratory, July 1973.

4. Bureau of Mines, Information Circular: Fuel and Energy Data, U.S. By States and Regions 1972, IC 8647, U.S. Department of Interior, Washington, D.C., 1974.

5. Bureau of the Census, Statistical Abstracts of the U.S., 1974, U.S. Department of Commerce, Washington, D.C., 1974.

6. Stanford Research Institute, Patterns of Energy Consumption in the U.S., Washington, D.C., January 1972.

7. Associated Universities, Inc., Energy Model Data Base, 1974, Brookhaven National Laboratory, Upton, N.Y.

8. Bureau of Mines, Minerals Yearbook 1972, Vol. I, U.S. Department of Interior, Washington, D.C., 1973.

9. Bureau of the Census, Census of Manufacturers, 1972 Fuels and Electric Energy Consumed, U.S. Department of Commerce, Washington, D.C., 1973.

10. Federal Highway Administration, Highway Statistics 1972, U.S. Department of Transportation, Washington, D.C.

11. Bureau of Mines, Mineral Industry Surveys--Fuel Oil Sales, 1972, U.S. Department of Interior, Washington, D.C.

12. Edison Electric Institute, Statistical Yearbook of the Electric Utility Industry for 1972, New York, N.Y., November 1973.

13. Summary of National Transportation Statistics, Report No. DOT - TSC - OST - 74 - 8, U.S. Department of Transportation, Washington, D.C., June 1974.

14. American Gas Association, Gas Facts, 1972, Arlington, Virginia, 1973.

15. Arthur D. Little, Inc., Implications of Natural Gas Consumption Patterns for the Implementation of End-Use Priority Programs, Report to the Office of the General Council, General Motors Corporation, Cambridge, Massachusetts.

16. Bureau of the Census, Census of Housing, 1970--Structural Characteristics of the Housing Inventory, U.S. Department of Commerce, Washington, D.C., 1973.

17. U.S. Departments of Commerce and Agriculture, OBERS Projections--1972 Regional Economic Activity in the U.S., Series E, Vol. 4 - States, U.S. Water Resources Council, Washington, D.C., April 1974.

18. The Conference Board, Energy Consumption in Manufacturing, A Report to the Energy Policy Project of the Ford Foundation, Cambridge, Massachusetts, 1974.

19. Ford Foundation, Energy Policy Project, A Time to Choose, Cambridge, Massachusetts, 1974.

20. Ninety-Fourth Congress, First Session, Energy Policy and Conservation Act, Conference Report No. 94-516, Washington, D.C., December 8, 1975.

21. Federal Highway Administration, Highway Travel Forecasts Related to Energy Requirements, FHWA Notice, U.S. Department of Transportation, February 28, 1973.

22. 1974 National Transportation Report, Summary, U.S. Department of Transportation, Washington, D.C., December 1974.

23. Project Independence Task Force Report, Project Independence and Energy Conservation: Transportation Sectors, Federal Energy Administration, Washington, D.C., November 1974.

24. Office of Technology Assessment, Energy, the Economy and Mass Transit, Washington, D.C., December 1975.

25. Federal Energy Administration, National Energy Outlook, Washington, D.C., February 1976.

26. "26th Annual Electrical-Industry Forecast," Electrical World, Vol. 184, No. 6, September 15, 1975.

27. Associated Universities, Inc., Sourcebook for Energy Assessment, Brookhaven National Laboratory, BNL 50483, Upton, New York, December 1975.

28. Energy Research and Development Administration, A National Plan for Energy Research, Development and Demonstration: Creating Energy for the Future, ERDA-48, Vol. 1, Washington, D.C., 1975.

29. Institute for Energy Analysis, The IEA Energy Simulation Model--A Framework for Long-Range U.S. Energy Analysis, ORAU-125, Oak Ridge, Associated Universities, Oak Ridge, Tennessee, January 1976.

30. Hermelee, A. L., Regional Reference Energy Systems, prepared by Brookhaven National Laboratory for the Electric Power Research Institute under contract no. RP442-1, to be published.

31. Lee, J., Energy Supply and Demand in the Northeast United States, BNL 20427, Brookhaven National Laboratory, Upton, New York, September 1975.

32. Bureau of Mines, Information Circular: Historical Fuels and Energy Consumption Data, 1960-1972--United States by States and Census Districts East of the Mississippi, IC 8704, U.S. Department of Interior, Washington, D.C., 1976.

33. Bureau of Mines, Information Circular: Historical Fuels and Energy Consumption Data, 1960-1972--United States by States and Census Districts West of the Mississippi, IC 8705, Department of Interior, Washington, D.C., 1976

34. Air Transport Association of America, Domestic Industry Passenger Demand Forecast, 1974-2000--Trunk and Regional Carriers, Executive Summary, June 1975.

35. Air Transport Association of America, International Air Travel, Industry Passenger Demand Forecast, United States Related Traffic, 1976-2000, Executive Summary, May 1976.

36. Allentuck, J., et al., Some Aspects of the Future Energy Demand-Supply Situation in New York State, BNL 21540, Brookhaven National Laboratory, Upton, New York, April 1976.

37. American Iron and Steel Institute, Annual Statistical Report 1974, Washington, D.C., 1975.

38. New York Power Pool, Report of Member Electric Systems of the New York Power Pool and the Empire State Electric Energy Research Corporation, Pursuant to Article VIII, Section 149-b of the Public Service Law, Vol. 1-3, April 1, 1976.

APPENDIX A

SUMMARY OF ENERGY DEMAND AND FUEL MIX

TABLE A-1

SUMMARY OF ENERGY DEMAND AND FUEL MIX, 1972

REGION: New York State

(10^{12} Btu)

	Methane	Oil	Coal	Nuclear	Hydro[a]	Electric[b]	Total Direct Use
RESIDENTIAL:							
Space Heat	234.8	433.7	6.6			5.8	680.9
Water Heat	80.3	99.2	2.0			10.1	191.6
Air Cond.						9.9	9.9
Cooking	41.0	4.2				5.0	50.2
Appl. & Light	5.3					71.8	77.1
SUBTOTAL	361.4	537.1	8.6			102.6	1009.7
COMMERCIAL:							
Space Heat	116.4	393.0				9.9	519.3
Water Heat	13.1	44.5				5.5	63.1
Cooking	12.2					1.0	13.2
Air Cond.	1.7					11.6	13.3
Mis. Electric						85.5	85.5
SUBTOTAL	143.4	437.5				113.5	694.4
INDUSTRIAL:							
Aluminum	3.1		4.3			13.9	21.3
Iron	1.8	2.3	94.1			1.4	99.6
Steel	15.4	0.5				4.6	20.5
Process Heat	104.1	88.4	86.9				279.4
Electric Drive						81.9	81.9
Feedstocks	6.0	167.4	5.7				179.1
SUBTOTAL	130.4	258.6	191.0			101.8	681.8
TRANSPORTATION:							
Automobile		591.9					591.9
Truck & Bus		187.9					187.9
Rail & Transit		12.9				9.5	22.4
Air		221.1					221.1
Pipelines	3.5						3.5
Ship		97.6					97.6
SUBTOTAL	3.5	1111.4				9.5	1124.4
ELEC. UTILITY	65.8	526.1	175.5	67.4	290.5	(327.4)	797.9[c]
Methane Prod.							
Coal Prod.			11.6				11.6
Refinery Use		13.8					13.8
TOTAL RESOURCES CONSUMED	704.5	2884.5	386.7	67.4	290.5		4333.6

[a]Hydropower resource consumption is based on a conversion efficiency of 33%.

[b]Gives energy consumed as electricity at 3412.8 BTU/KWH. For fuels consumed in producing electricity see row labeled "Electric Utility".

[c]Taken as total resources consumed by utilities less electricity delivered to end use.

TABLE A-2

SUMMARY OF ENERGY DEMAND AND FUEL MIX, 1980

REGION: New York State

(10^{12} Btu)

	Methane	Oil	Coal	Nuclear	Hydro[a]	Electric[b]	Total Direct Use
RESIDENTIAL:							
Space Heat	247.2	481.5				24.0	752.7
Water Heat	89.3	108.8				18.6	216.7
Air Cond.						14.7	14.7
Cooking	40.4	2.4				9.5	52.3
Appl. & Light	6.1					93.9	100.0
SUBTOTAL	383.0	592.7				160.7	1136.4
COMMERCIAL:							
Space Heat	124.2	493.6				22.4	640.2
Water Heat	13.9	53.0				10.2	77.1
Cooking	14.5					1.6	16.1
Air Cond.	1.7					19.5	21.2
Mis. Electric						107.0	107.0
SUBTOTAL	154.3	546.6				160.7	861.6
INDUSTRIAL:							
Aluminum	4.4		5.6			17.9	27.9
Iron	1.8	2.4	94.5			1.4	100.1
Steel	15.3	0.4				4.9	20.6
Process Heat	105.5	112.6	115.8				333.9
Electric Drive						109.5	109.5
Feedstocks	8.2	229.1	7.8				245.1
SUBTOTAL	135.2	344.5	223.7			133.7	837.1
TRANSPORTATION:							
Automobile		701.2					701.2
Truck & Bus		233.4					233.4
Rail & Transit		14.6				10.2	24.8
Air		278.0					278.0
Pipelines	3.4						3.4
Ship		129.7					129.7
SUBTOTAL	3.4	1356.9				10.2	1370.5
ELEC. UTILITY		676.9	227.3	320.9	324.2	(465.3)	1084.0[c]
Methane Prod.							
Coal Prod.			13.5				13.5
Refinery Use		17.0					17.0
TOTAL RESOURCES CONSUMED	675.9	3534.6	464.5	320.9	324.2		5320.1

[a]Hydropower resource consumption is based on a conversion efficiency of 33%.

[b]Gives energy consumed as electricity at 3412.8 BTU/KWH. For fuels consumed in producing electricity see row labeled "Electric Utility".

[c]Taken as total resources consumed by utilities less electricity delivered to end use.

TABLE A-3

SUMMARY OF ENERGY DEMAND AND FUEL MIX, 1985

REGION: New York State

(10^{12} Btu)

	Methane	Oil	Coal	Nuclear	Hydro[a]	Electric[b]	Total Direct Use
RESIDENTIAL:							
Space Heat	253.6	490.7				36.9	781.2
Water Heat	91.4	114.4				24.3	230.1
Air Cond.						20.3	20.3
Cooking	39.2	1.3				12.6	53.1
Appl. & Light	6.6					107.1	113.7
SUBTOTAL	390.8	606.4				201.2	1198.4
COMMERCIAL:							
Space Heat	120.7	514.5				41.7	676.9
Water Heat	13.6	55.6				13.2	82.4
Cooking	15.1					2.0	17.1
Air Cond.	1.7					24.0	25.7
Mis. Electric						116.3	116.3
SUBTOTAL	151.1	570.1				197.2	918.4
INDUSTRIAL:							
Aluminum	5.6		7.1			22.9	35.6
Iron	1.9	2.6	101.0			1.5	107.0
Steel	17.0	0.3				5.6	22.9
Process Heat	102.4	133.5	136.9				372.8
Electric Drive						131.4	131.4
Feedstocks	10.0	278.7	9.5				298.2
SUBTOTAL	136.9	415.1	254.5			161.4	967.9
TRANSPORTATION:							
Automobile		610.3					610.3
Truck & Bus		254.8					254.8
Rail & Transit		15.7				10.6	26.3
Air		364.1					364.1
Pipelines	3.4						3.4
Ship		149.8					149.8
SUBTOTAL	3.4	1394.7				10.6	1408.7
ELEC. UTILITY		689.3	305.6	550.9	305.6	(570.4)	1281.0[c]
Methane Prod.							
Coal Prod.			16.8				16.8
Refinery Use		17.7					17.7
TOTAL RESOURCES CONSUMED	682.2	3693.3	576.9	550.9	305.6		5808.9

[a] Hydropower resource consumption is based on a conversion efficiency of 34%.

[b] Gives energy consumed as electricity at 3412.8 BTU/KWH. For fuels consumed in producing electricity see row labeled "Electric Utility".

[c] Taken as total resources consumed by utilities less electricity delivered to end use.

TABLE A-4

SUMMARY OF ENERGY DEMAND AND FUEL MIX, 2000

REGION: New York State

(10^{12} Btu)

	Methane	Oil	Coal	Nuclear	Hydro[a]	Electric[b]	Total Direct Use
RESIDENTIAL:							
Space Heat	248.7	484.7				111.6	845.0
Water Heat	88.2	110.0				53.8	252.0
Air Cond.						37.8	37.8
Cooking	29.3					22.3	51.6
Appl. & Light	7.7					152.6	160.3
SUBTOTAL	373.9	594.7				378.1	1346.7
COMMERCIAL:							
Space Heat	89.4	593.1				109.5	792.0
Water Heat	9.5	63.9				25.2	98.6
Cooking	16.5					3.5	20.0
Air Cond.	1.7					42.2	43.9
Mis. Electric						146.4	146.4
SUBTOTAL	117.1	657.0				326.8	1100.9
INDUSTRIAL:							
Aluminum	10.6		12.0			39.4	62.0
Iron	2.3	3.3	126.5			1.9	134.0
Steel	20.4					7.2	27.6
Process Heat	80.7	202.6	221.4				504.7
Electric Drive						216.9	216.9
Feedstocks	15.6	434.2	14.8				464.6
SUBTOTAL	129.6	640.1	374.7			265.4	1409.8
TRANSPORTATION:							
Automobile		579.1					579.1
Truck & Bus		327.9					327.9
Rail & Transit		19.7				12.0	31.7
Air		772.8					772.8
Pipelines	3.1						3.1
Ship		221.7					221.7
SUBTOTAL	3.1	1921.2				12.0	1936.3
ELEC. UTILITY		642.6	800.3	1467.3	277.6	(982.3)	2205.5[c]
Methane Prod.							
Coal Prod.			35.3				35.3
Refinery Use		21.5					21.5
TOTAL RESOURCES CONSUMED	623.7	4477.1	1210.3	1467.3	277.6		8056.0

[a]Hydropower resource consumption is based on a conversion efficiency of 34%.

[b]Gives energy consumed as electricity at 3412.8 BTU/KWH. For fuels consumed in producing electricity see row labeled "Electric Utility".

[c]Taken as total resources consumed by utilities less electricity delivered to end use.

THIS PAGE

WAS INTENTIONALLY

LEFT BLANK

APPENDIX B

FUEL MIX TABLES

TABLE B-1

PROJECTED FUEL MIX

Region: NEW YORK STATE

Sector: RESIDENTIAL

Category: SPACE HEAT

DIRECT FUEL USE	1972 f_i	1972 e_i	1972 D_i	1980 f_i	1980 e_i	1980 D_i	1985 f_i	1985 e_i	1985 D_i	2000 f_i	2000 e_i	2000 D_i
Methane-Mobile Home	.19		1.7	.18		4.5	.17		5.1	.15		5.9
Single-Family Detached		.47	138.8			152.1			158.3			164.8
Single-Family Attached	.38		49.5	.36	.49	44.1	.35	.50	42.3	.29	.51	33.1
Multi-Family Low Rise			17.2			20.5			21.1			19.8
Multi-Family High Rise			27.6			26.0			26.8			25.1
Distillate-Oil-Mobile Home	.78		8.2	.75		22.3	.73		25.9	.60		28.0
Single-Family Detached			253.2			287.8			296.1			310.0
Single-Family Attached	.59	.40	90.4	.57		83.5	.55		79.2	.46		62.3
Multi-Family Low Rise			31.5		.41	38.7		.42	39.4		.43	37.2
Multi-Family High Rise			50.4			49.2			50.1			47.2
Coal-Single-Family Detached			3.9									
Single-Family Attached			1.4									
Multi-Family Low Rise	.01	.44	0.5									
Multi-Family High Rise			0.8									
Electricity-Mobile Home			0.1			0.9			1.5			5.0
Single-Family Detached			3.4			14.5			22.6			72.4
Single-Family Attached	.02	1.00	1.2	.07	1.00	4.2	.10	1.00	6.0	.25	1.00	14.5
Multi-Family Low Rise			0.4			1.9			3.0			8.7
Multi-Family High Rise			0.7			2.5			3.8			11.0
Total Fuel Demand, D, 10^{12} BTU			680.9			752.7			781.2			845.0
Basis												
10^6 Units Mobile Home			0.080			.234			.286			.385
Single-Family Detached			2.301			2.775			3.031			3.884
Single-Family Attached			1.462			1.433			1.443			1.389
Multi-Family Low Rise			0.796			1.039			1.124			1.296
Multi-Family High Rise			1.430			1.480			1.600			1.845
			6.069			6.961			7.484			8.799
Basic Energy Demand, E, 10^{12} BTU												
Mobile Home			4.2			12.2			14.9			20.0
Single-Family Detached			171.6			207.0			226.1			289.7
Single-Family Attached			61.2			60.0			60.4			58.2
Multi-Family Low Rise			21.3			27.8			30.1			34.8
Multi-Family High Rise			34.2			35.4			38.2			44.1
Unit Basic Demand, Eu, 10^6 BTU/Household												
Mobile Home			52.1			52.1			52.1			52.1
Single-Family Detached			74.6			74.6			74.6			74.6
Single-Family Attached			41.9			41.9			41.9			41.9
Multi-Family Low Rise			26.8			26.8			26.8			26.8
Multi-Family High Rise			23.9			23.9			23.9			23.9

REFERENCE TECHNOLOGIES: Burner devices for fossil fuels, electric resistance heat.

DATA SOURCES:

D_i and f_i (for 1972): Derived from yearly BTU/Household per housing type data from Ref. (1) for the Northeast: adjusted for average annual population weighted heating degree days in NYS (5480). The fraction of households per fuel type is based on 1970 census data (Ref. 2) escalated to 1972.

e_i : Derived as follows: Gas and oil burners at an efficiency of .75 and .63, respectively (Reference 6) results in an effectiveness for electric heat of 1.58 relative to the other fuels on account of the better insulation in electrically heated homes. The efficiencies utilized here are obtained by normalizing the values above, so that 1.00 represents the efficiency of an electrically heated home with levels of insulation found in such homes, and the values used for fossil burners are apparent relative efficiencies.

BASIS OF PROJECTIONS: The basic demands derived for 1972 are escalated in proportion to the respective number of households. The projection of total number of households is based on the 1972 series E population projections (Ref. 17) and the decreasing persons per household forecast. Shifts in housing type are derived from Ref. (1). It was assumed that 30% of all new homes built between 1972 and 1985 will be electrically heated and 50% thereafter. Other fuels are reduced proportionately.

TABLE B-2

Region: NEW YORK STATE — PROJECTED FUEL MIX — Sector: RESIDENTIAL

Category: WATER HEAT

	1972			1980			1985			2000		
DIRECT FUEL USE	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i
Methane	.42	.61	80.3	.41	.61	89.3	.39	.61	91.4	.32	.61	88.2
Jet Fuel												
Gasoline												
Distillate oil	.47	.55	99.2	.45	.55	108.8	.44	.55	114.4	.36	.55	110.0
Residual oil												
Coal	.01	.55	2.0									
Other												
ELECTRICITY	.09	1.00	10.1	.14	1.00	18.6	.17	1.00	24.3	.32	1.00	53.8
TOTAL FUEL DEMAND, D, 10^{12} Btu			191.6			216.7			230.1			252.0
BASIS 10^6 Households			6.069			6.961			7.484			8.799
SATURATION, S,	.99			1.00			1.00			1.00		
BASIC ENERGY DEMAND, E, 10^{12} Btu			114.7			132.9			143.0			168.1
UNIT BASIC DEMAND, E_u, 10^6 Btu/Household			19.1			19.1			19.1			19.1

REFERENCE TECHNOLOGIES: Gas and oil burners, electric resistance heat.

DATA SOURCES:

D_i and f_i (for 1972): Btu/household requirements from Ref. (1); number of households derived from 1970 census data (Ref. 2) escalated to 1972.

e_i : These are apparent relative efficiencies derived from Btu/household requirements assuming electric units have an apparent efficiency of 1.00.

BASIS OF PROJECTIONS: The basic demands derived for 1972 are escalated in proportion to the number of households projected in the reference years. Fuel distribution is projected in proportion to the changes forecast for space heat.

TABLE B-3

Region: NEW YORK STATE — PROJECTED FUEL MIX — Sector: RESIDENTIAL

Category: AIR CONDITIONING

	1972 f_i	1972 e_i	1972 D_i	1980 f_i	1980 e_i	1980 D_i	1985 f_i	1985 e_i	1985 D_i	2000 f_i	2000 e_i	2000 D_i
DIRECT FUEL USE												
Methane												
Jet Fuel												
Gasoline												
Distillate oil												
Residual oil												
Coal												
Other												
ELECTRICITY Room	.30	2.00	6.7	.41	3.00	7.0	.47	3.00	8.7	.55	3.00	11.9
Central	.06	2.50	3.2	.15	3.00	7.7	.21	3.00	11.6	.40	3.00	25.9
TOTAL FUEL DEMAND, D, 10^{12} Btu			9.9			14.7			20.3			37.8
BASIS 10^6 Households			6.069			6.961			7.484			8.799
SATURATION, S, Room	.30			.41			.47			.55		
Central	.06			.15			.21			.40		
BASIC ENERGY DEMAND, E, 10^{12} Btu Room			13.4			21.0			26.1			35.7
Central			8.0			23.1			34.8			77.7
UNIT BASIC DEMAND, E_u, 10^6 Btu/Household Room			7.4			7.4			7.4			7.4
Central			22.1			22.1			22.1			22.1

REFERENCE TECHNOLOGIES: Vapor compression cycle operating on electricity.

DATA SOURCE:

D_i and f_i (for 1972): Room air conditioners: derived from regional Btu/household requirements from Ref. (27); saturation fraction based on 1970 census data (Ref. 2) escalated to 1972. Central air conditioners: regional Btu/household requirements from Ref. (3); saturation fractions based on 1970 census data escalated to 1972.

e_i : The efficiency in this demand category is the coefficient of performance for air conditioning equipment. The 1972 values are taken from ASHRAE guide and Data Book, American Society of Heating, Refrigeration, and Air Conditioning Engineer, 1969, p. 514. The coefficients of performance are increased in future reference years to reflect the use of the more efficient devices that are available today.

BASIS OF PROJECTIONS: The basic demands derived for 1972 are escalated in proportion to the saturation and the number of households projected for the reference years. Saturation of room versus central air conditioning units is assumed to increase (Ref. 1) such that virtually all households have air conditioning by the year 2000.

TABLE B-4

Region: NEW YORK STATE — PROJECTED FUEL MIX — Sector: RESIDENTIAL

Category: COOKING

	1972 f_i	1972 e_i	1972 D_i	1980 f_i	1980 e_i	1980 D_i	1985 f_i	1985 e_i	1985 D_i	2000 f_i	2000 e_i	2000 D_i
DIRECT FUEL USE												
Methane	.71	.41	41.0	.61	.41	40.4	.55	.41	39.2	.35	.41	29.3
Jet Fuel												
Gasoline												
LPG, Oil and Other Fuels	.08	.45	4.2	.04	.45	2.4	.02	.45	1.3			
Coal												
Other												
ELECTRICITY	.21	1.00	5.0	.35	1.00	9.5	.43	1.00	12.6	.65	1.00	22.3
TOTAL FUEL DEMAND, D, 10^{12} Btu			50.2			52.3			53.1			51.6
BASIS 10^6 Households			6.069			6.961			7.484			8.799
SATURATION, S,	1.00			1.00			1.00			1.00		
BASIC ENERGY DEMAND, E, 10^{12} Btu			23.7			27.1			29.3			34.3
UNIT BASIC DEMAND, E_u, 10^6 Btu/Household			3.9			3.9			3.9			3.9

REFERENCE TECHNOLOGIES: Gas burner, electric resistance heat.

DATA SOURCES:

D_i and f_i (for 1972): Btu/household requirements from Ref. (1); fraction of households per fuel type from 1970 census data (Ref. 2).

e_i : These are apparent relative efficiencies derived from Btu/household requirements assuming electric units have an apparent efficiency of 1.00.

BASIS OF PROJECTIONS: The basic demand for 1972 is escalated in proportion to the number of households projected for the reference years. Fuel distribution is projected in proportion to the decreasing saturation of gas and increasing saturation of electric ranges as reported in Ref. (1).

TABLE B-5

Region: NEW YORK STATE — PROJECTED FUEL MIX — Sector: RESIDENTIAL

Category: APPLIANCES & LIGHTING

	1972			1980			1985			2000		
DIRECT FUEL USE	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i
Methane	.01	.36	5.3	.01	.36	6.1	.01	.36	6.6	.01	.36	7.7
Jet Fuel												
Gasoline												
Distillate oil												
Residual oil												
Coal												
Other												
ELECTRICITY	.43	1.00	71.8	.49	1.00	93.9	.52	1.00	107.1	.63	1.00	152.6
TOTAL FUEL DEMAND, D, 10^{12} Btu			77.1			100.0			113.7			160.3
BASIS 10^6 Households			6.069			6.961			7.484			8.799
SATURATION, S,	.44			.50			.53			.64		
BASIC ENERGY DEMAND, E, 10^{12} Btu			73.7			96.1			109.5			155.4
UNIT BASIC DEMAND, E_u, 10^6 Btu/Household			27.6			27.6			27.6			27.6

REFERENCE TECHNOLOGIES: Vapor compression cycle in refrigeration; AC induction motor in appliances; 1972 mix of lighting and of vacuum tube, transistor and integrated circuits in electronic equipment.

DATA SOURCES:

D_i and f_i (for 1972): Summarized in Table III. Btu/household requirements from Ref. (1). The saturation factor is derived from 1970 census data (Ref. 2) escalated to 1972.

e_i : Only non-electric appliances are gas clothes dryers. e_i is an apparent relative efficiency derived from Btu/household requirements assuming electric dryers have an apparent efficiency of 1.00.

BASIS OF PROJECTIONS: The basic demands derived for 1972 are escalated in proportion to the projected saturation derived from Ref. (1), and the number of households projected for the reference years. In 2000 new residential electrical devices not yet in use are assumed to use as much energy as small appliances did in 1970 (1.6×10^6 BTU/HOUSEHOLD).

TABLE B-6

Region: NEW YORK STATE | PROJECTED FUEL MIX | Sector: COMMERCIAL | Category: SPACE HEAT

	1972			1980			1985			2000		
DIRECT FUEL USE	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i
Methane	.22	.49	116.4	.19	.49	124.2	.17	.49	120.7	.10	.49	89.4
Jet Fuel												
Gasoline												
Fuel Oil	.74	.48	393.0	.74	.48	493.6	.71	.48	514.5	.65	.48	593.1
Coal												
Other												
ELECTRICITY	.04	1.00	9.9	.07	1.00	22.4	.12	1.00	41.7	.25	1.00	109.5
TOTAL FUEL DEMAND, D, 10^{12} Btu			519.3			640.2			676.9			792.0
BASIS 10^9 Sq Ft			2.278			2.854			3.100			3.904
SATURATION, S,	1.0			1.0			1.0			1.0		
BASIC ENERGY DEMAND, E, 10^{12} Btu			255.6			320.2			347.8			438.0
UNIT BASIC DEMAND, E_u, 10^3 BTU/Sq Ft			112.2			112.2			112.2			112.2

REFERENCE TECHNOLOGIES: Burner devices for fossil fuels, electric resistance heat.

DATA SOURCES:

D_i and f_i (for 1972): These are the balance of fuels to the residential and commercial sector after all other categories have been accounted for, as reported in Reference (4). 1970 commercial inventory for the Northeast from Reference (1), escalated to 1972. New York State commercial floor space per building type (office, retail, school, hospital and other) derived from the commercial inventory for the Northeast based on selected indices.

e_i : Derived from Ref. (6), adjusted in a similar fashion as space heat in the residential sector.

BASIS OF PROJECTIONS:

The basic demand derived for 1972 is escalated in proportion to the commercial inventory projected over the reference years. U.S. commercial inventory is projected based on employment in wholesale & retail trade, finance, insurance, real estate, services and civilian government (Ref. 17). Floor space per employee in 2000 is assumed to be 10% above what it was in 1972. New York State commercial inventory derived from the U.S. total based on the 1972 OBERS earnings projections in same categories.

TABLE B-7

Region: NEW YORK STATE

PROJECTED FUEL MIX

Sector: COMMERCIAL

Category: WATER HEAT

	1972			1980			1985			2000		
	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i
DIRECT FUEL USE												
Methane	.24	.70	13.1	.20	.70	13.9	.18	.70	13.6	.10	.70	9.5
Jet Fuel												
Gasoline												
Distillate oil	.62	.54	44.5	.59	.54	53.0	.57	.54	55.6	.52	.54	63.9
Residual oil												
Coal												
Other												
ELECTRICITY	.14	1.00	5.5	.21	1.00	10.2	.25	1.00	13.2	.38	1.00	25.2
TOTAL FUEL DEMAND, D, 10^{12} Btu			63.1			77.1			82.4			98.6
BASIS 10^9 Sq Ft			2.278			2.854			3.100			3.904
SATURATION, S,	1.0			1.0			1.0			1.0		
BASIC ENERGY DEMAND, E, 10^{12} Btu			38.7			48.5			52.7			66.4
UNIT BASIC DEMAND, E_u, 10^3 Btu/Sq Ft			17.0			17.0			17.0			17.0

REFERENCE TECHNOLOGIES: Gas burner, oil burner and electric resistance heat.

DATA SOURCES:

D_i and f_i (for 1972): Unit demand from Ref. (1).

e_i : The relative efficiencies of gas, oil and electric are held in the same ratio as is given in Ref. (6), p. 18.

BASIS OF PROJECTIONS:

The basic demand derived for 1972 is escalated in proportion to the commercial inventory projected over the reference years.

TABLE B-8

PROJECTED FUEL MIX

Region: NEW YORK STATE

Sector: COMMERCIAL

Category: COOKING

	1972			1980			1985			2000		
	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i
DIRECT FUEL USE												
Methane	.84	.41	12.2	.79	.41	14.5	.76	.41	15.1	.66	.41	16.5
Jet Fuel												
Gasoline												
Distillate oil												
Residual oil												
Coal												
Other												
ELECTRICITY	.16	1.00	1.0	.21	1.00	1.6	.24	1.00	2.0	.34	1.00	3.5
TOTAL FUEL DEMAND, D, 10^{12} Btu			13.2			16.1			17.1			20.0
BASIS 10^6 meals			3821			4787			5200			6548
SATURATION, S,	1.00			1.00			1.00			1.00		
BASIC ENERGY DEMAND, E, 10^{12} Btu			6.0			7.5			8.2			10.3
UNIT BASIC DEMAND, E_u, Btu/meal			1568			1568			1568			1568

REFERENCE TECHNOLOGIES: Gas burner device and electric resistance heat.

DATA SOURCES:

D_i and f_i (for 1972): Energy demand for the U.S. from Ref. (27). Regional allocation based on commercial inventory. Number of meals assumes 19% of all meals prepared in commercial establishments (Ref. 6).

e_i : Taken as equal to the apparent relative efficiencies in the residential cooking category.

BASIS OF PROJECTIONS: The basic demand derived for 1972 is escalated in proportion to the commercial inventory projected over the reference years.

TABLE B-9

PROJECTED FUEL MIX

Region: NEW YORK STATE

Sector: COMMERCIAL

Category: AIR CONDITIONING

	1972			1980			1985			2000		
DIRECT FUEL USE	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i
Methane	.04	1.80	1.7	.03	1.80	1.7	.03	1.80	1.7	.02	1.80	1.7
Jet Fuel												
Gasoline												
Distillate oil												
Residual oil												
Coal												
Other												
ELECTRICITY	.46	3.00	11.6	.62	3.00	19.5	.70	3.00	24.0	.98	3.00	42.2
TOTAL FUEL DEMAND, D, 10^{12} Btu			13.3			21.2			25.7			43.9
BASIS 10^9 Sq Ft			2.278			2.854			3.100			3.904
SATURATION, S,	.50			.65			.73			1.00		
BASIC ENERGY DEMAND, E, 10^{12} Btu			37.8			61.6			75.1			129.6
UNIT BASIC DEMAND, E_u, 10^3 Btu/Sq Ft			33.2			33.2			33.2			33.2

REFERENCE TECHNOLOGIES: Absorption cycle for gas systems, vapor compression cycle for electric systems.

DATA SOURCES:

D_i and f_i (for 1972): Annual unit demand per building type derived from Ref. (1).

e_i : The efficiency is the coefficient of performance for air-conditioning equipment. The 1972 values are taken from the ASHRAE Guide and Data Book, American Society of Heating, Refrigeration, and Air-Conditioning Engineers, 1969. p. 514 A range of performance is indicated in that reference and the value taken for the electric system is at the upper end of the range while the low range value is used for the gas system.

BASIS OF PROJECTIONS: The basic demand derived for 1972 is escalated in proportion to the market saturation and the commercial inventory projected over the reference years. All commercial floor space is assumed to be air conditioned by the year 2000.

TABLE B-10

Region: NEW YORK STATE — PROJECTED FUEL MIX — Sector: COMMERCIAL
Category: LIGHTING & APPLIANCES

	1972			1980			1985			2000		
	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i
DIRECT FUEL USE												
Methane												
Jet Fuel												
Gasoline												
Distillate oil												
Residual oil												
Coal												
Other												
ELECTRICITY	1.00	1.00	85.5	1.00	1.00	107.0	1.00	1.00	116.3	1.00	1.00	146.4
TOTAL FUEL DEMAND, D, 10^{12} Btu			85.5			107.0			116.3			146.4
BASIS 10^9 Sq Ft			2.278			2.854			3.100			3.904
SATURATION, S,	1.0			1.0			1.0			1.0		
BASIC ENERGY DEMAND, E, 10^{12} Btu			85.5			107.0			116.3			146.4
UNIT BASIC DEMAND, E_u, 10^3 Btu/Sq Ft			37.5			37.5			37.5			37.5

REFERENCE TECHNOLOGIES: Electrical energy.

DATA SOURCES:

D_i and f_i (for 1972): Ref. (1); regional allocations based on commercial floor space.

e_i : Taken as unity since there is only one energy source employed.

BASIS OF PROJECTIONS: The basic energy demand derived for 1972 is escalated in proportion to the commercial inventory projected over the reference years.

TABLE B-11

Region: NEW YORK STATE — PROJECTED FUEL MIX — Sector: INDUSTRY — Category: ALUMINUM

	1972 f_i	1972 e_i	1972 D_i	1980 f_i	1980 e_i	1980 D_i	1985 f_i	1985 e_i	1985 D_i	2000 f_i	2000 e_i	2000 D_i
DIRECT FUEL USE												
Methane	.16	.64	3.1	.17	.64	4.4	.17	.64	5.6	.18	.64	10.6
Jet Fuel												
Gasoline												
Distillate oil												
Residual oil												
Coal - for carbon electrodes	.34	1.0	4.3	.33	1.0	5.6	.33	1.0	7.1	.32	1.0	12.0
Other												
ELECTRICITY												
Electrolysis	.38	.40	12.3	.37	.40	15.7	.37	.40	20.1	.36	.40	34.0
Drive	.12	1.00	1.6	.13	1.00	2.2	.13	1.00	2.8	.14	1.00	5.4
TOTAL FUEL DEMAND, D, 10^{12} Btu			21.3			27.9			35.6			62.0
BASIS 10^6 lbs Primary Al			448			573			731			1237
10^6 lbs Scrap			103			191			244			619
10^6 lbs Total			551			764			975			1856
SATURATION, S,												
BASIC ENERGY DEMAND, E, 10^{12} Btu			12.8			16.9			21.5			37.8
UNIT BASIC DEMAND, E_u, BTU/lb			23230			22120			22050			20370

REFERENCE TECHNOLOGIES: Electrolytic smelting, carbon cathodes and pot linings.

DATA SOURCES:

D_i and f_i (for 1972): Energy requirements for methane, coal and electricity for smelting and other primary and secondary processes plus foundry operations from Ref. (6) and AUI estimates. Production level based on capacity data (Ref. 8).

e_i : The efficiency for methane use is taken from Ref. (6) for process steam production. The electrolytic efficiency is based on a minimum theoretical requirement of 13,300 Btu/lb and includes the oxidation of carbon at the anode.

BASIS OF PROJECTIONS: Production is escalated in proportion to aluminum projections for the U.S. (Ref. 30), adjusted by the ratio of N.Y.S. to U.S. earnings in manufacturing in the projected year divided by the N.Y.S. to U.S. earnings in 1970 (Ref. 17). Scrap represents 25 % of the total through 1985 and is increased to 33% thereafter.

TABLE B-12

PROJECTED FUEL MIX

Region: NEW YORK STATE

Sector: INDUSTRY

Category: IRON

	1972			1980			1985			2000		
DIRECT FUEL USE	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i
Methane	.04	.64	1.8	.04	.64	1.8	.04	.64	1.9	.04	.64	2.3
Jet Fuel												
Gasoline												
Fuel Oil	.06	.68	2.3	.06	.68	2.4	.06	.68	2.6	.06	.68	3.3
Residual oil												
Coal	.85	.24	94.1	.85	.25	94.5	.85	.25	101.0	.85	.25	126.5
Other												
ELECTRICITY	.05	1.0	1.4	.05	1.0	1.4	.05	1.0	1.5	.05	1.0	1.9
TOTAL FUEL DEMAND, D, 10^{12} Btu			99.6			100.1			107.0			134.0
BASIS 10^3 Tons			3933			4095			4375			5479
SATURATION, S,												
BASIC ENERGY DEMAND, E, 10^{12} Btu			26.7			27.8			29.7			37.2
UNIT BASIC DEMAND, E_u, 10^3 Btu/Ton			6789			6789			6789			6789

REFERENCE TECHNOLOGIES: Blast Furnace.

DATA SOURCES:

D_i and f_i (for 1972): Energy requirements for blast furnace from Ref. (6) and AUI estimates. Production level from Ref. (8).

e_i : The efficiencies for methane and fuel oil are taken from Ref. (6), p. 18 for process steam production. The efficiency for coal is based on a minimum theretical requirement of 2860 BTU/lb. for the reduction of iron ore and includes the efficiency of converting coal to coke.

BASIS OF PROJECTIONS:

Production is escalated in proportion to pig iron projections for the U.S. (Ref. 30), adjusted by the ratio of N.Y.S. to U.S. earnings in primary metals in the projected year divided by the N.Y.S. to U.S. earnings in 1970 (Ref. 17).

TABLE B-13

PROJECTED FUEL MIX

Region: NEW YORK STATE

Sector: INDUSTRY

Category: STEEL

		1972			1980			1985			2000		
DIRECT FUEL USE		f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i
Methane		.67	.64	15.4	.66	.64	15.3	.65	.64	17.0	.64	.64	20.4
Jet Fuel													
Gasoline													
Fuel Oil	O.H.	.02	.68	0.5	.02	.68	0.4	.01	.68	0.3			
Coal													
Other													
ELECTRICITY	ELEC.	.07	1.0	1.0	.07	1.0	1.1	.08	1.0	1.2	.08	1.0	1.6
	B.O.F.	.24	1.0	3.6	.25	1.0	3.8	.26	1.0	4.4	.28	1.0	5.6
TOTAL FUEL DEMAND, D, 10^{12} Btu				20.5			20.6			22.9			27.6
BASIS 10^3 Short Tons				4114			4152			4655			5674
SATURATION, S,													
BASIC ENERGY DEMAND, E, 10^{12} Btu				14.8			14.9			16.7			20.3
UNIT BASIC DEMAND, E_u, 10^3 BTU/Ton				3597			3589			3588			3578

REFERENCE TECHNOLOGIES: Mix of electric furnace, basic oxygen process and open hearth furnace.

DATA SOURCES:

D_i and f_i (for 1972): Energy requirements for each technology from Ref. (6) and AUI estimates. Production level from Ref. (37).

e_i : Ref. (6), p. 18.

BASIS OF PROJECTIONS:

Production is escalated in proportion to AUI steel projections for the U.S., adjusted by the ratio of N.Y.S. to U.S. earnings in primary metals in the projected year divided by the N.Y.S. to U.S. earnings in 1970 (Ref. 17).

TABLE B-14

PROJECTED FUEL MIX

Region: NEW YORK STATE

Sector: INDUSTRIAL
Category: PROCESS HEAT

	1972			1980			1985			2000		
DIRECT FUEL USE	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i
Methane	.36	.64	104.1	.30	.64	105.5	.26	.64	102.4	.15	.64	80.7
Jet Fuel												
Gasoline												
Distillate oil												
Residual oil	.32	.68	88.4	.34	.68	112.6	.36	.68	133.5	.40	.68	202.6
Coal	.32	.70	86.9	.36	.70	115.8	.38	.70	136.9	.45	.70	221.4
Other												
ELECTRICITY												
TOTAL FUEL DEMAND, D, 10^{12} Btu			279.4			333.9			372.8			504.7
BASIS, MULTIPLE OF 1972			1.000			1.200			1.344			1.836
SATURATION, S,												
BASIC ENERGY DEMAND, E, 10^{12} Btu			187.6			225.1			252.1			344.4
UNIT BASIC DEMAND, E_u,												

REFERENCE TECHNOLOGIES: Burner devices for fossil fuels.

DATA SOURCES:

D_i (for 1972): The different demands represent the balance of unaccounted fuels to the industrial sector minus the consumption of oil refineries.

e_i : Ref. (6), P. 18.

f_i : Apparent fractions derived from 1972 data.

BASIS OF PROJECTIONS:

A 2.6% growth rate from 1972 to 2000 in the U.S. is based on two assumptions: 1) The average GNP growth rate in real dollars will be 3.2% between 1972 and 2000; 2) The ratio of energy consumed by industry to GNP will continue declining at the rate observed historically between 1960 and 1972. The 2.6% national growth rate is reduced to 2.3% from 1972 to 1985 and 2.1% thereafter for N.Y.S. This is based on the ratio of N.Y.S. to U.S. manufacturing earnings in the projected year divided by the N.Y.S. to U.S. earnings in 1970 (Ref. 17).

TABLE B-15

Region: NEW YORK STATE | PROJECTED FUEL MIX | Sector: INDUSTRIAL
Category: ELECTRIC DRIVE

	1972			1980			1985			2000		
	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i
DIRECT FUEL USE												
Methane												
Jet Fuel												
Gasoline												
Distillate oil												
Residual oil												
Coal												
Other												
ELECTRICITY	1.00	1.00	81.9	1.00	1.00	109.5	1.00	1.00	131.4	1.00	1.00	216.9
TOTAL FUEL DEMAND, D, 10^{12} Btu			81.9			109.5			131.4			216.9
BASIS, MULTIPLE OF 1972			1.000			1.337			1.604			2.649
SATURATION, S,												
BASIC ENERGY DEMAND, E, 10^{12} Btu			81.9			109.5			131.4			216.9
UNIT BASIC DEMAND, E_u,												

REFERENCE TECHNOLOGIES: AC Induction motor.

DATA SOURCES:

D_i (for 1972): Adjusted to provide the balance of unaccounted electric demand in the industrial sector as reported in Ref. (4).

e_i and f_i : Taken as unity since there is only one energy source indicated.

PROJECTIONS: A projected growth rate of 4.2% in the U.S. is reduced to 3.7% from 1972 to 1985 and 3.4% thereafter. This is based on the ratio of N.Y.S. to U.S. manufacturing earnings in the projected year divided by the N.Y.S. to U.S. earnings in 1970 (Ref. 17).

TABLE B-16

PROJECTED FUEL MIX

Region: NEW YORK STATE

Sector: INDUSTRY

Category: PETROCHEMICAL FEEDSTOCKS

	1972			1980			1985			2000		
	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i
DIRECT FUEL USE												
Methane	.03	1.00	6.0	.03	1.00	8.2	.03	1.00	10.0	.03	1.00	15.6
Jet Fuel												
Gasoline												
Petroleum Products	.94	1.00	167.4	.94	1.00	229.1	.94	1.00	278.7	.94	1.00	434.2
Residual oil												
Coal	.03	1.00	5.7	.03	1.00	7.8	.03	1.00	9.5	.03	1.00	14.8
Other												
ELECTRICITY												
TOTAL FUEL DEMAND, D, 10^{12} Btu			179.1			245.1			298.2			464.6
BASIS MULTIPLE of 1972			1.000			1.369			1.665			2.594
SATURATION, S,												
BASIC ENERGY DEMAND, E, 10^{12} Btu			179.1			245.1			298.2			464.6
UNIT BASIC DEMAND, E_u,												

REFERENCE TECHNOLOGIES: Undefined

DATA SOURCES:

D_i (for 1972): N.Y.S. energy consumption derived from Middle Atlantic census region data (Ref. 30) regionalized based on earnings in SIC 28.

e_i : These are taken as unity since no substitution of resources is considered in the reference years.

f_i : Apparent fractions derived from D_i and e_i.

BASIS OF PROJECTIONS:

The basic energy demand is escalated at a 4% growth rate to 1985 and is decreased to 3% thereafter.

TABLE B-17

PROJECTED FUEL MIX

Region: NEW YORK STATE

Sector: TRANSPORATION
Category: AUTOMOBILE

	1972			1980			1985			2000		
	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i
DIRECT FUEL USE												
Methane												
Jet Fuel												
Gasoline	1.00	.20	591.9	1.00	.22	701.2	1.00	.29	610.3	1.00	.37	579.1
Distillate oil												
Residual oil												
Coal												
Other												
ELECTRICITY												
TOTAL FUEL DEMAND, D, 10^{12} Btu			591.9			701.2			610.3			579.1
BASIS 10^9 VEHICLE-MILES												
AUTO			63.853									
MOTORCYCLE			0.362									
TOTAL / SATURATION, S,			64.215			83.621			94.263			115.872
BASIC ENERGY DEMAND, E, 10^{12} Btu			118.4			154.3			177.0			214.3
FUEL EFFICIENCY (BTU/VEHICLE-MILE) mpg												
AUTO	(9256)		13.5	(8386)		14.9	(6474)		19.3	(4998)		25.0
MOTORCYCLE	(2499)		50.0									

REFERENCE TECHNOLOGIES: Internal combustion engine.

DATA SOURCES:

D_i and f_i (for 1972): Reference (10).

e_i : Estimated at 20%.

BASIS OF PROJECTIONS:

Fuel efficiency reduced by 10% of that mandated by the Energy Policy and Conservation Act (Ref. 20); the fleet efficiency derived using Ref. (19). Vehicle-miles per year assumed to remain at the 1972 level of 10,200 miles/vehicle. The ratio of vehicles to driving age population is projected to increase in proportion to growth in the U.S. fleet, from 0.49 in 1972 to 0.67 in 2000.

TABLE B-18

PROJECTED FUEL MIX

Region: NEW YORK STATE

Sector: TRANSPORTATION

Category: TRUCK AND BUS

	1972			1980			1985			2000		
	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i
DIRECT FUEL USE												
Methane												
Jet Fuel												
Gasoline	.80	.20	151.1	.62	.22	145.1	.50	.24	127.5	.43	.30	140.2
Diesel Fuel	.20	.20	36.8	.38	.22	88.3	.50	.24	127.3	.57	.30	187.7
Residual oil												
Coal												
Other												
ELECTRICITY												
TOTAL FUEL DEMAND, D, 10^{12} Btu			187.9			233.4			254.8			327.9
BASIS, 10^9												
PASSENGER-MILES												
LOCAL BUS			3.8			4.3			4.6			6.7
INTERCITY BUS			1.5			1.5			1.5			1.6
TON-MILES												
TRUCK			18			25			29			45
NON-FREIGHT TRUCKING VEHICLE-MILES			9			12			14			21
BASIC ENERGY DEMAND, E, 10^{12} Btu			37.6			51.3			61.2			98.4
ENERGY INTENSIVENESS												
BTU/PASSENGER-MILE												
LOCAL BUS			1704			1704			1704			1704
INTER-CITY BUS			1160			1160			1160			1160
BTU/TON-MILE												
TRUCK			3283			3152			2988			2823
BTU/VEHICLE-MILE												
NON-FREIGHT TRUCKING			13402			12126			11328			8935

REFERENCE TECHNOLOGIES: Internal combustion engine.

DATA SOURCES :

D_i (for 1972): Gasoline and diesel fuel consumption from Ref. (10). Bus passenger-miles from Ref. (36). Truck ton-miles and non-freight trucking vehicle-miles derived from U.S. data based on the fraction of fuel consumed in N.Y.S. relative to the U.S.

e_i : Estimated at 20%. Energy intensiveness by mode from Ref. (29).

f_i : Apparent fraction based on 1972 data.

BASIS OF PROJECTIONS :

Ton-miles and vehicle-miles derived from projected U.S. data based on 1) the fraction of fuel consumed in N.Y.S. relative to the U.S. and 2) the ratio of N.Y.S. to U.S. total earnings in the projected years divided by the N.Y.S. to U.S. earnings in 1970 (Ref. 17). Truck ton-miles in the U.S. projected to grow at the same rate as GNP (3.2%). Non-freight trucking vehicle-miles in the U.S. projected to grow at 4% to 1985 and 3% thereafter. Bus passenger-miles from Ref. (36).

TABLE B-19

Region: NEW YORK STATE PROJECTED FUEL MIX Sector: TRANSPORTATION

Category: RAILROADS AND TRANSIT

	1972			1980			1985			2000		
	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i
DIRECT FUEL USE												
Methane												
Jet Fuel												
Gasoline												
Distillate oil	.29	.30	12.9	.30	.30	14.6	.31	.30	15.7	.33	.30	19.7
Residual oil												
Coal												
Other												
ELECTRICITY	.71	1.0	9.5	.70	1.0	10.2	.69	1.0	10.6	.67	1.0	12.0
TOTAL FUEL DEMAND, D, 10^{12} Btu			22.4			24.8			26.3			31.7
BASIS 10^9 TON-MILES			18.2			20.6			22.1			27.8
SATURATION, S,	1.0			1.0			1.0			1.0		
BASIC ENERGY DEMAND, E, 10^{12} Btu			13.4			14.6			15.3			17.9
ENERGY INTENSIVENESS BTU/TON-MILE			709			709			709			709

REFERENCE TECHNOLOGIES: Diesel engine and electric motor propulsion on conventional tracks.

DATA SOURCES:

D_i (for 1972): Diesel fuel from Ref. 11, electricity consumption from Ref. 4.

e_i : Estimated relative efficiencies of oil and electric propelled vehicles.

f_i : Apparent fraction based on 1972 data.

BASIS OF PROJECTIONS: Diesel engines from Reference 36.

TABLE B-20

Region: NEW YORK STATE — PROJECTED FUEL MIX — Sector: TRANSPORTATION

Category: AIR

	1972 f_i	1972 e_i	1972 D_i	1980 f_i	1980 e_i	1980 D_i	1985 f_i	1985 e_i	1985 D_i	2000 f_i	2000 e_i	2000 D_i
DIRECT FUEL USE												
Methane												
Jet Fuel	1.00	.30	220.4	1.00	.32	278.0	1.00	.33	364.1	1.00	.34	772.8
Gasoline	~ 0	.30	0.7									
Distillate oil												
Residual oil												
Coal												
Other												
ELECTRICITY												
TOTAL FUEL DEMAND, D, 10^{12} Btu			221.1			278.0			364.1			772.8
BASIS 10^9 Passenger-Miles			22			30			40			86
10^9 Ton-Miles			1.1			1.6			2.7			5.4
SATURATION, S,												
BASIC ENERGY DEMAND, E, 10^{12} Btu			66.3			89.0			120.2			262.8
ENERGY INTENSIVENESS, BTU/PASSENGER-MILE			8698			7918			7431			7431
BTU/TON-MILE			26162			25306			24771			24771

REFERENCE TECHNOLOGIES: Aircraft gas turbines (turbofan).

DATA SOURCES:

D_i (for 1972): U.S. jet fuel consumption (Ref. 8) regionalized to N.Y.S. based on Bureau of Mines data (Ref. 32). Aviation gasoline consumption from Ref. (10).

e_i : Estimated efficiencies for aircraft gas turbines.

f_i : Apparent fraction based on 1972 data.

BASIS OF PROJECTIONS :

U.S. domestic and international passenger-miles from ATAA (Ref. 34&35) adjusted to include general aviation. Projection of U.S. air freight ton-miles from Ref. (30). U.S. air passenger-mile and ton-mile projections regionalized to N.Y.S. based on the 1972 ratio of N.Y.S. air transport fuel consumption to U.S. consumption, adjusted downward for the decreasing N.Y.S. to U.S. total earnings projections. Efficiency improvements from Ref. (29).

TABLE B-21

PROJECTED FUEL MIX

Region: NEW YORK STATE

Sector: TRANSPORTATION

Category: SHIPS

	1972			1980			1985			2000		
DIRECT FUEL USE	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i
Methane												
Jet Fuel												
Gasoline	.07	.20	6.8	.07	.20	9.1	.07	.20	10.6	.07	.20	14.6
Distillate oil												
Residual oil	.93	.20	90.8	.93	.20	120.6	.93	.20	139.2	.93	.20	207.1
Coal												
Other												
ELECTRICITY												
TOTAL FUEL DEMAND, D, 10^{12} Btu			97.6			129.7			149.8			221.7
BASIS 10^9 TON-MILES			160			213			246			365
SATURATION, S,			1.0			1.0			1.0			1.0
BASIC ENERGY DEMAND, E, 10^{12} Btu			19.5			25.9			30.0			44.3
ENERGY INTENSIVENESS BTU/TON-MILE			567			567			567			567

REFERENCE TECHNOLOGIES: Steam and internal combustion engines.

DATA SOURCES:

D_i (for 1972): Reference 36.

e_i : Estimated at 20%.

f_i : Apparent fraction based on 1972 data.

BASIS OF PROJECTIONS : Reference 36.

TABLE B-22

Region: NEW YORK STATE PROJECTED FUEL MIX Sector: ELECTRIC UTILITY

	1972			1980			1985			2000		
DIRECT FUEL USE	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i
Methane	.04	.326	46.3									
Methane Gas Turbine	.01	.22	19.5									
Residual Oil	.41	.326	452.5	.43	.33	668.5	.37	.34	673.2	.20	.34	624.4
Distillate Gas Turbine	.05	.22	73.6	.01	.25	8.4	.01	.28	16.1	~0	.28	18.2
Coal	.16	.326	175.5	.15	.33	227.3	.17	.34	305.6	.26	.35	800.3
Hydroelectric	.27	.326	290.5	.21	.33	324.2	.16	.34	305.6	.09	.34	277.6
Nuclear LWR	.06	.31	67.4	.20	.32	320.9	.29	.33	550.9	.45	.33	1467.3
TOTAL FUEL DEMAND, D, 10^{12} Btu			1125.3			1549.3			1851.4			3187.8
BASIS Σ Electric from other Categories			327.4			465.3			570.4			982.3
NET GENERATION = $\frac{\text{DEMAND}}{\text{TRANSMISSION LOSS}}$			327.4/0.92			465.3/0.92			570.4/0.92			982.3/0.92
PUMPED STORAGE LOSSES						1.6			3.0			8.4
BASIC ENERGY DEMAND, E, 10^{12} Btu			355.9			507.4			623.0			1076.1

REFERENCE TECHNOLOGIES: The fossil fuels are consumed in steam electric plants with no topping cycle. Oil and gas are consumed in gas turbine peaking units with no heat recovery.

DATA SOURCES:

D_i and f_i (for 1972): The fraction of the basic energy demand satisfied by each fuel from Ref. (38) and personal communication with the NYS utilities.

e_i : Conventional steam-electric and hydropower converted at an average heat rate of 10478 Btu/kWh (Ref. 8). Gas turbine efficiency derived from fuels consumed and generation data (Ref. 38). The LWR efficiency is reduced from its nominal value of 33% to reflect the electrical energy output required to operate gaseous diffusion plants to separate U-235.

BASIS OF PROJECTIONS: The basic energy demand for electricity is obtained from the summation of electrical demands in all other demand categories adjusted to include transmission, distribution, and pumped storage losses. The fraction of the basic energy demand that is satisfied by each fuel for 1980 and 1985 is from Ref. (38). Residual oil, distillate oil and hydro are held at the 1991 levels projected in Ref. (38) in the year 2000. Two additional 1000 mw pumped storage plants are assumed to become operational between 1991 and 2000 in addition to the four 1000 mw plants projected to be in operation by 1991 (Ref. 38). Nuclear capacity is increased from 1985 such that 45% of the demand for electricity is generated by nuclear power in 2000. The remainder of the demand for electricity in NYS is generated from coal.