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COMMERCIAL EQUIPMENT LOADS

END-USE LOAD AND CONSUMER ASSESSMENT PROGRAM (ELCAP)

PREPARED FOR

Bonneville Power Administration

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FOREWORD

The Office of Energy Resources of the Bonneville Power Administration is generally responsible for the agency's power and conservation resource planning. An associated responsibility which supports a variety of office functions is the analysis of historical trends in and determinants of energy consumption. The Office of Energy Resources' End-Use Research Section operates a comprehensive data collection program to provide pertinent information to support demand-side planning, load forecasting, and demand-side program development and delivery. Part of this on-going program is known as the End-Use Load and Consumer Assessment Program (ELCAP), an effort designed to collect electricity usage data through direct monitoring of end-use loads in buildings. This program is conducted for Bonneville by the Pacific Northwest Laboratory.

This report provides detailed information on electricity consumption of miscellaneous equipment from the commercial portion of ELCAP. Miscellaneous equipment includes all commercial end-uses except heating, ventilating, air conditioning, and central lighting systems. Some examples of end-uses covered in this report are office equipment, computers, task lighting, refrigeration, and food preparation. Electricity consumption estimates, in kilowatt-hours per square foot per year, are provided for each end-use by building type. The following types of buildings are covered: office, retail, restaurant, grocery, warehouse, school, university, and hotel/motel.

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Section 1

INTRODUCTION

A wide variety of equipment with highly varying patterns of usage is found in commercial buildings. Examples include typewriters, personal and mainframe computers, copying machines, refrigerators, ovens, grills, task lights, elevators, water heaters, dishwashers, and power tools. All these devices consume energy--but how much?

Utility billing information suggests that the miscellaneous equipment in commercial buildings draws a substantial load. Because certain equipment types (computers, for example) are expected to increase in number, planners expect that energy consumption by such equipment will also increase, thus becoming an even more significant determinant of overall electricity use in the commercial sector. If the anticipated increase does occur, equipment loads could become an important near-term target of conservation efforts or efficiency standards development in the Pacific Northwest.

Until recently, the extent and magnitude of energy consumed by equipment in the commercial sector were neither well-characterized nor well-quantified. However, as a result of an end-use metering effort in the Pacific Northwest region, the Bonneville Power Administration (Bonneville) now has the means with which to study commercial building equipment loads.

Bonneville began metering commercial electricity use through the End-Use Load and Consumer Assessment Program (ELCAP) in 1986. Conducted for Bonneville by the Pacific Northwest Laboratory (PNL), ELCAP involves collecting and analyzing hourly energy end-use data, as well as information on occupant and structure characteristics, in a sample of 126 commercial buildings. For a subset of 86 buildings in the Seattle area, the equipment inventories are particularly detailed, mapping each device to the data logger channel on which its energy consumption is measured (Bonneville Power Administration 1984). In addition, the equipment in those buildings has been inspected and documented in detail. Because of the rigorous metering and information collection procedures built into ELCAP, the resulting database offers a uniquely rich source of details for studying how commercial buildings in Bonneville's service territory use the electric power that the agency supplies.

The analysis documented in this report drew upon the ELCAP database to characterize and quantify energy consumption by equipment in commercial buildings. Pacific Northwest Laboratory researchers analyzed equipment loads for 11 types of buildings from the ELCAP commercial building sample. The loads examined were those associated with 17 types of equipment found in commercial buildings, including food preparation, laboratory, material handling, refrigeration, computing, shop, hot water, sanitation, task lighting, miscellaneous, and office equipment.

Three properties for each equipment category were determined for each building type:

- the capacity density: the numbers and kinds of equipment found, on average, in commercial buildings, in terms of both number of devices and kilowatts of installed capacity
- the utilization factor: the product of a device's average operating time (the fraction of total hours in the year that the equipment operates) and its average load factor (the fraction of the equipment's rated capacity that it actually draws when operating)
- electricity consumption estimates: the product of the density of the equipment and its utilization.

The key findings are presented in Section 2. Section 3 documents the underlying motivation and objectives of the analysis. In Section 4, the methodology is explained in terms of the commercial building sample, the data sources, and the analysis approach. The detailed analysis results are presented in three separate sections. Section 5 presents the results of the device counts and associated installed capacities by equipment category for each building type. The utilization factor results are provided in Section 6.

In Section 7, the estimates of electricity consumption for the various equipment categories within and across building types are presented. The complete analysis methodology is detailed in Appendixes A through F.

Section 2

KEY FINDINGS

The results of this analysis help close the knowledge gap about what constitutes commercial equipment loads. As presented in this report, the results are designed to inform other analysts of regional commercial sector loads and conservation resource potential.

In this section, key findings are used selectively to illustrate the significance of the results for each of three properties: capacity densities, utilization factors, and consumption estimates.

CAPACITY DENSITIES

As part of summarizing the equipment population, we determined the capacity density, or number of kilowatts per square foot of building floor area, for each type of equipment and each building type. The capacity density results are drawn from survey information in the ELCAP database (collected at the time of meter installations).

The equipment density data provides an unprecedented view of the composition of the equipment in a large number of commercial buildings. Until other data is collected and analyzed, this is the best such planning information available. Programs designed to lower the load consumed by a given type of equipment can now target market segments with the largest potential impact. Those programs can also use delivery mechanisms appropriate to the building type and the equipment involved. For example, retrofit programs may be feasible for large computers, which are few in number but large in size. On the other hand, the numerous small personal computers might require rebate or incentive programs designed to work with the retail or wholesale sales mechanisms.

The Pacific Northwest Nonresidential Survey (PNNonRES) is currently collecting survey data for a statistical sample of regional commercial buildings (Bonneville Power Administration and ADM Associates, Inc. 1989). As the survey data becomes available, it can be used in conjunction with the equipment utilization factors developed in this analysis to improve the regional load estimates.

UTILIZATION FACTORS

Utilization factors account for a device's average operating time (the fraction of total hours in the year that the equipment operates) and its average load factor (the fraction of the equipment's rated capacity that it actually draws when operating). Our utilization factor results are highlighted here by example.

As expected, the mainframe computers in offices appear to operate continuously. For comparison, we found that personal computer equipment utilization is about 19%, a reasonable factor, based on potential operation for only the usual 40-hour work week. The utilization factors for office equipment and task lighting equipment (both 14%) are similar but slightly less, indicating that a substantial number of the personal computers are probably left on overnight. Utilization factors for elevators (vertical transportation-intermittent), laboratory, materials handling, and food preparation equipment in offices are very low (less than 2%). Hot water equipment utilization is also low at 4%.

Higher utilization factors for computer equipment in retail stores (58%) and groceries (45%) are consistent with the greater number of operating hours per week, as well as with the use of computerized cash register and inventory control systems that typically remain on continuously in these buildings. Lower factors for restaurants (12%) and warehouses (8%) are consistent with the part-time use of personal computer systems for office-like functions in those building types.

Like the capacity density findings, the utilization results are directly relevant to the design of conservation programs and technologies. For example, the low utilization factors found for hot water equipment in much of the commercial sector suggest that the energy consumed by this equipment results largely from standby heat losses that could be reduced by better tank insulation. Similarly, devices to turn off large computer systems appear to be irrelevant, because these large systems are clearly left on most of the time. Technologies such as efficient computer chips that save energy during operation may be more appropriate. On the other hand, personal computer equipment is frequently turned off. Hence, programs built around devices that turn them off or place them in a low-power standby mode might be effective.

ELECTRICITY CONSUMPTION ESTIMATES

Consumption by equipment type and building type was also estimated. A consumption estimate is simply the product of the density of the equipment and its utilization. Table 2-1 gives a brief summary of the consumption estimates we developed, in terms of equipment types found to have the highest consumption within each building type.

Computers have the highest estimated consumption in office buildings, while water heat is the greatest equipment load in schools and universities. As indicated in Table 2-1, refrigeration and food preparation equipment, when present in a building, consume very large amounts of energy.

Such consumption estimates can provide the basis for constructing the composition of electricity consumption by miscellaneous equipment in a commercial building type and in the sector as a whole. Overall estimates of consumption by equipment type and building type can be used to target conservation programs toward equipment and building types that have large potential impact. Further, the process of estimating loads by equipment type can be used to project future consumption stemming from changes in equipment

TABLE 2-1

Highest Estimated Equipment Loads by Building Type

Building Type	Equipment Types with Highest Consumption	Estimated Energy Consumption, kWh/ft2-yr
Small office	Large computer	1.58
	Office equipment	0.93
Large office	Large computer	1.98
	Personal computer	1.07
Small retail	Unitary refrigeration	1.19
	Office equipment	0.85
Large retail	Task lighting	1.01
Restaurant	Continuous food preparation	7.66
	Central refrigeration	5.83
Grocery	Central refrigeration	25.56
	Unitary refrigeration	7.09
Warehouse	Office equipment	0.63
	Unitary refrigeration	0.46
School	Water heating	5.54
University	Water heating	1.24
Hotel/motel	Task lighting	1.60
	Water heating	1.18

population or usage. An example would be increased capacity densities and utlization factors for personal computer equipment because they are left on all night to maintain connectivity with a new local area network.

Finally, if the consumption estimates are multiplied by the estimated floor area in the Pacific Northwest region for each building type, a view of overall regional consumption by each category of commercial building equipment can be developed. This view would be valuable for quantifying the potential impact of technologies or programs that might be developed for an equipment type across various types of buildings.

In Table 2-2, the total estimated regional load for each equipment category in each building type is displayed in average megawatts (MWa). The four equipment categories with the largest contribution to the regional estimated loads are refrigeration (382 MWa), water heating (214 MWa), food preparation equipment (132 MWa), and personal and large computers (113 MWa).

The total consumption of commercial sector miscellaneous equipment is estimated to be greater than 1100 MWa. This level is roughly equivalent to the annual power output from two 500-MW coal-fired power plants. The magnitude of this estimated total load indicates considerable conservation potential in equipment loads.

TABLE 2-2

Estimated Regional Load for 17 Equipment Categories

Equipment Categories	Estimated Regional Megawatts
Office equipment	77.32
Food preparation	
Continuous	110.65
Intermittent	21.56
Laboratory	5.70
Material handling	20.87
Refrigeration	
Unitary	161.58
Central	220.40
Sanitation	36.90
Vertical transport	
Continuous	0.08
Intermittent	4.03
Shop	20.71
Miscellaneous	
Continuous	13.67
Intermittent	51.55
Hot water	214.08
Computers	
Personal	49.47
Large	63.47
Task lighting	34.18
TOTAL	1106.22

Section 3

ANALYSIS OVERVIEW

The reasons for undertaking this analysis are discussed in this section. In addition, the objectives of the analysis are listed in the form of research questions that we sought to answer.

MOTIVATION

This analysis was performed for two reasons. The first was to gain an understanding of the composition of equipment loads in the commercial sector. Equipment loads have long represented a large but poorly understood portion of commercial building energy use. The amount of power consumed by each individual device may be relatively inconsequential. However, the total consumption by all devices is large and suggested by many to be growing. The conservation potential of these loads varies for each equipment type, as a function of both the characteristics of the equipment itself and how it is used.

The second, and more specific, motivation for the analysis was to support Bonneville's ongoing evaluation of the load growth and future conservation potential for specific types of equipment. Computer equipment was of particular interest, because the use of personal computers in businesses is increasing and computer technology is evolving rapidly. Estimates of current numbers and usage of computers were required as a baseline, to develop load growth scenarios and to analyze the impacts of new technology and increased equipment efficiencies on load growth. Such analyses might suggest, for example, that conservation programs be designed to promote energy-efficient computer equipment.

Although other specific types of commercial building equipment (refrigeration equipment, for example) have previously been studied for their conservation potential, most equipment types had received little or no attention in this regard. Thus, there was also a need to determine whether any other equipment types show promise for further investigation as targets for conservation.

The equipment utilization factors developed in this study can be applied in three more general ways:

- predicting equipment loads from building survey data
- developing guidelines for estimating equipment loads for commercial building energy audits
- estimating end-use loads by disaggregating building total or mixed end-use load data.

These applications are explained in more detail below.

Bonneville's ongoing Pacific Northwest Nonresidential Survey (PNNonRES) is collecting survey data for a statistical sample of regional commercial buildings (Bonneville Power Administration and ADM Associates, Inc. 1989). Included is data on connected loads, and steps have been taken to make this data compatible with the ELCAP commercial inspection data. As the PNNnonRES data becomes available in the near future, it will provide a broader regional context for the results developed here, allowing the creation of truly regional estimates of equipment densities and building types. The equipment utilization factors developed in this analysis can then be used to develop regional load estimates from the PNNnonRES data as well.

Audit models have historically been used as one means of estimating equipment usage. However, other work using ELCAP data has shown that equipment loads are consistently overestimated by about 60% in energy audits of commercial buildings (Cambridge Systematics 1988; Pratt 1989). The estimated utilization factors resulting from this analysis can be used with onsite audit inspections of the equipment in the buildings to produce estimates of equipment loads based on average usage. While such estimates are accurate only on average, they are very useful in the absence of other information. When specific information on equipment use has been acquired through discussions with the building occupants, the estimates then serve as a starting point for adjusting equipment loads on the basis of the reported usage patterns.

Finally, the equipment load estimates can be used to disaggregate equipment loads from other end-use loads when they are not separately metered. For example, in some of the ELCAP buildings, portions of the lighting and equipment loads are metered together (and assigned to the Mixed General end use) for cost-efficiency reasons. The results of the analysis reported here can be used to estimate the individual contributions for lights and equipment in these buildings. With the individual contribution estimates, analysts can then subdivide the Mixed General end-use loads in each building into the individual end uses contributing to it, for summarizing ELCAP commercial end-use loads (Taylor and Pratt 1989).

OBJECTIVES

The objectives of this analysis fall into three general categories: equipment population summary; equipment utilization; and estimated electricity consumption for equipment types. The research objectives are phrased as questions and categorized below.

In ***summarizing the equipment population***, we sought answers to three questions:

- What are the equipment categories that permit comparison across the 11 building types?
- What is the average number of devices within each equipment category by building type?
- What is the average power capacity within each equipment category by building type?

Our ***determination of equipment utilization*** addressed one key question:

- What is the utilization of the equipment types with respect to installed capacities?

To determine a preliminary ***estimate of the electricity consumed by the various equipment types***, we pursued three questions:

- What is the estimated annual electricity consumption, in kilowatt-hours per square foot per year, for each equipment category by building type?
- What is the estimated contribution to regional load for each equipment type?
- What equipment categories present good conservation targets?

Section 4

METHODOLOGY

A commercial building's total equipment load--the amount of electric power drawn from a power source--is a composite of loads from a wide variety of devices that are subject to varied patterns of use. These diverse properties create difficulties in attempting to quantify equipment loads in the commercial sector with any certainty.

In this section, the analysis methodology devised to address those difficulties is described. First, we describe the sample of commercial buildings from which various kinds of data are collected as part of ELCAP. Next, we discuss the types of data we used as sources for this analysis. Finally, we document the approach we took to define the equipment categories, summarize the equipment population, determine the equipment utilization, and develop estimates of consumption by equipment category.

THE COMMERCIAL BUILDING SAMPLE

The ELCAP commercial sector buildings are divided into studies, each designed to support analysis of different issues relating to the basic character of commercial sector loads, energy standards, and conservation programs:

- The Commercial Base (Base) Study consists of a random sample of small and medium-sized buildings in Seattle. The Base Study sample is designed to represent the existing and new populations of regional commercial sector buildings for the purpose of developing a basic characterization of end-use loads and conservation potential.
- The Commercial Retrofit End-Use Study (CREUS) consists of a nonrandom selection of buildings from several cities in the Pacific Northwest region, all of which had received energy audits. The CREUS is designed to support analysis of the effectiveness of energy audit-based programs in predicting conservation savings resulting from retrofits in existing commercial buildings.

The number of buildings available in the ELCAP database and used at different stages of the analysis are shown in Table 4-1 by building type. Data from both the Base Study and the CREUS buildings was used to develop summaries of the equipment found in commercial buildings. Doing so maximizes the number of buildings used. The sample of metered commercial buildings for the Base Study and CREUS combined is shown by building type in the first column. The second column indicates the number of these buildings whose equipment survey data is summarized in Section 5 of this report.

TABLE 4-1

ELCAP Building Sample Used in Equipment Load Analysis

Building Type	Base Study+CREUS Buildings Originally Installed	Base Study+CREUS Buildings Equipment Summarized	Base Study Originally Installed	Base Study Currently Remaining	Used for Utilization Estimates
Office	29	26	20	19	14
Retail	28	27	20	17	12
Grocery	22	19	15	10	10
Restaurant	15	15	9	8	8
Warehouse	15	13	14	12	11
School	4	4	4	3	4
Other	6	5	6	2	4
Hotel	11	8	2	0	2
University	2	2	2	2	0
Total	132	119	92	73	65

Five of the major building types--office, retail, grocery, restaurant, and warehouse--have relatively large sample sizes. However, four building types--hotel, school, university, and other--are represented by much smaller sample sizes. Smaller sample sizes generally cause less statistically certain results. For this reason, we could not determine equipment utilization with confidence for some building and equipment types, particularly for the four building types represented by small samples.

Table 4-1 also shows the numbers of Base Study buildings that were originally installed with metering equipment, as well as the numbers of those buildings now remaining in the Base Study data collection effort. The right-hand column of Table 4-1 lists the numbers of buildings that were used in our estimation of equipment utilization. At present, only Base Study buildings can be used for this purpose. The CREUS buildings were installed before the equipment survey used in the Base Study was finalized, so the end use on which the load from any given piece of equipment appears is not known with any certainty. Thus, data from only the Base Study buildings was used in determining equipment utilization.

The term ***building*** is used, in the usual fashion, to indicate a structural entity contained by a continuous building shell. Under certain circumstances, multiple ***sites*** may be defined within a single building. The classic example is a retail strip building with a shoe store, a fast food restaurant, and a small office. Sites are defined where individual businesses are isolated physically and by the metering equipment, and so tend to have less mixture and therefore more clearly defined business types.

The unit on which this analysis is based is the commercial building (as opposed to a commercial site). We used buildings because one of our primary data sources--the inspection survey information--was collected on a building-by-building basis.

DATA SOURCES

Two sources of data from the ELCAP database were used in this analysis:

- metered end-use data, to estimate utilization factors
- survey data, to summarize the equipment population and to calculate the capacity in kilowatts for the equipment loads.

Each type of data is discussed in this section.

Metered Data

Data collection began in a few ELCAP buildings as part of a pilot study in Fall 1984. Most buildings, however, were not installed with fully operational metering equipment until mid-1986 or later.

This analysis used data collected from the earliest possible date for each building through calendar year 1988, though the data time series ends in October 1988 for most buildings. The version of the ELCAP preaggregated dataset accessed was PADS-COM-Dec88.

The ELCAP metered end-use data is very detailed. Data is collected in highly disaggregated form (up to 22 end uses) and at high time resolution (hourly). The ELCAP commercial end uses are listed in Table 4-2. Quality is ensured by checking that the sum of the metered loads is equal to the separately metered building total for every hour, within the accuracy of the equipment. This test is also performed at lower levels in each building's electrical distribution system (Pearson, Stokes, and Crowder 1985). Data failing this test is treated as missing.

Fourteen of the end uses listed in Table 4-2 measure electricity consumption by equipment as defined for this analysis. This detail was essential for our utilization analysis. Only much less detailed equipment utilization estimates would have been possible if the equipment loads were metered as a group without further detail. However, the level of detail with which these end uses is applied is a function of both the buildings' size and the complexity of their electrical distribution systems.

The hourly data were aggregated to monthly and then annual levels for use in this analysis. The hourly end-use data in each building was first averaged by hour of day for each month to create an average 24-hour profile. A monthly load was created by summing the 24 values in the profile. Thus, missing hourly values were implicitly filled with the average load for that hour of day. If too much data was missing for a month, and data for that calendar month from other years was not available, then no annual load was developed for that end use for that building, and its load data was not used in this analysis. Loads from more than one year for a given month were averaged to form an average monthly load for that calendar month. For example, if more than one January were available, then all those Januaries were averaged to form the average January load.

A fundamental consideration was the availability of sufficient end-use data to characterize the average annual loads in the utilization analysis. We used the average of the average monthly loads for each calendar month. Data from all 12 calendar months was not required because, unlike other end-use loads, equipment loads are not strongly dependent on time of the year.

The procedure we used for creating average annual loads from multiple years of metered hourly data, including inevitable periods of missing data, is described in detail in Taylor and Pratt (1989).

<u>Survey Data</u>

In addition to the metered data, extensive survey data was collected for each building when the metering equipment was installed. This data, collected by trained surveyors during onsite inspections, includes information such as building construction, occupancy, HVAC systems, and a connected load inventory.

TABLE 4-2

Commercial End-Use Definitions

End-Use Category	End Use
Heating, ventilating and air conditioning	Heating Cooling Ventilation Auxiliaries Mixed HVAC Electric Proxy for Fuel Heat
Lighting	Interior Lighting Exterior Lighting
Equipment	Mixed General Receptacles Data Processing Refrigeration Water Heating Vertical Transport Food Preparation Material Handling Sanitation Recreation Laboratory Shop Specialty 1-5 Electrical Proxy For Hot Water

Critical to our analysis, the connected load inventory is a catalogue of all equipment in each building, indicating the equipment type, nameplate capacity rating, location, type of fuel used (gas equipment is included in the inventory), and any special controls for each piece of equipment. The connected load inventory identifies equipment types in a very detailed fashion. A complete list of ELCAP equipment type codes is given in Table A-1 in Appendix A.

A label is required by law to be affixed to each piece of electrical equipment used in buildings, indicating certification by a testing laboratory as to its safety. Included on these labels is a nominal "nameplate" capacity rating, indicating the maximum power consumed by the device, in watts or kilowatts. Electricians use this information to determine the size of wire needed to carry power to the device, and to determine if the existing wiring is sufficient when a new device is being installed. Thus, the nameplate capacity is an indication of the power drawn when the device is operating. It actually is an upper limit for the power drawn (except for very short-duration startup transients for devices like electrical motors, for example).

In the ELCAP connected load inventory, nameplate capacity ratings of over 1 kilowatt (kW) are recorded for all equipment. When a number of devices of a single type are present in a building, they are recorded when their combined nameplate ratings exceed 1 kW. In this case, they often appear as a single entry, with an indication of the number of devices represented. Individual devices with capacity ratings less than 1 kW also frequently appear in the data, when the surveyors read their labels to determine whether they exceeded the 1-kW limit.

The connected load inventory documents a survey of the equipment population in the ELCAP buildings at the time the buildings were installed with program metering equipment. It is important to note that subsequent updates of this information are planned, but none had been conducted at the time of this analysis. Clearly, it is preferable to have the connected load inventory continually or periodically updated for the purpose of estimating utilization of the equipment. Nevertheless, the ELCAP sample is the largest and most detailed set of such information available for this analysis at the present time.

APPROACH

The approach we followed in analyzing equipment loads in commercial buildings is described in this section. The information presented here provides a general framework for understanding how we obtained the analysis results.

The methodology used in this analysis can be visualized as a four-step process:

1. Define equipment categories by combining types of equipment that are similar in function and use, and summarize the equipment in each building by adding up the number of pieces of equipment and their nameplate capacities (in kilowatts) for each equipment category.
2. Summarize the equipment population in each building type by averaging the number of devices and the nameplate capacities per square foot of floor area for each equipment category.
3. Create a model of how equipment loads vary in each building type as a function of the amount of equipment in the buildings, to determine the equipment utilization.
4. Use the model of equipment loads and the nameplate capacity ratings to estimate the loads generated by the equipment in each category of equipment in each building type.

Each of these steps is briefly described in the discussion that follows.

Creating the Equipment Categories

As can be seen from the small portion of the list of equipment type codes shown in Table 4-3, the equipment in each building is catalogued in great detail. Before we averaged this data across buildings and summarized how much and what types of equipment exist in various types of commercial buildings, we reduced this detail to a manageable level by combining similar types of equipment into broader categories. Thus, the only difference between equipment types and categories is that equipment types are much more specific than categories.

The equipment categories defined for the ELCAP connected load inventory do not necessarily correspond to the needs of the specific utility analyses toward which this effort was targeted. For example, if the ELCAP data processing equipment type codes listed in Table 4-3 were used to define an equipment category, that category would thereby include both office equipment

TABLE 4-3

Data Processing Equipment Types Listed in the Connected Load Survey

Equipment Code	Description
DPT001	Cash Register
DPT002	Microcomputer
DPT003	Copier
DPT004	Computer Printer/Accessories
DPT005	Terminal
DPT006	Typesetter
DPT007	Typewriter
DPT008	Word Processor
DPT009	Computer Central Processor
DPT010	Computer Disk Drive
DPT011	Internal Cooling Fan
DPT012	Printing Press
DPT013	Mimeograph/Ditto Machine
DPT014	Calculator/Adding Machine
DPT015	Dictating Machine
DPT016	Check Writer/Addressograph/Lettering
DPT017	Microfiche Reader
DPT018	Teletype Equipment
DPT019	Disk/Cartridge Cleaner/Rewinder
DPT020	Blueprint Equipment
DPT021	Electric File Equipment
DPT022	Modem
DPT023	Bank Machine
DPT024	Date Stamper

and computer equipment. Because the loads generated by computer equipment were of particular interest in this analysis, we redefined this category and other equipment categories as specified by Bonneville based on current objectives. These redefined categories are described in detail in Section 5.

Summarizing the Equipment Population

We next summarized two kinds of information about the equipment population in the ELCAP commercial buildings: counts of the number of individual devices (pieces of equipment) in each equipment category, and the total nameplate capacity ratings for each equipment category.

Commercial buildings vary greatly in size, so most forecasts and other planning analyses of buildings are conducted on the basis of loads per square foot of floor area. For this reason, we divided the equipment count and total capacity for each building by the floor area to produce an equipment count density (devices/square foot) and a capacity density (kilowatts/square foot) for each of the equipment categories. Once the device counts and capacity densities were computed for each building, we averaged them across buildings within a given building type to produce the equipment population summaries presented and discussed in Section 5.

Determining the Equipment Utilization

The ELCAP buildings are installed with electrical load monitoring equipment that collects end-use data on an hourly basis. While the surveyors developed the connected load inventory for each building, they traced individual pieces of equipment to circuits and then through the building electrical distribution system to the data logger channels on which they are metered. In this fashion, the end use on which each specific device is metered is determined. The amount of electricity consumed by the equipment of each category can then be estimated by observing how loads change across buildings that have varying amounts and types of equipment in them.

A series of linear regressions is used to derive utilization factors for each type of equipment within each building type. The regression procedure is described in detail in Appendix C. A separate regression equation is estimated for each metered end use. Regression coeffeicients have units of hours per year and, when multiplied by equipment capacity in kilowatts per square foot, provide estimates of annual energy consumption in kilowatt-hours per square foot per year. The estimated coefficients are divided by 8760, the number of hours in a year, to provide a fraction known as the utilization factor.

A utilization factor is interpreted as the product of 1) the fraction of hours that an appliance or piece of equipment is in use and 2) the ratio of average power drawn to nameplate capacity. For example, a laser printer might draw full power only while actually printing. At other times, the printer will draw far less power, even though it is switched on. The utilization factor converts nameplate capacity into average annual energy consumption.

Estimating Loads by Equipment Category

Estimating loads from individual types or categories of equipment is simple, once the equipment population is summarized and utilization factors are estimated. The product of the utilization factor for a given category of equipment and the capacity density of the equipment in a building or group of buildings is the predicted average load for the equipment (in average kilowatts/square foot). Multiplying by the number of hours in a year converts the load to more familiar units of kilowatt-hours/square foot-year. In this fashion, loads can be estimated for each individual equipment category.

Although estimating equipment loads by equipment category was not an objective of this analysis, we did it for two reasons. The first was simply to prove that the total equipment load is predicted reasonably accurately for the buildings used in estimating the utilization factors. This was a check on the process of selecting recommended utilization factors from among many regression results, which involved some judgments that are not readily expressed in mathematical or statistical terms (see Appendix C). If the predicted and actual loads were reasonably close, confidence was gained in the utilization factor estimates.

The second reason loads were estimated was to tie together the results of the equipment population summaries and the utilization factors. Obviously, an equipment category may have a very high capacity density but a low utilization factor or, conversely, a high utilization factor and a low capacity density. In both cases it might appear to be an important equipment category from one of the analysis stages but, when both are viewed together, it may not form a major component of a commercial building equipment load. Conversely, an equipment category may have modest capacity density and utilization, but the product of the two may make it one of the more important contributors to the load. Thus, we estimated the loads by equipment category to put the observations from both the capacity density and utilization analyses in sharper perspective.

Section 5

COMMERCIAL BUILDING EQUIPMENT POPULATION

In this section, the types of equipment found in commercial buildings are described. The equipment population is discussed and graphically portrayed. Certain aspects of the methodology used to arrive at the equipment population description are also presented in this section, to assist the reader in interpreting the results. Complete technical details of the methodology are provided in Appendix A.

SUMMARIZING THE EQUIPMENT POPULATION

A three-stage approach was used to create the summaries of equipment within each specific building and across building types:

- Equipment categories were defined.
- The connected load inventory was summarized.
- Missing data in the inventory was accounted for.

Each of these stages is discussed in the following paragraphs.

Defining Equipment Categories

In collaboration with Bonneville, PNL defined a set of equipment categories specifically for this analysis. The categories and their definitions are listed in Table 5-1. Included in Table 5-1 are the three-letter abbreviations for the categories.

Several of the equipment categories were subdivided further, to reflect known or suspected differences in such features as typical usage pattern or device size. The food preparation, vertical transport, and miscellaneous equipment types each were separated into two classes--continuous use and intermittent use--based on the likely possibility that their usage patterns are different.

TABLE 5-1

Commercial Building Equipment Categories

Category		Definition
OFF	Office Equipment	Typewriters, copiers, cash registers
FDPC	Food Preparation (continuous use)	Grills, ovens, fryers, broilers, steamers, hot drink machines, warmers, toasters
FDPI	Food Preparation (intermittent use)	Slicing, grinding, mixing, and all other non-cooking equipment
LAB	Laboratory	Medical, electronic, and testing equipment
HOT	Hot Water	All water heating equipment
MAT	Material Handling	Conveyors, wrappers, hoists, and compactors
REFU	Refrigeration (unitary)	Domestic-type refrigerators and freezers, ice machines, water coolers, other small coolers
REFC	Refrigeration (central)	All large cooling and freezing equipment or those powered by separate compressors
SAN	Sanitation	Washers, disposals, dryers, cleaning equipment
VTRC	Vertical Transport (continuous use)	Escalators
VTRI	Vertical Transport (intermittent use)	Elevators, dumb waiters, and window washers
SHP	Shop	Tools and electronic testing equipment
MISC	Miscellaneous (continuous use)	Sign motors, time clocks, vending machines, phone equipment, sprinkler controls
MISI	Miscellaneous (intermittent use)	Scoreboards, fire alarms, intercoms, television sets, radios, projectors, door operators
CMP	Personal Computer Equipment	Small terminals, personal computers, disk drives, central processors, and printers
LGC	Large Computer Equipment	Larger multi-user or network terminals, disk drives, central processors, and printers
TLT	Task Lighting	Lights metered on mixed use circuits (thus not strictly task lighting, see text)

Equipment in the refrigeration category also was subdivided into two classes--unitary and central. Unitary equipment is a stand-alone package; a residential-style refrigerator, a water cooler, and a restaurant salad case are examples. Central refrigeration equipment is larger, typically assembled from separate components, and often driven from a central compressor system that may service multiple refrigeration or freezer cases (as in grocery stores).

Personal computer equipment and large (mainframe or network) computer equipment were distinguished from one another primarily on the basis of size. See Appendix A for details on how these distinctions were made.

Task lighting equipment was defined as the lights metered on the Mixed General end use in the ELCAP database. However, because of the complexity of the electric circuitry in many commercial buildings, the Mixed General end use category does contain some fixed overhead (non-task) lights. Thus, compared to the other equipment categories, the task lighting category is somewhat less well-defined.

Summarizing the Connected Load Inventory

Two kinds of information about equipment were summarized in this analysis: the number of individual devices (pieces of equipment) in each equipment category and the total nameplate capacity ratings for each equipment category[a], for each building type. These types of information together constitute the ***connected load inventory***. The equipment device and total capacity for each building were divided by the building floor area to produce equipment device density (devices/square foot) and capacity density (kilowatts/square foot) for each of the equipment categories listed in Table 5-1. When the device and capacity densities had been computed for each building, they were averaged across buildings within a given building type to produce the equipment population summaries.

(a) There is no count of fixtures for lights, and so the value for counts for these types of equipment have no meaning and are defaulted to 1.

The building types used for the equipment summaries correspond to those used by Bonneville for its regional planning. The building types, floor areas that define the size categories, and the number of buildings of each type used to develop the summaries are shown in Table 5-2. Also shown in Table 5-2 are the total number of devices inventoried for each building type, illustrating the number of observations involved.

Note that, by averaging the device and capacity densities instead of the number of devices and total capacity in each building, each building in the sample is given equal weight in determining the average amount of equipment in its building type. The alternative, adding the number of devices and capacities for each building in a building type and dividing by the total floor area involved, produces an average weighted by floor area. Although this

TABLE 5-2

Commercial Building Types Used for the Equipment Summaries

Building Type	Number of Buildings	Total Number of Equipment Loads in Survey Data
Small Office (<30,000 ft^2)	19	1,482
Large Office (≥30,000 ft^2)	7	3,653
Small Retail (<30,000 ft^2)	19	592
Large Retail (≥30,000 ft^2)	8	885
Grocery	19	2,206
Restaurant	15	1,016
Warehouse	13	740
School	4	594
Other	5	198
Hotel/Motel	8	770
University	2	1,134
TOTAL	119	13,270

technique is potentially more accurate in representing the region, the averages from the ELCAP sample would then be dominated by the equipment in a few larger buildings. Therefore, we used the densities to do the averaging.

Computer equipment such as video display terminals, printers, central processing units, and modems were most often inventoried separately, even when tied together as components of a personal computer system. This may cause higher than expected device densities for personal computer equipment, if the reader is expecting the count of devices to represent a count of personal computer ***systems*** in the buildings. Central refrigeration system components, such as compressors, fans, heaters, and defrosters, also were usually inventoried separately; this is reflected in the device densities for this equipment category.

In creating the summaries, a series of intermediate steps between the connected load inventory and the final summaries was retained for future analyses that may find their greater levels of detail valuable. These intermediate data summaries have been formatted on floppy disk and are available from Bonneville's End-Use Research Section (RPEE). These intermediate data sets are described in Appendix A, where they are used to illustrate the process of developing the summaries of the equipment in greater detail.

Accounting for Missing Data

In the ELCAP connected load inventory, nameplate capacity ratings for all equipment over 1 kilowatt (kW) are recorded whenever possible. In some cases, the surveyors could not read the labels because of the age of the equipment (no rating) or the inaccessibility of the label. For this analysis, to obtain a complete set of nameplate ratings for a building, it was necessary to "fill" missing nameplate ratings. This was done by using the average nameplate ratings for this equipment type from other buildings. Appendix A contains a detailed explanation of this process and its results.

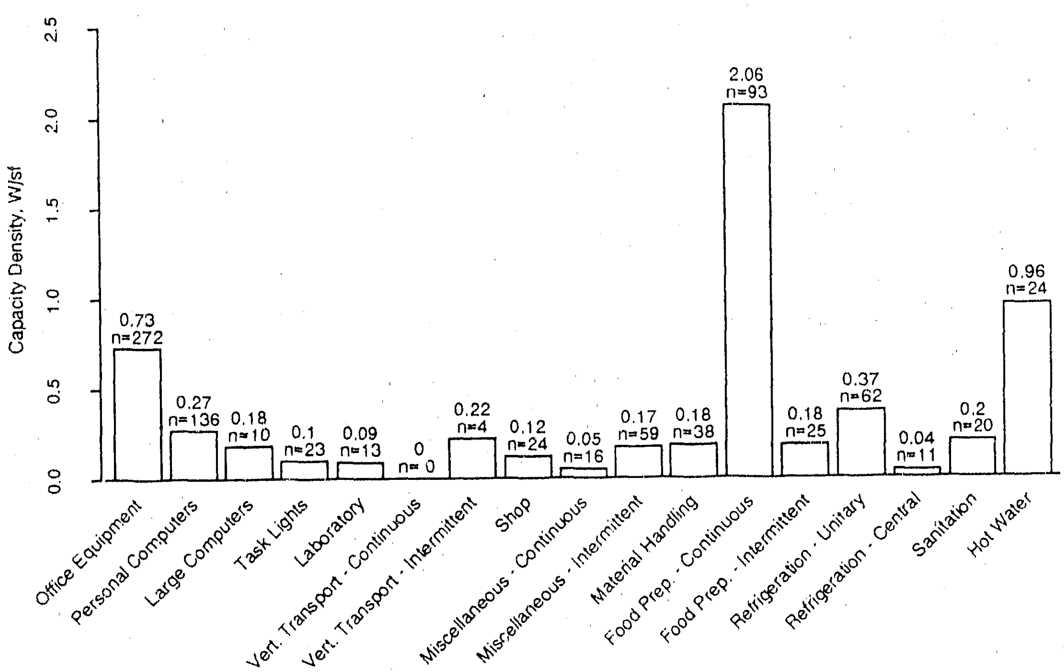
EQUIPMENT POPULATION SUMMARY RESULTS

The results of the device count and capacity density summaries are presented for each equipment category by building type below.

Explanation of the Summary Plots

Two basic types of plots are used here to summarize the equipment population in commercial buildings. The first is illustrated by Figure 5-1, which shows the average capacity density of each equipment category for a building type (in this case, small offices) for electricity-consuming equipment. The height of each bar shows the average capacity density in units of watts/square foot for the equipment category named beneath the bar. (This may be divided by 1000 to convert to units of kilowatts/square foot.) The heights of the bars can be scanned to determine the relative portion of the

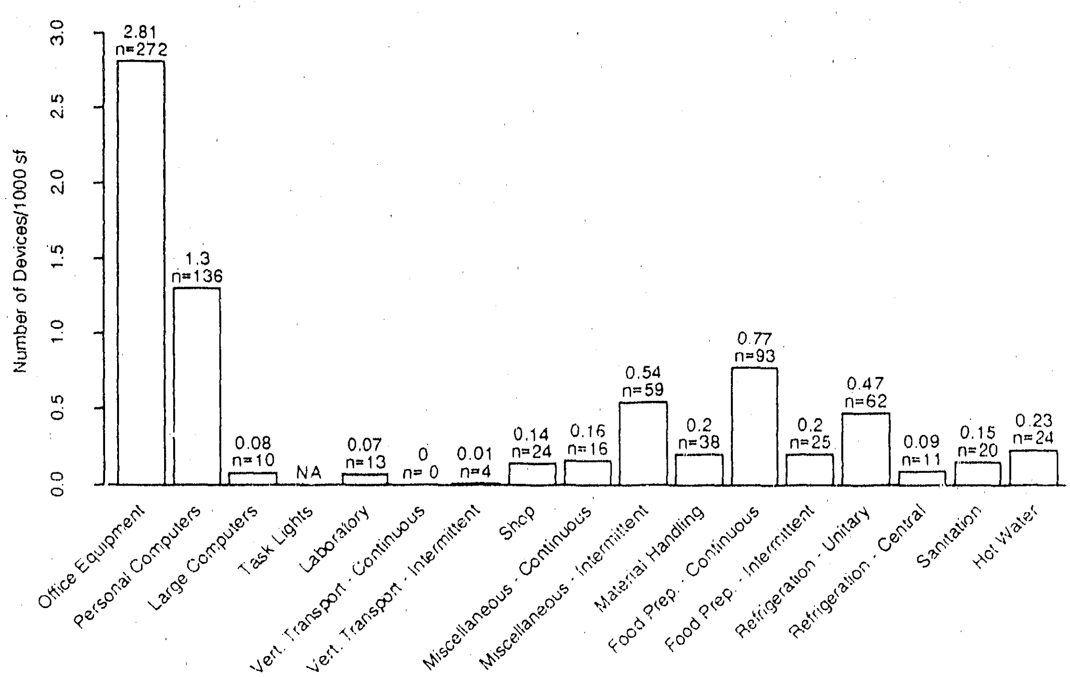
FIGURE 5-1. Small Office Equipment Average Capacity Density



capacity represented by any equipment category. Above each bar, the capacity density is printed along with the number of devices in the connected load inventory from all the buildings in the building type involved in developing the average.

The other type of summary plot is a similar bar chart showing the device densities (number of devices in each equipment category per 1000 square feet of floor area) for each equipment type, as shown in Figure 5-2. Note that the device density for task lights represents the number of individual lighting ***types*** represented in the connected lo?d inventory, rather than the number of individual fixtures involved. Thus, this device density does not have the same meaning as the device densities for the other equipment categories.

FIGURE 5-2. Small Office Equipment Device Density



Small Office Building Equipment Population

The small office equipment population summaries appeared in Figures 5-1 and 5-2. Continuous food preparation equipment has the largest capacity density (2.06 W/ft²) of all equipment types. Hot water is second at 0.96 W/ft². Office equipment is third at 0.73 W/ft². The capacity densities of all other equipment types are much lower than that of office equipment. As expected, and shown by the device densities in Figure 5-2, office equipment and personal computers represent large numbers of small devices. The opposite is true for the hot water and intermittent vertical transport (elevators) equipment categories.

Large Office Building Equipment Population

Summaries of the equipment in large office buildings are shown in Figures 5-3 and 5-4. Large office equipment capacity densities differ greatly from those in small offices. Laboratory equipment has the highest density (1.62 W/ft²), primarily because of the medical facilities in the ELCAP sample.

FIGURE 5-3. Large Office Equipment Average Capacity Density

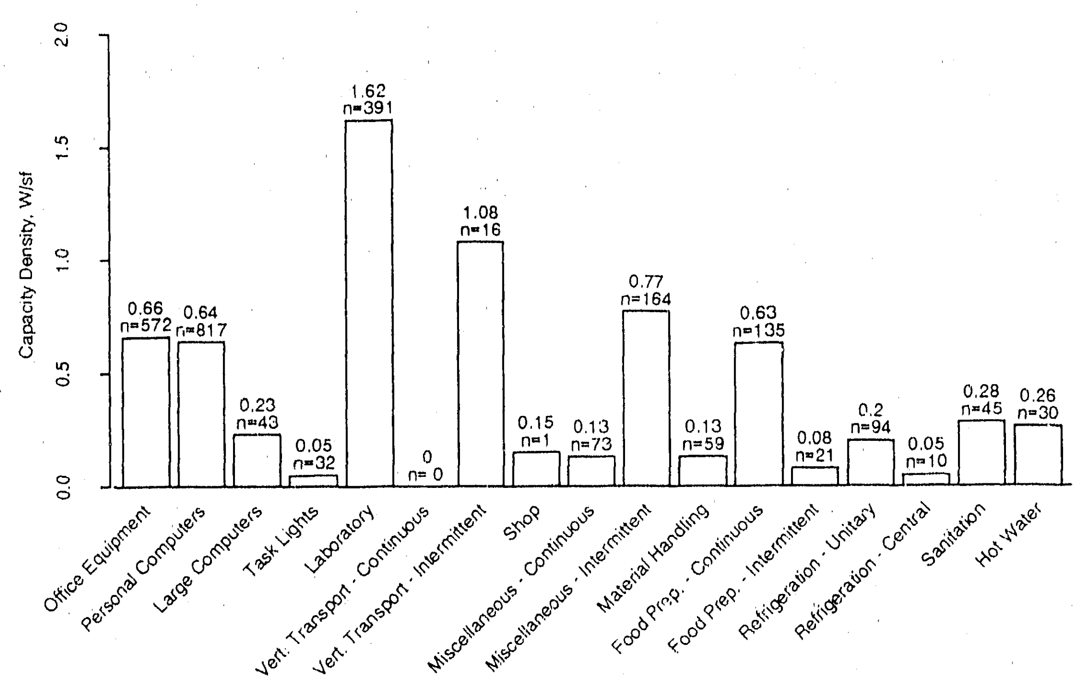
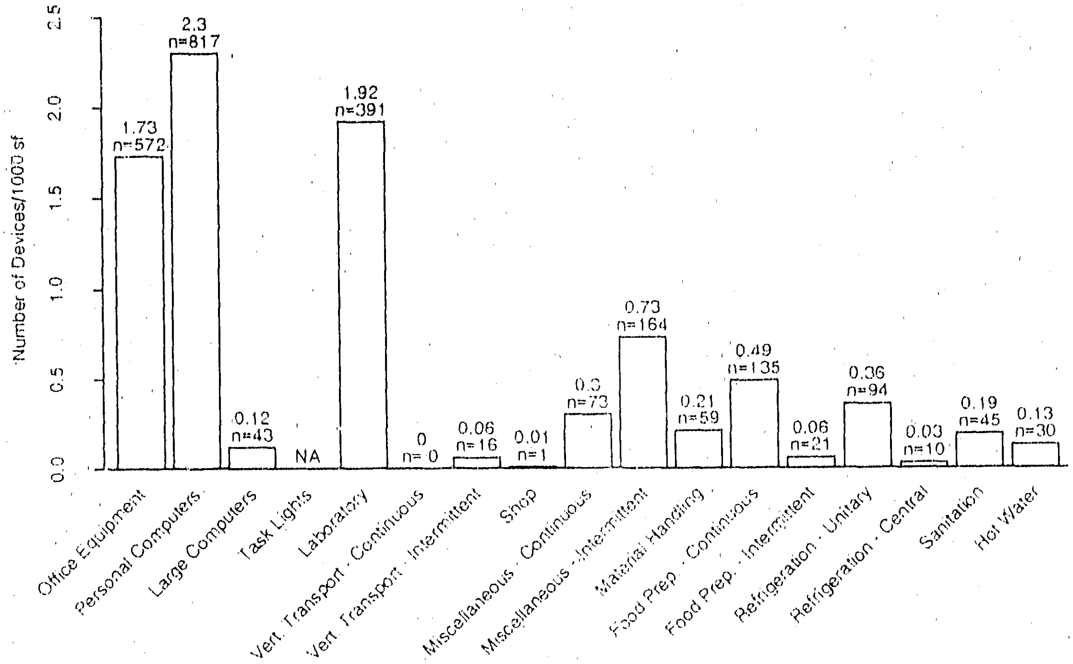


FIGURE 5-4. Large Office Equipment Device Density



Elevators (intermittent vertical transport) constitute the second highest capacity density at 1.08 W/ft². Office equipment density is 0.66 W/ft², similar to that of small offices. The personal computer density, however, is over twice that of small offices (0.64 W/ft² compared to 0.27 W/ft²). Other equipment types with densities similar in magnitude to office equipment are intermittent miscellaneous loads and continuous food preparation equipment. As indicated by Figure 5-4, office equipment and personal computer loads, as well as laboratory equipment, are made up of many small devices.

Small Retail Building Equipment Population

Equipment summaries for small retail buildings are shown in Figures 5-5 and 5-6. Hot water equipment has the highest capacity density at 1.99 W/ft². This is probably because there is generally at least one water heater per building, regardless of that building's floor area. Next highest is shop equipment (1.18 W/ft²) consisting of repair equipment in specialty stores and

FIGURE 5-5. Small Retail Equipment Average Capacity Density

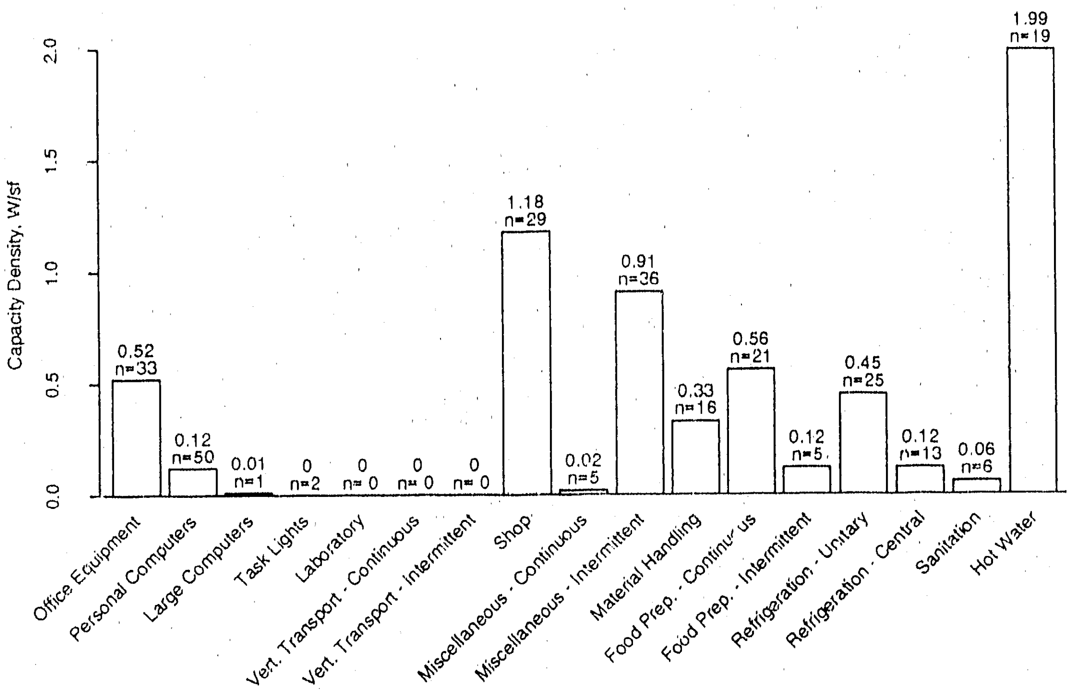
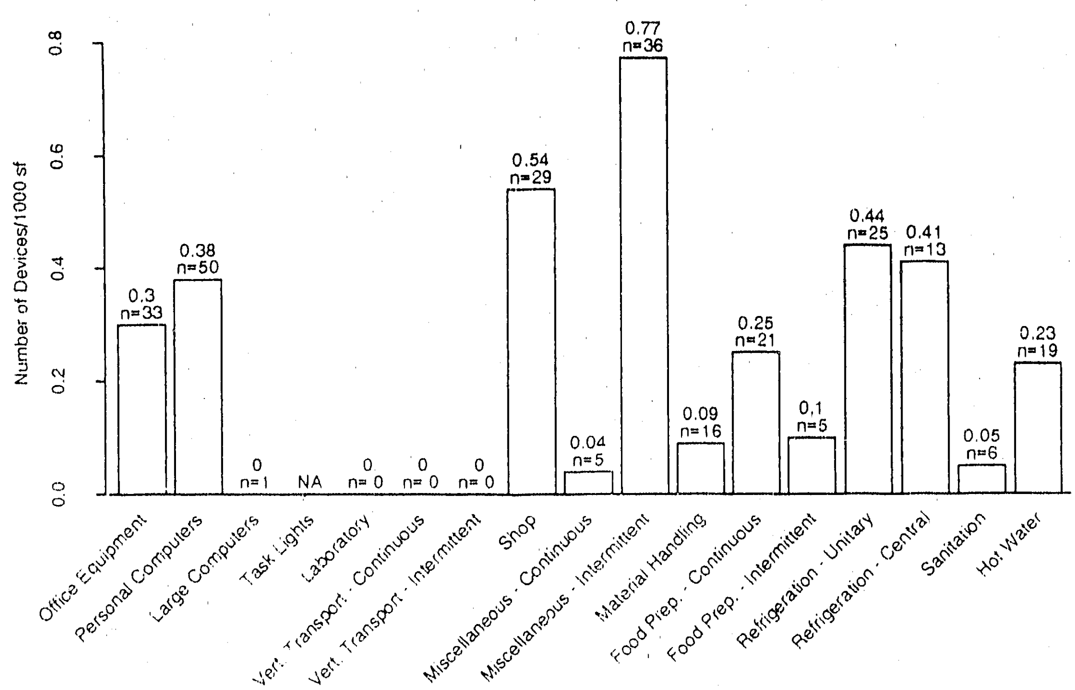


FIGURE 5-6. Small Retail Equipment Device Density



welders with large capacities in several sites. Office equipment capacity is 0.52 W/ft^2, lower than both intermittent miscellaneous (0.91 W/ft^2) and continuous food preparation equipment (0.56 W/ft^2). The Unitary refrigeration capacity density is almost as high as office equipment at 0.45 W/ft^2. The unitary refrigeration equipment consists primarily of food and drink display coolers in a few sites. The capacity densities for this equipment may not be representative of the small retail building population and should be used with caution.

Large Retail Building Equipment Population

The equipment summaries for large retail buildings are shown in Figures 5-7 and 5-8. With only one exception, the capacity densities for equipment in these buildings are all well below 0.5 W/ft^2. The need for materials-handling, office, and computer equipment may be somewhat constant on a per business basis, as opposed to being proportional to floor area.

The capacity densities observed for the remaining equipment categories in the retail sample are low also, perhaps because increased size in retail buildings usually means more display type space with little or no equipment.

The shop equipment category is the one exception to this trend. Shop equipment capacity density is much higher (1.76 W/ft^2) because of a large machinery sales and repair store in the large retail category that includes cranes, welders, and process heat equipment.

The very large capacity density of shop equipment in the ELCAP retail sample may not be representative and should be viewed with caution until confirmed or refuted by the PNNonRES regional survey.

FIGURE 5-7. Large Retail Equipment Average Capacity Density

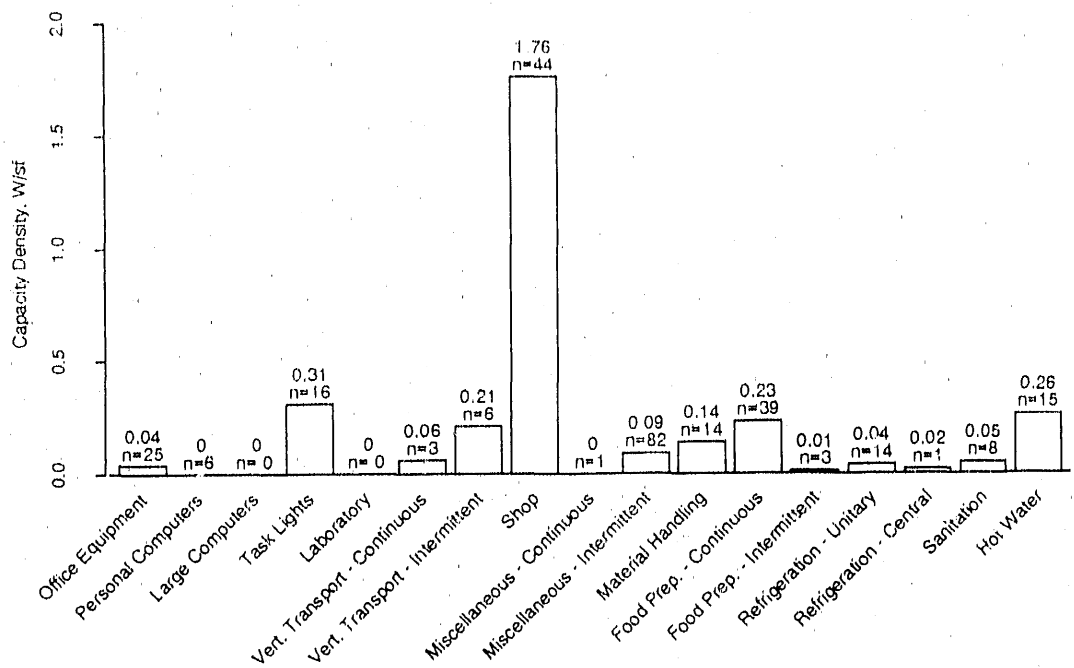
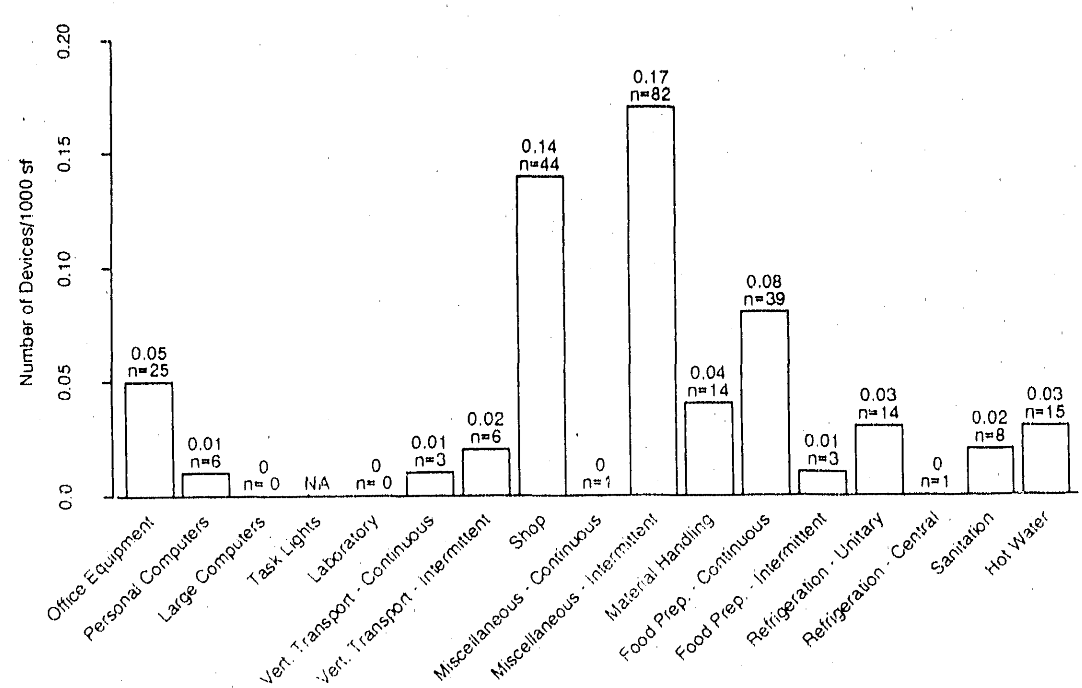


FIGURE 5-8. Large Retail Equipment Device Density



Restaurant Building Equipment Population

The equipment population in restaurants, as summarized in Figures 5-9 and 5-10, is as expected. Continuous food preparation (cooking) equipment is the predominant category, in terms of both installed capacity and number of devices. At 9.6 W/ft², this is the highest capacity density of all equipment types and building types except shop equipment in the "other" building category, in spite of the fact that much of the cooking equipment in ELCAP buildings is fueled by gas. Central and unitary refrigeration have high densities, although considerably lower than for food preparation (3.56 and 2.43 W/ft², respectively). Hot water capacity is also relatively high at 2.56 W/ft². Office equipment and personal computers are sparse, at 0.16 and 0.08 W/ft², respectively. The food preparation equipment consists of relatively few devices with large capacities.

FIGURE 5-9. Restaurant Equipment Average Capacity Density

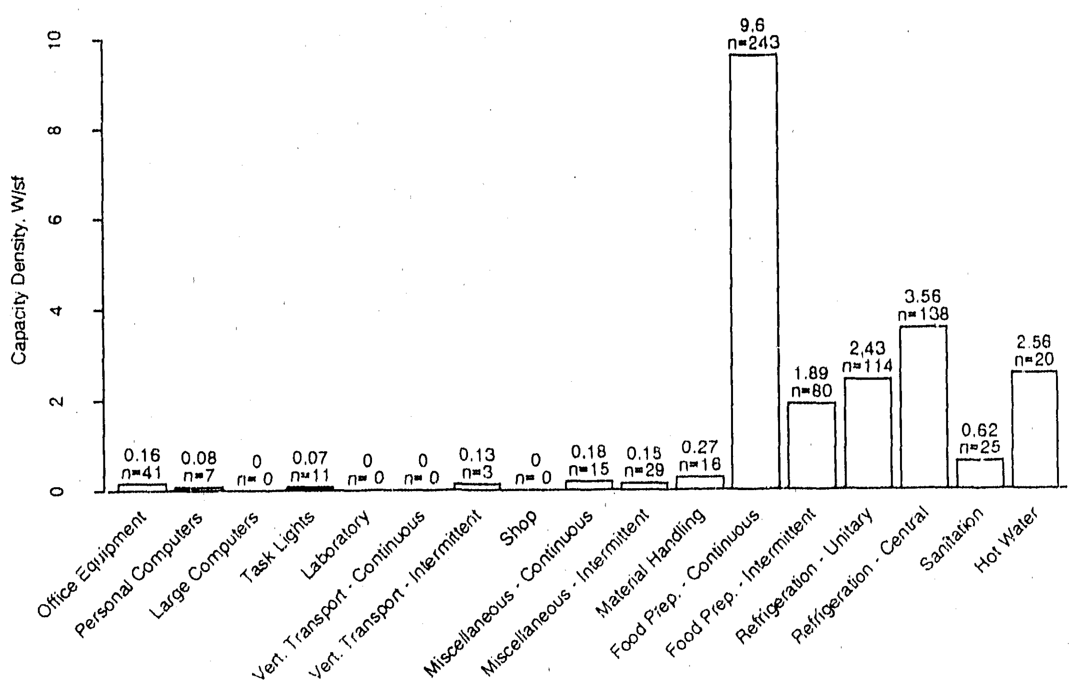
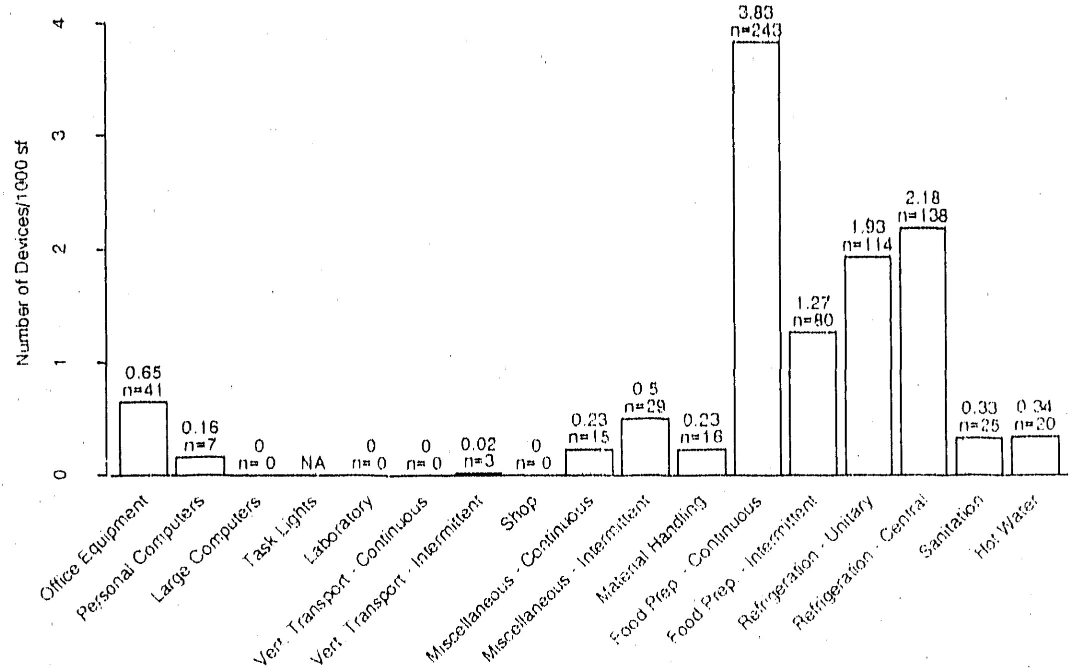


FIGURE 5-10. Restaurant Equipment Device Density



Grocery Building Equipment Population

Equipment summaries for groceries are shown in Figures 5-11 and 5-12. Capacity densities are similar to those of restaurants: food preparation and refrigeration equipment dominate in terms of number of devices per square foot. However, the relative preponderance of refrigeration and cooking equipment is reversed. As expected, central refrigeration dominates at 7.24 W/ft^2, with unitary refrigeration at 2.01 W/ft^2. Continuous and intermittent food preparation equipment have capacities of 2.41 and 0.64 W/ft^2, respectively. Except for hot water (1.09 W/ft^2), all other equipment types have capacities below 0.35 W/ft^2. The shop equipment consists of only a few large devices, and so may not be regionally representative.

FIGURE 5-11. Grocery Equipment Average Capacity Density

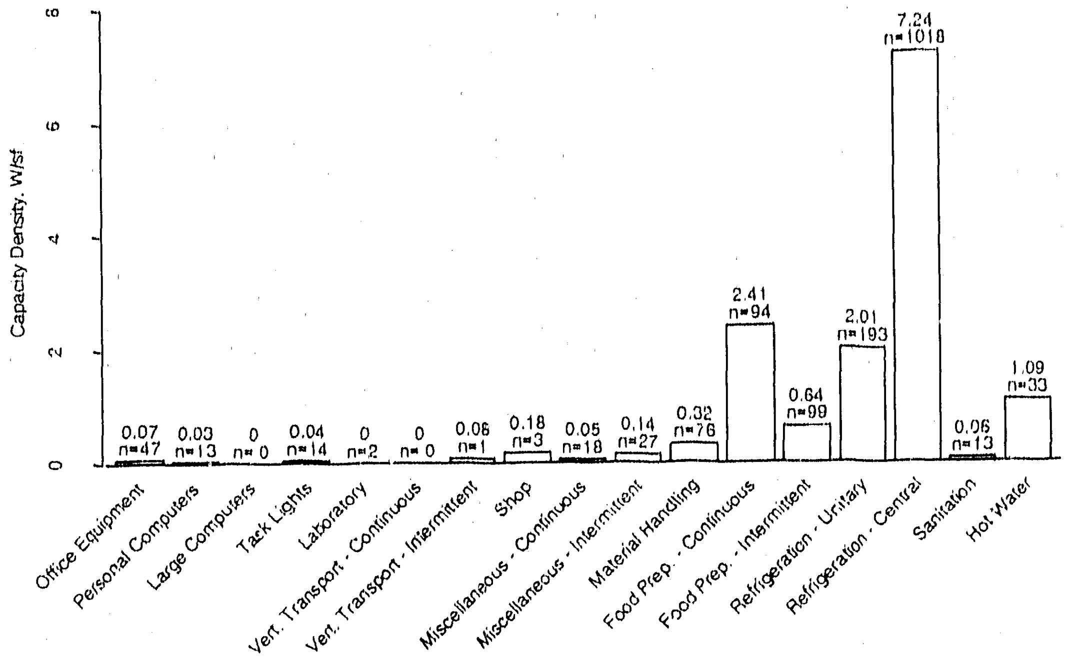
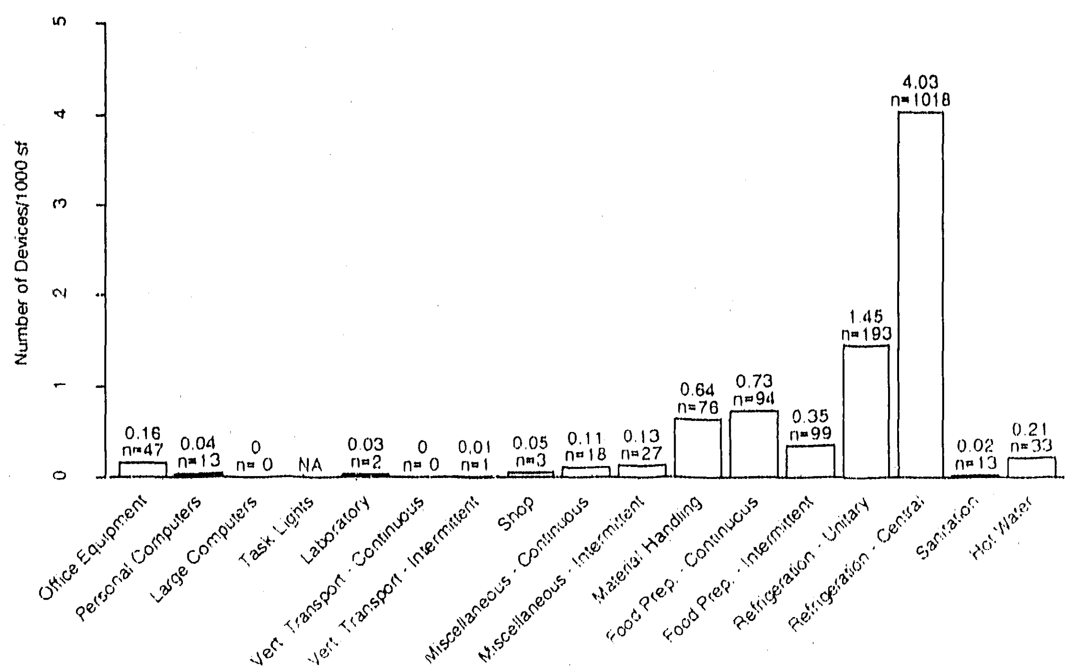


FIGURE 5-12. Grocery Equipment Device Density



Warehouse Building Equipment Population

The equipment summaries for warehouses appear in Figures 5-13 and 5-14. Shop equipment has the highest capacity density at 1.24 W/ft². Next is hot water at 0.87 W/ft². Material handling and continuous food preparation equipment both have densities around 0.3 W/ft². A restaurant facility located in part of one of the warehouses undoubtedly contributes to the food preparation and hot water densities. Office equipment density is a relatively low 0.22 W/ft², reflecting the small amount of office floor area relative to storage area. The office and personal computer equipment consist of many small devices as indicated by the high device densities relative to capacity densities for these equipment types.

FIGURE 5-13. Warehouse Equipment Average Capacity Density

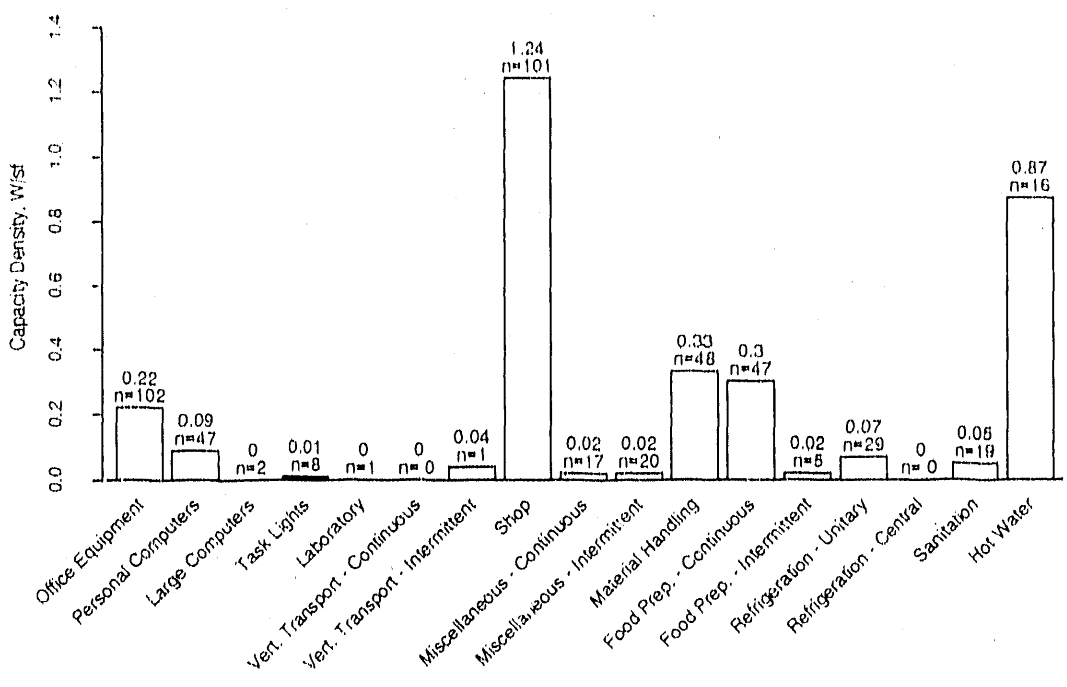
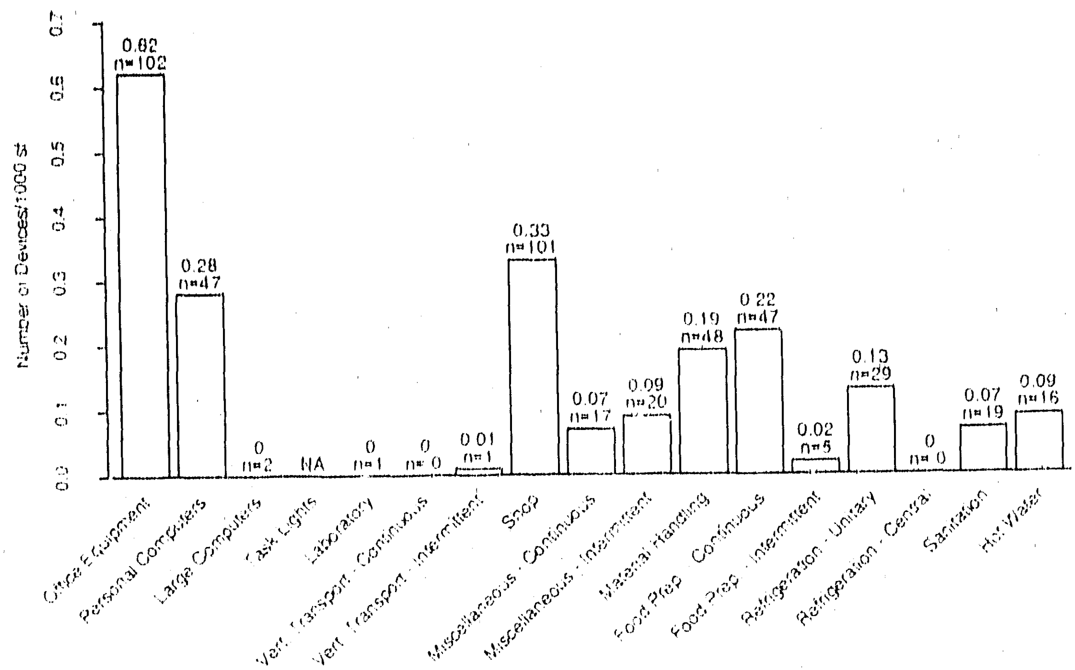


FIGURE 5-14. Warehouse Equipment Device Density



School Building Equipment Population

Figures 5-15 and 5-16 are equipment summaries for the school buildings in the ELCAP sample. Capacities for hot water equipment are very high at 3.28 W/ft². Continuous-use food preparation equipment is also high at 1.21 W/ft². These equipment capacity densities are consistent with needs for cafeteria services and showers in schools. The next highest equipment type (intermittent-use miscellaneous equipment), consists primarily of audio-visual equipment. Its capacity density is 0.42 W/ft², approximately one-third that of the food equipment. Because these results summarize equipment in only four schools, they may not be broadly representative of the entire population of school buildings in the region.

FIGURE 5-15. School Equipment Average Capacity Density

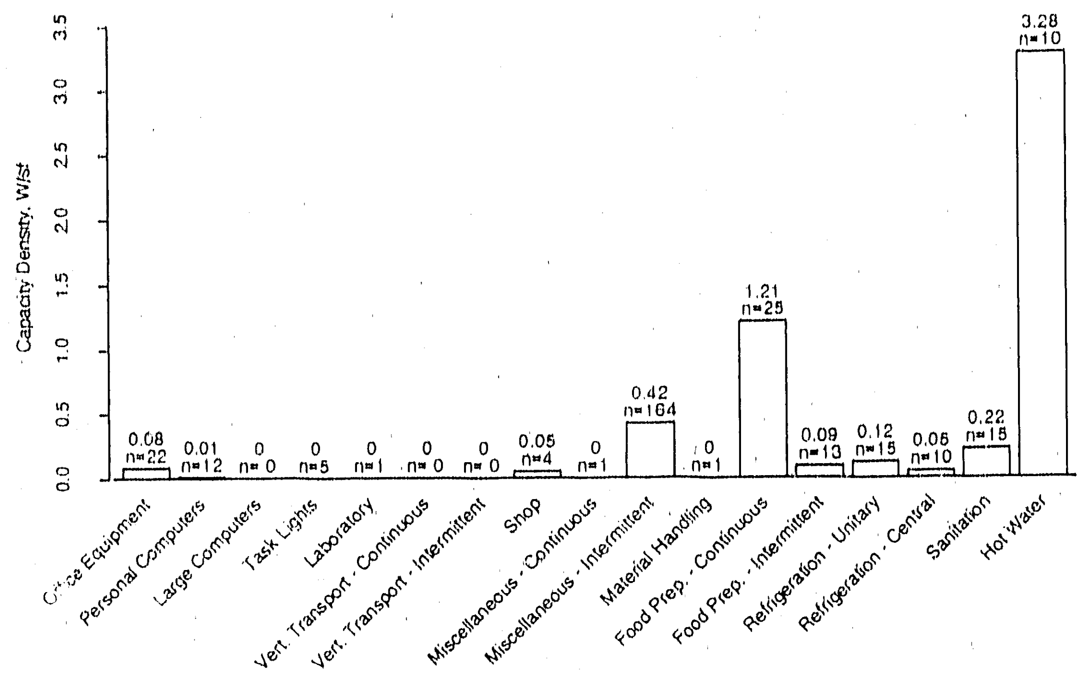
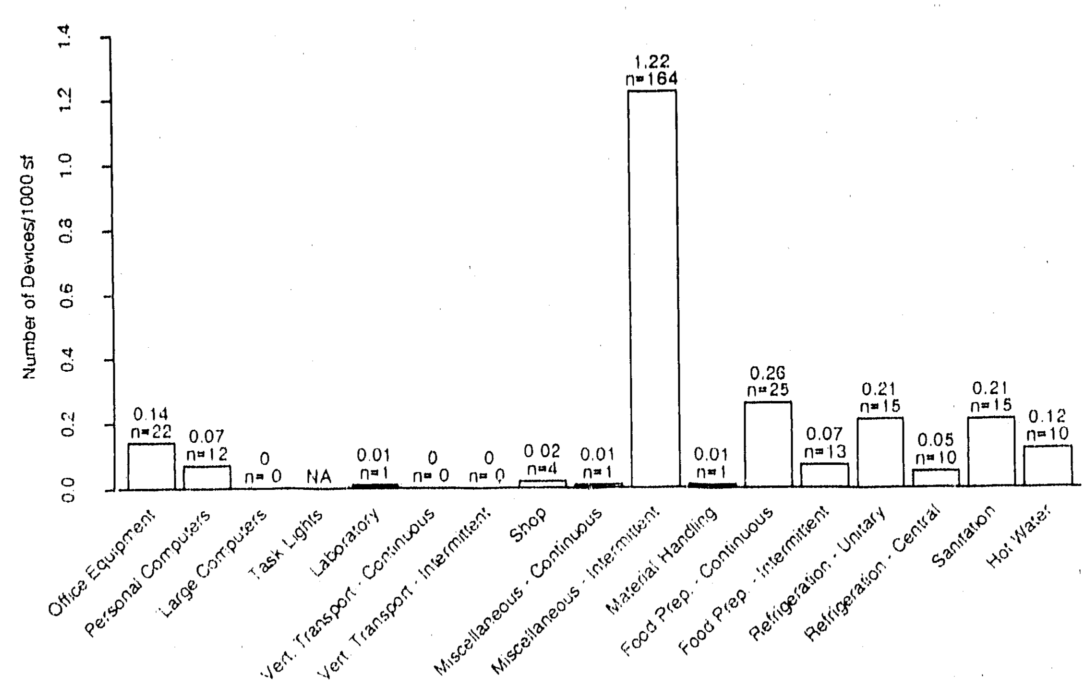


FIGURE 5-16. School Equipment Device Density



University Building Equipment Population

Equipment in university buildings is summarized in Figures 5-17 and 5-18. Note that the high capacity densities for hot water and food preparation equipment observed in the schools are not reflected in the two university classroom-type buildings summarized here. Both categories are close to 0.7 W/ft² in the universities. Like grade schools, the capacity density of intermittent-use miscellaneous equipment, consisting primarily of audio-visual equipment, is relatively high at 0.63 W/ft². Office and personal computer equipment capacity densities (0.59 and 0.32 W/ft², respectively) are similar to those of offices. Other relatively large densities are for shop equipment (0.68 W/ft²) and material handling equipment (0.43 W/ft²).

FIGURE 5-17. University Equipment Average Capacity Density

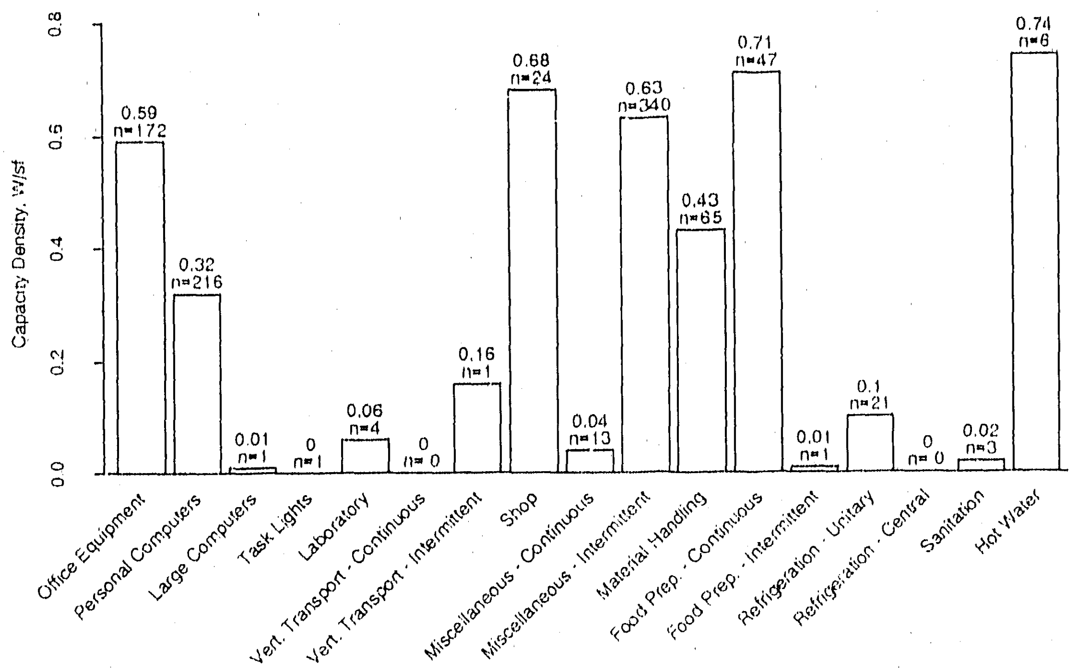
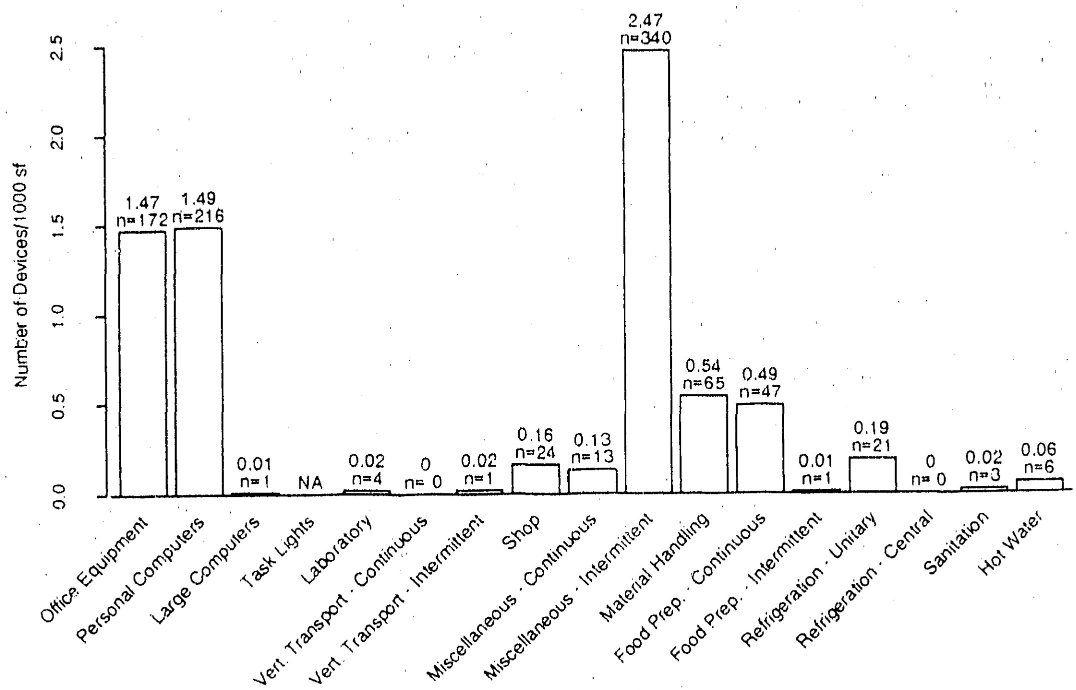


FIGURE 5-18. University Equipment Device Density



Hotel/Motel Building Equipment Population

Figures 5-19 and 5-20 summarize equipment in hotel/motel buildings. The buildings are all relatively small, one to three stories high, with exterior room access and no large lobbies or meeting rooms. These buildings typically include a manager's residence; several have kitchenette facilities. As such, they are best described as motels.

As might be expected, hot water capacity densities are highest at 3.14 W/ft^2. Continuous-use miscellaneous equipment, consisting largely of television sets, and continuous-use cooking equipment are also high, at 2.05 and 2.1 W/ft^2, respectively. Task lights (primarily room table lamps) average 1.29 W/ft^2. These observations are consistent with the function of motel buildings.

FIGURE 5-19. Hotel/Motel Equipment Average Capacity Density

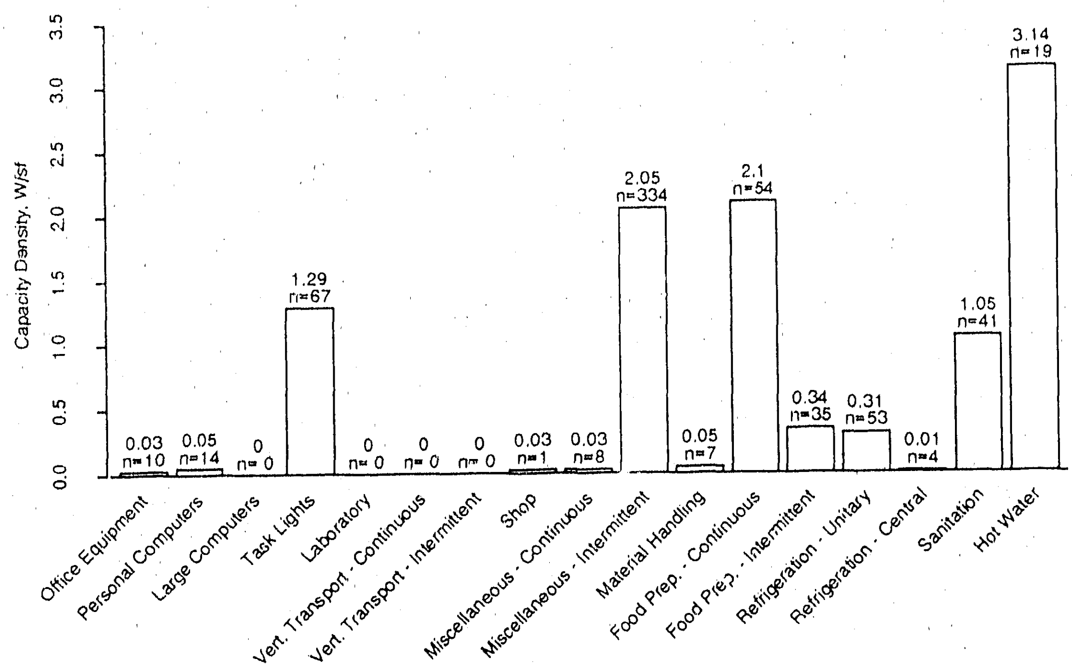
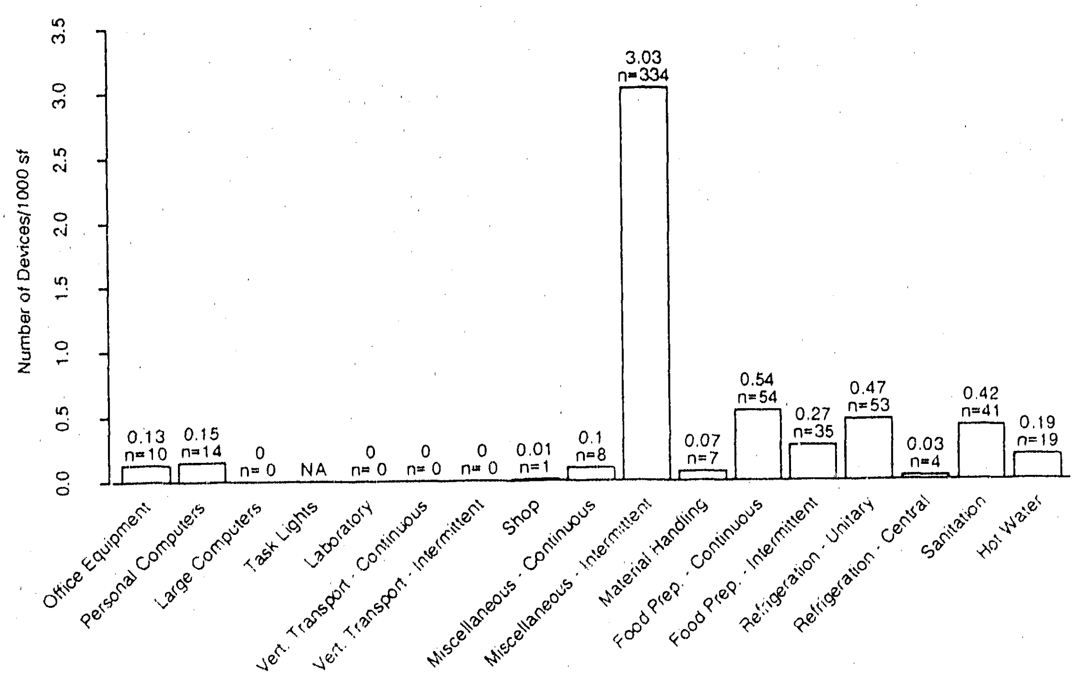


FIGURE 5-20. Hotel/Motel Equipment Device Density



Other Building-Type Equipment Population

Equipment summaries for the buildings in the "other" building-type category appear in Figures 5-21 and 5-22. The buildings in this category are a coin-operated laundry, library, church, gas station, and rental store. As this is such a diverse class of buildings, the equipment summaries here are unlikely to be regionally representative.

Very high capacity densities are observed for shop, materials handling, and sanitation equipment in these buildings. These are largely attributable to the laundry, gas station, and rental store. Except for hot water (0.85 W/ft^2), continuous-use food preparation (0.99 W/ft^2), and intermittent-use miscellaneous equipment (0.67 W/ft^2), all other equipment categories have very small capacity densities.

FIGURE 5-21. Other Equipment Average Capacity Density

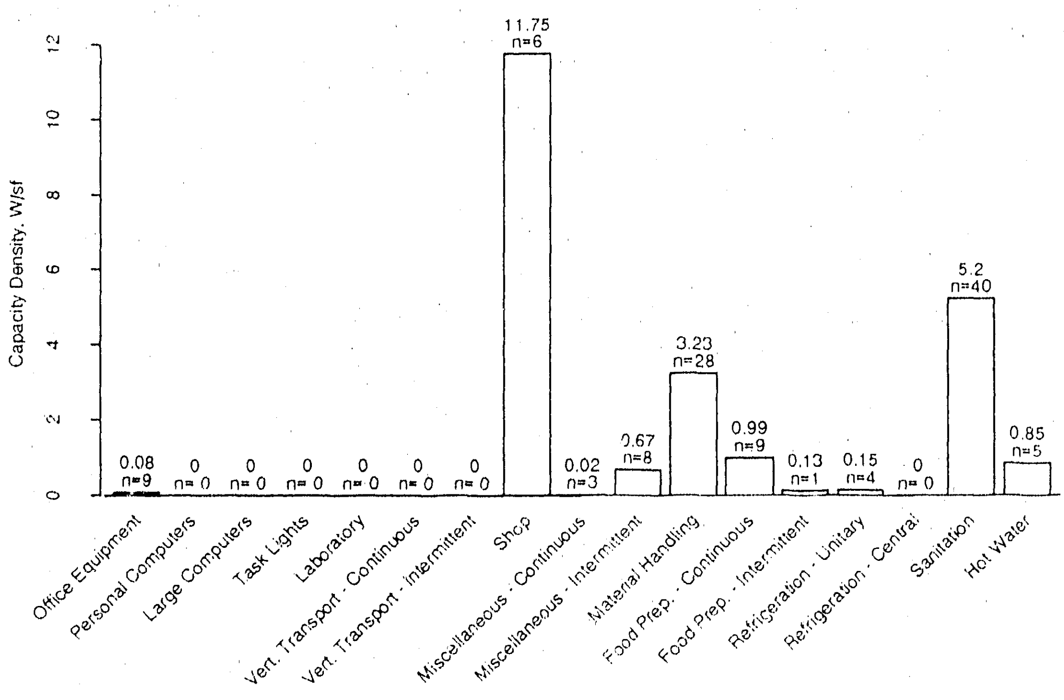
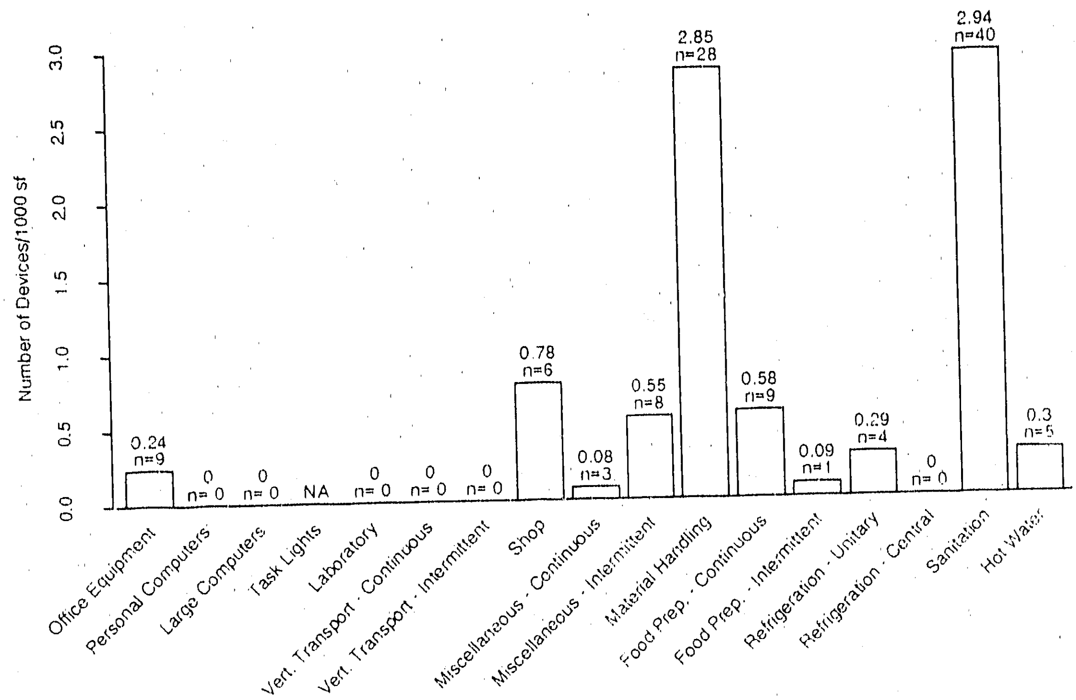


FIGURE 5-22. Other Equipment Device Density

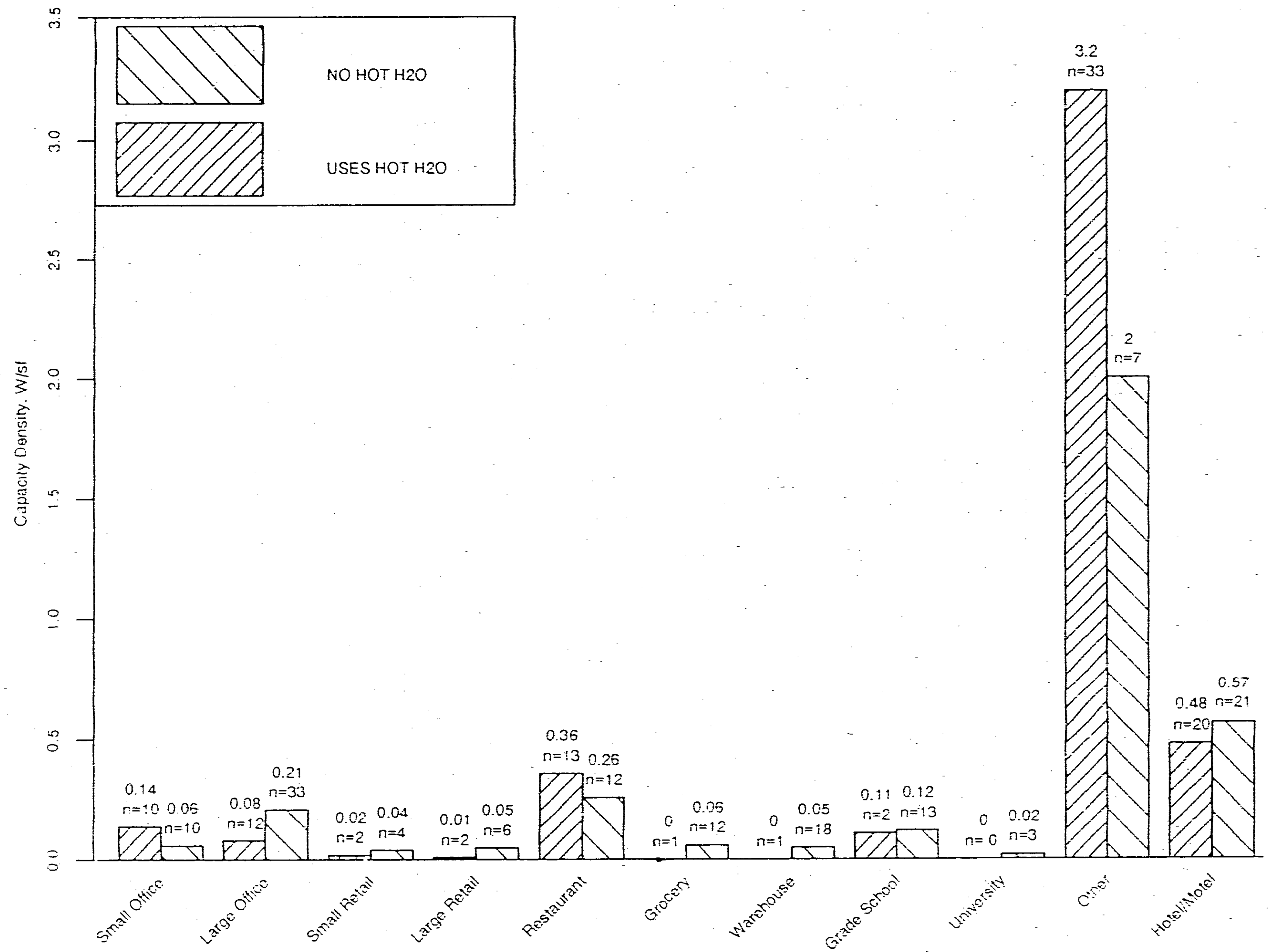


Sanitation Equipment and Water Heating: A Special Case

Of all the equipment found in most commercial buildings, two types of sanitation equipment exhibit a unique property: they use the direct product of the domestic hot water system. Dishwashers and clothes washers typically use relatively large quantities of hot water and may provide some insight into the hot water usage in commercial buildings. So, the sanitation equipment category is subdivided into equipment that uses hot water and that which does not.

Figure 5-23 shows capacity densities for the subcategories for each of the building types. The other building type is dominated in this case by the single laundry facility in the ELCAP sample, with hot-water using equipment at 3.2 W/ft^2.

FIGURE 5-23. Sanitation Equipment Average Capacity Density



Non-Electric Equipment Summaries

This study deals primarily with electricity-consuming equipment. However, equipment that uses other fuels is also of concern for some types of analyses, particularly those involving internal heat generated by the equipment and how it affects heating and cooling loads. In such cases, the fuel used to generate the heat is largely irrelevant. Also, the quantities and types of non-electric equipment in the buildings may be useful in identifying fuel-switching or marketing opportunities and to help explain low electricity consumption for certain metered ELCAP end uses.

To summarize the non-electric equipment in the buildings, similar bar plots of capacity and device densities were developed showing the electric and non-electric capacities for each equipment type. Because the electricity-consuming equipment is the focus of this study, bar plots summarizing the non-electric equipment are placed in Appendix B without interpretation.

As illustrated by Figure B-1, the bar charts in Appendix B stack the non-electric equipment capacities on top of the electric equipment capacities to show their relative capacities and the total for each building type (in this case, small offices).

CONCLUDING COMMENTS

Although we used only the capacity densities in subsequent stages of this analysis, the number of individual devices (or device density) is also important for some purposes. Subsequent investigations may prove it to be a useful predictor of certain types of equipment loads, particularly where it indicates the number of occupants and/or their business activity. Device density information may also influence the design of programs aimed toward reducing electricity consumption by types of equipment. For example, it may be easier to design retrofit programs for fewer large devices and standards and rebate programs for numerous but small devices.

Finally, it is important to note that although a wide variety of buildings and building types are represented in the ELCAP sample, the sample by itself may not accurately represent the characteristics of the regional equipment population. When the PNNonRES (Bonneville Power Administration and ADM Associates, Inc. 1989) regional commercial building survey is completed, the connected load inventory developed in it will likely supplant the equipment population summaries presented here.

Section 6

UTILIZATION OF EQUIPMENT

The utilization factors developed in this analysis are noted and discussed in this section. To set the stage for this discussion, certain elements of the methodology critical to interpreting the results are presented first. The results themselves are presented next. The section concludes with our presentation of the recommended utilization factors for all equipment categories by building type.

IMPORTANT METHODOLOGICAL CONSIDERATIONS

As explained in Section 4, an equipment category ***utilization*** is the average fraction of the rated power consumed by the equipment over the year. If equipment always consumed power at the level of its nameplate rating when in use, then the utilization would literally represent the fractional time of use for the equipment, across the metered buildings.

In reality, however, various types of equipment often consume power at levels below their nameplate rating in various modes of operation (for example, an idling printer compared to one actually printing). Consequently, the utilization factor determined from the regression actually represents the product of the time of use and the ***load factor*** (the ratio of average power to rated power when in use) of the equipment. For many types of equipment that operate steadily, the load factor is close to one (1) and so the utilization factor is approximately equal to the fractional time of use.

Fractional time of use is easier to interpret; it is also more directly indicative of occupant behavior than are the utilization factors. Because only rarely is a single device metered on a channel in the commercial buildings, load factors are not readily determined from the ELCAP database. However, they can be estimated from manufacturers' data or other sources and then used to divide the utilization factors to produce estimates of the fractional time of use.

On the other hand, utilization factors are very straightforward to use in estimating the resulting loads. For example, they can be multiplied by equipment nameplate capacities obtained from survey inspections, to estimate loads in individual or populations of buildings.

The use of ELCAP metered end-use and connected load inventory data to estimate utilization factors is not as straightforward in practice as it is in concept, for several reasons:

- Loads from more than one category of equipment generally appear on a single metered end use.
- Loads from equipment of a given category may appear on different end uses in different buildings, or on multiple end uses within a single building.
- For certain end uses, more equipment categories may be present than the number of buildings with a given metered end use (fewer observations than predictor variables)
- Equipment utilization factors for a given category of equipment may vary to some extent as a function of the end use from which they are derived if a tendency exists to meter specific subcategories of equipment on one end use or another. (An example is that larger computers are more likely to be metered on the Data end use than on the Receptacles end use.)

Complete details of the regressions methodology and its treatment of these issues are presented in Appendix C; the end-use and equipment capacity data used appear in Appendix D.

COMPRESSION OF EQUIPMENT CATEGORIES FOR UTILIZATION ESTIMATES

Seventeen categories of commercial building equipment are defined for the summaries of the number and capacity densities presented in Section 5. While this level of detail is appropriate for summaries of the population of equipment contained in the buildings, the number of equipment categories had to be reduced for use in estimating utilization factors with the relatively small sample sizes for each building type.

To achieve a workable ratio of sample size to the number of explanatory variables in each of the utilization factor regressions, we combined a number of the previously defined equipment categories, as shown in Table 6-1.

The categories that we combined were selected so that differences in their utilization should be illustrated to a large extent by the differences seen across the building types or across end uses used for the regressions. For example, the differences between unitary and central refrigeration equipment

TABLE 6-1

Comparison of Equipment Category Definitions Used for Equipment Summaries and Utilization Factor Estimates

Equipment Categories for Utilization Factors		Equipment Categories for Population Summaries	
OFF	Office Equipment	OFF	Office Equipment
FDP	Food Preparation	FDPC & FDPI	Food Preparation (Continuous and Intermittent)
LAB	Laboratory	LAB & PHO	Laboratory and Photography
HOT	Hot Water	HOT	Hot Water
MAT	Material Handling	MAT	Material Handling
REF	Refrigeration	REFU & REFC	Refrigeration (Unitary & Central)
SAN	Sanitation	SAN	Sanitation
VTR	Vertical Transport	VTRC & VTRI	Vertical Transport (Continuous and Intermittent)
SHP	Shop	SHP	Shop
MISC	Miscellaneous	MISC & MISI	Miscellaneous (Continuous and Intermittent)
COMP	Computer Equipment	CMP & LGC	Computer Equipment (Personal and Large)
TLT	Task Lighting	TLT	Task Lighting

are likely to be illustrated by the difference in utilization factors for offices and groceries, respectively. Similarly, large computers are much more likely to be metered on the Data Processing than on the Receptacles end use.

Other equipment categories were combined as a compromise between the detail desired and the limitations of the sample size. The laboratory and photography equipment categories were combined, since they occur in the ELCAP sample mostly in office-type situations, are metered on the same end uses, and are expected to have similar usage patterns. The intermittent-use and continuous-use categories of vertical transportation equipment were also combined, because very few such devices are present in the ELCAP buildings.

The intermittent-use and continuous-use miscellaneous equipment categories were combined because the sample contained very little intermittent-use equipment.

In addition, small quantities of non-task interior lighting and miscellaneous heating, ventilating, and air conditioning (HVAC) equipment metered on any of the end-use channels involved in the regressions were added to the Miscellaneous group, so that the equipment capacities used in the regressions are complete with respect to the metered loads.

GENERAL PERFORMANCE OF THE REGRESSIONS

The results of each of these regressions are provided in Appendix E. The fraction of the variance explained by the regressions (R^2) varies widely; most are greater than 0.6 and many were above 0.9. One or more utilization factor estimates were obtained from the various metered end-use regressions for about 80% of the pairs of equipment categories and building types, with multiple estimates available for most of these.

Particularly complete estimates are obtained for the food preparation and refrigeration end uses across building types, and for offices, groceries, restaurants, and warehouses for most of the end uses. These building types also tend to have the largest number of highly statistically significant utilization factors. Where multiple estimates for an equipment category were obtained, we found that they were often very similar, particularly those with high statistical significance.

No utilization factor estimates were obtained directly from the hotel/motel buildings, as the number of these buildings in the Commercial Base sample is too small to be useful. This must await development of connected loads traceable to circuits in these buildings for the CREUS sample, which contains a sizable number of hotel/motels. In any event, it is likely that their plug loads are strongly driven by occupancy rather than equipment.

RECOMMENDED UTILIZATION FACTORS

The utilization factors we selected are displayed in Table 6-2. In nearly all cases, the selection process resulted in a recommended utilization factor that was one of those with the highest significance available. When multiple estimates are available, the recommended utilization factor was chosen by following a process (described in Appendix C) designed to select the most valid and representative estimate. The recommended utilization factors for each category of equipment are discussed below.

Computers

The utilization factor for computer equipment in Offices is 200. (Remember that the utilization factors in Table 6-2 are multiplied by 1000, so 200 represents 200/1000 = 20%.) Two supplemental equipment categories appear in Table 6-2 for computers in offices, one each for personal computer (CMP) and large computer (LGC) equipment. These were derived from differences between the utilization factors obtained from the Data and the Mixed General\ Receptacles end uses, which had different amounts of large seasonal computer equipment metered on them. This is described in Appendix C.

TABLE 6-2

Recommended Utilization Factors

EQUIPMENT TYPE	ALL BUILDINGS	OFFICE	DRY GOOD RETAIL	GROCERY	RESTAURANT	WAREHOUSE	SCHOOL	OTHER
n=	65	14	12	10	7	11	4	4
COMP	339*	200*	580*	446*	121+	83*		
CMP		192@						
LGC		999@						
FDP	85*	15+	91+	151+	91*	54	9.6	9.8+
HOT	57*	43*	12*	151	138*	5.2	193+	50
LAB		19-						
MAT	59	15+		78	438+	132		3.3-
MISC		100*		928*	618*	8.6	122	
OFF	226*	144*	186*	449*	191*	329*		219
REF	270*	129*	301+	403*	187*	784*	259*	543*
SAN				65	17*			
SHOP		43	21*	581-		7.2		0.2
TLT	133	142	371*		218	126	258	
VRT		15*						

NOTES ON ESTIMATES:

Statistical Significance: * high ($\alpha \leq 0.05$) + moderate ($0.05 < \alpha < 0.1$) [none] ($0.1 \leq \alpha$)

Other Notes: - based on 1 building @ algebraic estimate

It is reassuring to note that the large computers appear to be in continuous operation (999 utilization), while personal computer equipment utilization is about 192 (or 19%). This is also reasonable, based on eight hours of operation out of each day, five days per week (8/24 * 5/7 = 24%). Theutilization of office equipment (144) is similar but slightly less, indicating that a significant number of the personal computers are probably left on over-night.

The higher utilization factors for computer equipment in retail stores (580) and groceries (446) are consistent with their longer hours of operation per week, and their use of computerized cash register and inventory control systems that typically remain on all the time. Lower factors for restaurants (121) and warehouses (83) are consistent with use of personal computer systems for office-like functions on a part-time basis. No significant utilization factors for computers in the remaining building types resulted.

Food Preparation

Food preparation equipment in groceries apparently is utilized to a greater extent than it is in other buildings (utilization factor 151). This may reflect use of broilers and warmers for the delicatessen sections in many groceries that serve both for cooking and display. Restaurants and retail stores both had the same utilization factor for food preparation (91). All these utilization factors reflect the fact that this equipment is not used continuously, even during business hours, probably because of both slack periods and thermostatic controls. The lower utilization factor in schools (9.6) compared to restaurants is noteworthy, probably reflecting significantly different usage in cafeterias that serve a single meal per day and are inactive on weekends and in summer.

A relatively large factor in warehouses (54) has low statistical significance, reflecting the presence and use of large cooking equipment in a few warehouses. The other warehouses apparently use such equipment for serving their employees rather than in their business activities. Significant but low factors in offices (15) and "other" buildings (9.8) probably also reflect services for their employees.

Hot Water

It should be noted that occupant characteristics such as the number of occupants or meals served were not included in the utilization models. Significant improvement and usefulness in the models might result, but this is left for future analysis. Following the general approach to utilization factors taken in this work, the hot water utilizations here are based solely on the size of the water heaters. Fortunately, the hot water equipment is almost always metered separately in ELCAP buildings, so correlation with other equipment capacities is not problematic.

Surprisingly, despite not including these occupancy effects, highly significant utilization factors were obtained for offices, retail stores, and restaurants, with a moderately significant factor determined for the schools. Schools had the highest factor (193), probably reflecting showers as well as cafeteria use. Grocery utilization was also high (153), probably for cleanup activities. Restaurants' utilization was also high (138), as would be expected to serve their sanitation and cleanup needs.

"Other" buildings (50), offices (43), retail (12), and warehouses (8.2) show a descending utilization that may be related to the density of occupants in the buildings and the minimum sizes of hot water equipment available. These low utilization factors may indicate a conservation opportunity, when it is recalled that the standby loads to maintain temperature in water heaters during periods of no water use are significant. Smaller tank sizes or instantaneous water heaters may be of benefit.

Laboratory

A low utilization factor (19) was obtained for offices, primarily reflecting medical equipment in a few buildings. No significant utilization factors for the remaining building types resulted.

Materials Handling

A wide range of utilization factors for materials handling equipment (conveyors, wrappers, hoists, compactors) was obtained across the building types, few of which show moderate or high degrees of significance. This broad range probably results from the wide variety of types of equipment in this category as well as its different function across the building types.

A large and significant utilization (438) resulted from packaging equipment, although this is in only two of the restaurants. Utilizations in warehouses (132) and grocery stores (78) probably reflect the use of loading and unloading equipment. Offices and "other" buildings show lower utilizations (15 and 3.3, respectively). No significant utilization factors in retail stores or schools resulted.

Miscellaneous

A wide range of utilizations also was obtained for miscellaneous equipment, several with high statistical significance. Investigation shows that a large fraction of the capacities for this equipment category in the end-use regressions is miscellaneous heating, cooling, and ventilation equipment that could not be isolated in the metering plans. This is particularly true for small ventilation equipment associated with food preparation and specialized shop areas. This helps explain the very significant and high utilization factors for groceries (928), restaurants (618), and offices (100). Factors with low significance were obtained in schools (122) and warehouses (8.6). While the warehouse utilization also reflects a majority of heating/ventilating equipment, no such equipment is present for the schools. Audio-visual equipment use is probably indicated in this utilization factor. No significant utilization factors in the remaining building types resulted.

Office Equipment

Very significant utilization factors were obtained for all five of the building types with large sample sizes. Office equipment use appears to generally reflect business hours. In offices, the utilization factor is 144, similar to, but slightly less than that for personal computers. It is somewhat higher in retail stores (186) and restaurants (191), and much higher in groceries (449), probably reflecting cash register use. The reason for the high use in warehouses (329) is not clear, but perhaps is related to inventory tracking. A value with low significance was obtained for the "other" buildings (219). None was developed for schools.

Refrigeration

Refrigeration equipment utilization factors were obtained for all building types, all with high statistical significance (except for retail stores, which had moderate significance). The utilization factors for this equipment category are uniformly the highest of any of the categories. Refrigeration utilization in groceries (403) is much higher than for restaurants (187), probably reflecting better system sizing for the central systems that predominate in groceries as opposed to the packaged unitary systems for display cases and smaller refrigerators in the other building types. This may explain the high refrigeration utilization in warehouses (784), also.

Utilization of refrigeration equipment in schools (259) and retail stores (301) is intermediate between restaurants and groceries. Office buildings are the lowest (129), probably reflecting use of residential-style unitary equipment almost exclusively. The reason for the high utilization factor in the "other" buildings (543) is not clear.

Sanitation

Utilization factors for sanitation equipment were obtained only for groceries (65) and restaurants (17) (just the restaurant factor was statistically significant). This is not surprising, as these are the only building types with significant loads resulting from the equipment in this category.

Shop

Shop equipment utilization factors varied broadly. Only in retail stores (43) was any high statistical significance shown. This represents use of repair equipment in several specialized retail stores in the sample, especially in one large machinery repair shop with large amounts of equipment. The very high utilization factor in groceries results from only one building. Thus, although utilization appears high in this building, this factor should be used with extreme caution.

Task Lights

As noted in Section 5, the definition of task lights used here necessarily includes most non-overhead and secondary lighting systems in the buildings. Consequently the estimated utilization factors may be somewhat higher than would result from a stricter definition of task lighting. This is because lighting in bathrooms, lobbies, and retail displays may reflect longer hours of use than true task lighting.

All utilization factors for task lighting had very low statistical significance, except for retail stores where the significance was high. Nevertheless, utilization estimates were obtained for all building types except groceries and "other" buildings.

The utilization factor in retail stores was also the highest of all building types (371), probably indicative of specialized display lighting. Restaurants also have a relatively high factor utilization (218), probably reflecting usage of table lighting and miscellaneous kitchen lighting during business hours. Task lighting utilization in schools (258) is high relative to offices (142) and warehouses (126).

Vertical Transportation

Vertical transportation utilization estimates were developed only for office buildings, given the lack of such equipment in the other building types in the sample. A highly significant utilization factor of 15 was estimated, but this figure is based on only a few buildings and may not be broadly applicable.

UTILIZATION FACTORS EXTRAPOLATED TO ALL EQUIPMENT IN ALL BUILDING TYPES

For many purposes, some estimate of the utilization of all the categories of equipment in a building type is better than none at all. To support this need, Table 6-3 shows the recommended utilization factors of Table 6-2 extrapolated to all equipment categories in all building types. Clearly, the extrapolated utilization factors, printed in ***bold italic type***, should be used with caution.

The reasons for selecting these factors are presented here. This selection process is essentially one of postulating that utilization is probably a function of the activities conducted in the buildings; e.g., the "office" function in a warehouse is probably much like an office building. The assumptions here are made on this basis.

Somewhat arbitrarily, we assumed that sanitation equipment use in most building types more closely resembles that in restaurants than in groceries. Further, the restaurant utilization factor has a high statistical significance, while the grocery estimate does not. The laboratory equipment utilization factor in offices is assumed for all other building types, as no other estimate is available.

TABLE 6-3

Utilization Factors Extrapolated to All Equipment Categories and Buildings Types

EQUIP-MENT TYPE	ALL BUILDINGS	OFFICE	DRY GOOD RETAIL	GROCERY	REST-AURANT	WAREHOUSE	SCHOOL	OTHER
n=	65	14	12	10	7	11	4	4
COMP	339*	200*	580*	446*	121+	83*	**200**	**83**
CMP		192@						
LGC		999@						
FDP	85*	15+	91+	151+	91*	54	9.6	9.8+
HOT	57*	43*	12*	151	138*	5.2	193+	50
LAB	***19***	19-	***19***	***19***	***19***	***19***	***19***	***19***
MAT	59	15+	***15***	78	438+	132	***15***	3.3-
MISC		100*	***8.6***	928*	618*	8.6	122	***8.6***
OFF	226*	144*	186*	449*	191*	329*	***144***	219
REF	270*	129*	301+	403*	187*	784*	259*	543*
SAN	***17***	***17***	***17***	65	17*	***17***	***17***	***17***
SHOP		43	21*	581-	***21***	7.2	***43***	0.2
TLT	133	142	371*	***371***	218	126	258	***126***
VRT	***15***	15*	***15***	-	-	-	-	-

NOTES ON ESTIMATES:

Statistical Significance: * high ($\alpha \leq 0.05$) + moderate ($0.05 < \alpha < 0.1$) [none] ($0.1 \leq \alpha$)

Other Notes: - based on 1 building @ algebraic estimate

[***bold***] extrapolated from other building types

The diverse group of "other" buildings was arbitrarily assigned computer, miscellaneous, and task lighting utilization factors like warehouses. In subsequent applications of these results, the user may wish to use values from another building type that most closely resemble a specific building of interest. Similarly, the warehouse usage for miscellaneous equipment was arbitrarily assumed for miscellaneous equipment in retail buildings.

Shop equipment usage in retail stores was assumed to be similar to that in restaurants. For task lighting, groceries were assumed to most closely resemble retail stores. The materials-handling utilization factor of offices was used for retail stores.

Schools were assumed to most closely resemble offices in most functions, so utilization factors for computers, office, laboratory, materials-handling, and shop equipment in schools were assigned values like offices. The user might wish to use office utilization factors for food preparation, refrigeration, and hot water equipment if a particular school of interest does not have cafeteria or gymnasium facilities. Similarly modified assumptions are suggested for university buildings, as required.

Section 7

LOAD ESTIMATES BY EQUIPMENT CATEGORY

The primary unit of energy consumption used in the commercial sector is the end-use intensity (EUI). The EUI is defined as the energy (kilowatt-hours) consumed by a specific end use over a specified time period divided by the floor area of the building (square feet). Therefore, the annual EUI (kilowatt-hours/square foot-year) for an equipment category can be estimated as the product of the capacity density (kilowatts/square foot) multiplied by the number of hours in the year (8760), and the utilization factor (time of use multiplied by the load factor).

The EUIs derived in this study were used in two ways. First, we used the recommended utilization factors to calculate EUIs for each of the 17 equipment categories for which capacity densities were available for all 11 building types. Second, we combined the estimated EUIs with regional estimates for total floor area by building type to predict total regional load for each equipment category. This calculation points to several equipment categories as likely targets for conservation programs.

We also made a consistency check by comparing the EUIs for metered end-use loads with those estimated from capacity densities and regressed utilization factors. Details of this comparison are presented in Appendix F.

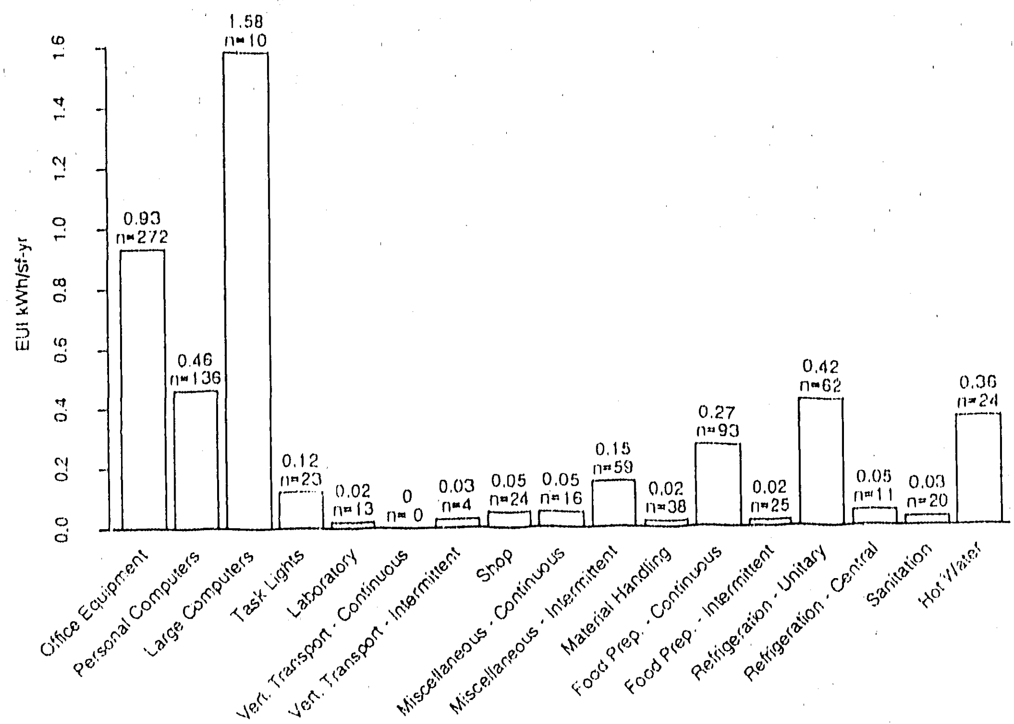
ANNUAL ENERGY USE INTENSITIES FOR EQUIPMENT LOADS

End-use intensities were estimated for 17 equipment categories and the 11 building types. The information is displayed graphically and discussed by building type. In the figures presented in this section, the height of each bar represents the number of kilowatt-hours/square foot consumed annually for each equipment category. The number of devices used in the calculation of capacity densities is also shown at the top of each bar, to indicate the extent to which this estimate may be generalized beyond the sample. No comparisons across building types are made.

Small Offices

For small offices, large computer equipment has the highest annual EUI, 1.58 kWh/ft²-yr, as shown in Figure 7-1. Office equipment has the second highest EUI with an average of 0.93 kWh/ft²-yr. The next four highest equipment categories, in descending order, are personal computers, unitary refrigeration, hot water, and continuous food preparation.

FIGURE 7-1. Small Office EUI by Equipment Category

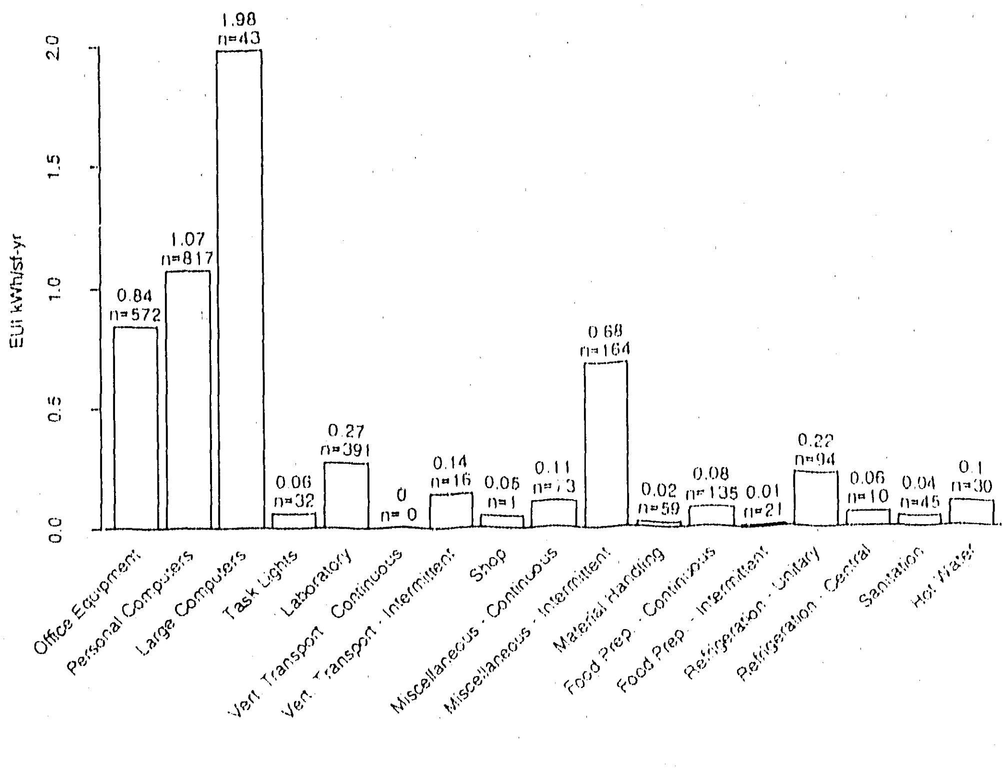


Large Offices

Figure 7-2 shows that large computer equipment constitutes the highest annual EUI, 1.98 kWh/ft²-yr for large offices. The personal computers category has the second highest EUI, 1.07 kWh/ft²-yr. Office equipment ranks third with 0.84 kWh/ft²-yr. Both laboratory equipment and elevators, which have very high capacity densities in this building type, have relatively small EUIs (0.27 and 0.14 kWh/ft²-yr, respectively).

Note that the EUI for large computer equipment is higher for large offices than it is for small offices, while the EUI for personal computers is higher for small offices than it is for large offices. This is logical, as the computing needs for the occupants of smaller offices can be met primarily by personal computers, while the occupants of larger offices rely more on integrated, larger, multi-user systems.

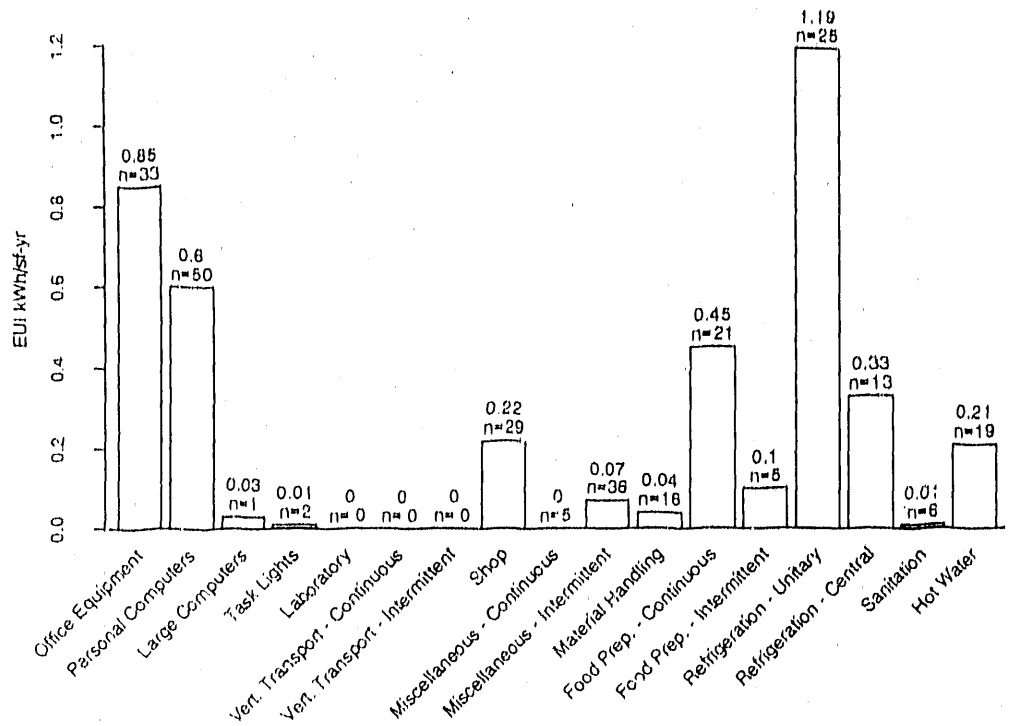
FIGURE 7-2. Large Office EUI by Equipment Category



Small Retail

In small retail buildings, unitary refrigeration has the highest EUI, 1.19 kWh/ft²-yr, as shown in Figure 7-3. Office equipment is next highest at 0.85 kWh/ft²-yr, followed by personal computer and continuous food preparation equipment, in descending order. The sizable refrigeration loads in small retail may be due, in part, to the presence of refrigerated vending machines and medicine coolers in drug stores.

FIGURE 7-3. Small Retail EUI by Equipment Category

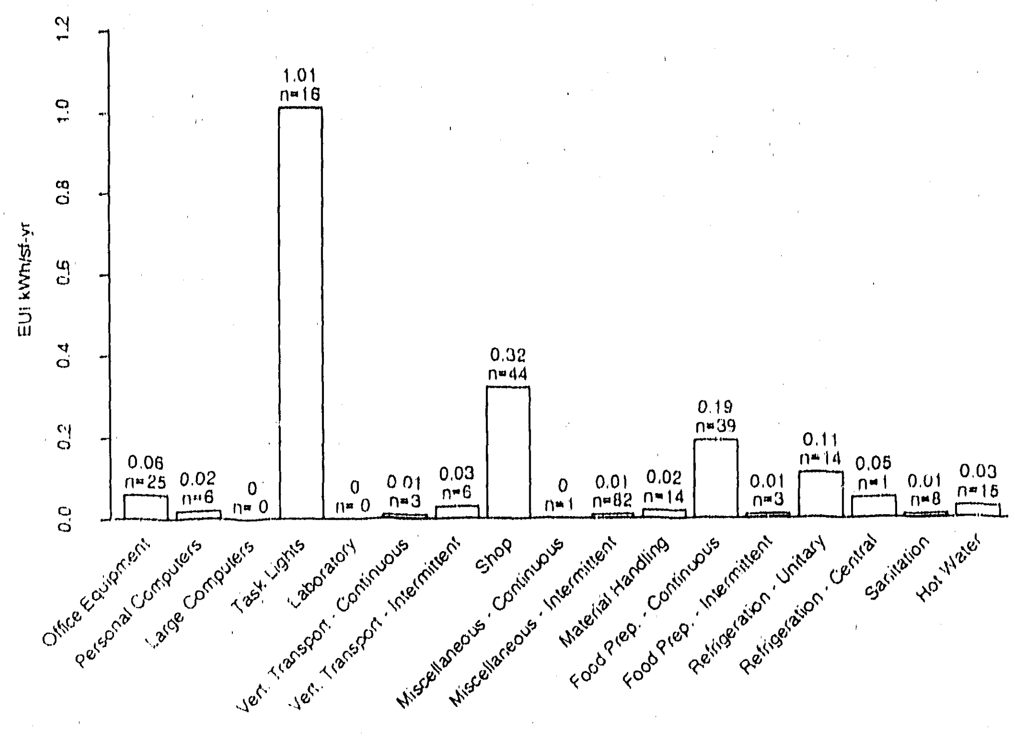


Large Retail

The EUIs for large retail buildings (Figure 7-4) are dominated by task lighting, with an average of 1.01 kWh/ft²-yr. Most of this lighting is for display purposes.

Note that all other equipment categories are relatively low on a per square foot basis for large retails. As shown in Figure 7-4, the EUIs for shop and continuous food preparation equipment, the next highest, are less than half that of task lighting. The extremely low consumption by office equipment and personal computers compared to the case in small retails supports the suggestion that these functions are somewhat constant on a per business basis rather than being proportional to floor area.

FIGURE 7-4. Large Retail EUI by Equipment Category

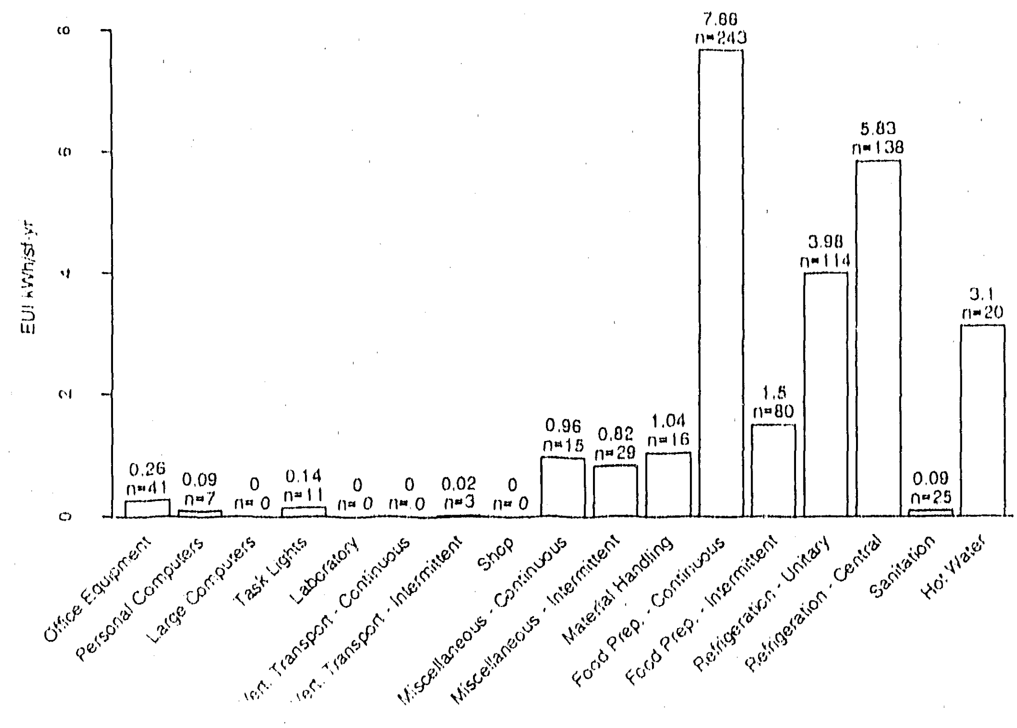


Restaurants

Figure 7-5 shows that for restaurants, continuous food preparation equipment has the highest EUI, 7.66 kWh/ft^2-yr. The next most significant equipment categories are the refrigeration types: 5.83 kWh/ft^2-yr for central refrigeration and 3.98 kWh/ft^2-yr for unitary. The hot water EUI of 3.10 kWh/ft^2-yr is also quite large.

These four categories have some of the highest EUIs seen in any of the building types. This is not surprising, given the level of food storage and cooking in restaurants. Other notable EUIs are intermittent food preparation, material handling, and both the continuous and intermittent miscellaneous equipment categories.

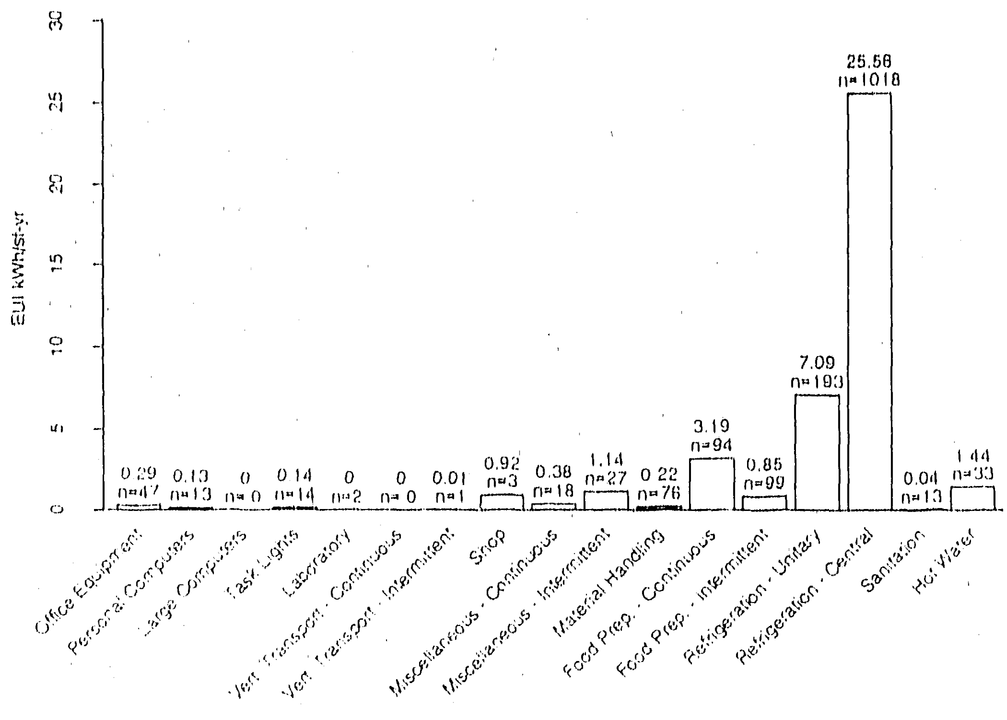
FIGURE 7-5. Restaurant EUI by Equipment Category



Groceries

The EUIs for equipment in groceries are shown in Figure 7-6. Central refrigeration has, by far, the highest EUI (25.56 kWh/ft²-yr) seen for any category in any building. The unitary refrigeration EUI is also large, 7.09 kWh/ft²-yr, with continuous food preparation next highest at 3.19 kWh/ft²-yr. Water heating, intermittent miscellaneous, and shop equipment also have significant EUIs.

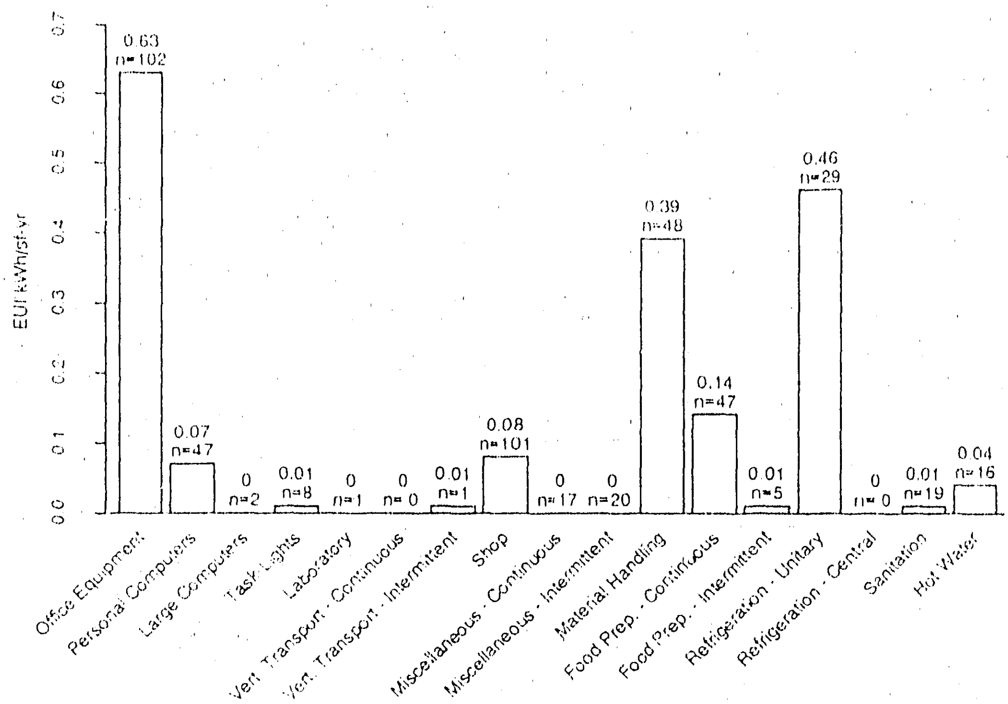
FIGURE 7-6. Grocery EUI by Equipment Category



Warehouses

The largest EUI for warehouses (Figure 7-7) is only 0.63 kWh/ft^2-yr, and is for the office equipment category. Unitary refrigeration and material handling are the next highest, with EUIs of 0.46 kWh/ft^2-yr and 0.39 kWh/ft^2-yr, respectively. Note that shop and hot water equipment, which dominate with respect to installed capacity, have very low EUIs in warehouses.

FIGURE 7-7. Warehouse EUI by Equipment Category

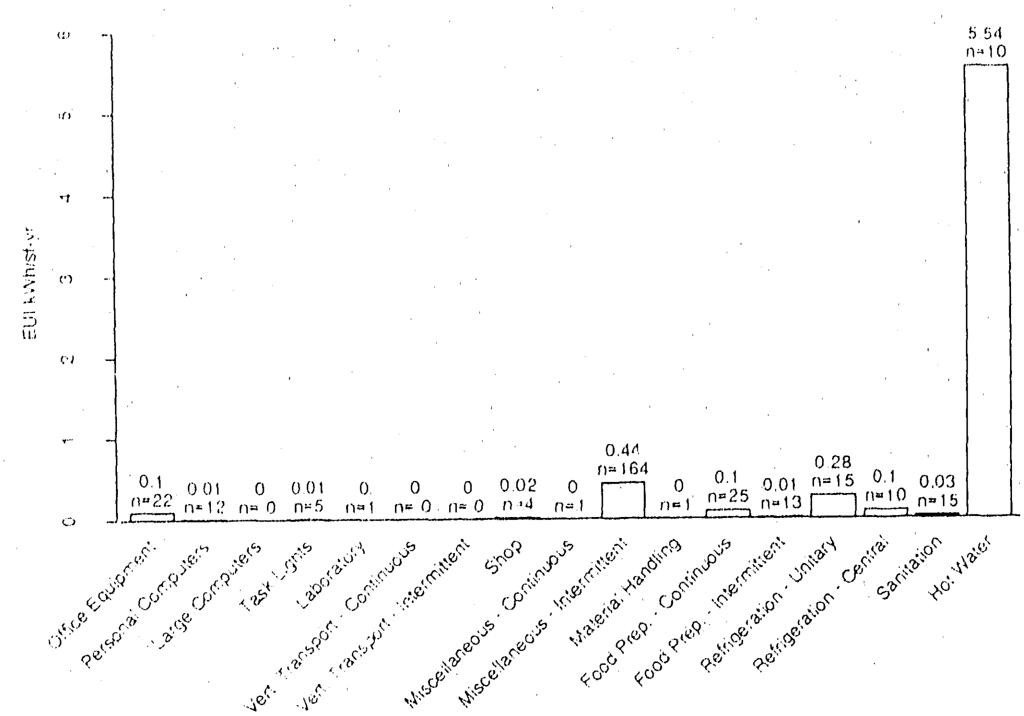


Schools

The hot water EUI dominates all other categories displayed in Figure 7-8 for schools. In fact, at 5.54 kWh/ft²-yr, the hot water EUI is higher for schools than for any other building type. This probably reflects the use of water for both cafeteria cooking/cleaning and showers.

In schools, the only other categories with significant EUIs are intermittent miscellaneous equipment and unitary refrigeration. Although the numbers of intermittent-use miscellaneous devices (primarily audio-visual equipment) are large (n = 164), their energy consumption is small.

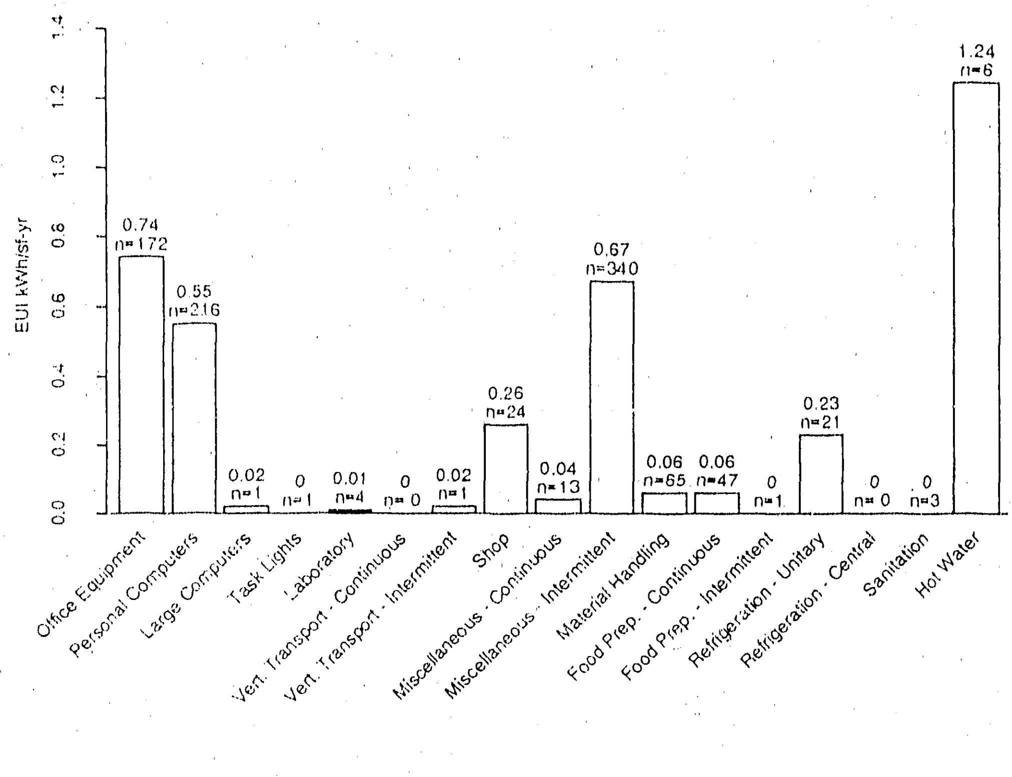
FIGURE 7-8. School EUI by Equipment Category



University

As with schools, hot water equipment has the largest EUI, 1.24 kWh/ft^2-yr, of any equipment type (Figure 7-9), although this represents less than one-fourth the hot water EUI in schools. Office equipment is next highest, with an EUI of 0.74 kWh/ft^2-yr. Intermittent miscellaneous equipment and personal computers are the next most significant categories, with EUIs of 0.67 kWh/ft^2-yr and 0.55 kWh/ft^2-yr, respectively.

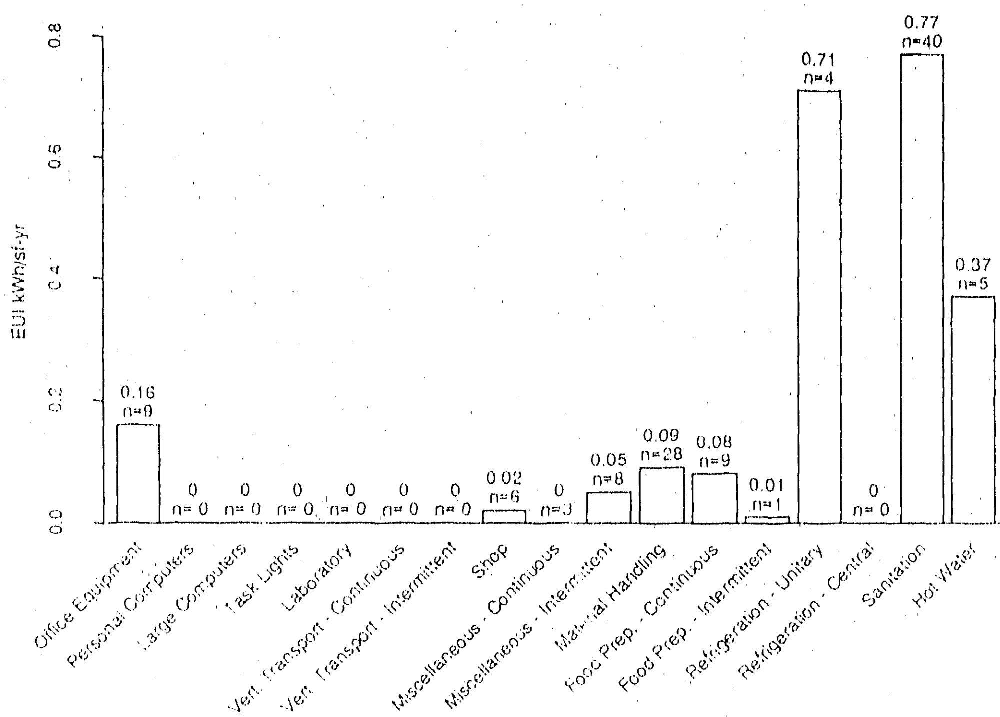
FIGURE 7-9. University EUI by Equipment Category



Other Building-Type

The EUIs for other building types presented in Figure 7-10 are for a sample of five diverse buildings: a coin-operated laundry, a library, a church, a gas station, and a rental store. The three highest EUIs are sanitation (0.77 kWh/ft^2-yr), unitary refrigeration (0.71 kWh/ft^2-yr), and hot water (0.37 kWh/ft^2-yr). Because hot water and dryer heat are provided by fossil fuels in the laundry, the hot water and sanitation EUIs are lower than might be expected for this building type.

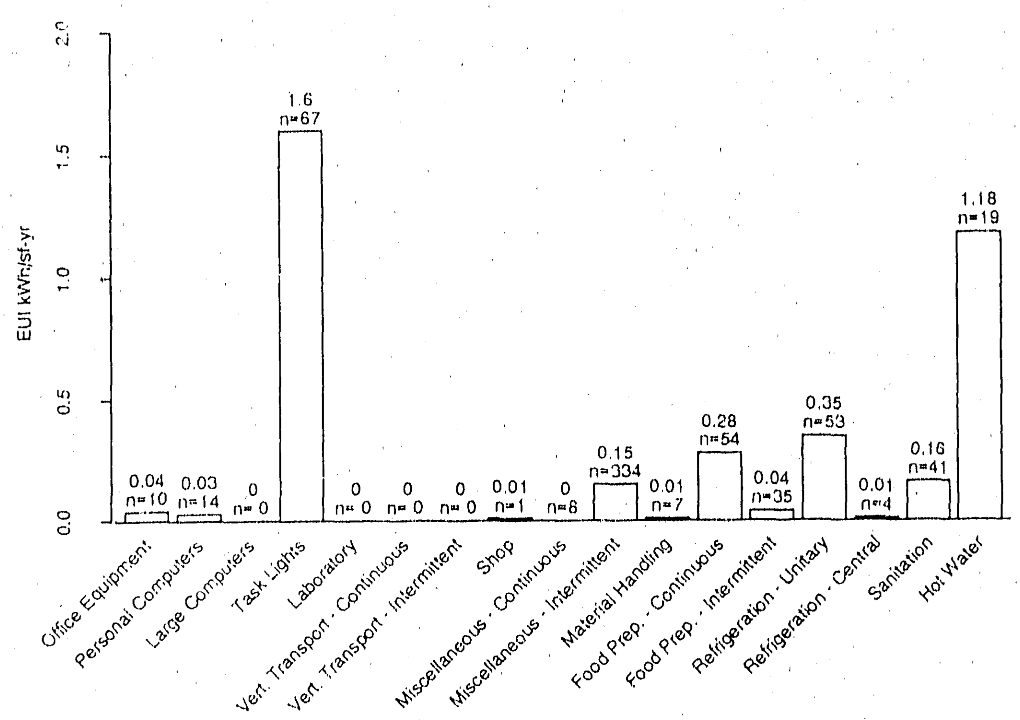
FIGURE 7-10. Other Building - EUI by Equipment Category



Hotels/Motels

The EUIs for the hotel/motel building type are given in Figure 7-11. Task lighting, with an EUI of 1.60 kWh/ft²-yr, is the predominant equipment category. This is likely due to the preponderance of plug-in lamps in these building types. Hot water has the second highest EUI, 1.18 kWh/ft²-yr.

FIGURE 7-11. Hotel/Motel EUI by Equipment Category



POTENTIAL CONSERVATION TARGETS

The cumulative conservation potential for a specific equipment category may be examined by estimating total regional loads within each equipment category and summing across building types. Regional equipment category loads were estimated by multiplying the estimated equipment EUIs (kilowatt hours/square foot-year) by the total floor area in the region for each business type and dividing by the number of hours in the year (8760).

Estimated total floor areas for each building type in the Pacific Northwest region are shown in Table 7-1. These floor areas are abstracted from the Pacific Northwest Nonresidential Energy Survey (Bonneville Power Administration and ADM Associates, Inc. 1989).

TABLE 7-1

Estimated Total Square Footage of Commercial Buildings by Primary Building Type

Building Type	Total Floor Area, thousand ft^2
Small Office	129,153
Large Office	174,545
Small Retail	186,595
Large Retail	97,977
Restaurant	71,097
Grocery	55,302
Warehouse	108,550
School	201,020
University	85,214
Other	359,410
Hotel/Motel	95,147

In Figure 7-12, the total estimated regional load for each equipment category is displayed. The total regional load in average megawatts for each category is represented by a stacked bar. The top height of the bar gives the estimated total regional consumption in average megawatts. The contribution of each building type to the total estimated consumption for each equipment category is distinguished by the hatching within the bar.

FIGURE 7-12. Estimated Regional Electricity Consumption by Equipment Category

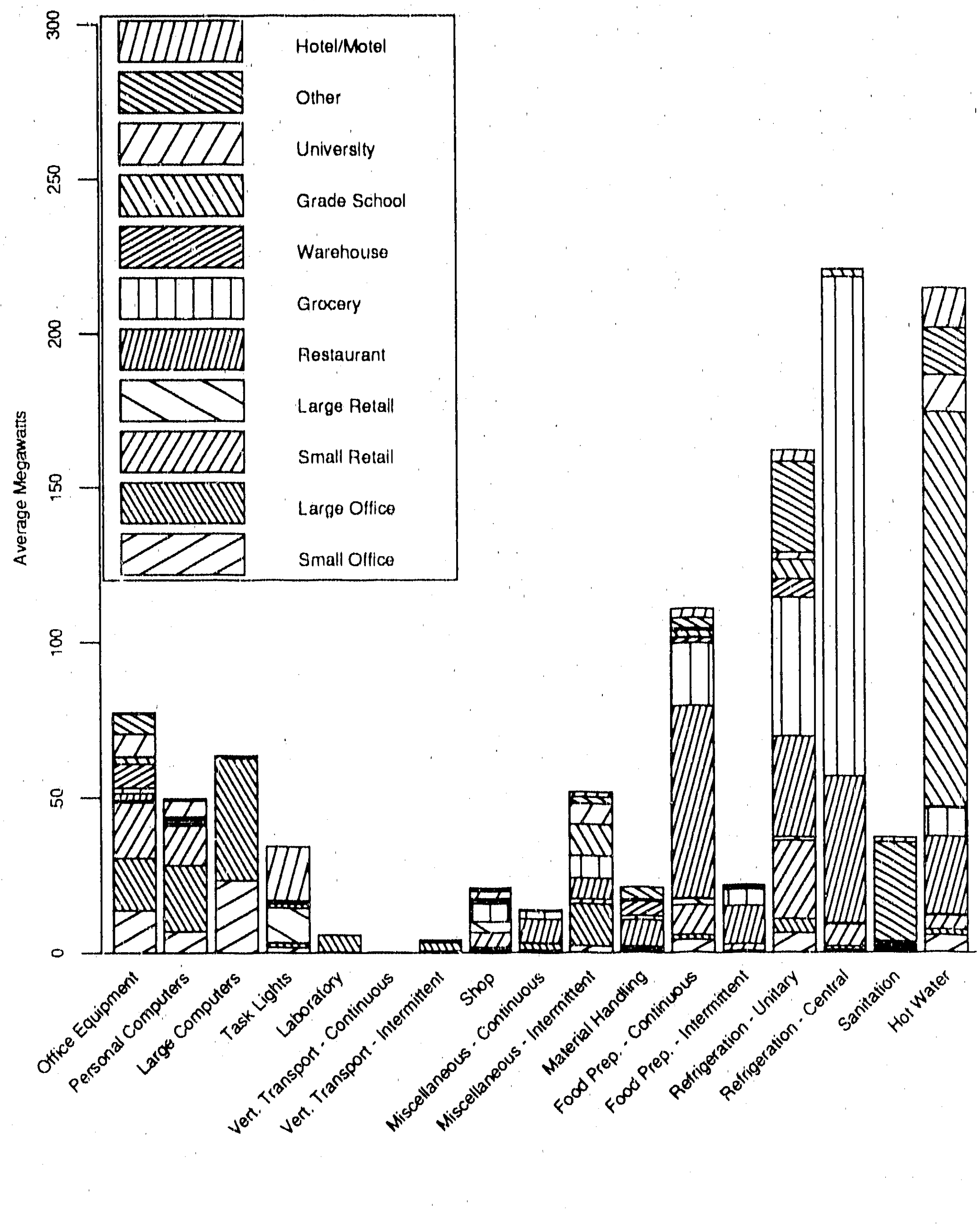


TABLE 7-2

Regionally Weighted Building Contribution to Annual Estimated Loads for 17 Equipment Categories (MWa)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Small Office	13.66	6.74	23.22	1.80	0.22	0.00	0.43	0.67	0.70	2.16	0.35	3.99	0.35	6.21	0.74	0.44	5.31
Large Office	16.69	21.38	39.41	1.19	5.39	0.00	2.82	1.10	2.23	13.47	0.34	1.64	0.22	4.41	1.13	0.84	1.92
Small Retail	18.17	12.80	0.64	0.24	0.00	0.00	0.00	4.62	0.02	1.46	0.91	9.51	2.12	25.31	6.94	0.19	4.47
Large Retail	0.69	0.23	6.00	11.27	0.00	0.08	0.31	3.63	0.00	0.07	0.21	2.09	0.07	1.18	0.53	0.09	0.30
Restaurant	2.12	0.73	0.00	1.15	0.00	0.00	0.14	0.00	7.79	6.68	8.45	62.14	12.20	32.32	47.28	0.75	25.15
Grocery	1.80	0.83	0.00	0.85	0.00	0.00	0.06	5.83	2.40	7.21	1.38	20.16	5.38	44.76	161.33	0.23	9.07
Warehouse	7.83	0.84	0.03	0.12	0.00	0.00	0.06	0.97	0.02	0.02	4.77	1.74	0.12	5.76	0.00	0.09	0.49
School	2.24	0.20	0.00	0.13	0.00	0.00	0.00	0.43	0.06	10.18	0.00	2.34	0.16	6.38	2.34	0.76	127.16
University	7.24	5.37	0.17	0.00	0.09	0.00	0.20	2.49	0.36	6.55	0.55	0.58	0.01	2.21	0.00	0.02	12.09
Other	6.45	0.00	0.00	0.00	0.00	0.00	0.00	0.84	0.05	2.06	3.83	3.47	0.45	29.27	0.00	31.80	15.27
Hotel/Motel	0.41	0.36	0.00	17.43	0.00	0.00	0.00	0.13	0.02	1.68	0.07	3.00	0.49	3.77	0.11	1.69	12.85
Total Est	77.32	49.47	63.47	34.18	5.70	0.08	4.03	20.71	13.67	51.55	20.87	110.65	21.56	161.58	220.40	36.90	214.08

Equipment Types:

1 = Office equipment
2 = Personal Computers
3 = Large Computers
4 = Task Lights
5 = Laboratory
6 = Vertical Transport - Continous
7 = Vertical Transport - Intermittent
8 = Shop
9 = Miscellaneous - Continous
10 = Miscellaneous - Intermittent
11 = Material Handling
12 = Food Preparation - Continous
13 = Food Preparation - Intermittent
14 = Refrigeration - Unitary
15 = Refrigeration - Central
16 = Sanitation
17 = Hot Water

If the conservation potential is assumed to be directly proportional to the total load, several equipment types appear as likely conservation targets. The most notable are equipment in the refrigeration, hot water, computer, continuous food processing, and office categories. The annual estimated loads for each equipment type are summarized in Table 7-2 by building type. In the following paragraphs, the loads are discussed in terms of average megawatts (MWa).

Refrigeration

The total consumption for central refrigerati load is the highest for all equipment categories at 220 MWa. Combined with unitary refrigeration, a total of 382 MWa is consumed by refrigeration equipment--35% of the energy consumed by all devices studies here. The large continuous refrigeration load for the small retail is dominated by cooler storage in the deli tenant of a single site. Similarly, the unitary refrigeration load is driven by the small retail load due to a tenant drugstore with a carbonated soft drink cooler. However, even if we cut the contribution of the refrigeration for small retails in half--because our sample of buildings may be giving elevated small retail EUIs--the refrigeration equipment category would still reflect the highest load. Thus, this category exhibits the largest potential for conservation.

Hot Water

The second-highest estimated total load is for water heating equipment--a surprising 214 MWa. Grade schools dominate this category because of a combination of a high estimated EUI and the large regional floor area associated with schools.

Food Preparation

Continuous- and intermittent-use food preparation equipment are estimated to consume 132 MWa, 75% of which is due to restaurants and groceries. The continuous-use subcategory dominates with 84% of the total estimated load.

Computers

Personal and large computers combine to form the next highest consumption estimate (113 MWa). Large computers constitute about 56% of this total and exist in office buildings almost exclusively. Personal computers make up the remaining 44% of the estimated load and are applicable to small retails and universities as well as offices.

Other Sizable Loads

Office equipment consumes an estimated 77 MWa. Continuous- and intermittent-use miscellaneous equipment are estimated to consume 65 MWa. Sanitation and task lighting consume 37 and 34 MWa, respectively.

Section 8

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APPENDIX A

SUMMARIZATION OF EQUIPMENT IN COMMERCIAL BUILDINGS

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SUMMARIZATION OF EQUIPMENT IN COMMERCIAL BUILDINGS

EQUIPMENT CATEGORIES DEFINED BY CONNECTED LOAD SURVEY EQUIPMENT TYPES

The equipment in the ELCAP commercial buildings is surveyed in great detail, with each device classified into one of numerous possible equipment types. A list of the equipment types used in the ELCAP survey is provided in Table A-1. Each equipment type code consists of a three-letter designation as to its general type and a three-number designation as to its specific type (for example, DPT001 is data processing equipment - cash register). It should be noted that, although most of the equipment codes identify specific equipment (i.e., typewriter), some refer to closely related groups of equipment (i.e., packaging equipment).

The ELCAP equipment type coding scheme provides a plausible set of equipment categories for use in developing the equipment population summaries. However, to provide more detail and different categories better suited to Bonneville's expressed needs, the connected load survey equipment type codes were used to define a modified set of the equipment categories. This modification allowed for distinction between larger versus smaller, constant versus intermittent, and unitary versus central types of use among the equipment by applying, wherever applicable, three general characteristics of the loads.

The first is the general type of load (i.e., data processing versus refrigeration versus food preparation, etc.). The second is the amount or type of power used by the load. This divides large use loads, such as those with large motors or resistance heating functions, from other small-capacity items. The third characteristic is the perceived usage of the load. Equipment that is generally "on" during business hours is separated from that which is used intermittently.

TABLE A-1

ELCAP Connected Load Survey Equipment Codes

Equipment Code	Description
DPT001	Cash Register
DPT002	Microcomputer
DPT003	Copier
DPT004	Computer Printer/Accessories
DPT005	Terminal
DPT006	Typesetter
DPT007	Typewriter
DPT008	Word Processor
DPT009	Computer Central Processor
DPT010	Computer Disk Drive
DPT011	Internal Cooling Fan
DPT012	Printing Press
DPT013	Mimeograph/Ditto Machine
DPT014	Calculator/Adding Machine
DPT015	Dictating Machine
DPT016	Check Writer/Addressograph/Lettering
DPT017	Microfiche Reader
DPT018	Teletype Equipment
DPT019	Disk/Cartridge Cleaner/Rewinder
DPT020	Blueprint Equipment
DPT021	Electric File Equipment
DPT022	Modem
DPT023	Bank Machine
DPT024	Date Stamper
FDP001	Heated Display Case
FDP002	Coffee Machine - Warmer
FDP003	Hot Drink Dispenser/Maker
FDP004	Cold Drink Dispenser/Maker
FDP005	Food Warmer
FDP006	Fryer
FDP007	Fryer Filter
FDP008	Meat Preparation Equipment
FDP009	Kitchen Food Preparation Equipment
FDP010	Microwave
FDP011	Mixer/Blender
FDP012	Oven
FDP013	Range
FDP014	Steam Table
FDP015	Toaster
FDP016	Broiler
FDP017	Can Opener
FDP018	Grill/Griddle

TABLE A-1 (contd)

Equipment Code	Description
FDP019	Gas Control Valve
FDP020	Smokehouse Equipment
LAB001	Centrifuge
LAB002	Hot Plate
LAB003	X-Ray Machine
LAB004	Adjustable Exam Furniture
LAB005	Medical Exam Equipment
LAB006	X-Ray Processing/Duplication
LAB007	Lab Sanitizer/Autoclave
LAB008	Lab Processing Equipment
MAT001	Non_HVAC Pump
MAT002	Battery Charger
MAT003	Conveyor Belt
MAT004	Incinerator
MAT005	Packaging Equipment
MAT006	Paint Shaker
MAT007	Ticket Dispenser
MAT008	Scale
MAT009	Hoist/Cranes
MAT010	Trash Compactor/Shredder
MAT011	Non-HVAC Motor
MAT012	Gas Pump Monitor
MAT013	Ice Machine Harvest Motor
MAT014	Ice Machine Water Pump
MAT015	Pencil Sharpener
MAT016	Postage Equipment
MAT017	Photographic Equipment
MAT018	Letter/Package Opening Equipment/Hole Punch
MAT019	Money Counter
REC001	Video Game/Pinball Machine/Toys
REF001	Refrigeration Controller
REF002	Refrigeration Cooler
REF003	Refrigeration Defrost Heater
REF004	Refrigerated Display Case
REF005	Freezer Display Case
REF006	Freezer
REF007	Ice Cream Maker
REF008	Ice Machine
REF009	Lights

TABLE A-1 (contd)

Equipment Code	Description
REF010	Refrigerator
REF011	Water Cooler
REF012	Central Compressor
REF013	Unit Compressor
REF014	Condenser Fan
REF015	Anti-condensation Heater
REF016	Refrigeration/Evaporator Fans
SAN001	Dishwasher
SAN002	Disposal
SAN003	Dryer
SAN004	Washer
SAN005	Water Softener
SAN006	Vacuum System
SAN007	Hand Dryer
SAN008	Air Freshener
SAN009	Steam Cleaner/Shampooer
SAN010	Floor Polisher
SAN011	Dry Cleaner
SHP001	Tool Motors
SHP002	Welding Machine
SHP003	Air Compressor
SHP004	Kiln/Foundry Furnace/Process Heat
SHP005	Soldering Gun/Iron
SHP006	Chain saw, Electric
SHP007	Demagnetizer/Magnetic Equipment
SHP008	Shop Press/Forming Machine
SHP009	Electronic Equipment
SHP010	Process Tank-Heat
SHP011	Cranes
SHW001	Water Heater With Tank
SHW002	Booster Heater
SHW003	Circulating Pump
SHW004	Service Hot Water Controls
SHW005	Domestic HW Heat Exchanger/Preheat
SPE001	Curtain Motor
SPE002	Door Operator
SPE003	Fire Alarm/Other Alarm
SPE004	Intercom/Amplifier/Sound System
SPE005	Revolving Sign Motor

TABLE A-1 (contd)

Equipment Code	Description
SPE006	Scoreboard
SPE007	Safe
SPE008	Vending Machine
SPE009	Insect Killer
SPE010	Video Equipment/Television
SPE011	Time Clock
SPE012	Stereo/Radio
SPE013	Punch Clock
SPE014	Phone Controller
SPE015	Scanner
SPE016	Paper Shredder
SPE017	Engine Heater/Heat Tape/Battery Charger
SPE018	Sprinkler Control/Heater
SPE019	Iron
SPE021	Hair Dryer/Curling Iron/Hair Equipment
SPE022	Projectors Audio/Visual/Art Equipment
SPE023	Transformer
SPE024	Sewing Machine/Tailor Equipment
SPE025	Transformers/Electric Power Controller
SPE026	Aquarium Heater/Lights/Equipment
SPE027	Generator/Compressor
SPE028	Electric Fence
VTR001	Dumb Waiter
VTR002	Elevator
VTR003	Escalator
VTR004	Window Washer

These definitions are shown in terms of specific ELCAP equipment type codes in Table A-2.

TABLE A-2

Equipment Categories Defined by Connected Load Survey Equipment Type Codes

Mnemonic	Equipment Category	Connected Load Survey Equipment Type Codes Included	Equipment Included
OFF	Office Equipment	DPT001, 003, 006, 007, 012-018, 020, 021, 023, 024 and MAT015, 016, 018, 019	Typewriters, copiers, cash registers, filing & miscellaneous office equipment
FDPC	Food Preparation (Continuous Use)	FDP001-006, 010, 012-014, 016-018, 020	Grills, ovens, fryers, broilers, steamers, hot drink machines, warmers, toasters
FDPI	Food Preparation (Intermittent Use)	all other FDP*	Slicing, grinding, mixing, and all other non-cooking equipment
LAB	Laboratory	all LAB	Medical and electronic testing equipment
PHO	Photography	MAT017	Photographic processing equipment
HOT	Hot Water	all SHW	All water heating equipment
MAT	Material Handling	all other MAT*	Conveyors, wrappers, scales and hoists, compactors, material dispensers, and all other automatic material handling equipment, and non-HVAC pumps and motors
REFU	Refrigeration (Unitary)	REF002, 004-008, 010, 011	Domestic-type refrigerators & freezers, ice machines, water coolers, other small coolers
REFC	Refrigeration (Central)	all other REF*	All large cooling and freezing equipment or those powered by separate compressors

* All equipment type codes not specified in other categories.

TABLE A-2 (contd)

Mnemonic	Equipment Category	Connected Load Survey Equipment Type Codes Included	Equipment Included
SAN	Sanitation	all SAN	Washers, dishwashers, disposals, dryers, vacuum systems, steam clean equipment, and other miscellaneous cleaning equipment
VTRC	Vertical Transport (Continuous Use)	VTR003	Escalators
VTRI	Vertical Transport (Intermittent Use)	all other VTR*	Elevators, dumb waiters and window washers
SHP	Shop	all SHP, (process heat items too few to split out)	Power tools, fabrication/repair equipment, and electronic apparatus
MISC	Miscellaneous (Continuous Use)	SPE005, 008, 009, 011, 013, 014, 018, 025	Sign motors, time clocks, vending machines, phone equipment, sprinkler controls
MISI	Miscellaneous (Intermittent Use)	all other SPE*	Scoreboards, fire alarms, intercoms, TVs, radios, projectors, door operators
CMP	Personal Computer Equipment	DPT002, 004, 005, 008-011, 019, 022	Small terminals, personal computers, disk drives, central processors, and printers
LGC	Large Computer Equipment	DPT002, 004, 005, 008-010	Larger multi-user or network terminals, disk drives, central processors, and printers
TLT	Task Lighting	INL001-006 where not metered as lighting end use	Lights metered on mixed use circuits (not strictly task lighting, see text)

* All equipment type codes not specified in other categories.

DISTINGUISHING SMALL (PERSONAL) AND LARGE COMPUTER EQUIPMENT

The distinction between personal and large computer equipment is primarily one of size, since many of the specific computer equipment types apply to both personal use or large systems. To split the surveyed equipment into these types, sorted outputs of the load capacities were produced for the six main types of computer equipment. We then determined cut-off values for each type, to distinguish equipment obviously part of large systems from smaller personal-use equipment. Figures A-1 through A-6 show the spread of individual device capacities, with lines indicating the selected cutoff points.

EQUIPMENT LOAD SUMMARIES

We summarized two kinds of information about the equipment in each building type for this analysis: the number of individual devices (pieces of equipment) in each equipment category and the total nameplate capacity ratings for each equipment category. The number of devices and total capacity for each building were divided by the floor area to produce device density (devices/square foot) and capacity density (kilowatts/square foot) for each of the equipment categories listed in Table A-2. Once the device and capacity densities were computed for each building, they were averaged across buildings within a given building type to produce the equipment population summaries.

In the process of creating the summaries, a series of four intermediate steps between the connected load inventory and the final summaries has been retained, for future analyses that may find their greater levels of detail valuable. These intermediate data sets are useful in illustrating the process of developing the reported equipment population summaries. These intermediate data summaries have been formatted on floppy disk and are available from Bonneville's End-Use Research Section (RPEE).

FIGURE A-1. Sorted Frequency Distribution for Terminals

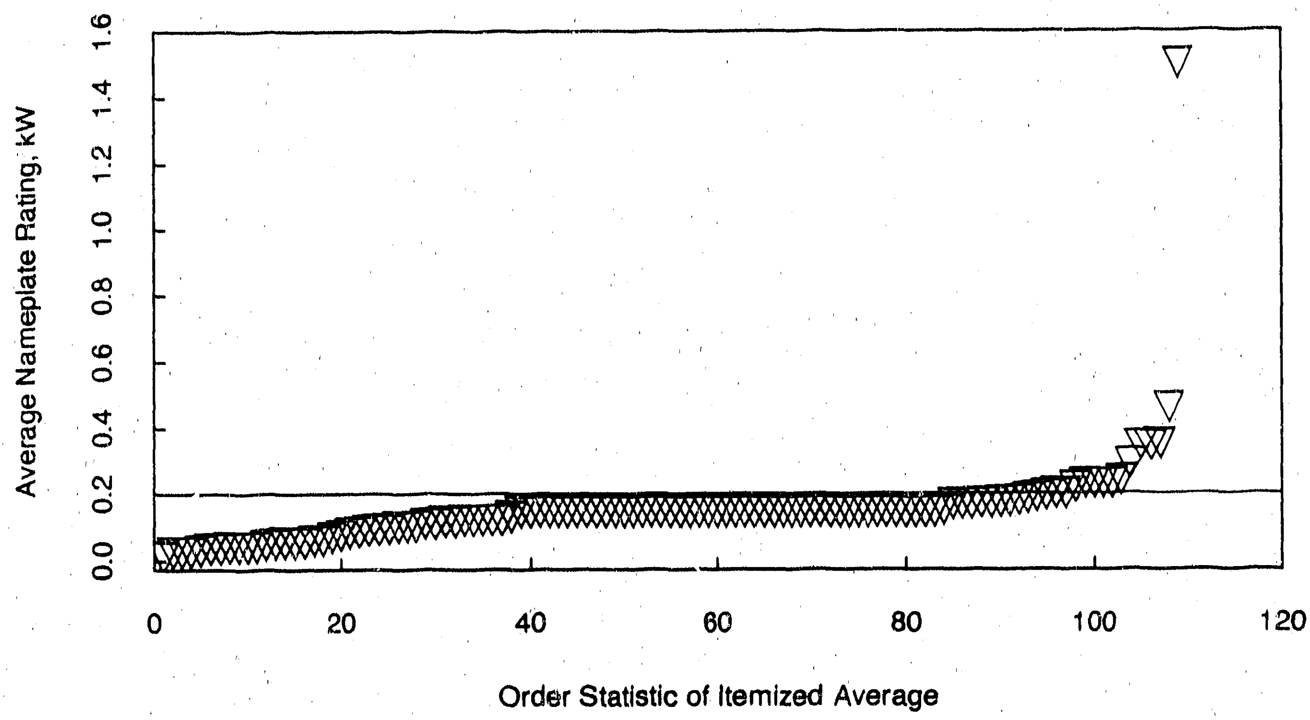


FIGURE A-2. Sorted Frequency Distribution for Central Processing Units

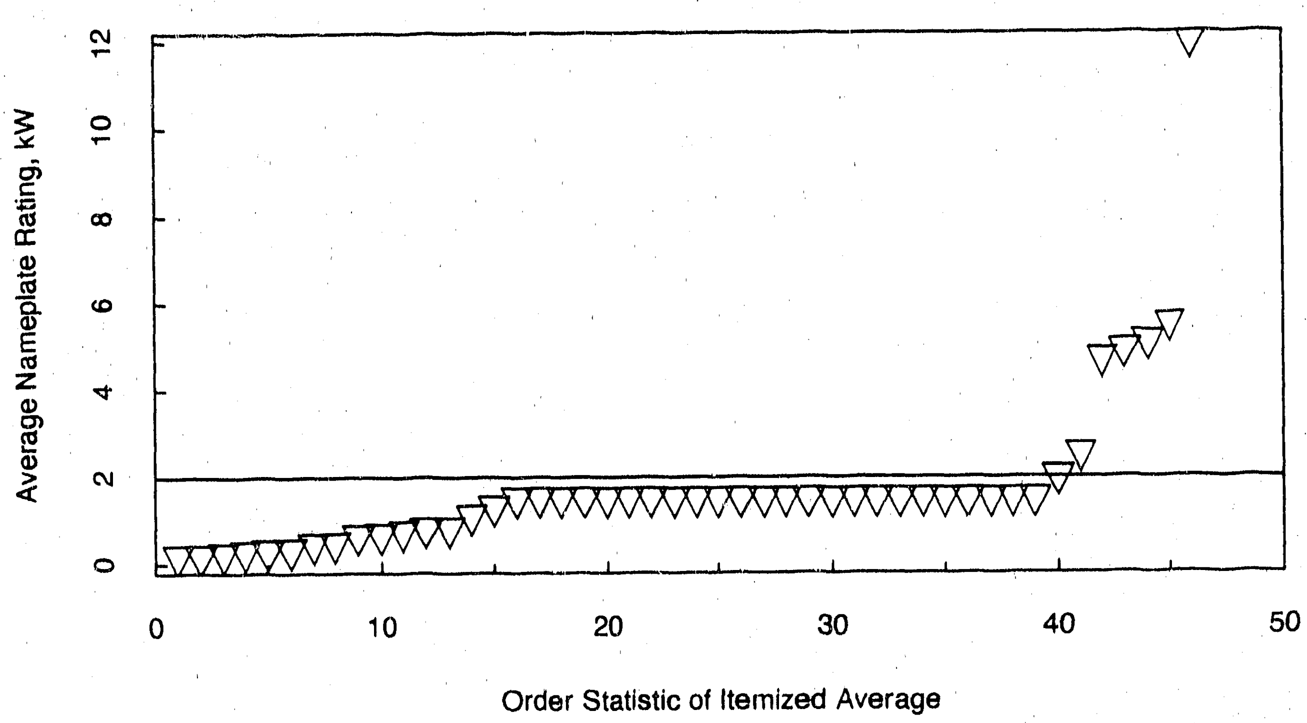


FIGURE A-3. Sorted Frequency Distribution for Word Processors

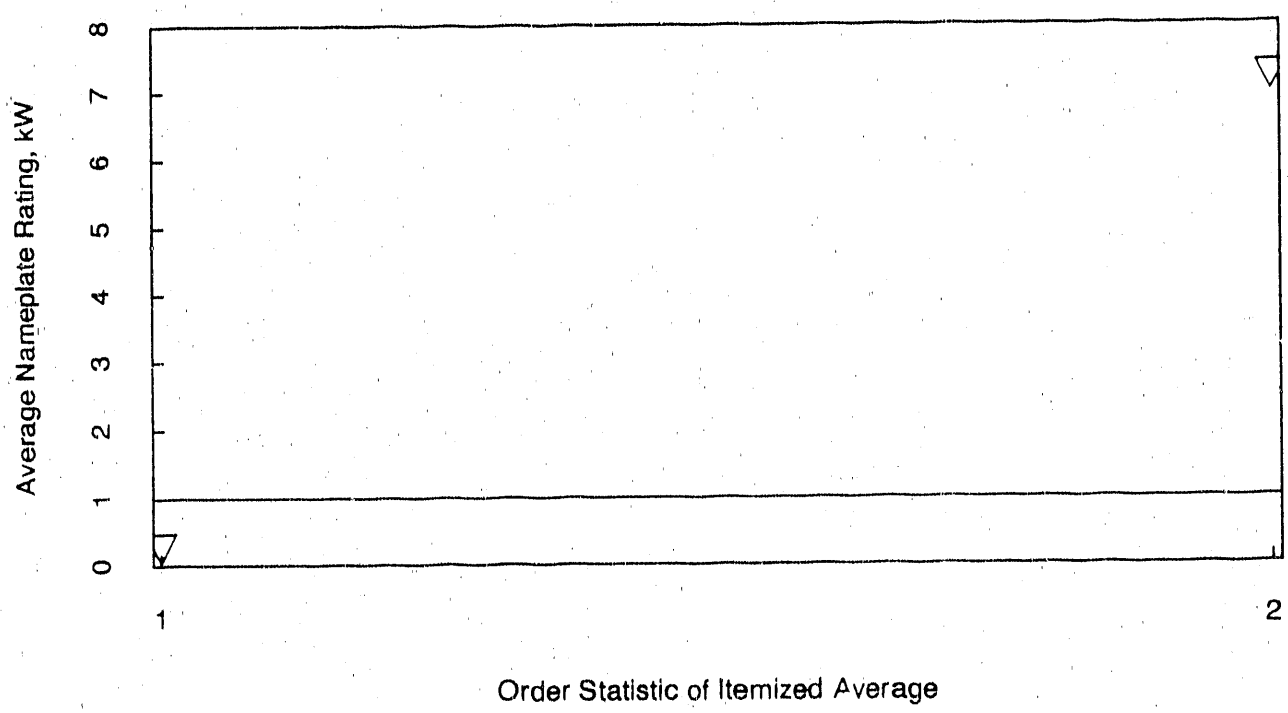


FIGURE A-4. Sorted Frequency Distribution for Printer Accessories

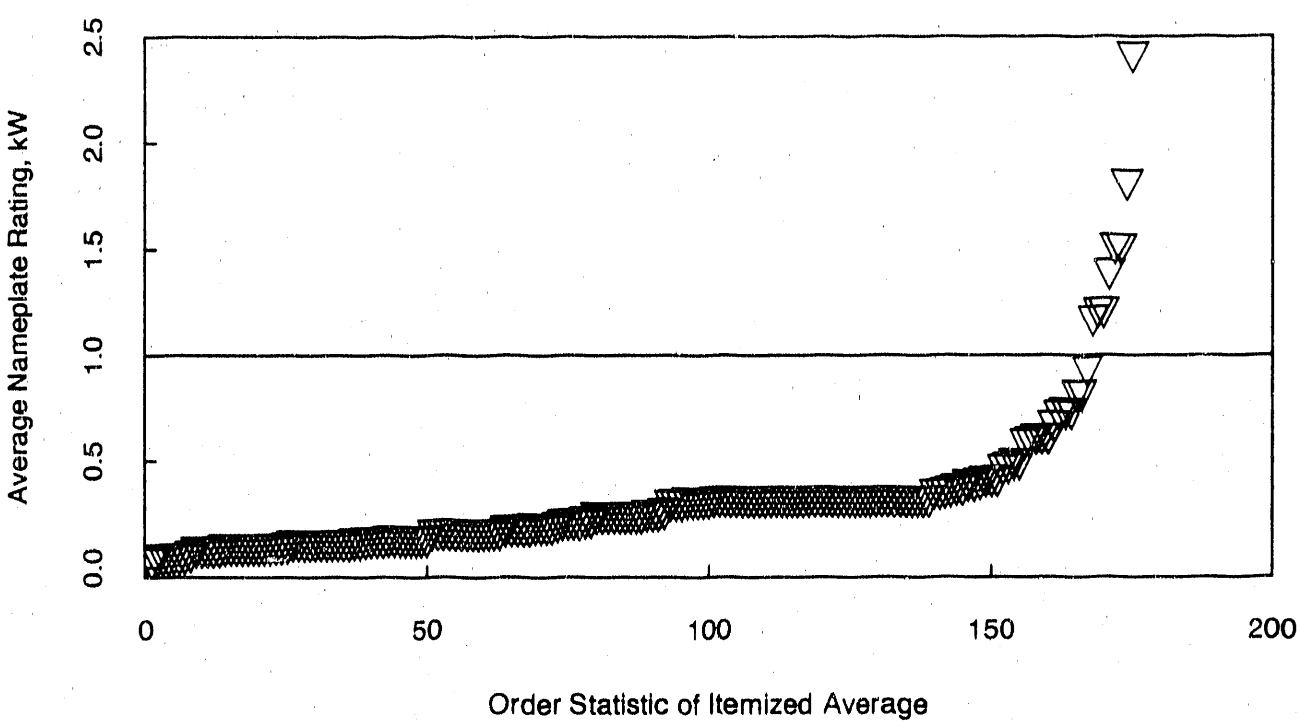


FIGURE A-5. Sorted Frequency Distribution for Microcomputers

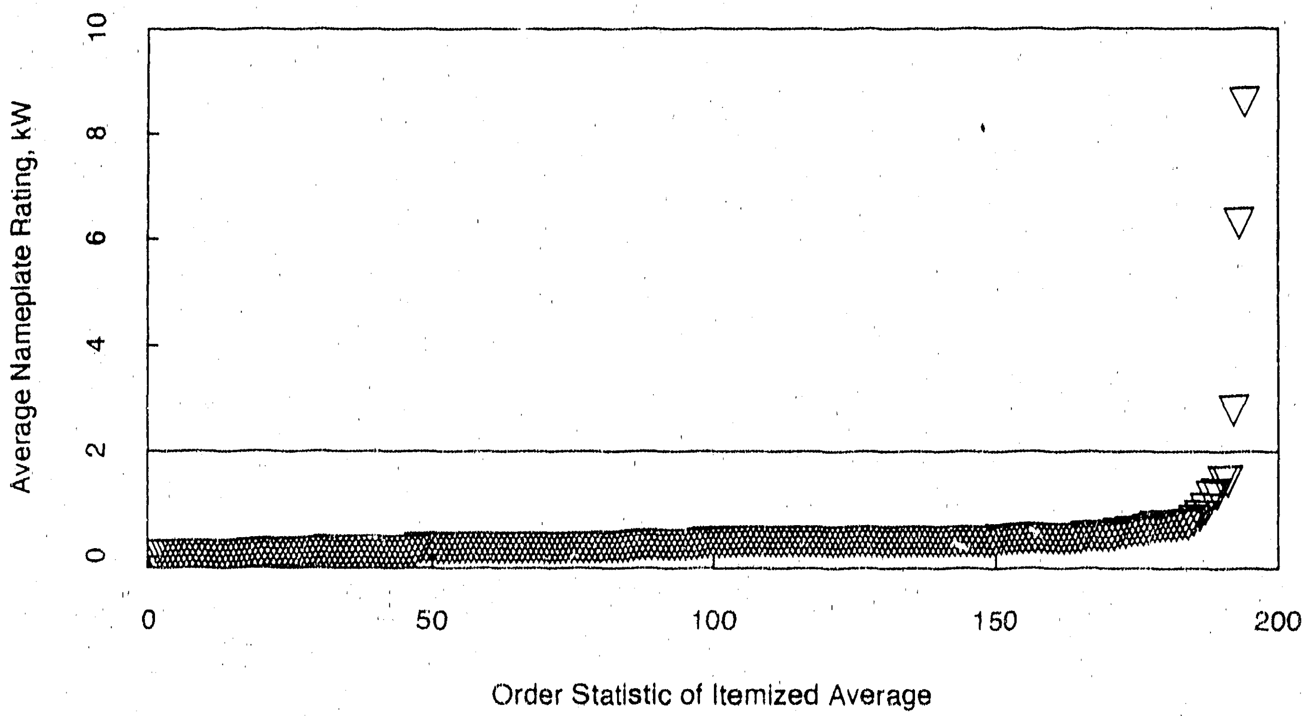
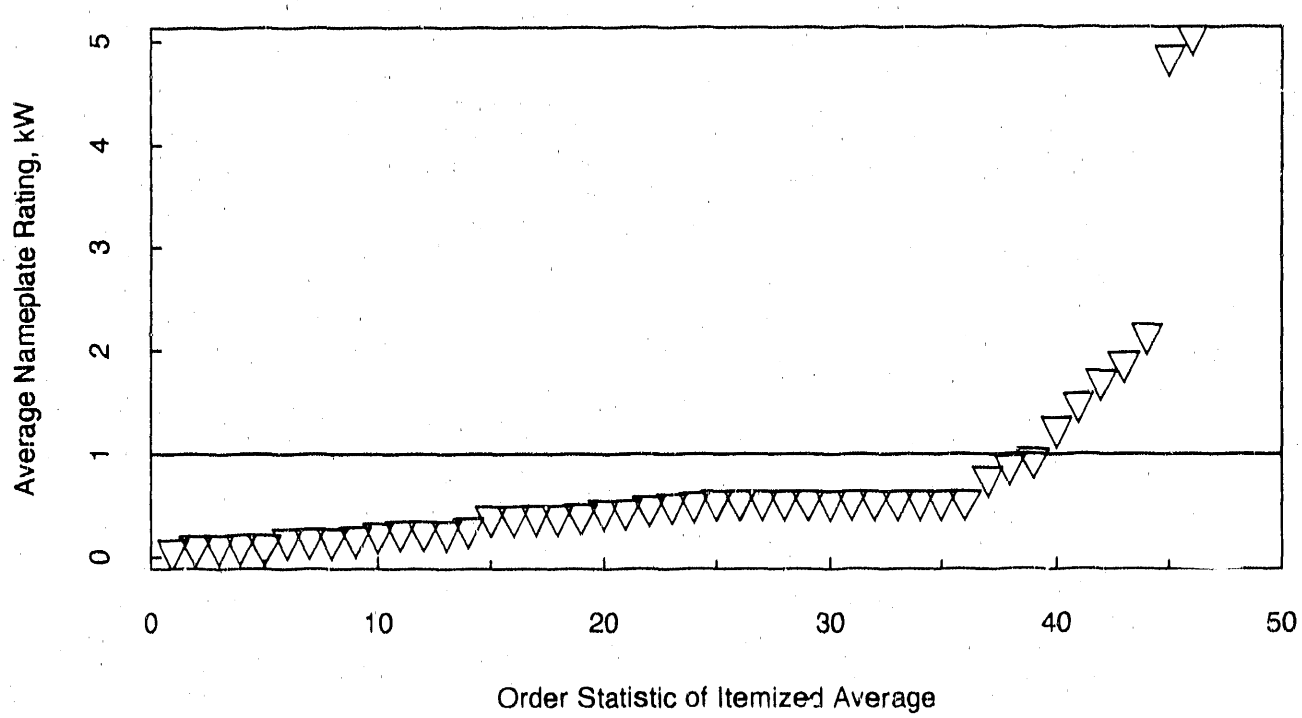


FIGURE A-6. Sorted Frequency Distribution for Disk Drives



Raw ELCAP Connected Load Survey Data

The first intermediate data set is illustrated in Table A-3, and contains a formatted version of the raw connected load survey data. It is organized by site (the ELCAP site identification number) and equipment code (the connected load survey code assigned to each piece of equipment). The count for task lighting is always defaulted to 1, as the connected load survey counted lighting systems rather than individual lighting fixtures.

Equipment Type Summaries

In the second summary, the capacities, counts, and end uses for each equipment code within each building were combined. This produced a summary of one equipment type code per fuel type per building, as shown in Table A-4. In addition, equipment and capacity densities were produced by dividing by floor area. Also determined but not shown in Table A-4 are the minimum and maximum values for capacity for each equipment type.

This summary can be used to identify device counts and capacity totals as well as device and count densities, for a particular type of equipment (e.g., typewriter, microwave, ice machine, packaging equipment) in each specific building. By examining the distribution of these values across all the buildings, this summary can be used to determine average or typical values for capacity per device for each equipment type.

Equipment Category/Fuel Type Summaries

As a further summarization, the average capacity, number of devices, the total capacity, and their densities for equipment types within each equipment category were combined. These values were tabulated separately by fuel type and end use in each of the buildings.

The combination of loads into these general equipment categories produced the summary in Table A-5. This summary is useful in identifying density and capacity values for a specific category of equipment (i.e., data processing,

TABLE A-3

Raw Personal Computer Connected Load Survey Data from Two Buildings

Site	Equipment Type	Fuel Type	Capacity (kW)	Number of Devices	Floor Area (ft^2)	End Use
458	Micro-computer	Elec.	0.30	1	7911	Receptacles
458	Micro-computer	Elec.	0.48	2	7911	Receptacles
458	Micro-computer	Elec.	0.48	5	7911	Receptacles
458	Printer	Elec.	0.12	1	7911	Receptacles
458	Printer	Elec.	0.30	1	7911	Receptacles
458	Terminal	Elec.	0.29	2	7911	Data Processing
458	Disk Drive	Elec.	0.49	1	7911	Data Processing
458	Disk Drive	Elec.	0.99	2	7911	Data Processing
538	Micro-computer	Elec.	0.23	1	12130	Receptacles
538	Micro-computer	Elec.	0.60	2	12130	Receptacles
538	Printer	Elec.	0.24	1	12130	Receptacles
538	Terminal	Elec.	0.43	3	12130	Receptacles
538	Terminal	Elec.	1.90	21	12130	Receptacles
538	Computer CPU	Elec.	0.69	2	12130	Receptacles
538	Computer Fan	Elec.	0.24	1	12130	Receptacles

TABLE A-4

Personal Computer Equipment Type Summaries for Two Buildings

Site	Equipment Type	Device No. (#)	Device Density (#/ft^2)	Mean Capacity Total (kW)	Mean Capacity Density (kW/ft^2)	Fuel Type	End Use
458	Micro-computer	8	0.00101	1.28	0.00016	Elec.	Receptacles
458	Printer	2	0.00025	0.42	0.00005	Elec.	Receptacles
458	Terminal	2	0.00025	0.28	0.00004	Elec.	Data Processing
458	Disk Drive	3	0.00038	1.47	0.00019	Elec.	Data Processing
538	Micro-computer	3	0.00025	0.84	0.00007	Elec.	Receptacles
538	Printer	1	0.00008	0.24	0.00002	Elec.	Receptacles
538	Terminal	24	0.00198	2.40	0.00019	Elec.	Receptacles
538	Computer CPU	2	0.00016	0.68	0.00006	Elec.	Receptacles
538	Computer Fan	1	0.00008	0.24	0.00002	Elec.	Receptacles

TABLE A-5

Personal Computer Equipment Category/End Use Summaries for Two Buildings

Site	Equipment Category	Device No. (#)	Device Density (#/ft²)	Mean Capacity Total (kW)	Mean Capacity Density (kW/ft²)	Fuel Type	End Use
458	Personal Comp.	10	0.00126	1.70	0.00021	Elec.	Receptacles
458	Personal Comp.	5	0.00063	1.75	0.00023	Elec.	Data Processing
538	Personal Comp.	31	0.00255	4.34	0.00036	Elec.	Receptacles

food preparation, material handling, etc.) in a specific building. It also forms the basis of the regression data set used for the utilization factor estimates described in Appendix C.

Equipment Category Summaries

The final summary is subsequently created by combining the data across sites, within building types. The building types and details are shown in Table A-6. This creates a summary of one equipment category per fuel type per building type. This summary forms the basis for the equipment population summaries presented in Section 5.

TABLE A-6

Personal Computer Equipment Category Summaries for Two Buildings

Site	Equipment Category	Device No. (#)	Device Density (#/ft²)	Mean Capacity Total (kW)	Mean Capacity Density (kW/ft²)	Fuel Type	End Use
458	Personal Comp.	15	0.00189	3.45	0.00044	Elec.	Data Processing and Receptacles
538	Personal Comp.	31	0.00255	4.34	0.00036	Elec.	Receptacles

TREATMENT OF MISSING DATA

A part of the connected load survey data collection included notation of the nameplate capacity. In some cases this was not available due to the age of the equipment (no rating) or inaccessibility of the labels. Of the 13,642 total survey loads representing 18,001 devices (including HVAC and lighting equipment), a total of 2488 or 18% had no available nameplate capacity rating. To obtain a complete set of capacities for more accurate reporting of the equipment populations, it was necessary to account for missing capacities in some fashion.

Two methods of filling were tried. The first method simply assumed the average of all similar equipment (with the same equipment code) as the value for each missing device capacity. This method reduced the number of missing capacities to 35.

The second method used the average from similar equipment but only the buildings of the same type. This method was investigated because it was hypothesized that there might be significant variation in average capacities for a type of equipment between building types. This method left 284 capacities still missing. This is due to the lack of any available capacity for some of the equipment types within certain building types, since some types of equipment exist in very small numbers in certain building types.

Using the second method of filling, we noted that the numbers of individual devices for a specific type of equipment within a building type (typically 2 to 15) proved to be too small in many cases to provide a useful mean capacity for filling. We also noted that the variance in capacity per device between building types is small for most equipment types. The equipment types that would be more likely to exhibit a variance (i.e., miscellaneous, shop, material handling) tend to be concentrated in particular building types, thus eliminating most of the influence of variance across building types.

To determine if any valid differences did exist between the two methods, a set of equipment population summaries similar to those in Section 5 was developed using the data filled by building type. These appear in Figures A-7 through A-17.

By comparing this set of graphs with the figures in Section 5, some differences are noted. There is a general trend in each of the building types: the capacity density is usually slightly smaller in the building type filled data when there is any difference. This is expected because of the greater number of remaining missing capacities in the building type filled data causing lower densities.

Those cases where the filled values based on building type are much higher or lower may indicate a general difference in equipment capacity between building types if the sample is large enough to be meaningful. A summary of the differences that are greater than 10% is shown in Table A-7. Those that affected capacity densities by less than 1 Wt/ft^2 or that had less than 10 missing values are not included. Also not included are differences associated with the "other" building type, which consists of too broad a variety of businesses is to be meaningful.

Note that the number of values (except for task lighting) are total pieces of equipment in the survey. The number of capacities available in this number for calculation of building filled capacity densities may be considerably less if there are duplicate devices in the survey. Although the differences in Table A-7 appear significant, the number of devices in the sample and remaining missing capacities must be considered. To adopt the building-type filled data would, at a minimum, generally bias the results to consistently lower values.

It was decided that filling missing values using the average across all buildings rather than within building types provides the most valid view of commercial equipment load capacity densities. For this reason, the graphs in Section 5 use the data with missing values filled from all buildings. Although this was not done, the values in Table A-7 that have plausible explanations

TABLE A-7

Equipment Categories with Significant Changes in Mean Device Capacity When Averaged by Building Type

Equipment Category	Building Type	Change in Capacity Density	Number of Devices	Notes
MAT	Small Retail	-30%	14	
REFC	Restaurant	-41%	138	May be overshadowed by larger grocery units
SHP	Small Retail	-19%	29	
	Large Retail	+37%	44	Large cranes, welders and process heat found mostly in one large machinery sales and repair business
MISI	Small Retail	-17%	36	
	Hotel/Motel	+24%	334	Hotel/Motel MISI is mostly smaller loads such as TVs and clocks in rooms
HOT	Small Retail	-34%	16	Smallest type of hot water equipment in sample - residential equipment
	Hotel/Motel	+46%	19	Largest type of hot water equipment for service to rooms
TLT	-	-	-	No comparisons are valid since the n is per load and not per device

could be applied. Other methods of determining more exact changes among the 205 equipment types within the 11 building types could be applied but are beyond the scope of this analysis.

FIGURE A-7. Small Office Capacity Density of Electric Equipment (n=19) (Missing Data Filled by Building Type)

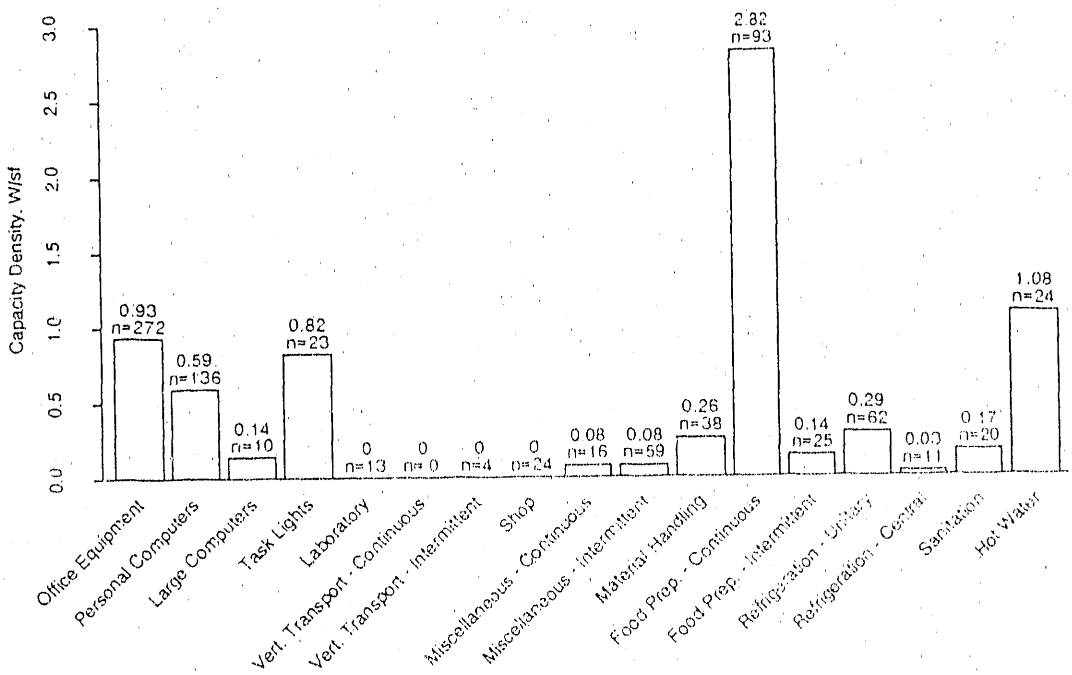


FIGURE A-8. Large Office Capacity Density of Electric Equipment (n=7) (Missing Data Filled by Building Type)

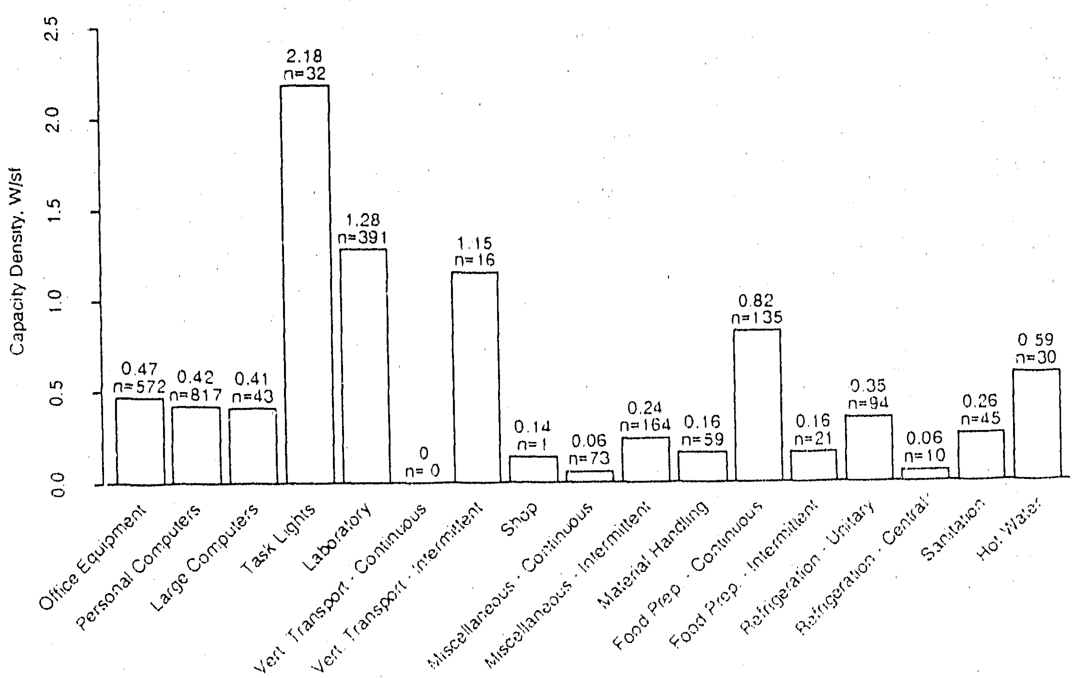


FIGURE A-9. Small Retail Capacity Density of Electric Equipment (n=19) (Missing Data Filled by Building Type)

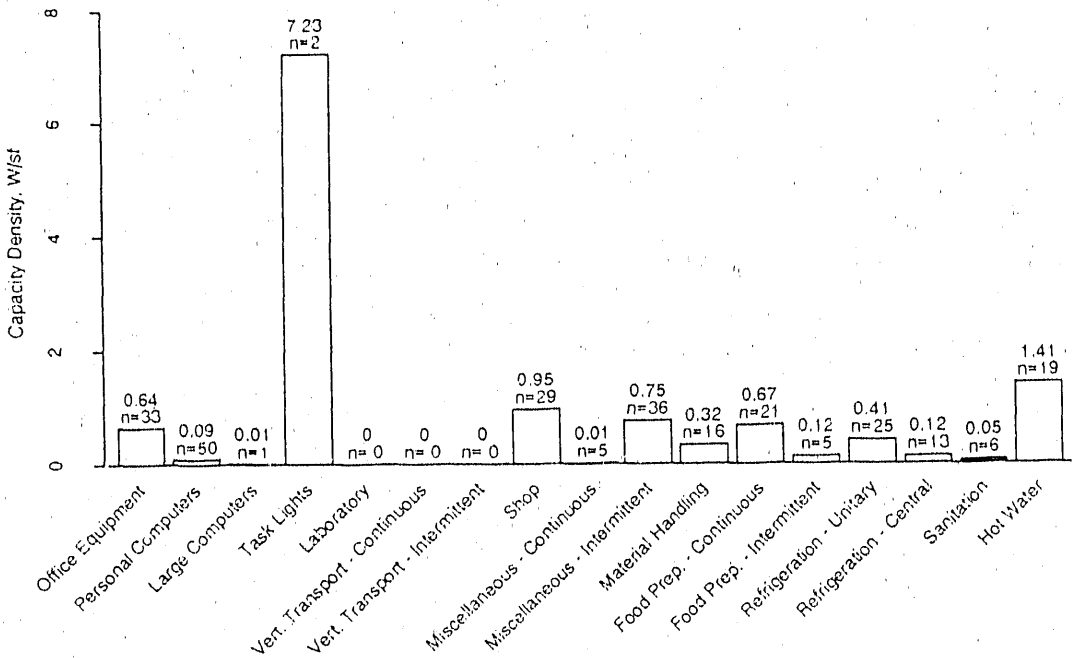


FIGURE A-10. Large Retail Capacity Density of Electric Equipment (n=8) (Missing Data Filled by Building Type)

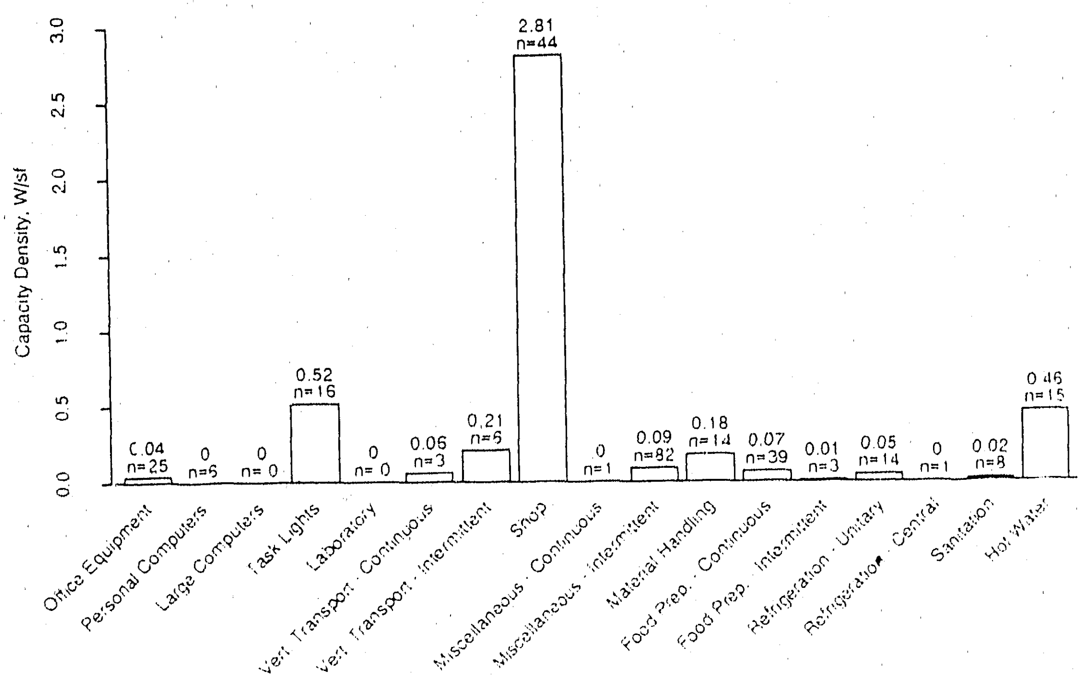


FIGURE A-11. Grocery Capacity Density of Electric Equipment (n=19) (Missing Data Filled by Building Type)

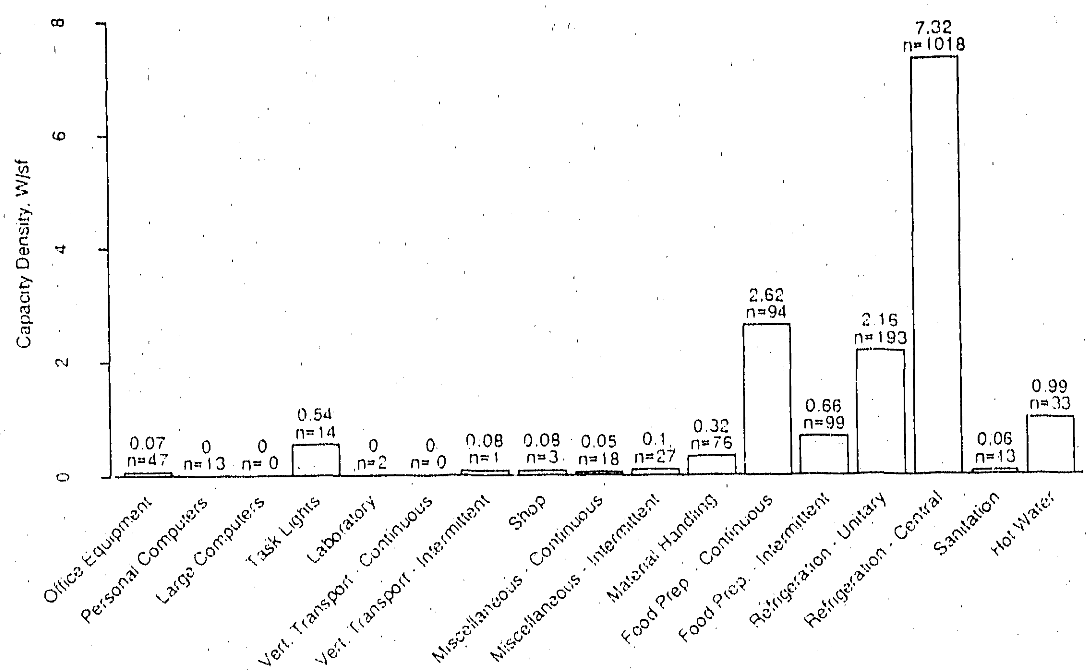


FIGURE A-12. Restaurant Capacity Density of Electric Equipment (n=15) (Missing Data Filled by Building Type)

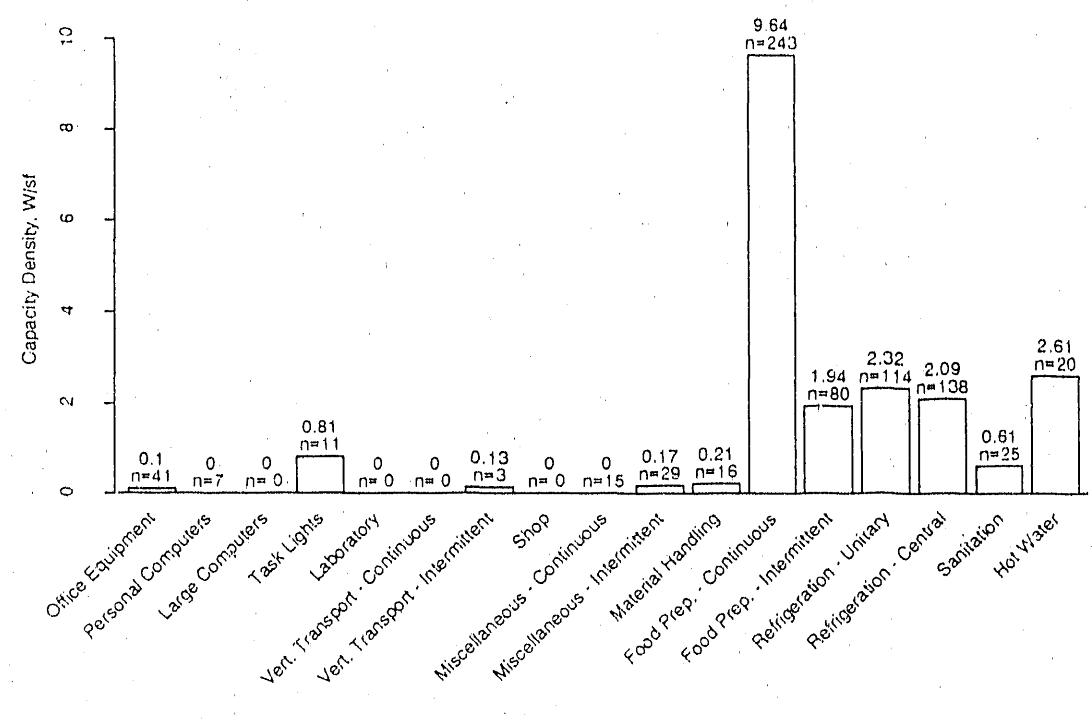


FIGURE A-13. Warehouse Capacity Density of Electric Equipment (n=13) (Missing Data Filled by Building Type)

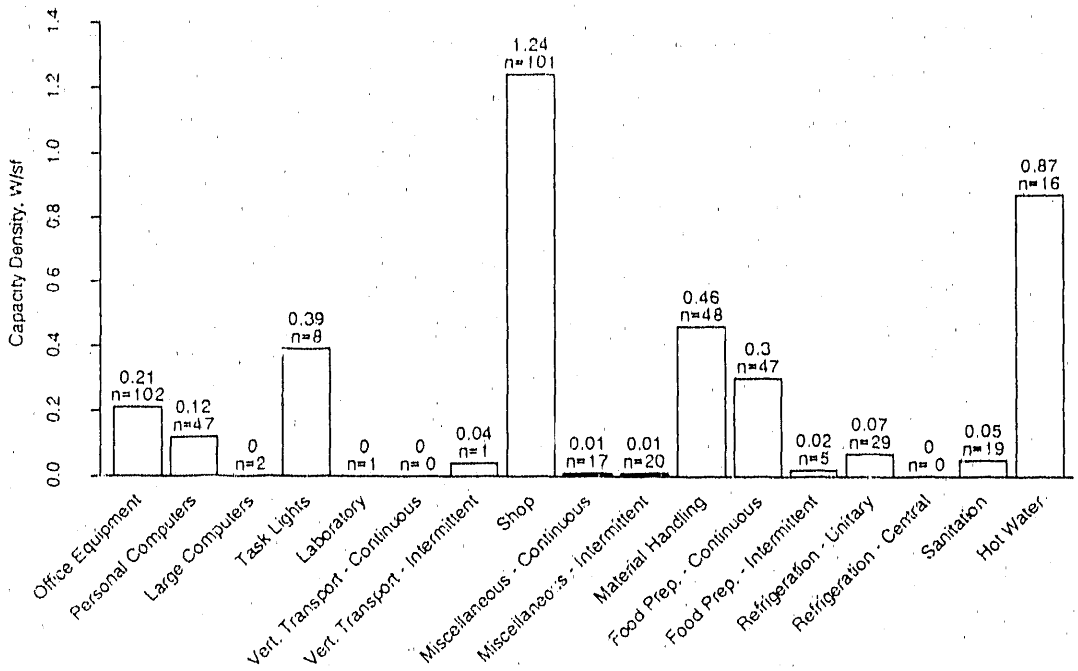


FIGURE A-14. School Capacity Density of Electric Equipment (n=4) (Missing Data Filled by Building Type)

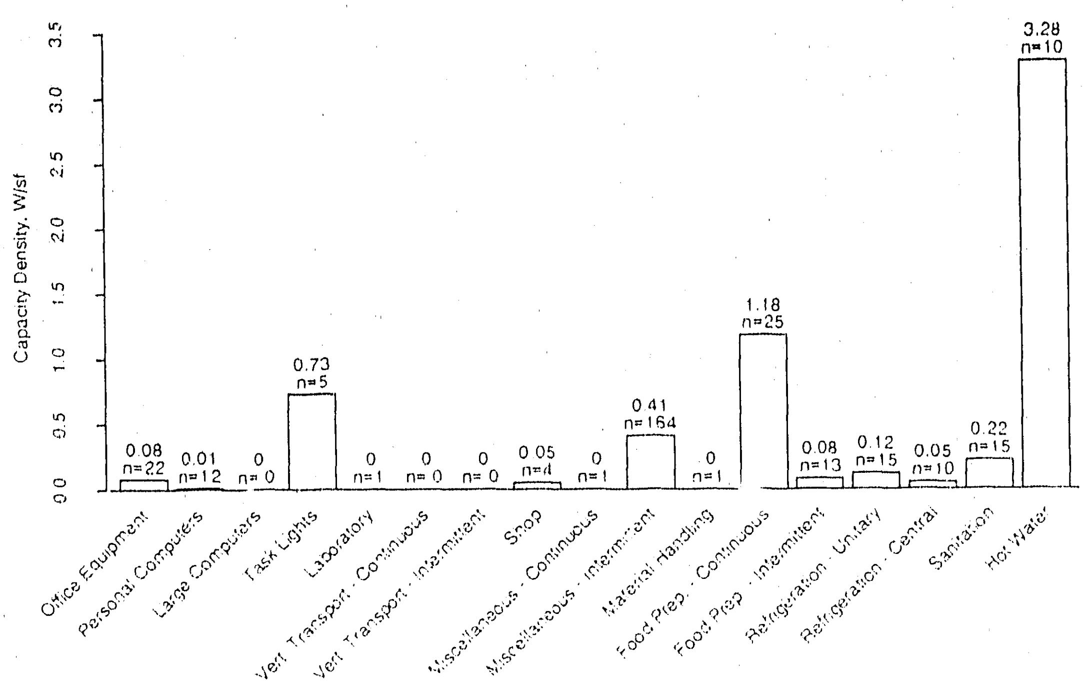


FIGURE A-15. Other Buildings Capacity Density of Electric Equipment (n=5) (Missing Data Filled by Building Type)

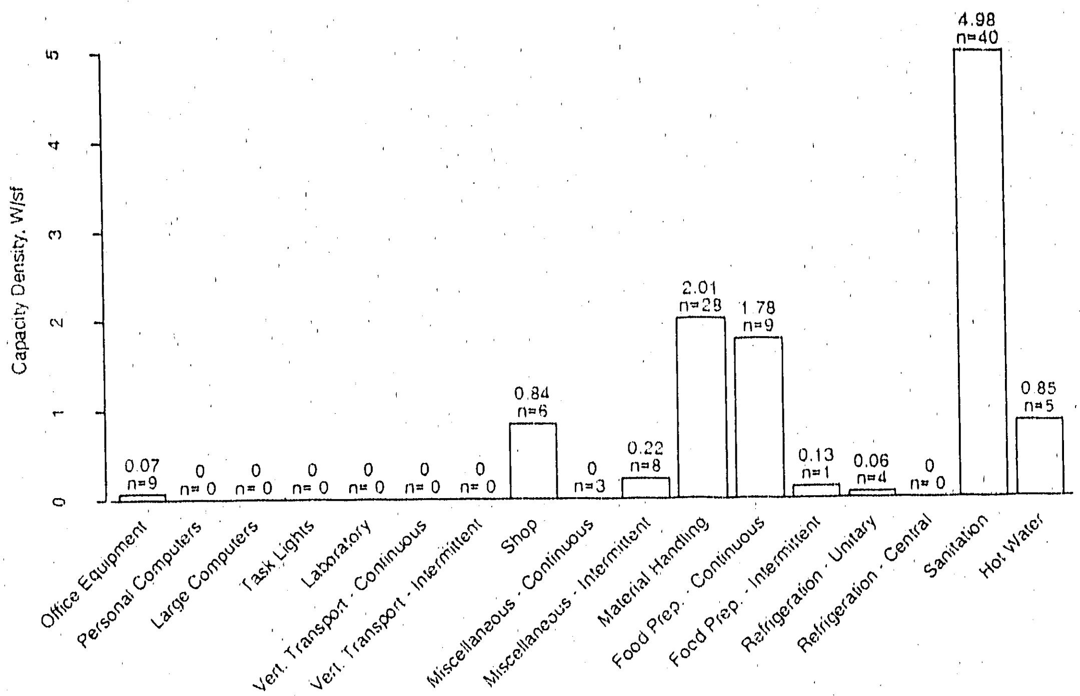


FIGURE A-16. Hotel/Motel Capacity Density of Electric Equipment (n=8) (Missing Data Filled by Building Type)

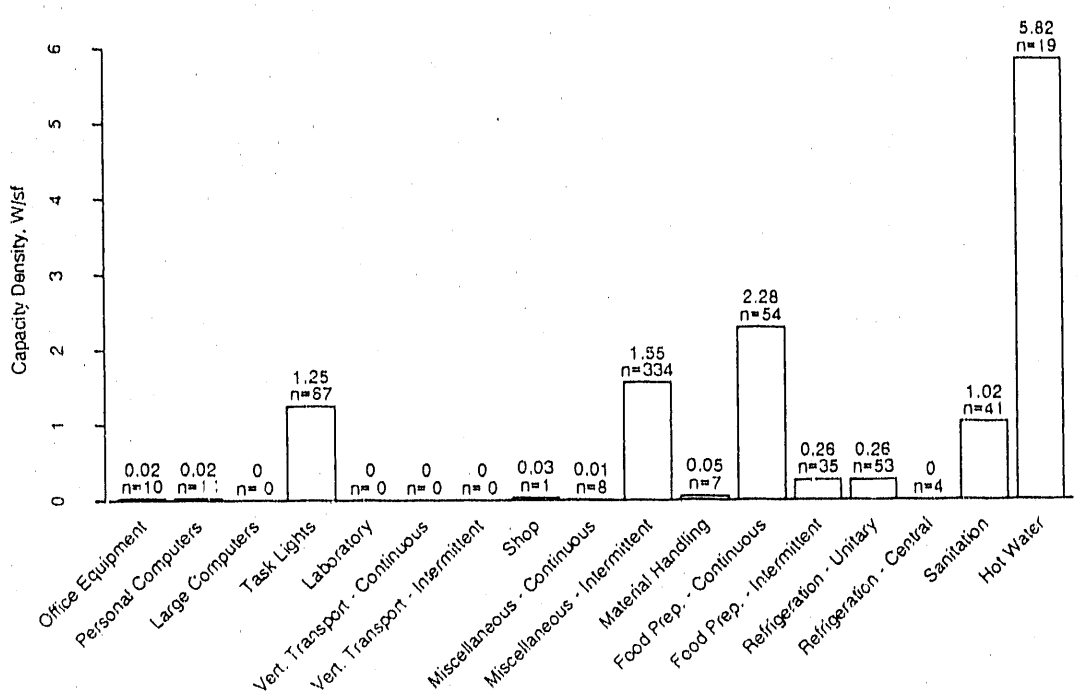
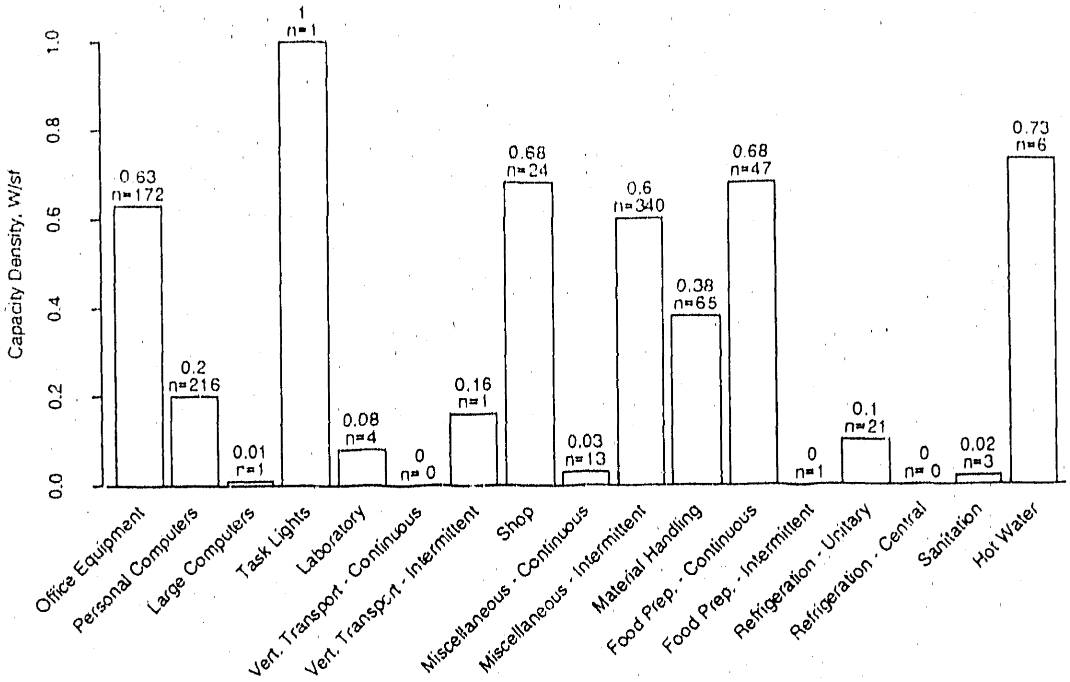


FIGURE A-17. University Capacity Density of Electric Equipment (n=2) (Missing Data Filled by Building Type)



APPENDIX B

EQUIPMENT CAPACITIES AND DENSITIES (ALL FUELS)

FIGURE B-1. Small Retail Capacity Density of Equipment (All Fuels)

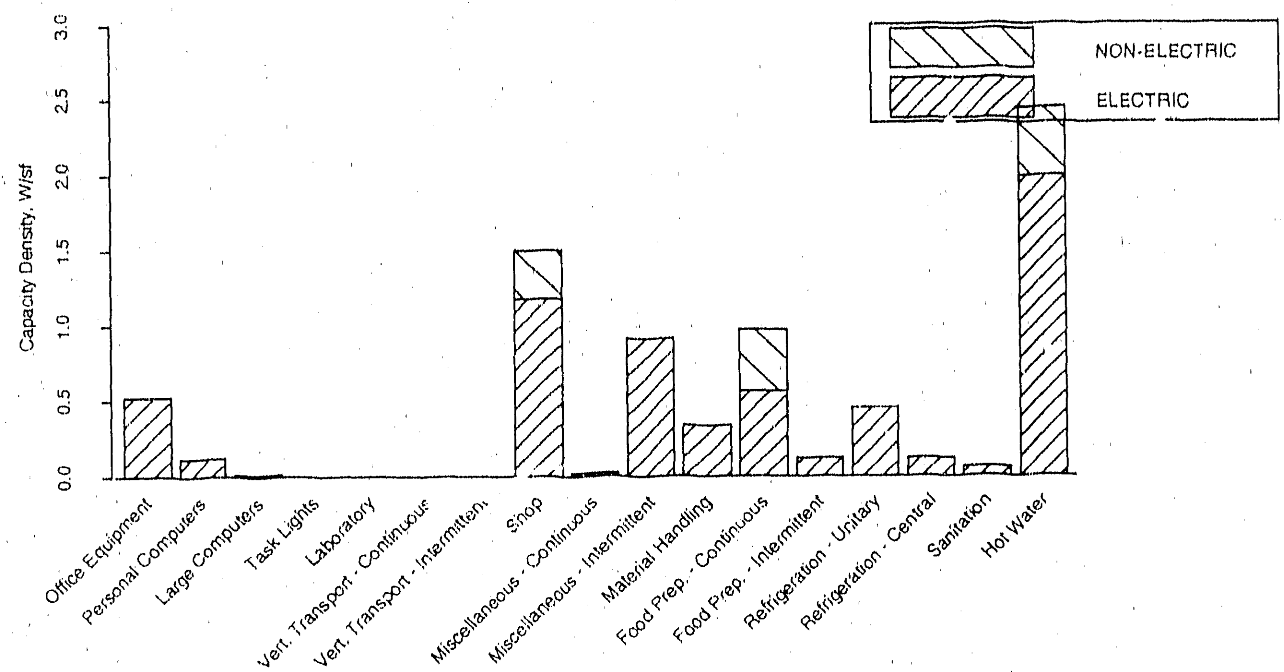


FIGURE B-2. Large Retail Capacity Density of Equipment (All Fuels)

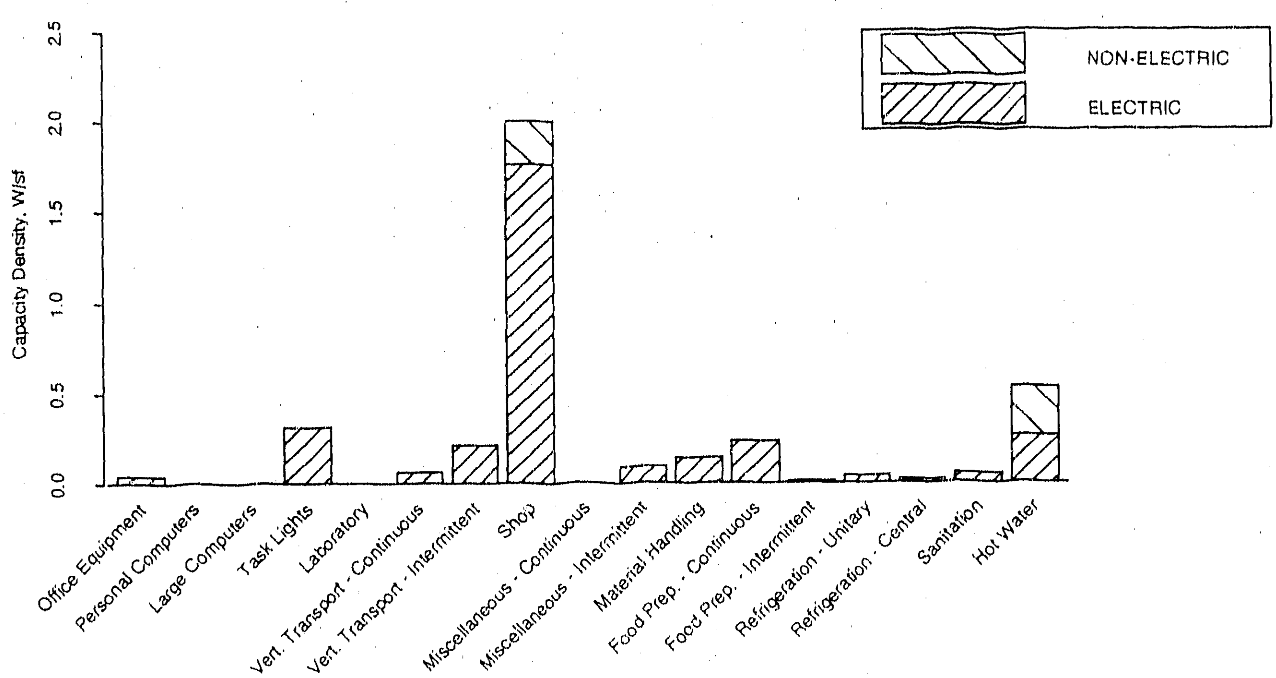


FIGURE B-3. Small Office Capacity Density of Equipment (All Fuels)

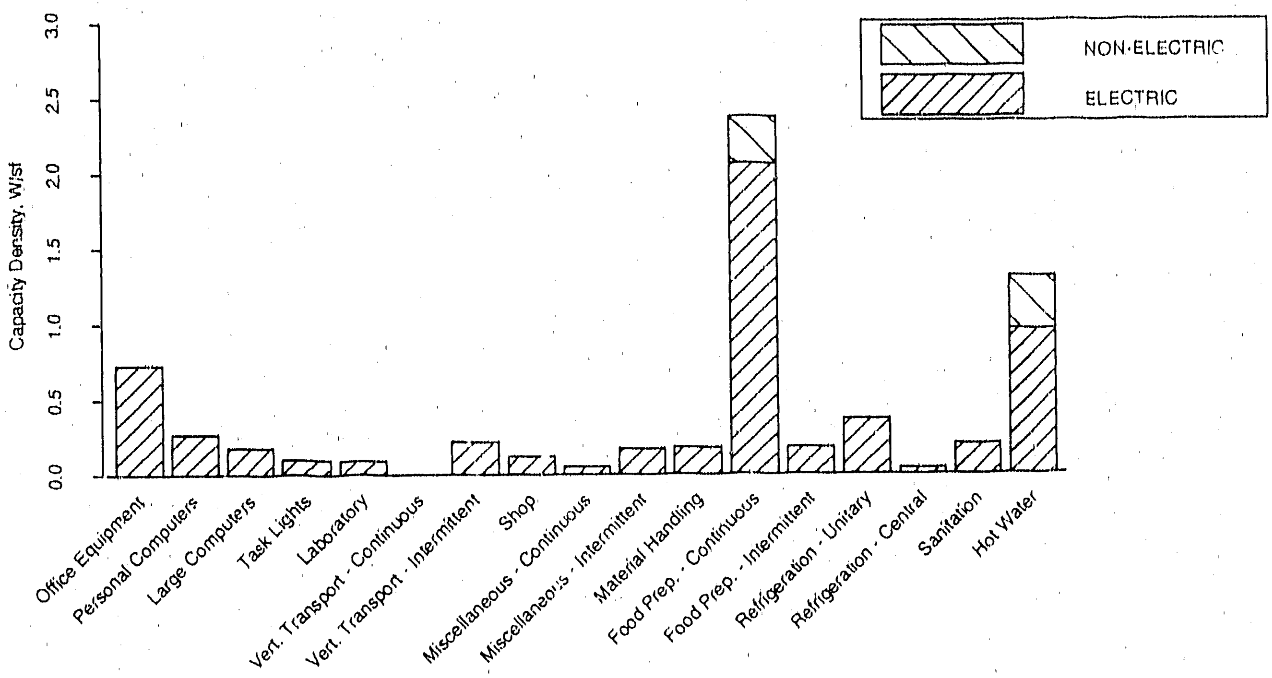


FIGURE B-4. Large Office Capacity Density of Equipment (All Fuels)

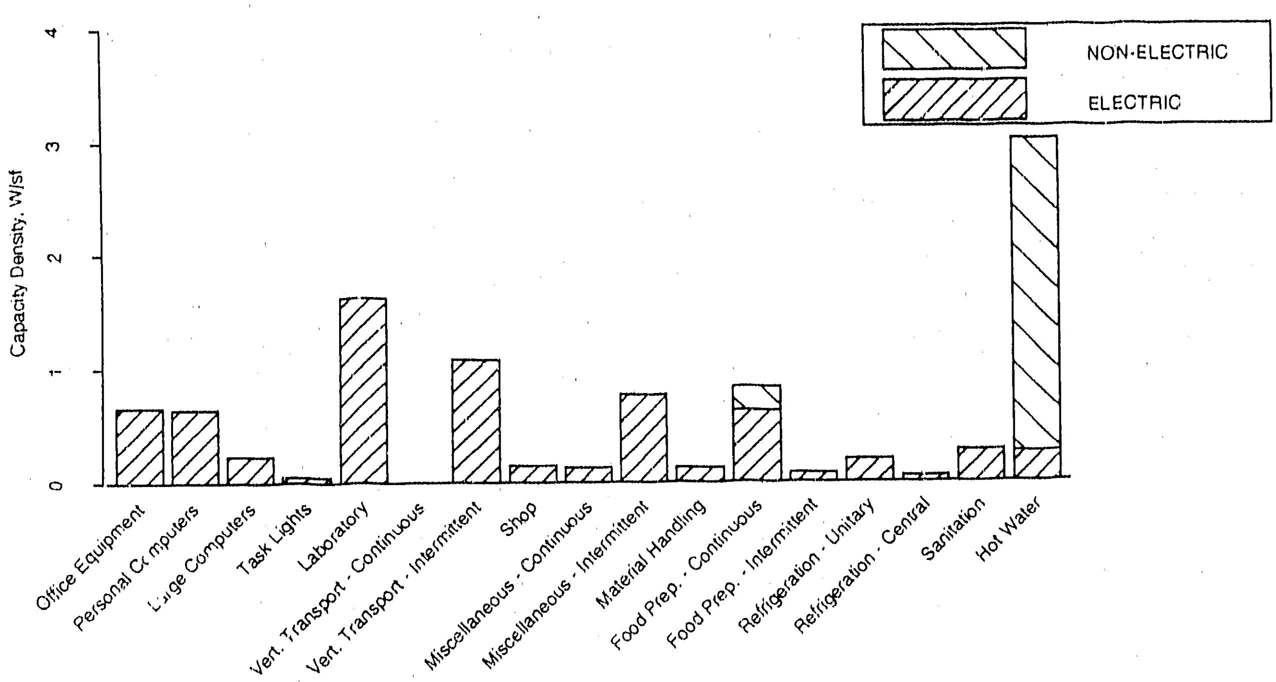


FIGURE B-5. Warehouse Capacity Density of Equipment (All Fuels)

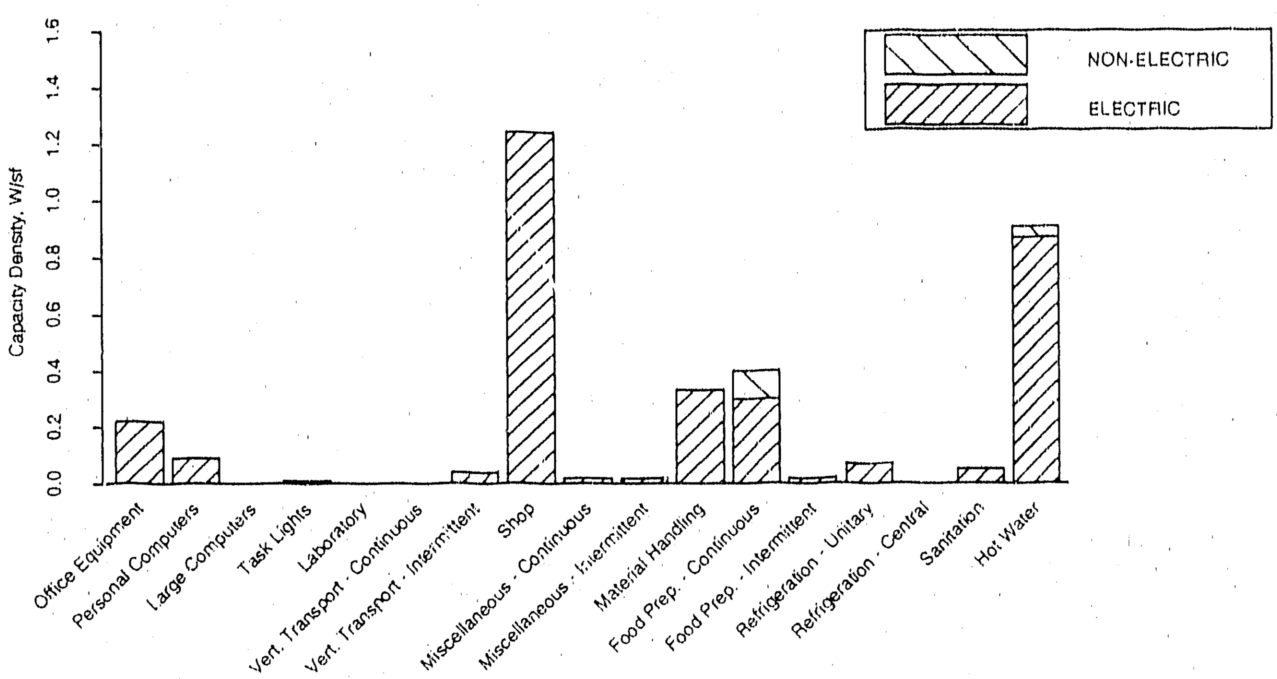


FIGURE B-6. Restaurant Capacity Density of Equipment (All Fuels)

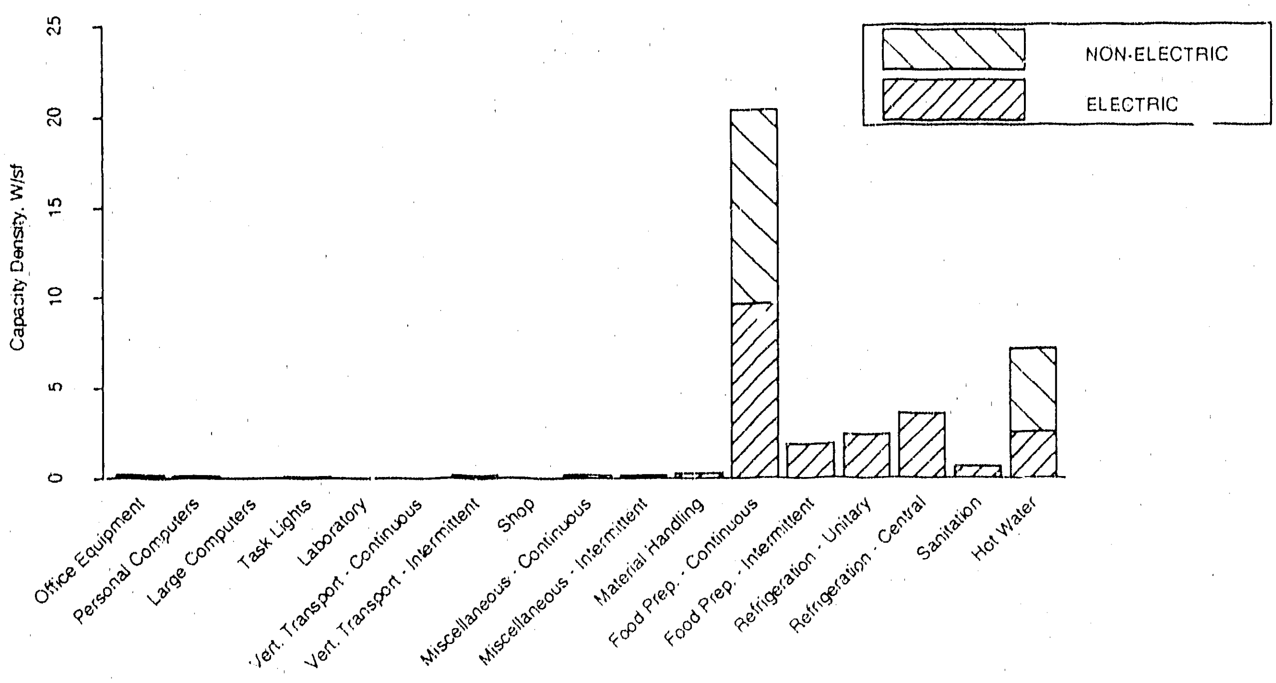


FIGURE B-7. School Capacity Density of Equipment (All Fuels)

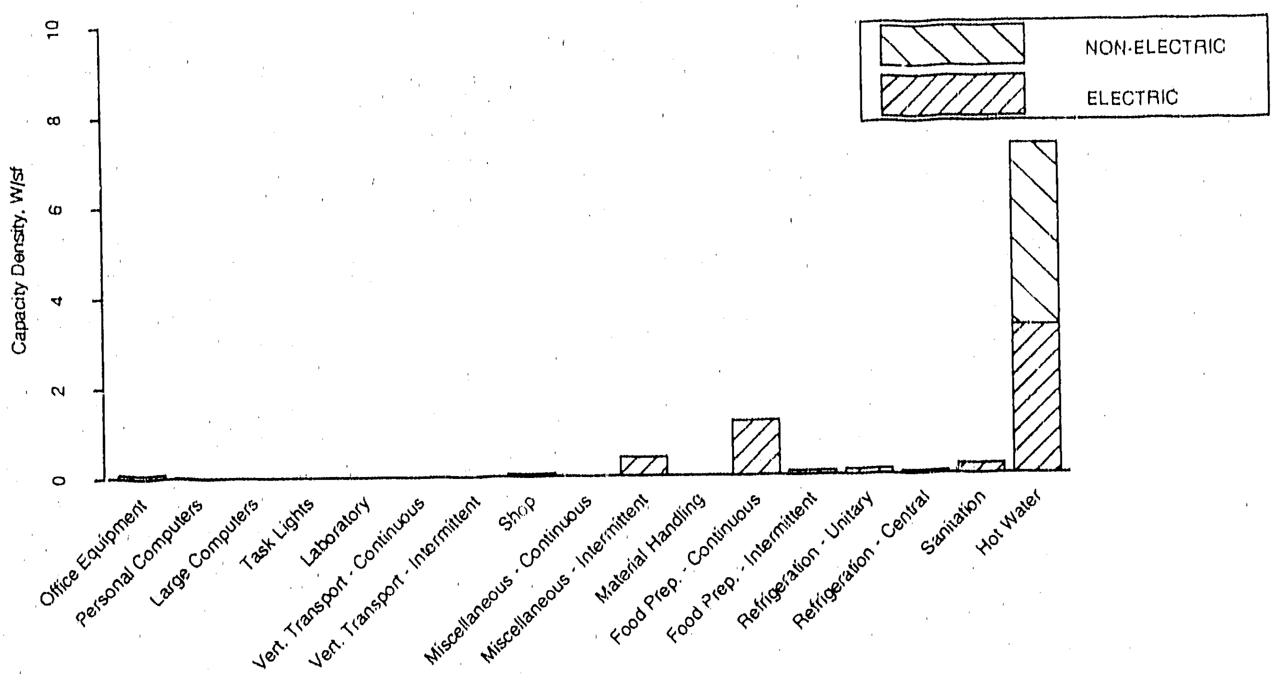


FIGURE B-8. University Capacity Density of Equipment (All Fuels)

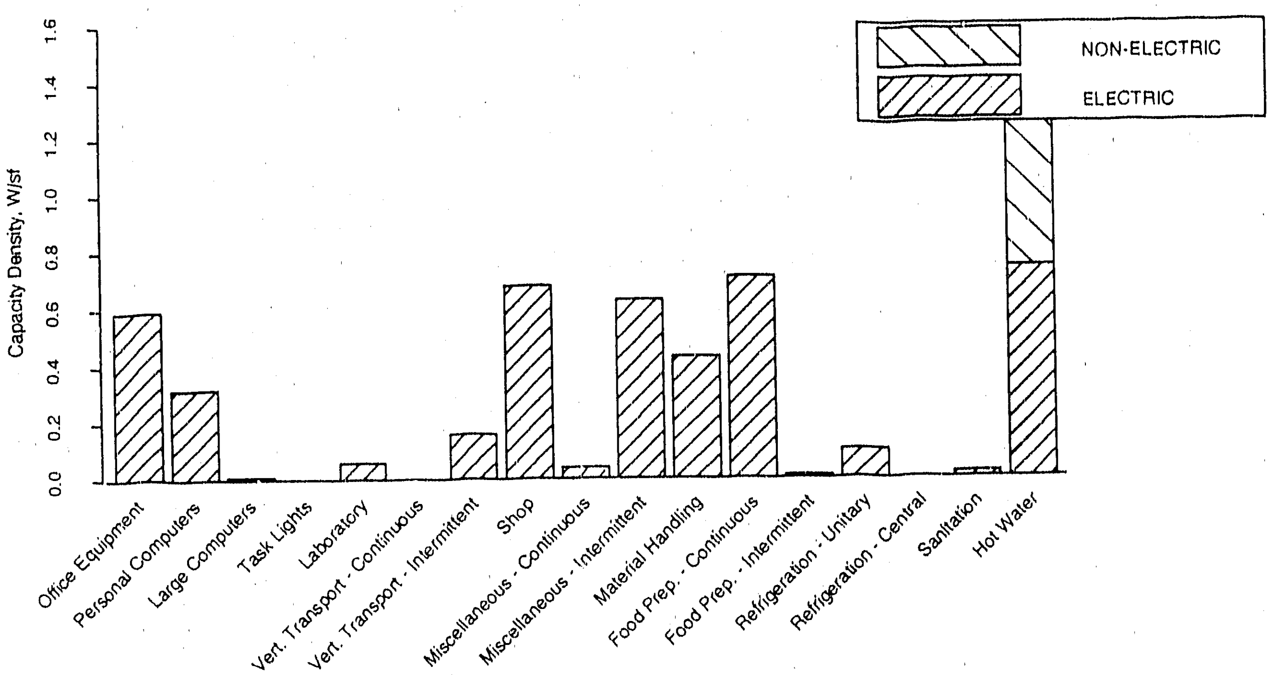


FIGURE B-9. Grocery Capacity Density of Equipment (All Fuels)

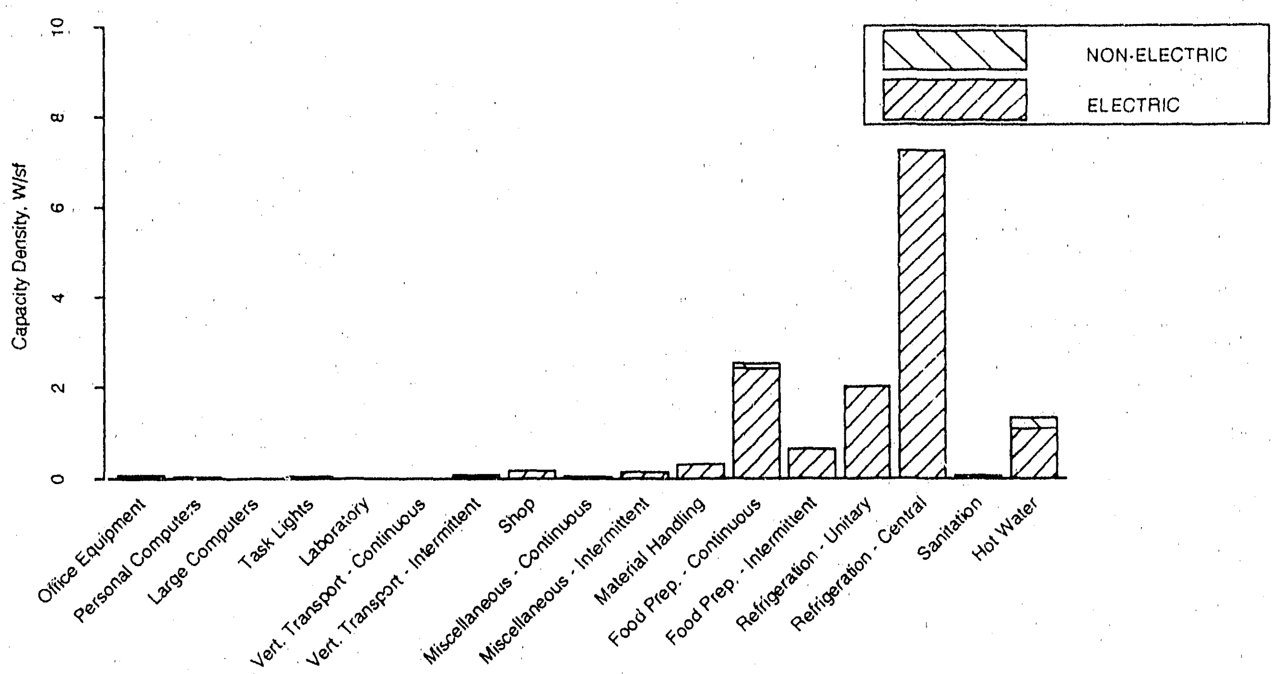


FIGURE B-10. Hotel/Motel Capacity Density of Equipment (All Fuels)

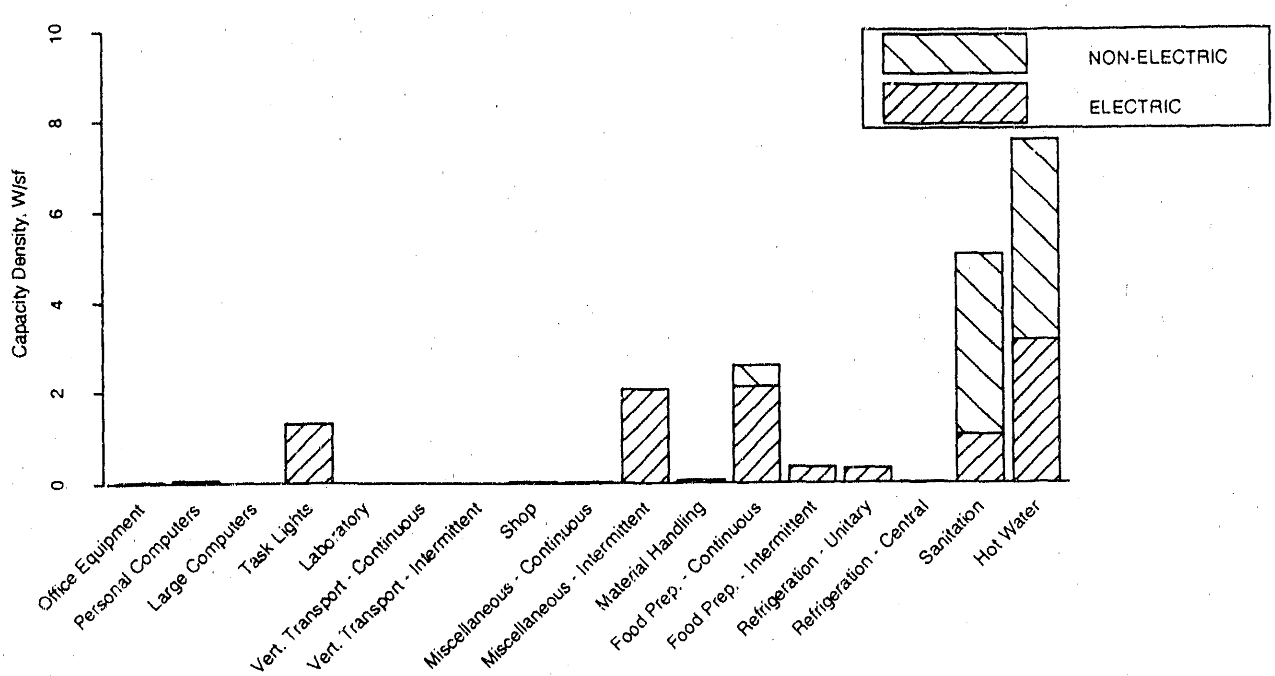


FIGURE B-11. Other Buildings Capacity Density of Equipment (All Fuels)

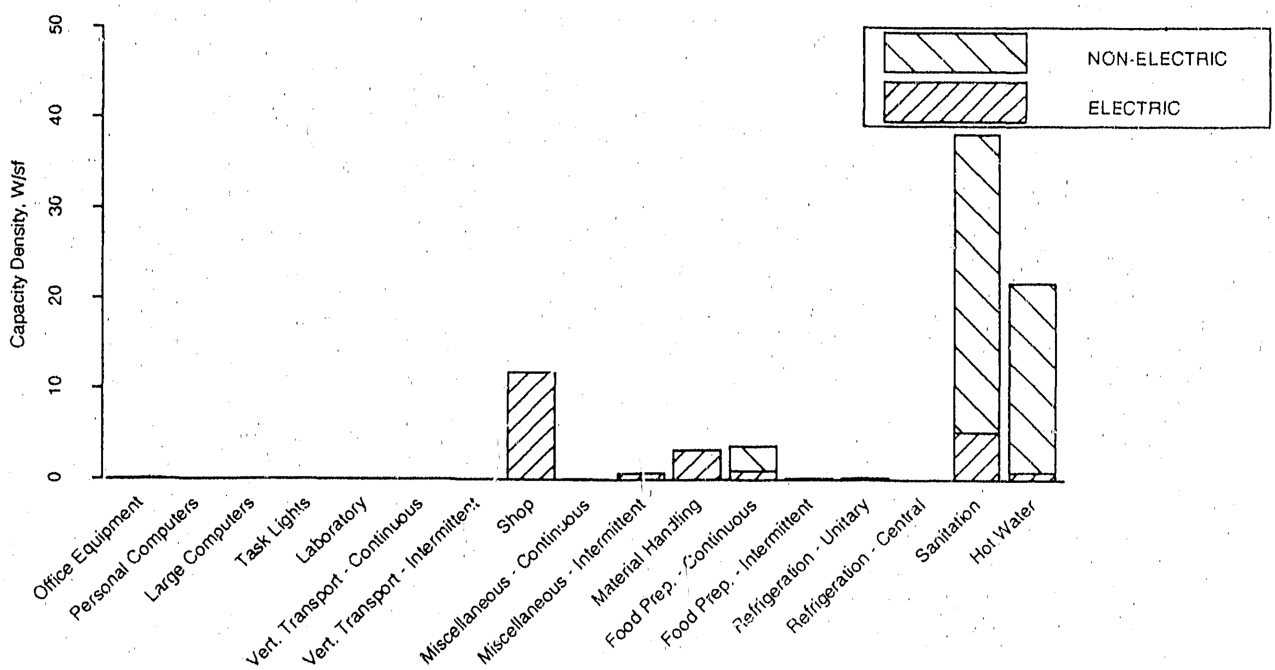


FIGURE B-12. Small Retail Device Density of Equipment (All Fuels)

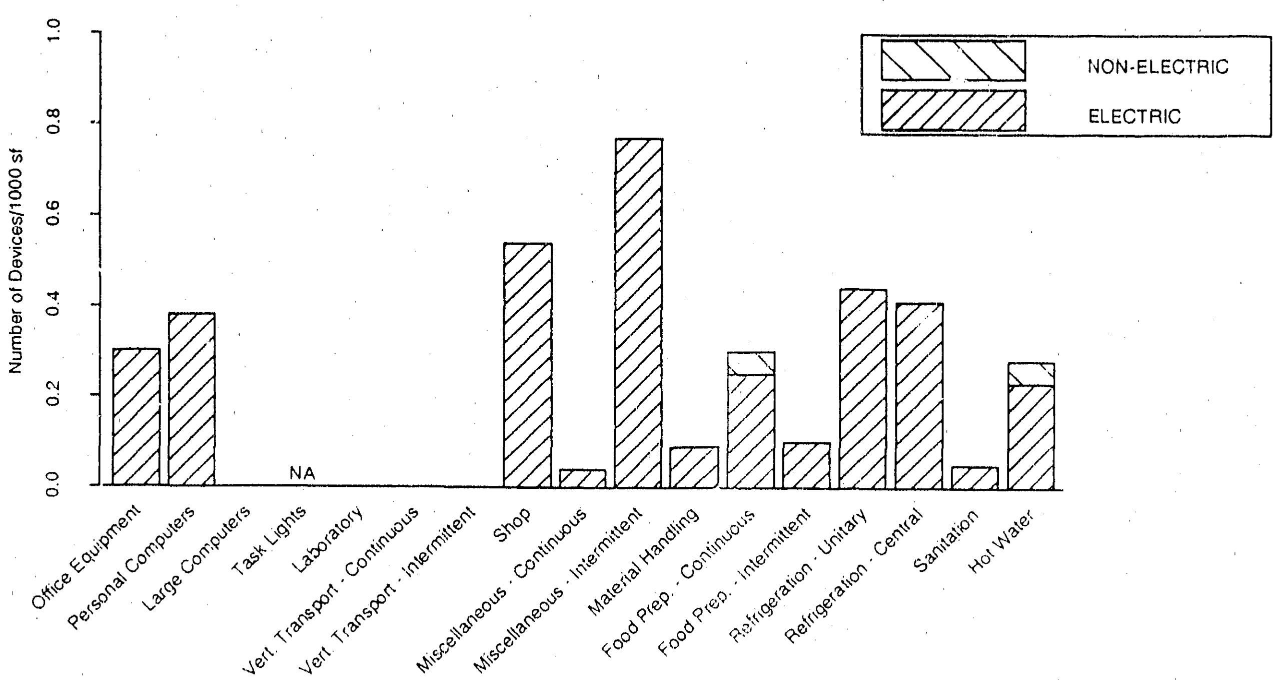


FIGURE B-13. Large Retail Device Density of Equipment (All Fuels)

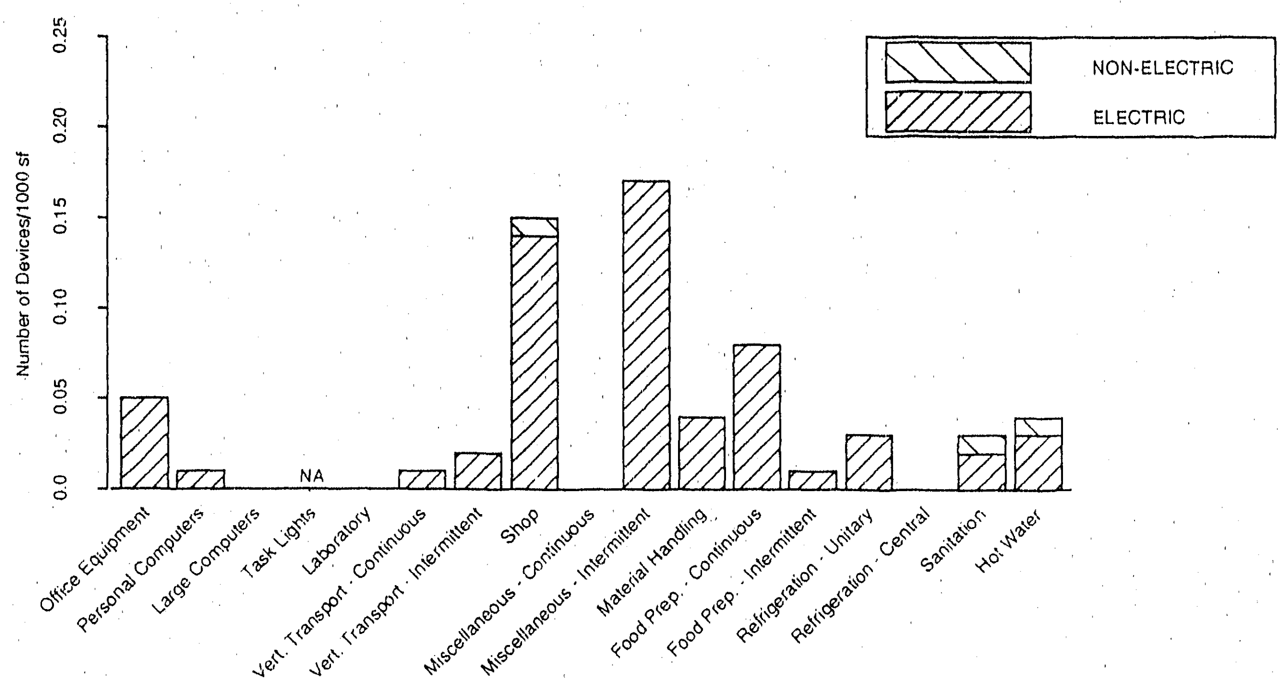


FIGURE B-14. Small Office Device Density of Equipment (All Fuels)

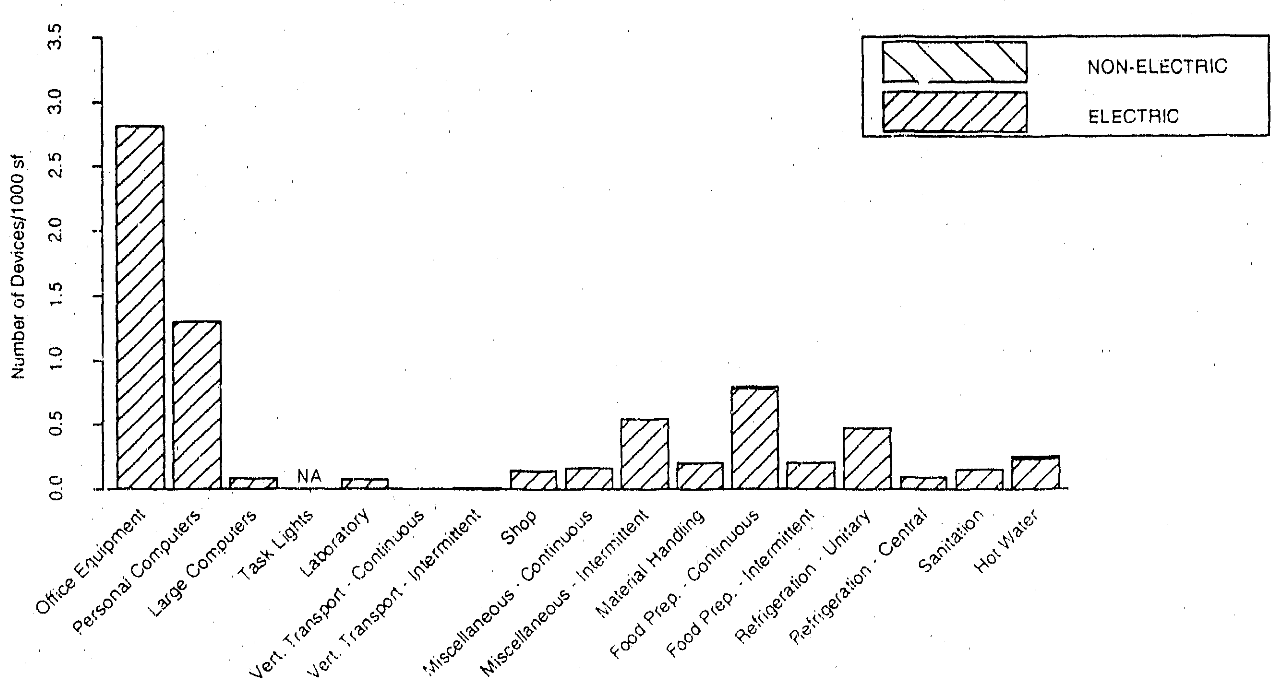


FIGURE B-15. Large Office Device Density of Equipment (All Fuels)

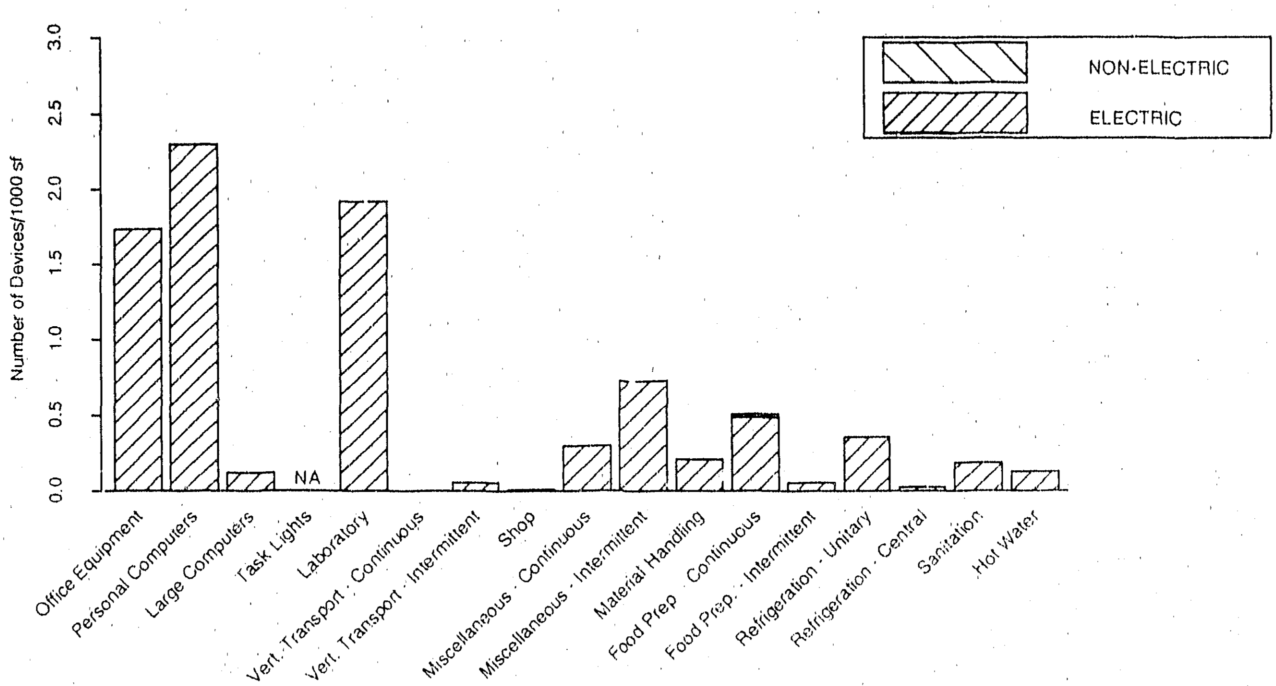


FIGURE B-16. Warehouse Device Density of Equipment (All Fuels)

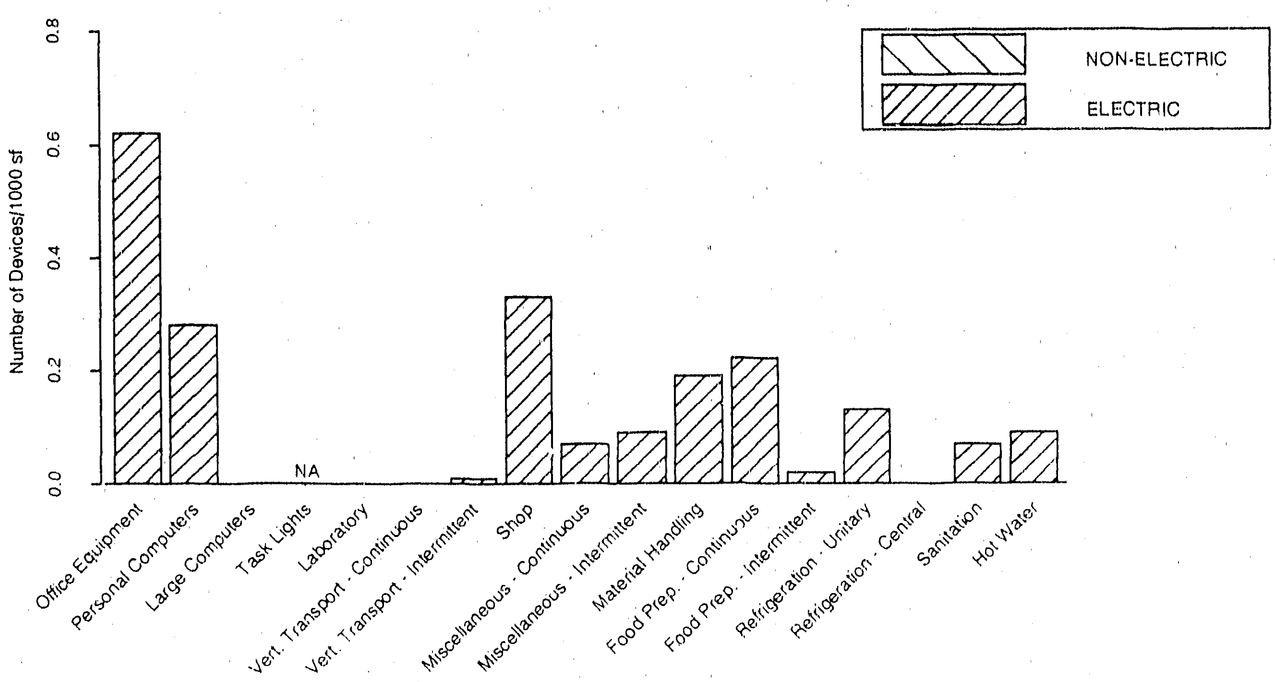


FIGURE B-17. Restaurant Device Density of Equipment (All Fuels)

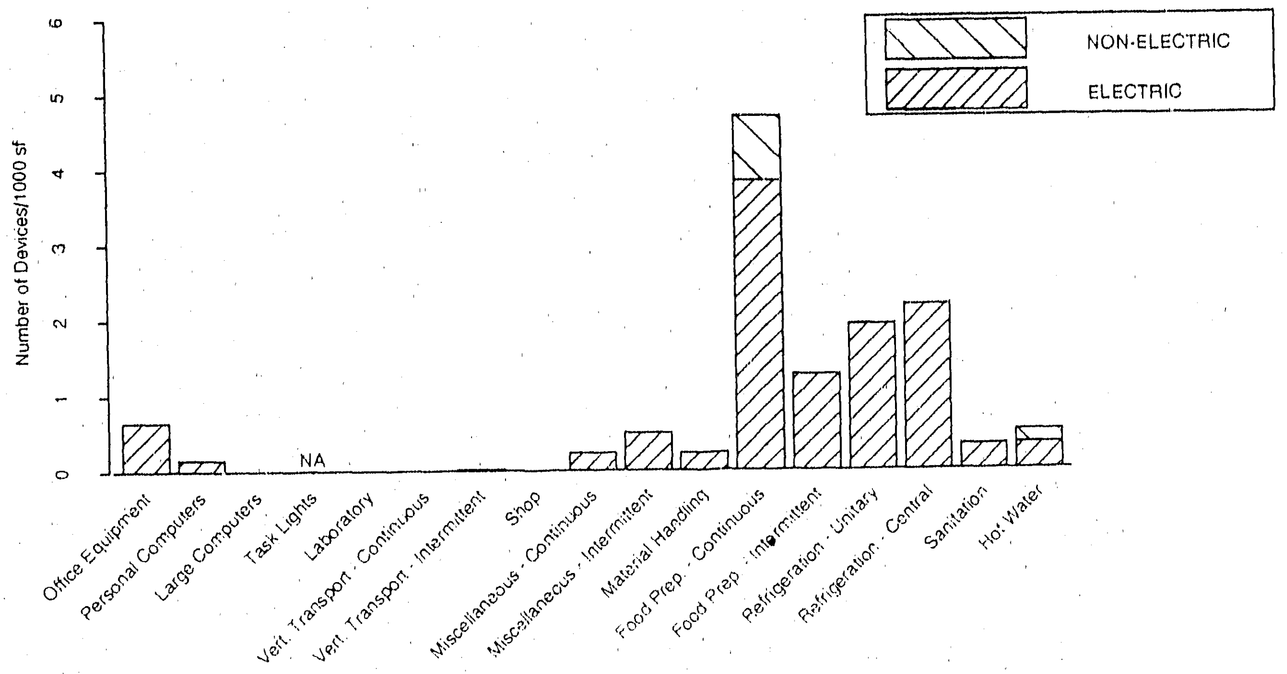


FIGURE B-18. School Device Density of Equipment (All Fuels)

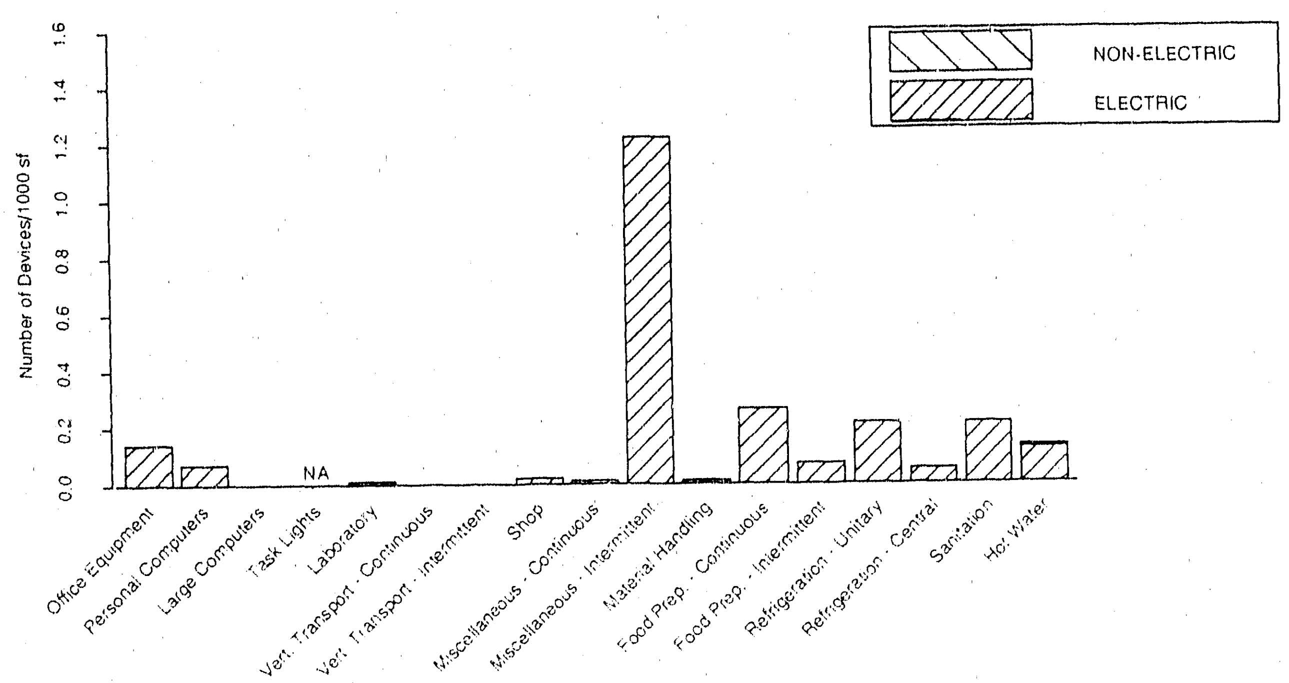


FIGURE B-19. University Device Density of Equipment (All Fuels)

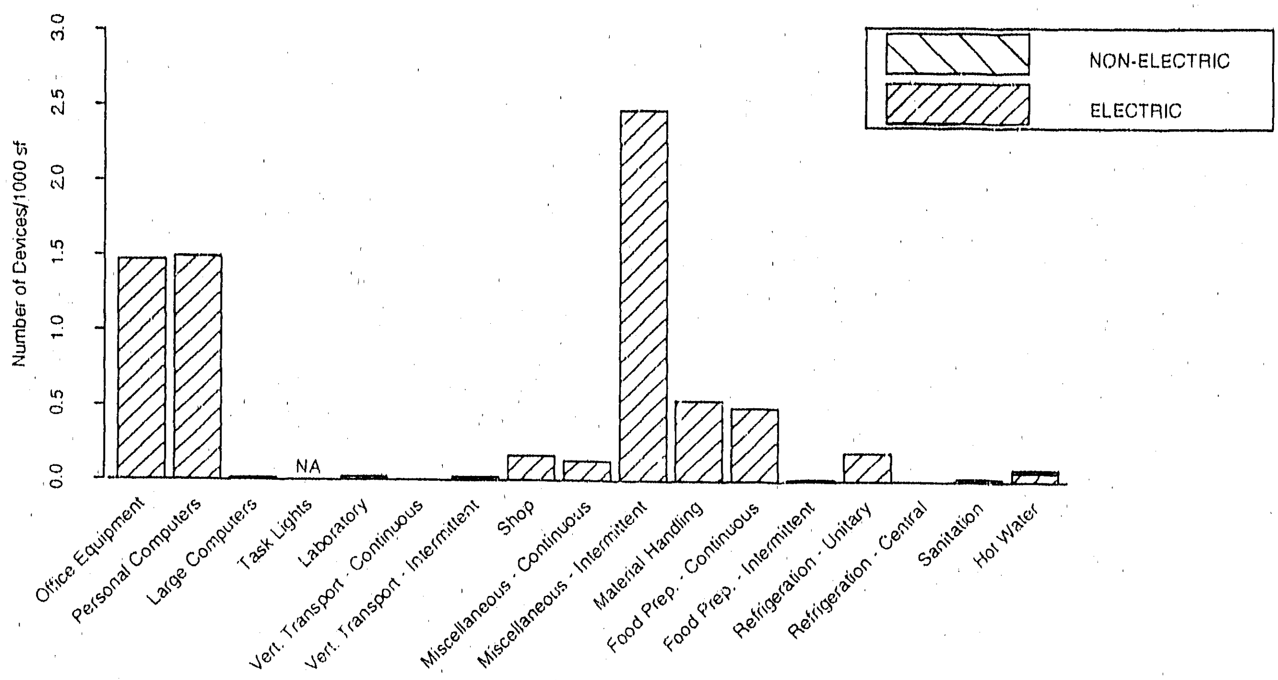


FIGURE B-20. Grocery Device Density of Equipment (All Fuels)

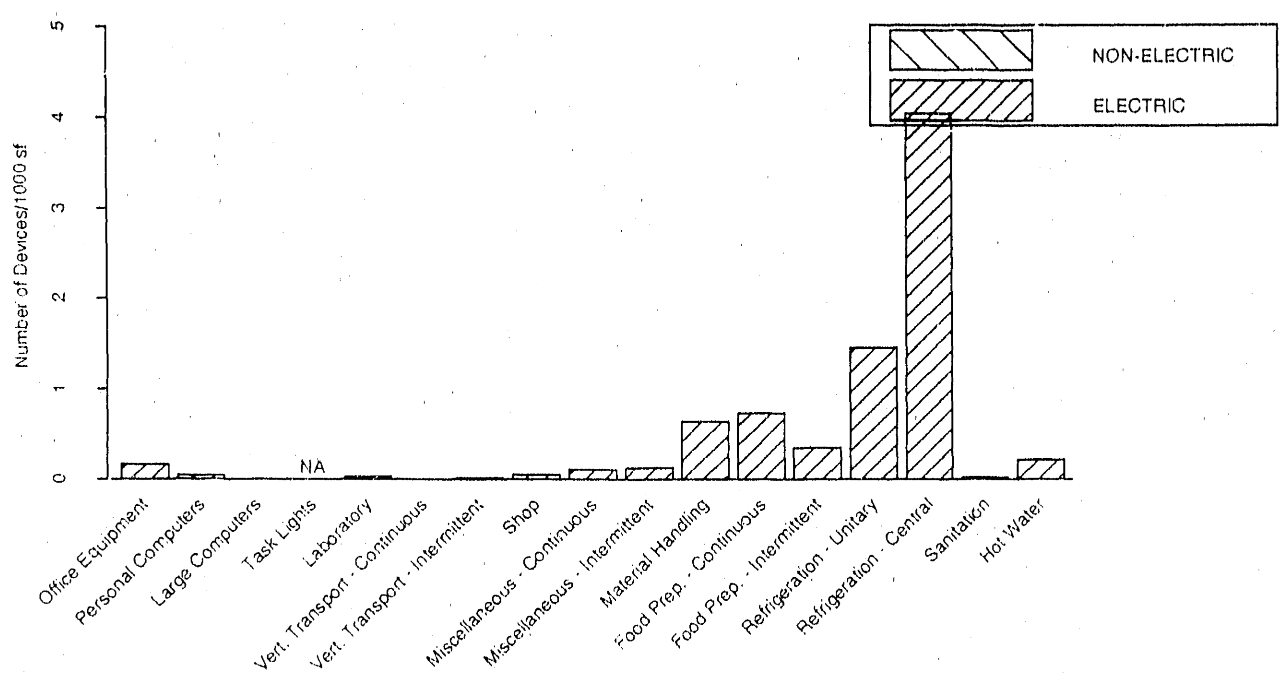


FIGURE B-21. Hotel/Motel Device Density of Equipment (All Fuels)

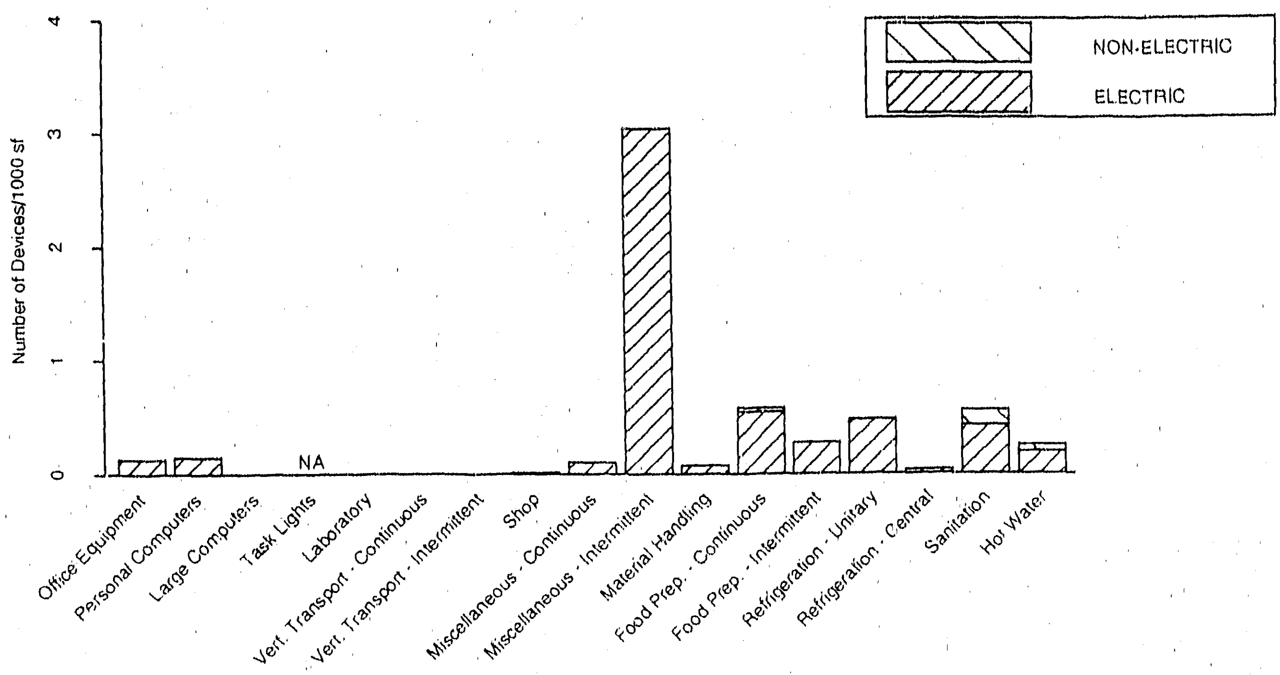
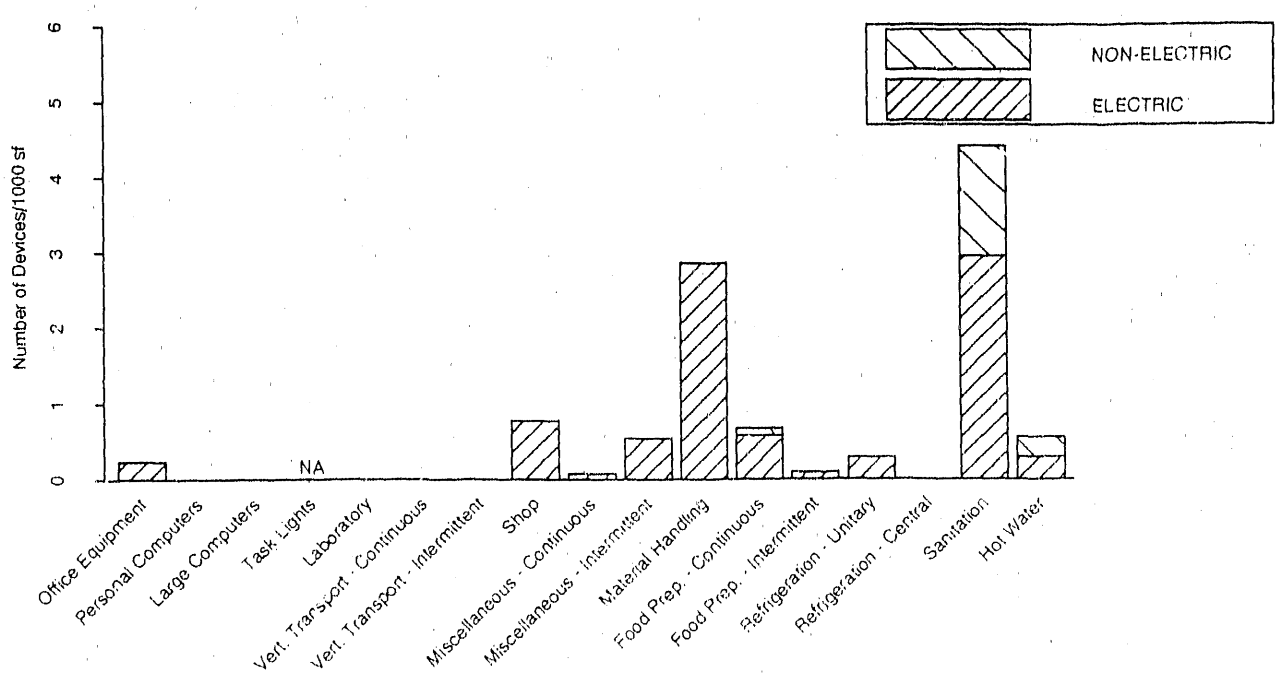


FIGURE B-22. Other Device Density of Equipment (All Fuels)



APPENDIX C

REGRESSION METHODOLOGY AND UTILIZATION ESTIMATE SELECTION

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REGRESSION METHODOLOGY AND UTILIZATION ESTIMATE SELECTION

The purpose of this analysis is to relate the sizes and quantities of various types of equipment in commercial buildings to the metered end-use energy data. In its simplest form, this can be visualized as a simple regression across a number of buildings of the form

$$Y = A \cdot X \qquad \text{(C-1)}$$

where Y is a vector of metered end-use data, X is a vector of nameplate connected capacities for the metered equipment, and A is a vector of constants (the coefficients from the regression). The coefficient A can be interpreted as a utilization factor for the equipment, and is proportional to the fraction of time the equipment is used.

However, using ELCAP metered end-use and characteristics data to regress utilization factors is not as simple in practice as it is in concept. Several reasons for this are listed below.

The utilization factor is logically expected to vary across building types and across equipment categories. Examples are food preparation in office buildings vs. restaurants (infrequent use in offices, frequent use in restaurants), and office equipment vs. food preparation equipment in office buildings (office equipment used many hours per day, food preparation equipment used less than an hour per day).

More than one type of equipment is often metered as a single end use in any given building. A notable example is the presence of computers, office equipment, and task lighting together on the Receptacles end use.

A given type of equipment may be metered on two different end uses in different buildings. A large computer may have a dedicated metering channel defined as the Data end use in a small building, whereas it might be metered with other Receptacle loads in a large office building. This resulted from a desire to maximize end-use resolution

The subsequent discussions in this appendix outline how ELCAP energy and characteristics data were manipulated to develop a data set suitable for regressions of equipment utilization factors, how the regressions were conducted, and how specific regression coefficients were selected as the recommended utilization factors for the various types of equipment and building types.

DATA PREPARATION

Of the 16 end uses defined in the ELCAP commercial sector, 10 meter equipment of interest to this analysis. Two pairs of these 10 end uses are combined, resulting in eight basic end-use regressions for each building type as shown in Table C-1. The Mixed General and Receptacles end uses are combined, since they meter essentially identical mixes of equipment. (Mixed General is used when the load is not purely equipment, typically in the case of some low-voltage lighting powered from the receptacle circuits in a building.) Data Processing and Laboratory end uses were also combined. Virtually all of the Laboratory equipment found in the ELCAP sample comes from medical exam and office testing functions in two medical office/clinic type buildings. This equipment "replaces" much of the more general data processing type of equipment that is found in other offices.

Some uncertainty is associated with the fact that some equipment from some categories may be metered on any of several end uses in a particular building. Since regressions are conducted on all the end uses, this would not be a significant issue. However, different utilizations would (correctly) occur if specific types of equipment within an equipment category tend to be metered on one of the end uses, and selection of either of them to represent the entire equipment category would be incorrect.

To help mitigate this problem, larger combinations of metered end uses were prepared so that regressions could also be undertaken with these loads. Regressions using the end-use combinations increase the uniformity of the metered equipment loads within a building type. In particular, due to the small quantity and miscellaneous nature of the equipment metered on the Shop,

TABLE C-1

Metered End Uses Used in the Utilization Factor Regressions

	Mnemonic End Use Abbreviation	Definition in Terms of Standard ELCAP End Uses
Basic End Uses	DATA	Data Processing and Laboratory
	FDP	Food Preparation
	HOT	Hot Water
	MAT	Material Handling
	MIX	Mixed General and Receptacles
	REF	Refrigeration
	SAN	Sanitation
	ELV	Vertical Transportation
Combinations of End Uses	FDP/REF	Food Preparation and Refrigeration
	MIX/RF/FP	Mixed General, Receptacles, Refrigeration, and Food Preparation
	MIX/S/S/S	Mixed General, Receptacles, Sanitation, Shop, Specialty, Recreation and Miscellaneous, and Unknown
	EQUIP	All equipment end uses except Hot Water

Specialty, Recreation, and Unknown end uses, these were not analyzed separately, but rather were added to the Mixed General/Receptacles and Sanitation end uses to form one such combination.

In many buildings, significant capacities of food preparation and refrigeration equipment were inseparable in the measurement plans (such as in office building lunch rooms), so these basic end uses were combined in two ways (for separate regressions): combined with each other, and combined together with the Mixed General/Receptacles loads. Finally, all equipment end uses (except Hot Water) were combined to produce an Equipment combination that is entirely uniform across all buildings and building types.

Once the end uses and end-use combinations are defined, the capacities of each equipment category metered on them in each building is tabulated similarly. The equipment categories used are discussed in Section 5, and are repeated here in Table C-2 for convenience. Most tables in this appendix (and in Appendixes D and E) use the abbreviations for both equipment categories and end uses, to allow the tables to fit on a single page.

The resulting regression data set is shown in Tables D.1 through D.9 in Appendix F. These data are included to allow the reader to see the distributions and magnitudes of the equipment capacities and loads involved in the regressions. This information is subsequently used in a subjective fashion as an aid in judging the validity of the regressed utilization factors.

Finally, as the regressions were conducted, all the data were normalized by floor area in recognition of the fact that the ELCAP Commercial Base sample is somewhat biased toward smaller buildings than the target population. This essentially provides an equal weight to the observations from each site in the sample. It also prevents heavily weighting the results toward the loads and equipment in the larger buildings, which have more "leverage" in the regression.

TABLE C-2

Equipment Categories for Utilization Factor Regressions

Equipment Abbreviation	Definition
COMP	Large and Small Computer Equipment
FDP	Food Preparation Equipment
HOT	Hot Water Equipment
LAB	Laboratory and Photography Equipment
MAT	Materials Handling Equipment
MISC	Miscellaneous Equipment
OFF	Office Equipment
REF	Refrigeration Equipment
SAN	Sanitation Equipment
SHOP	Shop Equipment
TLT	Task Lighting Equipment
VTR	Vertical Transportation Equipment

REGRESSION METHODOLOGY

Because many equipment categories may be metered on a given end use, a multiple linear regression model of each end use was used. This model is of the form

$$Y = A_1X_1 + A_2X_2 + \ldots A_iX_i \ldots + A_nX_n \qquad (C-1)$$

where Y is a vector of floor-area-normalized metered loads, X_i is a vector of the floor-area-normalized rated capacity for equipment category i, and A_i is a utilization factor for equipment type i. The list of n equipment categories in the regression equation includes all the categories of equipment represented in the sample of buildings for the metered end use. In the regressions that follow, Y has units of average watts and X has units of kilowatts, so A is dimensionless and is the product of the fractional time of use and the load factor for the equipment (times 1000). For example, a type of equipment with a known load factor of one and a regressed utilization factor of 500 would be expected to be operated 50% (500/1000) of the hours of the year.

In the simple case where n = 1 and Y is exactly the total normalized load associated with equipment type category i = 1 for a single building, it is clear that $A_1 = Y/X_1$. When more than one building is involved, the model of Equation (C-2) reduces to that of Equation (C-1), and may be thought of as a mean model, where A_1 is estimated across buildings using least squares regression techniques (without an intercept term). The utilization factors A_i thus represent an "average", across the buildings and metered end-use loads represented in Y, that minimizes the sum of the squared deviations from the linear model.

Estimating a mean model for multiple buildings when n>1 is somewhat more problematic. Referring to Equation (C-2), examples of the kinds of difficulties which can arise include the following:

- Suppose that n = 2 and that X_1/X_2 is approximately constant across sites. Then X_1 and X_2 will be highly correlated, and it will be difficult to accurately determine the relative magnitudes of A_1 and A_2. This may lead to an unrealistically high utilization factor for one of A_1 or A_2, and a correspondingly low estimate for the other.
- Suppose that n = 2 and that X_2 is strongly negatively correlated with Y across buildings. This may lead to a negative estimate for A_2, even though it is known that equipment produces only positive loads.

The above examples illustrate situations that may exist wherein the data do not provide adequate information regarding the equipment utilization, even though the data may be quite representative of typical usage patterns. When sample sizes are small (as is often the case in this analysis), spurious correlations may present similar difficulties.

In view of these problems, an iterative stepwise regression procedure was used to estimate the utilization factors. Generally, having fixed the end use and building type(s) of interest for the regression, the stepwise procedure for developing multi-variable linear models can be essentially described as follows:

Step 1: Analyze the variance explained by each individual explanatory variable (equipment capacity) and select the one that explains the most variance.

Step 2: Test the significance level of the selected variable. If it is less than the minimum level, keep it in the model.

Step 3: Analyze the remaining variance explained by each of the other individual explanatory variables (using their partial correlation coefficient) and select the one that explains the most remaining variance. This step adjusts for the variance explained by all previously selected variables, and also adjusts the candidate dependent variables for correlation with previously included variables.

Step 4: Test the significance level of the selected variable. If it is less than the minimum level, include it in the model.

Step 5: Repeat Steps 1 and 2 for each remaining explanatory variable until all have been selected or rejected, continually testing whether all previously selected variables should remain in the model.

Step 6: Regress all selected variables to determine their coefficients in the final "best" model and the total variance explained.

The procedure is designed to include only those variables in the model that explain significant variance, preventing "absorption" of the signal by extraneous variables. By selecting variables in decreasing order of variance explained, if two variables are very highly correlated only the most significant one is selected.

Since retaining only very highly significant equipment categories in the model would ensure inflation of their coefficients to reflect the load generated by the rejected equipment categories, very loose selection criteria were employed: the significance level for entry into the model was set at 0.90, as was the level for staying in the model. After each stepwise model was developed, equipment capacity variables for which negative (and therefore impossible) coefficients were obtained were dropped, and stepwise was re-applied. This process was repeated until all resulting coefficients were positive.

Also in recognition of the uncertainties involved in the regressions, a heuristic approach to estimating the utilization factors was taken, which allows for some cross-checking of the estimates obtained. Individual regressions were run for all the basic metered end uses and a set of combinations of end uses. The regressions were also performed for each individual building type, and across all building types. This redundant approach to estimating the utilization factors was taken to allow for some cross-checking of the estimates obtained. The guidelines for this process were as follows:

- Estimate parameters separately by building type, as the data permit. This allows for cross-checking whenever building types are expected to have similar usage patterns, and is essential whenever building types are expected to differ. Also, produce more global estimates by combining building types where warranted.
- Estimate parameters separately by end use, as the data permit. Also produce more global estimates by combining end uses generated by similar equipment type mixes.

- Where possible, isolate "pure" end uses; i.e., cases where n = 1 in Equation (C-2).
- Increase the "purity" of end uses by dropping observations introducing new equipment types when such observations represent only a small fraction of all observations.

REGRESSION RESULTS

The results of the regression process are displayed in Table E.1 of Appendix E. Included there are the coefficients obtained for each equipment category, the number of observations, and the fraction of variance explained (R^2) for each metered end-use regression for each building type. The results of the regressions are briefly summarized here.

The iterative stepwise regression procedure selected roughly half of the candidate equipment categories as significant explanatory variables. The number of variables selected shows some tendency to be larger for building types with larger sample sizes, as might be expected. Roughly 40% of the selected variables have significance levels at better than the 0.05 level, 20% have significance levels between 0.05 and 0.10, and the remaining 40% have less significance.

The R^2 for the regressions vary widely; most are greater than 0.6 and many were above 0.9. Particularly good results were obtained for offices, retail stores, restaurants, groceries, and warehouses, as might be expected due to the larger sample of these building types. The quality of the results is reflected by both the number and significance level of the regressed utilization factors, and in the generally high R^2 for these building types.

Some deceptively high correlation coefficients (greater than 0.99) for some of the remaining building types resulted from regressions with few observations relative to the number of explanatory equipment categories, and so are discounted here. This was usually for specific end-use regressions for the school, other, hotel, and university building types that have small sample sizes.

One or more utilization factor estimates were obtained from the various metered end-use regressions for about 80% of the pairs of equipment categories and building types, with multiple estimates available for most of these. A particularly large number of estimates is indicated for the food preparation and refrigeration end uses across building types, and for offices, retail stores, groceries, restaurants, and warehouses for most of the end uses. Typically, the more regressions for which an equipment category is selected as an explanatory variable, the more likely there are to be one or more highly significant coefficients. Thus, the building types and equipment types listed above also tend to have the largest number of highly statistically significant utilization factors. Where multiple estimates are available, it is reassuring to note that the estimates are often very similar, particularly those with high statistical significance.

REORGANIZATION OF REGRESSION RESULTS BY EQUIPMENT TYPE

The regression process generally provides more than one utilization factor estimate for each equipment category. For example, a utilization factor for computers in offices results from a regression for the Equipment end-use combination that includes loads from all the equipment categories, and from the basic Data end use that more specifically focuses on computer equipment. For the reasons noted in the preceding discussion, each estimate has a varying degree of statistical significance, and includes any bias related to the type, size, and utilization of equipment metered on one end use as opposed to another.

To facilitate comparisons of the utilization factors for each equipment category and their significance levels across the various possible regressions from which they were obtained, the regression results in Appendix E are re-organized by equipment category, with the results shown in Table C-3. As in Appendix E, the significance level for each variable is indicated. Superscripts on coefficients judged to be statistically significant at the 0.05 level are marked by a "*", while coefficients significant at the 0.10 level (but not at the 0.05 level) are marked by a "+". (Note that a lower significance level indicates a higher degree of confidence in the estimate.)

TABLE C-3

Equipment Utilization Factors by Equipment Type and Metered End-Use Regression

Metered End Use	Equipment Category	All Buildings	Office	Dry Good Retail	Grocery	Restaurant	Warehouse	School	Other	Hotel	University
EQUIP	COMP	277	[200]*		1625					1521	
DATA	COMP	[339]*	358*	[580]*	[446]*	[121]+	[83]*				
MIX/S/S/S	COMP	130									
EQUIP	FDP	84*	5.6	[91]+	121*	89*	[54]	15	8.1	71	
FDP	FDP	79*	4.8+		153*	89*		13+	9.8+		
FDP/REF	FDP	84*	[15]+		[151]*	[91]*	5.9	[9.6]	[9.8]+	[73]*	
MAT	FDP	21*			16						
MIX	FDP	98			403	66					
REF	FDP				4194						
MIX/RF/FP	FDP	[85]*	5.6		148*	90*	49	8.1	7.4	70+	
MIX/S/S/S	FDP	190*		91+	283	144+					226*
HOT	HOT	[57]*	[43]*	[12]*	[151]	[138]*	[5.2]	[193]+	[50]		
MIX/S/S/S	HOT									568	
EQUIP	LAB		[19]								

Notes on statistical significance levels: * = ≤ 0.05 + = > 0.05 and < 0.10 [blank] = ≥ 0.10

TABLE C-3 (contd)

Metered End Use	Equipment Category	All Buildings	Office	Dry Good Retail	Grocery	Restaurant	Warehouse	School	Other	Hotel	University
EQUIP	MAT	[59]			626+	[438]+	117		[3.3]		179
MAT	MAT	4.9	15+		[78]						
MIX/S/S/S	MAT				698		[132]				
FDP	MISC		59								
FDP/REF	MISC	433				797+					
EQUIP	MISC	27	101*			[618]*	[8.6]	80			75*
DATA	MISC	312*									
MIX	MISC		49		933*	201	21				
REF	MISC	576				783+					
MIX/RF/FP	MISC	7.9	98*	103		641*		[122]			157*
MIX/S/S/S	MISC	15	[100]*		[928]*	574*					
EQUIP	OFF	161+	[144]*	186+			[329]*		[219]		22
DATA	OFF	45	27		[449]*	[191]*	64*				
MIX	OFF	226*	225	147				91	389	1787*	
MIX/RF/FP	OFF	227	165*				216	3845*	397*	429	
MIX/S/S/S	OFF	140*	186*	[186]*			454*			1787*	

Notes on statistical significance levels: * = ≤ 0.05 + = > 0.05 and < 0.10 [blank] = ≥ 0.10

TABLE C-3 (contd)

Metered End Use	Equipment Category	All Buildings	Office	Dry Good Retail	Grocery	Restaurant	Warehouse	School	Other	Hotel	University
FDP	REF					269					
FDP/REF	REF	268*	170*		416*	182*	70	[259]*	28	377*	90
EQUIP	REF	269*	[129]*	[301]+	404*	184*	[784]*	146	[543]*	376*	90
MIX	REF	314		1556	1207*	525	736*		566+		
REF	REF	270*	165*		[403]*	180*	70	237		[377]*	
MIX/RF/FP	REF	[270]*	133+	1568	404*	[187]*	444	64	543	376*	91
MIX/S/S/S	REF	180*		301*	45	180*	1006*		574*		
EQUIP	SAN	81	250		1779					33	
MIX	SAN		523						27		
MIX/RF/FP	SAN	568	480		4795+				24		
MIX/S/S/S	SAN	20	361			73			17		
SAN	SAN				[65]	[17]*					
EQUIP	SHOP	1.7	[43]	21*	581*		7.7		0.19		
MIX	SHOP	274*	157				392*				
MIX/RF/FP	SHOP	287	124		[581]+		456*	323			
MIX/S/S/S	SHOP	1.8		[21]*			[7.2]		[0.19]		

Notes on statistical significance levels: * = ≤ 0.05 + = > 0.05 and < 0.10 [blank] = ≥ 0.10

TABLE C-3 (contd)

Metered End Use	Equipment Category	All Buildings	Office	Dry Good Retail	Grocery	Restaurant	Warehouse	School	Other	Hotel	University
EQUIP	TLT			371*				[258]+			
MIX	TLT	[133]	[142]			[218]	[126]	260			
MIX/S/S/S	TLT			[371]*							
ELV	VRT		[15]*								

Notes on statistical significance levels: * = ≤ 0.05 + = > 0.05 and < 0.10 [blank] = ≥ 0.10

Since the definition of the utilization factor is 1000 times the product of fraction of hours of use and the equipment load factor (the actual power divided by nameplate rated power), and equipment load factors should always be less than 1, any utilization factors significantly greater than 1000 are theoretically impossible. Only a few utilization factors greater than 1000 appear in Table C-3; most of these are not statistically significant.

The most notable exceptions occur for office equipment in the School and Hotel/Motel samples. This may indicate a systematic under-reporting (by the characteristics survey teams) of the connected loads metered on the Mixed General and Receptacles end uses for these buildings. In such an instance, the apparent utilization factor for the equipment that is reported will be inflated, since the reported capacity will not represent all the actual load generating equipment being metered.

The process used to examine the statistical validity, consistency, and reasonableness of the various utilization estimates is described in the following discussion. To facilitate use of Table C-3 in the following discussion, the regressed utilization factor judged by this process to be the most reliable for each equipment category and building type is enclosed in brackets in the table.

METHODOLOGY FOR SELECTING RECOMMENDED UTILIZATION FACTORS

The process used to recommend specific coefficients from the various metered end-use regressions in describing equipment utilization is essentially one of investigating and resolving differences in the utilization factors for a specific equipment category when multiple coefficients are derived from the regressions. These must be carefully examined to make a determination as to which one is the most representative and should be used. Where only a single coefficient is available, the conditions surrounding its estimation must also be examined before accepting it for use.

This process is heavily dependent on careful examination of the input data for the individual regressions, and using judgement as to the reasonableness of the utilization factors estimated from them with respect to both the ELCAP commercial measurement plan protocol and the nature of the equipment in the category and building type. The process can be generically described as follows.

Step 0: Select a building type.

Step 1: For the building type, order the regressions by their fraction of variance explained (R^2), from highest to lowest (using the data in Appendix E).

Step 2: For the building type, examine the number of observations with respect to the number of selected explanatory equipment categories for the regressions (using Appendix E), and move to the bottom of the list any regressions where the resulting degrees of freedom may overly constrain the results. Suspect regressions were identified as having R^2 over 0.99, or with greater than a 1:4 ratio of the number of selected explanatory variables to number of observations.

Step 3: Select an equipment category for the building type.

Step 4: For the building type and equipment category, select a "trial" utilization factor from among those with the highest statistical significance. Use the rank order of the regressions as a second criterion to choose between two or more coefficients with equal significance.

Step 5: Check the regression equation from which the trial coefficient is estimated (using the data in Appendix E) to see if it might be contaminated by any impossibly large coefficients for other equipment categories with large capacities. (If this combination of large capacity and a very large coefficient is present, this extraneous equipment category may have "absorbed" a significant amount of the energy "signal" in the regression and reduced the other coefficients involved accordingly.) If so, reject the trial utilization factor and return to Step 4.

Step 6: Check the input data to the regressions to determine the fraction of the total capacity for the equipment category that is metered on the end-use of the trial utilization factor. If large equipment capacities for the category appear on other end use(s), and there is reason to believe that this equipment category may have a bias as to its nature or use with respect to the end use on which it is metered, reject the trial utilization factor and return to Step 4.

For example, it was found that the majority of the computer capacity on the Data end use was classified as large equipment (mini and mainframe computers), while almost none of the capacity on the Mixed General/Receptacles end use was large computers. Since the Equipment end-use regression includes loads and capacities from all equipment, the trial utilization factor from the Data f end-use regression was rejected.

Step 7: If a large capacity for the equipment type exists on other end use(s) but no bias is suggested, check to see if the equipment is more "purely" metered on the end use of the trial utilization factor than on the alternate end use(s). If not, return to Step 4.

Step 8: Repeat Steps 4 through 7 for each equipment category for the selected building type.

Step 9: Repeat Steps 1 through 8 for each building type.

This process was generally successful in selecting a particular regression coefficient as a recommended utilization factor. The utilization factors recommended by this process are shown in Table C-4. Next to each utilization factor in the table, the end use regression from which it is obtained is indicated. In nearly all cases, the selection process resulted in a recommended utilization factor that was one of those with the highest significance available. Exceptions to this are noted in the discussion of the selection process for each building type in the following section.

UTILIZATION ESTIMATES FOR PERSONAL AND LARGE COMPUTER EQUIPMENT

One pair of supplemental equipment categories appears in Table C-4, for small computers (CMP) and large computer (LGC) equipment. The utilization factors for them were derived from the relative capacities of each category metered on the Data and the Mixed General/Receptacles end uses. Of the computer capacity on the Data end use, 20.6% was classified as large equipment (mini and mainframe computers), while only 1.0% of the capacity on the Mixed General/Receptacles end use was from large computers. (This bias is not unexpected, since the ELCAP measurements are made at the circuit panels, and large computer equipment is much more likely to have a dedicated circuit and thus appear on the Data end use.) Highly significant coefficients were estimated for computers from regressions on both of these end uses (see Table C-4).

TABLE C-4

Estimated Utilization Factors and The End-Use Regressions From Which They are Derived

EQUIPMENT TYPE	ALL BUILDINGS Utilization EU	OFFICE Utilization EU	DRY GOOD RETAIL Utilization EU	GROCERY Utilization EU	RESTAURANT Utilization EU	WAREHOUSE Utilization EU	SCHOOL Utilization EU	OTHER Utilization EU	HOTEL/MOTEL Utilization EU
COMP	339* d	200* e	580* d	446* d	121+ e	83* d			
CMP		192@ e							
LGC		999@ e							
FDP	85* mr	15+ fr	91+ e	151* fr	91* fr	54 e	9.6* f	9.8+ f	73* fr
HOT	57* h	43* h	12* h	151 h	138* h	5.2 h	193+ h	50 h	
LAB		19- e							
MAT	59 e	15+ t		78 t	438+ e	132 t		3.3- e	
MISC		100* ms		928* ms	618 e	8.6 e	122 e		
OFF	226* m	144* e	186* ms	449* d	191* d	329* e		219 e	
REF	270* mr	129* e	301+ e	403* r	187* mr	784* e	259* fr	543* e	377* r
SAN				65 s	17* s				33- e
SHOP		43 e	21* ms	581- mr		7.2 ms		0.2 ms	
TLT	133 m	142 m	371* ms		218 m	126 m	258+ e		
VRT		15 v							
n =	65	14	12	10	7	11	4	4	2

Notes on statistical significance levels: * = ≤ 0.05 + = > 0.05 and < 0.10 [blank] = ≥ 0.10

Other notes: - based on 1 building @ algebraic estimate

End-use regression from which estimate is obtained:

d - DATA
e - EQUIP
f - FDP
fr - FDP/REF
h - HOT
t - MAT
m - MIX
mr - MIX/RF/FP
ms - MIX/S/S/S
r - REF
s - SAN
v - ELV

This bias in the types of computer equipment metered on the Data and Mixed/Receptacles end uses is used to estimate separate utilization factors for large and small computer equipment, since the utilization of the larger equipment is reflected in the coefficient from the Data end-use regression, and conversely the Mixed/Receptacle regression coefficient is dominated by the small computers. The separate utilization estimates are obtained by algebraically solving a system of two equations and two unknowns, as follows:

Data End Use:	358 =	CMP * (1 - 0.2060) + LGC * 0.2060
Mixed/Receptacle End Use:	200 =	CMP * (1 - 0.0103) + LGC * 0.0103
Solution:	CMP =	192 and LGC = 999

This is a reassuring result, as it is well known that large computer equipment is kept on continuously.

NOTES ON SELECTION OF UTILIZATION FACTORS BY BUILDING TYPE

This section contains a discussion of the utilization factors selected from Table E.3 as best representing each equipment category for each specific building type. The rationale for key decisions involved in the selection process and observations regarding the relative magnitudes and significance levels of the regressed utilization factors is included. This information is provided so that researchers can examine the rationale used in recommending utilization factors and apply their own judgment as to the use of the recommended utilization factors, or select alternatives, should different criteria be better suited to a specific application.

Office Buildings

The highly significant office equipment coefficient from the Equipment end use combination was selected over similarly significant but different coefficients from regressions involving the Mixed end use. This was because significant amounts of refrigeration equipment was metered on the Mixed end use, yet refrigeration did not appear significant in the Mixed regressions and so the effect of refrigeration was not controlled in the Mixed end-use regressions.

Two highly significant coefficients for computer equipment were determined with values that varied by roughly 50% from the Data and Equipment regressions. As noted above, this differential is used to separately estimate utilization factors for large and small computer equipment. Use of these separate utilization factors is recommended for office buildings.

The coefficient for Refrigeration equipment from the Equipment regression is recommended. Refrigerators in office buildings are most frequently incidental loads metered on the Mixed General/Receptacles end use. The coefficient from Equipment regression has a higher statistical significance than that from the Mixed/Sanitation/Shop/Specialty regression, although they are very similar in magnitude. The coefficients from the two regressions involving the Refrigeration end use are both comparable, but about 30% higher than that from the Equipment regression and so may be biased in the type of refrigeration equipment represented.

Two very different (by a factor of three) and moderately significant coefficients were determined for food preparation equipment from the Food Preparation and Food Preparation/Refrigeration regressions. The coefficient from the combined end-use regression was judged more reliable due because significant amounts of each equipment category are metered on both end uses. (This is true for most other building types as well.) The office equipment coefficient from the Mixed/Sanitation/Shop/Specialty regression is recommended from among several relatively comparable and significant coefficients for similar reasons.

The utilization factor for shop equipment is recommended from the Equipment regression, since it reflects all three occurrences of the equipment that appear on the Shop (n = 2) and the Mixed General/Receptacles (n = 1) end uses. This coefficient must be used with caution, if at all, due to the small sample of equipment involved. No recommendation was made for sanitation equipment, since it appears in only low capacities, primarily on the Mixed regression where other equipment capacities are a much larger fraction of the total. The task lighting coefficient from the Mixed regression is recommended, despite relatively low significance, as the best available estimate.

Dry Good Retail Buildings

Very low R^2 and only three significant utilization factors were obtained for retail buildings, until a single observation (site 735) was removed from the Mixed end use. This site has an extremely large load relative to its equipment capacities, and probably represents a site that had changed dramatically in its equipment mix since the connected load survey was conducted. With the removal of this outlier, a number of consistent and statistically significant utilization factors were obtained that required no further special considerations.

Grocery Stores

The coefficient for food preparation equipment from the food preparation regression is recommended because it more nearly dominates the capacity on the end use. Similar and significant values were obtained from two other regressions, and a third significant but somewhat different (20% lower) value from the Equipment regression was rejected. For refrigeration equipment, several very similar and significant coefficients were obtained, along with another significant but very different (300% higher) coefficient from the Mixed regression that is rejected since it contains a relatively small fraction of the capacity of all the refrigeration equipment.

A moderately significant coefficient for materials handling from the Equipment end use was rejected in favor of a much smaller coefficient from the Materials Handling regression. The equipment involved dominates the Materials Handling end use, but is only a small fraction of the Equipment end-use capacity leading to correlation with other variables.

The coefficient for sanitation equipment from the Mixed/Refrigeration/Food Preparation regression was rejected, although it has moderate significance, because it results from a sample of one in a regression whose total capacity is dominated by refrigeration equipment. The remaining coefficients both have low significance, and are very different in magnitude. The coefficient from the Sanitation regression is recommended since sanitation equipment dominates these loads and is a very small component of loads on the Equipment regression. This coefficient must be used with caution, if at all, due to its low significance and the small sample of equipment involved (n = 3). The coefficient for hot water equipment is accepted despite low significance since it is a "pure" end use and reflects an "average" of data from all the buildings.

Restaurants

Significant and reasonable utilizations for refrigeration equipment in restaurants could not be obtained until a single site (457) was removed from the analysis. This site is an ice cream parlor with very large refrigeration capacity that has low usage. Following removal of this site from the analysis, statistically significant results were obtained for refrigeration that is comparable to that in grocery stores.

The coefficient for miscellaneous equipment from the Equipment regression recommended is because it includes the capacity of all this equipment, substantial quantities of which appear on the Specialty and Refrigeration end uses. The coefficient from the Mixed/Refrigeration/Food Preparation regression is also significant, and very similar in magnitude. The task lighting coefficient from the Mixed regression is recommended, despite relatively low significance, as the best available estimate. The coefficient for materials handling equipment from the Food Preparation regression is accepted, despite the fact that the capacity involved is small and represents a sample of two sites, as it does represent a sizeable load at these two sites.

Warehouses

The coefficient recommended as the food preparation equipment utilization factor in warehouses is from the Equipment regression because the majority of the capacity is metered on the Mixed-General/Receptacles end use. The coefficient from the Mixed/Refrigeration/Food Preparation regression is similar (10% lower), but is rejected because it has a high ratio of explanatory variables to sample size (5:14). Also rejected is the coefficient from the Food Preparation/Refrigeration regression, as it reflects only one building. None of the three coefficients obtained has high or even moderate significance.

A coefficient with low significance is accepted for materials handling equipment from the Mixed/Sanitation/Shop/Specialty regression in preference to a similar value (10% lower) from the Equipment end use, as the equipment capacity represents a larger fraction of the capacity on this regression.

A majority of the miscellaneous equipment loads are metered on the Equipment end use, and the utilization factor from it is therefore accepted despite low significance. This coefficient must be used with caution, if at all, due to the small sample of equipment involved. The highly significant coefficient for office equipment from the Equipment regression is recommended for similar reasons. The value from the Data regression, which differs markedly from the other two significant coefficients (by a factor of over five), is rejected due to sample size problems.

The coefficient for refrigeration equipment from the Equipment end-use is recommended since it represents the loads from all the refrigeration equipment, which appears on both the Refrigeration and Mixed-General/Receptacles end uses.

Two highly significant coefficients for shop equipment from the Mixed and Mixed/Refrigeration/Food Preparation end uses are rejected. The majority of the capacity appears on the Shop end use, whose loads are reflected in the coefficient from the Mixed/Sanitation/Shop/Specialty regression. The shop equipment represents a larger fraction of the total capacity in this regression than the Equipment regression, which has a similar (7% higher) utilization estimate.

The coefficient for hot water equipment is accepted despite low significance since it is a "pure" end use and reflects the average of data with a lot of scatter. The task lighting coefficient from the Mixed regression is also recommended, despite relatively low significance, as the best available estimate.

Schools

The coefficient for miscellaneous equipment from the Equipment regression is recommended over another significant coefficient from the Food Preparation end use, as the latter represents a sample size of one.

The coefficients for sanitation and shop equipment are rejected as unreliable because they represent sample sizes of two and one, respectively, and are from regressions in which they represent a small fraction of the total capacity. The task lighting coefficient from the Mixed regression is also recommended, despite relatively low significance, as the best available estimate.

Other Buildings

The coefficient for hot water equipment is accepted despite low significance since it is a "pure" end use and reflects the average of data with a lot of scatter. The coefficients for materials handling and office equipment are also accepted on this basis, reflecting a sample size of two. The office equipment coefficient from the Mixed/Receptacles/Food Preparation regression is rejected as it represents a sample of one, although it has greater statistical significance. These coefficients must be used with caution, if at all, due to the small sample sizes involved.

The refrigeration equipment coefficient from the Equipment end use is recommended, as the significant coefficient from the Mixed/Sanitation/

Shop/Specialty regression is judged unreliable because the regression has a high ratio of explanatory variables to observations (4:7). (The difference of these two coefficients is only 5%.) All other equipment coefficients obtained are rejected for similar reasons.

Hotel/Motels

The coefficients for food preparation and refrigeration equipment are accepted despite a high ratio of explanatory variables to observations as representing the "average" of a sample of two buildings, supported by very similar coefficients obtained from the Equipment, Refrigeration, and Food Preparation/Refrigeration regressions. The sanitation equipment coefficient obtained from the Equipment regression is accepted as representing a sample of one. These coefficients must be used with caution, if at all, due to the small sample sizes involved (n = 2 buildings).

APPENDIX D

REGRESSION DATA SET: END-USE DATA, EQUIPMENT CAPACITIES, AND FLOOR AREAS FOR EACH BUILDING

TABLE D-1

Input Data for Office Regressions

		END-USE DATA		EQUIPMENT CAPACITIES (kW)											
OBS	SITE	Area (ft^2)	(Avg. watts)	OFF	FDP	LAB	MAT	REFR	SAN	VERT	SHOP	MISC	HOT	COMP	TLT
Metered End-Use: DATA PROCESSING (DATA) Building Type: OFFICE															
1	444	3157	453.26	1.877	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.529	0.0	1.125	0.0
2	458	7911	3053.29	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.084	0.0	8.621	0.0
3	538	12130	33.32	0.547	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000	0.0	0.000	0.0
4	547	3015	243.36	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000	0.0	0.720	0.0
5	565	2921	275.24	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000	0.0	0.300	0.0
6	600	6423	375.23	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000	0.0	1.396	0.0
7	601	2508	270.86	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000	0.0	0.693	0.0
8	602	28649	87.10	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000	0.0	0.305	0.0
Metered End-Use: FOOD PREPARATION (FDP) Building Type: OFFICE															
29	444	3157	0.00	0.0	1.500	0.0	0.000	0.000	0.0	0.0	0.0	0.000	0.0	0.0	0.00
30	456	11318	3.78	0.0	6.500	0.0	0.000	0.000	0.0	0.0	0.0	0.000	0.0	0.0	0.00
31	458	7911	121.00	0.0	4.850	0.0	0.000	0.000	0.0	0.0	0.0	0.000	0.0	0.0	0.00
32	538	12130	3080.16	0.0	31.692	0.0	1.448	2.540	0.0	0.0	0.0	0.100	0.0	0.0	0.00
33	547	3015	48.18	0.0	10.053	0.0	0.000	0.000	0.0	0.0	0.0	0.000	0.0	0.0	0.00
34	548	16372	61.67	0.0	0.000	0.0	0.000	0.000	0.0	0.0	0.0	0.597	0.0	0.0	0.00
35	565	2921	96.97	0.0	15.350	0.0	0.000	0.357	0.0	0.0	0.0	0.597	0.0	0.0	0.06
36	595	4800	157.29	0.0	1.590	0.0	0.000	0.000	0.0	0.0	0.0	0.000	0.0	0.0	0.00
37	600	6423	75.96	0.0	9.860	0.0	0.000	0.253	0.0	0.0	0.0	0.000	0.0	0.0	0.00
38	601	2508	63.18	0.0	3.320	0.0	0.000	0.000	0.0	0.0	0.0	0.597	0.0	0.0	0.00
39	602	28649	95.76	0.0	1.000	0.0	0.000	0.000	0.0	0.0	0.0	0.000	0.0	0.0	0.00
Metered End-Use: HOT WATER (HOT) Building Type: Office															
65	298	9959	246.06	0.0	0.0	0.0	0.000	0.0	0.0	0.0	0.0	0.0	9.000	0.0	0.0
66	299	5128	125.87	0.0	0.0	0.0	0.000	0.0	0.0	0.0	0.0	0.0	4.000	0.0	0.0
67	444	3157	143.22	0.0	0.0	0.0	0.000	0.0	0.0	0.0	0.0	0.0	6.500	0.0	0.0
68	456	11318	1493.00	0.0	0.0	0.0	0.000	0.0	0.0	0.0	0.0	0.0	24.200	0.0	0.0
69	458	7911	302.47	0.0	0.0	0.0	0.000	0.0	0.0	0.0	0.0	0.0	5.880	0.0	0.0
70	538	12130	1194.10	0.0	0.0	0.0	0.000	0.0	0.0	0.0	0.0	0.0	13.000	0.0	0.0
71	547	3015	103.68	0.0	0.0	0.0	0.000	0.0	0.0	0.0	0.0	0.0	4.000	0.0	0.0
72	548	16372	1963.85	0.0	0.0	0.0	0.373	0.0	0.0	0.0	0.0	0.0	16.320	0.0	0.0
73	565	2921	123.83	0.0	0.0	0.0	0.000	0.0	0.0	0.0	0.0	0.0	4.000	0.0	0.0
74	601	2508	152.32	0.0	0.0	0.0	0.000	0.0	0.0	0.0	0.0	0.0	1.250	0.0	0.0
75	602	28649	114.00	0.0	0.0	0.0	0.000	0.0	0.0	0.0	0.0	0.0	0.195	0.0	0.0
Metered End-Use: MATERIAL HANDLING (MAT) Building Type: Office															
115	548	16372	114.222	0.0	0.0	0.0	7.042	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
116	595	4800	11.542	0.0	0.0	0.0	1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE D-1 (contd)

OBS	SITE	Area (ft2)	END-USE DATA (Avg. watts)	OFF	FDP	LAB	MAT	REFR	SAN	VERT	SHOP	MISC	HOT	COMP	TLT
				EQUIPMENT CAPACITIES (kW)											
Metered End-Use: MIXED GENERAL/RECEPTACLES (MIX) Building Type: Office															
128	2	15732	5261.29	12.060	16.515	0.0	0.000	3.778	0.000	0.00	0.00	7.597	4.5	0.920	0.000
129	298	9959	1267.38	1.200	5.800	0.0	0.000	1.950	0.000	0.00	5.92	0.000	0.0	0.000	0.460
130	299	5128	2325.93	0.135	3.030	0.0	0.000	0.750	0.000	0.00	0.00	4.406	0.0	0.902	14.650
131	444	3157	157.06	0.000	1.730	0.0	0.000	0.724	0.000	0.00	0.00	0.000	0.0	0.060	0.000
132	456	11318	2538.69	1.760	6.250	3.1	0.000	2.810	4.610	0.00	0.00	2.496	0.0	0.290	6.183
133	458	7911	894.47	5.913	5.875	0.0	0.348	0.640	1.300	0.00	0.00	0.996	0.0	1.680	0.080
134	538	12130	217.16	8.320	16.366	0.0	0.000	6.999	2.568	0.00	0.00	6.902	1.3	7.815	0.240
135	547	3015	330.95	3.402	1.800	0.0	0.000	0.000	0.000	0.00	0.00	0.555	0.0	0.125	0.644
136	548	16372	2507.22	1.587	7.400	0.0	0.960	2.120	1.380	0.00	0.00	1.450	0.0	0.595	0.200
137	565	2921	3194.59	4.763	1.556	0.0	0.000	0.000	0.780	0.00	0.00	5.517	0.0	0.711	0.913
138	595	4800	1571.08	3.186	1.840	0.0	0.000	0.864	0.000	0.00	0.00	1.315	0.0	0.000	1.880
139	600	6423	2223.31	8.554	2.158	0.0	1.693	1.380	0.000	0.00	0.00	5.018	0.0	2.245	3.036
140	601	2508	1018.73	4.230	1.800	0.0	0.000	0.300	0.000	0.00	0.00	9.020	0.0	0.300	0.660
141	602	28649	3567.40	8.723	10.874	0.0	6.556	1.134	0.000	3.24	0.00	10.697	0.0	2.025	10.739
Metered End-Use: REFRIGERATION (REF) Building Type: OFFICE															
189	444	3157	121.33	0.0	0.00	0.0	0.0	0.780	0.0	0.0	0.0	0.000	0.0	0.0	0.0
190	538	12130	4501.47	0.0	1.02	0.0	0.0	26.981	0.0	0.0	0.0	0.391	0.0	0.0	0.1
191	565	2921	4.10	0.0	0.00	0.0	0.0	0.633	0.0	0.0	0.0	0.000	0.0	0.0	0.0
Metered End-Use: SANITATION (SAN) Building Type: OFFICE															
218	444	3157	5.629	0.0	0.0	0.0	0.0	0.0	0.69	0.0	0.0	0.0	0.0	0.0	0.0
219	565	2921	2.586	0.0	0.0	0.0	0.0	0.0	0.84	0.0	0.0	0.0	0.0	0.0	0.0
Metered End-Use: SHOP Building Type: OFFICE															
231	298	9959	7.281	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.94	0.0	0.0	0.0	0.03
232	548	16372	3.500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.50	0.0	0.0	0.0	0.00
Metered End-Use: SPECIAL Building Type: OFFICE															
242	298	9959	1848.00	0.0	0.0	0.000	1.700	0.0	1.26	0.0	8.01	14.110	0.0	0.0	0.03
243	444	3157	110.74	0.0	0.0	0.000	0.675	0.0	0.00	0.0	0.00	0.300	0.0	0.0	0.00
244	456	11318	300.00	0.0	0.0	12.656	0.000	0.0	0.00	0.0	0.00	0.000	0.0	0.0	0.00
245	547	3015	58.77	0.0	0.0	0.000	0.000	0.0	0.00	0.0	0.00	0.389	0.0	0.0	0.00
246	548	16372	1093.29	0.0	0.3	0.000	0.000	0.0	0.00	0.0	0.00	5.987	0.0	0.0	0.00
247	565	2921	508.07	0.0	0.0	0.000	0.000	0.0	0.00	0.0	0.00	2.937	0.0	0.0	0.00
248	595	4800	273.92	0.0	0.0	0.000	0.000	0.0	0.00	0.0	0.00	0.150	0.0	0.0	0.00
249	600	6423	50.31	0.0	0.0	0.000	6.470	0.0	0.00	0.0	0.00	0.782	0.0	0.0	0.00
250	602	28649	232.80	0.0	0.0	0.000	0.000	0.0	0.00	0.0	0.00	1.399	0.0	0.0	0.00
Metered End-Use: VERTICAL TRANSPORTATION (ELV) Building Type: Office															
270	2	15732	421.958	0.0	0.0	0.0	0.0	0.0	0.0	29.4	0.0	0.0	0.0	0.0	0.0
271	602	28649	386.042	0.0	0.0	0.0	0.0	0.0	0.0	4.6	0.0	0.0	0.0	0.0	0.0

TABLE D-2

Input Data for Dry Good/Retail Regressions

OBS	SITE	Area (ft^2)	END-USE DATA (Avg. watts)	OFF	FDP	LAB	MAT	REFR	SAN	VERT	SHOP	MISC	HOT	COMP	TLT
				EQUIPMENT CAPACITIES (kW)											
Metered End-Use: DATA PROCESSING (DATA) Building Type: DRY GOOD/RETAIL															
9	443	2800	225.500	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.300	0.0
10	447	7050	291.000	1.210	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.600	0.0
11	532	4131	63.846	0.080	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.200	0.0
12	571	24048	285.368	0.273	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.396	0.0
Metered End-Use: HOT WATER (HOT) Building Type: DRY GOOD/RETAIL															
76	12	4479	206.250	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.000	0.0	0.0
77	289	4667	190.150	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.500	0.0	0.0
78	443	2800	304.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.556	0.0	0.0
79	447	7050	280.786	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.056	0.0	0.0
80	532	4131	91.462	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.000	0.0	0.0
81	546	10157	9.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.000	0.0	0.0
82	571	24048	92.737	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.113	0.0	0.0
83	716	2045	142.080	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.056	0.0	0.0
84	723	14960	308.909	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.500	0.0	0.0
85	735	19026	314.714	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.056	0.0	0.0
86	751	20819	402.211	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.500	0.0	0.0
Metered End-Use: MATERIAL HANDLING (MAT) Building Type: DRY GOOD/RETAIL															
117	735	19026	0.0	0.0	0.0	0.0	9.37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Metered End-Use: MIXED GENERAL/RECEPTACLES (MIX) Building Type: DRY GOOD/RETAIL															
142	12	4479	347.5	1.959	2.952	0.0	2.910	0.000	0.000	0.0	0.000	1.885	0.0	0.450	0.84
143	289	4667	508.9	0.000	1.458	0.0	0.000	0.130	0.000	0.0	1.760	2.930	0.0	0.000	0.00
144	443	2800	1043.0	1.350	2.917	0.0	0.000	0.564	0.000	0.0	0.000	0.000	0.0	0.800	0.20
145	447	7050	1221.9	0.000	0.000	0.0	0.000	0.564	0.000	0.0	2.890	1.300	0.0	0.000	1.62
146	532	4131	160.9	0.000	2.650	0.0	0.000	0.564	0.000	0.0	0.000	1.130	0.0	0.000	0.24
147	546	10157	222.9	1.500	0.000	0.0	0.000	0.000	0.000	0.0	0.000	0.000	0.0	0.000	0.00
148	571	24048	1954.2	0.000	1.520	0.0	0.000	0.000	0.000	0.0	0.000	0.000	0.0	0.000	0.36
149	610	2330	403.7	0.000	0.000	0.0	0.000	0.000	0.000	0.0	0.000	0.550	0.0	0.000	0.90
150	716	2045	144.5	0.000	0.000	0.0	0.000	0.564	0.000	0.0	3.830	0.000	0.0	0.000	0.08
151	723	14960	2112.5	0.000	0.701	0.0	0.000	0.000	0.000	0.0	3.459	0.000	0.0	0.000	0.00
[152	735	19025	33348.9	0.000	0.701	0.0	0.000	1.384	0.000	0.0	0.000	0.000	0.0	0.000	0.00
Note that this observation is considered an outlier due to its extremely large consumption relative to equipment capacities, and was not used.]															
153	751	20819	976.5	0.000	3.801	0.0	0.000	0.564	2.202	0.0	0.000	0.000	0.0	0.600	0.00
Metered End-Use: SHOP Building Type: DRY GOOD/RETAIL															
233	289	4667	231.050	0.0	0.0	0.0	2.910	0.0	1.42	0.0	24.170	0.0	0.0	0.0	0.00
234	447	7050	425.286	0.0	0.0	0.0	0.000	0.0	0.00	0.0	29.285	0.0	0.0	0.0	0.08
235	716	2045	443.840	0.0	0.0	0.0	0.000	0.0	0.00	0.0	15.550	0.0	0.0	0.0	0.00

TABLE D-2 (contd)

			END-USE DATA	EQUIPMENT CAPACITIES (kW)											
OBS	SITE	Area (ft2)	(Avg. watts)	OFF	FDP	LAB	MAT	REFR	SAN	VERT	SHOP	MISC	HGT	COMP	TLT
Metered End-Use: SPECIAL Building Type: DRY GOOD/RETAIL															
251	12	4479	26.0	0.0	0.0	0.0	2.910	0.00	0.0	0.0	0.0	0.000	0.0	0.0	0.0
252	532	4131	29.2	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.0	1.510	0.0	0.0	0.0
253	571	24048	1208.1	0.0	0.0	0.0	0.000	2.58	0.0	0.0	0.0	0.000	0.0	0.0	0.0
254	723	14960	15341.8	82.3	0.0	0.0	45.791	0.00	0.0	0.0	0.0	0.760	45.0	0.0	0.0
255	751	20819	188.6	0.0	0.0	0.0	0.000	0.00	0.0	0.0	0.0	0.440	0.0	0.0	0.0

TABLE D-3

Input Data for Grocery Regressions

OBS	SITE	Area (ft2)	END-USE DATA (Avg. watts)	OFF	FDP	LAB	MAT	REFR	SAN	VERT	SHOP	MISC	HOT	COMP	TLT
Metered End-Use: DATA PROCESSING (DATA) Building Type: GROCERY															
13	7	22232	7726.8	0.273	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.24	0.0	5.584	0.0
14	284	3200	28.3	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.000	0.0
15	560	23928	10930.4	0.873	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	1.396	0.0
16	588	39668	3366.9	4.673	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	2.792	0.0
17	594	23725	728.2	0.273	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	1.396	0.0
Metered End-Use: FOOD PREPARATION (FDP) Building Type: GROCERY															
40	7	22232	1660.0	0.0	25.879	0.0	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	37	22307	150.8	0.0	9.190	0.0	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
42	284	3200	2819.7	0.0	15.560	0.0	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43	297	3287	4081.9	0.0	26.618	0.0	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
44	560	23928	8041.4	0.0	72.749	0.0	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45	588	39668	13529.3	0.0	73.696	0.0	3.312	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
46	597	7552	94.7	0.0	7.583	0.0	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
47	724	36847	9386.9	0.0	117.630	0.0	0.600	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Metered End-Use: HOT WATER (HOT) Building Type: GROCERY															
87	7	22232	418.93	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.113	0.0	0.24
88	284	3200	334.67	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.000	0.0	0.00
89	297	3287	2012.71	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.500	0.0	0.00
90	560	23928	3946.11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.270	0.0	0.00
91	588	39668	7289.67	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.060	0.0	0.00
92	690	1072	771.32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.000	0.0	0.00
93	724	36847	6588.48	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.020	0.0	0.03
Metered End-Use: MATERIAL HANDLING (MAT) Building Type: GROCERY															
118	7	22232	481.62	0.0	0.000	0.0	2.740	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
119	37	22307	607.69	0.0	6.704	0.0	13.850	0.51	0.0	0.0	0.0	0.0	0.0	0.0	0.0
120	284	3200	380.67	0.0	0.000	0.0	0.348	0.00	0.0	0.0	0.0	0.0	0.0	0.1	0.0
121	297	3287	321.00	0.0	15.100	0.0	1.006	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
122	560	23928	902.79	0.0	0.000	0.0	10.635	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
123	588	39668	1031.20	0.0	0.000	0.0	5.532	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
124	597	7552	82.17	0.0	0.000	0.0	1.940	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
125	724	36847	1271.30	0.0	3.150	0.0	14.910	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Columns OFF through TLT: EQUIPMENT CAPACITIES (kW)

TABLE D-3 (contd)

OBS	SITE	Area (ft^2)	END-USE DATA (Avg. watts)	OFF	FDP	LAB	MAT	REFR	SAN	VERT	SHOP	MISC	HOT	COMP	TLT
Metered End-Use: MIXED GENERAL/RECEPTACLES (MIX) Building Type: GROCERY															
154	37	22307	359.92	0.0	3.905	0.0	0.000	0.00	0.0	0.0	0.000	0.000	0.0	0.0	0.00
155	284	3200	3541.67	0.0	0.000	0.0	0.000	0.00	0.0	0.0	6.091	3.820	0.0	0.0	0.50
156	560	23928	5067.14	0.0	1.403	0.0	1.461	0.00	0.0	0.0	0.000	0.629	0.0	0.0	0.00
157	594	23725	833.46	0.0	1.090	0.0	1.300	0.00	0.0	0.0	0.000	0.000	0.0	0.0	0.45
158	597	7552	1704.33	0.0	0.000	0.0	0.000	0.12	0.0	0.0	0.000	0.000	0.0	0.0	0.16
159	690	1072	729.56	0.0	0.000	0.0	0.000	0.61	0.0	0.0	0.000	0.000	0.0	0.0	0.00
160	724	36847	2454.70	0.0	0.000	0.0	0.000	1.75	0.0	0.0	0.000	0.000	0.0	0.0	0.00
Metered End-Use: REFRIGERATION (REF) Building Type: GROCERY															
192	7	22232	61881	0.0	0.00	0.0	0.00	260.218	0.0	0.0	0.0	0.597	0.0	0.0	0.00
193	37	22307	106813	0.0	7.02	0.0	0.00	193.201	5.8	0.0	0.0	0.000	0.0	0.0	0.20
194	284	3200	13499	0.0	0.00	0.0	2.30	22.315	0.0	0.0	0.0	0.000	0.0	0.0	0.00
195	297	3287	18906	0.0	0.00	0.0	0.00	44.068	0.0	0.0	0.0	0.000	0.0	0.0	0.00
196	560	23928	83134	0.0	0.10	0.0	0.30	112.114	0.0	0.0	0.0	0.538	0.0	0.0	0.92
197	588	39668	140295	0.0	0.00	0.0	0.00	267.857	0.0	0.0	0.0	0.000	0.0	0.0	0.00
198	594	23725	22413	0.0	0.00	0.0	0.00	79.722	0.0	0.0	0.0	5.543	0.0	0.0	0.00
199	597	7552	17575	0.0	0.00	0.0	0.85	48.635	0.0	0.0	0.0	0.800	0.0	0.0	0.00
200	690	1072	6148	0.0	0.00	0.0	0.00	18.158	0.0	0.0	0.0	0.000	0.0	0.0	0.00
201	724	36847	115277	0.0	0.00	0.0	0.00	262.245	0.0	0.0	0.0	0.000	0.0	0.0	0.00
Metered End-Use: SANITATION (SAN) Building Type: GROCERY															
220	560	23928	144.92	0.0	0.0	0.0	0.000	0.0	5.030	0.0	0.0	0.0	0.0	0.0	0.0
221	588	39668	1123.70	0.0	0.0	0.0	0.000	0.0	8.542	0.0	0.0	0.0	0.0	0.0	0.0
222	594	23725	0.00	0.0	0.0	0.0	1.461	0.0	0.000	0.0	0.0	0.0	0.0	0.0	0.0
223	724	36847	97.29	0.0	0.0	0.0	0.000	0.0	6.270	0.0	0.0	0.0	0.0	0.0	0.0
Metered End-Use: SPECIAL Building Type: GROCERY															
256	37	22307	615.03	0.0	0.000	0.0	0.000	0.000	0.0	0.0	0.0	0.660	0.0	0.0	0.0
257	560	23928	44.85	0.0	0.000	0.0	0.000	62.386	0.0	0.0	0.0	0.755	0.0	0.0	0.0
258	588	39668	2869.52	0.0	0.761	0.0	0.000	0.000	0.0	0.0	0.0	0.000	0.0	0.0	0.0
259	594	23725	134.54	0.0	0.000	0.0	0.000	0.000	0.0	0.0	0.0	0.922	0.0	0.0	0.0
260	597	7552	3003.83	0.0	1.493	0.0	3.768	0.000	0.0	0.0	0.0	0.000	0.0	0.0	0.0
Metered End-Use: VERTICAL TRANSPORTATION (ELV) Building Type: GROCERY															
272	597	7552	7.00	0.0	0.0	0.0	0.0	0.0	0.0	10.81	0.0	0.0	0.0	0.0	0.0

TABLE D-4

Input Data for Restaurant Regressions

OBS	SITE	Area (ft²)	END-USE DATA (Avg. watts)	OFF	FDP	LAB	MAT	REFR	SAN	VERT	SHOP	MISC	HOT	COMP	TLT
				EQUIPMENT CAPACITIES (kW)											
Metered End-Use: DATA PROCESSING (DATA)				Building Type: RESTAURANT											
18	9	2777	326.300	1.875	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000	0.0	0.000	0.0
19	11	8554	634.462	0.702	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000	0.0	0.000	0.0
20	593	6600	141.000	0.621	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000	0.0	1.407	0.0
21	598	2457	483.857	1.532	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.167	0.0	1.396	0.0
Metered End-Use: FOOD PREPARATION (FDP)				Building Type: RESTAURANT											
48	9	2777	7718.90	0.0	37.463	0.0	1.460	1.985	0.0	0.0	0.0	0.00	0.0	0.0	0.0
49	11	8554	9340.23	0.0	47.735	0.0	3.450	28.417	0.0	0.0	0.0	0.00	0.0	0.0	0.0
50	441	1876	2066.00	0.0	14.320	0.0	0.000	0.720	0.0	0.0	0.0	0.24	0.0	0.0	0.0
51	457	1134	221.46	0.0	8.285	0.0	0.000	2.344	0.0	0.0	0.0	0.00	0.0	0.0	0.0
52	559	6833	9170.55	0.0	121.368	0.0	0.000	0.564	0.0	0.0	0.0	0.00	0.0	0.0	0.0
53	564	3550	5946.61	0.0	103.833	0.0	0.000	0.322	0.0	0.0	0.0	0.00	0.0	0.0	0.0
54	593	6600	8670.00	0.0	82.017	0.0	0.000	0.000	0.0	0.0	0.0	0.06	0.0	0.0	0.0
55	598	2457	4906.71	0.0	23.456	0.0	0.000	0.000	0.0	0.0	0.0	0.00	0.0	0.0	0.0
Metered End-Use: HOT WATER (HOT)				Building Type: RESTAURANT											
94	11	8554	1295.17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.00	0.0	0.0
95	457	1134	547.46	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.50	0.0	0.0
96	559	6833	5592.72	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.00	0.0	0.0
97	564	3550	2763.17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.00	0.0	0.0
98	593	6600	127.65	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.17	0.0	0.0
99	598	2457	509.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.00	0.0	0.0
Metered End-Use: MATERIAL HANDLING (MAT)				Building Type: RESTAURANT											
126	9	2777	24.8	0.0	0.0	0.0	3.16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Metered End-Use: MIXED GENERAL/RECEPTACLES (MIX)				Building Type: RESTAURANT											
161	11	8554	3888.85	0.000	2.738	0.0	0.0	1.610	0.000	0.0	0.0	1.417	0.0	0.000	0.050
162	441	1876	1816.00	0.273	1.760	0.0	0.0	2.290	0.000	0.0	0.0	2.334	0.0	0.880	0.400
163	457	1134	802.42	0.273	0.370	0.0	0.0	2.940	0.000	0.0	0.0	0.791	0.0	0.000	0.700
164	559	6833	747.72	0.327	0.701	0.0	0.0	0.060	0.000	0.0	0.0	2.486	0.0	0.000	0.965
165	564	3550	2261.72	0.273	2.236	0.0	0.0	1.760	0.792	0.0	0.0	3.305	0.0	0.000	2.359
166	593	6600	545.50	0.000	5.428	0.0	0.0	1.516	0.000	0.0	0.0	0.686	0.0	0.000	0.000
167	598	2457	2294.14	0.000	8.235	0.0	0.0	2.420	0.000	0.0	0.0	0.764	0.0	0.000	1.400

TABLE D-4 (contd)

OBS	SITE	Area (ft²)	END-USE DATA (Avg. watts)	OFF	FDP	LAB	MAT	REFR	SAN	VERT	SHOP	MISC	HOT	COMP	TLT
Metered End-Use: REFRIGERATION (REF) Building Type: RESTAURANT															
202	9	2777	2781.9	0.0	0.000	0.0	0.0	8.513	0.0	0.0	0.0	0.000	0.0	0.0	0.000
203	11	8554	4378.5	0.0	1.731	0.0	0.0	7.695	0.0	0.0	0.0	0.000	0.0	0.0	0.000
204	441	1876	2913.3	0.0	0.560	0.0	0.0	5.860	0.0	0.0	0.0	0.000	0.0	0.0	0.040
205	457	1134	277.2	0.0	0.660	0.0	0.0	24.012	0.0	0.0	0.0	0.000	0.0	0.0	0.000
206	559	6833	4744.4	0.0	0.000	0.0	0.0	10.959	0.0	0.0	0.0	3.078	0.0	0.0	0.000
207	564	3550	2006.2	0.0	4.084	0.0	0.0	17.080	0.0	0.0	0.0	0.000	0.0	0.0	0.075
208	593	6600	10822.3	0.0	0.000	0.0	0.0	27.162	0.0	0.0	0.0	7.754	0.0	0.0	0.120
209	598	2457	3303.4	0.0	0.000	0.0	0.0	23.190	0.0	0.0	0.0	0.000	0.0	0.0	0.000
Metered End-Use: SANITATION (SAN) Building Type: RESTAURANT															
224	9	2777	68.70	0.0	0.0	0.0	0.0	0.0	4.600	0.0	0.0	0.00	0.0	0.0	0.0
225	11	8554	4921.68	0.0	0.0	0.0	0.0	0.0	3.321	0.0	0.0	0.06	15.0	0.0	0.0
226	559	6833	76.52	0.0	0.0	0.0	0.0	0.0	2.180	0.0	0.0	0.00	0.0	0.0	0.0
227	564	3550	61.17	0.0	0.0	0.0	0.0	0.0	1.495	0.0	0.0	0.00	0.0	0.0	0.0
228	593	6600	548.75	0.0	0.0	0.0	0.0	0.0	6.862	0.0	0.0	0.00	10.0	0.0	0.0
Metered End-Use: SPECIAL Building Type: RESTAURANT															
261	9	2777	48.60	0.0	0.000	0.0	0.0	0.000	0.0	0.0	0.0	1.218	0.0	0.0	0.0
262	11	8554	1730.41	0.0	4.275	0.0	0.0	0.000	0.0	0.0	0.0	0.000	0.0	0.0	0.0
263	564	3550	84.22	0.0	0.000	0.0	0.0	0.000	0.0	0.0	0.0	0.782	0.0	0.0	0.0
264	593	6600	276.70	0.0	0.000	0.0	0.0	0.564	0.0	0.0	0.0	0.807	0.0	0.0	0.0

Columns OFF through TLT: EQUIPMENT CAPACITIES (kW)

TABLE D-5

Input Data for Warheouse Regressions

OBS	SITE	Area (ft2)	END-USE DATA (Avg. watts)	OFF	FDP	LAB	MAT	REFR	SAN	VERT	SHOP	MISC	HOT	COMP	TLT
				EQUIPMENT CAPACITIES (kW)											
Metered End-Use: DATA PROCESSING (DATA) Building Type: WAREHOUSE															
22	294	5403	149.286	1.604	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000	0.0	0.540	0.0
23	300	7997	136.231	1.400	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000	0.0	0.640	0.0
24	446	12151	113.550	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000	0.0	1.536	0.0
25	580	21973	182.750	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.092	0.0	0.575	0.0
26	586	20567	147.750	1.665	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.030	0.0	0.529	0.0
Metered End-Use: FOOD PREPARATION (FDP) Building Type: WAREHOUSE															
56	300	7997	17.923	0.0	3.92	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Metered End-Use: HOT WATER (HOT) Building Type: WAREHOUSE															
100	40	10950	234.304	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0
101	282	12000	61.273	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0
102	294	5403	200.714	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	45.0	0.0	0.0
103	300	7997	576.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0
104	446	12151	259.850	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	0.0	0.0
105	448	9600	64.500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0
106	580	21973	242.350	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.5	0.0	0.0
107	586	20567	193.250	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0
108	707	51409	312.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	0.0	0.0
Metered End-Use: MIXED GENERAL/RECEPTACLES (MIX) Building Type: WAREHOUSE															
168	18	5850	416.75	2.334	1.458	0.0	0.000	0.000	0.00	0.0	0.000	15.060	0.0	2.442	0.813
169	40	10950	978.96	0.000	0.000	0.0	0.000	0.000	0.00	0.0	0.000	0.119	0.0	0.000	1.350
170	282	12000	195.82	0.000	0.000	0.0	0.000	0.000	0.00	0.0	0.000	2.720	0.0	0.000	0.100
171	294	5403	451.64	0.000	2.900	0.0	1.461	0.290	0.00	0.0	0.000	0.190	0.0	0.000	3.190
172	300	7997	916.62	0.570	0.000	0.0	0.000	0.000	0.00	0.0	0.000	0.400	0.0	0.000	0.600
173	446	12151	5566.15	5.560	6.679	0.0	0.240	1.604	0.00	0.0	7.110	10.490	0.0	0.965	10.573
174	448	9600	134.82	0.054	1.220	0.0	0.250	0.000	0.00	0.0	0.000	1.449	0.0	0.000	0.050
175	580	21973	5531.55	3.900	17.590	0.0	1.311	4.984	1.44	0.0	2.415	3.144	0.0	0.920	4.178
176	586	20567	1283.25	0.054	2.218	0.0	1.560	3.564	0.00	3.0	2.530	2.124	0.0	2.792	2.208
177	707	51409	2511.58	2.555	19.148	0.0	5.235	1.776	1.40	0.0	8.810	15.452	0.0	4.325	3.216
178	736	12587	1699.05	0.000	0.000	0.0	3.290	0.110	0.00	0.0	2.650	1.380	0.0	0.000	0.275
Metered End-Use: REFRIGERATION (REF) Building Type: WAREHOUSE															
210	300	7997	78.461	0.0	0.0	0.0	0.0	0.60	0.0	0.0	0.0	0.000	0.0	0.0	0.0
211	448	9600	6.928	0.0	0.0	0.0	0.0	0.66	0.0	0.0	0.0	0.097	0.0	0.0	0.0

TABLE D-5 (contd)

OBS	SITE	Area (ft^2)	END-USE DATA (Avg. watts)	OFF	FDP	LAB	MAT	REFR	SAN	VERT	SHOP	MISC	HOT	COMP	TLT
											EQUIPMENT CAPACITIES (kW)				
Metered End-Use: SHOP Building Type: WAREHOUSE															
236	40	10950	225.96	0.0	0.0	0.0	0.000	0.0	0.00	0.0	5.727	0.000	0.0	0.0	0.00
237	282	12000	8.00	0.0	0.0	0.0	0.000	0.0	0.00	0.0	12.600	0.000	0.0	0.0	0.00
238	446	12151	133.25	0.0	0.0	0.0	0.000	0.0	0.48	0.0	17.000	0.000	0.0	0.0	0.00
239	580	21973	1267.11	0.0	0.0	0.0	0.000	0.0	0.00	0.0	175.386	0.207	0.0	0.0	0.00
240	707	51409	1531.06	0.0	0.0	0.0	23.325	0.0	0.00	0.0	93.472	7.070	0.0	0.0	0.81
Metered End-Use: SPECIAL Building Type: WAREHOUSE															
265	282	12000	66.318	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.01	0.0	0.0	0.0

TABLE D-6

Input Data for Grade School Regressions

OBS	SITE	Area (ft2)	END-USE DATA (Avg. watts)	OFF	FDP	LAB	MAT	REFR	SAN	VERT	SHOP	MISC	HOT	COMP	TLT
				EQUIPMENT CAPACITIES (kW)											
Metered End-Use: FOOD PREPARATION (FDP) Building Type: SCHOOL															
57	36	53602	3491.50	0.0	32.120	0.0	0.0	11.156	1.511	0.0	4.6	8.417	0.0	0.0	0.0
58	558	3611	93.15	0.0	10.500	0.0	0.0	0.000	0.000	0.0	0.0	0.000	0.0	0.0	0.0
59	753	32069	354.07	0.0	12.000	0.0	0.0	0.000	0.000	0.0	0.0	0.000	0.0	0.0	0.0
60	756	52911	251.84	0.0	14.400	0.0	0.0	0.000	0.000	0.0	0.0	0.000	0.0	0.0	0.0
Metered End-Use: HOT WATER (HOT) Building Type: SCHOOL															
109	558	3611	892.692	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.500	0.0	0.0
110	753	32069	828.810	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.196	0.0	0.0
Metered End-Use: MIXED GENERAL/RECEPTACLES (MIX) Building Type: SCHOOL															
179	36	53692	14875.5	0.00	0.00	0.000	0.0	0.372	0.00	0.0	0.0	0.599	0.0	0.00	66.813
180	558	3611	716.3	0.00	0.50	0.000	0.0	0.460	1.43	0.0	0.0	6.530	0.0	0.00	1.190
181	753	32069	19636.1	4.79	2.82	0.015	0.0	0.000	0.84	0.0	0.0	5.419	0.0	0.19	4.365
Metered End-Use: REFRIGERATION (REF) Building Type: SCHOOL															
212	558	3611	166.96	0.0	0.0	0.0	0.0	0.78	0.0	0.0	0.0	0.0	0.0	0.0	0.0
213	753	32069	1167.19	0.0	0.0	0.0	0.0	1.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Metered End-Use: SPECIAL Building Type: SCHOOL															
266	36	53602	1178	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.782	0.0	0.0	0.0

TABLE D-7

Input Data for Other Regressions

OBS	SITE	Area (ft2)	END-USE DATA (Avg. watts)	OFF	FDP	LAB	MAT	REFR	SAN	VERT	SHOP	MISC	HOT	COMP	TLT
				EQUIPMENT CAPACITIES (kW)											
Metered End-Use: DATA PROCESSING (DATA) Building Type: OTHER															
28	752	7595	111.167	1.653	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.564	0.0	0.0	0.0
Metered End-Use: FOOD PREPARATION (FDP) Building Type: OTHER															
62	13	7992	155.741	0.0	15.564	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.0	0.000
63	752	7595	20.833	0.0	3.480	0.0	0.0	0.0	0.0	0.0	0.0	0.11	0.0	0.0	3.415
Metered End-Use: HOT WATER (HOT) Building Type: OTHER															
111	8	1434	159.37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0
112	13	7992	1015.26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.0	0.0	0.6
113	752	7595	90.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0
Metered End-Use: MATERIAL HANDLING (MAT) Building Type: OTHER															
127	8	1434	28.033	0.0	0.0	0.0	8.766	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Metered End-Use: MIXED GENERAL/RECEPTACLES (MIX) Building Type: OTHER															
183	8	1434	330.300	0.000	1.458	0.0	1.56	0.564	0.000	0.0	0.0	0.000	0.0	0.0	0.00
184	13	7992	570.556	0.000	1.458	0.0	0.06	0.564	4.404	0.0	0.0	0.000	0.0	0.0	0.00
185	722	2112	320.077	0.000	2.730	0.0	0.00	0.564	1.260	0.0	0.0	9.870	0.0	0.0	2.80
186	752	7595	663.167	1.421	0.000	0.0	0.00	0.000	4.143	0.0	0.0	6.237	0.0	0.0	4.14
Metered End-Use: REFRIGERATION (REF) Building Type: OTHER															
215	752	7595	5.0	0.0	0.0	0.0	0.0	0.18	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Metered End-Use: SANITATION (SAN) Building Type: OTHER															
229	722	2112	57.5	0.0	0.0	0.0	0.0	0.0	5.52	0.0	0.0	0.0	0.0	0.0	0.0
Metered End-Use: SHOP Building Type: OTHER															
241	8	1434	100.033	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.38	0.0	0.0	0.0	0.0
Metered End-Use: SPECIAL Building Type: OTHER															
268	8	1434	9.667	0.0	0.0	0.0	0.0	0.0	0.0	0.0	78.257	0.0	0.0	0.0	0.0
269	13	7992	528.482	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000	0.0	0.0	0.0	0.6

TABLE D-8

Input Data for Hotel/Motel Regressions

OBS	SITE	Area (ft2)	END-USE DATA (Avg. watts)	OFF	FDP	LAB	MAT	REFR	SAN	VERT	SHOP	MISC	HOT	COMP	TLT
				EQUIPMENT CAPACITIES (kW)											
Metered End-Use: FOOD PREPARATION (FDP) Building Type: HOTEL/MOTEL															
64	148	1846	795.167	0.0	10.877	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Metered End-Use: HOT WATER (HOT) Building Type: HOTEL/MOTEL															
114	148	1846	1019.46	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	4.5	0.0	0.0
Metered End-Use: MIXED GENERAL/RECEPTACLES (MIX) Building Type: HOTEL/MOTEL															
187	41	8575	2669.45	1.567	6.060	0.0	0.0	2.128	0.0	0.0	0.0	7.706	0.0	0.944	7.960
188	148	1846	523.96	0.273	2.650	0.0	0.0	1.128	0.0	0.0	0.0	25.492	0.0	0.000	1.002
Metered End-Use: REFRIGERATION (REF) Building Type: HOTEL/MOTEL															
216	41	8575	306.11	0.0	2.806	0.0	0.0	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
217	148	1846	5448.83	0.0	0.000	0.0	0.0	14.461	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Metered End-Use: SANITATION (SAN) Building Type: HOTEL/MOTEL															
230	41	8575	459.556	0.0	0.0	0.0	0.0	0.0	13.92	0.0	0.0	4.0	0.809	0.0	0.0

TABLE D-9

Input Data for University Regressions

OBS	SITE	Area (ft^2)	END-USE DATA (Avg. watts)	OFF	FDP	LAB	MAT	REFR	SAN	VERT	SHOP	MISC	HOT	COMP	TLT
				EQUIPMENT CAPACITIES (kW)											
Metered End-Use: DATA PROCESSING (DATA) Building Type: UNIVERSITY															
27	562	27183	37.705	1.725	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Metered End-Use: FOOD PREPARATION (FDP) Building Type: UNIVERSITY															
61	562	27183	32.882	0.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Metered End-Use: MIXED GENERAL/RECEPTACLES (MIX) Building Type: UNIVERSITY															
182	562	27183	2707.47	6.981	12.08	0.0	6.806	1.139	0.0	0.0	0.0	10.825	0.0	0.768	5.745
Metered End-Use: REFRIGERATION (REF) Building Type: UNIVERSITY															
214	562	27183	50.896	0.0	0.0	0.0	0.0	0.564	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Metered End-Use: SPECIAL Building Type: UNIVERSITY															
267	562	27183	459.647	0.0	1.223	0.0	0.309	0.0	0.0	0.0	0.0	5.295	0.0	0.0	0.124

APPENDIX E

REGRESSION RESULTS

APPENDIX E

REGRESSION RESULTS

The results of the regression process are presented in this appendix. The mnemonic abbreviations used to identify the equipment categories and end uses involved in each regression are provided in Tables E-1 and E-2, respectively. Abbreviations are used to allow the tables to be displayed on a single page.

Included in Table E-3 are the coefficients obtained for each equipment category, the number of observations, and the fraction of variance explained (R^2) for each metered end-use regression for each building type. The significance level for each variable is indicated with superscripts. Coefficients judged to be statistically significant at the 0.05 level are marked by a "*", while coefficients significant at the 0.10 level (but not at the 0.05 level) are marked by a "+". (Note that a lower significance level indicates a higher degree of confidence in the estimate.)

It should be noted that the number of observations is not always equal to the number of buildings in a building type. Multiple observations per building are possible when end uses are combined for a regression. For example, if refrigeration equipment appears on both the Refrigeration end use and the Mixed-General end use in a given building, each is retained as a separate observation.

The list of explanatory variables (equipment categories) that are candidates for each regression can be derived from the regression input data in Appendix D. Any equipment category for which a non-zero capacity is present in any building is a candidate explanatory variable in regressions involving the end use on which it is metered.

TABLE E-1

Equipment Categories for Utilization Factor Regressions

Abbreviation	Definition
COMP	Large and Small Computer Equipment
FDP	Food Preparation Equipment
HOT	Hot Water Equipment
LAB	Laboratory and Photography Equipment
MAT	Materials Handling Equipment
MISC	Miscellaneous Equipment
OFF	Office Equipment
REF	Refrigeration Equipment
SAN	Sanitation Equipment
SHOP	Shop Equipment
TLT	Task Lighting Equipment
VRT	Vertical Transportation Equipment

TABLE E-2

Metered End Uses Used in the Utilization Factor Regressions

	Abbreviation	Definition in Terms of Standard ELCAP End Uses
Basic End Uses	DATA	Data Processing & Laboratory
	FDP	Food Preparation
	HOT	Hot Water
	MAT	Material Handling
	MIX	Mixed General and Receptacles
	REF	Refrigeration
	SAN	Sanitation
	ELV	Vertical Transportation
Combinations of End Uses	FDP/REF	Food Preparation and Refrigeration
	MIX/RF/FP	Mixed General, Receptacles, Refrigeration, and Food Preparation
	MIX/S/S/S	Mixed General, Receptacles, Sanitation, Shop, Specialty, Recreation and Miscellaneous, and Unknown
	EQUIP	All equipment end uses except Hot Water

TABLE E-3

Estimated Equipment Utilization Factors by Metered End-Use Regression

METERED END-USE	EQUIP-MENT CATEGORY	ALL BUILD-INGS	OFFICE	DRY GOOD/ RETAIL*	GROC-ERY	REST-AURANT	WARE-HOUSE	SCHOOL	OTHER	HOTEL	UNI-VER-SITY
EQUIP	REF	269*	129*	301+	404*	184*	784*	146	543*	376*	90
EQUIP	FDP	84*	5.6	91+	121*	89*	54	15	8.1	71	
EQUIP	MISC	27	101*			618*	8.6	80			75*
EQUIP	OFF	161+	144*	186+			329*		219		22
EQUIP	SAN	81	250		1779					33	
EQUIP	SHOP	1.7	43	21*	581*		7.7		0.19		
EQUIP	MAT	59			626+	438+	117		3.3		179
EQUIP	COMP	277	200*		1625					1521	
EQUIP	LAB		19								
EQUIP	TLT			371*				258+			
	N=	268	61	36	54	43	34	12	16	7	5
	R^2 =	0.63	0.71	0.33	0.93	0.80	0.75	0.35	0.68	0.97	0.99
DATA	OFF	45	27		449*	191*	64*				
DATA	COMP	339*	358*	580*	446*	121+	83*				
DATA	MISC	312*									
	N=	28	8	4	3	4	5				
	R^2 =	0.63	0.98	0.87	0.99	0.94	0.97				

Notes on statistical significance levels: * = ≤ 0.05 + = > 0.05 and < 0.10 [blank] = ≥ 0.10

TABLE E-3 (contd)

METERED END-USE	EQUIP-MENT CATEGORY	ALL BUILD-INGS	OFFICE	DRY GOOD RETAIL	GROC-ERY	REST-AURANT	WARE-HOUSE	SCHOOL	OTHER	HOTEL	UNI-VER-SITY
FDP	FDP	79*	4.8+		153*	89*		13+	9.8+		
FDP	REF					269					
FDP	MISC		59								
	N=	31	10		6	5		4	2		
	R^2 =	0.76	0.65		0.97	0.78		0.31	0.99		
HOT	HOT	57*	43*	12*	151	138*	5.2	193+	50		
	N=	49	10	11	7	6	9	2	3		
	R^2 =	0.38	0.77	0.8	0.64	0.96	0.24	0.99	0.76		
MAT	MAT	4.9	15+		78						
MAT	FDP	21*			16						
	N=	13	2		8						
	R^2 =	0.38	0.99		0.53						

Notes on statistical significance levels: * = ≤ 0.05 + = > 0.05 and < 0.10 [blank] = ≥ 0.10

TABLE E-3 (contd)

METERED END-USE	EQUIP-MENT CATEGORY	ALL BUILD-INGS	OFFICE	DRY GOOD RETAIL	GROC-ERY	REST-AURANT	WARE-HOUSE	SCHOOL	OTHER	HOTEL	UNI-VER-SITY
MIX	REF	314		1556	1207*	525	736*		566+		
MIX	MISC		49		933*	201	21				
MIX	FDP	98			403	66					
MIX	OFF	226*	225	147				91	389	1787*	
MIX	SAN		523						27		
MIX	SHOP	274*	157				392*				
MIX	TLT	133	142			218	126	260			
	N=	60	13	12	7	6	11	3	4	2	
	R^2 =	0.49	0.79	0.12	0.96	0.96	0.93	0.35	0.99	0.997	
REF	REF	270*	165*		403*	180*	70	237		377*	
REF	MISC	576				783+					
REF	FDP				4194						
	N=	29	3		10	7	2	2		2	
	R^2 =	0.65	0.99		0.95	0.83	0.75	0.79		0.99	

Notes on statistical significance levels: * = ≤ 0.05 + = > 0.05 and < 0.10 [blank] = ≥ 0.10

TABLE E-3 (contd)

METERED END-USE	EQUIP-MENT CATEGORY	ALL BUILD-INGS	OFFICE	DRY GOOD RETAIL	GROC-ERY	REST-AURANT	WARE-HOUSE	SCHOOL	OTHER	HOTEL	UNI-VER-SITY
FDP/REF	REF	268*	170*		416*	182*	70	259*	28	377*	90
FDP/REF	MISC	433				797+					
FDP/REF	FDP	84*	15+		151*	91*	5.9	9.6	9.8+	73*	
	N=	65	14		18	14	3	6	3	3	2
	R^2 =	0.49	0.79	0.12	0.96	0.80	0.93	0.90	0.99	0.99	
MIX/RF/FP	REF	270*	133+	1568	404*	187*	444	64	543	376*	91
MIX/RF/FP	MISC	7.9	98*	103		641*		122			157*
MIX/RF/FP	FDP	85*	5.6		148*	90*	49	8.1	7.4	70+	
MIX/RF/FP	OFF	227	165*				216	3845*	397*	429	
MIX/RF/FP	SAN	568	480		4795+				24		
MIX/RF/FP	SHOP	287	124		581+		456*	323			
	N=	125	27	12	25	23	14	9	7	5	3
	R^2 =	0.65	0.75	0.13	0.95	0.80	0.91	0.95	0.99	0.99	0.99

Notes on statistical significance levels: * = ≤ 0.05 + = > 0.05 and < 0.10 [blank] = ≥ 0.10

TABLE E-3 (contd)

METERED END-USE	EQUIP-MENT CATEGORY	ALL BUILD-INGS	OFFICE	DRY GOOD RETAIL	GROC-ERY	REST-AURANT	WARE-HOUSE	SCHOOL	OTHER	HOTEL	UNI-VER-SITY
MIX/S/S/S	REF	180*		301*	45	180*	1006*		574*		
MIX/S/S/S	MISC	15	100*		928*	574*					
MIX/S/S/S	FDP	190*		91+	283	144+					226*
MIX/S/S/S	OFF	140*	186*	186*			454*			1787*	
MIX/S/S/S	SAN	20	361			73			17		
MIX/S/S/S	SHOP	1.8		21*			7.2		0.19		
MIX/S/S/S	HOT									568	
MIX/S/S/S	COMP	130									
MIX/S/S/S	MAT				698		132				
MIX/S/S/S	TLT			371*							
	N=	112	26	20	16	14	17		8	2	2
	R^2 =	0.42	0.78	0.34	0.68	0.82	0.84		0.84	0.99	0.99
SAN	SAN				65	17*					
	N=				3	3					
	R^2 =				0.60	0.86					
ELV	VRT		15*								
	N=		2								
	R^2 =		0.86								

Notes on statistical significance levels: * = ≤ 0.05 + = > 0.05 and < 0.10 [blank] = ≥ 0.10

APPENDIX F

TESTING OF THE UTILIZATION FACTORS

APPENDIX F

TESTING OF THE UTILIZATION FACTORS

The summarized capacity densities were combined with the derived utilization factors to produce predictions of end-use energy consumption for the buildings that were used to develop the utilization factors. We then compared these predictions to the metered end-use loads as a consistency check on the methodology used to calculate the capacity densities and utilization factors.

CALCULATION OF PREDICTED AND ACTUAL LOADS

Actual loads for **only** Base sites were used. This is because only metered data from Base buildings was used to calculate the utilization factors. (CREUS sites did not have the connected load inventory that was required for inclusion in the utilization analysis.)

The categories in the consistency check are the same end-use categories on which the utilization factors were based. This is readily observed by comparing the end-use data categories reported in the regression data set found in Appendix D to the row or end-use labels found in Table F-1. The comparison between predicted loads and actual loads was made for seven building types. The end-use load was averaged across the set of buildings within a given building type and is reported in kilowatt-hours/square foot-year.

The actual loads, reported in Table F-1, were computed directly from the data in Appendix D. To compute the reported actual loads, the end-use data (in Appendix D) were divided by floor area and then averaged across sites within each building type for each end-use category[a].

(a) Comparisons with EUIs found in other ELCAP documents (Taylor and Pratt 1989) may be slightly different because data from all 12 months during any given year were not required. Unlike other end-uses, equipment loads are not highly dependent on season of the year. Thus, missing data are easily tolerated.

TABLE F-1

Comparison of Predicted to Actual Loads for the Buildings in the Regression Data Set (kWh/ft²-yr)

End Use	Office		Retail		Grocery		Restaurant		Warehouse		School		Other	
	PRED.	ACTUAL	PRED.	ACTUAL	PRED.	ACTUAL	PRED.	ACTUAL	PRED.	ACTUAL	PRED.	ACTUAL	PRED.	ACTUAL
DATA	0.89	0.88	0.18	0.15	0.96	0.93	0.42	0.41	0.21	0.07	0.00	0.00	0.05	0.01
FDP	0.34	0.40	0.00	0.00	3.62	3.15	11.11	11.50	0.02	0.00	0.12	0.11	0.02	0.02
HOT	0.51	0.62	0.31	0.39	1.76	1.98	2.39	2.46	0.05	0.19	0.30	0.27	0.21	0.25
MAT	0.01	0.01	0.01	0.00	0.97	0.37	0.50	0.01	0.00	0.00	0.00	0.00	0.02	0.02
MIX	3.97	3.88	1.37	1.31	2.56	2.34	5.52	3.89	1.41	1.35	0.75	1.09	0.54	0.54
REFR	0.35	0.41	0.00	0.00	34.12	36.70	7.03	7.91	0.13	0.01	0.07	0.08	0.01	0.00
SAN	0.01	0.00	0.00	0.00	0.04	0.04	0.53	0.71	0.00	0.00	0.00	0.00	0.04	0.03
SHOP	0.03	0.00	0.37	0.33	0.00	0.00	0.00	0.00	0.15	0.12	0.00	0.00	0.00	0.07
SPC	0.40	0.61	1.15	1.10	1.22	0.51	0.54	0.29	0.00	0.01	0.00	0.02	0.01	0.07
ELV	0.03	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	6.55	6.86	3.39	3.27	45.26	46.02	28.04	27.18	1.98	1.74	1.23	1.57	0.91	1.02
ERROR	-5%		4%		-2%		3%		13%		-22%		-11%	

The predicted loads reported in Table F-1 were calculated using the capacity density data (shown in Appendix D) and the recommended utilization factors (found in Table 8-3). The predicted loads were calculated for each site/end-use combination by summing the product of capacity densities and the recommended utilization factor across equipment categories. The predictions were then averaged across sites within a building type.

COMPARISON OF PREDICTED AND ACTUAL LOADS

As indicated by the data in Table F-1, the agreement between actual and predicted loads is very close for office, retail, grocery, and restaurant buildings; the average discrepancies across end-use categories were -5%, 4%, -2%, and 3%, respectively. Within end-use categories, the EUIs also are in fairly close agreement. The average discrepancy for warehouses is larger at 13%. The discrepancy between actual and predicted loads for schools and the other building type is large, because most of the utilization factors were "assigned" from other types of buildings. Regression techniques could not be used successfully because of the small number of buildings of this type in the sample.

This test indicates that the process of selecting recommended utilization factors from among multiple statistically significant candidates produced reasonable results. It should be noted that a test such as this is somewhat meaningless for normal regressions models, which are, by definition, good fits to the data. Here, however, such a test has more meaning when a variety of judgments is applied. For example, a grossly erroneous utilization factor for computers in restaurants, derived from the Equipment regression, would likely be indicated by a discrepancy between predicted and actual values for the Data end use.

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