CHAPTER 35

ENERGY USE AND MANAGEMENT

ENERGY management in buildings is the control of energy use and cost while maintaining indoor environmental conditions to meet comfort and functional needs. Electricity and fossil fuels are sold as commodities, and their spot market and long-term pricing are driven by supply and demand. These costs also depend on seasonal and regional conditions. Understanding energy use and cost are essential in managing this financial risk. Effective energy management is critical to control energy use, cost, and impact.

Energy management combines minimizing unit costs of all purchased fuels and energy with continual improvements to energy efficiency to achieve the desired function (e.g., comfortably conditioned space, an industrial process) with the lowest possible energy consumption and cost. Energy efficiency improvements do not need to cause any sacrifice in the function of the facility. Some believe that energy conservation improvements cause building occupants to be uncomfortable. This is far from true: effective energy management uses the most efficient equipment, operated in an optimum manner, with diligent purchasing practices, to obtain the lowest operating cost for the facility.

This chapter provides guidance on establishing and implementing an effective, ongoing energy management program, as well as information on planning and carrying out specific energy management projects, independently or as part of an overall program.

Energy management requires technical knowledge to understand how well, or how poorly, a building and its systems are functioning, to identify opportunities for improvement, and to implement effective upgrades. Well-trained and diligent building operators are very important to the financial success of energy management. They have the knowledge to operate and maintain systems so they actually attain their energy savings potential over time. Communications skills are also essential because the cooperation of both operating staff and building occupants is needed if energy management is to be successful. The importance of all parties to the overall success of energy management initiatives, and the benefits that will result, must be communicated effectively.

Motivating Energy Management

The success of an energy management program depends on the visible support of top management and on the interests and motivation of the people implementing it. Participation and communication are key points. Employees can be stimulated to support an energy management program through awareness of the

- Amount of energy they use, particularly if compared to a reasonable goal
- Cost of energy and environmental consequences of energy use
- Significance of energy savings in their employer's operations
- Relationship between production rates and energy consumption
- Benefits of effective energy management, such as greater comfort and improved air quality

The preparation of this chapter is assigned to TC 9.6, Systems Energy Utilization.

Energy management can be included in each supervisor's performance or job standards. If supervisors know that top management is solidly behind the energy management program and the overall performance rating depends partially on the energy savings the department or group achieves, they will motivate employee interest and cooperation.

The potential cost savings from effective energy management are significant. Several projects have shown that when a dedicated energy manager oversees energy costs and usage, the value of the energy savings substantially exceeds the cost of this manager (Duff 1999; Miller 1999; Sikorski and O'Donnell 1999).

Energy Management Program Overview

The specific processes by which building owners and operators control energy consumption and costs are as variable as their building types. Many buildings, such as residences and small retail businesses, usually involve the efforts of one person. Energy management procedures should be as simple, specific, and direct as possible. General advice, such as from utility energy surveys, can provide ideas but these must be evaluated to determine whether they are applicable to a specific building. Often, owners and operators of smaller buildings only need advice about specific energy management projects (e.g., boiler replacement, lighting retrofit).

On the other hand, very large and complex facilities, such as hospital or university campuses, industrial complexes, or large office buildings, usually require a team effort as represented in Figure 1.

Regardless of the number of people involved or the size and complexity of the facilities, energy management for existing buildings has the same basic steps:

1. An energy manager is usually appointed to oversee the process.
2. Establish an energy accounting system that records energy consumption and costs, thus providing data for analyzing energy use

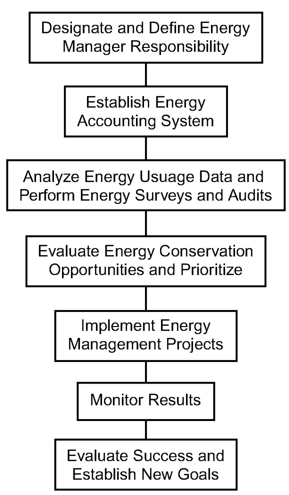

Fig. 1 Energy Management Program

and identifying energy conservation opportunities. It also should include comparisons with energy use and costs of other similar buildings, for use in setting energy performance goals.
3. Analyze energy usage data and carry out energy surveys or audits to provide the information needed to identify energy conservation opportunities relevant to the specific building or buildings. Often a qualified energy professional is hired to do this.
4. Evaluate energy conservation opportunities for expected savings, estimated implementation costs (including any design work required), risks, and nonenergy benefits (e.g., improved system operation, better indoor comfort). Recommend a number of prioritized energy management projects for implementation.
5. Implement approved energy management projects.
6. Monitor results, using the energy accounting system for overall performance supplemented as needed by energy monitoring related to specific projects, and report to senior management.
7. Return to Step 2, compare energy performance to past goals, and set new goals. Continue the process; it requires ongoing diligence to maintain and continually improve energy savings.

Each of these energy management program components is discussed in more detail in the following sections.

ENERGY MANAGEMENT PLANNING AND RESOURCE EVALUATION

Because energy management is performed in existing facilities, this chapter focuses mainly on these facilities. Information on energy conservation in new design can be found in all volumes of the ASHRAE Handbook and in ASHRAE *Standards* 90.1 and 90.2. The area most likely to be overlooked in new design is the ability to measure and monitor energy consumption and trends for each energy use category given in Chapter 40.

Organizing for Energy Management

To be effective, energy management must be given the same emphasis as management of any other cost/profit center. In this regard, the functions of top management are as follows:

- Establish the energy cost/profit center
- Assign management responsibility for the program
- Hire or assign an energy manager
- Allocate resources
- Ensure that the energy management program is clearly communicated to all departments to provide necessary support for achieving effective results
- Monitor the program's cost-effectiveness
- Clearly set program goals
- Encourage ownership of the program to the lowest possible level in the organization
- Set up an ongoing reporting and analysis procedure to monitor the energy management program

Effective energy management requires that the manager (supported by a suitable budget) act and be held accountable for those actions. It is common for a facility to allocate 3 to 10% of the annual energy cost for administration of an energy management program. The budget should include funds for additional personnel as needed and for continuing education of the energy manager and staff.

If it is not possible to add a full-time, first-line manager to the staff, an existing employee, preferably with a technical background, should be considered for a full- or part-time position. This person must be trained to organize an energy management program. Energy management should not be a collateral duty of an employee who is already fully occupied. Another option is to hire a professional energy management consultant to design, implement, and maintain energy efficiency improvements. Some energy services companies (ESCOs) and other firms provide energy management services as part of a contract, with payments based on realized savings.

Develop Energy Accounting Procedures

The energy manager establishes procedures for meter reading, monitoring, and tabulating facility energy use and profiles. These tabulations indicate the cost of energy management efforts and the resulting energy cost avoidance. Also, the energy manager periodically reviews utility rates, rate structures, and trends as they affect the facility. Many utilities have free mailing lists for changes in their rate tariffs. The energy manager provides periodic reports of energy management efforts to top management, summarizing the work accomplished, its cost-effectiveness, plans and suggested budget for future work, and projections of future utility costs. If energy conservation measures are to be cost-effective, continued monitoring and periodic reauditing are necessary, because many energy conservation measures lose effectiveness if they are not carefully monitored and maintained. The procedures in ASHRAE *Guideline* 14 for determining energy savings can be used as energy accounting procedures to track changes in consumption and cost.

Explore Financing and Other Resource Options

When evaluating proposed energy management projects, particularly those with a significant capital cost, it is important to include a life-cycle cost analysis. This not only provides good information about the financial attractiveness (or otherwise) of a project, but also assures management that the project has been carefully considered and evaluated before presentation.

Several life-cycle cost procedures are available. Chapter 36, Owning and Operating Costs, contains details on these, and on other factors that should be considered in such an analysis.

Capital for energy efficiency improvements is available from various public and private sources, and can be accessed through a wide and flexible range of financing instruments. There are variations and combinations, but the five general mechanisms for financing investments in energy efficiency are the following:

- **Internal funds**, or direct allocations from an organization's own internal capital or operating budget
- **Debt financing**, with capital borrowed directly by an organization from private lenders
- **Lease** or **lease-purchase agreements** in which equipment is acquired through an operating or financing lease with little or no up-front costs, and payments are made over five to ten years
- **Energy performance contracts**, in which improvements are financed, installed, and maintained by a third party, which guarantees savings and payments based on those savings
- **Utility (or other) incentives**, such as rebates, grants, or other financial assistance offered by an energy utility (or other provider of efficiency public benefits funding) for design and purchase of energy-efficient systems and equipment

An organization may use several of these financing mechanisms in various combinations. The most appropriate set of options depends on the type of organization (public or private), size and complexity of a project, internal capital constraints, in-house expertise, and other factors (see Turner 2001).

PREPARING FOR COST AND EFFICIENCY IMPROVEMENTS

The first step in preparing for cost and efficiency improvements is understanding how energy is used. Opportunities for savings come in reducing (1) the cost per unit of energy, and then (2) energy consumption. It is very important to understand how a building's energy use relates to other similar facilities. If the energy budget is much higher than those for comparable facilities, there are likely to be many ways to reduce energy use cost-effectively. If the energy budget is much lower, there are likely to be few cost-effective opportunities.

Historically, energy users had little choice in selecting energy suppliers, and regulated tariffs applied based on certain customer usage characteristics. In recent years, though, there has been a move in North America and other parts of the world toward deregulation of energy markets, and electricity and gas markets have much more flexibility in supply and pricing than in the past.

Because most energy management activities are dictated by economics, the energy manager must understand the utility rates that apply to each facility. Special rates are commonly applied for variables such as time of day, interruptible service, on peak/off peak, summer/winter, and peak demand. Electric rate structures vary widely in North America; Chapter 40 discusses these in detail. The energy manager should work with local utility companies to develop the most cost-effective methods of metering and billing and enable energy cost avoidance to be calculated effectively.

Electric utilities commonly meter both consumption and demand. **Demand** is the peak rate of consumption, typically integrated over a 15 or 30 min period. Electric utilities may also establish a ratchet billing procedure for demand. To fully understand the cost effect of the demand component of the utility bill, contact the local distribution company (LDC) supplying the energy. The LDC can explain the details of ratchet demand and associated billing. Some arbitrary peak demand scenarios could be represented to the utility to see the impact on billing costs for the specific building.

Some utilities use **real-time pricing (RTP)**, in which the utility calculates the marginal cost of power per hour for the next day, determines the price, and sends this hourly price (for the next day) to customers. The customer can then determine the amount of power to be consumed at different times of the day. A variation on RTP is **demand exchange and active load management**, where customers are paid to shed load during periods of high utility demand.

There are many variations of billing methods, and it is important to understand the applicable rates. Caution is advised in designing or installing energy management and energy retrofit systems that take advantage of utility rate provisions, because these provisions can change. The structure or provisions of utility rates cannot be guaranteed for the life of the energy conservation opportunities. Some provisions that change include on-peak times, declining block rates, and demand ratchets.

Analyzing Energy Usage Data

Establishing and maintaining an energy accounting system to track energy consumption and costs on a continuing basis is essential. It provides energy use data to building occupants, helping them see the results of their conservation efforts and support their continued efforts. It also provides some data needed to confirm savings from specific energy conservation projects. The starting point is gathering energy and related data and evaluating the relative intensity of energy use. Data sources include the following:

- Invoices from utilities and fuel suppliers
- Detailed printouts from time of use meters
- Combustion efficiency, eddy current and water quality tests
- Recordings of temperature and relative humidity
- Interviews with building owners, managers, and occupants
- Submetered data
- Data from building pressurization/depressurization
- Event recordings
- Climatic data
- Sets of data from similar buildings in similar climates
- Infrared scans
- Production records
- Computer modeling

Any reliable, applicable utility data should be examined. Utilities often provide metered usage and demand data, often with measurement intervals as short as 15 min. Data from shorter time intervals are preferable to monthly data because anomalies are more apparent. High consumption at certain periods may reveal opportunities for cost reduction (Haberl and Komor 1990a, 1990b). If monthly data are used, they should be analyzed over several years.

A base year should be established as a reference point for future energy and energy cost reduction activities. In tabulating such data, the dates of meter readings should be recorded so that energy use can be normalized for differences in the number of days in a period. Any periods during which consumption was estimated rather than measured should be noted.

If energy data are available for more than one building and/or department under the energy manager's authority, each should be tabulated separately. Initial tabulations should include both energy and cost per unit area (in an industrial facility, this may be energy and cost per unit of goods produced). Document any information on variables that may have affected past energy use, such as heating or cooling degree-days, percent occupancy for a hotel, quantity of goods produced, building occupancy, hours of operation, or average daily weather conditions (see Chapter 27, Climatic Design Information in the 2001 *ASHRAE Handbook—Fundamentals*).

Because such variables may not be directly proportional to energy use, it is best to plot information separately or to superimpose one plot over another, rather than developing units such as Btu per square foot per degree-day. As the data are tabulated, ongoing energy accounting procedures should be developed for consistent data collection and use in the future. Several examples of ways to normalize energy consumption for temperature and other variations are provided in ASHRAE *Guideline* 14.

Energy Use Benchmarking

To determine whether a building or industrial process is a good candidate for energy efficiency improvements, **benchmarking** (comparing a building's annual per-square-foot energy consumption to that of other buildings) can be a useful first measure of energy efficiency. Benchmarking is less accurate than an audit or engineering analysis, but can provide a good overall picture of relative energy usage for a given facility, and is an important first step to understand energy usage and savings potential.

Databases. Compiling a database of past energy usage and cost is important in developing an energy management program. All applicable, reliable utility data should be examined.

Comparing a building's energy use with that of many different buildings is a good way to check its relative efficiency. Data on buildings in all sectors are summarized in reports published periodically by the U.S. Department of Energy's Energy Information Administration (DOE/EIA). More complete and up-to-date information on the Commercial Buildings Energy Consumption Survey is available at www.eia.doe.gov/emeu/cbecs, and on the Residential Energy Consumption Survey at www.eia.doe.gov/emeu/recs. The following tables present DOE/EIA data in a combined format. Table 1 lists physical characteristics of the buildings surveyed. Table 2 lists measured energy consumption. Table 3 lists various residential end uses. The EIA also collects data on household characteristics and energy consumption, summarized in Table 4.

When an energy management program for a new building is established, the energy use database may consist solely of typical data for similar buildings, as in Table 2. This may be supplemented by energy simulation data for the specific building if such data were developed during design. In addition, a new building and its systems should be properly commissioned on completion of construction to ensure proper operation of all systems, including any energy conservation features. Refer to ASHRAE *Guideline* 1, and Chapter 42 of this volume.

All the data presented in these tables are derived from detailed reports of consumption patterns in buildings. Before using them, however, it is important to understand how they were derived. For example, all household energy consumption data in Table 4 are averages, and may not reflect variations in appliances or fuel selections for different buildings. Therefore, when using the data, verify the correct use with the original EIA documents.

ASHRAE *Standard* 105, Standard Methods of Measuring and Expressing Building Energy Performance, contains information that allows uniform, consistent expressions of energy consumption in both proposed and existing buildings. Its use is recommended. However, the data collected by EIA and presented here are not in accordance with this standard.

Mazzucchi (1992) lists data elements useful for normalizing and comparing utility billing information. Metered energy consumption and cost data are also gathered and published by building owners' trade associations, such as the Building Owners and Managers Association International (BOMA), the National Restaurant Association (NRA), and the American Hotel and Lodging Association (AH&LA).

The quality of published energy consumption data for buildings varies because the data are collected for different purposes by people with different levels of technical knowledge of buildings. The data presented here are primarily national. In some cases, local energy consumption data may be available from local utility companies or state or provincial energy offices.

MANAGING ENERGY COSTS AND IMPLEMENTING IMPROVEMENTS

Basic Energy Management

Control Energy System Use. The most effective method to reduce energy costs, both economically and environmentally, is turning off energy systems when they provide no benefit. Management of existing systems and design of new ones should emphasize ease and simplicity of system control. For example, an energy management system may be effective in large and complicated buildings, but inappropriate for smaller buildings or in those with rapid turnover of operators who are unfamiliar with the building systems.

Extensive labeling and inclusive, clear instruction on how to operate systems leads to better control of their use. Ways to conserve energy include the following:

- Reduce air leakage
- Reduce water leakage
- Turn off lighting: remove unnecessary lighting, add switched circuits, use motion sensors and light-sensitive controls
- Use temperature setup and setback
- Cool with outside air
- Seal unused vents and ducts to the outside
- Take transformers offline during idle periods
- Disconnect or turn off all nonessential loads
- Educate tenants and occupants

Purchase Lower-Cost Energy. This is the second most effective method for reducing energy costs for all owners and operators. Building operators and managers must understand all the options in purchasing energy and design systems to take advantage of changing energy costs. The following options should be considered:

- Choosing or negotiating lower-cost utility rates
- Procuring electricity or fuels through brokers
- Correcting power factor penalties
- Controlling peak electric billing demand
- Transportation and interruptible natural gas rates
- Deregulated electricity or natural gas options
- Cogeneration
- Lower-cost liquid fuels
- Increasing volume for onsite storage
- Avoiding sales or excise taxes where possible
- Rebates from utilities and manufacturers

Optimize Energy Systems Operation. The third most effective method for reducing energy costs is to tune energy systems to optimal performance, an ongoing process combining training, preventive maintenance, and system adjustment. Tasks for optimizing performance include the following:

- Training operating personnel
- Tuning combustion equipment
- Adjusting gas burners to optimal efficiency
- Following an established maintenance program
- Cleaning or replacing filters
- Cleaning fan blades and ductwork
- Adjusting timing of system starts and stops
- Using water treatment

Purchase Efficient Replacement Systems. This method is more expensive than the other three, presents energy managers with the greatest liability, and may be less cost-effective. Because the greatest profit by suppliers is made by system replacement, it often draws the greatest attention from building owner/operators and equipment suppliers. It is critical to ensure that possible equipment or system replacements are objectively evaluated to confirm both the replacement costs and benefits to the owner. The optimum time for replacing less-efficient equipment is near the end of its expected life or when major repairs are needed. Systems that may be replaced include the following:

- Lighting systems and lamps
- Heating and cooling equipment
- Energy distribution systems
- Motors
- Thermal envelope components
- Industrial process equipment
- Controls and energy management systems

Optimizing More Complex System Operation

Basic energy management is appropriate for many types of facilities, but as the level of complexity of building systems increases, additional strategies are needed to optimize energy systems. Approaches include **recommissioning**, **retrocommissioning**, and **continuous commissioning**.

This approach to reducing energy costs typically requires a strong team effort on the part of the facility staff and a consultant team to identify and fix comfort problems in the building, accompanied by an aggressive approach to optimizing HVAC operation and control in the building. It is most effective when preceded by installation of good energy metering and a strong energy accounting program. The most important measures typically implemented include the following:

- Optimizing hot and cold deck reset schedules
- Optimizing duct static pressure reset schedules
- Optimizing pump control
- Optimizing terminal box settings/control
- Optimizing sequencing of boilers and chillers
- Diagnosing and fixing fundamental causes of comfort problems
- Diagnosing and repairing stuck or leaky valves and dampers
- Training operating personnel in optimum operating strategies

Implementing these measures has been found to reduce energy use by an average of about 20% (Claridge et al. 1998). Approaches to commissioning and optimizing operation of existing buildings can be found in Claridge and Liu (2000), Haasl and Sharp (1999), and Liu et al. (1997).

Energy Audits

Three levels of energy audits or analysis have been defined (Mazzucchi 1992). Depending on the physical and energy use characteristics of a building and the needs and resources of the owner, these steps require different levels of effort. After a preliminary energy use evaluation, an energy analysis can generally be classified into the following three categories:

Table 1 1995 Commercial Building Characteristics

Source: DOE/EIA 0246(95) 1997

Source Table Number	1	1	1	1	1	2	2	2	2
			Mean			Median			
Building Characteristics	Total Number of Buildings, Thousands	Total Floor Space, 10^6 ft^2	Floor Area per Bldg, 1000 ft^2	Floor Area per Person, ft^2	Hours Worked per Week	Floor Area per Bldg, 1000 ft^2	Floor Area per Person, ft^2	Hours Worked per Week	Age of Building, Years
All Buildings	4,579	58,772	12.8	706	62	5.0	938	50	30.5
Building Floor Space									
1001 to 5000 ft^2	2,399	6,338	2.6	599	59	2.5	750	48	30.5
5001 to 10,000 ft^2	1,035	7,530	7.3	993	58	7.0	1,250	50	35.5
10001 to 25,000 ft^2	745	11,617	15.6	896	67	15.0	1,667	53	27.5
25001 to 50,000 ft^2	213	7,676	36.1	752	72	35.0	1,125	56	26.5
50001 to 100,000 ft^2	115	7,968	69.3	819	80	65.0	1,316	60	25.5
100001 to 200,000 ft^2	48	6,776	140.9	796	87	140.0	1,500	75	26.5
200001 to 500,000 ft^2	19	5,553	294.9	731	102	275.0	1,190	80	25.5
Over 500,000 ft^2	6	5,313	806.4	553	108	700.0	813	84	24.5
Principal Building Activity									
Education	309	7,740	25.1	767	51	8.5	1,000	45	33.5
Food sales	137	642	4.7	984	112	2.5	1,001	99	25.5
Food service	285	1,353	4.8	578	85	3.0	667	81	22.5
Health care	105	2,333	22.2	520	79	4.5	650	52	23.5
Lodging	158	3,618	22.8	1,317	156	9.0	2,267	168	30.5
Mercantile and service	1,289	12,728	9.9	945	61	4.0	1,083	52	35.5
Office	705	10,478	14.9	387	52	4.0	464	45	23.5
Public assembly	326	3,948	12.1	1,317	53	6.0	1,500	50	31.5
Public order and safety	87	1,271	14.6	746	72	5.0	875	20	32.5
Religious worship	269	2,792	10.4		41	8.0	3,125	20	31.5
Warehouse and storage	580	8,481	14.6	1,730	59	5.5	2,000	48	18.5
Other	67	1,004	14.9	544	79	5.0	1,000	50	26.5
Vacant	261	2,384	9.1	3,735	19	4.0	1,000	0	39.5
Year Constructed									
1919 or before	353	3,673	10.4	1,004	56	5.5	1,250	48	93.5
1920 to 1945	562	6,710	11.9	913	55	4.8	1,000	48	62.5
1946 to 1959	867	9,298	10.7	910	54	4.3	1,000	48	42.5
1960 to 1969	718	10,858	15.1	755	62	5.5	893	50	31.5
1970 to 1979	813	11,333	13.9	754	68	5.0	875	51	20.5
1980 to 1989	846	12,252	14.5	607	67	5.0	882	50	10.5
1990 to 1992	218	2,590	11.9	554	61	3.5	667	50	4.5
1993 to 1995	202	2,059	10.2	1,025	71	3.5	1,250	50	1.5
Floors									
One	3,018	24,552	8.1	966	59	3.8	929	48	25.5
Two	1,002	14,122	14.1	785	66	7.0	882	50	35.5
Three	399	7,335	18.4	867	62	9.5	1,250	52	57.5
Four to nine	148	8,789	59.4	603	84	25.0	1,000	60	42.5
Ten or more	12	3,975	328.9	383	96	200.0	429	68	28.5
Census Region and Division									
Northeast	725	11,883	16.4	784	67	5.0	1,000	52	38.5
Midwest	1,139	14,322	12.6	844	59	4.5	1,250	48	36.5
South	1,750	20,830	11.9	786	60	4.8	893	50	23.5
West	964	11,736	12.2	647	63	5.5	833	50	28.5
Climate Zones: 45-Year Average									
<2000 CDD and >7000 HDD	493	5,098	10.3	855	60	4.0	938	50	29.5
5500 to 7000 HDD	975	14,597	15.0	864	64	5.0	1,100	50	39.5
4000 to 5499 HDD	1,070	15,155	14.2	719	64	5.5	1,000	50	32.5
Fewer than 4000 HDD	1,103	13,491	12.2	656	61	5.0	800	50	25.5
>2000 CDD and <4000 HDD	937	10,430	11.1	849	59	4.8	950	48	25.5
Workers (Main Shift)									
Fewer than 5	2,505	13,885	5.5	2,992	58	3.0	1,583	48	31.5
5 to 9	798	6,291	7.9	1,220	61	4.8	688	50	35.5
10 to 19	625	7,102	11.4	907	63	7.5	600	50	25.5
20 to 49	400	9,132	22.8	792	72	16.3	542	56	26.5
50 to 99	138	6,931	50.3	777	72	37.5	563	55	24.5
100 to 249	71	5,988	84.4	608	85	55.0	400	65	23.5
250 or more	43	9,443	220.1	327	84	120.0	283	63	19.5
Weekly Operating Hours									
39 or fewer	899	6,134	6.8	1,064	14	4.0	1,500	8	32.5
40 to 48	1,257	13,233	10.5	799	43	4.8	833	44	32.5
49 to 60	969	12,242	12.6	689	54	5.5	833	53	29.5
61 to 84	567	10,052	17.7	761	72	6.0	1,000	72	31.5
85 to 167	420	6,202	14.8	891	105	4.3	833	102	24.5
Open continuously	466	10,908	23.4	661	168	6.0	1,250	168	23.5
Ownership and Occupancy									
Nongovernment owned	4,025	46,696	11.6	772	62	4.8	938	50	29.5
Owner occupied	3,158	35,573	11.3	759	63	4.5	1,000	50	29.5
Nonowner occupied	698	9,697	13.9	725	65	5.5	833	53	25.5
Unoccupied	170	1,426	8.4	6,481		3.8	750		39.5

A blank space indicates data are not available, or less than 20 buildings, or error is >50%. A * indicates more than one may apply.

Table 1 1995 Commercial Building Characteristics (*Continued*)

Source: DOE/EIA 0246(95) 1997

Source Table Number	1	1	1	1	1	2	2	2	2
			Mean			Median			
Building Characteristics	Total Number of Buildings, Thousands	Total Floor Space, 10^6 ft^2	Floor Area per Bldg, 1000 ft^2	Floor Area per Person, ft^2	Hours Worked per Week	Floor Area per Bldg, 1000 ft^2	Floor Area per Person, ft^2	Hours Worked per Week	Age of Building, Years
Government owned	553	12,076	21.8	742	61	7.0	950	45	35.5
Energy Sources*									
Electricity	4,343	57,076	13.1	746	63	5.0	929	50	30.5
Natural gas	2,478	38,145	15.4	760	64	6.0	917	50	35.5
Fuel oil	607	14,421	23.7	628	64	4.8	1,000	50	35.5
District heat	110	5,658	51.5	543	91	12.5	944	60	36.5
District chilled water	53	2,521	47.7	568	88	12.5	1,250	65	30.5
Propane	589	5,344	9.1	693	66	4.0	1,000	50	20.5
Wood	126	699	5.6	1,278	53	3.3	1,500	50	32.5
Coal		397	22.9	1,997	61	7.0	7,000	53	20.5
Other	71	1,154	16.2	670	72	4.0	750	60	38.5
Space-Heating Energy Sources*									
Electricity	1,467	22,156	15.1	651	66	5.5	792	50	21.5
Natural gas	2,211	31,535	14.3	784	61	5.5	917	50	35.5
Fuel oil	504	6,606	13.1	804	61	4.0	1,000	50	38.5
District heat	109	5,606	51.4	540	91	12.5	944	60	37.5
Propane	301	2,025	6.7		64	3.3	1,500	48	18.5
Wood	103	509	5.0	1,271	53	3.3	1,500	50	35.5
Other	25	318	12.9	735	57	3.0	750	48	36.5
Primary Space-Heating Energy Source									
Electricity	1,007	13,500	13.4	655	68	5.0	750	50	20.5
Natural gas	2,106	28,808	13.7	791	61	5.5	917	50	35.5
Fuel oil	439	4,207	9.6	1,037	59	4.0	1,000	50	39.5
District heat	107	5,289	49.3	536	91	12.5	944	60	36.5
Propane	260	1,545	5.9		62	3.0	1,500	48	15.5
Other	61	514				11.3	1,607	51	37.5
Cooling Energy Source*									
Electricity	3,293	47,761	14.5	705	65	5.0	833	50	28.5
Natural gas	65	1,314	20.1	638	67	9.5	855	50	40.5
District chilled water	53	2,521	47.4	568	88	12.5	1,250	65	30.5
Water-Heating Energy Sources*									
Electricity	1,684	23,056	13.7	681	63	5.0	800	50	22.5
Natural gas	1,577	24,859	15.8	764	68	6.0	893	54	35.5
Fuel oil	120	2,151	17.9	931	59	4.3	875	50	39.5
District heat	54	3,949	73.7	553	97	27.5	1,300	82	30.5
Propane	110	1,020	9.2	875	94	3.5	1,167	88	27.5
Cooking Energy Sources*									
Electricity	487	12,249	25.2	647	82	5.5	750	80	23.5
Natural gas	448	13,195	29.4	658	81	8.5	800	75	33.5
Propane	123	1,480	12.0	816	84	3.3	500	84	19.5
Energy End Uses*									
Buildings with space heating	4,024	54,347	13.5	725	63	5.0	893	50	30.5
Buildings with cooling	3,381	49,935	14.8	702	66	5.0	833	50	28.5
Buildings with water heating	3,486	51,560	14.8	709	66	5.0	859	50	30.5
Buildings with cooking	828	20,713	25.0	650	79	7.0	800	72	28.5
Buildings with manufacturing	204	3,893	19.1	787	53	8.0	1,100	48	29.5
Buildings with electric gen.	247	13,366	54.2	585	90	12.5	833	67	30.5
Percent of Floorspace Heated									
Not heated	554	4,425	8.0	2,394	51	3.8	1,250	36	25.5
1 to 50	555	6,227	11.2	1,466	49	5.5	1,625	45	30.5
51 to 99	633	8,868	14.0	770	69	6.0	875	55	35.5
100	2,836	39,252	13.8	664	64	5.0	833	50	28.5
Percent of Floorspace Cooled									
Not cooled	1,198	8,837	7.4	1,572	49	3.8	1,500	41	34.5
1 to 50	930	15,027	16.2	1,211	57	7.0	1,250	50	35.5
51 to 99	635	12,549	19.8	651	73	5.5	750	56	35.5
100	1,816	22,359	12.3	567	68	4.8	750	50	23.5
Percent Lit When Open									
Zero	36	189	5.2		57	1.8	938	50	16.5
1 to 50	666	6,008	9.0	2,250	62	4.8	2,000	50	35.5
51 to 99	745	9,692	13.0	804	61	5.0	917	49	34.5
100	2,814	40,514	14.4	656	65	5.0	833	50	26.5
Electricity not used	318	2,369	7.5	3,096	33	4.0	4,250	0	35.5
Percent Lit When Closed									
Zero	1,644	13,101	8.0	1,033	42	4.0	1,188	44	30.5
1 to 50	2,109	30,711	14.6	684	59	5.5	761	50	30.5
51 to 100	87	1,914	22.0	744	74	6.0	818	60	30.5
Never closed	421	10,677	25.4	652	168	6.0	1,250	168	25.5
Electricity not used	318	2,369	7.5	9,344	33	4.0	4,250	0	35.5

A blank space indicates data are not available, or less than 20 buildings, or error is >50%. A * indicates more than one may apply.

Table 1 1995 Commercial Building Characteristics (*Continued*)
Source: DOE/EIA 0246(95) 1997

Source Table Number	1	1	1	1	1	2	2	2	2
			Mean			Median			
Building Characteristics	Total Number of Buildings, Thousands	Total Floor Space, 10^6 ft^2	Floor Area per Bldg, 1000 ft^2	Floor Area per Person, ft^2	Hours Worked per Week	Floor Area per Bldg, 1000 ft^2	Floor Area per Person, ft^2	Hours Worked per Week	Age of Building, Years
Heating Equipment*									
Heat pumps	394	5,843	14.8	638	63	5.0	667	48	19.5
Furnaces	1,676	14,923	8.9	853	60	4.8	938	50	34.5
Individual space heaters	1,188	16,809	14.1	796	57	5.0	1,125	49	30.5
District heat	115	5,911	51.5	553	91	12.5	944	65	35.5
Boilers	610	16,754	27.5	682	73	9.0	909	53	39.5
Packaged heating units	1,031	16,893	16.4	720	68	5.5	750	50	21.5
Other	161	6,249	38.8	563	61	10.0	1,300	52	29.5
Cooling Equipment*									
Residential central A/C	878	9,238	10.5	669	65	5.0	750	50	30.5
Heat pumps	457	6,931	15.2	646	65	5.0	700	48	19.5
Individual A/C	862	12,494	14.5	881	68	4.5	1,125	50	40.5
District chilled water	53	2,521	47.7	568	87	12.5	1,250	65	30.5
Central chillers	109	11,065	101.4	526	87	45.0	1,000	65	28.5
Packaged A/C units	1,431	26,628	18.6	697	69	6.5	800	52	23.5
Evaporative coolers	186	2,451	13.2	876	66	4.8	792	56	30.5
Other	18	949	51.9	601	74	18.8	900	60	39.5
Lighting Equipment Types*									
Incandescent	2,479	35,715	14.4	725	65	5.0	917	50	32.5
Standard fluorescent	3,885	53,984	13.9	721	65	5.0	889	50	29.5
Compact fluorescent	364	14,273	39.2	557	85	11.3	750	66	23.5
High-intensity discharge	393	16,259	41.4	742	72	12.5	1,067	53	27.5
Halogen	303	9,665	32.0	587	78	8.0	915	60	28.5
Other	30	554	18.7	458	44	2.0	1,500	45	32.5
Water-Heating Equipment*									
Central system	2,671	31,656	11.9	752	65	4.8	833	50	31.5
Distributed system	742	16,495	22.2	642	71	9.5	875	55	25.5
Combination central/distributed	73	3,409	46.4	694	73	10.0	1,000	50	26.5
Personal Computers/Terminals									
None	2,039	12,571	6.2	1,568	54	3.5	1,500	45	31.5
1 to 4	1,408	11,401	8.1	983	68	4.3	900	53	30.5
5 to 9	437	5,372	12.3	823	66	6.0	600	50	23.5
10 to 19	344	5,947	17.3	798	61	8.5	563	50	25.5
20 to 49	198	7,048	35.6	815	69	20.0	694	50	25.5
50 to 99	81	4,938	61.2	663	71	40.0	625	54	29.5
100 to 249	46	5,189	112.9	616	84	65.0	600	60	24.5
250 or more	26	6,307	240.9	338	92	140.0	360	70	18.5
Energy-Related Functions*									
Communal food preparation	828	20,713	25.0	650	79	7.0	800	72	28.5
Computer room	234	12,890	55.0	502	72	16.3	654	50	19.5
Large hot water activities	243	6,753	27.8	689	99	8.0	882	85	31.5
Shell Conservation Features*									
Roof/ceiling insulation	3,380	46,355	13.7	704	64	5.0	875	50	26.5
Wall insulation	2,372	31,694	13.4	654	62	5.0	833	50	21.5
Storm or multiple glazing	1,897	28,876	15.2	673	66	5.5	813	50	26.5
Tinted, reflective, shaded glass	1,202	24,245	20.2	580	66	6.0	750	50	21.5
Shading or awnings	2,271	37,208	16.4	668	65	6.0	813	50	28.5
HVAC Conservation Features*									
Variable-volume system	327	13,473	41.2	553	76	12.5	750	50	23.5
Economizer cycle	461	16,550	35.9	573	75	10.0	800	57	21.5
HVAC maintenance	2,403	43,134	18.0	669	68	6.0	833	51	28.5
Other efficient equipment	196	6,453	32.5	568	66	7.0	688	55	23.5
Lighting Conservation Features*									
Specular reflectors	749	17,868	23.9	637	69	6.0	1,000	50	28.5
Energy efficient ballasts	1,363	28,375	20.8	614	67	6.0	750	50	25.5
Natural lighting sensors	237	6,431	27.2	622	83	8.0	885	63	28.5
Occupancy sensors	131	5,958	45.6	515	66	12.5	1,111	50	38.5
Time clock	467	13,262	28.4	593	73	8.0	724	55	27.5
Manual dimmer switches	501	13,056	26.1	655	69	9.5	1,100	55	26.5
Other	79	2,836	35.8	630	71	10.0	688	60	20.5
Energy Conservation Features*									
Any conservation feature	4,075	55,288	13.6	732	63	5.0	900	50	29.5
Building shell	3,906	53,190	13.6	717	63	5.0	875	50	28.5
HVAC	2,529	44,657	17.7	677	68	6.0	850	50	28.5
Lighting	2,084	38,537	18.5	660	67	6.0	875	51	28.5
Off-Hour Equipment Reduction*									
Heating	3,211	38,326	11.9	738	52	4.8	875	48	30.5
Cooling	2,707	35,605	13.2	711	54	5.0	833	50	28.5
Lighting	3,753	44,937	12.0	753	52	5.0	889	48	30.5

A blank space indicates data are not available, or less than 20 buildings, or error is >50%. A * indicates more than one may apply.

Table 2A 1995 Commercial Building Energy Consumption

Consumption shown is on an annual basis per square foot of building area. *Source*: DOE/EIA 0318(95) 1998

Source Table Number	1	1	3	3	10	10	19	19	21	21	27	31	33	33	33	33	33	33
			Major Fuels		Electricity				Nat. Gas		Fuel Oil	Distr. Heat	Energy End Use					
Building Characteristics	Total # Bldgs., Thousands	Total Floor Space, 10^6 ft²	1000 Btu/ft²	$/ft²	kWh/ft²	Med. kWh/ft²	Med. Peak W/ft²	Med. Load Fact.	CF/ft²	Med. CF/ft²	Gal/ft²	lb/ft²	Total	Space Heat	Cool	Ventilation	Water Heat	Lighting
All Buildings	4,579	58,772	90.5	1.19	13.4	7.2	5.4	0.253	49.7	39.7	0.12	94.14	90.5	29.0	6.0	2.8	13.8	20.4
Building Floor Space																		
1001 to 5000 ft²	2,399	6,338	111.7	1.83	18.7	8.5	8.0	0.239	87.2	51.0	0.34		111.7	39.5	7.0	2.9	9.7	22.7
5001 to 10,000 ft²	1,035	7,530	82.8	1.07	9.9	6.2	5.2	0.248	58.8	29.1	0.28		82.8	38.5	4.4	1.7	11.1	13.6
10001 to 25,000 ft²	745	11,617	70.9	0.96	10.0	5.6	3.3	0.246	45.9	29.3	0.23	103.56	70.9	27.4	4.8	1.7	9.1	14.7
25001 to 50,000 ft²	213	7,676	82.0	1.13	12.1	7.3	3.6	0.295	42.8	27.2	0.17	84.62	82.0	28.2	6.7	2.1	11.6	18.5
50001 to 100,000 ft²	115	7,968	87.6	1.11	13.5	8.9	3.2	0.337	42.3	23.4	0.11	81.02	87.6	27.0	7.0	3.2	12.9	21.3
100001 to 200,000 ft²	48	6,776	101.4	1.16	15.0	12.4	3.5	0.393	51.3	28.4	0.07	75.38	101.4	26.6	6.2	3.3	19.6	25.0
200001 to 500,000 ft²	19	5,553	114.6	1.31	16.2	10.5	3.1	0.458	52.1	25.9	0.06	77.72	114.6	24.0	6.7	4.5	25.2	27.4
Over 500,000 ft²	6	5,313	96.8	1.23	16.3	13.2	3.2	0.521	32.9	8.8	0.03	68.71	96.8	18.5	6.0	3.9	18.0	28.6
Principal Building Activity																		
Education	309	7,740	79.3	0.92	8.4	6.1	4.3	0.210	41.1	38.6	0.17	84.51	79.3	32.8	4.8	1.6	17.4	15.8
Food sales	137	642	213.5	4.11	54.1	55.6	14.7	0.463	42.6	31.7			213.5	27.5	13.4	4.4	9.1	33.9
Food service	285	1,353	245.5	3.56	36.0	25.5	12.7	0.333	153.5	135.2			245.5	30.9	19.5	5.3	27.5	37.0
Health care	105	2,333	240.4	2.26	26.5	15.7	5.9	0.253	143.0	66.3	0.10	109.51	240.4	55.2	9.9	7.2	63.0	39.3
Lodging	158	3,618	127.3	1.41	15.2	11.7	4.9	0.364	73.2	57.6		92.63	127.3	22.7	8.1	1.7	51.4	23.2
Mercantile and service	1,289	12,728	76.4	1.10	11.8	6.9	4.9	0.249	45.2	40.4	0.14		76.4	30.6	5.8	2.5	5.1	23.4
Office	705	10,478	97.2	1.51	18.9	12.2	6.0	0.285	35.7	33.2	0.06	49.28	97.2	24.3	9.1	5.2	8.7	28.1
Public assembly	326	3,948	113.7	1.26	12.7	5.8	5.5	0.197	51.9	45.6	0.09		113.7	53.6	6.3	3.5	17.5	21.9
Public order and safety	87	1,271	97.2	1.22	11.3	3.9	5.0	0.280	43.6	43.6	0.22		97.2	27.8	6.1	2.3	23.4	16.4
Religious worship	269	2,792	37.4	0.48	3.4	2.9	4.2	0.092	28.0	27.4	0.21		37.4	23.7	1.9	0.9	3.2	5.0
Warehouse and storage	580	8,481	38.3	0.56	6.4	3.2	2.2	0.265	22.4	21.2	0.09		38.3	15.7	0.9	0.3	2.0	9.8
Other	67	1,004	172.2	1.86	22.1	11.3	7.3	0.227	82.4	35.4			172.2	59.6	9.3	8.3	15.3	26.7
Vacant	261	2,384	21.5	0.27	3.9	2.4	2.4	0.189	38.8	21.0	0.16		21.5	11.9	0.6	0.3	2.4	3.6
Year Constructed																		
1919 or before	353	3,673	79.4	0.90	8.3	4.8	4.0	0.231	49.8	47.6	0.17	55.73	79.4	34.2	2.6	1.6	10.0	14.9
1920 to 1945	562	6,710	75.7	0.84	8.2	5.1	4.7	0.240	44.9	40.4	0.23	98.36	75.7	37.0	3.4	1.6	10.7	12.3
1946 to 1959	867	9,298	88.9	1.06	10.4	6.5	4.2	0.231	58.8	44.1	0.20	60.24	88.9	37.2	4.4	2.1	14.1	15.5
1960 to 1969	718	10,858	94.3	1.21	13.0	7.2	5.9	0.266	50.9	47.5	0.13	88.27	94.3	30.2	5.7	2.7	16.8	20.4
1970 to 1979	813	11,333	99.3	1.36	16.0	8.8	6.2	0.259	51.8	32.7	0.07	92.42	99.3	26.0	7.2	3.6	15.8	25.6
1980 to 1989	846	12,252	86.5	1.30	15.9	10.0	6.0	0.269	39.0	28.4	0.05		86.5	19.8	7.8	3.2	11.5	23.5
1990 to 1992	218	2,590	114.6	1.55	18.8	9.4	8.0	0.292	58.9	29.1	0.03		114.6	26.6	8.4	3.5	17.2	28.7
1993 to 1995	202	2,059	92.2	1.32	17.5	8.4	4.9	0.295	48.2	42.5	0.10		92.2	24.3	7.9	3.2	11.7	22.7
Floors																		
One	3,018	24,552	75.2	1.10									75.2	26.0	5.6	2.1	7.9	17.0
Two	1,002	14,122	79.4	1.09									79.4	28.2	5.7	2.1	10.9	18.3
Three	399	7,335	92.0	1.09									92.0	34.8	5.1	2.3	15.0	18.6
Four to nine	148	8,789	139.8	1.51									139.8	36.5	7.5	4.8	30.2	31.0
Ten or more	12	3,975	113.4	1.54									113.4	23.1	7.3	5.6	21.8	29.6
Census Region and Division																		
Northeast	725	11,883	87.1	1.39	11.2	5.2	3.7	0.260	40.6	29.1	0.22	76.31	87.1	32.4	4.0	2.0	14.2	17.7
New England	204	3,140	87.3	1.28	9.4	5.8	5.3	0.295	50.0	40.8	0.28	100.91	87.3	37.7	3.3	1.6	15.2	16.0
Middle Atlantic	521	8,743	87.1	1.43	11.8	5.2	3.3	0.246	38.3	28.6	0.19	72.71	87.1	30.4	4.3	2.1	13.9	18.4
Midwest	1,139	14,322	104.5	1.05	11.8	6.8	5.1	0.238	66.9	59.8	0.04	91.17	104.5	46.7	4.3	2.5	15.6	18.8
East North Central	739	9,655	102.2	1.05	11.1	5.6	4.5	0.238	65.2	62.1	0.05	93.69	102.2	45.5	4.3	2.2	16.0	17.4
West North Central	401	4,668	109.3	1.06	13.3	8.1	6.8	0.228	71.0	54.3	0.03	86.73	109.3	49.1	4.3	3.0	14.8	21.8
South	1,750	20,830	80.8	1.07	14.9	8.5	5.8	0.261	41.9	29.3	0.08	80.25	80.8	18.0	8.4	3.2	10.5	21.3
South Atlantic	676	9,475	81.5	1.15	15.4	8.5	6.7	0.294	39.9	34.9	0.10	139.92	81.5	17.3	8.8	3.3	9.3	22.2
East South Central	477	4,917	84.8	0.99	14.9	9.8	6.6	0.253	50.5	38.3	0.06		84.8	24.4	7.5	2.7	11.7	21.2
West South Central	597	6,438	76.7	1.00	14.3	7.8	5.2	0.249	37.7	22.0			76.7	14.2	8.7	3.3	11.4	20.1
West	964	11,736	94.2	1.38	14.8	7.3	6.7	0.244	46.1	30.4	0.02		94.2	23.4	5.5	3.1	17.0	23.6
Mountain	319	3,855	111.3	1.15	13.9	6.5	6.8	0.244	55.5	42.2			111.3	40.8	5.9	3.3	21.4	21.7
Pacific	646	7,881	85.9	1.49	15.3	8.8	6.7	0.244	41.3	26.8	0.02	70.65	85.9	14.9	5.4	3.1	14.8	24.5
Climate Zones: 45-Year Average																		
<2000 CDD and >7000 HDD	493	5,098	97.8	0.98	10.6	5.2	5.8	0.263	68.7	50.2	0.20	110.09	97.8	47.3	3.1	1.8	14.2	17.7
5500 to 7000 HDD	975	14,597	109.0	1.22	11.7	5.6	5.0	0.238	62.6	51.0	0.13	134.98	109.0	48.4	4.1	2.4	18.2	18.6
4000 to 5499 HDD	1,070	15,155	92.8	1.24	14.1	6.2	4.0	0.251	48.4	40.0	0.14	67.32	92.8	29.5	5.4	2.9	13.3	22.2
Fewer than 4000 HDD	1,103	13,491	79.9	1.25	14.3	9.3	6.7	0.257	37.7	28.8		93.65	79.9	15.9	6.8	2.9	12.3	21.6
>2000 CDD and <4000 HDD	937	10,430	71.6	1.10	15.0	8.7	5.4	0.253	35.0	22.9			71.6	9.1	9.7	3.3	10.2	20.3
Workers (Main Shift)																		
Fewer than 5	2,505	13,885	56.8	0.79	7.8	5.3	5.3	0.218	44.1	41.0	0.25		56.8	26.9	2.5	1.3	8.1	9.5
5 to 9	798	6,291	80.8	1.10	10.5	8.5	5.3	0.268	52.9	42.6	0.20		80.8	36.1	4.6	1.8	8.8	15.3
10 to 19	625	7,102	86.5	1.18	12.1	9.5	6.1	0.253	55.9	30.1	0.27		86.5	31.9	5.9	2.0	9.9	17.9
20 to 49	400	9,132	95.1	1.29	13.6	12.9	5.5	0.314	50.4	39.8	0.19	106.84	95.1	30.5	6.8	2.2	12.9	20.6
50 to 99	138	6,931	90.9	1.17	13.2	10.6	4.2	0.330	44.6	29.3	0.12	103.56	90.9	27.6	6.8	2.3	16.2	22.3
100 to 249	71	5,988	108.3	1.35	16.4	15.1	4.9	0.366	50.4	32.3	0.09	74.51	108.3	27.4	8.5	3.6	20.2	26.7
250 or more	43	9,443	133.7	1.65	21.7	16.4	5.1	0.454	51.0	27.2	0.03	74.62	133.7	25.7	8.9	6.3	23.5	36.5
Weekly Operating Hours																		
39 or fewer	899	6,134	29.3	0.39	3.6	2.7	4.9	0.142	33.8	29.1	0.21		29.3	16.8	1.6	0.7	3.0	3.6
40 to 48	1,257	13,233	66.4	0.89	9.0	6.8	4.5	0.217	41.6	33.9	0.15		66.4	31.6	4.3	1.9	5.3	12.4
49 to 60	969	12,242	76.6	1.08	12.0	6.9	4.6	0.240	36.6	30.9	0.15	83.27	76.6	29.4	5.1	2.9	6.7	18.3
61 to 84	567	10,052	79.2	1.16	12.7	10.2	5.1	0.276	38.6	45.7	0.10	70.74	79.2	24.7	6.3	2.7	8.6	21.8
85 to 167	420	6,202	134.0	1.87	20.7	31.4	10.2	0.362	59.6	72.6	0.11		134.0	34.0	8.9	3.6	20.5	32.0
Open continuously	466	10,908	155.7	1.76	21.3	12.7	5.8	0.374	81.7	55.4	0.08	87.69	155.7	33.2	9.5	4.4	39.1	34.3
Ownership and Occupancy																		

Blank = data not available, or less than 20 buildings, or error is >50%. * = more than one may apply; ** = for demand metered buildings. Med. = Median

Table 2B 1995 Commercial Building Energy Consumption

Consumption shown is on an annual basis per square foot of building area. *Source*: DOE/EIA 0318(95) 1998

Source Table Number	33	33	33	33	35	35	35	35	35	35	35	35	35	35	37	37	37	37	37
	Sum Major Fuels, 1000 Btu				Energy End Use: Electricity, 1000 Btu/ft^2·yr										Natural Gas, 1000 Btu/ft^2·yr				
Building Characteristics	Cooking	Refr.	Office Equip	Other	Total	Space Heat	Cool	Ventilation	Water Heat	Lighting	Cooking	Refr.	Office Equip	Other	Total	Space Heat	Water Heat	Cooking	Other
All Buildings	3.7	3.1	5.7	6.1	45.7	2.0	6.0	2.8	0.8	21.1	0.3	3.2	5.8	3.7	51.0	28.6	13.7	5.2	3.5
Building Floor Space																			
1001 to 5000 ft^2	8.9	10.4	5.4	5.1	63.9	5.0	7.4	3.1	2.1	24.2	1.1	11.1	5.7	4.1	89.6	56.9	13.3	17.0	
5001 to 10,000 ft^2	4.3	2.5	3.8	2.9	33.7	2.6	4.6	1.8	1.0	14.5	0.2	2.7	4.0	2.2	60.4	42.9	9.8	6.9	
10001 to 25,000 ft^2	2.6	2.5	4.3	3.7	34.0	1.9	4.9	1.8	0.6	15.1	0.2	2.6	4.5	2.4	47.1	31.6	9.9	3.8	1.9
25001 to 50,000 ft^2	2.1	2.5	5.0	5.2	41.4	2.0	6.6	2.1	0.8	18.6	0.2	2.6	5.0	3.3	44.0	26.5	12.3	2.8	
50001 to 100,000 ft^2	2.0	2.1	6.1	6.0	46.0	1.0	6.9	3.2	0.6	21.5	0.2	2.1	6.2	4.2	43.4	26.0	12.5	2.5	2.4
100001 to 200,000 ft^2	3.1	1.4	7.2	8.9	51.0	1.3	6.2	3.4	0.4	25.6	0.2	1.5	7.4	4.9	52.6	23.0	20.2	4.2	5.3
200001 to 500,000 ft^2	4.6	1.6	8.5	11.9	55.3	1.1	6.1	4.5	0.5	27.4	0.3	1.6	8.5	5.1	53.5	16.5	21.6	6.1	9.2
Over 500,000 ft^2	3.5	2.2	7.0	9.1	55.6	0.8	5.5	4.1	0.5	30.0	0.4	2.3	7.4	4.6	33.8	9.9	13.2	4.4	6.3
Principal Building Activity																			
Education	1.4	1.0	1.5	2.9	28.7	1.8	4.7	1.6	0.8	15.9	0.2	1.0	1.5	1.0	42.3	25.5	12.5	1.6	2.7
Food sales	5.6	110.9	1.3	7.4	184.7		13.4	4.4	2.5	33.9	0.9	110.9	1.3	6.1	43.7	24.3	9.9	7.5	1.9
Food service	77.5	31.6	2.6	13.7	122.8	3.6	19.4	5.3	3.6	37.0	6.2	31.6	2.6	13.5	157.7	33.4	27.7	96.2	
Health care	11.2	4.7	15.5	34.4	90.4	1.4	9.2	7.2	0.9	39.3	0.3	4.7	15.5	12.0	146.9	45.1	59.6	14.4	27.7
Lodging	6.6	2.3	3.8	7.5	52.0	3.2	8.0	1.7	3.4	23.3	0.5	2.3	3.8	5.7	75.2	13.5	51.4	7.9	2.4
Mercantile and service	1.5	0.9	2.9	3.7	40.2	2.0	5.8	2.5	0.5	23.6	0.2	0.9	2.9	1.9	46.4	36.9	5.2	2.0	2.3
Office	1.1	0.4	15.1	5.2	64.5	2.0	8.8	5.2	0.6	28.1	0.1	0.4	15.2	4.2	36.7	24.5	9.0	1.6	1.6
Public assembly	2.8	1.8	2.4	3.8	43.3	2.7	6.1	3.5	0.9	22.0	0.4	1.8	2.5	3.3	53.3	39.7	9.4	3.5	
Public order and safety		0.2	5.8	12.7	38.5	0.2	6.1	2.3		16.4		0.2	5.8	7.2	44.7	20.1	15.4		
Religious worship	0.5	0.6	0.4	1.1	11.7	1.3	1.9	0.9	0.4	5.0	0.2	0.6	0.4	1.0	28.7	24.8	3.4	0.5	
Warehouse and storage		1.7	4.4	3.4	22.0	0.8	1.0	0.3	0.2	10.4		1.8	4.7	2.7	23.0	20.3	1.7	0.1	1.0
Other		0.7	15.2	35.9	75.5	2.2	8.6	8.4	0.2	26.8		0.7	15.3	13.3	84.6	37.7	11.7		33.5
Vacant		0.2	0.5	1.9	13.2	1.0	1.0	0.4	0.1	6.3		0.4	0.9	3.0	39.8	31.9	7.0		
Year Constructed																			
1919 or before	4.0	1.3	3.2	7.5	28.2	0.7	2.7	1.7	0.6	15.5	0.3	1.4	3.3	2.1	51.2	30.9	8.4	5.2	
1920 to 1945	1.8	1.6	3.3	4.1	28.0	1.2	3.6	1.7	0.4	13.3	0.2	1.8	3.6	2.3	46.1	32.8	8.5	2.5	2.4
1946 to 1959	3.0	2.7	4.6	5.2	35.6	1.9	4.4	2.1	0.8	15.8	0.2	2.7	4.7	2.9	60.4	39.4	13.6	4.0	3.3
1960 to 1969	4.0	3.0	5.3	6.1	44.3	1.8	5.7	2.8	0.9	20.8	0.2	3.0	5.4	3.6	52.2	26.2	17.2	5.8	3.2
1970 to 1979	3.2	3.7	6.7	7.5	54.7	2.2	6.9	3.7	0.9	25.8	0.4	3.7	6.7	4.3	53.2	29.0	14.9	4.3	5.0
1980 to 1989	4.2	3.0	7.6	5.9	54.4	2.3	8.0	3.3	0.9	24.2	0.4	3.1	7.8	4.4	40.1	19.1	12.4	6.4	2.2
1990 to 1992	9.3	5.6	7.9	7.4	64.1	2.2	8.2	3.5	0.8	29.2	0.8	5.7	8.1	5.6	60.5	24.0	20.1	13.3	
1993 to 1995	3.3	7.4	4.9	6.8	59.6		8.1	3.4	1.0	24.5	0.6	8.0	5.3	4.1	49.5	24.9	15.3	5.1	4.1
Floors																			
One	4.3	4.6	4.1	3.7	42.0	2.6	5.9	2.2	0.9	17.9	0.4	4.8	4.3	3.0	46.5	30.4	8.2	6.7	1.1
Two	2.4	2.7	4.6	4.6	39.4	1.7	5.7	2.1	0.9	18.5	0.2	2.7	4.6	2.9	48.9	31.0	12.7	3.2	2.0
Three	2.8	1.4	5.2	6.7	39.2	1.6	5.1	2.3	0.9	18.9	0.2	1.4	5.3	3.5	51.2	31.3	12.3	3.4	4.2
Four to nine	4.7	1.8	10.0	13.2	63.3	1.1	7.0	4.9	0.7	31.2	0.3	1.8	10.1	6.1	67.0	24.1	26.8	6.3	9.8
Ten or more	4.1	1.4	10.8	9.6	63.0	1.7	6.5	5.7	0.4	30.3	0.3	1.5	11.1	5.6	45.6	14.8	18.7	6.0	6.1
Census Region and Division																			
Northeast	2.7	3.0	4.5	6.4	38.1	1.6	3.8	2.1	0.7	18.4	0.3	3.2	4.7	3.2	41.7	22.9	10.2	4.0	4.6
New England	1.9	1.9	4.1	5.5	32.1	0.8	3.1	1.6	1.0	16.4	0.3	1.9	4.2	2.7	51.3	28.7	14.8	3.5	4.3
Middle Atlantic	3.0	3.4	4.6	6.7	40.3	1.9	4.1	2.2	0.7	19.2		3.6	4.8	3.4	39.3	21.5	9.1	4.1	4.6
Midwest	3.5	2.4	5.1	5.6	40.2	1.6	4.3	2.6	0.8	19.4	0.3	2.4	5.3	3.4	68.8	47.6	14.1	4.2	2.9
East North Central	4.4	2.5	4.6	5.2	37.8	1.5	4.3	2.3	0.8	17.8	0.4	2.6	4.7	3.3	66.9	45.0	14.4	5.1	2.4
West North Central	1.8	2.1	6.1	6.3	45.2	1.8	4.5	3.1	0.7	22.8	0.2	2.2	6.4	3.6	72.9	53.4	13.4	2.2	
South	4.0	3.4	5.9	6.0	50.9	2.1	8.5	3.3	1.0	22.0	0.3	3.5	6.1	4.1	43.0	20.3	13.2	6.2	3.2
South Atlantic	4.6	3.0	6.6	6.0	52.4	2.2	8.6	3.4	1.1	22.6	0.3	3.1	6.7	4.3	41.0	17.0	11.8	8.5	3.7
East South Central	2.2	3.7	5.3	6.2	50.9	3.2	7.8	2.8	1.0	22.4	0.4	3.9	5.6	3.8	51.9	30.1	15.4	2.8	3.6
West South Central	4.5	3.8	5.2	5.4	48.8	1.2	9.0	3.4	0.7	20.9	0.3	4.0	5.4	3.9	38.7	16.8	13.2	6.3	2.3
West	4.3	3.4	7.2	6.5	50.6	2.4	5.5	3.2	0.7	23.9	0.3	3.5	7.3	3.8	47.3	20.5	16.9	6.0	4.0
Mountain	2.8	3.2	6.8	5.4	47.6	1.9	5.9	3.3	0.7	21.9	0.3	3.2	6.8	3.5	57.0	35.4	15.1	3.7	2.9
Pacific	5.1	3.6	7.5	7.1	52.2	2.6	5.4	3.1	0.7	24.9	0.4	3.6	7.6	4.0	42.4	12.9	17.8	7.1	4.6
Climate Zones: 45-Year Average																			
<2000 CDD and >7000 HDD	2.2	2.3	4.6	4.6	36.2	1.8	3.2	1.9	0.7	18.3	0.2	2.4	4.7	3.0	70.5	51.4	14.5	2.8	
5500 to 7000 HDD	3.4	3.0	5.2	5.8	39.8	1.8	3.9	2.5	0.9	18.9	0.3	3.0	5.3	3.5	64.3	43.1	13.8	4.1	3.2
4000 to 5499 HDD	3.3	2.6	6.2	7.4	48.1	2.3	5.3	3.0	0.6	23.1	0.3	2.7	6.4	3.8	49.7	27.2	12.1	4.9	5.5
Fewer than 4000 HDD	4.4	3.7	6.2	6.1	48.8	1.9	6.8	2.9	0.8	22.0	0.4	3.8	6.3	3.9	38.7	15.7	14.3	5.7	3.1
>2000 CDD and <4000 HDD	4.6	3.6	5.5	5.3	51.3	1.8	10.1	3.5	1.1	21.3	0.3	3.8	5.8	3.8	36.0	10.5	14.4	8.5	2.6
Workers (Main Shift)																			
Fewer than 5	0.9	3.4	1.9	2.3	26.5	2.4	2.8	1.5	0.9	10.6	0.1	3.8	2.2	2.0	45.3	33.6	9.1	1.7	
5 to 9	2.8	3.9	3.5	4.1	35.7	2.5	4.5	1.8	1.1	15.3	0.4	3.9	3.5	2.6	54.4	40.7	8.2	3.4	2.1
10 to 19	7.0	3.5	4.7	3.4	41.2	2.4	5.9	2.0	1.1	17.9	0.6	3.5	4.7	3.0	57.4	36.7	10.4	9.7	0.6
20 to 49	6.1	4.3	5.4	6.2	46.3	2.1	6.8	2.2	0.8	20.6	0.4	4.3	5.5	3.6	51.8	28.4	12.5	7.8	3.0
50 to 99	2.9	2.3	5.3	5.2	45.2	1.4	6.8	2.4	0.5	22.5	0.3	2.3	5.4	3.7	45.8	23.3	17.1	3.8	1.6
100 to 249	3.0	1.5	8.1	9.2	55.8	1.4	8.2	3.6	0.8	26.8	0.2	1.5	8.1	5.1	51.7	24.9	17.6	3.9	5.3
250 or more	4.6	2.2	12.3	13.7	74.2	1.3	8.2	6.3	0.6	36.6	0.4	2.2	12.3	6.3	52.4	16.4	20.1	5.9	10.0
Weekly Operating Hours																			
39 or fewer	0.4	0.5	0.9	1.5	12.4	1.3	2.0	0.9	0.3	4.4		0.7	1.2	1.5	34.7	29.2	4.2	1.0	
40 to 48	1.1	0.9	6.1	2.9	30.7	2.1	4.3	1.9	0.5	12.5	0.1	0.9	6.1	2.4	42.8	34.6	5.9	1.6	0.7
49 to 60	0.8	1.1	7.5	4.6	41.0	2.0	5.1	2.9	0.5	18.5	0.1	1.1	7.6	3.1	37.6	28.4	6.2	1.1	1.9
61 to 84	4.1	2.6	4.1	4.3	43.4	2.0	6.1	2.7	0.7	21.9	0.3	2.6	4.1	3.0	39.6	24.6	7.8	5.4	1.9
85 to 167	11.8	11.8	4.6	6.8	70.6	1.9	8.9	3.6	1.2	32.2	1.3	11.9	4.7	5.0	61.2	28.4	14.1	16.4	2.3
Open continuously	6.9	4.9	7.9	15.5	72.7	2.0	9.1	4.5	1.7	35.0	0.4	5.0	8.0	6.8	83.9	26.0	37.8	8.8	11.3
Ownership and Occupancy																			

Blank = data not available, or less than 20 buildings, or error is >50%. * = more than one may apply; ** = for demand metered buildings. Med. = Median

Table 2A 1995 Commercial Building Energy Consumption (*Continued*)

Consumption shown is on an annual basis per square foot of building area. *Source*: DOE/EIA 0318(95) 1998

Source Table Number	1	1	3		10	10	19	19	21	21	27	31	33	33	33	33	33	33
	Total #	Total	Major Fuels		Electricity				Nat. Gas		Fuel Oil	Distr. Heat	Energy End Use					
Building Characteristics	Bldgs., Thou-sands	Floor Space, 10^6 ft^2	1000 Btu/ft^2	\$/ft^2	kWh/ft^2	Med. kWh/ft^2	Med. Peak W/ft^2	Med. Load Fact.	CF/ft^2	Med. CF/ft^2	Gal/ft^2	lb/ft^2	Total	Space Heat	Cool	Venti-lation	Water Heat	Light-ing
Nongovernment owned	4,025	46,696	84.6	1.17	13.1	7.2	5.6	0.255	47.4	38.8	0.11	105.65	84.6	25.8	5.9	2.6	12.2	19.4
Owner occupied	3,158	35,573	92.4	1.21	13.4	6.9	5.6	0.253	50.6	39.7	0.11	114.17	92.4	28.7	6.1	2.7	14.5	20.2
Nonowner occupied	698	9,697	66.7	1.15	12.4	9.8	5.8	0.267	35.0	34.0	0.10		66.7	18.1	5.9	2.3	5.7	19.2
Unoccupied	170	1,426	11.0	0.16	2.8	0.6	1.6	0.184		51.0			11.0	5.2		0.1		
Government owned	553	12,076	113.6	1.28	14.6	7.7	4.3	0.246	58.5	46.0	0.13	82.95	113.6	41.2	6.2	3.5	19.8	24.3
Federal	76	1,752	151.8	1.73									151.8	43.9	7.4	6.9	19.5	41.2
State	99	2,851	153.6	1.68									153.6	47.3	8.5	4.9	32.6	33.7
Local	379	7,473	89.4	1.02									89.4	38.2	5.1	2.2	15.0	16.8
Space Vacant for at Least 3 Months																		
Yes	787	15,844	70.7	0.96	11.9	5.1	3.2	0.144	40.9	32.4	0.05	53.43	70.7	20.5	5.3	2.6	9.0	18.3
No	3,791	42,928	97.9	1.27	13.9	7.6	5.8	0.171	52.7	40.0	0.15	109.80	97.9	32.1	6.2	2.8	15.6	21.2
Energy Sources*																		
Electricity	4,343	57,076	93.1	1.22	13.4	7.2	5.4	0.164	49.6	39.7	0.12	94.22	93.1	29.7	6.1	2.8	14.2	21.1
Natural gas	2,478	38,145	103.0	1.26	13.1	7.4	5.1	0.166	49.7	39.7	0.07	83.01	103.0	34.5	6.2	2.9	16.5	21.4
Fuel oil	607	14,421	120.1	1.40	15.9	5.0	4.3	0.178	58.4	28.6	0.12	74.76	120.1	33.9	6.8	4.1	23.1	26.3
District heat	110	5,658	185.8	1.87	18.9	10.2	5.0	0.223	60.6	11.8	0.03	94.14	185.8	64.4	5.0	5.6	41.6	33.4
District chilled water	53	2,521	214.8	2.01	21.9	10.2	4.0	0.228	76.7	24.0	0.02	116.82	214.8	68.0	1.6	7.9	47.4	40.3
Propane	589	5,344	73.4	1.15	12.3	5.9	5.8	0.177	55.8	42.1	0.28		73.4	20.0	5.7	2.4	19.0	17.5
Other	213	2,336	110.7	1.16	10.9	5.1	4.3	0.145	42.0	36.8	0.12		110.7	45.5	4.8	2.3		18.0
Energy End Uses*																		
Buildings with space heating	4,024	54,347	96.5	1.25	13.8	7.7	5.6	0.169	49.7	39.8	0.12	94.38						
Buildings with cooling	3,381	49,935	98.6	1.30	14.6	9.0	5.8	0.180	49.4	38.3	0.10	95.11						
Buildings with water heating	3,486	51,560	98.7	1.29	14.2	8.7	5.9	0.176	50.4	40.0	0.11	91.35						
Buildings with cooking	828	20,713	121.0	1.53	17.7	13.5	8.1	0.200	59.5	58.2	0.09	89.33						
Buildings w/manufacturing	204	3,893	78.8	1.03	11.8	6.3	3.8	0.155	42.4	47.7	0.15							
Buildings w/elec. generation	247	13,366	127.6	1.56	18.9	12.2	5.0	0.223	54.4	40.8	0.06	77.10						
Space-Heating Energy Sources*																		
Electricity	1,467	22,156	86.1	1.28			6.9	0.179					86.1	19.5	8.0	3.1	11.7	23.4
Natural gas	2,211	31,535	98.2	1.20					52.0	39.9			98.2	36.8	5.9	2.7	14.5	20.4
Fuel oil	504	6,606	109.3	1.22							0.24		109.3	43.4	4.7	2.7	20.7	20.3
District heat	109	5,606	184.8	1.87								94.55	184.8	64.9	5.0	5.6	41.1	33.4
Propane		2,025	63.8	1.21									63.8	9.7	5.6	2.3	8.6	18.2
Other	135	1,050	72.9	0.91									72.9	19.3	4.3	2.1	10.8	15.2
Electricity					16.2	10.9	6.89	0.266										
Electricity main					17.6	12.9	8.00	0.264										
Electricity secondary					14.0	7.0	5.10	0.268										
Other excluding electricity					12.1	6.7	4.80	0.248										
Buildings without space heating					6.4	1.8	2.22	0.230										
Primary Space-Heating Energy Source																		
Electricity	1,007	13,500	74.5	1.28	17.6	12.9	8.0	0.162		27.7	0.03		74.5	8.5	9.5	3.2	8.7	
Natural gas	2,106	28,808	98.5	1.19	12.2	7.3	4.9	0.160	54.5	41.2	0.02		98.5	38.0	5.7	2.6	14.3	20.3
Fuel oil	439	4,207	72.6	0.93	6.5	4.1	3.9	0.173	11.8	6.5	0.33		72.6	35.9	2.8	1.2	13.2	10.9
District heat	107	5,289	184.7	1.89	19.1	10.2	5.0	0.223	56.4	7.8	0.03	95.98	184.7	64.1	5.0	5.6	40.8	33.8
Propane	260	1,545	45.9	1.14	12.4	5.7	6.7	0.197		40.4			45.9		4.9	2.1	2.2	16.9
Other	61	514	31.5	0.54	6.9	1.8	3.1	0.248		44.5			31.5	5.6		1.3	4.0	10.3
Cooling Energy Source*																		
Electricity	3,293	47,761	94.9	1.29	14.4	8.9	5.8	0.256					94.9	28.2	7.2	3.0	14.1	22.2
Natural gas	65	1,314	167.3	1.77					86.0	63.9			167.3	51.4	8.1	5.3	25.1	36.1
District chilled water	53	2,521	214.8	2.01									214.8	68.0	1.6	7.9	47.4	40.3
Water-Heating Energy Sources*																		
Electricity	1,684	23,056	71.9	1.16	14.5	9.3	5.9	0.267					71.9	20.9	6.8	2.9	3.2	21.7
Natural gas	1,577	24,859	111.4	1.31					59.3	45.4			111.4	36.2	6.7	2.9	21.7	22.2
Fuel oil	120	2,151	94.2	1.08							0.37		94.2	32.6	4.5	1.3	30.9	12.9
District heat	54	3,949	192.9	1.91								102.89	192.9	58.7	5.3	5.6	51.7	32.9
Propane	110	1,020	73.6	1.55									73.6	11.4	8.6	2.8	4.6	23.0
Cooking Energy Sources*																		
Electricity	487	12,249	122.1	1.58	19.9	15.7	9.6	0.336					122.1	26.4	8.9	4.1	20.7	31.6
Natural gas	448	13,195	128.7	1.53					59.1	66.2			128.7	28.4	8.1	3.5	26.6	26.4
Propane	123	1,480	84.3	1.66									84.3	16.8	9.7	3.1	9.7	23.4
Percent of Floorspace Heated																		
Not heated	554	4,425	16.8	0.41	6.4	1.8	2.2	0.230		7.7			16.8	0.0	1.7	0.6		7.0
1 to 50	555	6,227	39.7	0.65	6.9	4.7	2.8	0.205	22.6	25.0	0.10		39.7	13.8	2.6	1.1	2.4	10.1
51 to 99	633	8,868	90.7	1.32	14.6	7.3	5.3	0.269	44.0	38.3	0.11	54.84	90.7	26.5	6.8	3.1	12.4	23.3
100	2,836	39,252	106.9	1.33	14.7	8.8	6.1	0.260	54.6	42.2	0.12	101.13	106.9	35.2	6.8	3.2	17.4	22.9
Percent of Floorspace Cooled																		
Not cooled	1,198	8,837	45.1	0.55	5.4	2.7	2.5	0.218					45.1	24.0	0.0	0.5	6.8	7.9
1 to 50	930	15,027	69.5	0.79	7.0	5.2	3.3	0.225					69.5	35.1	2.8	1.0	9.3	11.8
51 to 99	635	12,549	108.4	1.47	17.0	9.8	6.0	0.272					108.4	26.8	8.1	4.0	17.9	27.7
100	1,816	22,359	112.6	1.56	18.2	11.9	7.0	0.272					112.6	28.0	9.2	4.2	17.3	27.2
Percent Lit When Open																		
Zero	36	189				1.9	1.3	0.158										
1 to 50	666	6,008	51.2	0.71	6.1	4.9	3.6	0.213					51.2	24.9	2.5	1.1	6.4	7.2
51 to 99	745	9,692	91.2	1.21	12.4	7.5	5.8	0.263					91.2	29.6	5.5	2.7	14.9	19.2
100	2,814	40,514	101.3	1.33	14.9	8.5	5.8	0.261					101.3	30.8	6.9	3.2	15.4	24.0
Electricity not used	318	2,369	10.8	0.10		0.3	0.7	0.152					10.8	7.5		0.1	1.3	0.2
Percent Lit When Closed																		

Blank = data not available, or less than 20 buildings, or error is >50%. * = more than one may apply; ** = for demand metered buildings. Med. = Median

Table 2B 1995 Commercial Building Energy Consumption (*Continued*)

Consumption shown is on an annual basis per square foot of building area. *Source*: DOE/EIA 0318(95) 1998

Source Table Number	33	33	33	33	35	35	35	35	35	35	35	35	35	35	37	37	37	37	37
	Sum Major Fuels, 1000 Btu				Energy End Use: Electricity, 1000 Btu/ft^2·yr										Natural Gas, 1000 Btu/ft^2·yr				
Building Characteristics	Cooking	Refr.	Office Equip	Other	Total	Space Heat	Cool	Ventilation	Water Heat	Lighting	Cooking	Refr.	Office Equip	Other	Total	Space Heat	Water Heat	Cooking	Other
Nongovernment owned	4.0	3.4	5.5	5.7	44.6	2.0	5.9	2.6	0.8	20.1	0.3	3.5	5.7	3.6	48.6	26.8	13.1	5.7	3.0
Owner occupied	4.5	3.8	5.6	6.2	45.8	2.0	6.0	2.8	0.9	20.5	0.4	3.9	5.6	3.7	52.0	27.7	14.7	6.2	3.4
Nonowner occupied	2.9	2.5	5.9	4.4	42.3	2.1	5.8	2.3	0.7	19.6	0.2	2.5	6.0	3.1	35.9	23.3	6.6	4.3	
Unoccupied		0.1	0.2	1.1	9.7		0.9	0.3		4.6		0.3	0.5	2.5					
Government owned	2.3	1.8	6.5	7.8	49.8	1.7	6.1	3.6	0.8	24.8	0.3	1.8	6.6	4.1	60.1	35.7	15.8	3.1	5.4
Federal	1.7	1.7	14.9	14.5	85.3	1.2	7.5	7.2	0.7	43.1		1.8	15.6	7.6	59.6	26.1	14.5	2.6	
State	3.3	2.0	8.6	12.2	68.1		8.1	5.0	1.0	34.2	0.3	2.0	8.8	5.4	71.1	30.6	23.6	4.9	12.0
Local	2.1	1.8	3.7	4.6	34.8	1.3	5.1	2.2	0.7	17.1	0.2	1.8	3.7	2.8	56.7	38.6	13.6	2.6	2.0
Space Vacant for at Least 3 Months																			
Yes	2.3	1.2	5.4	6.0	40.6	1.3	5.4	2.8	0.5	19.8	0.2	1.3	5.9	3.5	42.0	23.6	10.5	3.5	4.4
No	4.2	3.8	5.8	6.1	47.4	2.2	6.2	2.8	0.9	21.5	0.4	3.8	5.8	3.8	54.1	30.4	14.7	5.8	3.2
Energy Sources*																			
Electricity	3.8	3.2	5.8	6.3	45.7	2.0	6.0	2.8	0.8	21.1	0.3	3.2	5.8	3.7	51.0	28.6	13.6	5.2	3.5
Natural gas	5.5	3.1	5.6	7.4	44.8	1.1	6.0	2.9	0.6	21.5	0.3	3.1	5.7	3.8	51.0	28.6	13.7	5.2	3.5
Fuel oil	4.1	2.0	8.1	11.7	54.3	1.1	6.4	4.2	0.7	26.5	0.3	2.0	8.1	5.1	60.0	23.5	22.0	5.9	8.6
District heat	3.6	2.1	10.9	19.1	64.5	0.3	4.5	5.6	0.9	33.5	0.3	2.1	10.9	6.3	62.2		17.1	7.9	
District chilled water	4.8	2.5	13.3	29.1	74.6	0.3	1.5	7.9	0.8	40.3	0.4	2.5	13.3	7.6	78.8	11.6	18.5	8.6	40.1
Propane	1.9	4.6	3.8	6.7	41.9	2.1	5.7	2.4	1.2	17.5	0.8	4.6	3.8	3.8	57.3	31.1	16.2	3.7	6.3
Other	2.9	1.6	4.2		37.2	0.9	4.9	2.4	0.8	18.8	0.3	1.7	4.4	2.9	43.1	20.2	11.2	4.0	
Energy End Uses*																			
Buildings with space heating																			
Buildings with cooling																			
Buildings with water heating																			
Buildings with cooking																			
Buildings with manufacturing																			
Buildings with elec. generation																			
Space-Heating Energy Sources*																			
Electricity	4.3	3.5	6.6	6.1															
Natural gas	4.2	3.0	5.5	5.1															
Fuel oil	2.6	1.6	5.6	7.6															
District heat	3.5	2.1	10.9	18.1															
Propane	1.5	7.7	3.8	6.5															
Other	2.6	2.2	3.3																
Electricity																			
Electricity main																			
Electricity secondary																			
Other excluding electricity																			
Buildings without space heating																			
Primary Space-Heating Energy Source																			
Electricity	4.8	4.0	6.9	5.4															
Natural gas	4.2	3.0	5.4	5.0															
Fuel oil	1.2	1.2	2.6	3.7															
District heat	3.3	2.1	11.1	18.5															
Propane		8.6	3.2	5.6															
Other	0.8	1.8	1.4	2.5															
Cooling Energy Source*																			
Electricity	4.3	3.4	6.2	6.2															
Natural gas	6.3	2.7	9.2	23.0															
District chilled water	4.8	2.5	13.3	29.1															
Water-Heating Energy Sources*																			
Electricity	2.3	3.0	6.3	4.7															
Natural gas	6.1	3.8	5.5	6.2															
Fuel oil	1.5	1.7	3.0	5.7															
District heat	4.4	2.3	10.7	21.1															
Propane			2.7	7.9															
Cooking Energy Sources*																			
Electricity	8.8	6.5	6.4	8.7															
Natural gas	15.6	5.6	5.1	9.4															
Propane	2.5	9.8	2.6	6.6															
Percent of Floorspace Heated																			
Not heated		1.8	1.6	2.3	21.7	0.0	2.5	0.8	0.3	10.5	0.1	2.7	2.3	2.4					
1 to 50	1.4	2.3	3.2	2.8	23.5	1.6	2.5	1.1	0.4	10.3	0.1	2.3	3.2	2.1	23.2	17.1	2.9	2.3	
51 to 99	3.9	3.5	6.0	5.1	49.7	2.5	6.6	3.1	0.9	23.4	0.3	3.5	6.0	3.4	45.2	26.2	11.5	5.1	2.3
100	4.4	3.3	6.5	7.3	50.1	2.0	6.6	3.2	0.9	23.0	0.4	3.3	6.5	4.1	56.0	30.9	15.5	5.5	4.1
Percent of Floorspace Cooled																			
Not cooled	0.6	1.1	1.9	2.3	18.5	1.9	0.0	0.6	0.7	9.6	0.1	1.4	2.4	1.8	53.6	40.2	9.8	1.6	
1 to 50	1.0	1.5	3.0	3.9	24.0	1.3	2.8	1.0	3.0	11.8	0.1	1.5	3.0	2.0	47.6	36.9	7.5	1.2	1.9
51 to 99	5.0	3.5	7.3	8.0	58.0	1.7	7.8	4.0	0.8	27.7	0.4	3.5	7.3	4.8	49.4	22.4	16.6	6.3	4.2
100	6.0	4.7	8.0	8.0	62.2	2.5	9.0	4.2	1.2	27.2	0.5	4.7	8.0	4.8	54.0	24.2	17.1	8.1	4.6
Percent Lit When Open																			
Zero																			
1 to 50	1.0	2.1	2.5	3.5	20.7	2.2	2.5	1.1	0.4	7.2	0.1	2.1	2.5	2.6	36.5	26.8	7.1	1.4	
51 to 99	3.4	2.6	6.1	7.2	42.5	1.7	5.4	2.7	0.8	19.2	0.2	2.6	6.1	3.7	50.3	28.3	12.9	4.4	4.6
100	4.4	3.5	6.4	6.6	51.0	2.0	6.7	3.2	0.9	24.0	0.4	3.5	6.4	3.9	53.4	28.9	14.9	6.0	3.6
Electricity not used			0.3	0.6				0.2		0.6			0.9	2.0					
Percent Lit When Closed																			

Blank = data not available, or less than 20 buildings, or error is >50%. * = more than one may apply; ** = for demand metered buildings. Med. = Median

Table 2A 1995 Commercial Building Energy Consumption (*Continued*)

Consumption shown is on an annual basis per square foot of building area. *Source*: DOE/EIA 0318(95) 1998

Building Characteristics	Total # Bldgs., Thousands	Total Floor Space, 10^6 ft²	Major Fuels: 1000 Btu/ft²	Major Fuels: $/ft²	Electricity: kWh/ft²	Electricity: Med. kWh/ft²	Electricity: Med. Peak W/ft²	Electricity: Med. Load Fact.	Nat. Gas: CF/ft²	Nat. Gas: Med. CF/ft²	Fuel Oil Gal/ft²	Distr. Heat lb/ft²	Energy End Use: Total	Space Heat	Cool	Venti-lation	Water Heat	Light-ing
Source Table Number	1	1	3		10	10	19	19	21	21	27	31	33	33	33	33	33	33
Zero	1,644	13,101	57.4	0.79	7.6	4.7	4.2	0.217					57.4	27.9	3.2	1.6	4.5	10.7
1 to 50	2,109	30,711	85.9	1.21	12.8	9.8	6.0	0.263					85.9	30.1	6.1	2.7	9.7	19.9
51 to 100	87	1,914	108.6	1.61	21.6	8.8	4.0	0.260					108.6	17.5	10.1	4.5	13.5	39.9
Never closed	421	10,677	158.9	1.80	21.3	12.7	5.8	0.374					158.9	33.9	9.7	4.5	39.8	35.0
Electricity not used	318	2,369	10.8	0.10		0.3	0.7	0.152					10.8	7.5		0.1		0.2
Energy Conservation Features																		
Any conservation feature	4,075	55,288	95.1	1.24														
Building shell	3,906	53,190	96.5	1.26														
HVAC	2,529	44,657	103.5	1.34														
Lighting	2,084	38,537	104.1	1.36														
Heating Equipment*																		
Heat pumps													85.6	14.9	9.0	2.9	15.9	23.1
Furnaces													77.1	32.2	4.6	2.0	7.4	16.2
Individual space heaters													87.4	31.0	5.4	2.5	11.8	20.2
District heat													179.9	61.6	4.9	5.5	39.2	33.3
Boilers													112.9	40.2	6.4	3.1	22.1	22.4
Packaged heating units													86.7	20.2	8.1	2.8	10.9	23.2
Other													107.2	21.7	8.3	4.8	15.8	32.3
Cooling Equipment*																		
Residential central A/C													102.4	34.0	7.2	2.8	15.3	20.8
Heat pumps													86.5	16.1	9.0	3.0	14.6	23.4
Individual A/C													96.1	36.0	5.5	1.7	19.5	16.5
District chilled water													214.8	68.0	1.6	7.9	47.4	40.3
Central chillers													133.1	29.0	10.0	5.7	26.2	34.0
Packaged A/C units													97.0	26.0	7.9	3.2	12.9	24.6
Evaporative coolers													102.8	21.6	6.5	3.4	21.4	22.7
Other													111.2	28.3	5.9	3.8	14.2	31.8
Lighting Equipment Types*																		
Incandescent													98.4	30.3	6.3	2.9	17.7	21.6
Standard fluorescent													96.4	30.5	6.4	3.0	14.7	21.9
Compact fluorescent													122.3	29.9	8.4	4.3	22.8	29.7
High-intensity discharge													102.9	30.9	6.5	3.2	17.5	25.3
Halogen													113.5	33.4	7.1	3.8	20.5	26.4
Other													86.6	12.4	8.9	4.7	11.1	31.2
Water-Heating Equipment*																		
Central system													108.8	35.8	6.5	3.1	18.8	22.2
Distributed system													74.7	20.3	6.6	2.6	7.5	21.4
Combination central/distributed													120.8	32.9	6.8	3.8	27.0	27.8
Personal Computers/Terminals																		
None													53.0	23.9	2.6	1.2	7.3	
1 to 4													80.9	30.0	4.9	1.9	9.4	15.9
5 to 9													97.2	36.3	6.8	2.1	11.8	20.7
10 to 19													94.1	32.7	6.3	2.0	16.9	20.7
20 to 49													91.6	28.5	7.1	2.5	15.2	21.6
50 to 99													98.4	28.0	7.6	2.9	15.9	24.6
100 to 249													112.7	27.9	8.0	4.4	20.9	29.2
250 or more													148.2	29.8	9.3	7.6	24.4	40.4
Commercial Refrigeration*																		
Any equipment													122.0	27.2	8.6	3.9	21.3	28.9
Walk in units													133.7	26.3	9.6	4.3	23.8	32.4
Cases and cabinets													124.0	27.5	8.9	3.9	21.8	29.5
None													71.5	30.0	4.4	2.1	9.2	15.3
Shell Conservation Features*																		
Roof/ceiling insulation													98.8	30.5	6.6	3.0	15.5	22.4
Wall insulation													97.3	26.9	7.0	3.1	16.1	22.7
Storm or multiple glazing													106.5	32.9	6.6	3.2	18.1	23.3
Tinted, reflective, shaded glass													106.9	27.1	7.8	4.0	16.9	26.5
Shading or awnings													101.4	29.8	6.8	3.3	16.5	23.2
HVAC Conservation Features*																		
Variable-volume system													128.1	28.2	8.5	5.3	24.1	32.4
Economizer cycle													127.5	33.2	8.5	4.6	23.0	29.8
HVAC maintenance													104.6	31.7	7.0	3.3	17.0	23.9
Other efficient equipment													120.2	29.5	8.1	4.5	21.6	28.9
Lighting Conservation Features*																		
Specular reflectors													108.2	31.7	7.1	3.5	17.4	26.1
Energy efficient ballasts													109.9	30.7	7.5	3.7	17.9	26.6
Natural lighting sensors													117.1	34.6	8.2	3.4	20.3	28.0
Occupancy sensors													121.1	29.5	7.4	4.4	21.9	28.3
Time clock													103.0	22.3	8.5	4.1	16.5	29.1
Manual dimmer switches													125.7	33.0	8.4	4.6	22.2	29.4
Other													116.9	30.4	8.4	4.3	18.3	30.6
Off-Hour Equipment Reduction*																		
Heating													78.9	29.7	5.3	2.5	8.8	
Cooling													80.1	28.3	6.0	2.7	8.8	18.7
Lighting													79.0	29.2	5.4	2.5	8.4	18.1

Blank = data not available, or less than 20 buildings, or error is >50%. * = more than one may apply; ** = for demand metered buildings. Med. = Median

Table 2B 1995 Commercial Building Energy Consumption (*Continued*)

Consumption shown is on an annual basis per square foot of building area. *Source*: DOE/EIA 0318(95) 1998

Source Table Number	33	33	33	33	35	35	35	35	35	35	35	35	35	35	37	37	37	37	37
	Sum Major Fuels, 1000 Btu				Energy End Use: Electricity, 1000 Btu/ft^2·yr										Natural Gas, 1000 Btu/ft^2·yr				
Building Characteristics	Cooking	Refr.	Office Equip	Other	Total	Space Heat	Cool	Ventilation	Water Heat	Lighting	Cooking	Refr.	Office Equip	Other	Total	Space Heat	Water Heat	Cooking	Other
Zero	0.8	1.4	3.9	3.5	25.9	2.3	3.1	1.6	0.5	10.7	0.1	1.4	3.9	2.3	41.1	33.6	4.7	1.1	1.7
1 to 50	4.0	3.1	6.1	4.3	43.8	1.8	6.0	2.7	0.7	19.9	0.4	3.1	6.1	3.2	43.1	28.6	7.9	5.3	1.3
51 to 100	5.0	6.5		6.1	73.5	2.2	10.1	4.5	0.7	39.9	0.6	6.5		3.5	40.8	16.8	14.3	6.2	
Never closed	7.0	5.0	8.0	15.8	72.7	2.1	9.1	4.5	1.7	35.0	0.4	5.0	8.0	6.9	83.8	26.0	37.7	8.8	11.3
Electricity not used			0.3	0.6						0.6			0.9	2.0					
Energy Conservation Features																			
Any conservation feature																			
Building shell																			
HVAC																			
Lighting																			
Heating Equipment*																			
Heat pumps	3.1	2.4	7.3	6.9	54.9	3.9	9.0	2.9	1.4	23.2	0.3	2.4	7.4	2.4	47.5	13.0	25.1	5.4	3.9
Furnaces	3.2	4.3	3.7	3.5	36.3	1.6	4.5	2.0	0.7	16.3	0.4	4.3	3.8	2.8	46.0	34.2	7.5	3.5	0.8
Individual space heaters	2.2	2.9	5.7	5.6	44.3	2.9	5.3	2.5	0.8	20.3	0.3	3.0	5.7	3.5	47.8	31.2	11.5	2.6	2.5
District heat	3.9	2.1	10.8	18.3	64.1	0.3	4.4	5.5	0.8	33.4	0.3	2.1	10.8	6.2	60.0	7.8	15.4	8.6	28.2
Boilers	3.6	1.6	6.4	7.1	45.7	1.0	6.1	3.1	2.5	22.6	0.2	1.6	6.4	4.1	65.8	37.2	21.5	3.9	3.2
Packaged heating units	6.1	4.4	5.9	5.1	52.0	2.5	8.0	2.8	0.9	23.3	0.4	4.4	5.9	3.8	42.1	21.1	12.2	7.4	1.4
Other	3.6	2.5	9.3	8.9	66.5	2.9	8.1	4.8	0.8	32.3	0.3	2.5	9.4	5.3	40.8	16.9	14.7	4.9	4.3
Cooling Equipment*																			
Residential central A/C	5.8	4.6	5.4	6.4	46.8	1.2	7.1	2.8	0.8	20.9	0.4	4.6	5.4	3.4	60.0	34.9	14.6	7.1	3.3
Heat pumps	3.2	2.8	7.6	6.6	56.0	3.8	9.0	3.0	1.3	23.4	0.5	2.8	7.6	4.4	44.3	14.2	21.5	5.2	3.4
Individual A/C	3.9	2.4	3.9	6.6	36.3	1.7	5.4	1.7	0.9	16.6	0.3	2.4	4.0	3.2	60.1	33.4	18.2	4.9	3.6
District chilled water	4.8	2.5	13.3	29.1	74.6	0.3	1.5	7.9	0.8	40.3	0.4	2.5	13.3	7.6	78.8	11.6	18.5	8.6	40.1
Central chillers	4.6	1.9	10.5	11.2	70.4	1.6	9.2	5.7	0.8	34.0	0.3	1.9	10.5	6.3	60.4	23.8	24.5	5.6	6.5
Packaged A/C units	5.1	4.1	6.7	6.4	54.0	2.0	7.7	3.2	0.8	24.7	0.4	4.1	6.7	4.1	46.2	24.4	12.7	6.2	2.8
Evaporative coolers	8.6	5.2	6.4	6.9	51.5	1.5	6.5	3.4	0.5	22.8	0.5	5.3	6.4	4.6	61.8	23.1	25.5	10.6	2.7
Other	4.5	4.9	9.5	8.3	62.0	1.0	5.9	3.8	0.6	31.8	0.5	4.9	9.5	4.1	40.5	22.1	9.3		4.1
Lighting Equipment Types*																			
Incandescent	4.7	2.9	5.5	6.5	45.7	1.7	6.1	2.9	0.8	21.6	0.3	2.9	5.5	3.7					
Standard fluorescent	4.0	3.3	6.1	6.5	47.4	2.0	6.2	3.0	0.8	21.9	0.3	3.3	6.1	3.8					
Compact fluorescent	5.7	3.1	8.3	10.3	61.5	1.6	7.9	4.3	0.8	29.7	0.5	3.1	8.3	5.3					
High-intensity discharge	3.6	2.4	6.3	7.3	50.0	1.5	6.2	3.2	0.6	25.3	0.3	2.4	6.3	4.2					
Halogen	4.5	2.5	7.0	8.3	54.0	1.7	6.8	3.8	0.7	26.4	0.4	2.5	7.0	4.7					
Other	2.6		5.4	8.3	58.2	1.3	8.6	4.7	0.5	31.2	0.4	2.0	5.4	4.1					
Water-Heating Equipment*																			
Central system	4.8	4.1	6.3	7.1	49.6	2.0	6.3	3.2	1.8	22.3	0.4	4.1	6.4	4.1	59.8	33.0	16.7	6.1	4.0
Distributed system	2.9	2.1	5.7	5.6	45.2	2.1	6.5	2.7	1.1	21.4	0.2	2.1	5.7	3.3	34.3	19.6	7.7	4.0	2.9
Combination central/distributed	4.9	2.7	7.0	7.9	55.2	1.8	6.6	3.8	0.6	27.8	0.4	2.7	7.0	4.4	56.2	24.3	22.0	5.8	4.1
Personal Computers/Terminals																			
None	2.5	2.7	1.3	3.0	23.6	1.7	3.0	1.4	0.7	9.7	0.2	3.1	1.5	2.4					
1 to 4	6.1	5.8	2.8	4.2	38.5	2.7	4.9	1.9	1.0	15.9	0.4	5.8	2.8	3.1					
5 to 9	5.1	4.4	4.9	5.1	47.5	2.6	6.7	2.1	1.3	20.8	0.7	4.4	4.9	3.8					
10 to 19	2.5	2.4	6.0	4.7	43.9	2.3	6.3	2.0	0.7	20.8	0.2	2.4	6.1	3.2					
20 to 49	2.6	2.1	5.9	6.0	45.4	1.4	7.1	2.5	0.8	21.8	0.2	2.1	6.0	3.5					
50 to 99	2.6	1.4	7.2	8.0	50.2	1.3	7.3	2.9	0.7	24.7	0.2	1.4	7.3	4.5					
100 to 249	3.1	2.3	8.3	8.6	59.2	1.7	7.6	4.4	0.6	29.2	0.2	2.3	8.3	4.9					
250 or more	4.2	1.7	16.2	14.5	83.1	1.6	8.6	7.6	0.7	40.5	0.4	1.7	16.3	5.9					
Commercial Refrigeration*																			
Any equipment	9.5	7.0	6.0	9.7	63.8	2.3	8.4	3.9	1.1	29.1	0.8	7.0	6.0	5.3					
Walk in units	11.5	8.5	6.5	10.8	71.8	2.3	9.3	4.3	1.2	32.6	1.0	8.5	6.6	6.0					
Cases and cabinets	10.0	7.1	5.7	9.6	64.7	2.4	8.6	3.9	1.2	29.6	0.9	7.2	5.8	5.2					
None	0.2	0.7	5.5	3.9	34.3	1.8	4.4	2.2	0.6	16.0		0.8	5.8	2.7					
Shell Conservation Features*																			
Roof/ceiling insulation	4.1	3.5	6.4	6.7	49.4	2.0	6.5	3.1	0.9	22.7	0.4	3.5	6.4	4.0	53.0	29.3	14.6	5.5	3.6
Wall insulation	4.4	3.5	6.8	6.9	50.8	1.9	6.8	3.1	1.0	22.8	0.4	3.6	6.8	4.3	49.6	25.0	15.2	5.8	3.5
Storm or multiple glazing	5.1	3.2	6.9	7.3	51.2	2.0	6.5	3.2	1.0	23.5	0.4	3.2	6.9	4.3	57.9	30.3	17.1	6.7	3.9
Tinted, reflective, shaded glass	5.1	3.1	8.3	8.0	57.6	2.1	7.6	4.0	0.8	26.6	0.4	3.1	8.3	4.6	49.8	22.8	15.7	6.7	4.6
Shading or awnings	4.4	2.6	7.1	7.6	50.2	2.0	6.6	3.3	0.9	23.3	0.3	2.6	7.2	4.1	52.0	26.1	15.2	5.9	4.8
HVAC Conservation Features*																			
Variable-volume system	5.8	2.7	10.3	10.9	67.8	1.9	8.1	5.3	0.8	32.5	0.4	2.7	10.4	5.8	59.7	23.3	22.0	7.6	6.7
Economizer cycle	5.9	3.1	9.4	10.1	63.8	1.8	8.1	4.6	0.8	30.0	0.5	3.2	9.4	5.4	56.9	25.1	18.5	7.2	6.0
HVAC maintenance	4.4	3.0	6.9	7.4	51.4	1.8	6.8	3.3	0.9	24.0	0.4	3.0	6.9	4.2	53.1	28.0	15.3	5.7	4.1
Other efficient equipment	4.9	3.1	9.0	10.5	61.1	1.8	7.6	4.5	0.7	28.9	0.3	3.1	9.0	5.3	54.6	23.2	18.5	6.1	6.8
Lighting Conservation Features*																			
Specular reflectors	4.6	2.9	7.1	7.8	53.9	1.6	6.9	3.5	0.8	26.1	0.4	2.9	7.1	4.5					
Energy efficient ballasts	4.4	3.4	7.8	8.0	56.8	2.1	7.2	3.7	0.9	26.6	0.4	3.4	7.8	4.6					
Natural lighting sensors	4.4	3.4	6.2	8.6	56.7	1.9	8.0	3.4	0.8	28.0	0.3	3.4	6.2	4.6					
Occupancy sensors	5.7	3.3	9.7	10.9	60.1	1.2	6.9	4.4	0.7	28.3	0.3	3.3	9.7	5.2					
Time clock	4.2	3.1	7.9	7.3	59.4	1.6	8.2	4.1	0.6	29.1	0.3	3.1	7.9	4.5					
Manual dimmer switches	7.2	2.5	8.8	9.6	62.0	1.8	8.1	4.6	0.8	29.4	0.4	2.5	8.8	5.5					
Other	3.3	3.1	10.0	8.4	64.4	1.7	8.3	4.3	0.6	30.6	0.4	3.1	10.0	5.3					
Off-Hour Equipment Reduction*																			
Heating	3.2	2.3	5.2	4.0	38.8	1.9	5.2	2.5	0.6	17.9	0.3	2.3	5.3	2.8	41.4	28.6	7.1	4.2	1.5
Cooling	3.4	2.4	5.6	4.1	41.1	1.7	5.9	2.7	0.6	18.8	0.3	2.4	5.6	2.9	41.0	27.7	7.3	4.5	1.5
Lighting	3.1	2.7	5.5	4.1	40.0	2.0	5.3	2.5	0.6	18.1	0.3	2.7	5.5	3.0	42.4	29.3	7.3	4.3	1.5

Blank = data not available, or less than 20 buildings, or error is >50%. * = more than one may apply; ** = for demand metered buildings. Med. = Median

Level I—Walk-Through Assessment. This involves assessing a building's energy cost and efficiency by analyzing energy bills and briefly surveying the building. Level I analysis identifies and provides a savings and cost analysis of low-cost/no-cost measures. It also lists potential capital improvements that merit further consideration, along with an initial judgment of potential costs and savings. The level of detail depends on the experience of the auditor or on the client's specifications.

Level II—Energy Survey and Analysis. This includes a more detailed building survey and energy analysis. A breakdown of energy use in the building is provided. Level II analysis identifies and provides the savings and cost analysis of all practical measures that meet the owner's constraints and economic criteria, along with a discussion of any effect on operation and maintenance procedures. It also lists potential capital-intensive improvements that require more thorough data collection and analysis, along with an initial judgment of potential costs and savings. This level of analysis is adequate for most buildings and measures.

Level III—Detailed Analysis of Capital-Intensive Modifications. This focuses on potential capital-intensive projects identified during Level II and involves more detailed field data gathering and engineering analysis. It provides detailed project cost and savings information with a high level of confidence sufficient for major capital investment decisions.

The levels of energy audits do not have sharp boundaries. They are general categories for identifying the type of information that can be expected and an indication of the level of confidence in the results; that is, various measures may be subjected to different levels of analysis during an energy analysis of a particular building. In the complete development of an energy management program, Level II audits should be performed on all facilities, although Level I audits are useful in establishing the program. The collected data are used to calculate an energy use profile that includes all end-use categories. From the energy use profiles, it is possible to develop and evaluate energy conservation opportunities.

In conducting an energy audit, a thorough systems approach produces the best results. This approach has been described as starting at the end rather than at the beginning. For example, consider a factory with steam boilers in constant operation. An expedient (and often cost-effective) approach is to measure the combustion efficiency of each boiler and to improve boiler efficiency. Beginning at the end requires finding all or most of the end uses of steam in the plant, which could reveal considerable quantities of steam being wasted by venting to the atmosphere, venting through defective steam traps, uninsulated lines, and passing through unused heat exchangers. Eliminating such end-use waste could produce greater savings than those easily and quickly developed by improving boiler efficiency. This approach requires care to ensure cost-effective use of time. It may not be cost-effective to track down every end use.

When conducting an energy audit, it is important to become familiar with operating and maintenance procedures and personnel. The energy manager can then recommend, through appropriate departmental channels, energy-saving operating and maintenance procedures. The energy manager should determine, through continued personal observation, the effectiveness of the recommendations.

Stewart et al. (1984) tabulated 139 different energy audit input procedures and forms for 10 different building types, each using 62 factors. They discuss features of selected audit forms that can help develop an audit procedure.

To calculate the energy cost avoidance of various energy conservation opportunities, it is helpful to develop an energy cost distribution chart. Preliminary information of this nature can be developed from monthly utility data by calculating end-use energy profiles (Spielvogel 1984).

Analysis of electrical operating costs starts with recording data from the bills on a form similar to that in Table 5. Dividing the consumption by the days between readings gives the average daily consumption, which should be plotted to detect errors in meter readings or reading dates and to detect consumption variances (see Figure 2). For this example, 312 kWh/day is chosen as the "base electrical consumption" to cover year-round electrical needs such as lighting, business machines, domestic hot water, terminal reheat, security, and safety lighting. At this point, consumptions or spans that appear to be in error should be reexamined and corrected as necessary. If the reading date for the 10Nov bill in Table 5 had been 05Nov, the curve in Figure 2 would be more continuous. On the basis of a 05Nov reading, the minimum daily consumption of 312 kWh on the continuous curve (Figure 2) occurred in the February billing.

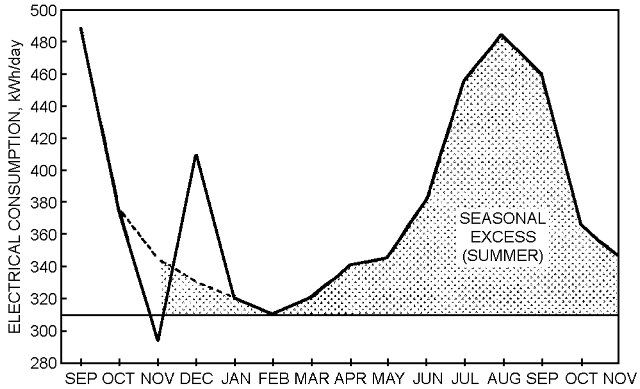

Fig. 2 Average Daily Electrical Consumption

To start analysis, calculate the monthly base consumption (base daily consumption times billing days) and subtract it from each monthly total; the difference is the summer or winter excess. Excess consumption in the summer is primarily from the air-conditioning load. A similar analysis is made of the actual monthly demand. In Table 5, the base demand is 33.0 kW, and it is usually found in the same or adjacent months as the month with the base consumption. Substantial errors may arise if missing bills are not accounted for.

Base consumption can be further analyzed by calculating its associated electrical load factor (ELF). If the base demand had operated 24 h per day, then base consumption would be

$$33.0 \text{ kW} \times 24 \text{ h/day} = 792 \text{ kWh/day} \tag{1}$$

But if the daily base consumption is 312 kWh/day, then the electrical load factor is

$$\text{ELF} = \frac{\text{Base consumption}}{\text{Base demand} \times 24} = \frac{312}{792} = 0.394 \text{ or } 39.4\% \tag{2}$$

In this example, the electrical load factor (39.4%) is higher than the occupancy factor (29.8%).

$$\begin{array}{l}\text{Occupancy}\\ \text{factor}\end{array} = \frac{\text{Occupied hours}}{24 \text{ h} \times 7 \text{ days}} = \frac{50}{168} = 0.298 = 29.8\% \tag{3}$$

One reason for this difference may be that the lights are left energized beyond the occupied hours.

Because of the air-conditioning demand, summer demand is 46.8 kW. If this additional demand of 13.8 kW had operated 24 h each day, the summer extra would be 13.8 × 24 or 331.2 kWh/day. The ratio of each summer month's excess as a percent of 331.2 kWh yields the summer electrical load factor. Summer ELFs higher than the occupancy factor indicate that air conditioning is not shut off as early as possible in the evening. Winter excess demand and consumption are analyzed in the same way to yield winter monthly ELFs.

Base load energy use is the amount of energy consumed independent of weather. When a building has electric cooling and no electric heating, the base load energy use is normally the energy consumed during the winter. The opposite is true for heating. The annual estimated base load energy consumption can be obtained by establishing the average monthly consumption during the nonheating or noncooling months and multiplying by 12. For many buildings, subtracting the base load energy consumption from the total annual energy consumption yields an accurate estimate of the heating or cooling energy consumption. This approach is not valid when building use differs from summer to winter; when cooling operates year-round; or when space heating is used during summer, as for reheat. In many cases, base load energy use analysis can be improved by using hourly load data that may be available from the utility company. ELFs and occupancy factors can also be used instead of hourly energy profiles (Haberl and Komor 1990a, 1990b).

Although it can be difficult to relate heating and cooling energy used in commercial buildings directly to the severity of the weather, several authors, including Fels (1986) and Spielvogel (1984), suggest that this is possible using a curve-fitting method to calculate the balance point of a building (discussed in Chapter 31 of the 2001 *ASHRAE Handbook—Fundamentals*). The pitfalls of such an analysis are (1) estimated rather than actual utility usage data are used; (2) the actual dates of the metered information must be used, together with average billing period weather data; and (3) building use and/or operation are not regular.

More detailed breakdown of energy usage requires that some metered data be collected daily (winter days versus summer days, weekdays versus weekends) and that some hourly information be collected to develop profiles for night (unoccupied), morning warm-up, day (occupied), and shutdown. This discussion presumes that submetering is not installed in the building. Individual metering of various energy end uses provides the energy manager with information to apply energy management principles optimally. For more information, see also Chapter 40, Building Energy Monitoring.

Evaluate Energy Conservation Opportunities

Various energy conservation opportunities (ECOs) can be quantitatively evaluated from end-use energy profiles. Important considerations in this process are as follows:

- System interaction
- Utility rate structure
- Payback

Table 3 1997 Residential Annual End Use Consumption

Energy Source and End Use/Appliance	Households, 10^6	Usage per Household
Electricity, total	101.4	10,219 kWh
Space heating	42.0	2,807 kWh
Air conditioning	72.6	1,677 kWh
Water heating	40.2	2,835 kWh
Appliances	101.4	6,733 kWh
Natural Gas, total	61.9	83×10^3 ft^3
Space heating	54.5	65×10^3 ft^3
Water heating	52.8	24×10^3 ft^3
Appliances	40.4	9×10^3 ft^3
Fuel Oil, total	10.0	730 gal
Space heating	9.8	625 gal
Water heating	5.2	219 gal
LPG, total	8.1	488 gal
Space heating	5.6	502 gal
Water heating	3.3	258 gal
Appliances	4.8	55 gal
Kerosene, total, space heating	3.5	126 gal

Source: www.eia.doe.gov/emeu/recs/recs97 Fuel Tables 1 to 5.

- Installation requirements
- Life of the measure
- Maintainability
- Tenant/occupant comfort
- Effect on building operation and appearance

Accurate energy savings calculations can be made only if system interaction is allowed for and fully understood. Annual simulation models may be necessary to accurately estimate the interactions between various ECOs. The calculated remaining energy use should be verified against a separately calculated zero-based energy target.

Further, actual energy cost avoidance may not be proportional to the energy saved, depending on the method of billing for energy used. Using average costs per unit of energy in calculating the energy cost avoidance of a particular measure is likely to result in incorrect values.

PNL (1990) discusses 118 ECOs; some examples include the following:

Boilers	Outside air ventilation
Boiler auxiliaries	Ventilation layout
Condensate systems	Envelope infiltration
Water treatment	Weatherstripping
Fuel acquisition	Caulking
Fuel systems	Vestibules
Chillers	Elevator shafts
Chiller auxiliaries	Space insulation
Steam distribution	Vapor barrier
Hydronic systems	Glazing
Pumps	Infrared reflection
Piping insulation	Windows/treatments
Steam traps	Instrumentation
Domestic water heating	Shading
Lavatory fixtures	Vegetation
Water coolers	Trombe walls
Fire protection systems	Thermal shutters
Swimming pools	Surface color
Cooling towers	Roof covering
Condensing units	Lamps
City water cooling	Fixtures
Air-handling units	Ballasts
Coils	Switch design
Outside air control	Photo controls
Balancing	Interior color
Air volume control	Demand limiting
Shutdown	Current leakage
Air purging	Power factor
Minimizing reheat	Transformers
Air heat recovery	Power distribution
Filters	Cooking practices
Dampers	Hoods
Humidification	Refrigeration
Duct resistance	Dishwashing
System air leakage	Laundry
Diffusers	Vending machines
System interaction	Chiller heat recovery
System reconfiguration	Heat storage
Space segregation	Time-of-day rates
Equipment relocation	Computer controls
Fan-coil units	Cogeneration
Heat pumps	Active solar systems
Radiators	Staff training
System infiltration	Occupant indoctrination
Relief air	Documentation
Space heaters	Management structure
Controls	Financial practices
Thermostats	Building geometry
Setback	Space planning

Table 4 1997 Residential Energy Consumption

	Total Households, 10^6	Per Household, 10^6 Btu
Total Households	101.5	101.0
Weekday Home Activities		
Home used for business		
Yes	7.4	114.4
No	94.1	99.9
Energy intensive activity		
Yes	2.4	121.4
No	99.1	100.5
Someone home all day		
Yes	51.3	106.7
No	50.1	95.1
Winter Temperature Settings		
Lower when no one home		
Yes	45.5	99.9
No	56.0	101.8
Lower during sleeping hours		
Yes	47.4	101.6
No	54.0	100.4
Use a secondary heating fuel		
Yes	34.3	116.0
No	66.5	94.0
Adequacy of insulation		
Well Insulated	38.0	98.6
Adequately Insulated	44.4	102.5
Poorly Insulated	18.5	103.0
Central air conditioning use		
All summer	24.6	97.9
Quite a bit	10.4	103.1
Only a few times	12.4	103.5
No central system	53.7	101.6
Room air conditioning use		
All summer	5.7	96.3
Quite a bit	6.6	113.3
Only a few times	13.5	107.5
No room units	75.0	99.0
Use a dishwasher		
Yes	50.9	109.6
No	50.6	92.2
Use a clothes washer		
Yes	78.5	112.3
No	22.9	62.2
Use a clothes dryer		
Yes	72.2	113.7
No	29.3	69.5
Use two or more refrigerators		
Yes	15.4	135.0
No	86.1	94.9
Outdoor lights on all night		
Yes	26.3	108.2
No	75.2	98.4
Census Region and Division		
Northeast	19.7	120.6
New England	5.3	122.9
Middle Atlantic	14.4	119.7
Midwest	24.1	134.0
East North Central	16.9	138.2
West North Central	7.2	124.1
South	35.9	83.9
South Atlantic	18.7	75.1
East South Central	6.3	87.7
West South Central	10.8	96.7
West	21.8	74.9
Mountain	6.2	94.0
Pacific	15.6	67.3
Largest populated states		
California	11.5	63.9
Florida	5.9	54.9
New York	6.8	123.4
Texas	7.0	96.1
Urban/rural location		
City	48.2	95.8
Town	18.2	104.2
Suburbs	18.6	110.4
Rural	16.5	101.9
Climate zone		
<2,000 CDD, >7000 HDD	9.3	123.1
Climate zone (*continued*)		
5,500 to 7,000 HDD	28.0	127.8
4,000 to 5,499 HDD	22.5	105.5
Under 4,000 HDD	19.5	74.3
>2000 CDD, <4000 HDD	22.2	76.6
Type of Housing Unit		
Single-family	73.7	114.7
Multifamily		
2 to 4 units	5.6	91.5
5 or more units	15.8	48.6
Mobile home	6.3	79.5
Heated Floorspace (square feet)		
Fewer than 600	7.9	61.1
600 to 999	21.5	77.4
1,000 to 1,599	30.4	97.4
1,600 to 1,999	15.3	116.6
2,000 to 2,399	7.9	124.3
2,400 to 2,999	5.3	137.7
3,000 or more	4.1	175.2
No estimate provided	9.1	101.5
Year of Construction		
1949 or before	27.9	124.8
1950 to 1959	12.5	106.1
1960 to 1969	14.4	96.0
1970 to 1979	19.6	87.4
1980 to 1989	17.3	81.7
1990 to 1997	9.7	94.6
All Utilities Paid By Household		
All major fuels		
Yes	89.7	104.3
No	11.8	75.3
Electricity		
Yes	96.2	103.0
No	5.3	65.0
Natural gas		
Yes	53.3	123.5
No	8.6	78.8
Fuel oil		
Yes	7.6	145.8
No	2.3	91.9
LPG		
Yes	7.9	103.8
No	0.2	88.5
Kerosene		
Yes	3.5	100.5
No		
1997 Family Income		
Less than $10,000	13.3	76.4
$10,000 to $24,999	29.1	87.3
$25,000 to $49,999	31.1	102.6
$50,000 or more	27.9	125.2
Below Poverty Line		
100%	14.6	83.0
125%	19.7	82.9
150%	26.7	84.2
Eligible for Federal assistance	34.1	86.7
Age of Householder		
Under 25 years	5.7	69.7
25 to 34 years	18.5	87.7
35 to 44 years	23.2	107.4
45 to 59 years	25.6	113.4
60 years and over	28.5	99.4
Race of Householder		
White	78.5	103.9
Black	12.7	105.3
Other	10.3	72.8
Householder of Hispanic descent		
Yes	9.4	75.9
No	92.1	103.5
Household Size		
1 person	25.6	74.7
2 persons	33.0	101.2
3 persons	17.4	109.5
4 persons	15.2	117.7
5 persons	6.4	123.9
6 or more persons	3.9	129.6

Source: www.eia.doe.gov/emeu/recs/recs97 Tables CE1.

CDD = cooling degree-day (65°F base); HDD = heating degree-day (65°F base).

Table 5 Example of Analytical Method for Analyzing Electrical Operating Costs

Billing Date	Billing Days	Consumption, kWh: Total Actual	Consumption, kWh: Actual per Day	Consumption, kWh: Base[b]	Air Conditioning, kWh: Difference	Air Conditioning, kWh: ELF, %	Air Conditioning, kWh: Excess	Demand, kW: Actual	Demand, kW: Winter Excess	Demand, kW: Summer Excess
12Aug								46.2		0.6
11Sep	30	14,700	490	9,360	5,340	53.7	1,859	46.8		1.2
10Oct	29	10,860	374.5	9,048	1,812	18.9		46.8		1.2
10Nov	31	9,120	294.2	9,672	1,008[a]	11.7		45.6		0.0
06Dec	26	10,680	410.8	8,112	1,008[a]			33.0[c]	0.0	
09Jan	34	10,860	319.4	10,608	252			33.0	0.0	
13Feb	35	10,920	312[b]	10,920	0			33.6	0.6	
11Mar	27	8,700	322.2	8,424	276			33.0	0.0	
10Apr	30	10,140	338	9,360	780			33.6	0.6	
12May	32	11,020	344.4	9,984	1,036	9.8		45.6[d]		0.0
12Jun	31	11,760	379.4	9,672	2,088	20.3		46.8		1.2
13Jul	31	14,160	456.8	9,672	4,488	43.7	893	46.8		1.2
11Aug	29	14,340	494.5	9,048	5,292	55.2	1,937	46.8		1.2
10Sep	30	13,740	458	9,360	4,380	44.1	904	46.2		0.6
14Oct	34	12,120	356.5	10,608	1,512	13.4		45.6		0.0
10Nov	27	9,360	346.7	8,424	936			33.6	0.6	

[a]Estimated from corrected monthly consumption from Figure 2.
[b]Base electrical consumption = 312 kWh/day.
[c]Base winter demand = 33 kW.
[d]Base summer demand = 45.6 kW. Base summer excess demand = (45.6 − 33) = 12.6.

In addition, previously implemented energy conservation measures should be evaluated (1) to ensure that they have remained effective, and (2) to consider revising them to reflect changes in technology, building use, and/or energy cost.

Prioritize Resources

Once a list of ECOs is established, it should be evaluated, prioritized, and implemented. In establishing priorities, the capital cost, cost-effectiveness, and resources available must be considered. Factors involved in evaluating the desirability of a particular energy conservation retrofit measure are as follows:

- Rate of return (simple payback, life-cycle cost)
- Total savings (energy, cost avoidance)
- Initial cost (required investment)
- Other benefits (safety, comfort, improved system reliability, improved productivity)
- Liabilities (increased maintenance costs, potential obsolescence)
- Risk of failure (confidence in predicted savings, rate of increase in energy costs, maintenance complications, success of others with the same measures)

To reduce the risk of failure, documented performance of ECOs in similar situations should be obtained and evaluated. One common problem is that energy consumption for individual end uses is overestimated, and the predicted savings are not achieved. When doubt exists about energy consumption, temporary measurements should be made and evaluated. Also, some owners are reluctant to implement ECOs because of bad experiences with energy projects. The causes of past failures should be analyzed carefully to minimize the possibility of their reoccurrence.

Resources available for an energy conservation retrofit opportunity should include the following:

- Management attention, commitment, and follow-through
- Skills
- Manpower
- Investment capital

Financing alternatives also need to be considered. When all these considerations are weighed and a prioritized list of recommendations is developed, a report should be prepared for management. Each recommendation should include the following:

- Present condition of the system or equipment to be modified
- Recommended action
- Who should accomplish the action
- Necessary documentation or follow-up required
- Potential interferences to successful completion
- Staff effort required
- Risk of failure
- Interactions with other end uses and ECOs
- Economic analysis (including payback, investment cost, and estimated savings figures) using corporate economic evaluation criteria
- Schedule for implementation

The energy manager must be prepared to sell the plans to upper management. Energy conservation measures must generally be financially justified if they are to be adopted. Every organization has limited funds available that must be used in the most effective way. The energy manager competes with others in the organization for the same funds. A successful plan must be presented in a form that is easily understood by the decision makers. Finally, the energy manager must present nonfinancial benefits, such as improved product quality or the possibility of postponing other expenditures.

Accomplish Measures

After approval by management, the energy manager directs the completion of energy conservation retrofit measures. If utility rebates are used, the necessary approvals should be acquired before proceeding with the work. Certain measures require that an architect or engineer prepare plans and specifications for the retrofit. The package of services required usually includes drawings, specifications, assistance in obtaining competitive bids, evaluation of the bids, selection of the best bid, construction observation, final checkout, and assistance in training personnel in the proper application of the revisions.

Maintain Measures

Once energy conservation measures are under way, procedures need to be established to record, frequently and regularly, energy consumption and costs for each building and/or end-use category in a manner consistent with functional cost accountability. Turner et al. (2001) found that consumption increased by more than 5% over two years because of component failures and controls changes after implementing optimum practices in a group of 10 buildings. Additional metering may be needed to monitor energy consumption accurately. Metering can use devices that automatically read and transmit data to a central location, or less expensive metering devices that require regular readings by building maintenance and/or security personnel. Many energy managers find it helpful to collect energy consumption information hourly. Data may also be obtained from the utility. However, if the energy manager is not able to evaluate data as frequently as it is collected, it may be more practical to collect data less frequently. The energy manager should review data while they are current and take immediate action if profiles indicate a trend in the wrong direction. Such trends could be caused by uncalibrated controls, changes in operating practices, or mechanical system failure, all of which are problems that should be isolated and corrected as soon as possible.

BUILDING EMERGENCY ENERGY USE REDUCTION

The need for occasional reductions in energy use during specific periods has increased because of rising energy costs and supply reductions (voluntary or mandatory) or equipment failures. Emergencies include short-term shortages of a particular energy source brought about by natural disasters, extreme weather conditions, utility system equipment disruptions, labor strikes, failures in building systems or equipment, self-imposed cutbacks in energy use, world political activities, or other forces beyond the control of the building owner and operator. Recently, some areas have been subject to electric power supply constraints, with building owners and managers asked or required to cut their electricity consumption for short- or long-term periods. In limited instances, utilities have implemented rolling blackouts, requested voluntary reductions, and asked users to operate emergency generators. This section provides information to help building owners and operators maintain the best operating condition for the facilities during various energy emergencies.

Implementing Energy Reductions

Each building owner, lessor, and operator should use the energy team approach and identify an individual with the necessary authority to review and fit recommendations into a plan for the particular building or complex of buildings. For each type of energy emergency, the responsible party recommends a specific plan to reduce building energy use that still maintains the best building environment under the given circumstances. Implementation of the particular recommendations should then be coordinated through the building operators with assistance from the responsible party and building occupants, as necessary. In some cases, the existing building or energy management systems can be used to implement demand shedding. The plan should be tested occasionally.

Depending on the type of building, its use, the energy source(s) for each function, and local conditions such as climate and availability of other similar buildings, the following steps should be taken in developing a building energy emergency plan:

1. Develop a list of measures applicable to the building.
2. Estimate the amount and type of energy savings for each measure and appropriate combination of measures (e.g., account for air-conditioning savings from reduced lighting and other internal loads). Tabulate demand and usage savings separately for response to different types of emergencies.
3. For various levels of possible energy emergency, develop a plan that maintains the best building environment under the circumstances. Develop the plan so that actions taken can be energy-source-specific. That is, group those actions to be taken to reduce energy consumption for each type of energy used in the building. Include both short- and long-term measures in the plan. Operational changes may be implemented quickly and prove adequate for short-term emergencies.
4. Experiment with the plan developed, record energy consumption and demand reduction data, and revise the plan as necessary. Much of the experimentation may be done on weekends to minimize disruption.
5. Meet with the local utility company(s) to review the plan.
6. Meet with building occupants to review the plan to ensure that actions taken do not cause major disruptions or compromise life safety or security provisions. Establish a procedure for notification of building occupants before actions are taken.
7. Be certain that there is a plan to minimize entrapment of occupants in elevators in case of a rolling blackout or other emergency disruptions.
8. Review the plan with building security and the fire department to ensure that emergency efforts are not hindered by the plan and to ensure that security or emergency people know what to expect (reduced lighting, lower temperatures, elevators out of operation, etc.).
9. When preparing the plan, **do not**
   - Take lighting fixtures out of service that are on night lighting circuits, provide lighting for security cameras, or provide egress lighting during a power failure
   - Remove elevators or lifts from service that will be required for emergency or ADA purposes
   - Reduce ventilation or exhaust in laboratories or other areas where hazardous conditions exist

Some measures can be implemented permanently. Depending on the level of energy emergency and the building priority, the following actions may be considered in developing the plan for emergency energy reduction in the building:

General
- Change operating hours
- Move personnel into other building areas (consolidation)
- Shut off nonessential equipment

Thermal Envelope
- Use all existing blinds, draperies, and window coverings during summer
- Install interior window insulation
- Caulk and seal around unused exterior doors and windows (but do not seal doors required for emergency egress or that may be required by the fire department in an emergency).
- Install solar shading devices in summer
- Seal all unused vents and ducts to outside

HVAC Systems and Equipment
- Modify controls or control set points to raise and lower temperature and humidity as necessary
- Shut off or isolate all nonessential equipment and spaces
- Tune up equipment
- Lower thermostat set points in winter
- Raise chilled water temperature
- Lower hot water temperature (*Note*: Keep hot-water temperature higher than 145°F if a gas boiler is used)
- Reduce or eliminate reheat
- Reduce or eliminate mechanical ventilation and exhaust airflow
- Raise thermostat set points in summer or turn cooling equipment off
- Reduce amount of recooling in summer

Lighting Systems
- Remove lamps or reduce lamp wattage
- Use task lighting where appropriate
- Move building functions to exterior or daylit areas
- Turn off electric lights in areas with adequate natural light
- Lower luminaire height where appropriate
- Clean all lamps and luminaires
- Replace fluorescent ballasts with high-efficiency or multilevel ballasts
- Revise building cleaning and security procedures to minimize lighting periods
- Consolidate parking and turn off unused parking security lighting

Special Equipment

- Take transformers offline during periods of nonuse
- Shut off or regulate the use of vertical transportation systems
- Shut off unused or unnecessary equipment, such as photocopiers, music systems, and computers
- Reduce or turn off hot water supply

Building Operation Demand Reduction

- Sequence or interlock heating or air-conditioning systems
- Disconnect or turn off all nonessential loads
- Turn off some lights
- Preheat or precool prior to the emergency period

REFERENCES

ASHRAE. 1999. Standard methods of measuring and expressing building energy performance. ANSI/ASHRAE *Standard* 105-1984 (RA 99).

ASHRAE. 1996. The HVAC commissioning process. *Guideline* 1-1996.

Claridge, D.E., M. Liu, W.D. Turner, Y. Zhu, M. Abbas, and J.S. Haberl. 1998. Energy and comfort benefits of continuous commissioning in buildings. *Proceedings of the International Conference Improving Electricity Efficiency in Commercial Buildings*, Amsterdam, pp. 12.5.1-12.5.17.

Claridge, D.E. and M. Liu. 2000. HVAC system commissioning. In *Handbook of Heating, Ventilation, and Air Conditioning*, pp. 7.1-7.25. J.F. Kreider, ed. CRC Press, Boca Raton, FL.

DOE/EIA. 1999. Residential energy consumption and survey (RECS) (1997). http://www.eia.doe.gov/emeu/recs/recs97.

DOE/EIA. 1998. Nonresidential buildings energy consumption survey: Commercial buildings consumption and expenditures 1995. DOE/EIA-0318(95).

DOE/EIA. 1997. Nonresidential buildings energy consumption survey: Characteristics of commercial buildings 1995. DOE/EIA-0246(95).

Duff, J.M. 1999. A justification for energy managers. *ASHRAE Transactions* 105(1):988-992.

Fels, M. 1986. Special issue devoted to the Princeton Scorekeeping Method (PRISM). *Energy and Buildings* 9(1 and 2).

Haberl, J.S. and P.S. Komor. 1990a. Improving energy audits—How daily and hourly consumption data can help, Part 1. *ASHRAE Journal* 90(8):26-33.

Haberl, J.S. and P.S. Komor. 1990b. Improving energy audits—How daily and hourly consumption data can help, Part 2. *ASHRAE Journal* 90(9):26-36.

Haasl, T. and T. Sharp. 1999. *A practical guide for commissioning existing buildings*. Portland Energy Conservation, Inc. and Oak Ridge National Laboratory for U.S. DOE, ORNL/TM-1999/34.

Liu, M., D.E. Claridge, J.S. Haberl, and W.D. Turner. 1997. Improving building energy systems performance by continuous commissioning. *Proceedings of the Thirty-Second Intersociety Energy Conversion Engineering Conference*, Honolulu, Vol. 3.

Mazzucchi, R.P. 1992. A guide for analyzing and reporting building characteristics and energy use in commercial buildings. *ASHRAE Transactions* 92(1):1067-1080.

Miller, W. 1999. Resource conservation management. *ASHRAE Transactions* 105(1):993-1002.

PNL (Pacific Northwest Laboratories). 1990. *Architect's and engineer's guide to energy conservation in existing buildings*, Vol. 2, Chapter 1. DOE/RL/ 01830 P-H4.

Sikorski, B.D. and B.A. O'Donnell. 1999. Savings impact of a corporate energy manager. *ASHRAE Transactions* 105(1):977-987.

Spielvogel, L.G. 1984. One approach to energy use evaluation. *ASHRAE Transactions* 90(1B):424-435.

Stewart, R., S. Stewart, and R. Joy. 1984. Energy audit input procedures and forms. *ASHRAE Transactions* 90(1A):350-362.

Turner, W.C. 2001. *Energy management handbook*, 4th ed. Fairmount Press, Lilburn, GA.

Turner, W.D., D. Claridge, S. Deng, S. Cho, M. Liu, T. Hassl, C. Dethell, Jr., and H. Bruner, Jr. 2001. Persistence of savings from continuous commissioning. 9th National Conference on Building Commissioning, Cherry Hill, NJ.

BIBLIOGRAPHY

Hay, J.C. and I. Sud. 1997. Evaluation of proposed ASHRAE energy audit form and procedures. *ASHRAE Transactions*103(2):90-120.

MacDonald, J.M. and D.M. Wasserman. 1989. Investigation of metered data analysis methods for commercial and related buildings. ORNL/CON-279. Oak Ridge National Laboratories, Oak Ridge, TN.