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

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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

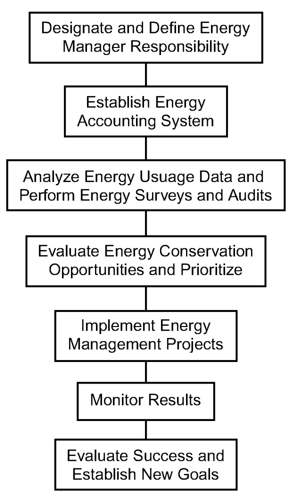

Fig. 1 Energy Management Program

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 kilojoules per square metre 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-metre 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 m^2**	**Floor Area per Bldg, m^2**	**Floor Area per Person, m^2**	**Hours Worked per Week**	**Floor Area per Bldg, m^2**	**Floor Area per Person, m^2**	**Hours Worked per Week**	**Age of Building, Years**
All Buildings	4579	5460	1189	66	62	465	87	50	30.5
Building Floor Space									
93 to 465 m^2	2399	589	242	56	59	232	70	48	30.5
465 to 930 m^2	1035	700	678	92	58	650	116	50	35.5
930 to 2323 m^2	745	1079	1449	83	67	1394	155	53	27.5
2323 to 4645 m^2	213	713	3354	70	72	3252	105	56	26.5
4645 to 9290 m^2	115	740	6438	76	80	6039	122	60	25.5
9290 to 13 580 m^2	48	630	13090	74	87	13006	139	75	26.5
18580 to 46 450 m^2	19	516	27397	68	102	25548	111	80	25.5
Over 46450 m^2	6	494	74917	51	108	65032	76	84	24.5
Principal Building Activity									
Education	309	719	2332	71	51	790	93	45	33.5
Food sales	137	60	437	91	112	232	93	99	25.5
Food service	285	126	446	54	85	279	62	81	22.5
Health care	105	217	2062	48	79	418	60	52	23.5
Lodging	158	336	2118	122	156	836	211	168	30.5
Mercantile and service	1289	1182	920	88	61	372	101	52	35.5
Office	705	973	1384	36	52	372	43	45	23.5
Public assembly	326	367	1124	122	53	557	139	50	31.5
Public order and safety	87	118	1356	69	72	465	81	20	32.5
Religious worship	269	259	966	0	41	743	290	20	31.5
Warehouse and storage	580	788	1356	161	59	511	186	48	18.5
Other	67	93	1384	51	79	465	93	50	26.5
Vacant	261	221	845	347	19	372	93	0	39.5
Year Constructed									
1919 or before	353	341	966	93	56	511	116	48	93.5
1920 to 1945	562	623	1106	85	55	446	93	48	62.5
1946 to 1959	867	864	994	85	54	399	93	48	42.5
1960 to 1969	718	1009	1403	70	62	511	83	50	31.5
1970 to 1979	813	1053	1291	70	68	465	81	51	20.5
1980 to 1989	846	1138	1347	56	67	465	82	50	10.5
1990 to 1992	218	241	1106	51	61	325	62	50	4.5
1993 to 1995	202	191	948	95	71	325	116	50	1.5
Floors									
One	3018	2281	753	90	59	353	86	48	25.5
Two	1002	1312	1310	73	66	650	82	50	35.5
Three	399	681	1709	81	62	883	116	52	57.5
Four to nine	148	817	5518	56	84	2323	93	60	42.5
Ten or more	12	369	30556	36	96	18581	40	68	28.5
Census Region and Division									
Northeast	725	1104	1524	73	67	465	93	52	38.5
Midwest	1139	1331	1171	78	59	418	116	48	36.5
South	1750	1935	1106	73	60	446	83	50	23.5
West	964	1090	1133	60	63	511	77	50	28.5
Climate Zones: 45-Year Average									
<1110 CDD and >3890 HDD	493	474	957	79	60	372	87	50	29.5
3055 to 3890 HDD	975	1356	1394	80	64	465	102	50	39.5
2220 to 3055 HDD	1070	1408	1319	67	64	511	93	50	32.5
Fewer than 2220 HDD	1103	1253	1133	61	61	465	74	50	25.5
>1110 CDD and <2220 HDD	937	969	1031	79	59	446	88	48	25.5
Workers (Main Shift)									
Fewer than 5	2505	1290	511	278	58	279	147	48	31.5
5 to 9	798	584	734	113	61	446	64	50	35.5
10 to 19	625	660	1059	84	63	697	56	50	25.5
20 to 49	400	848	2118	74	72	1514	50	56	26.5
50 to 99	138	644	4673	72	72	3484	52	55	24.5
100 to 249	71	556	7841	56	85	5110	37	65	23.5
250 or more	43	877	20448	30	84	11148	26	63	19.5
Weekly Operating Hours									
39 or fewer	899	570	632	99	14	372	139	8	32.5
40 to 48	1257	1229	975	74	43	446	77	44	32.5
49 to 60	969	1137	1171	64	54	511	77	53	29.5
61 to 84	567	934	1644	71	72	557	93	72	31.5
85 to 167	420	576	1375	83	105	399	77	102	24.5
Open continuously	466	1013	2174	61	168	557	116	168	23.5
Ownership and Occupancy									
Nongovernment owned	4025	4338	1078	72	62	446	87	50	29.5
Owner occupied	3158	3305	1050	71	63	418	93	50	29.5
Nonowner occupied	698	901	1291	67	65	511	77	53	25.5
Unoccupied	170	132	780	602		353	70		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 m^2	Floor Area per Bldg, m^2	Floor Area per Person, m^2	Hours Worked per Week	Floor Area per Bldg, m^2	Floor Area per Person, m^2	Hours Worked per Week	Age of Building, Years
Government owned	553	1122	2025	69	61	650	88	45	35.5
Energy Sources*									
Electricity	4343	5303	1217	69	63	465	86	50	30.5
Natural gas	2478	3544	1431	71	64	557	85	50	35.5
Fuel oil	607	1340	2202	58	64	446	93	50	35.5
District heat	110	526	4785	50	91	1161	88	60	36.5
District chilled water	53	234	4431	53	88	1161	116	65	30.5
Propane	589	496	845	64	66	372	93	50	20.5
Wood	126	65	520	119	53	307	139	50	32.5
Coal		37	2127	186	61	650	650	53	20.5
Other	71	107	1505	62	72	372	70	60	38.5
Space-Heating Energy Sources*									
Electricity	1467	2058	1403	60	66	511	74	50	21.5
Natural gas	2211	2930	1329	73	61	511	85	50	35.5
Fuel oil	504	614	1217	75	61	372	93	50	38.5
District heat	109	521	4775	50	91	1161	88	60	37.5
Propane	301	188	622	0	64	307	139	48	18.5
Wood	103	47	465	118	53	307	139	50	35.5
Other	25	30	1198	68	57	279	70	48	36.5
Primary Space-Heating Energy Source									
Electricity	1007	1254	1245	61	68	465	70	50	20.5
Natural gas	2106	2676	1273	73	61	511	85	50	35.5
Fuel oil	439	391	892	96	59	372	93	50	39.5
District heat	107	491	4580	50	91	1161	88	60	36.5
Propane	260	144	548	0	62	279	139	48	15.5
Other	61	48	0	0		1050	149	51	37.5
Cooling Energy Source*									
Electricity	3293	4437	1347	65	65	465	77	50	28.5
Natural gas	65	122	1867	59	67	883	79	50	40.5
District chilled water	53	234	4404	53	88	1161	116	65	30.5
Water-Heating Energy Sources*		0	0	0		0	0		
Electricity	1684	2142	1273	63	63	465	74	50	22.5
Natural gas	1577	2309	1468	71	68	557	83	54	35.5
Fuel oil	120	200	1663	86	59	399	81	50	39.5
District heat	54	367	6847	51	97	2555	121	82	30.5
Propane	110	95	855	81	94	325	108	88	27.5
Cooking Energy Sources*									
Electricity	487	1138	2341	60	82	511	70	80	23.5
Natural gas	448	1226	2731	61	81	790	74	75	33.5
Propane	123	137	1115	76	84	307	46	84	19.5
Energy End Uses*									
Buildings with space heating	4024	5049	1254	67	63	465	83	50	30.5
Buildings with cooling	3381	4639	1375	65	66	465	77	50	28.5
Buildings with water heating	3486	4790	1375	66	66	465	80	50	30.5
Buildings with cooking	828	1924	2323	60	79	650	74	72	28.5
Buildings with manufacturing	204	362	1774	73	53	743	102	48	29.5
Buildings with elec. generator	247	1242	5035	54	90	1161	77	67	30.5
Percent of Floorspace Heated									
Not heated	554	411	743	222	51	353	116	36	25.5
1 to 50	555	579	1041	136	49	511	151	45	30.5
51 to 99	633	824	1301	72	69	557	81	55	35.5
100	2836	3647	1282	62	64	465	77	50	28.5
Percent of Floorspace Cooled									
Not cooled	1198	821	687	146	49	353	139	41	34.5
1 to 50	930	1396	1505	113	57	650	116	50	35.5
51 to 99	635	1166	1839	60	73	511	70	56	35.5
100	1816	2077	1143	53	68	446	70	50	23.5
Percent Lit When Open									
Zero	36	18	483	0	57	167	87	50	16.5
1 to 50	666	558	836	209	62	446	186	50	35.5
51 to 99	745	900	1208	75	61	465	85	49	34.5
100	2814	3764	1338	61	65	465	77	50	26.5
Electricity not used	318	220	697	288	33	372	395	0	35.5
Percent Lit When Closed									
Zero	1644	1217	743	96	42	372	110	44	30.5
1 to 50	2109	2853	1356	64	59	511	71	50	30.5
51 to 100	87	178	2044	69	74	557	76	60	30.5
Never closed	421	992	2360	61	168	557	116	168	25.5
Electricity not used	318	220	697	868	33	372	395	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

Building Characteristics	Total Number of Buildings, Thousands	Total Floor Space, 10^6 m^2	Mean: Floor Area per Bldg, m^2	Mean: Floor Area per Person, m^2	Mean: Hours Worked per Week	Median: Floor Area per Bldg, m^2	Median: Floor Area per Person, m^2	Median: Hours Worked per Week	Age of Building, Years
Source Table Number	1	1	1	1	1	2	2	2	2
Heating Equipment*									
Heat pumps	394	543	1375	59	63	465	62	48	19.5
Furnaces	1676	1386	827	79	60	446	87	50	34.5
Individual space heaters	1188	1562	1310	74	57	465	105	49	30.5
District heat	115	549	4785	51	91	1161	88	65	35.5
Boilers	610	1556	2555	63	73	836	84	53	39.5
Packaged heating units	1031	1569	1524	67	68	511	70	50	21.5
Other	161	581	3605	52	61	929	121	52	29.5
Cooling Equipment*									
Residential central A/C	878	858	975	62	65	465	70	50	30.5
Heat pumps	457	644	1412	60	65	465	65	48	19.5
Individual A/C	862	1161	1342	82	68	418	105	50	40.5
District chilled water	53	234	4431	53	87	1161	116	65	30.5
Central chillers	109	1028	9420	49	87	4181	93	65	28.5
Packaged A/C units	1431	2474	1728	65	69	604	74	52	23.5
Evaporative coolers	186	228	1226	81	66	446	74	56	30.5
Other	18	88	4822	56	74	1747	84	60	39.5
Lighting Equipment Types*									
Incandescent	2479	3318	1338	67	65	465	85	50	32.5
Standard fluorescent	3885	5015	1291	67	65	465	83	50	29.5
Compact fluorescent	364	1326	3642	52	85	1050	70	66	23.5
High-intensity discharge	393	1511	3846	69	72	1161	99	53	27.5
Halogen	303	898	2973	55	78	743	85	60	28.5
Other	30	51	1737	43	44	186	139	45	32.5
Water-Heating Equipment*									
Central system	2671	2941	1106	70	65	446	77	50	31.5
Distributed system	742	1532	2062	60	71	883	81	55	25.5
Combination central/distributed	73	317	4311	64	73	929	93	50	26.5
Personal Computers/Terminals									
None	2039	1168	576	146	54	325	139	45	31.5
1 to 4	1408	1059	753	91	68	399	84	53	30.5
5 to 9	437	499	1143	76	66	557	56	50	23.5
10 to 19	344	552	1607	74	61	790	52	50	25.5
20 to 49	198	655	3307	76	69	1858	64	50	25.5
50 to 99	81	459	5686	62	71	3716	58	54	29.5
100 to 249	46	482	10489	57	84	6039	56	60	24.5
250 or more	26	586	22380	31	92	13006	33	70	18.5
Energy-Related Functions*									
Communal food preparation	828	1924	2323	60	79	650	74	72	28.5
Computer room	234	1198	5110	47	72	1514	61	50	19.5
Large hot water activities	243	627	2583	64	99	743	82	85	31.5
Shell Conservation Features*									
Roof/ceiling insulation	3380	4307	1273	65	64	465	81	50	26.5
Wall insulation	2372	2944	1245	61	62	465	77	50	21.5
Storm or multiple glazing	1897	2683	1412	63	66	511	76	50	26.5
Tinted, reflective, shaded glass	1202	2252	1877	54	66	557	70	50	21.5
Shading or awnings	2271	3457	1524	62	65	557	76	50	28.5
HVAC Conservation Features*									
Variable-volume system	327	1252	3828	51	76	1161	70	50	23.5
Economizer cycle	461	1538	3335	53	75	929	74	57	21.5
HVAC maintenance	2403	4007	1672	62	68	557	77	51	28.5
Other efficient equipment	196	600	3019	53	66	650	64	55	23.5
Lighting Conservation Features*									
Specular reflectors	749	1660	2220	59	69	557	93	50	28.5
Energy efficient ballasts	1363	2636	1932	57	67	557	70	50	25.5
Natural lighting sensors	237	597	2527	58	83	743	82	63	28.5
Occupancy sensors	131	554	4236	48	66	1161	103	50	38.5
Time clock	467	1232	2638	55	73	743	67	55	27.5
Manual dimmer switches	501	1213	2425	61	69	883	102	55	26.5
Other	79	263	3326	59	71	929	64	60	20.5
Energy Conservation Features*									
Any conservation feature	4075	5136	1263	68	63	465	84	50	29.5
Building shell	3906	4942	1263	67	63	465	81	50	28.5
HVAC	2529	4149	1644	63	68	557	79	50	28.5
Lighting	2084	3580	1719	61	67	557	81	51	28.5
Off Hour Equipment Reduction*									
Heating	3211	3561	1106	69	52	446	81	48	30.5
Cooling	2707	3308	1226	66	54	465	77	50	28.5
Lighting	3753	4175	1115	70	52	465	83	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. *Source*: DOE/EIA 0318(95) 1998

Source Table Number	1	1	3	4	10	10	19	19	21	21	27	31	33	33	33	33	33
			Major Fuels		Electricity				Nat. Gas		Fuel Oil,	Distr. Heat,	Energy End Use				
Building Characteristics	Total No. Bldgs., Thousand	Total Floor Space, 10^6 m^2	MJ/m^2	\$/m^2	kWh/m^2	Med. kWh/m^2	Med. Peak W/m^2	Load Factor	MJ/m^2	Med. MJ/m^2	L/m^2	MJ/m^2	Total	Space Heat	Cool	Ventilation	Water Heat
All Buildings	4579	5460	1028	12.81	144	78	58	0.253	564	451	4.9	1037	1028	329	68	32	157
Building Floor Space																	
93 to 465 m^2	2399	589	1268	19.70	201	91	86	0.239	990	579	13.9		1268	449	79	33	110
465 to 930 m^2	1035	700	940	11.52	107	67	56	0.248	668	330	11.4		940	437	50	19	126
930 to 2323 m^2	745	1079	805	10.33	108	60	35	0.246	521	333	9.4	1140	805	311	55	19	103
2323 to 4645 m^2	213	713	931	12.16	130	79	39	0.295	486	309	6.9	932	931	320	76	24	132
4645 to 9290 m^2	115	740	995	11.95	145	96	34	0.337	480	266	4.5	892	995	307	79	36	146
9290 to 13580 m^2	48	630	1151	12.49	161	133	38	0.393	583	323	2.9	830	1151	302	70	37	223
18580 to 46450 m^2	19	516	1301	14.10	174	113	33	0.458	592	294	2.4	856	1301	273	76	51	286
Over 46450 m^2	6	494	1099	13.24	175	142	34	0.521	374	100	1.2	757	1099	210	68	44	204
Principal Building Activity																	
Education	309	719	901	9.90	90	66	46	0.210	467	438	6.9	931	901	372	55	18	198
Food sales	137	60	2424	44.24	582	598	158	0.463	484	360			2424	312	152	50	103
Food service	285	126	2788	38.32	388	274	136	0.333	1743	1535			2788	351	221	60	312
Health care	105	217	2730	24.33	285	169	63	0.253	1624	753	4.1	1206	2730	627	112	82	715
Lodging	158	336	1446	15.18	164	126	53	0.364	831	654		1020	1446	258	92	19	584
Mercantile and service	1289	1182	868	11.84	127	74	53	0.249	513	459	5.7		868	347	66	28	58
Office	705	973	1104	16.25	203	131	65	0.285	405	377	2.4	543	1104	276	103	59	99
Public assembly	326	367	1291	13.56	137	62	59	0.197	589	518	3.7		1291	609	72	40	199
Public order and safety	87	118	1104	13.13	122	42	54	0.280	495	495	9.0		1104	316	69	26	266
Religious worship	269	259	425	5.17	37	31	45	0.092	318	311	8.6		425	269	22	10	36
Warehouse and storage	580	788	435	6.03	69	34	24	0.265	254	241	3.7		435	178	10	3	23
Other	67	93	1955	20.02	238	122	79	0.227	936	402			1955	677	106	94	174
Vacant	261	221	244	2.91	42	26	26	0.189	441	238	6.5		244	135	7	3	27
Year Constructed																	
1919 or before	353	341	902	9.69	89	52	43	0.231	566	541	6.9	614	902	388	30	18	114
1920 to 1945	562	623	860	9.04	88	55	50	0.240	510	459	9.4	1083	860	420	39	18	122
1946 to 1959	867	864	1010	11.41	112	70	46	0.231	668	501	8.1	663	1010	422	50	24	160
1960 to 1969	718	1009	1071	13.02	140	78	63	0.266	578	539	5.3	972	1071	343	65	31	191
1970 to 1979	813	1053	1128	14.64	172	95	67	0.259	588	371	2.9	1018	1128	295	82	41	179
1980 to 1989	846	1138	982	13.99	171	108	65	0.269	443	323	2.0		982	225	89	36	131
1990 to 1992	218	241	1301	16.68	202	101	86	0.292	669	330	1.2		1301	302	95	40	195
1993 to 1995	202	191	1047	14.21	188	90	53	0.295	547	483	4.1		1047	276	90	36	133
Floors																	
One	3018	2281	854	11.84									854	295	64	24	90
Two	1002	1312	902	11.73									902	320	65	24	124
Three	399	681	1045	11.73									1045	395	58	26	170
Four to nine	148	817	1588	16.25									1588	414	85	55	343
Ten or more	12	369	1288	16.58									1288	262	83	64	248
Census Region and Division																	
Northeast	725	1104	989	14.96	121	56	40	0.260	461	330	9.0	840	989	368	45	23	161
New England	204	292	991	13.78	101	62	57	0.295	568	463	11.4	1111	991	428	37	18	173
Middle Atlantic	521	812	989	15.39	127	56	35	0.246	435	325	7.7	801	989	345	49	24	158
Midwest	1139	1331	1187	11.30	127	73	55	0.238	760	679	1.6	1004	1187	530	49	28	177
East North Central	739	897	1161	11.30	119	60	48	0.238	740	705	2.0	1032	1161	517	49	25	182
West North Central	401	434	1241	11.41	143	87	73	0.228	806	617	1.2	955	1241	558	49	34	168
South	1750	1935	918	11.52	160	91	62	0.261	476	333	3.3	884	918	204	95	36	119
South Atlantic	676	880	926	12.38	166	91	72	0.294	453	396	4.1	1541	926	196	100	37	106
East South Central	477	457	963	10.66	160	105	71	0.253	573	435	2.4		963	277	85	31	133
West South Central	597	598	871	10.76	154	84	56	0.249	428	250			871	161	99	37	129
West	964	1090	1070	14.85	159	79	72	0.244	524	345	0.8		1070	266	62	35	193
Mountain	319	358	1264	12.38	150	70	73	0.244	630	479			1264	463	67	37	243
Pacific	646	732	975	16.04	165	95	72	0.244	469	304	0.8	778	975	169	61	35	168
Climate Zones: 45-Year Average																	
<1110 CDD and >3890 HDD	493	474	1111	10.55	114	56	62	0.263	780	570	8.1	1212	1111	537	35	20	161
3055 to 3890 HDD	975	1356	1238	13.13	126	60	54	0.238	711	579	5.3	1486	1238	550	47	27	207
2220 to 3055 HDD	1070	1408	1054	13.35	152	67	43	0.251	550	454	5.7	741	1054	335	61	33	151
Fewer than 2220 HDD	1103	1253	907	13.45	154	100	72	0.257	428	327		1031	907	181	77	33	140
>1110 CDD and <2220 HDD	937	969	813	11.84	161	94	58	0.253	397	260			813	103	110	37	116
Workers (Main Shift)																	
Fewer than 5	2505	1290	645	8.50	84	57	57	0.218	501	466	10.2		645	305	28	15	92
5 to 9	798	584	918	11.84	113	91	57	0.268	601	484	8.1		918	410	52	20	100
10 to 19	625	660	982	12.70	130	102	66	0.253	635	342	11.0		982	362	67	23	112
20 to 49	400	848	1080	13.89	146	139	59	0.314	572	452	7.7	1176	1080	346	77	25	146
50 to 99	138	644	1032	12.59	142	114	45	0.330	506	333	4.9	1140	1032	313	77	26	184
100 to 249	71	556	1230	14.53	177	163	53	0.366	572	367	3.7	820	1230	311	97	41	229
250 or more	43	877	1518	17.76	234	177	55	0.454	579	309	1.2	822	1518	292	101	72	267
Weekly Operating Hours																	
39 or fewer	899	570	333	4.20	39	29	52	0.142	384	330	8.6		333	191	18	8	34
40 to 48	1257	1229	754	9.58	97	73	48	0.217	472	385	6.1		754	359	49	22	60
49 to 60	969	1137	870	11.63	129	74	50	0.240	416	351	6.1	917	870	334	58	33	76
61 to 84	567	934	899	12.49	137	110	55	0.276	438	519	4.1	779	899	280	72	31	98
85 to 167	420	576	1522	20.13	223	338	110	0.362	677	824	4.5		1522	386	101	41	233
Open continuously	466	1013	1768	18.94	229	137	62	0.374	928	629	3.3	966	1768	377	108	50	444
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. *Source*: DOE/EIA 0246(95) 1998

Source Table Number	33	33	33	33	33	35	35	35	35	35	35	35	35	35	35	37	37	37	37	37
	Sum Major Fuels, MJ/m^2					Energy End Use: Electricity, MJ/m^2										Natural Gas, MJ/m^2				
Building Characteristics	Lighting	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	232	42	35	65	69	519	23	68	32	9	240	3	36	65.9	42.0	579	325	156	59	40
Building Floor Space																				
93 to 465 m^2	258	101	118	61	58	726	57	84	35	24	275	12	126	64.7	46.6	1017	646	151	193	
465 to 930 m^2	154	49	28	43	33	383	30	52	20	11	165	2	31	45.4	25.0	686	487	111	78	
930 to 2323 m^2	167	30	28	49	42	386	22	56	20	7	171	2	30	51.1	27.3	535	359	112	43	22
2323 to 4645 m^2	210	24	28	57	59	470	23	75	24	9	211	2	30	56.8	37.5	500	301	140	32	
4645 to 9290 m^2	242	23	24	69	68	522	11	78	36	7	244	2	24	70.4	47.7	493	295	142	28	27
9290 to 13 580 m^2	284	35	16	82	101	579	15	70	39	5	291	2	17	84.0	55.6	597	261	229	48	60
18 580 to 46 450 m^2	311	52	18	97	135	628	12	69	51	6	311	3	18	96.5	57.9	608	187	245	69	104
Over 46 450 m^2	325	40	25	79	103	631	9	62	47	6	341	5	26	84.0	52.2	384	112	150	50	72
Principal Building Activity																				
Education	179	16	11	17	33	326	20	53	18	9	181	2	11	17.0	11.4	480	290	142	18	31
Food sales	385	64	1259	15	84	2097	0	152	50	28	385	10	1259	14.8	69.3	496	276	112	85	22
Food service	420	880	359	30	156	1395	41	220	60	41	420	70	359	29.5	153.3	1791	379	315	1092	
Health care	446	127	53	176	391	1027	16	104	82	10	446	3	53	176.0	136.3	1668	512	677	164	315
Lodging	263	75	26	43	85	591	36	91	19	39	265	6	26	43.2	64.7	854	153	584	90	27
Mercantile and service	266	17	10	33	42	457	23	66	28	6	268	2	10	32.9	21.6	527	419	59	23	26
Office	319	12	5	171	59	732	23	100	59	7	319	1	5	172.6	47.7	417	278	102	18	18
Public assembly	249	32	20	27	43	492	31	69	40	10	250	5	20	28.4	37.5	605	451	107	40	
Public order and safety	186		2	66	144	437	2	69	26	0	186		2	65.9	81.8	508	228	175		
Religious worship	57		7	5	12	133	15	22	10	5	57	2	7	4.5	11.4	326	282	39	6	
Warehouse and storage	111		19	50	39	250	9	11	3	2	118		20	53.4	30.7	261	231	19	1	11
Other	303		8	173	408	857	25	98	95	2	304		8	173.7	151.0	961	428	133		380
Vacant	41		2	6	22	150	11	11	5	1	72		5	10.2	34.1	452	362	79		
Year Constructed																				
1919 or before	169	45	15	36	85	320	8	31	19	7	176	3	16	37.5	23.8	581	351	95	59	
1920 to 1945	140	20	18	37	47	318	14	41	19	5	151	2	20	40.9	26.1	524	372	97	28	27
1946 to 1959	176	34	31	52	59	404	22	50	24	9	179	2	31	53.4	32.9	686	447	154	45	37
1960 to 1969	232	45	34	60	69	503	20	65	32	10	236	2	34	61.3	40.9	593	298	195	66	36
1970 to 1979	291	36	42	76	85	621	25	78	42	10	293	5	42	76.1	48.8	604	329	169	49	57
1980 to 1989	267	48	34	86	67	618	26	91	37	10	275	5	35	88.6	50.0	455	217	141	73	25
1990 to 1992	326	106	64	90	84	728	25	93	40	9	332	9	65	92.0	63.6	687	273	228	151	
1993 to 1995	258	37	84	56	77	677	0	92	39	11	278	7	91	60.2	46.6	562	283	174	58	47
Floors																				
One	193	49	52	47	42	477	30	67	25	10	203	5	55	48.8	34.1	528	345	93	76	12
Two	208	27	31	52	52	447	19	65	24	10	210	2	31	52.2	32.9	555	352	144	36	23
Three	211	32	16	59	76	445	18	58	26	10	215	2	16	60.2	39.7	581	355	140	39	48
Four to nine	352	53	20	114	150	719	12	79	56	8	354	3	20	114.7	69.3	761	274	304	72	111
Ten or more	336	47	16	123	109	715	19	74	65	5	344	3	17	126.1	63.6	518	168	212	68	69
Census Region and Division																				
Northeast	201	31	34	51	73	433	18	43	24	8	209	3	36	53.4	36.3	474	260	116	45	52
New England	182	22	22	47	62	365	9	35	18	11	186	3	22	47.7	30.7	583	326	168	40	49
Middle Atlantic	209	34	39	52	76	458	22	47	25	8	218	0	41	54.5	38.6	446	244	103	47	52
Midwest	213	40	27	58	64	457	18	49	30	9	220	3	27	60.2	38.6	781	541	160	48	33
East North Central	198	50	28	52	59	429	17	49	26	9	202	5	30	53.4	37.5	760	511	164	58	27
West North Central	248	20	24	69	72	513	20	51	35	8	259	2	25	72.7	40.9	828	606	152	25	
South	242	45	39	67	68	578	24	97	37	11	250	3	40	69.3	46.6	488	231	150	70	36
South Atlantic	252	52	34	75	68	595	25	98	39	12	257	3	35	76.1	48.8	466	193	134	97	42
East South Central	241	25	42	60	70	578	36	89	32	11	254	5	44	63.6	43.2	589	342	175	32	41
West South Central	228	51	43	59	61	554	14	102	39	8	237	3	45	61.3	44.3	439	191	150	72	26
West	268	49	39	82	74	575	27	62	36	8	271	3	40	82.9	43.2	537	233	192	68	45
Mountain	246	32	36	77	61	541	22	67	37	8	249	3	36	77.2	39.7	647	402	171	42	33
Pacific	278	58	41	85	81	593	30	61	35	8	283	5	41	86.3	45.4	481	146	202	81	52
Climate Zones: 45-Year Average																				
<1110 CDD and >3890 HDD	201	25	26	52	52	411	20	36	22	8	208	2	27	53.4	34.1	801	584	165	32	
3055 to 3890 HDD	211	39	34	59	66	452	20	44	28	10	215	3	34	60.2	39.7	730	489	157	47	36
2220 to 3055 HDD	252	37	30	70	84	546	26	60	34	7	262	3	31	72.7	43.2	564	309	137	56	62
Fewer than 2220 HDD	245	50	42	70	69	554	22	77	33	9	250	5	43	71.5	44.3	439	178	162	65	35
>1110 CDD and <2220 HDD	231	52	41	62	60	583	20	115	40	12	242	3	43	65.9	43.2	409	119	164	97	30
Workers (Main Shift)																				
Fewer than 5	108	10	39	22	26	301	27	32	17	10	120	1	43	25.0	22.7	514	382	103	19	
5 to 9	174	32	44	40	47	405	28	51	20	12	174	5	44	39.7	29.5	618	462	93	39	24
10 to 19	203	79	40	53	39	468	27	67	23	12	203	7	40	53.4	34.1	652	417	118	110	7
20 to 49	234	69	49	61	70	526	24	77	25	9	234	5	49	62.5	40.9	588	323	142	89	34
50 to 99	253	33	26	60	59	513	16	77	27	6	256	3	26	61.3	42.0	520	265	194	43	18
100 to 249	303	34	17	92	104	634	16	93	41	9	304	2	17	92.0	57.9	587	283	200	44	60
250 or more	414	52	25	140	156	843	15	93	72	7	416	5	25	139.7	71.5	595	186	228	67	114
Weekly Operating Hours																				
39 or fewer	41	5	6	10	17	141	15	23	10	3	50		8	13.6	17.0	394	332	48	11	
40 to 48	141	12	10	69	33	349	24	49	22	6	142	1	10	69.3	27.3	486	393	67	18	8
49 to 60	208	9	12	85	52	466	23	58	33	6	210	1	12	86.3	35.2	427	323	70	12	22
61 to 84	248	47	30	47	49	493	23	69	31	8	249	3	30	46.6	34.1	450	279	89	61	22
85 to 167	363	134	134	52	77	802	22	101	41	14	366	15	135	53.4	56.8	695	323	160	186	26
Open continuously	390	78	56	90	176	826	23	103	51	19	397	5	57	90.8	77.2	953	295	429	100	128
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. *Source*: DOE/EIA 0318(95) 1998

Source Table Number	1	1	3	4	10	10	19	19	21	21	27	31	33	33	33	33	33
			Major Fuels		Electricity				Nat. Gas		Fuel Oil,	Distr. Heat,	Energy End Use				
Building Characteristics	Total No. Bldgs., Thousand	Total Floor Space, 10^6 m^2	MJ/m^2	$\$/m^2$	kWh/m^2	Med. kWh/m^2	Med. Peak W/m^2	Load Factor	MJ/m^2	Med. MJ/m^2	L/m^2	MJ/m^2	Total	Space Heat	Cool	Ventilation	Water Heat
Nongovernment owned	4025	4338	961	12.59	141	78	60	0.255	538	441	4.5	1163	961	293	67	30	139
Owner occupied	3158	3305	1049	13.02	144	74	60	0.253	575	451	4.5	1257	1049	326	69	31	165
Nonowner occupied	698	901	757	12.38	133	105	62	0.267	397	386	4.1		757	206	67	26	65
Unoccupied	170	132	125	1.72	30	6	17	0.184		579			125	59		1	
Government owned	553	1122	1290	13.78	157	83	47	0.246	664	522	5.3	913	1290	468	70	40	225
Federal	76	163	1724	18.62									1724	499	84	78	221
State	99	265	1744	18.08									1744	537	97	56	370
Local	379	694	1015	10.98									1015	434	58	25	170
Space Vacant for at Least 3 Months																	
Yes	787	1472	803	10.33	128	55	34	0.144	464	368	2.0	588	803	233	60	30	102
No	3791	3988	1112	13.67	150	82	62	0.171	598	454	6.1	1209	1112	365	70	32	177
Energy Sources*																	
Electricity	4343	5303	1057	13.13	144	78	58	0.164	563	451	4.9	1038	1057	337	69	32	161
Natural gas	2478	3544	1170	13.56	141	80	55	0.166	564	451	2.9	914	1170	392	70	33	187
Fuel oil	607	1340	1364	15.07	171	54	47	0.178	663	325	4.9	823	1364	385	77	47	262
District heat	110	526	2110	20.13	203	110	54	0.223	688	134	1.2	1037	2110	731	57	64	472
District chilled water	53	234	2439	21.64	236	110	43	0.228	871	273	0.8	1286	2439	772	18	90	538
Propane	589	496	834	12.38	132	64	62	0.177	634	478	11.4		834	227	65	27	216
Other	213	217	1257	12.49	117	55	47	0.145	477	418	4.9		1257	517	55	26	
Energy End Uses*																	
Buildings with space heating	4024	5049	1096	13.45	149	83	60	0.169	564	452	4.9	1039					
Buildings with cooling	3381	4639	1120	13.99	157	97	62	0.180	561	435	4.1	1047					
Buildings with water heating	3486	4790	1121	13.89	153	94	63	0.176	572	454	4.5	1006					
Buildings with cooking	828	1924	1374	16.47	191	145	88	0.200	676	661	3.7	984					
Buildings with manufacturing	204	362	895	11.09	127	68	41	0.155	481	542	6.1						
Buildings with elec. generation	247	1242	1449	16.79	203	131	54	0.223	618	463	2.4	849					
Space-Heating Energy Sources*																	
Electricity	1467	2058	978	13.78			74	0.179					978	221	91	35	133
Natural gas	2211	2930	1115	12.92					591	453			1115	418	67	31	165
Fuel oil	504	614	1241	13.13							9.8		1241	493	53	31	235
District heat	109	521	2099	20.13								1041	2099	737	57	64	467
Propane		188	725	13.02									725	110	64	26	98
Other	135	98	828	9.80									828	219	49	24	123
Electricity					174	117	74	0.266									
Electricity main					189	139	86	0.264									
Electricity secondary					151	75	55	0.268									
Other excluding electricity					130	72	52	0.248									
Buildings without space heating					69	19	24	0.230									
Primary Space-Heating Energy Source																	
Electricity	1007	1254	846	13.78	189	139	86	0.162		315	1.2		846	97	108	36	99
Natural gas	2106	2676	1119	12.81	131	79	53	0.160	619	468	0.8		1119	432	65	30	162
Fuel oil	439	391	824	10.01	70	44	42	0.173	134	74	13.4		824	408	32	14	150
District heat	107	491	2097	20.34	206	110	54	0.223	640	89	1.2	1057	2097	728	57	64	463
Propane	260	144	521	12.27	133	61	72	0.197		459			521		56	24	25
Other	61	48	358	5.81	74	19	33	0.248		505			358	64		15	45
Cooling Energy Source*																	
Electricity	3293	4437	1078	13.89	155	96	62	0.256					1078	320	82	34	160
Natural gas	65	122	1900	19.05					977	726			1900	584	92	60	285
District chilled water	53	234	2439	21.64									2439	772	18	90	538
Water-Heating Energy Sources*																	
Electricity	1684	2142	816	12.49	156	100	63	0.267					816	237	77	33	36
Natural gas	1577	2309	1265	14.10					673	516			1265	411	76	33	246
Fuel oil	120	200	1070	11.63							15.1		1070	370	51	15	351
District heat	54	367	2191	20.56								1133	2191	667	60	64	587
Propane	110	95	836	16.68									836	129	98	32	52
Cooking Energy Sources*																	
Electricity	487	1138	1387	17.01	214	169	103	0.336					1387	300	101	47	235
Natural gas	448	1226	1462	16.47					671	752			1462	323	92	40	302
Propane	123	137	957	17.87									957	191	110	35	110
Percent of Floorspace Heated																	
Not heated	554	411	191	4.41	69	19	24	0.230		87			191		19	7	
1 to 50	555	579	451	7.00	74	51	30	0.205	257	284	4.1		451	157	30	12	27
51 to 99	633	824	1030	14.21	157	79	57	0.269	500	435	4.5	604	1030	301	77	35	141
100	2836	3647	1214	14.32	158	95	66	0.260	620	479	4.9	1114	1214	400	77	36	198
Percent of Floorspace Cooled																	
Not cooled	1198	821	512	5.92	58	29	27	0.218					512	273		6	77
1 to 50	930	1396	789	8.50	75	56	35	0.225					789	399	32	11	106
51 to 99	635	1166	1231	15.82	183	105	64	0.272					1231	304	92	45	203
100	1816	2077	1279	16.79	196	128	75	0.272					1279	318	104	48	196
Percent Lit When Open																	
Zero	36	18				20	14	0.158									
1 to 50	666	558	581	7.64	66	53	39	0.213					581	283	28	12	73
51 to 99	745	900	1036	13.02	133	81	62	0.263					1036	336	62	31	169
100	2814	3764	1150	14.32	160	91	62	0.261					1150	350	78	36	175
Electricity not used	318	220	123	1.08		3	7	0.152					123	85		1	15
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. *Source*: DOE/EIA 0246(95) 1998

Source Table Number	33	33	33	33	33	35	35	35	35	35	35	35	35	35	35	37	37	37	37	37
	Sum Major Fuels, MJ/m²					Energy End Use: Electricity, MJ/m²										Natural Gas, MJ/m²				
Building Characteristics	Lighting	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																				
Owner occupied	229	51	43	64	70	520	23	68	32	10	233	5	44	63.6	42.0	591	315	167	70	39
Nonowner occupied	218	33	28	67	50	480	24	66	26	8	223	2	28	68.1	35.2	408	265	75	49	
Unoccupied			1	2	12	110		10	3		52	0	3	5.7	28.4					
Government owned	276	26	20	74	89	566	19	69	41	9	282	3	20	74.9	46.6	682	405	179	35	61
Federal	468	19	19	169	165	969	14	85	82	8	489	0	20	177.2	86.3	677	296	165	30	
State	383	37	23	98	139	773	0	92	57	11	388	3	23	99.9	61.3	807	347	268	56	136
Local	191	24	20	42	52	395	15	58	25	8	194	2	20	42.0	31.8	644	438	154	30	23
Space Vacant for at Least 3 Months																				
Yes	208	26	14	61	68	461	15	61	32	6	225	2	15	67.0	39.7	477	268	119	40	50
No	241	48	43	66	69	538	25	70	32	10	244	5	43	65.9	43.2	614	345	167	66	36
Energy Sources*																				
Electricity	240	43	36	66	72	519	23	68	32	9	240	3	36	65.9	42.0	579	325	154	59	40
Natural gas	243	62	35	64	84	509	12	68	33	7	244	3	35	64.7	43.2	579	325	156	59	40
Fuel oil	299	47	23	92	133	617	12	73	48	8	301	3	23	92.0	57.9	681	267	250	67	98
District heat	379	41	24	124	217	732	3	51	64	10	380	3	24	123.8	71.5	706		194	90	
District chilled water	458	55	28	151	330	847	3	17	90	9	458	5	28	151.0	86.3	895	132	210	98	455
Propane	199	22	52	43	76	476	24	65	27	14	199	9	52	43.2	43.2	651	353	184	42	72
Other	204	33	18	48		422	10	56	27	9	213	3	19	50.0	32.9	489	229	127	45	
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	266	49	40	75	69															
Natural gas	232	48	34	62	58															
Fuel oil	231	30	18	64	86															
District heat	379	40	24	124	206															
Propane	207	17	87	43	74															
Other	173	30	25	37																
Electricity																				
Electricity main																				
Electricity secondary																				
Other excluding electricity																				
Buildings without space heating																				
Primary Space-Heating Energy Source																				
Electricity	267	55	45	78	61															
Natural gas	231	48	34	61	57															
Fuel oil	124	14	14	30	42															
District heat	384	37	24	126	210															
Propane	192		98	36	64															
Other	117	9	20	16	28															
Cooling Energy Source*																				
Electricity	252	49	39	70	70															
Natural gas	410	72	31	104	261															
District chilled water	458	55	28	151	330															
Water-Heating Energy Sources*																				
Electricity	246	26	34	72	53															
Natural gas	252	69	43	62	70															
Fuel oil	146	17	19	34	65															
District heat	374	50	26	122	240															
Propane	261			31	90															
Cooking Energy Sources*																				
Electricity	359	100	74	73	99															
Natural gas	300	177	64	58	107															
Propane	266	28	111	30	75															
Percent of Floorspace Heated																				
Not heated	79		20	18	26	246		28	9	3	119	1	31	26.1	27.3					
1 to 50	115	16	26	36	32	267	18	28	12	5	117	1	26	36.3	23.8	263	194	33	26	
51 to 99	265	44	40	68	58	564	28	75	35	10	266	3	40	68.1	38.6	513	298	131	58	26
100	260	50	37	74	83	569	23	75	36	10	261	5	37	73.8	46.6	636	351	176	62	47
Percent of Floorspace Cooled																				
Not cooled	90	7	12	22	26	210	22		7	8	109	1	16	27.3	20.4	609	457	111	18	
1 to 50	134	11	17	34	44	273	15	32	11	34	134	1	17	34.1	22.7	541	419	85	14	22
51 to 99	315	57	40	83	91	659	19	89	45	9	315	5	40	82.9	54.5	561	254	189	72	48
100	309	68	53	91	91	706	28	102	48	14	309	6	53	90.8	54.5	613	275	194	92	52
Percent Lit When Open																				
Zero																				
1 to 50	82	11	24	28	40	235	25	28	12	5	82	1	24	28.4	29.5	414	304	81	16	
51 to 99	218	39	30	69	82	483	19	61	31	9	218	2	30	69.3	42.0	571	321	146	50	52
100	273	50	40	73	75	579	23	76	36	10	273	5	40	72.7	44.3	606	328	169	68	41
Electricity not used	2			3	7				2		7			10.2	22.7					
Percent Lit When Closed																				

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

Consumption shown is on an annual basis. *Source*: DOE/EIA 0318(95) 1998

Source Table Number	1	1	3	4	10	10	19	19	21	21	27	31	33	33	33	33	33
			Major Fuels		Electricity				Nat. Gas		Fuel Oil,	Distr. Heat,	Energy End Use				
Building Characteristics	Total No. Bldgs., Thou-sand	Total Floor Space, 10^6 m²	MJ/m²	\$/m²	kWh/m²	Med. kWh/m²	Med. Peak W/m²	Load Factor	MJ/m²	Med. MJ/m²	L/m²	MJ/m²	Total	Space Heat	Cool	Venti-lation	Water Heat
Zero	1644	1217	652	8.50	82	51	45	0.217					652	317	36	18	51
1 to 50	2109	2853	975	13.02	138	105	65	0.263					975	342	69	31	110
51 to 100	87	178	1233	17.33	233	95	43	0.260					1233	199	115	51	153
Never closed	421	992	1804	19.38	229	137	62	0.374					1804	385	110	51	452
Electricity not used	318	220	123	1.08		3	7	0.152					123	85		1	
Energy Conservation Features																	
Any conservation feature	4075	5136	1080	13.35													
Building shell	3906	4942	1096	13.56													
HVAC	2529	4149	1175	14.42													
Lighting	2084	3580	1182	14.64													
Heating Equipment*																	
Heat pumps													972	169	102	33	181
Furnaces													876	366	52	23	84
Individual space heaters													993	352	61	28	134
District heat													2043	700	56	62	445
Boilers													1282	457	73	35	251
Packaged heating units													985	229	92	32	124
Other													1217	246	94	55	179
Cooling Equipment*																	
Residential central A/C													1163	386	82	32	174
Heat pumps													982	183	102	34	166
Individual A/C													1091	409	62	19	221
District chilled water													2439	772	18	90	538
Central chillers													1511	329	114	65	298
Packaged A/C units													1102	295	90	36	146
Evaporative coolers													1167	245	74	39	243
Other													1263	321	67	43	161
Lighting Equipment Types*																	
Incandescent													1117	344	72	33	201
Standard fluorescent													1095	346	73	34	167
Compact fluorescent													1389	340	95	49	259
High-intensity discharge													1169	351	74	36	199
Halogen													1289	379	81	43	233
Other													983	141	101	53	126
Water-Heating Equipment*																	
Central system													1236	407	74	35	213
Distributed system													848	231	75	30	85
Combination central/distributed													1372	374	77	43	307
Personal Computers/Terminals																	
None													602	271	30	14	83
1 to 4													919	341	56	22	107
5 to 9													1104	412	77	24	134
10 to 19													1069	371	72	23	192
20 to 49													1040	324	81	28	173
50 to 99													1117	318	86	33	181
100 to 249													1280	317	91	50	237
250 or more													1683	338	106	86	277
Commercial Refrigeration*																	
Any equipment													1385	309	98	44	242
Walk in units													1518	299	109	49	270
Cases and cabinets													1408	312	101	44	248
None													812	341	50	24	104
Shell Conservation Features*																	
Roof/ceiling insulation													1122	346	75	34	176
Wall insulation													1105	305	79	35	183
Storm or multiple glazing													1209	374	75	36	206
Tinted, reflective, shaded glass													1214	308	89	45	192
Shading or awnings													1151	338	77	37	187
HVAC Conservation Features*																	
Variable-volume system													1455	320	97	60	274
Economizer cycle													1448	377	97	52	261
HVAC maintenance													1188	360	79	37	193
Other efficient equipment													1365	335	92	51	245
Lighting Conservation Features*																	
Specular reflectors													1229	360	81	40	198
Energy efficient ballasts													1248	349	85	42	203
Natural lighting sensors													1330	393	93	39	231
Occupancy sensors													1375	335	84	50	249
Time clock													1170	253	97	47	187
Manual dimmer switches													1427	375	95	52	252
Other													1328	345	95	49	208
Off-Hour Equipment Reduction*																	
Heating													896	337	60	28	100
Cooling													910	321	68	31	100
Lighting													897	332	61	28	95

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. *Source*: DOE/EIA 0246(95) 1998

Source Table Number	33	33	33	33	33	35	35	35	35	35	35	35	35	35	35	37	37	37	37	37
	Sum Major Fuels, MJ/m^2					Energy End Use: Electricity, MJ/m^2										Natural Gas, MJ/m^2				
Building Characteristics	Light-ing	Cook-ing	Refr.	Office Equip	Other	Total	Space Heat	Cool	Venti-lation	Water Heat	Light-ing	Cook-ing	Refr.	Office Equip	Other	Total	Space Heat	Water Heat	Cook-ing	Other
Zero	122	9	16	44	40	294	26	35	18	6	122	1	16	44.3	26.1	467	382	53	12	19
1 to 50	226	45	35	69	49	497	20	68	31	8	226	5	35	69.3	36.3	489	325	90	60	15
51 to 100	453	57	74		69	835	25	115	51	8	453	7	74		39.7	463	191	162	70	
Never closed	397	79	57	91	179	826	24	103	51	19	397	5	57	90.8	78.4	952	295	428	100	128
Electricity not used	2			3	7						7			10.2	22.7					
Energy Conservation Features																				
Any conservation feature																				
Building shell																				
HVAC																				
Lighting																				
Heating Equipment*																				
Heat pumps	262	35	27	83	78	623	44	102	33	16	263	3	27	84.0	27.3	539	148	285	61	44
Furnaces	184	36	49	42	40	412	18	51	23	8	185	5	49	43.2	31.8	522	388	85	40	9
Individual space heaters	229	25	33	65	64	503	33	60	28	9	231	3	34	64.7	39.7	543	354	131	30	28
District heat	378	44	24	123	208	728	3	50	62	9	379	3	24	122.6	70.4	681	89	175	98	320
Boilers	254	41	18	73	81	519	11	69	35	28	257	2	18	72.7	46.6	747	422	244	44	36
Packaged heating units	263	69	50	67	58	591	28	91	32	10	265	5	50	67.0	43.2	478	240	139	84	16
Other	367	41	28	106	101	755	33	92	55	9	367	3	28	106.7	60.2	463	192	167	56	49
Cooling Equipment*																				
Residential central A/C	236	66	52	61	73	531	14	81	32	9	237	5	52	61.3	38.6	681	396	166	81	37
Heat pumps	266	36	32	86	75	636	43	102	34	15	266	6	32	86.3	50.0	503	161	244	59	39
Individual A/C	187	44	27	44	75	412	19	61	19	10	189	3	27	45.4	36.3	682	379	207	56	41
District chilled water	458	55	28	151	330	847	3	17	90	9	458	5	28	151.0	86.3	895	132	210	98	455
Central chillers	386	52	22	119	127	799	18	104	65	9	386	3	22	119.2	71.5	686	270	278	64	74
Packaged A/C units	279	58	47	76	73	613	23	87	36	9	280	5	47	76.1	46.6	525	277	144	70	32
Evaporative coolers	258	98	59	73	78	585	17	74	39	6	259	6	60	72.7	52.2	702	262	290	120	31
Other	361	51	56	108	94	704	11	67	43	7	361	6	56	107.9	46.6	460	251	106	0	47
Lighting Equipment Types*																				
Incandescent	245	53	33	62	74	519	19	69	33	9	245	3	33	62.5	42.0					
Standard fluorescent	249	45	37	69	74	538	23	70	34	9	249	3	37	69.3	43.2					
Compact fluorescent	337	65	35	94	117	698	18	90	49	9	337	6	35	94.3	60.2					
High-intensity discharge	287	41	27	72	83	568	17	70	36	7	287	3	27	71.5	47.7					
Halogen	300	51	28	79	94	613	19	77	43	8	300	5	28	79.5	53.4					
Other	354	30	0	61	94	661	15	98	53	6	354	5	23	61.3	46.6					
Water-Heating Equipment*																				
Central system	252	55	47	72	81	563	23	72	36	20	253	5	47	72.7	46.6	679	375	190	69	45
Distributed system	243	33	24	65	64	513	24	74	31	12	243	2	24	64.7	37.5	390	223	87	45	33
Combination central/distributed	316	56	31	79	90	627	20	75	43	7	316	5	31	79.5	50.0	638	276	250	66	47
Personal Computers/Terminals																				
None	97	28	31	15	34	268	19	34	16	8	110	2	35	17.0	27.3					
1 to 4	181	69	66	32	48	437	31	56	22	11	181	5	66	31.8	35.2					
5 to 9	235	58	50	56	58	539	30	76	24	15	236	8	50	55.6	43.2					
10 to 19	235	28	27	68	53	499	26	72	23	8	236	2	27	69.3	36.3					
20 to 49	245	30	24	67	68	516	16	81	28	9	248	2	24	68.1	39.7					
50 to 99	279	30	16	82	91	570	15	83	33	8	280	2	16	82.9	51.1					
100 to 249	332	35	26	94	98	672	19	86	50	7	332	2	26	94.3	55.6					
250 or more	459	48	19	184	165	944	18	98	86	8	460	5	19	185.1	67.0					
Commercial Refrigeration*																				
Any equipment	328	108	79	68	110	725	26	95	44	12	330	9	79	68.1	60.2					
Walk in units	368	131	97	74	123	815	26	106	49	14	370	11	97	74.9	68.1					
Cases and cabinets	335	114	81	65	109	735	27	98	44	14	336	10	82	65.9	59.1					
None	174	2	8	62	44	390	20	50	25	7	182		9	65.9	30.7					
Shell Conservation Features*																				
Roof/ceiling insulation	254	47	40	73	76	561	23	74	35	10	258	5	40	72.7	45.4	602	333	166	62	41
Wall insulation	258	50	40	77	78	577	22	77	35	11	259	5	41	77.2	48.8	563	284	173	66	40
Storm or multiple glazing	265	58	36	78	83	581	23	74	36	11	267	5	36	78.4	48.8	658	344	194	76	44
Tinted, reflective, shaded glass	301	58	35	94	91	654	24	86	45	9	302	5	35	94.3	52.2	566	259	178	76	52
Shading or awnings	263	50	30	81	86	570	23	75	37	10	265	3	30	81.8	46.6	591	296	173	67	55
HVAC Conservation Features*																				
Variable-volume system	368	66	31	117	124	770	22	92	60	9	369	5	31	118.1	65.9	678	265	250	86	76
Economizer cycle	338	67	35	107	115	725	20	92	52	9	341	6	36	106.7	61.3	646	285	210	82	68
HVAC maintenance	271	50	34	78	84	584	20	77	37	10	273	5	34	78.4	47.7	603	318	174	65	47
Other efficient equipment	328	56	35	102	119	694	20	86	51	8	328	3	35	102.2	60.2	620	263	210	69	77
Lighting Conservation Features*																				
Specular reflectors	296	52	33	81	89	612	18	78	40	9	296	5	33	80.6	51.1					
Energy efficient ballasts	302	50	39	89	91	645	24	82	42	10	302	5	39	88.6	52.2					
Natural lighting sensors	318	50	39	70	98	644	22	91	39	9	318	3	39	70.4	52.2					
Occupancy sensors	321	65	37	110	124	682	14	78	50	8	321	3	37	110.2	59.1					
Time clock	330	48	35	90	83	675	18	93	47	7	330	3	35	89.7	51.1					
Manual dimmer switches	334	82	28	100	109	704	20	92	52	9	334	5	28	99.9	62.5					
Other	347	37	35	114	95	731	19	94	49	7	347	5	35	113.6	60.2					
Off Hour Equipment Reduction*																				
Heating	202	36	26	59	45	441	22	59	28	7	203	3	26	60.2	31.8	470	325	81	48	17
Cooling	212	39	27	64	47	467	19	67	31	7	213	3	27	63.6	32.9	466	315	83	51	17
Lighting	206	35	31	62	47	454	23	60	28	7	206	3	31	62.5	34.1	481	333	83	49	17

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).

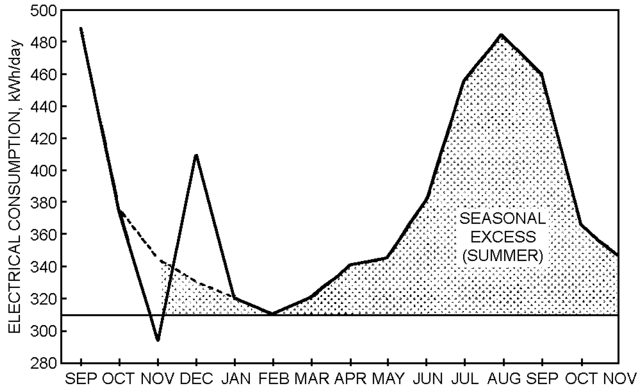

Fig. 2 Average Daily Electrical Consumption

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.

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%).

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

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

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	2 350 m^3
Space heating	54.5	1 841 m^3
Water heating	52.8	680 m^3
Appliances	40.4	255 m^3
Fuel Oil, total	10.0	2.76 m^3
Space heating	9.8	2.37 m^3
Water heating	5.2	0.83 m^3
LPG, total	8.1	1.85 m^3
Space heating	5.6	1.90 m^3
Water heating	3.3	0.98 m^3
Appliances	4.8	0.21 m^3
Kerosene, total, space heating	3.5	0.48 m^3

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

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, GJ
Total Households	101.5	106.6
Weekday Home Activities		
Home used for business		
Yes	7.4	120.7
No	94.1	105.4
Energy intensive activity		
Yes	2.4	128.1
No	99.1	106.0
Someone home all day		
Yes	51.3	112.6
No	50.1	100.3
Winter Temperature Settings		
Lower when no one home		
Yes	45.5	105.4
No	56.0	107.4
Lower during sleeping hours		
Yes	47.4	107.2
No	54.0	105.9
Use a secondary heating fuel		
Yes	34.3	122.4
No	66.5	99.2
Adequacy of insulation		
Well Insulated	38.0	104.0
Adequately Insulated	44.4	108.1
Poorly Insulated	18.5	108.7
Central air conditioning use		
All summer	24.6	103.3
Quite a bit	10.4	108.8
Only a few times	12.4	109.2
No central system	53.7	107.2
Room air conditioning use		
All summer	5.7	101.6
Quite a bit	6.6	119.5
Only a few times	13.5	113.4
No room units	75.0	104.4
Use a dishwasher		
Yes	50.9	115.6
No	50.6	97.3
Use a clothes washer		
Yes	78.5	118.5
No	22.9	65.6
Use a clothes dryer		
Yes	72.2	120.0
No	29.3	73.3
Use two or more refrigerators		
Yes	15.4	142.4
No	86.1	100.1
Outdoor lights on all night		
Yes	26.3	114.2
No	75.2	103.8
Census Region and Division		
Northeast	19.7	127.2
New England	5.3	129.7
Middle Atlantic	14.4	126.3
Midwest	24.1	141.4
East North Central	16.9	145.8
West North Central	7.2	130.9
South	35.9	88.5
South Atlantic	18.7	79.2
East South Central	6.3	92.5
West South Central	10.8	102.0
West	21.8	79.0
Mountain	6.2	99.2
Pacific	15.6	71.0
Largest populated states		
California	11.5	67.4
Florida	5.9	57.9
New York	6.8	130.2
Texas	7.0	101.4
Urban/rural location		
City	48.2	101.1
Town	18.2	109.9
Suburbs	18.6	116.5
Rural	16.5	107.5
Climate zone		
<2,000 CDD, >7000 HDD	9.3	129.9
Climate zone (*continued*)		
5,500 to 7,000 HDD	28.0	134.8
4,000 to 5,499 HDD	22.5	111.3
Under 4,000 HDD	19.5	78.4
>2000 CDD, <4000 HDD	22.2	80.8
Type of Housing Unit		
Single-family	73.7	121.0
Multifamily		
2 to 4 units	5.6	96.5
5 or more units	15.8	51.3
Mobile home	6.3	83.9
Heated Floorspace (square metre)		
Fewer than 600	7.9	64.5
600 to 999	21.5	81.7
1,000 to 1,599	30.4	102.8
1,600 to 1,999	15.3	123.0
2,000 to 2,399	7.9	131.1
2,400 to 2,999	5.3	145.3
3,000 or more	4.1	184.8
No estimate provided	9.1	107.1
Year of Construction		
1949 or before	27.9	131.7
1950 to 1959	12.5	111.9
1960 to 1969	14.4	101.3
1970 to 1979	19.6	92.2
1980 to 1989	17.3	86.2
1990 to 1997	9.7	99.8
All Utilities Paid By Household		
All major fuels		
Yes	89.7	110.0
No	11.8	79.4
Electricity		
Yes	96.2	108.7
No	5.3	68.6
Natural gas		
Yes	53.3	130.3
No	8.6	83.1
Fuel oil		
Yes	7.6	
No	2.3	
LPG		
Yes	7.9	109.5
No	0.2	93.4
Kerosene		
Yes	3.5	106.0
No		
1997 Family Income		
Less than $10,000	13.3	80.6
$10,000 to $24,999	29.1	92.1
$25,000 to $49,999	31.1	108.2
$50,000 or more	27.9	132.1
Below Poverty Line		
100%	14.6	87.6
125%	19.7	87.5
150%	26.7	88.8
Eligible for Federal assistance	34.1	91.5
Age of Householder		
Under 25 years	5.7	73.5
25 to 34 years	18.5	92.5
35 to 44 years	23.2	113.3
45 to 59 years	25.6	119.6
60 years and over	28.5	104.9
Race of Householder		
White	78.5	109.6
Black	12.7	111.1
Other	10.3	76.8
Householder of Hispanic descent		
Yes	9.4	80.1
No	92.1	109.2
Household Size		
1 person	25.6	78.8
2 persons	33.0	106.8
3 persons	17.4	115.5
4 persons	15.2	124.2
5 persons	6.4	130.7
6 or more persons	3.9	136.7

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

CDD = cooling kelvin-days (18.3°C base); HDD = heating kelvin-days (18.3°C base).

Table 5 Example of Analytical Method for Analyzing Electrical Operating Costs

		Consumption, kWh			Air Conditioning, kWh			Demand, kW		
Billing Date	Billing Days	Total Actual	Actual per Day	Base[b]	Difference	ELF, %	Excess	Actual	Winter Excess	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 63°C 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

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