3. Central Physical Plant Outputs and Inputs

One purpose of this study was to obtain information about energy aspects of the central physical plants on multibuilding facilities. The Facility Survey tried to obtain estimates for the amounts and forms of energy these central physical plants consumed (inputs) and the amounts and forms of energy they sent out to the facility (outputs). Many data and reporting problems were encountered, as described in Appendix B, "Data Quality."

The best results obtained were those identifying the types of energy inputs and outputs at central physical plants. The only potentially significant problem with the data identifying forms of energy output from the central physical plant involved electricity. Electricity supplied by an off-site utility may have been incorrectly identified as a central plant output. The identification of central plant energy inputs was also fairly reliable, although some energy sources reported as central plant inputs may actually have been consumed at another part of the facility, bypassing the central physical plant.

The reported quantities of energy output and input from the central physical plant, however, should be treated as rough estimates. Many respondents were unable to provide information on energy output quantities, necessitating high imputation rates (Table B4). Electricity quantities shown in the tables are the inputs and outputs that were reported by the respondents rather than a calculated net electricity quantity (output minus input). These estimates may be overstated, since some of this electricity may not have been generated by the central plant.

Central Physical Plant Outputs

In all sectors, steam was by far the most common output of central physical plants (Table 9).

- Of the 30,729 facilities with central plants, 75 percent produced steam, while 25 percent produced hot water, 18 percent produced chilled water, and 24 percent produced electricity.

- Eighty-three percent of the 7,395 facilities that produced electricity also produced steam. This number can be considered an upper bound on the number of plants with cogeneration systems.

- Production of chilled water was generally associated with either steam (66 percent of chilled water plants) and/or hot water (39 percent of chilled water plants).

In commercial-sector facilities, steam was slightly less prevalent as a central plant output, while hot water and chilled water were more common.

- Sixty-seven percent of central plants on commercial facilities produced steam, 32 percent produced hot water, and 33 percent produced chilled water.

- The commercial sector accounted for 75 percent of all chilled water plants, but only 20 percent of all plants that reported electricity output (Figure 4).

- Chilled water was least common as a central plant output among schools other than colleges and universities (16 percent); 50 percent of the rest of the central plants in the commercial sector produced chilled water.

Table 9. Number of Multibuilding Facilities by Types of Central Physical Plant Energy Outputs

Facility Characteristics	Number of Facilities	Types of Energy Outputs			
		Steam	Hot Water	Chilled Water	Electricity
	All Sectors				
All Facilities	30,729	23,131	7,570	5,655	7,395
Census Region					
Northeast	4,739	Q	882	730	Q
Midwest	5,472	2,678	Q	699	Q
South	16,637	13,927	Q	2,381	Q
West	3,881	2,518	Q	Q	Q
Energy Outputs					
Steam	23,131	23,131	1,836	3,712	6,135
Hot Water	7,570	1,836	7,570	2,185	Q
Chilled Water	5,655	3,712	2,185	5,655	Q
Electricity	7,395	6,135	Q	Q	7,395
Energy Inputs					
Fuel Oil	14,332	12,941	1,344	Q	Q
Natural Gas	19,693	15,608	4,746	4,574	3,886
Coal	Q	Q	Q	Q	Q
Electricity	14,983	10,518	4,593	4,789	Q
	Commercial Sector				
All Facilities	12,790	8,567	4,127	4,259	1,481
Principal Facility Activity					
College and University	2,267	1,861	530	994	Q
Other School	6,244	Q	Q	1,005	Q
Office	947	291	Q	Q	Q
Hospital	2,146	1,756	Q	902	Q
Other	1,185	769	Q	687	Q
Census Region					
Northeast	1,691	1,304	Q	613	Q
Midwest	2,379	1,589	Q	568	Q
South	6,048	Q	Q	1,734	Q
West	2,672	1,728	842	1,345	Q
Energy Outputs					
Steam	8,567	8,567	1,180	2,443	Q
Hot Water	4,127	1,180	4,127	1,617	Q
Chilled Water	4,259	2,443	1,616	4,259	Q
Electricity	1,481	Q	Q	Q	1,481
Energy Inputs					
Fuel Oil	3,355	2,613	832	1,069	Q
Natural Gas	8,691	5,419	3,575	3,337	1,441
Coal	Q	Q	Q	Q	Q
Electricity	5,559	3,454	1,891	3,411	1,358

See footnotes at end of table.

Table 9. Number of Multibuilding Facilities by Types of Central Physical Plant Energy Outputs (Continued)

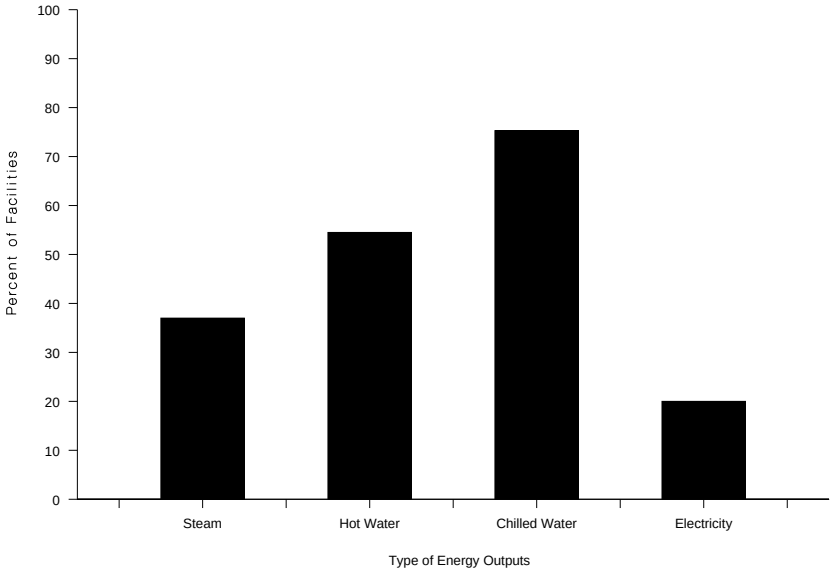
Facility Characteristics	Number of Facilities	Types of Energy Outputs			
		Steam	Hot Water	Chilled Water	Electricity
	Industrial Sector				
All Facilities	17,241	14,180	Q	Q	Q
Census Region					
Northeast	Q	Q	Q	Q	Q
Midwest	Q	Q	Q	Q	Q
South	10,521	9,913	Q	Q	Q
West	Q	Q	Q	Q	Q
Energy Outputs					
Steam	14,180	14,180	Q	Q	Q
Hot Water	Q	Q	Q	Q	Q
Chilled Water	Q	Q	Q	Q	Q
Electricity	Q	Q	Q	Q	Q
Energy Inputs					
Fuel Oil	10,491	10,151	Q	Q	Q
Natural Gas	10,318	9,819	Q	Q	Q
Coal	Q	Q	Q	Q	Q
Electricity	9,121	Q	Q	Q	Q

Q = Data withheld because the Relative Standard Error (RSE) was greater than 50 percent, or fewer than 20 buildings were sampled.

Notes: •"All Sectors" estimates include multibuilding residential facilities. •See the "Glossary" for definitions of terms used in this report. •Totals may not equal sum of components because of independent rounding.

Source: Energy Information Administration, Office of Energy Markets and End Use, Form EIA-871B, "Facility Form" of the 1989 Commercial Buildings Energy Consumption Survey.

Figure 4. Commercial Multibuilding Facilities As a Percent of All Multibuilding Facilities by Types of Energy Outputs



Source: Energy Information Administration, Office of Energy Markets and End Use, Form EIA-871B, "Facility Form" of the 1989 Commercial Buildings Energy Consumption Survey.

To estimate total central physical plant output, it was necessary to assign a Btu value to outputs of chilled water. Chilled water amounts (usually reported in ton-hours) were converted to Btu equivalents by assuming a coefficient of performance (COP). The COP is the ratio of the rate of heat removal (where 1 ton-hour equals 12,000 Btu of cooling) to the rate of energy input (Btu). There was little basis for choosing a COP, as the Facility Survey did not ask (1) whether the output quantities were measured as produced at the central physical plant or as received at the buildings served by the plant or (2) the type of equipment used at the central physical plant. A COP of 4.3 would be appropriate for an efficient chiller. Lower COPs, accounting for distribution energy and losses, would lead to higher chilled water Btu equivalents. The effective system-wide COP could actually be closer to 1.0. The estimates presented here assumed a COP of 2.0, a value chosen arbitrarily to represent distribution losses of about 50 percent.

Central physical plants produced 3.8 quadrillion Btu in 1989 (Table 10), consisting primarily of steam (79 percent of the total). Although commercial sector physical plants produced less than 20 percent of the total (735 trillion Btu), they produced 68 percent of the hot water and 78 percent of the chilled water.

The quantity of district heat produced at central physical plants on commercial facilities can be estimated by adding together commercial sector steam production (426 trillion Btu) and commercial sector hot water production (134 trillion Btu), for a total of 560 trillion Btu. This value is close to the 527 trillion Btu estimated as 1989 commercial buildings' district heat consumption (Table 5). Although this is a relatively small net difference, the gross difference may be much larger. This is because the commercial buildings total includes some buildings on industrial facilities, while some commercial facilities include buildings that are not commercial.

Electricity output estimates can be compared with independent estimates of electricity generation obtained from EIA's "Annual Nonutility Power Producer Report," which was completed by nonutility power producers with an installed capacity of 5 or more megawatts.[9] The 428 trillion Btu of electricity output by all central plants (Table 10) corresponds to 125 billion kilowatthours of delivered electricity, while the 74 trillion Btu output by commercial facility central plant corresponds to 23 billion kilowatthours. According to EIA's nonutility power estimates, nonutility power producers generated 215 billion kilowatthours in 1990, of which 61 billion kilowatthours was generated by producers in the transportation, public utilities, and mining industries. This leaves 154 billion kilowatthours in industry groups likely to have had at least some associated commercial buildings, which is roughly comparable to the 125 billion kilowatthours estimated here. However, EIA's total nonutility power production estimate of 7 billion kilowatthours for nonutility generators in the services and public administration industry groups was considerably lower than the Facility Survey total, a further indication that output electricity was misreported in the 1989 Facility Survey.

[9]Lawrence Prete, Janet Gordon, and Betty Williams, "Nonutility Power Producers," *Electric Power Monthly*, DOE/EIA-0226(92/04) (Washington, DC: Energy Information Administration, April 1992), Table FE8.

Table 10. Central Physical Plant Energy Output Quantities
(Trillion Btu)

Facility Characteristics	Total Outputs	Steam	Hot Water	Chilled Water	Electricity
	All Sectors				
All Facilities	3,776	2,982	196	129	428
Census Region					
Northeast	Q	Q	Q	Q	Q
Midwest	631	482	Q	Q	107
South	Q	Q	Q	Q	Q
West	241	96	Q	Q	27
Energy Inputs					
Fuel Oil	Q	Q	Q	Q	Q
Natural Gas	1,744	1,269	171	115	188
Coal	900	Q	Q	Q	Q
Electricity	1,386	928	156	111	190
Energy Outputs					
Steam	3,556	2,982	Q	98	Q
Hot Water	375	Q	196	Q	Q
Chilled Water	624	Q	Q	129	Q
Electricity	Q	Q	Q	Q	428
	Commercial Sector				
All Facilities	735	426	134	101	74
Principal Facility Activity					
College and University	375	200	Q	49	Q
Other School	38	23	Q	Q	Q
Office	54	22	Q	Q	Q
Hospital	208	147	Q	27	20
Other	60	Q	Q	Q	Q
Census Region					
Northeast	131	96	Q	Q	Q
Midwest	236	176	Q	Q	Q
South	183	79	Q	38	16
West	186	75	Q	Q	Q
Energy Inputs					
Fuel Oil	371	243	Q	32	31
Natural Gas	660	371	123	94	72
Coal	Q	Q	Q	Q	Q
Electricity	551	280	Q	89	69
Energy Outputs					
Steam	617	426	Q	78	60
Hot Water	221	47	134	Q	Q
Chilled Water	408	187	Q	101	53
Electricity	266	141	Q	41	74

See footnotes at end of table.

Table 10. Central Physical Plant Energy Output Quantities (Continued)
(Trillion Btu)

Facility Characteristics	Total Outputs	Steam	Hot Water	Chilled Water	Electricity
	Industrial Sector				
All Facilities	2,955	Q	Q	Q	Q
Census Region					
Northeast	Q	Q	Q	Q	Q
Midwest	385	302	Q	Q	Q
South	Q	Q	Q	Q	Q
West	Q	Q	Q	Q	Q
Energy Inputs					
Fuel Oil	Q	Q	Q	Q	Q
Natural Gas	1,043	879	Q	Q	112
Coal	Q	Q	Q	Q	Q
Electricity	806	630	Q	Q	Q
Energy Outputs					
Steam	2,906	Q	Q	Q	Q
Hot Water	Q	Q	Q	Q	Q
Chilled Water	Q	Q	Q	Q	Q
Electricity	Q	Q	Q	Q	Q

Q = Data withheld because the Relative Standard Error (RSE) was greater than 50 percent, or fewer than 20 buildings were sampled.

Notes: •"All Sectors" estimates include multibuilding residential facilities. •See the "Glossary" for definitions of terms used in this report. •Totals may not equal sum of components because of independent rounding.

Source: Energy Information Administration, Office of Energy Markets and End Use, Form EIA-871B, "Facility Form" of the 1989 Commercial Buildings Energy Consumption Survey.

Central Physical Plant Inputs

Natural gas was the most common energy input used to produce steam, hot water, chilled water, and onsite-generated electricity (used at 64 percent of the 30,729 multibuilding facilities). Fuel oil and electricity were each used at about half of the facilities. Few central physical plants used coal as an input, and the limited amount of data resulted in estimates that were unpublishable even at the national level (Table 11).

- An estimated 9,444 facilities (31 percent) used both fuel oil and natural gas. This overlap in fuel use may reflect either separate pieces of equipment, or use of both fuels in equipment with multiple fuel capability.

- Ninety percent of the plants that used fuel oil as an input produced steam, versus 79 percent of those that used natural gas. Of plants that produced chilled water, 81 percent used natural gas and 85 percent used electricity.

- In commercial facilities, 68 percent of the central plants used natural gas, but only 26 percent used fuel oil. Natural gas was used by 68 percent of the central plants using fuel oil.

Table 11. Number of Multibuilding Facilities by Types of Central Physical Plant Energy Inputs

Facility Characteristics	Number of Facilities	Types of Energy Inputs			
		Fuel Oil	Natural Gas	Coal	Electricity
	All Sectors				
All Facilities	30,729	14,332	19,693	Q	14,983
Census Region					
Northeast	4,739	Q	Q	Q	1,034
Midwest	5,472	Q	3,264	275	Q
South	16,637	8,611	9,512	Q	7,984
West	3,881	Q	2,980	Q	2,614
Energy Inputs					
Fuel Oil	14,332	14,332	9,444	Q	Q
Natural Gas	19,693	9,444	19,693	386	11,279
Coal	Q	Q	386	Q	332
Electricity	14,983	Q	11,279	331	14,983
Energy Outputs					
Steam	23,131	12,941	15,608	Q	10,518
Hot Water	7,570	1,344	4,746	Q	4,593
Chilled Water	5,655	Q	4,574	Q	4,789
Electricity	7,395	Q	3,886	Q	Q
	Commercial Sector				
All Facilities	12,790	3,355	8,691	Q	5,559
Principal Facility Activity					
College and University	2,267	Q	1,769	Q	1,347
Other School	6,244	Q	3,486	Q	1,334
Office	947	Q	516	Q	Q
Hospital	2,146	1,020	1,905	Q	1,502
Other	1,185	Q	1,014	Q	711
Census Region					
Northeast	1,691	1,179	Q	Q	584
Midwest	2,379	Q	2,347	Q	1,092
South	6,048	Q	3,477	Q	2,038
West	2,672	Q	1,962	Q	1,845
Energy Inputs					
Fuel Oil	3,355	3,355	2,280	Q	1,875
Natural Gas	8,691	2,280	8,691	Q	4,410
Coal	Q	Q	Q	Q	Q
Electricity	5,559	1,875	4,410	Q	5,559
Energy Outputs					
Steam	8,567	2,613	5,419	Q	3,454
Hot Water	4,127	832	3,575	Q	1,891
Chilled Water	4,259	1,069	3,337	Q	3,411
Electricity	1,481	Q	1,441	Q	1,358

See footnotes at end of table.

Table 11. Number of Multibuilding Facilities by Types of Central Physical Plant Energy Inputs (Continued)

Facility Characteristics	Number of Facilities	Types of Energy Inputs			
		Fuel Oil	Natural Gas	Coal	Electricity
	Industrial Sector				
All Facilities	17,241	10,491	10,318	Q	9,121
Census Region					
Northeast	Q	Q	Q	Q	Q
Midwest	Q	Q	Q	118	Q
South	10,521	Q	Q	Q	Q
West	Q	Q	Q	Q	Q
Energy Inputs					
Fuel Oil	10,491	10,491	Q	Q	Q
Natural Gas	10,318	Q	10,318	Q	Q
Coal	Q	Q	Q	Q	Q
Electricity	9,121	Q	Q	Q	9,121
Energy Outputs					
Steam	14,180	10,151	9,819	Q	Q
Hot Water	Q	Q	Q	Q	Q
Chilled Water	Q	Q	Q	Q	Q
Electricity	Q	Q	Q	Q	Q

Q = Data withheld because the Relative Standard Error (RSE) was greater than 50 percent, or fewer than 20 buildings were sampled.

Notes: •"All Sectors" estimates include multibuilding residential facilities. •See the "Glossary" for definitions of terms used in this report. •Totals may not equal sum of components because of independent rounding.

Source: Energy Information Administration, Office of Energy Markets and End Use, Form EIA-871B, "Facility Form" of the 1989 Commercial Buildings Energy Consumption Survey.

- Some regional differences were evident. Seventy percent of the commercial plants in the Northeast used fuel oil, while 99 percent of the plants in the Midwest used natural gas.
- Ninety-seven percent of the commercial plants that produced electricity used natural gas as an input.
- In the industrial sector, roughly equal proportions of plants used fuel oil (61 percent) and natural gas (60 percent). Nearly all of the industrial plants that used either fuel oil or natural gas produced steam.

Total inputs to central plants were estimated at 5.8 quadrillion Btu, 32 percent of which was natural gas (Table 12). The commercial sector accounted for 1.2 quadrillion Btu, 50 percent in the form of natural gas. Little detail on the quantities of central physical plant inputs was publishable.

Table 12. Central Physical Plant Energy Input Quantities
(Trillion Btu)

Facility Characteristics	Total Inputs	Fuel Oil	Natural Gas	Coal	Electricity
	All Sectors				
All Facilities	5,776	Q	1,827	Q	Q
Census Region					
Northeast	530	Q	Q	Q	Q
Midwest	916	Q	261	488	Q
South	Q	Q	985	Q	Q
West	299	Q	190	Q	92
Energy Inputs					
Fuel Oil	Q	Q	721	Q	Q
Natural Gas	2,876	69	1,827	364	592
Coal	Q	Q	Q	Q	Q
Electricity	2,316	72	989	Q	Q
Energy Outputs					
Steam	5,503	Q	1,697	Q	Q
Hot Water	508	27	Q	Q	Q
Chilled Water	Q	Q	357	Q	Q
Electricity	Q	Q	477	Q	Q
	Commercial Sector				
All Facilities	1,153	Q	575	Q	211
Principal Facility Activity					
College and University	602	Q	217	Q	Q
Other School	71	Q	48	Q	Q
Office	78	Q	39	Q	32
Hospital	331	37	223	Q	Q
Other	72	Q	49	Q	Q
Census Region					
Northeast	216	Q	121	Q	20
Midwest	452	Q	161	Q	Q
South	272	Q	136	Q	Q
West	213	Q	157	Q	Q
Energy Inputs					
Fuel Oil	560	Q	309	Q	59
Natural Gas	1,046	29	575	Q	188
Coal	Q	Q	Q	Q	Q
Electricity	863	33	364	Q	211
Energy Outputs					
Steam	991	Q	462	Q	171
Hot Water	307	Q	169	Q	Q
Chilled Water	623	21	267	Q	166
Electricity	434	Q	141	Q	Q

See footnotes at end of table.

Table 12. Central Physical Plant Energy Inputs (Continued)
(Trillion Btu)

Facility Characteristics	Total Inputs	Fuel Oil	Natural Gas	Coal	Electricity
	Industrial Sector				
All Facilities	Q	Q	1,213	Q	Q
Census Region					
Northeast	Q	Q	Q	Q	Q
Midwest	450	Q	Q	Q	Q
South	Q	Q	849	Q	Q
West	Q	Q	Q	Q	Q
Energy Inputs					
Fuel Oil	Q	Q	Q	Q	Q
Natural Gas	1,778	Q	1,213	Q	Q
Coal	Q	Q	Q	Q	Q
Electricity	Q	Q	593	Q	Q
Energy Outputs					
Steam	Q	Q	1,202	Q	Q
Hot Water	Q	Q	Q	Q	Q
Chilled Water	Q	Q	Q	Q	Q
Electricity	Q	Q	Q	Q	Q

Q = Data withheld because the Relative Standard Error (RSE) was greater than 50 percent, or fewer than 20 buildings were sampled.

Notes: •"All Sectors" estimates include multibuilding residential facilities. •"Total Inputs" includes inputs of other fuels, not shown separately. •See the "Glossary" for definitions of terms used in this report. •Totals may not equal sum of components because of independent rounding.

Source: Energy Information Administration, Office of Energy Markets and End Use, Form EIA-871B, "Facility Form" of the 1989 Commercial Buildings Energy Consumption Survey.

Central Physical Plant Output-Input Ratios

Although central physical plant input and output quantities are highly variable, the ratio between the two may be considerably less variable. The output-input ratios (Table 13) may be interpreted as measures of central physical plant efficiency. An output-input ratio of 0.5, for example, would indicate half of the Btu value of the primary energy was lost when it was converted to the form delivered to the rest of the facility (steam, hot water, chilled water, or electricity). Besides conversion losses, other losses are sustained in circulating the heating or cooling medium (steam, hot water, or chilled water), and in transmitting the medium through imperfectly insulated pipes to the serviced buildings. The arguments for and against the efficiency of district heating and cooling depend on whether these losses are offset by the efficiency advantages of being able to operate a large-scale, centralized, heating and cooling system.

Because these output-input ratios are subject to reporting errors in both inputs and outputs, the ratios in Table 13 must be interpreted carefully.

- Input totals and, to a lesser extent, output totals were contaminated by some reports that covered the entire facility, rather than just the central physical plant. In other words, some of the energy reported as a central plant input may instead have been consumed directly at other buildings on the facility. Electricity consumed directly at other buildings may also have been reported as an output (Appendix B, "Data Quality").

Table 13. Central Physical Plant Energy Output-Input Ratios

Facility Characteristics	Total Outputs (trillion Btu)	Total Inputs (trillion Btu)	Output/Input Ratios
	All Sectors		
All Facilities	3,776	5,776	0.66
Census Region			
Northeast	Q	530	.52
Midwest	631	916	.69
South	Q	Q	.68
West	241	299	.81
Energy Inputs			
Fuel Oil	Q	Q	.67
Natural Gas	1,744	2,876	.61
Coal	900	Q	.72
Electricity	1,386	2,316	.61
Energy Outputs			
Steam	3,556	5,503	.67
Hot Water	375	508	.74
Chilled Water	624	Q	.68
Electricity	Q	Q	.75
	Commercial Sector		
All Facilities	735	1,153	.64
Principal Facility Activity			
College and University	375	602	.63
Other School	38	71	.55
Office	54	78	.69
Hospital	208	331	.64
Other	60	72	.85
Census Region			
Northeast	131	216	.61
Midwest	236	452	.52
South	183	272	.68
West	186	213	.88
Energy Inputs			
Fuel Oil	371	560	.67
Natural Gas	660	1,046	.63
Coal	Q	Q	.49
Electricity	551	863	.64
Energy Outputs			
Steam	617	991	.63
Hot Water	221	307	.72
Chilled Water	408	623	.66
Electricity	266	434	.62

See footnotes at end of table.

Table 13. Central Physical Plant Energy Output-Input Ratios (Continued)

Facility Characteristics	Total Outputs (trillion Btu)	Total Inputs (trillion Btu)	Output/Input Ratios
	Industrial Sector		
All Facilities	2,955	Q	0.67
Census Region			
Northeast	Q	Q	Q
Midwest	385	450	.86
South	Q	Q	.68
West	Q	Q	Q
Energy Inputs			
Fuel Oil	Q	Q	.68
Natural Gas	1,043	1,778	.58
Coal	Q	Q	.81
Electricity	806	Q	.59
Energy Outputs			
Steam	2,906	Q	.68
Hot Water	Q	Q	Q
Chilled Water	Q	Q	.87
Electricity	Q	Q	.78

Q = Data withheld because the Relative Standard Error (RSE) was greater than 50 percent, or fewer than 20 buildings were sampled.

Notes: •"All Sectors" estimates include multibuilding residential facilities. •See the "Glossary" for definitions of terms used in this report. •Totals may not equal sum of components because of independent rounding.

Source: Energy Information Administration, Office of Energy Markets and End Use, Form EIA-871B, "Facility Form" of the 1989 Commercial Buildings Energy Consumption Survey.

- The point of measurement for outputs was not specified in the Facility Survey. For example, steam outputs could be measured (1) leaving the boiler, (2) leaving the central physical plant, or (3) entering a serviced building. Different efficiency ratios may be associated with each of these points. If the facility's steam pipes are poorly insulated, the output-input ratio measured at the central plant will be considerably higher than that measured entering the serviced building.

- From a building energy analysis perspective, measurements of energy entering serviced buildings would be most useful; however, steam meters are notoriously unreliable. Measurement problems would remain even if the Facility Survey had requested quantities of delivered steam.

The net effect of these reporting problems on the estimated output-input ratios is unclear. Unreliable meters would not have a systematic effect on the output-input ratios. The output-input ratios are decreased by reported input energy that instead was consumed directly at buildings, without offsetting reported central plant outputs. The output-input ratio is increased, however, by cases where the same electricity was reported as both an input and an output. From a building-delivered energy perspective, any reported outputs measured other than at the serviced building would increase the output-input ratio. The effects of these reporting errors may cancel out. Unfortunately, while there is some evidence on the amount of central plant versus facility-wide reporting (Appendix B), the point-of-measurement issue awaits the results of the 1992 CBECS District Heating and Cooling Suppliers Survey, which included questions on the point of measurement.

The overall output-input ratio was estimated to be 0.66 in all facilities, 0.64 in the commercial-sector facilities and 0.67 in the industrial-sector facilities. These ratios are most useful in conjunction with the CBECS district heating

and cooling data, which are collected from similar respondents under similar conditions. By using 0.66 as the ratio, it could be estimated that 798 trillion Btu of primary energy were required to produce the 527 trillion Btu of district heat consumed by commercial buildings on multibuilding facilities (Table 5).

The output-input ratios reported in Table 13 can be contrasted with the efficiency of 0.33 percent usually reported for electricity generation by electric utilities. The 0.33 percent is calculated by dividing the heat content of one kilowatthour of electricity (3,412 Btu) by an annual average amount of fossil fuel energy required to produce one kilowatthour at a fossil-fuel steam-electric power plant. In this calculation, any byproduct heat is ignored, regardless of whether the byproduct heat is used for some other purpose (such as heating buildings). If useful energy outputs other than electricity were accounted for in the efficiency calculations, the ratio would be larger than 0.33 percent.

Shortcomings of the output-input ratios in Table 13 include the measurement problems discussed above (non-central plant consumption included, uncertainty about the point of measurement, and unreliable steam meters), plus uncertainty about the coefficient of performance to use for chilled water. Direct comparison with fossil-fuel power plants is also not possible because some central physical plants may have contained a mix of processes, i.e., some cogeneration of steam and electricity along with a separate chilled water system. Nevertheless, the ratios in Table 13 did attempt to account for all usable outputs.