EIA's Commercial Buildings Energy Consumption Survey: Strengths and Weaknesses of the Data

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ABSTRACT

The Commercial Buildings Energy Consumption Survey (CBECS) is the only national database of energy consumption and buildings characteristics information for commercial buildings in the United States. The 1999 CBECS was largely longitudinal with the 1995 CBECS and permits direct comparison of energy consumption in the same buildings for two different survey years. In this paper two building types (office buildings and inpatient health care buildings) and two energy sources (electricity and natural gas) were examined. About half of office buildings showed an increase in electricity and natural gas consumption. About three-fourths of inpatient health care buildings had increased electricity consumption while 70 percent of inpatient health care buildings had reduced natural gas consumption.

Introduction

The Energy Information Administration (EIA) was mandated by Congress to be the independent statistical agency within the Department of Energy that collects, analyzes, and disseminates impartial, comprehensive data about energy—how much is produced, who uses it, and the purposes for which it is used. EIA collects data from two distinct sources that, in their entirety, provide a comprehensive picture of energy production, marketing, and use in the United States. The first group of surveys, termed "supply" surveys, measure the quantity of the specific fuel produced and/or supplied to the market. The second group of surveys, termed "consumption" surveys, collect data from samples of the end-use consumers.

The end-use consumption surveys consist of the Manufacturing Energy Consumption Survey (MECS) conducted for manufacturing establishments, the Residential Energy Consumption Survey (RECS) conducted for residential households, and the Commercial Buildings Energy Consumption Survey (CBECS) conducted for commercial buildings. This paper will focus on the two most recent CBECS (1995 and 1999).

Overview of CBECS

The CBECS, which was first conducted in 1979, is a sample survey of approximately 6,000 commercial buildings throughout the United States. Data are collected every four years with the most recent survey conducted in 1999. From 1986 through 1995 the survey data were collected via personal interviews while the 1999 CBECS data were collected by telephone interviews. The CBECS data provide information about: the physical characteristics of commercial buildings, how the buildings are used, the prevalence of energy-related equipment, and the types and amount of energy used.

For over 20 years, building and energy analysts, including the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy, have used this statistical database of commercial buildings characteristics and energy consumption to answer fundamental questions about the use of energy in commercial buildings.

Strengths and Weaknesses of CBECS

Since the CBECS data are used for both projecting energy use in the commercial buildings sector and as a benchmark for programs such as the Energy Star buildings, it is incumbent on the analysts using the data to understand both its strengths and weaknesses.

The strengths of the CBECS databases are *well known* and do not need extensive discussion. First and foremost, CBECS is the only national database of commercial buildings in the U.S. that provides both characteristics data and energy consumption data for a wide range of building types and sizes. Buildings that would not normally be considered "commercial" in the economic sense, such as public schools, correctional institutions, and religious and fraternal organizations are included.

Energy consumption data are based on the billing data of the sampled buildings and thus are a direct measure of the amount of energy used for those buildings. Building data are now available for data years spanning more than two decades. These data can be used to measure changes in the commercial buildings sector over time. Because the CBECS databases contain information on major characteristics of a building (e.g., type of building, size, year constructed, operating hours, energy-related equipment, and prevalence of conservation measures) along with the amount and types of energy consumed by the building, the relationships between building characteristics and energy use can be analyzed.

There are two principal weaknesses of the CBECS data: limitations in the appropriateness of the use of the data and limitations related to the quality of the data. The limitations in the former are fairly well understood and include timing of surveys, coverage, confidentiality, and the general lack of longitudinal data.

CBECS, which is now conducted every four years, requires approximately two years lead-time for designing the survey and developing the questionnaire, and then another two years for collecting and processing the data. The length of time required in conducting one survey cycle limits CBECS' use in addressing topical issues in a timely manner.

CBECS' coverage also limits the type of analysis that can be performed. The data cannot be used to analyze energy use or building characteristics at the state level, often a severe drawback for many building and energy analysts. The smallest geographic unit covered is the Census division, a group of three to eight states defined by the U.S. Census Bureau. Additionally, the CBECS data can only be used to measure energy use in the commercial *buildings* sector, not the commercial sector as a whole, since CBECS excludes energy not associated with buildings, such as streetlights, billboards, or water and fuel pumps.

The issue of respondent confidentiality also constrains analyses of CBECS data. Because individual buildings are not identified by name or location in the databases, the measurement of energy use or characteristics associated with specific buildings, such as the Energy Star buildings, is not possible. Finally, with the exception of a few survey cycles (1986/1992 and 1995/1999), a new sample of buildings is selected for each survey, limiting

the ability to conduct longitudinal analyses of energy use in the same building across survey cycles.

The second weakness is related to the quality of the CBECS data and is less understood by those using the data. How the data are collected, how the questions are asked, the level of respondent and interviewer knowledge about the questions, the way the data are edited after data collection, and the handling of missing data all affect the data quality.

1995 and 1999 CBECS Longitudinal Buildings

Since the CBECS was redesigned in 1986, generally a new sample of buildings has been selected for each successive survey, with relatively few buildings overlapping from previous surveys. The 1999 CBECS, however, was largely longitudinal with the 1995 CBECS—the only new buildings added to the sample were those built between 1995 and 1999. The large longitudinal component provides an opportunity to directly compare data collected from the same buildings by the two different surveys. This is important for two reasons; first, direct comparisons of energy consumption and energy-related characteristics of the same set of buildings are possible between 1995 and 1999. Second, the quality of data collection by the 1999 CBECS, in particular, the collection of energy consumption data can be studied. In previous CBECS, those data were collected from the sampled buildings' energy suppliers via a separate mail supplier survey in which the suppliers provided one year's worth of actual billing data for the sampled buildings. In 1999 the approach to collecting the energy consumption data was changed and about 60 percent of the consumption data were collected directly from the building respondents during the building survey.

The following sections examine data for two commercial building types—office buildings and inpatient health care buildings (including hospitals)—and two energy sources—electricity and natural gas. In many cases, a complete set of building characteristics data and consumption data for both 1995 and 1999 buildings was not collected—missing data items were not unusual. These items were statistically imputed in the final data file. In this paper, only data reported (i.e., not imputed) for each longitudinal building pair for both years was used. We further refined the comparison of the longitudinal buildings by excluding buildings where the building was enlarged or reduced in size, and excluding buildings where the electricity[1] or natural gas[2] end uses were different. That is, the buildings were unchanged in size and had the same end uses for both years (Table 1).

In the figures in the following sections we plotted the change in electricity or natural gas consumption with the ratio of consumption in 1999 to consumption in 1995. An increase in consumption would have a ratio greater than one and a decrease would have a ratio less than one.

[1] Electricity end uses: main space heating, secondary space heating, cooling, cooking, water heating, and manufacturing.

[2] Natural gas end uses: main space heating, secondary space heating, cooling, cooking, water heating, manufacturing, and electricity generation.

Table 1. Number of Buildings in 1995 and 1999 CBECS Samples, and 1995/1999 Longitudinal Buildings

	All Commercial Buildings	Office Buildings	Inpatient Health Care Buildings
Total 1995 CBECS building sample	5,766	1,228	205
Total 1999 CBECS building sample	5,430	1,139	176
1995/1999 longitudinal buildings:			
All	4,380	807	153
Electricity consumption reported	2,051	480	103
Electricity consumption reported and electricity end uses equal and reported	506	140	25
Natural gas consumption reported	1,108	212	55
Natural gas consumption reported and natural gas end uses equal and reported	309	69	23

Buildings that Used Electricity

Office Buildings

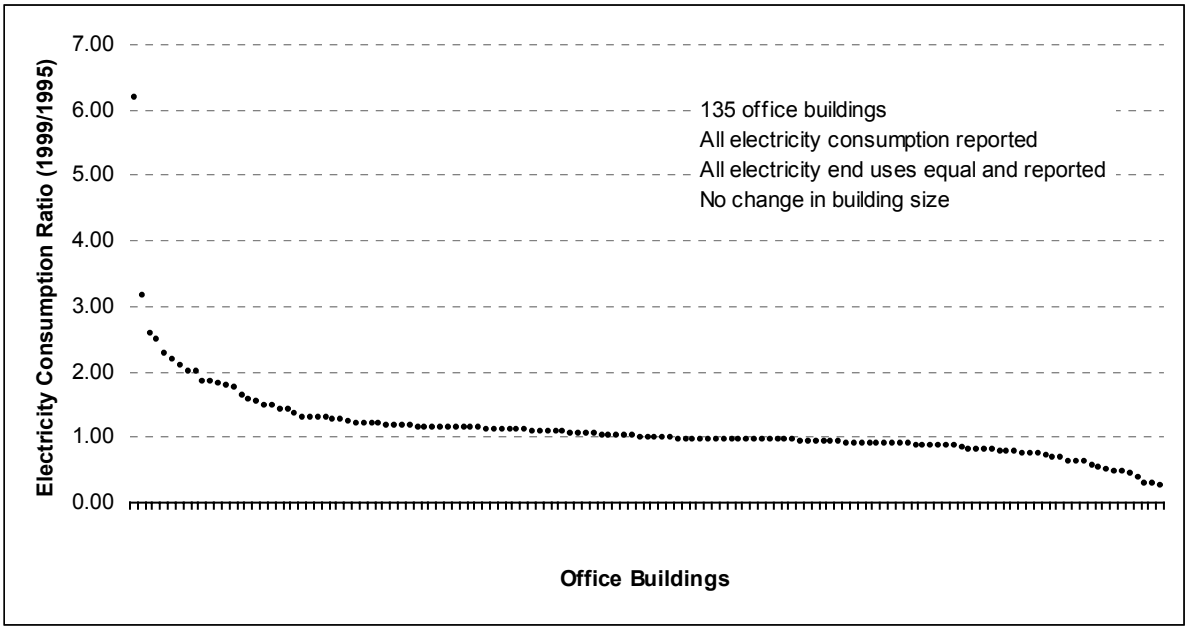
A total of 480 office buildings had electricity data reported for both 1995 and 1999 (Table 1). Of those buildings, 140 had the same reported electricity end uses for both years and had no additions or demolition. A number of these buildings had either significantly greater or less electricity consumption in 1999 than in 1995. Data from five of these buildings were considered questionable and were not included in the final number of office buildings that were examined. In these cases, total consumption and consumption intensity (consumption per square foot) were at least an order of magnitude higher or lower but no change in building characteristics to account for such a change in consumption was observed. For example, there were no major changes in commercial activity (operating hours, number of workers), and no periods of vacancy. A possible source of error for these five buildings may relate to the change in the data collection methodology in 1999 where the consumption data were obtained from the building respondent via a telephone interview instead of from the energy supplier in a mail survey. Often the respondent had to provide very large consumption numbers over the telephone that the interviewer, in turn, had to correctly record.

Figure 1 shows the electricity consumption ratio (1999 consumption/1995 consumption) for the remaining 135 office buildings. No obvious trend is apparent in the figure—about half showed an increase in consumption and about half a decrease. The buildings with significantly larger or smaller consumption increases (more than or less than 50 percent) were often smaller buildings that consumed relatively small amounts in both years and were susceptible to large percentage changes.

Some of the increase in electricity consumption may be due to an increased use of computer and telecommunications equipment between 1995 and 1999. While a limited amount of computer and other office equipment information was collected in 1999, only the number of personal computers in a building was collected in 1995. Of the 71 buildings that had increased consumption, 28 reported more computers in 1999, 30 reported the same number, while 11 reported using fewer computers (and data were missing for 2 buildings). In contrast, of the 64 buildings that had decreased consumption, 11 used fewer computers, 38 the same number, and 13 more computers (and data were missing for 2 buildings) (Table 2).

These data suggest that increased electricity consumption was consistent with increased computer use and it is reasonable to assume that many of these buildings also had increased use of other computer and telecommunications equipment. However, other factors, such as weather, cannot be ruled out.

Figure 1. Electricity Consumption Ratio (1999/1995) for Office Buildings



Source: EIA 1995 and 1999

Table 2. Change in the Number of Computers Used in Buildings in CBECS Sample Between 1995 and 1999

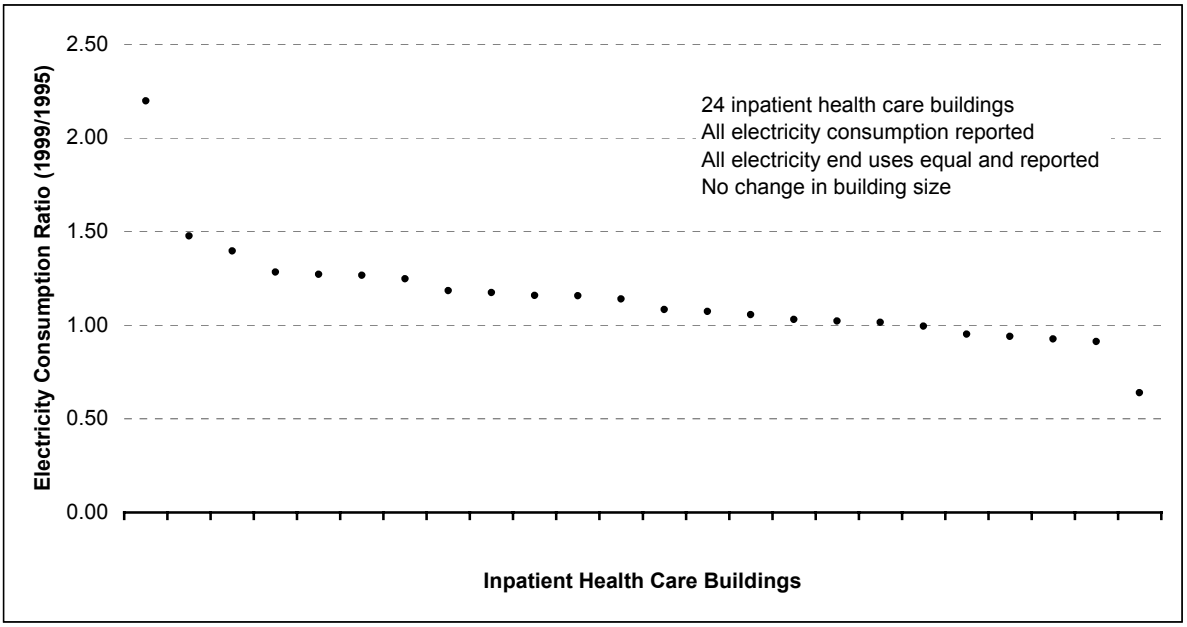
	More Computers	Unchanged	Fewer Computers	Data Not Reported
Office Buildings				
Electricity consumption ratio ≥ 1	28	30	11	2
Electricity consumption ratio < 1	13	38	11	2
Inpatient Health Care Buildings				
Electricity consumption ratio ≥ 1	6	8	4	0
Electricity consumption ratio < 1	2	1	3	0

Inpatient Health Care Buildings

Electricity consumption was reported for both years for 103 inpatient health care buildings and 25 of those were unchanged in size and had reported electricity end uses that were the same for both years. Figure 2 shows the electricity consumption ratio for 24 buildings (one was excluded because of unreliable consumption data). These data do show a trend—electricity consumption was greater for 18 (or 75 percent) of the 24 buildings. The general increase in electricity consumption may well be related to the increased use of electricity-intensive medical diagnostic equipment. The 1999 CBECS did ask about the presence of medical diagnostic equipment in inpatient health care buildings, but the 1995 CBECS did not include this question, so we could not determine if the increase in electricity

consumption in 1999 correlated with a change in equipment use. As with office buildings, the number of computers was collected for both years. However, unlike office buildings, there was not a discernible trend in the use of computers with respect to consumption. Of the 18 buildings with more consumption, 6 reported more, 8 the same, and 4 fewer computers (Table 2).

Figure 2. Electricity Consumption Ratio (1999/1995) for Inpatient Health Care Buildings



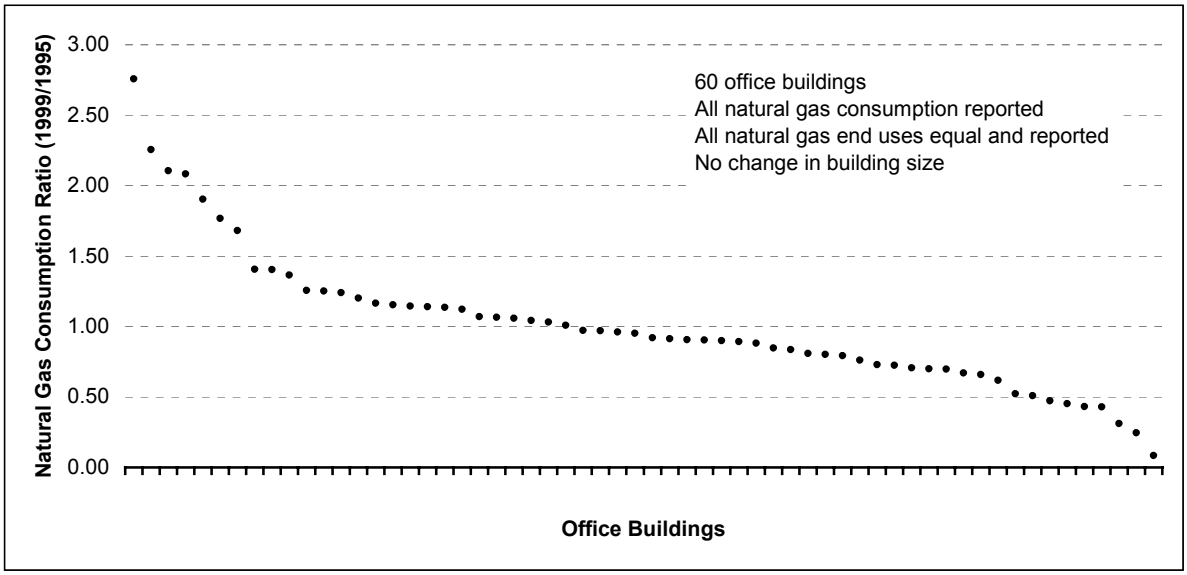
Source: EIA 1995 and 1999

Buildings that Used Natural Gas

Office Buildings

Natural gas consumption was reported for both years for 212 office buildings (Table 1). Of those buildings, 69 reported the same natural gas end uses and had no changes in building size. The natural gas consumption data that are reliable for 60 office buildings are shown in Figure 3. Eleven of the 12 buildings that had the greatest percentage increase (25 percent or more) in natural gas consumption were buildings that used small amounts of the fuel in both years and were thus susceptible to large percentage changes with a small change in amount consumed. The other building (the one with the natural gas consumption ratio of 1.9) had a significantly colder heating season in 1999 than in 1995. Of the 13 buildings with the largest percentage drop in natural gas consumption, nine used small amounts of natural gas, and all experienced milder heating seasons in 1999 than in 1995.

Figure 3. Natural Gas Consumption Ratio (1999/1995) for Office Buildings



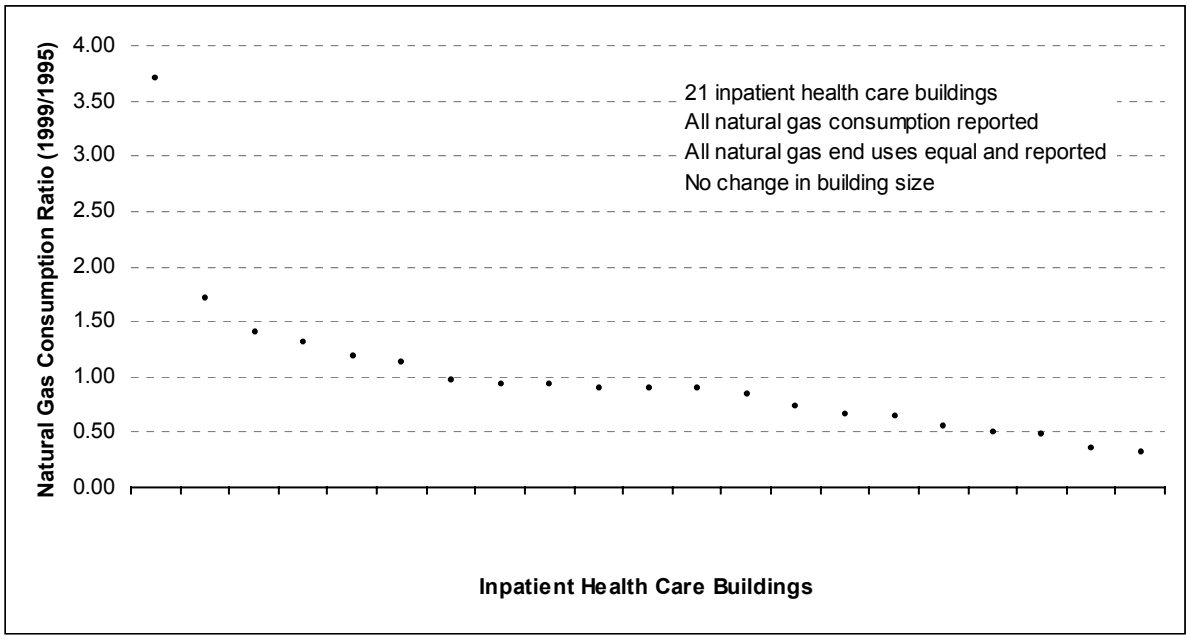
Source: EIA 1995 and 1999

Inpatient Health Care Buildings

Natural gas consumption data were reported for 55 inpatient health care buildings (Table 1). Of these buildings, 23 had the same natural gas end uses for both 1995 and 1999 and had no change in building size. Figure 4 shows the natural gas consumption ratio for the 21 buildings with reliable data.

Three of the eight buildings that had the largest percentage declines in natural gas consumption used small amounts of natural gas for both years, and seven of those buildings experienced a milder heating season in 1999 than in 1995. The building with the largest percentage increase used a small amount of natural gas for both years. There was no correlation between heating degree-days and consumption for the six buildings that showed an increase in consumption.

Figure 4. Natural Gas Consumption Ratio (1999/1995) for Inpatient Health Care Buildings



Source: EIA 1995 and 1999

Summary and Conclusions

The Commercial Buildings Energy Consumption Survey is a sample survey that is designed to give national and Census division level building characteristics and energy consumption statistics for the commercial buildings sector. The statistics reported by CBECS are weighted estimates based on the individual building level data. Generally the building sample is changed with every survey cycle and changes in CBECS estimates between surveys reflect changes across a different sample; however, both samples are representative of the commercial buildings sector as a whole.

The 1999 CBECS sample contains a large percentage of buildings that are longitudinal with the 1995 CBECS. Direct comparison of data for the longitudinal buildings is possible, but care must be taken in any analysis using these data. First, data should be compared only for those buildings with data reported for both years. Missing or unreliable data are imputed in the public use microdata files and imputed data for any element cannot be compared at the individual record level. The public use files contain additional variables ("z" variables or imputation flags) that indicate whether each data element is reported or imputed. Second, the collection of energy consumption data in the 1999 CBECS from the respondent via a telephone survey (rather than a separate supplier survey) probably introduced additional error.

Planning for the 2003 CBECS is currently underway. The 2003 survey will collect the data in personal interviews and include more questions about office equipment, medical diagnostic equipment in health care buildings, distributed generation, and identification of data centers as a separate building activity. Consumption and expenditures data will again be collected at the building level from respondents; however, more rigorous editing procedures than employed than in 1999 will be used.

References

Energy Information Administration (EIA). 1995. *1995 Commercial Buildings Energy Consumption Survey Public Use Files.* (http://www.eia.doe.gov/emeu/cbecs/public_use.html)

Energy Information Administration (EIA). 1999. *1999 Commercial Buildings Energy Consumption Survey Public Use Files.* (http://www.eia.doe.gov/emeu/cbecs/public_use.html)