Appendix A

How the Survey Was Conducted

Introduction

The Commercial Buildings Energy Consumption Survey (CBECS) is conducted by the Energy Information Administration (EIA) to provide basic statistical information on energy consumption and expenditures for U.S. commercial buildings and data on energy-related characteristics of these buildings. To obtain this information, a survey is conducted, which is based upon a sample of commercial buildings selected according to the sample design requirements described in this appendix. A "building" as opposed to an "establishment" is the basic unit for the CBECS because a building is the energy-consuming unit.

This is the sixth in a series of surveys covering the commercial sector. The first survey was conducted in 1979; surveys were then conducted on a triennial basis beginning in 1983 until 1995. Future CBECS will be conducted on a quadrennial basis, with the next CBECS scheduled for 1999.

The CBECS is conducted in two major data-collection stages: a Building Characteristics Survey and an Energy Suppliers Survey. The first stage is a Building Characteristics Survey that collects information about selected commercial buildings through voluntary personal interviews with the buildings' owners, managers, or tenants. In 1995, the data were collected by using Computer-Assisted Personal Interviewing (CAPI) techniques. An authorization form signed by the respondent is used to secure the release of the building's energy consumption and expenditures records from the energy supplier. These energy consumption and expenditures data are collected during the Energy Suppliers Survey, which is the second stage.

The Energy Suppliers Survey obtains data about the building's actual consumption of energy and associated expenditures for that energy from records maintained by energy suppliers. The information is obtained by means of a mail survey conducted under EIA's mandatory data collection authority. Additionally, the CBECS asked energy suppliers about any demand-side management programs they may have provided to the building. Under EIA's direction, a survey research firm conducted both the personal interviews for the Building Characteristics Survey and the mail survey for the Energy Suppliers Survey.

This appendix discusses in greater detail how the CBECS is conducted. It describes the sample design, the survey forms, response rates, data collection and data processing procedures, and the data preparation for the statistical reports based on the survey results.

Target Population

The target population for CBECS consisted of all commercial buildings in the United States larger than 1,000 square feet, with the exception of commercial buildings located on manufacturing sites. To be eligible for the survey, a building had to satisfy three criteria: (1) it had to meet the survey's definition of a building, (2) it had to be used primarily for some commercial purpose, and (3) it had to measure 1,001 square feet or more.

A building is defined by CBECS as a structure totally enclosed by walls that extend from the foundation to the roof and is intended for human access. To be used primarily for some commercial purpose, the building must have more than 50 percent of its floorspace devoted to activities that are neither residential, industrial, nor agricultural. The 1995 CBECS estimated that there were 4,579 thousand buildings in the target population.

Sample Design

The sample design for the CBECS is a multistage area probability cluster sample design supplemented by a list sample of "large" buildings, recently constructed buildings, and "special" buildings (Federal Government buildings and post offices, hospitals, colleges, and universities). The area sample portion of the design is a sample from the broad spectrum of commercial buildings. The supplemental list sample provides an oversample of "large" buildings and "special" buildings. Similarly, for recently constructed buildings, the area sample is used to provide a sample from the broad spectrum of new buildings and the supplemental list sample provides an oversample of "large" new buildings.

Multistage Area Probability Sample

The area component of the CBECS sample used a four-stage cluster sampling design that selected primary sampling units (PSU's), secondary sampling units (SSU's), segments, and, ultimately, buildings. The first three of these stages involved sampling progressively smaller geographic areas. For the 1995 CBECS, the same PSU's, SSU's, and segments that were selected for the 1986 CBECS were reused. For the fourth stage of sampling, the 1995 selection of buildings was executed by using procedures to update the 1986 CBECS building lists to include new construction in the sampled segments.

Supplementary List Sample from Lists of Large and Specialized Buildings

To ensure adequate coverage of buildings that were significant energy users, the multistage area probability sample was supplemented within each selected PSU by a sample from a list of "large" buildings (buildings over 250,000 square feet) or facilities. In addition, to improve the precision of energy consumption estimates for certain types of buildings, a supplementary sample was drawn from several lists of special buildings. These list frame files differ from the area segment listings in that the list files are primarily facility or construction-project based as opposed to building based.

Desired Sampling Results

The goal of the 1995 CBECS sampling procedures (both the area sample and the supplemental list sample) was to achieve completed interviews for 5,500 buildings — 4,450 buildings from the area sample and 1,050 buildings from the supplemental list sample.

Actual Sample Selected

In order to achieve the 1995 CBECS goal for number of respondents, a sample of 8,074 potential cases was selected, consisting of 6,633 buildings from the area sample frame and 1,441 buildings from the supplemental list sample frames consisting of large buildings and special buildings. Of these 8,074 buildings, 6,590 buildings were found eligible for interviewing. The three primary eligibility criteria, building definition, building use, and building size are described in the "Determining Building Eligibility" section below. Other reasons for sample building listings to be classified as ineligible included duplication of buildings, demolished buildings, buildings under construction, or commercial buildings on industrial facilities.

Response Rates

Of the 6,590 eligible buildings, interviews were completed for 87.5 percent, or 5,766 buildings (4,728 buildings from the area sample and 1,038 buildings from the supplemental list sample). Of the 5,766 CBECS respondents, 5,668 reported some energy use in the building. For 92.6 percent, or 5,250, of these buildings, an authorization form was obtained which allowed the survey contractor to contact the energy suppliers for release of the energy billing data for the building.

Building Characteristics Survey

This section describes how the building characteristics survey is conducted. It includes information about what constitutes a commercial building for the CBECS, how the questionnaire is designed, the type of interviewer training that occurs, how the data are collected (including procedures to minimize nonresponse), and what the data edit specifications are.

Determining Building Eligibility

Determining building eligibility was a three-step process. The first step occurred during the development of the area and supplemental sample listings. The second step occurred when the interviewer observed the building, and the third step occurred during the interview of the building owner or manager. While criterion one, the definition of a building, can be determined during the first and second steps, criteria two and three are based more on lister or interviewer judgment and could result in exclusion of eligible buildings or the inclusion of ineligible buildings during those steps. The third step is crucial in identifying ineligible buildings. Once the interviewer begins the interview, initial screening questions instruct the interviewer to terminate the interview if criterion two or three is not met.

Criterion 1: Building Definition: The definition of a building was the same one used in previous CBECS: a structure totally enclosed by walls that extend from the foundation to the roof and intended for human access. Thus, structures such as water, radio, and television towers were excluded from the survey. Also excluded were (1) parking garages and partially open structures, such as lumber yards; (2) enclosed structures that people usually do not enter or are not buildings, such as pumping stations, cooling towers, oil tanks, statues, and monuments; and (3) dilapidated or incomplete buildings missing a roof or a wall. There is one exception to the building definition criterion: a structure built on pillars so that the first fully enclosed level is elevated. These were included because such buildings fall short of meeting the definition due only to the technical shortcoming of being raised from the foundation. They are totally enclosed, are used for common commercial purposes, and use energy in much the same way as buildings that sit directly on a foundation.

Criterion 2: Building Use: The second criterion was that a building had to be used primarily for some commercial purpose; that is, more than 50 percent of the building's floorspace must have been devoted to activities that were neither residential, industrial, nor agricultural. The primary use of the sampled building governed whether the building was included in the CBECS. In 1995, there was one exception to this criterion: commercial buildings on manufacturing sites were considered out of scope. (In previous CBECS, if a commercial building (e.g., an office building), was located on a manufacturing site, it would have been considered in scope).

Examples of nonresidential buildings that were not included in the CBECS samples are:

- Farm buildings, such as barns, unless space is used for retail sales to the general public
- Industrial or manufacturing buildings that involve the processing or procurement of goods, merchandise, or food
- Buildings on most military bases
- Buildings where access is restricted for national security reasons
- Single-family detached dwellings that are primarily residential, even if the occupants use part of the dwelling for business purposes
- Mobile homes that are not placed on a permanent foundation (even if the mobile home is used for nonresidential purposes).

During the interviewing stage, interviewers were instructed not to begin interviews at buildings where they observed that 75 percent or more of the floorspace was used for residential, industrial, or agricultural purposes. Once the interview began, screening questions instructed the interviewer to terminate the interview if the respondent indicated that 50 percent or more of the square footage was used for residential, industrial, or agricultural purposes.

Criterion 3: Building Size: The third criterion was that a commercial building had to measure more than 1,000 square feet (about twice the size of a two-car garage) to be considered in scope for the 1995 CBECS. This building size criterion was met in two successive size cutoffs, which were enacted during the listing and interviewing processes. During the listing stage, buildings judged to be less than 500 square feet were not listed. Interviewers did not begin interviews when they observed a building to be 500 square feet or less. Then during the interviewing stage, interviewers asked screening questions designed to terminate the interview when the square footage was reported to be 1,000 square feet or less.

Data Collection

Data collection encompasses several phases, including: (1) designing the questionnaire, (2) training supervisors and interviewers, (3) collecting data, (4) minimizing nonresponse, and (5) processing the data. A survey contractor performed the data collection under the direction of EIA.

Designing the Building Characteristics Survey Questionnaire

Questionnaire design work for the 1995 CBECS was conducted by EIA. Although a set of core questions remained the same or very similar to those used in previous surveys, the 1995 Building Questionnaire was redesigned to improve data quality and to allow the data to be collected by use of Computer-Assisted Personal Interviewing (CAPI) techniques.

Use of CAPI: Increasingly, in an effort to provide more timely data and to enhance the quality of data, surveys are conducted by using Computer-Assisted Interviewing (CAI) systems. Because of the complexity of the CBECS, a personal interview with a building respondent is the most preferable method of collecting information about a particular building. Thus, using CAPI was the most logical CAI method for CBECS. Interviewers were provided laptop computers that had been preloaded with questionnaires for the buildings they were to interview.

The CBECS questionnaire requires the interviewer to ask specific follow-up questions based on the responses to previous questions. Therefore, a major benefit of converting to CAPI from a paper and pencil questionnaire was the ability to build edits into the questionnaire that would reduce the need for the interviewer to decide which of the follow-up questions to ask the respondents. This, in turn, reduced the number of skip pattern errors that needed correcting during the post-interview edit phase and the number of item nonresponses. Additionally, these built-in edits alerted the interviewer to data inconsistencies that might occur when the respondent selected an answer that was technically incorrect or incompatible with a previous answer. For example, if the respondent reported the presence of heating equipment types that were unlikely for a given energy source, CAPI alerted the interviewer to this inconsistency and provided directions, via data screen messages, on how to resolve the inconsistency. (See "CAPI Edits During Interviewing" in this appendix for other types of edits.)

CAPI also allows the interviewers to transmit data for completed cases electronically from the field to the home office so that data processing can start immediately. This capability allows processing to proceed more smoothly and ultimately results in faster dissemination of the data to CBECS customers.

Training Supervisors and Interviewers

The CBECS building questionnaire is a complex instrument designed to collect data during a personal interview at the building site. Well-trained interviewers are imperative to the collection of technical information. Training for the 1995 CBECS included three in-person training sessions: one session for the interviewer trainers, monitors, and regional supervisors and two sessions for the interviewers. Because the 1995 CBECS was collected for the first time by using CAPI, all interviewers were trained in the general use of the computer and in interviewing and administering the CAPI questionnaire. Training sessions included lectures, interviewers slide presentations, and small group sessions where the interviewers practiced administering the questionnaire by using laptop computers. EIA personnel participated in all training sessions, providing an overview of the CBECS and a presentation on the key 1995 CBECS energy concepts.

Prior to interviewer training, all prospective interviewers received the CBECS Training Video, a *CBECS Interviewer's Manual*, a *CBECS Computer Assisted Personal Interviewing (CAPI) Reference Guide*, a home-study exercise to be completed prior to training, and a training agenda. The CBECS Training Video included: (1) concepts of sampling, (2) the CBECS definition of a building and the eligibility criteria, (3) information on how to determine the boundaries of a building, and (4) the area sample listing materials. The video was used to familiarize the interviewer with these materials prior to the in-person interviewer training. The *CBECS Interviewer's Manual* included instructions for locating sampled buildings and conducting interviews, as well as describing administrative and reporting procedures. The *CBECS Computer Assisted Personal Interviewing (CAPI) Reference Guide* described the care and operation of the computer hardware for the 1995 CBECS and the Case Management and Interviewing System that was loaded onto the laptops. Home-study exercises were related directly to materials covered in the video.

Interviewers who had not previously worked for the survey contractor received the *General Interviewing Techniques Manual* and a home study guide with exercises to be completed prior to training. Interviewers with no prior experience with CAPI participated in a 3-4 hour hands-on, self-paced instruction program on how to use the laptop computer.

During the training, all interviewers received (1) question-by-question specifications that described the intent of each question, the definitions of terms used in the survey, and how to ask each question and (2) Hand Cards that were to be used during the interview. By the conclusion of the training session, all interviewers had completed four scripted practice interviews that covered various types of situations they might encounter in the field.

Because the feedback EIA received from energy suppliers indicated that the primary reason for delays in processing the Energy Suppliers Survey was missing account numbers, special emphasis was placed on obtaining account numbers. The importance of this was stressed, along with the importance of obtaining signed authorization forms from the respondent. These forms are used to secure the release of the buildings' energy consumption and expenditures records from the energy supplier. With the 1995 survey, account numbers were added as a data item collected during the interview rather than in conjunction with preparing the authorization form.

The 1995 CBECS interviewing training sessions included a formalized evaluation process. Based on the results of a key concepts quiz/test and an evaluation by trainers and/or supervisors, the interviewer trainees were considered either to have successfully completed training, were placed on probation, or were released from the study.

Collecting the Data

Initial contacts with the building representatives were made through an introductory letter mailed to them at each building or facility in the survey sample. The letter, signed by a representative of EIA, was addressed to the building owner or manager. The letter explained that the building had been selected for the survey, introduced the survey contractor, assured the building manager that the data would remain confidential, and discussed the uses and needs for the CBECS data in setting national energy policies. To protect confidentiality, the letter was addressed by the survey contractor after it was signed at EIA.

A worksheet was attached to the letter that listed several pieces of information that the respondent should have ready for the interviewer. This information included square footage of the building, year constructed, energy sources used, types of heating and cooling equipment, number of workers, energy billing account numbers, and names and addresses of the energy suppliers. The worksheet alerted the respondent to questions that might be difficult to answer "on-the-spot" and which, if gathered prior to data collection, could reduce the length of the interview or the need for callbacks. Additionally, 989 buildings selected in 1995 that were from the 1992 CBECS and 21 buildings from the 1993 Federal Buildings Supplemental Survey were sent information that they had previously reported during those two surveys.

Data collection began August 28, 1995, and ended December 8, 1995. The data were collected by the survey contractor's field staff. This staff consisted of 149 interviewers under the supervision of seven regional supervisors and their assistants and a central office staff consisting of a project manager, a field director, and a subsampling assistant.

Interviewers: Prior to beginning the interview, the interviewer observed the outside of the building to ascertain if the structure met the size and building-use eligibility requirements of the survey. If the building failed to meet any one of the definitional criteria, the building was classified as ineligible and no interview was conducted. (See "Determining Building Eligibility" section of this appendix for an explanation of these criteria.)

During the initial visit to the sampled buildings, the interviewers identified and attempted to schedule an interview with a knowledgeable respondent who met the survey criteria for a building representative. The respondent could be the owner of the building, a tenant, a hired building manager or engineer, or a spokesperson for a management company.

The Interview: Each interview began with a series of screening questions designed to verify the building's address and eligibility for the survey. Respondents were asked about the building as a whole rather than individual establishments located within the building. The completed building interview lasted an average of 40 minutes. This included the time for the interviewer to record the results of the screening, to ask all questions on the building characteristics questionnaire, and to obtain a signed authorization form from the respondent for the release of energy billing data from the energy supplier to the building. It did not include the observation time prior to the interview to determine if the building was eligible or the time needed to obtain a signed authorization form from someone other than the building respondent in those cases when the building respondent did not have the authority to sign the form.

The average time to obtain each completed interview, including interviewer preparation, travel, callbacks, interviewing, and transmitting the completed interviews to the home office, was 6 hours and 54 minutes. Each interviewer conducted an average of 53 interviews: 5 interviewers each completed 10 or fewer interviews, while 6 interviewer each completed more than 70.

Interviewer Supervision: Procedures were taken to ensure that the interviews were conducted as intended. Ten percent of each interviewer's cases were preselected for validation to verify that the interview had been conducted and that it had been conducted at the correct building according to specified procedures. This validation occurred by telephone at the survey contractor's home office. If a disproportionate percentage of an interviewer's validation cases were classified as ineligibles or nonrespondents, additional cases were selected as needed to ensure 10 percent coverage of responding cases for each interviewer. Interviewers were informed that a sample of their work would be validated, but they were not informed which completed interviews would be checked. If a field supervisor was concerned about a particular interviewer, he or she conducted discretionary validations.

Minimizing Nonresponse

Several approaches were employed in an effort to minimize nonresponse, including: advance mailings to building owners or managers (see 'Data Collection' in this appendix); in-person visits; telephone callbacks; establishment of a toll-free "hot-line" number to address respondents' concerns or questions; personalized letters to documented refusals; and provision of additional field staff in several Metropolitan Statistical Areas to help those who still had problem cases. These approaches dealt with the three categories of nonresponse for CBECS: (1) refusals, (2) cases where the knowledgeable respondent was located outside of the sample PSU's, and (3) cases where the respondent was unavailable during the field data collection period.

An additional type of nonresponse conversion dealt with respondents who declined to sign the authorization forms that would allow their energy suppliers to release the building's energy consumption records and information on demand-side management program participation. Personalized written requests for signed authorization forms were mailed for all buildings for which energy usage had been reported and a signed form had not been obtained by an interviewer. Such requests were mailed to 219 buildings interviewed by field staff. A total of 24 signed authorization forms were received by mail.

Processing the Data

The initial processing of the CBECS data occurred at the survey contractor's home office and included receipt of the CBECS questionnaires as they were transmitted from the field, editing the questionnaires, calculating the survey weights for each building, and masking the data for confidentiality before it was transmitted to EIA. Final data preparation occurred at EIA and consisted of checking the data for internal consistency, checking the data against data from previous surveys, conducting imputation procedures for missing data, and preparing cross-tabulations for release to the public.

Data Editing: Data editing for the 1995 CBECS Building Characteristics Survey occurred at several points during data collection and processing. Initial editing occurred during the Computer-Assisted Personal Interviewing (CAPI) interview. Additional editing occurred upon receipt of the questionnaire for data processing and during data entry. The final data editing occurred during review of data frequencies and cross-tabulations.

CAPI Edits During Interview: Data collection using CAPI techniques allows for some data editing to occur during the interview, thus ensuring a higher quality of data, as well as reducing the time required for post-interview editing. Higher quality of data was achieved through building procedures to control the skip patterns and to prohibit the entry of ineligible codes directly into the CAPI questionnaire. CAPI edits that occurred during the interview included:

- Arithmetic checks for items that were required to total 100 (or more), with corrections required before the interviewer could proceed;
- Double entry of square footage and energy account numbers, with reconciliation of inconsistencies before the interviewer could proceed;
- Verification of the response when an open-ended numeric response fell outside of a preset range;
- Inter-item consistency checks that prompted interviewers to confirm that the responses were being reported and recorded as intended.

Data Editing at Home Office: Completed questionnaires were transmitted electronically to the survey contractor's home office and the hard-copy materials were mailed. Clerks reviewed the hard-copy materials to locate a signed authorization form and any hard-copy listings of account numbers and supplier customer lists used to supplement CAPI. Linkage of the building with the energy supplier was completed as part of the processing of building survey data.

Edits at this stage were of three types: (1) missing data checks, (2) automated logic checks that verified compliance with codes and skip patterns as specified in the codebook, and (3) inter-item consistency checks.

The survey contractor took several steps to resolve inconsistencies or ambiguities in the data. First, the contractor reviewed other parts of the questionnaire for explanations that might help solve the problem. Several open-ended questions were included in the questionnaire that allowed the respondent to either describe or include additional information about a particular item. Also, the interviewers had been asked to write comments in the "comment boxes" explaining unusual circumstances. These open-ended questions and notes were relied upon extensively in the resolution process and were very helpful in explaining some of the inconsistencies. Second, in some hard-to-resolve cases, EIA personnel provided technical guidance on how to reconcile some questionnaire responses. Finally, when these efforts failed to resolve a problem, especially when the energy sources or heating and cooling equipment were involved, the survey contractor contacted the respondent by telephone for clarification.

Overall, telephone contacts to clarify both questionable or missing information were completed for the respondents of 602 buildings, 10 percent of all completed cases. All changes made to any questionnaire response as a result of these reviews were carefully documented and explained on an error-resolution sheet attached to the questionnaire.

As the last step prior to the delivery of the draft data tape to EIA, the contractor produced data frequencies and cross-tabulations. These were reviewed to reveal any outlying values and inconsistencies that the edits may not have identified. Inconsistencies were corrected by the contractor before data tapes were transmitted to EIA.

Using EIA's review of the initial draft data tape, the survey contractor provided EIA with a second draft data tape that included the survey weights for each observation. These data were reviewed by EIA and provided the basis for the final masked data tape.

Energy Suppliers Survey

This section describes how the Energy Suppliers Survey portion of the CBECS is conducted. It contains information about the data collection instruments, how the data are collected, and procedures used to adjust for nonresponse and weather.

During the Building Characteristics Survey, each respondent was asked to provide the name, address, and account numbers for all suppliers of energy to the building. In addition, respondents were asked to sign an authorization form that gave permission to the suppliers to release the building's monthly billing data to EIA. EIA's survey contractor sent copies of this form to the suppliers to secure the release of the buildings' billing records, as well as the buildings' participation in any demand-side management programs, if programs were available from the energy supplier. Attempts were made to contact all suppliers of electricity, natural gas (including suppliers of natural gas transported for the account of others), fuel oil, district sources (steam, hot water, and chilled water) that were identified during the Building Characteristics Survey.

Data Collection Instruments

Consumption and Expenditures Forms: Each supplier of electricity, natural gas, fuel oil, or district sources to a sampled building was asked to provide consumption and expenditures data on a mailed survey form. Because there were minor differences in data items by energy source, there were corresponding variations in the reporting forms as well. For example, the electricity forms requested kilowatt (kW) demand; the natural gas forms included transportation gas, as well as provision for reporting variable units of measures (such as therms, cubic feet, or 1,000 cubic feet); the fuel oil forms requested information about the type of fuel oil used; and the district heating forms asked for information concerning the entire district or system.

Despite the above-mentioned differences, the forms for the different fuels were similar in terms of the data requested. In each case, the supplier was asked to report the following data: (1) quantity of specific energy source consumed or delivered; (2) total cost; (3) unit of measure; (4) dates of deliveries or consumption; and (5) number of customers included in both the consumption and cost data reported on the form.

Suppliers were not required to transcribe data onto the survey forms. Responses were accepted in any format (including computer printouts), as long as the necessary information was provided. Additionally, electric, natural gas, and fuel oil suppliers could submit their data on a formatted computer diskette provided by EIA. Response to the forms was mandatory for the supplier.

The data were requested for a 14-month period between December 1, 1994, and January 31, 1996, in order to ensure that data would cover a full calendar year no matter what the actual billing period had been. For example, if the billing period began on the 10th of each month, the first bill would be from December 10 through January 9. The bills were then prorated (annualized) to obtain data for the calendar year. (See Appendix B, "Nonsampling and Sampling Errors," for details on the annualization procedures.)

Demand-Side Management (DSM) Forms: An additional form was inserted in the electricity and natural gas usage forms to collect data about the building's participation in utility-offered energy-savings programs. Both forms collected essentially the same type of information, although each was tailored to the particular energy source, either electricity or natural gas. For example, the electricity suppliers were asked about DSM programs, such as lighting, energy-efficient motors, metered peak demand, time-of-day pricing, and standby electricity generation. The natural gas form asked about DSM programs but did not include those measures that were not applicable to natural gas suppliers, such as peak demand or time-of-day pricing. (The energy supplier forms are available from EIA upon request.)

Data Collection

Advance Mailings: An initial letter from EIA was mailed in September 1995 to electricity and natural gas utility companies that served buildings surveyed in the 1992 CBECS, explaining the survey and requesting a contact person be designated for the 1995 survey. A second letter from EIA, which included a copy of the 1992 CBECS executive summary from the Commercial Buildings Energy Consumption and Expenditures 1992, was mailed in November 1995 to companies that had not responded to the earlier request for information.

Survey Mailings: For the 5,766 buildings for which responses had been obtained in the Building Characteristics Survey, a total of 11,091 energy suppliers forms were mailed to 1,218 suppliers of energy. Of these suppliers, 518 (43 percent) were electricity and natural gas suppliers (including suppliers of gas transported for the account of others), 415 (34 percent) were fuel oil suppliers, and the remaining 285 (23 percent) were district heating suppliers.

The initial mailing of the survey forms to the energy suppliers occurred in early February 1996, with a due date of March 1, 1996, for the forms. Reminder letters to suppliers who had not returned the forms were sent shortly after the due date, with a second written request to nonrespondents in May 1996. Survey closeout was September 5, 1996 (the closeout date was extended by 3 weeks to accommodate several late-responding suppliers.)

Minimizing Nonresponse

Extensive efforts were used to obtain usable energy supplier data. Letters and telephone prompts were made to the energy suppliers throughout the data collection period to remind the suppliers to provide the data within the required time period. In addition, a toll-free telephone hot-line number was provided to all suppliers, both in the cover letter accompanying the survey forms and on the face of each survey form. Suppliers were encouraged to call this number if they had any questions. Hot-line staff were knowledgeable regarding the most frequent technical problems encountered by suppliers and the instructions to be given to suppliers calling with these questions.

Electricity, Natural Gas, and Purchased District Heat Suppliers: The nonresponse effort for the suppliers of electricity, natural gas, and purchased district heat began with a personalized reminder letter to all companies that had not returned *any* survey forms as of the March 1, 1996, date. Another nonresponse conversion letter was mailed May 1, 1996, to companies that had returned *some* but not all of their forms, as well as to companies that had not responded at all. Beginning May 23, 1996, nonrespondents were then telephoned and asked for the expected forms' completion date. These calls resulted in 128 requests for more forms. The companies were called again if that date arrived and they still had not responded. The nonresponse procedure was followed both for complete nonresponse by an energy supplier and for incomplete or missing buildings within a supplier's response.

Fuel Oil and Nonpurchased District Heat Suppliers: On March 6, 1996, a reminder letter was sent to each fuel oil supplier and each supplier of nonpurchased district heat that had not returned all forms. This was followed in April by a remailing of the entire packages of survey forms to those companies that had not yet responded. Telephone nonresponse conversion calls began on June 5, 1996, after a third letter was sent in May alerting the respondent to the telephone calls. The telephone calls resulted in numerous requests for additional survey forms, which were mailed in mid-June to 57 companies. When possible, the telephone interviewers attempted to obtain data over the telephone if a limited number of survey forms was missing.

Energy Suppliers Survey Response Rates: The overall response rate for the 1995 Energy Suppliers Survey was 84.9 percent (Table A1). The response rate is defined as:

$$\frac{\text{Usable Records}}{\text{All Records Minus Out-of-Scope Records}}$$

Each record corresponds to a single energy supplier for a particular energy source to a particular building. For example, a building with one electricity supplier, two fuel oil suppliers, and no other energy suppliers would have a total of three energy supplier records, one for electricity and two for fuel oil. Records were initially created on the basis of the Building Characteristics Survey respondents' reports of the names and addresses of their energy suppliers. A record was declared out-of-scope if it turned out to correspond to a supplier that did not actually serve the building during calendar year 1995.

Response rates for natural gas that was not identified as gas transported for the account of others and for electricity were 86.5 and 89.1 percent, respectively, which were similar to results obtained in previous CBECS. The response rate for the suppliers of gas transported for the account of others was 79.1 percent. The response rate for fuel oil was 77.7 percent and the rates for steam and hot water (district sources) were 62.3 percent and 25.7 percent, respectively.

Of the forms mailed, 1,516 (about 14 percent) were classified as nonresponse. This category included refusals, inability to respond within the data collection period, and inability to locate the correct account for the building.

Data Editing

As the suppliers' forms were received, they were screened for accuracy and completeness. The forms were then keyed and edited. (In 1995, for the first time, PC-based key entry was used for the suppliers survey forms.) The Energy Suppliers Survey used an extensive program of automated machine edits, including:

(1) Basic Energy Range and Skip Checks. The EIA specified ranges and values to be used for the technical edits. These values were based on previous CBECS responses and on knowledge of utility rates

Table A1. Response Rates for Energy Suppliers Survey by Energy Source, 1995

Survey Category	Electricity	Natural Gas	Transported Gas(a)	Fuel Oil	Steam	Hot Water	Total
Total Mailed Out	5486	3684	338	869	518	196	11091
Out of Scope	206	302	42	162	27	29	768
Nonresponse	545	448	56	158	185	124	1516
Complete: Usable Records	4705	2924	234	549	306	43	8761
Complete: Unusable Records(b)	30	10	6	0	0	0	46
Response Rate(c) (Percent)	89.1	86.5	79.1	77.7	62.3	25.7	84.9

[a] Transported gas is natural gas purchased from a source other than the local utility company but delivered to the building by the local utility. Transported gas is also called gas transported for the account of others.

[b] An unusable record contains all of the information requested on the survey form, but either does not cover all of the building's square footage or includes more square footage than is in the building, as defined by CBECS, and information is not available for calculating a disaggregation or aggregation factor.

[c] A response rate is calculated by dividing the complete usable record by the difference of total mailed out minus out of scope and multiplying the result by 100.

Source: Energy Information Administration, Office of Energy Markets and End Use, 1995 Commercial Buildings Energy Consumption Survey.

and practices. The first edits were range and basic logic checks.

(2) Consistency Checks Among Data Items. Edit failures at these levels were most often due to coding or data entry error. If the causes of the error were not apparent to the technical reviewer, it was referred to supervisory staff for resolution.

(3) Technical Edits. EIA specified a series of sophisticated edit checks to ensure that, to the extent possible, errors of the following types were detected and corrected: a too-long or too-short billing period; a consumption ratio that indicated there was extreme variability across the periods; a failure to report expenditures despite the presence of consumption, and vice versa; reported expenditures that were out of range for the consumption amount, for the price per unit of consumption based on known market prices, or for the metered demand.

Data Adjustments: Adjustments for unit nonresponse were performed in conjunction with weighting of the sample, as described in the "Unit Nonresponse Adjustments" in Appendix B. Cases missing all or part of calendar year 1995 consumption or expenditures were considered as a particular kind of item nonresponse. Adjustments for these cases were made as described under "Annual Consumption and Expenditures" in Appendix B.

Weather Data: A file of heating and cooling degree-days for each of the billing periods reported by each building supplier was created in the following manner:

- A National Oceanic and Atmospheric Administration (NOAA) division code was assigned to each building in the CBECS sample. Working with NOAA division maps and building address information, EIA assigned one of 356 division codes to each building.

- A file of NOAA data covering the 27-month period from January 1994 to March 1996 (the most recent information available at the time) was used to compute the average daily temperature for each day in the 27-month period for each weather division.

- Daily heating and cooling degree-day averages were computed for each of 10 base temperatures (degrees Fahrenheit): 50, 55, 57, 60, 65, 68, 70, 73, 75, and 80. Only base temperature 65 degrees Fahrenheit is covered in this report.

- Degree-day totals were constructed for each billing period, or gap between billing periods, for each energy supplier for each building. In addition, degree-day totals were constructed for each of the 12 calendar months of 1995 for each sampled building, whether or not the building had any energy supplied in 1995.

- As part of the annualization and imputation procedures described in Appendix B, "Nonsampling and Sampling Errors," billing period dates were imputed. The edited dates were used for the final degree-day computations.

Data Preparation for Report

After receiving the CBECS data tapes from the survey contractor, EIA data analysts reviewed and processed the data to prepare them for the final data tape. Cross-tabulations were run to check for internal consistency of the data, and the 1995 CBECS data were compared with data from previous CBECS. Commercial buildings' consumption and expenditure data are complex and interrelated. The EIA review was extensive and paid special attention to the issues of peak electricity demand, gas transported for the account of others, and incomplete data for buildings. Questions concerning data accuracy or outlier values were referred to the survey contractor for verification. EIA staff reviewed the data questionnaires at the survey contractor's site, and EIA's staff judgment was the final authority on some of the data items.

The sections above on data editing, data adjustments, and weather data provide details on the work undertaken to prepare the data for this report. In addition, if retrieval of missing data for one or more items failed, or if retrieval was not performed because the item was not a key item, data values were supplied by imputation. Additionally, the consumption and expenditures data were annualized; that is, they were adjusted by proration methods to estimates for calendar year 1995, when the reported data spanned a longer, shorter, or offset time period. When consumption or expenditures data were completely missing, the annual amounts were imputed by regression. (See Appendix B for a discussion of the separate imputation and annualization procedures used for the building characteristics and the energy consumption and expenditures.)

Once the annualized consumption and expenditures were computed or imputed for each building, statistical tables of aggregated data were then produced and analyzed. The report text was based on these tables, which are presented both in the text and in the "Detailed Tables" section of this report.

Public-use data are available in 21 micro data files in both ASCII and dBASE format. These micro data files contain the building characteristics data, energy consumption and expenditures data, and modeled energy end use data. They can be accessed from the World Wide Web at the URL http://www.eia.doe.gov/emeu/cbecs/contents.html (The files are listed under Data: Micro-Data Files.)

Confidentiality of Information

EIA does not receive or take possession of the names or addresses of individual respondents or any other individually identifiable energy data that could be specifically linked with an individual sample building or building respondent. All names and addresses are maintained by the survey contractor for survey verification purposes only. Geographic identifiers and NOAA Weather Division identifiers are not included on any data files delivered to EIA. Geographic location information is provided to EIA at the Census division level. In addition, building characteristics, such as number of floors, building square footage, and number of workers in the building, that could uniquely identify a particular responding building, are masked on data files provided to EIA, as well as on all public-use data files.

Appendix B

Nonsampling and Sampling Errors

Introduction

All of the statistics published in this report are estimates of population values, such as the total floorspace of commercial buildings in the United States. These estimates are based on reported data from representatives of a randomly chosen subset of the entire population of commercial buildings. As a result, the estimates always differ from the true population values.

The differences between the estimated values and the actual population values are due to two types of errors, sampling errors and nonsampling errors.

- *Sampling errors* are errors that are random differences between the survey estimate and the population value that occur because the survey estimate is calculated from a randomly chosen subset of the entire population. The sampling error, averaged over all possible samples, would be zero, but since there is only one sample for the 1995 CBECS, the sampling error is nonzero and unknown for the particular sample chosen. However, the sample design permits sampling errors to be estimated. “Estimation of Standard Errors” in this appendix describes how the sampling error is estimated and presented for statistics given in this report.

- *Nonsampling errors* are related to sources of variability that originate apart from the sampling process and are expected to occur in all possible samples or in the average of all estimates from all possible samples.

The first two sections, “Data Collection Problems” and “Nonresponse,” following this introduction describe some of the sources of nonsampling error in the Building Characteristics Survey and how that portion of the CBECS is designed and conducted to minimize such errors. Nonsampling errors can result from (1) inaccuracy in data collection due to questionnaire design errors, interviewer error, respondent misunderstanding, and data processing errors; (2) nonresponse for an entire sampled building (unit nonresponse); and (3) nonresponse on a particular question from a responding building (item nonresponse). The section “Data Collection Problems” addresses some of the difficulties encountered in trying to obtain meaningful energy data on questionnaire items in the 1995 survey. The section “Nonresponse” presents survey design and data collection procedures used to minimize unit and item nonresponse in both the Building Characteristics Survey and the Energy Suppliers Survey.

The energy consumption and expenditures data that are featured in this report were based on monthly billing records submitted by the buildings’ energy suppliers. The section “Annual Consumption and Expenditures” provides a detailed explanation of the procedures used to obtain annual consumption and expenditure estimates from the bills, as well as the procedures used to handle partial or completely missing data. The peak electricity demand estimates in this report were also based on the monthly billing data, as described in the section “Annual Peak Electricity Demand.”

The section titled “Additional Data Notes” discusses reconciliation of building and supplier reports on the types of energy sources use, attempts to collect natural gas expenditures from both the local natural gas suppliers and non-local natural gas suppliers, and account classification issues that relate to the discrepancies between two sources of EIA estimates of the amount of energy used in the commercial building sector. The section “Energy End-Use Estimates” briefly discusses the estimation of energy end-use intensities. The final section in this appendix discusses the estimation of standard errors.

Data Collection Problems

Most unit nonresponse cases occurred because an appropriate respondent was unavailable or declined to participate in the survey. Item nonresponse resulted when the building respondent did not know, or, less frequently, refused to give the answer to a particular question.

Even though the interviewer was instructed to conduct the interview with the person most knowledgeable about the building, there was a great deal of variation in how much CBECS respondents knew about their buildings. Some respondents did not know some of the information requested; some were able to provide certain information only if the questions were expressed in the particular terms they understood. This presented a special challenge to the CBECS questionnaire designers—with such a diverse population of respondents, it is difficult to construct standard wording for energy concepts that would be understood by all respondents. Thus, a certain amount of respondent error can be expected. Additionally, even when a question is worded clearly and the respondent understands the question and has the required knowledge, simple clerical errors (possibly the fault of the questionnaire layout) can sometimes lead to inaccuracies in the data. Unlike the sampling error, the magnitude of nonsampling error cannot easily be estimated from the sample data. For this reason, avoiding biases at the outset is a primary objective of all stages of survey design and field procedures. The wording and format of survey questionnaires; the procedures used to select and train interviewers; and the quality control built into the data collection, receipt, and processing operations were all designed to minimize these sources of error. For a discussion of the questionnaire design, interviewer training, and data control, see Appendix A, "How the Survey Was Conducted."

Following is a summary of some of the most significant difficulties that EIA staff has identified with the survey responses. The extent of these comments should not be viewed as a failure of the questionnaire or the interview process; the data collection process worked well. Rather, these comments indicate areas that require further refinements to improve overall data quality.

Principal Building Activity. The principal building activity refers to the primary function or activity that occupies the most floorspace in the building sampled. In some cases, particularly if the sampled building was one of a number of buildings on a facility, the respondent reported the overall function of the facility or establishment to which the building belonged. In CBECS, for instance, a library is classified as a public assembly building, but a library on a university campus may have been reported as an education building (academic or technical instruction). To help alleviate this confusion, the 1995 CBECS asked a separate question for the overall facility activity for those buildings identified as being part of a facility. The principal activities of respondent buildings were checked against other available information, including the facility activity, interviewer observations, the building's name, and recoded if an obvious assignment error was made.

Another difficulty with identifying principal building activities is that buildings with the same title may, in fact, have different primary functions. For example, space in a building referred to as a "courthouse" can be devoted primarily to office activities (office), to jail cells (public order and safety), or to hearing rooms (public assembly).

For some buildings, no one activity occupied 50 percent or more of the floorspace, but the activity occupying more space than any other was either industrial or residential. For example, it is possible for a building to have 30 percent of the floorspace devoted to assembly, 30 percent to food sales, and 40 percent to residential. Since more than 50 percent of the floorspace was occupied by commercial activity, these buildings were retained in the sample as commercial buildings but were included in the "Other" category.

Number of Workers. The CBECS collects data on the number of people who work in commercial buildings. Included in this number are volunteer workers, but not clients, students, or employees who work away from the building. In 1995, the number of people working during the main shift was requested. In the 1995 CBECS, if a building was not in use during the previous 12 months, it was still included in the "less-than-five" category of number of workers.

Heating and Cooling. The phrasing of questions on heating and cooling equipment has presented difficulties in every CBECS conducted thus far and, unfortunately, illustrates difficulties both in question wording and in respondent knowledge. Commercial buildings' heating and cooling systems vary greatly in design and complexity. The CBECS questionnaire designers try to formulate a few questions that could broadly characterize a building's heating and cooling system.

In previous CBECS, some building respondents (especially those from larger buildings) found the questions to be too general to adequately describe their buildings' systems. Other building respondents lacked even the rudimentary knowledge of their buildings' systems required by the questionnaire. To alleviate some of the problems encountered in earlier CBECS in which inconsistencies appeared between types of equipment, fuel sources, and the distribution system, the 1995 CBECS questionnaire limited the respondents' choices in such a way that only answers to sensible combinations of heating or cooling equipment with distribution equipment could appear.

Additionally, a general question asked the respondent to describe the heating and cooling system. This verbatim description was not coded on the computer file but was of immeasurable value in deciphering the respondents' intentions. In particular, the question of whether the buildings uses "heat pumps" elicited some surprising responses at some of the interviewed buildings. Several respondents indicated that they used a heat pump for heating but not cooling, or vice versa. After review of the verbatim description and callbacks to the respondents, corrections were made in cases where this information was in error. However, there were 212 cases where the heat pumps did indeed have a single use.

Electricity Generation or Cogeneration. A series of questions was asked about the buildings' electricity generating systems and the sources of electricity. Respondents were asked whether the building could generate electric power and, if yes, what was the primary use of the generators. Of the 5,656 buildings that use electricity, approximately 1,257 reported that they had the capability to generate electric power. Of these, 87 percent use the generators for emergency backup use only.

Respondents reporting that their buildings could generate electricity but that the primary use was for something other than emergency backup were then asked whether the electric power generating system was also a cogeneration system. Because the number of sampled buildings that had a cogeneration system was less than 20, the data were not published.

Two new questions were asked in 1995 in an attempt to gather information about different purchasing arrangements of electricity. With the probability of deregulation in the electric utility sector, increasing numbers of consumers will be able to purchase their electricity from nonutility sources, similar to purchasing natural gas from independent suppliers. Respondents were asked if any of the electricity used in the building was obtained from a nonutility, non-in-house source, such as an independent power producer, and, if yes, how much of the electricity used was obtained from this source. While the vast majority of buildings purchased all of their electricity from a local utility, there were 26 sampled buildings that obtained some of the electricity used from a nonutility, non-in-house source. After these 26 buildings were examined, it was determined that most of these buildings were on facilities with central heating plants or had the capability of generating electricity themselves. It appears that the respondents might have confused nonutility source of electricity with the ability to generate electricity on the facility or in-house.

Gas Transported for the Account of Others. The respondents to the 1995 CBECS were asked whether the building bought or contracted for natural gas from someone other than the local distribution company and the name and address of the company or broker from whom the direct purchase gas was bought or contracted. This purchasing arrangement is known as "gas transported for the account of others." It is also known as "direct purchase gas" or "spot market gas."

This general question, plus several other specific, price-related questions were first asked during the building characteristics portion of the survey in the 1992 CBECS. (Prior to 1992, this information was asked only of the energy suppliers. Although suppliers could provide the volume of natural gas delivered, they could not, in many cases, report the expenditures since they did not know the purchase price of the transported gas.) It was believed that the building respondent would be better able to provide information about whether they purchased natural gas under this arrangement, who the suppliers were, and what were the wellhead costs, city gate price, local distribution company (LDC) charge, and other costs associated with gas transported for the account of others. This, however, proved to be another area where the building respondents had difficulty providing information. Therefore, based on the 1992 CBECS experience, where only 18 percent of the building respondents could report one or more of the costs associated with the purchase, the cost questions were eliminated in 1995 from the building characteristics questionnaire.

It appears that CBECS respondents, the people who are supposed to be most knowledgeable about the energy-using systems of the buildings, are not the most knowledgeable about billing arrangements. In future CBECS, it may be necessary to target the person most knowledgeable about billing with a separate data collection effort in order to make reliable estimates about gas transported for the account of others.

Renewable Energy Source: The CBECS attempted to collect information on the use of renewable energy sources by including wood and solar thermal panels in the list of possible energy sources that were used to supply energy to the building. In 1995, wood was used in about 3 percent of the buildings as an energy source. Data on the use of solar panels could not be published because either the number of buildings reporting the use was too small or the relative standard error (RSE) was greater than 50 percent.

Additional questions were asked about the use of the renewable energy features and the sponsors to each one. The energy features included passive solar features, photovoltaic (PV) arrays, geothermal or ground source heat pumps, wind generation, and well water for cooling. The sponsors included utilities, the Federal Government, in-house or self-sponsored, third party, or other. With the exception of passive solar features (which included trees that could be used for shade), fewer than 20 buildings of the 5,766 sampled responded to each of the renewable energy features. Therefore, these data were not imputed or published.

Nonresponse

Unit Nonresponse

The response rate for the Building Characteristics Survey portion of the 1995 CBECS was 87.5 percent. That is, of the 6,590 buildings eligible for interview, 12.5 percent did not participate in the Building Characteristics Survey. The unit response rate for the Energy Suppliers Survey was 84.9 percent. This response rate for that portion of the CBECS varied by energy source. (See the section "Energy Suppliers Survey Response Rates" in Appendix A for more discussion on the nonresponse rate by energy source.)

Weight adjustment was the method used to reduce unit nonresponse bias in the survey statistics. The CBECS sample was designed so that survey responses could be used to estimate characteristics of the entire stock of commercial buildings in the United States. The method of estimation used was to calculate basic sampling weights (base weights) that related the sampled buildings to the entire stock of commercial buildings. In statistical terms, a base weight is the reciprocal of the probability of selecting a building into the sample. A base weight can be explained as the number of actual buildings represented by a sampled building: a sampled building that has a base weight of 1,000 represents itself and 999 similar (but unsampled) buildings in the total stock of buildings.

To reduce the bias from unit nonresponse in the survey statistics, the base weights of respondent buildings were adjusted upward, so that the respondent buildings would represent not only the unsampled buildings they were designed to represent, but also nonrespondent buildings and the unsampled buildings they were designed to represent. The base weights of respondent buildings were multiplied by an adjustment factor A, defined as the sum of the base weights over all buildings selected for the sample divided by the corresponding sum over all respondent buildings. Respondent weights remained nonzero after weight adjustment. Nonrespondent weights were set to zero because they were accounted for by the upward adjustment of respondent weights.

Unit nonrespondents tended to fall into certain categories. For example, nonresponse tended to be lower in the Northeast than in the Midwest (11.9 percent and 14.8 percent, respectively). To reduce nonresponse bias as much as possible, adjustment factors were computed independently within 38 subgroups according to characteristics known from the sampling stage for both responding and nonresponding buildings. These characteristics included the general building activity, the rough size of the building, Census region, and metropolitan versus nonmetropolitan location.

Item Nonresponse

Table B1 contains item nonresponse rates for some of the building characteristics presented in this report. "Eligible" in this context refers to interviewed buildings to which the question item applied; certain sequences of responses to previous questions would make some question items not applicable for some respondents.

Nonresponses to several items in otherwise completed the Building Characteristics Survey questionnaires were treated by a technique known as "hot-deck imputation." In hot-decking, when a certain response is missing for a given building, another building, called a "donor," is randomly chosen to furnish its reported value for that missing item. That value is then assigned to the building with item nonresponse (the nonrespondent, or "receiver").

Table B1. Item Nonresponse Percentages for Selected Building Characteristics, 1995

Building Characteristics	Eligible Buildings	Number Missing	Percent Nonresponse
Square footage	5766	722	12.52
Square footage category	5766	9	0.16
Year construction was completed	5766	777	13.48
Year of construction category	5766	1	0.02
Multibuilding facility or complex	5766	1	0.02
Number of businesses/organizations	5766	66	1.14
Number of businesses/organizations category	5766	8	0.14
Owned by government agency	5766	7	0.12
Occupant status	5653	29	0.51
Space vacant for at least 3 months	5766	13	0.23
Months in use out of past 12 months	5766	2	0.03
Total weekly hours open	5646	127	2.25
Total weekly hours open category	5646	6	0.11
Number of workers (main shift)	5646	667	11.81
Number of workers category (main shift)	5646	42	0.74
Wall construction material	5766	2	0.03
Roof construction material	5766	53	0.92
Exterior wall insulation	5766	252	4.37
Roof or ceiling insulation	5766	164	2.84
Storm windows or doors	5766	26	0.45
Tinted or reflective glass	5766	16	0.28
Shadings or awnings	5766	8	0.14
Energy management and control system	5766	56	0.97
Variable air volume (VAV) system	5463	149	2.73
Economizer cycle	5463	71	1.30
Regular preventive maintenance program	5463	32	0.59
PCS/computer terminals in building	5766	14	0.24
Commercial refrigerator/freezer equipment present	5766	10	0.17
Percent heated in 1995	5369	46	0.86
Energy used for main heating	5766	6	0.10
Main equipment for heating	5369	339	6.31
Percent cooled in 1995	4947	29	0.59
Main cooling equipment	4947	222	4.49
Type of water heating system	5108	48	0.94
Percent lit during operating hours	5593	34	0.61
Percent lit during off-hours	4506	17	0.38
Reduction in lighting during off-hours	4662	352	7.55
Building uses transportation gas	3689	108	2.93

Source: Energy Information Administration, Office of Energy Markets and End Use, 1995 Commercial Buildings Energy Consumption Survey.

To serve as a donor, a building had to be similar to the nonrespondent in characteristics correlated with the missing item. This procedure was used to reduce the bias caused by different nonresponse rates for a particular item among different types of buildings. Which characteristics were used to define "similar" depended on the nature of the item to be imputed. The most frequently used characteristics were principal building activity, floorspace category, year constructed category, and Census region. Other characteristics (such as type of heating fuel and type of heating and cooling equipment) were used for specific items. To hot-deck values for a particular item, all buildings were first grouped according to the values of the matching characteristics specified for that item. Within each group defined by the matching variables, donor buildings were assigned randomly to receiver buildings.

As was done in previous surveys, the 1995 CBECS used a vector hot-deck procedure. With this procedure, the building that donated a particular item to a receiver also donated certain related items if any of these were missing. Thus, a vector of values, rather than a single value, is copied from the donor to the receiver. This procedure helps to keep the hot-decked values internally consistent, avoiding the generation of implausible combinations of building characteristics.

Annual Consumption and Expenditures

The estimates of energy consumption and expenditures in commercial buildings are for calendar year 1995. These estimates were computed from the annual consumption and expenditures determined for each building in the CBECS sample. However, these "annual" values were not obtained directly from the suppliers for the buildings. Rather, energy suppliers provided monthly billing data that were used to calculate calendar year consumption and expenditures for each building, according to the procedures described in this section. Also described in this section are the imputation procedures used in cases where the energy supplier survey data were unavailable or inadequate.

To ensure that the energy consumption for calendar year 1995 would be completely accounted for, the data requested from suppliers were bills covering the period from December 1994 through January 1996. These bills formed the basis for the annual energy consumption and expenditures estimates.

Billing Data: Ideal and Reality

The basic consumption and expenditures data were reported for each building by billing period. Ideally, the data for each continuous-delivery energy source (electricity, natural gas, and district heating) used in each sampled building should have been in the form of complete records for every billing period that fell within calendar year 1995, providing complete coverage for 1995 and covering exactly the energy consumed within the sampled building. The data for the discrete-delivery energy source (fuel oil) should have been in the form of complete data records for all deliveries during 1995. For both continuous- and discrete-delivery energy sources, the delivered energy source should have been used entirely within the sampled building.

In practice, though, the billing data often covered more or less square footage than just the sampled building's square footage, or did not match the target time frame, calendar year 1995. There were several common types of discrepancies between the bill coverage and the ideal of a single building and fixed time frame.

- Bill coverage included days in 1994 and 1996, as well as in calendar year 1995. This was the typical situation for a complete billing record. Rarely would one billing period begin on January 1 and another end on December 31, 1995.

- Bill coverage spanned at least a 1-year period, but did not include all of 1995. In most such cases, the time frame covered by the bills extended from the middle of 1995 into the middle of 1996. Many energy suppliers maintain accessible billing records only for the most recent 13 months. Thus, at the time of reporting, the data available did not cover the beginning of 1995.

- Bill coverage spanned less than a 1-year period.

- Bill coverage was for several sampled buildings combined. This occurred when no authorization form was obtained to authorize the supplier to provide data for individual buildings. In such cases, the supplier reported only annual totals for a group of sampled buildings summed together.

- Bill coverage included nonsampled buildings or equipment outside the sampled buildings, as well as the one sampled building.

- Bill coverage excluded some of the building's occupants or tenants. This undercoverage occurred when the energy supplier had several customers in a sampled building and was unable to identify all of them on the basis of the information provided by the Building Characteristics Survey respondent. In a few cases, energy suppliers were unwilling to release information on all customers in a building, even in aggregate form, without having a separate authorization from each.

- The problem of determining bill coverage was compounded by incomplete dates. In the most common case, the billing period date included a month and year, but not the day of the month.

To reconcile the discrepancies between the ideal billing data and what could actually be obtained, the following six processing steps were taken:

1. Each set of bills from a particular energy supplier for a particular building was classified according to the extent of coverage in terms of both building and time frame.

2. Billing dates for all energy bills were completed.

3. Bills with full-year time-frame coverage were annualized.

4. Bills with part-year time-frame coverage were annualized.

5. Annualized bills were adjusted for building overcoverage and undercoverage.

6. Annual energy consumption and expenditures for buildings with completely missing data were imputed.

Each of these processing steps is explained below.

Step 1. Classifying Coverage of Building and Time Frame

This classification was performed by the CBECS contractor as part of the data collection record keeping. To track responses to the mailed Energy Suppliers Survey, a determination had to be made as to whether a response received represented complete data for a building. In many cases, follow-up letters converted initial responses from partial to complete, or more nearly complete. In other cases, the incomplete response was all that could be obtained.

Determining Time Frame. An important aspect of the time-frame classification was determining why data were missing for part of calendar year 1995. The main question was whether consumption had actually taken place during the entire year or was actually zero during the unreported time.

If consumption occurred through the entire year, data might be missing for several reasons. For example, the supplier's active records might not go back far enough or the data may simply have been lost from the supplier's record, even though in general these records did go back to the beginning of 1995.

A more complicated situation occurred when a new customer occupied a building in the middle of the target year. The data provided for this customer, for which the authorization form was signed, would be complete, but the data for the previous occupant, who consumed energy in the first part of the year, would be missing. In a case where part of the year's consumption data were missing, annual consumption would be understated if the reported 1995 data were treated as complete, rather than being inflated to account for the missing period.

The opposite situation could occur if a customer first occupied the building in the middle of the year, with no previous customer occupying the building. In this case, with no consumption during the first part of the year, annual consumption would be overstated if the reported data were annualized as if consumption occurred year round.

A special set of questions on the Energy Suppliers Survey forms was designed to determine if any change in customers had occurred during the target year and, if so, how these customers were covered in the reported data. However, most suppliers did not answer these questions. As a general rule, data were treated as complete if they covered a full year, whether calendar 1995 or not. Part-year data were treated as incomplete, unless the supplier specifically indicated otherwise.

Particularly complicated were some electricity and natural gas cases where individual records were provided for each customer in a building with several customers. In most such cases, bills for all the customers covered the same time frame. Sometimes, though, different customers' records covered different time frames. In these cases, it was assumed that the data were complete for each customer, but the customers began or ended service at different times during the year. Aggregate consumption and expenditures were therefore computed for each time period by summing whichever customers had consumption during that period. If consumption was present for a particular customer in a particular period but expenditures were missing (or vice versa), aggregate expenditures (or consumption) were left as missing.

Determining Building Coverage. Building coverage was determined from information obtained from both the Building Characteristics Survey respondent and the energy suppliers. Two types of problems could arise: (1) the energy bills covered more buildings than just the sampled building or (2) the energy bills omitted some of the building's occupants. In the first case, if the Building Characteristics Survey respondent indicated that a particular supplier's bill covered several buildings, the total square footage of buildings on that bill was requested. Then a disaggregation factor was computed as the ratio of the sampled building's square footage to this total square footage. This factor allowed the total reported consumption to be adjusted downward to cover only the sampled building. In the second case, when the billing data omitted some customers in a building, an aggregation factor was computed. This factor was usually the ratio of the number of customers in the building to the number reported. Where more detailed information was available, the aggregation factor was the ratio of the total building floorspace to the floorspace occupied by the reported customers. For those cases, the reported consumption of only a portion of the building was adjusted upward to represent consumption in the building as a whole.

Step 2. Assigning Billing Dates

Virtually all missing billing dates were one of two types. The first type of dates that were incomplete had the month and year entered, but the day was missing for the beginning and ending dates of all billing periods on a record. These cases were imputed by assigning "16" to each beginning date and "15" to each ending date.

The second type of incomplete dates were missing the day of the month for some, but not all, billing periods. For each case of this second type, the billing periods affected were either bounded (surrounded by billing periods with known beginning and ending dates) or unbounded (either at the beginning or end of the set of billing periods). Any set of consecutive bounded billing periods with missing dates was assigned billing dates that would make all billing periods in the set have as close to the same number of days as possible. Unbounded billing periods were assigned beginning and/or ending dates as needed so that the number of days in each unbounded period was the same as the median number of days in billing periods of known length.

Step 3. Annualizing Full-Year Data

One of the main reasons that the CBECS requested energy supplier data from December 1994 through January 1996 was to assure that 1995 consumption would be completely accounted for in the case of a complete response. However, unless a billing period happened to end on December 31, 1994, or December 31, 1995, consumption as reported by the energy suppliers ran over from the target period of calendar 1995, forward into 1996 and backward into 1994. In general, then, procedures were required to trim away these excess data. For this trimming, different procedures were used for continuous- and discrete-delivery energy sources.

Continuous-Delivery Energy Sources (electricity, natural gas, and district sources). Consumption and expenditures for a billing period extending into 1996 were adjusted by splitting the overlapping period into two subperiods, one running from the beginning date through December 31, the other from January 1 through the billing or meter reading date. Consumption and expenditures were prorated according to the number of days in each subperiod, and the consumption and expenditures for the subperiod that fell in 1995 were included in the total expenditures and consumption for 1995. An analogous procedure was used for a billing period extending into 1994. The assumption that the use of continuous-delivery energy sources took place at a constant rate throughout the billing period may be incorrect for any particular building. However, the procedure should yield approximately unbiased overall estimates.

Discrete-Delivery Energy Source (fuel oil). Billing periods extending outside 1995 did not affect the discrete-delivery energy source (fuel oil) because, for this energy source, all deliveries during 1995 were accumulated. For fuel oil, the ending dates on the bills were used to determine which bills were for deliveries during 1995. No attempt was made to prorate bills, since there was no necessary connection between billing dates and consumption, as was the case for continuous-delivery energy sources.

For both continuous- and discrete-delivery cases where the billing time frame covered a full year but was shifted so that either the beginning or the end of 1995 was not included, a similar procedure was used. In these cases, the data were annualized to a 1-year period within the reported time frame, overlapping as much as possible with 1995.

Step 4. Annualizing Part-Year Data

The annualization procedures for cases that had partial billing data, but less than a full year's data, were also different for continuous- and discrete-delivery energy sources.

Continuous-Delivery Energy Sources. The number of reported days of consumption was at least as large as the number of reported days of expenditures for almost all sets of bills. Expenditures were annualized by using the partial expenditures data and the annualized consumption data.

The part-year annualization method for the consumption of continuous-delivery energy sources depended on the number of days of reported consumption. If at least 331 days were reported, then consumption for the missing portion of the year was imputed by computing the average consumption per day for the adjacent billing period(s), then multiplying by the number of days of missing data. In certain cases, at least 331 days of consumption were reported, but 365 days of expenditures were reported. In these cases, the missing consumption was computed by using the average price for billing periods in which both consumption and expenditures were reported. Summing all reported and imputed consumption then yielded the total annual consumption.

Expenditure imputations were performed after completion of all imputations for partially missing consumption since (1) consumption data were usually more complete than expenditures data, and (2) given a value for consumption, the expenditures could be estimated without a great deal of difficulty.

As was true for consumption, the imputation procedure for missing continuous-delivery expenditures was determined by the number of days of reported data. If 30 or fewer days of expenditures were reported, then the expenditures were treated as completely missing. Otherwise, expenditures were imputed that were based on average prices within the set of bills for a given building. Using bills where both consumption and expenditures were reported, the consumption and the expenditures were summed. The average price was then calculated as the sum of the expenditures divided by the sum of the consumption. This average price was multiplied by the reported (or imputed) consumption to obtain the estimated expenditures.

Discrete-Delivery Energy Source. The billing dates for fuel oil, a discrete-delivery energy source, are not linked to the time of consumption. Thus, the annualized data represent the total deliveries of fuel oil during the year. Furthermore, unlike continuous-delivery bills, discrete-delivery bills tend to be irregularly spaced. Gaps between bills could represent either missing data or periods during which no deliveries were required. The completeness of a set of bills was determined by relying on reports of suppliers. A set of bills was treated as complete if the supplier stated that the bills were complete for the year, and treated as missing otherwise, even if a partial set of bills was available.

Buildings rarely had more than one supplier for a continuous-delivery energy source, such as electricity, but multiple suppliers for fuel oil occurred frequently. If data for one or more of several suppliers were missing, even though responding suppliers had reported all their 1995 deliveries, these buildings were also treated as if no data were available.

Imputations for both deliveries and expenditures made use of the observed price(s). An average price, P_x, for each set of bills, was computed by using the data from billing periods in which both consumption and expenditures were reported. If expenditures were missing, the expenditures were imputed as P_x times the quantity delivered. For missing deliveries, the reported expenditures were divided by P_x to impute the amount delivered.

Step 5. Adjusting for Building Overcoverage and Undercoverage

The annualization procedures for full- and part-year data were adjusted for inconsistent time-frame coverage. After the nonmissing consumption and expenditures data were annualized, the annual values were adjusted for building coverage. Where data were requested from the supplier for a single sampled building, but were provided only for a group of buildings, including the sampled one, or were provided only for a portion of the building, the coverage adjustment was a simple multiplication of the annualized consumption and expenditures by the disaggregation or aggregation factor. As described under Step 1 above, this factor was computed by the survey contractor directly on the basis of information received on the building or suppliers survey.

Step 6. Imputing for Completely Missing Consumption and Expenditures

In a significant fraction of cases, the energy supplier did not provide the consumption or expenditures data for some or all billing periods or deliveries in 1995. Reasons for missing data included energy supplier refusal; archived, lost, or destroyed billing records; and authorization form refusal on the part of the building respondent. In other cases, the energy supplier provided data, but either the building data were combined with those of nonsampled buildings and could not be disaggregated or the consumption or expenditures, or both, were incomplete enough to be treated as missing.

The general approach taken to the problem of imputing annual consumption or expenditures was to annualize the complete or partial sets of bills first, then to use these annualized bills in regression equations to develop imputed values for the data that were totally missing. The regression imputation approach was chosen because data from the Building Characteristics Survey were already available for all of the buildings lacking energy supplier data. The first step was the estimation of missing consumption that was based on characteristics of buildings. After the consumption had been imputed, missing expenditures were estimated that were based on the reported or imputed consumption.

Completely Missing Consumption. Each of the energy sources presented in this report was imputed separately, although the overall methodology was similar for all. The consumption imputation method is, therefore, described in general terms, referring to individual energy sources only where necessary. The regression equations were developed primarily to serve as adequate predictors of building consumption based on building characteristics.

The data used to specify regression equations and estimate the regression parameters used for consumption imputation had to meet several criteria. Only cases with essentially complete consumption data were used. For continuous-delivery energy sources, "essentially complete data" included buildings with 331 to 365 days of reported consumption; for discrete-delivery energy sources, only buildings with completely reported deliveries were included. In addition, cases were not used to estimate regression parameters if the information received from the energy supplier included too much data from unsampled buildings (before disaggregation) or the data reported from the building respondent were missing key regressor variables.

The development of regression equations began by an examination of the distributions of the dependent variable, consumption. Previous experience showed that the error term associated with the regression procedure is highly skewed in the positive direction. Consequently, the regression procedures used for the 1995 CBECS minimized the sum of squares of the difference between the log of the actual consumption and the log of the predicted consumption rather than the sum of squares of the difference between the actual consumption and the predicted consumption. Accordingly, the imputed consumption values were calculated by using parameter values estimated in two stages: the initial regression of consumption on building characteristics, and a bias correction. The bias correction coefficient was estimated by (1) summing the total actual consumption of cases used to estimate the regression parameters, (2) summing the total of the predicted values for these same cases, and (3) dividing the sum of the actual values (1) by the sum of the predicted values (2).

Completely Missing Expenditures. Similar to consumption imputations, expenditure imputations were performed separately for each of the four major fuels, although the overall methodologies for each fuel were similar. Again, the imputations are described in general terms, referring to individual energy sources only where necessary.

Energy supplier rate schedules are usually structured so that the price per unit of energy is lower as consumption increases. The rate schedule is usually a step function with the definition of steps and rates varying by energy supplier and by rate class. For the CBECS, rate schedules were not collected for the sampled buildings, but many suppliers did submit an overall rate schedule for their commercial customers. This was useful in estimating expenditures. In cases where rate schedules were not supplied, a statistical procedure was needed to relate the expenditures to the consumption for imputation purposes.

As with the consumption imputations, the data used to specify the form and estimate the parameters of the expenditure imputation equations had to meet two criteria. First, only cases with essentially complete consumption and expenditures were used. For continuous-delivery energy sources, “essentially complete data” included buildings with 331 to 365 days of reported data for both consumption and expenditures; for discrete-delivery energy sources, only buildings with completely reported deliveries and expenditures were included. In addition, cases were not used to estimate regressor parameters if the information received from the supplier included too much data from unsampled buildings before disaggregation.

Once cases with complete expenditures data were chosen, they were used to develop an ordinary least squares regression equation to relate expenditures to consumption and to the fuel price for commercial customers. The independent variables were chosen to mimic a decreasing block rate structure. The resulting fitted equation was used to impute for cases where expenditures were missing.

Annual Peak Electricity Demand

Peak electricity demand data were requested for the same billing periods for which electricity consumption and expenditures were reported. Ideally, the metered demand represented the maximum consumption rate (in kilowatts) during the billing period. However, two special data problems affect the availability of peak electricity demand data.

First, although virtually all electricity consumption is metered, peak electricity demand is metered where it is economical to do so. In general, peak demand meters are installed only for larger consumers of electricity. Second, in multicustomer buildings, each customer with a demand meter has its own peak demand. Since these peaks would rarely be coincident, the building peak cannot be taken as the sum of individual peaks. However, the overall building peak must be greater than or equal to the maximum customer peak.

Following Step 2 described in the section “Annual Consumption and Expenditures,” the peak electricity demand data was processed in three additional steps:

1. **Using the billing data, each building was classified as either demand-metered or not demand-metered:** For the 1995 CBECS, a building was considered to be demand-metered if the billing data for any account within the building showed metered peak demand. (The 1989 CBECS obtained demand-metered information from both the building respondent and the energy supplier. However, there was considerable discrepancy between the two sources of data. As a result of the building respondent to adequately provide demand-metered data, subsequent CBECS obtained this information only from the energy supplier.)

2. **The annual peak demand, the season of the peak, and the annual load factor were determined for each building:** For single-account buildings that were determined to be demand-metered, the annual peak demand was taken as the maximum of the billing period peaks. For the few buildings that had part-year electricity billing data, the annual peak was taken as the maximum of the peaks in the reported billing periods. This approach results in a slight understatement of the annual peak, because the actual peak may have occurred during one of the unreported periods. However, since the number of buildings involved was relatively small, the difference between the part-year and full-year maxima would be small in most cases.

In multicustomer buildings, the overall building peak demand was not available. However, the overall peak had to be at least as high as the highest peak reported for any single customer. In buildings where one customer’s peak was substantially larger than that of any other customer, that customer’s peak would have been close to the overall peak. Therefore, in processing bills from multicustomer buildings, the peak demand for any single customer was designated as a “partial peak” (associated with part of the building electricity consumption), although the overall building peak was still treated as missing.

Before assigning the peak to a season, the month of the peak was found. Since the exact time of the billing period peak was unknown, the peak was taken to have occurred in whichever month contained the most days in the billing period during which the peak occurred. Peaks occurring November through April were classified as winter peaks, while those occurring May through October were classified as summer peaks.

The annual load factor was then calculated, using previously calculated annual electricity consumption, as follows:

$$\text{annual load factor} = \frac{\text{annual consumption}}{365 \times 24 \times \text{peak annual demand}}.$$

As an edit, the annual load factor was calculated by using the partial peak, and the partial peak was set to missing if the load factor was less than .10 or greater than 1.

3. **Peak demand and season of peak were imputed for demand-metered buildings missing these data:** Although any electricity consumer has a peak demand, three types of buildings were missing peak demand: (1) buildings determined to be not demand-metered; (2) buildings with completely missing supplier data; (3) multicustomer buildings, and other buildings with partial peaks. No attempt was made to impute for the first type of missing demand, mainly because buildings without demand-metering tended to be smaller than the demand-metered buildings, so that imputation would involve extrapolation beyond the range of the reported data. Accordingly, tables dealing with peak electricity demand have been limited to buildings with (reported or imputed) demand-metering. Once the decision was made to exclude buildings that had not been demand-metered, imputation became a two-step process. First, it was necessary to impute whether the building with missing data was demand-metered. If the building was imputed to be a demand-metered building, then the peak and season of the peak were imputed.

Imputation of the demand-metering attribute made use of the relationship observed within suppliers between the presence of demand-metering and annual electricity consumption. For those buildings with reported data, the probability of being a demand-metered building was estimated as a logistic function of the annual consumption. The parameters estimated from the reported data regression were used to estimate probabilities for each unclassified building, and a uniform random number was generated. If the random number was less than or equal to the estimated probability, then the building was imputed to be demand-metered. For buildings imputed to be demand-metered, the season of peak demand was imputed by hot-decking, the same method used to impute missing items from the Building Characteristics Survey.

Finally, annual load factors were imputed for each building imputed to be demand-metered. Values were imputed by using parameters estimated from a linear regression of the logistic transformation of the annual load factor on various building characteristics (such as weekly operating hours, end uses of electricity, and percent of floorspace heated). Separate imputation equations were estimated for each of nine principal building activities. The imputed annual peak demand was then calculated by solving the load factor equation for the annual peak.

Load factors were imputed, and peak demand values calculated, for multiple-account buildings that had partial peaks. If the partial peak was less than the imputed peak, then the imputed peak was treated as the buildings' annual peak demand; otherwise, the partial peak was used.

Load factors and peak intensities were computed for each building reported or imputed to have metered demand. Also of interest are the analogous ratios over a utility service region, or other large area. The ratio of a region's consumption to the annual peak for the region as a whole would represent the average utilization of the region's generating capacity. The ratio of the region's annual peak to the total floorspace in the region would represent the average capacity requirement per square foot. However, the regional peak cannot be determined from the individual annual (or even monthly) peaks alone, since these peaks are not coincident. That is, the individual peaks occur at different times, so that the sum of the individual peaks can be considerably greater than the overall regional peak.

Additional Data Notes

Energy Sources Used—Building and Supplier Survey Estimates

As explained in Appendix A, "How the Survey Was Conducted," the CBECS was conducted in two stages. During the first stage, the building representative was asked which energy sources were used in the building during 1995. In the second stage, the energy suppliers, identified by the building representative during the first stage, were asked to provide consumption and expenditures data. In some cases, contacts with the energy suppliers revealed inaccuracies in the Building Characteristics Survey response as to which energy sources had been used in the building. All statistics in this report on energy sources used are based on the final determination made during the Energy Suppliers Survey.

When a supplier reported that a particular building was not a customer during 1995, calls were made to the building respondent to determine the reason for the discrepancy. In some cases, a different supplier was identified for the same energy source. In others, it turned out that the energy source had not actually been used; in some of these cases, a different energy source was identified instead. For example, natural gas may have been reported originally, but the callback determined that natural gas was consumed only in a central plant outside the sampled building, while the building itself used district steam, which had not been reported originally. In this case, natural gas would be coded as “not used in the building,” and district steam would be added as “used in the building.” The net discrepancies between the Building Characteristics Survey and Energy Suppliers Survey estimates for the use of each energy source were small for both the building counts and the floorspace totals.

The Energy Suppliers Survey was able to correct the energy sources used only in cases where a supplier had been misreported as supplying a particular building with an energy source. If the Building Characteristics Survey respondent happened to omit an energy supplier, but reported all the other supplier data correctly, the omitted supplier would not have been discovered. However, the number of such cases was probably quite small.

In some cases, a supplier reported that a particular building had been a customer for a given energy source, but not during calendar year 1995. For continuous-delivery energy sources (electricity, natural gas, and district heating), the building was classified as not using the energy source. For the discrete-delivery energy source fuel oil, though, the building was classed as using the energy source, but with zero consumption and expenditures for 1995. Thus, for example, those buildings whose respondents reported that fuel oil was used during 1995, but which received no fuel oil deliveries in that year, were included in the count of buildings and floorspace using fuel oil, though they did not contribute to the fuel oil delivery total.

The revised information on the type of energy sources that were used in the building had an impact on the energy end-use data also. The Building Characteristics Survey data on the type of energy sources that were used for a particular end use were collected in concert with the data on energy sources used. Edit checks on the Building Characteristics Survey data assured consistency between energy sources reported for end uses and energy sources reported at all. However, when the information on energy sources used “at all” was revised during the Energy Suppliers Survey, no new information was obtained on energy sources used for particular end uses. As a result, some energy sources were dropped from a building’s list of energy sources used, even though these energy sources had end uses reported. Conversely, no associated end uses were coded for energy sources that were added for a building. For any energy source whose use was changed from “yes” to “no” for a particular building, the use of that energy source for any given end use was also changed to “no.” However, the end use was still treated as having been performed in the building. That is, it was assumed that the building respondent correctly reported which end uses were performed, even if the energy source used for the end use had been incorrectly reported. This approach left some buildings identified as having a particular end use, but with no energy source indicated for that use.

All building characteristics tables for the 1995 CBECS on the Internet, as well as the Public Use Micro-Data, have been updated to reflect the latest supplier information on the types of fuels used.

Gas Transported for the Account of Others

The 1995 CBECS collected data on natural gas transported for the account of others (also referred to as “direct purchase gas,” “spot market gas,” or “transportation gas”) from both the building respondent and the natural gas suppliers—both utility suppliers and non-utility suppliers. Gas transported for the account of others is a type of purchasing arrangement where large natural gas users purchase their natural gas directly from a source other than the local distribution company (LDC) or utility. The LDC then delivers the gas to the building via the local pipelines.

The natural gas survey form requested (1) the volume of natural gas and expenditures for that gas purchased from the LDC; (2) the volume of natural gas purchased from a source other than the LDC; (3) delivery charges for gas purchased from other than the LDC; and (4) total charges for this gas.

Since local distribution companies know the total volume of natural gas delivered, the total consumption data seem complete. (If natural gas consumption was completely missing, then the volume was imputed as described in Step 6 of "Annual Consumption and Expenditures"). The allocation of consumption between transported gas and local utility-owned gas was then imputed by hot-decking the proportion of gas that was transported gas. This method allowed imputed buildings to have both transported and local utility gas, as might happen if (1) building demand exceeded the direct purchase contract amount or (2) the building switched to or from a direct purchase contract during the year.

Estimating consumption and expenditures could become complicated because frequently the LDC filled out the gas transported for the account of others portion of the supplier form since they knew that the gas being provided was transportation gas. Conversely, transportation gas companies, which provide only transported gas, did not always fill in the form correctly. They often filled in the first available space, which was intended for utility gas only. Similar confusion occurred when filling in transported gas expenditures: the LDC would be expected to fill out the transport charges column but, because this was the only expense collected by the LDC, they sometimes recorded it in the "total" column. Finally, since the same volume of gas was reported by the LDC and the transportation gas company, double reporting of volumes sometimes occurred. All these problems were identified by visual inspection of the appropriate records.

CBECS Coverage Related to EIA Supply Surveys

The primary purpose of the CBECS is to collect accurate statistics of energy consumption by individual buildings. The statistics are totaled and presented by building characteristic. The Energy Information Administration (EIA) also collects data on total energy supply (sales). For the information on sales totals, a different reporting system is used for each fuel and the boundaries between the different sectors (e.g., residential, commercial, industrial) are drawn differently for each fuel. This appendix provides (1) background on the issue of consumption versus supply coverage, and (2) an analysis of the account classification as reported in the 1995 CBECS Energy Suppliers Survey.

Background: EIA sales data on the different fuels are compiled in individual fuel reports. Annual electricity sales data are currently collected on Form EIA-861, "Annual Electric Utility Report," which is sent to all electric utilities in the United States. Supply data for natural gas are collected on Form EIA-176, "Annual Report of Natural and Supplemental Gas Supply and Disposition." This form must be submitted by all gas pipeline companies and other plant operators that deliver gas directly to consumers. Fuel oil and kerosene sales are collected on Form EIA-821, "Annual Fuel Oil and Kerosene Sales Report." The supply data are compiled and summarized at the national level, as well as the State level, in several EIA reports, including the *State Energy Data Report* (SEDR) and the *Monthly Energy Review* (MER). When the CBECS totals are compared with the national commercial sales totals reported in the SEDR or MER, only electricity, natural gas, and fuel oil can be compared directly. CBECS does not collect data on coal consumption, and sales data for district heating are not collected by EIA.

Differences between CBECS totals and sales totals can result from either (a) consumption that is included in the CBECS but not in the sales totals and, conversely, (b) consumption that is included in commercial sales totals but is not considered commercial in CBECS and, therefore, is excluded from CBECS totals. A principal reason that a component of consumption may be in the CBECS totals but not in the sales totals, or vice versa, is the differences in how **buildings** are classified for CBECS and how customer **accounts** are classified in the sales reporting system. Each energy supplier has its own system of classifying accounts. When reporting sales totals to EIA by end-use sector, the supplier uses EIA guidelines, as well as the supplier's own account classification, to determine whether a particular account belongs in the residential, commercial, industrial, or transportation sector.

There are several general differences between the CBECS and the energy suppliers as to how each defines which buildings or accounts are commercial.

1. CBECS covers consumption only in buildings. Commercial accounts are not necessarily associated only with buildings, but may also be associated with unenclosed equipment or outdoor lighting. This outdoor lighting is included in commercial sales data reported in the SEDR but is not included in the commercial sales data reported in the MER.

2. CBECS covers consumption for the entire building whose principal activity is commercial, i.e.,

Table B2. Energy Suppliers' Account Classification of Commercial Buildings, 1995

Energy Suppliers' Accounnt Classification	Number of Buildings (thousand)	Percent	Square Feet (million)	Percent	Consumption (trillion Btu)	Percent
Electricity Suppliers						
All Commercial Buildings Using Electricity	4,343	100	57,076	100	2,608	100
Residential	64	1	336	1	5	0
Commercial	3,860	89	48,131	84	2,133	82
Industrial	63	1	2,238	4	115	4
Mixed	357	8	6,371	11	355	14
Natural Gas Suppliers						
All Commercial Buildings Using Natural Gas	2,478	100	38,145	100	1,946	100
Residential	81	3	273	1	19	1
Commercial	2,094	85	32,516	85	1,523	78
Industrial	22	1	530	1	28	1
Mixed	282	11	4,826	13	375	19
Fuel Oil Suppliers						
All Commercial Buildings Using Fuel Oil	607	100	14,421	100	235	100
Residential	25	4	265	2	11	5
Commercial	500	82	11,994	83	188	80
Industrial	5	1	565	4	8	3
Mixed	69	11	1,497	10	27	11
Not Classified	8	1	100	1	1	0

Note: Due to rounding, data may not sum to totals.
Source: Energy Information Administration, Office of Energy Markets and End Use, 1995 Commercial Buildings Energy Consumption Survey.

nonindustrial or nonresidential; CBECS covers no consumption in other buildings. As a result, consumption for commercial activity in noncommercial buildings is not included in CBECS, whereas consumption for noncommercial activity in a commercial building is included. For example, in the first case, if the building's principal activity is manufacturing but there is a small office in the building, the energy associated with the office space would not be included in the CBECS. In the second case, if the building's principal activity is retail but there is a small portion of the building devoted to manufacturing, the energy associated with the manufacturing would be included and reported as commercial in CBECS. While energy suppliers may have several accounts within a building and those accounts could be classified as commercial or noncommercial sales, energy consumed in the CBECS buildings is classified as commercial.

3. The activities included as commercial differ between the CBECS and the supply-side reporting systems. On the supply side, as noted, the definitions also differ among fuels.

To help understand the relationship between CBECS consumption totals and EIA's commercial sales totals, the CBECS Energy Suppliers Survey collected information from the suppliers on how they classified each of the accounts for the CBECS sample.

The 1995 CBECS energy suppliers' account classification information showed the amount of consumption in commercial buildings that is likely to be excluded from commercial sales totals. Accounts classified by the energy supplier as residential or industrial are ordinarily included in EIA's sales totals for those sectors, not in commercial sales, as reported in the CBECS. Accounts classified by the supplier as commercial, school, government, or institutional are ordinarily included in EIA's commercial sales total: accounts with hybrid or combination classifications, however, are probably included partly in commercial and partly in noncommercial totals.

Table B2 shows the number of buildings, total floorspace, and energy consumption by the CBECS suppliers' account classification for 1995 CBECS buildings. The shaded area indicates agreement between the CBECS definition of a building and the energy suppliers' classification of their accounts for the CBECS buildings, as reported in the Energy Suppliers Survey portion of the CBECS. Since the SEDR and MER are based on data from the energy suppliers, the unshaded areas could potentially be classified by SEDR or MER as either residential, industrial, or other. However, they are included in the CBECS totals for commercial buildings.

Electricity: In 1995, about 82 percent of the 2.6 quadrillion Btu of electricity consumed in commercial buildings was classified by both CBECS and the electricity suppliers as commercial. This represented about 84 percent of total floorspace in buildings supplied with electricity. About 4 percent of the 1995 CBECS electricity consumption estimate and 5 percent of the floorspace were classified by the suppliers as either residential or industrial accounts. The remaining 14 percent of electricity consumption and 11 percent of floorspace were classified as mixed noncommercial/commercial by the supplier.

Natural gas: For buildings supplied with natural gas, about 78 percent of the 1.9 quadrillion Btu of natural gas consumed and about 85 percent of the floorspace was classified by both CBECS and the natural gas suppliers as commercial. About 1 percent of the natural gas consumed was consumed in buildings classified as industrial by the supplier. This represented about 1 percent of the floorspace in buildings that use natural gas. An additional 1 percent of the natural gas consumption and 1 percent of the floorspace were classified as residential accounts. The remaining 19 percent of consumption and 13 percent of floorspace were classified by the supplier as mixed noncommercial/commercial accounts.

Fuel oil: About 80 percent of the 0.2 quadrillion Btu of fuel oil consumed and 83 percent of the floorspace in buildings supplied with fuel oil in 1995 were classified by both the CBECS and the suppliers as commercial accounts. Energy suppliers classified about 8 percent of the consumption and 6 percent of the floorspace as either industrial or residential accounts. The remaining 11 percent of fuel oil consumed and 10 percent of floorspace were in buildings with mixed account classifications.

Therefore, about 18 percent of the CBECS electricity consumption, 22 percent of the CBECS natural gas consumption, and 20 percent of the CBECS fuel oil consumption are potentially excluded from the 1995 commercial sales because of differences in account classifications between the energy suppliers and the CBECS.

Energy End-Use Intensities

The 1995 energy end-use tables provide estimates of the amount of natural gas and electricity used specifically for nine end uses: space heating, cooling, ventilation, water heating, lighting, cooking, refrigeration, office equipment, and other.

The end-use estimates were calculated by using two main sources of data: (1) survey data collected by the CBECS and (2) building energy simulations provided by the Facility Energy Decision Screening (FEDS) system. The CBECS provided data on building characteristics and total energy consumption (i.e., for all end uses) for a national sample of commercial buildings. Using data collected by the CBECS, the FEDS engineering modules were used to produce estimates of energy consumption by end use. The FEDS engineering estimates were then statistically adjusted to match the CBECS total energy consumption.

This section briefly describes the FEDS load estimation methodology, the statistical adjustment procedure, and the remaining steps necessary to produce the final end-use estimates.

The Facility Energy Decision Screening Engineering Estimates: The energy consumption data provided by energy suppliers cover all end uses performed within commercial buildings. Total energy consumption can be disaggregated into end-use consumption by several approaches: engineering simulations, statistical modeling, or a hybrid approach known as a statistically adjusted engineering (SAE) approach. The CBECS end-use estimates were developed by using the SAE approach, with the FEDS system providing the initial engineering estimates.

The FEDS software was developed for the U.S. Department of Energy's Federal Energy Management Program and the U.S. Army Construction Engineering Research Laboratory as a tool for screening groups of buildings on Federal facilities (such as Army bases) for energy efficiency retrofits. The engineering modules, which estimate the energy load to be subjected to retrofit optimization, are one in a series of well-known building energy simulations which include DOE-2 and ASEAM. The FEDS uses high-level installation information (number, age, size, and types of buildings and energy systems), an internal data base of typical energy-system configurations and performance data, and sophisticated energy simulation and optimization models to estimate the net present value of potential energy retrofits in Federal installations.

The FEDS engineering models are designed to produce estimates for five end uses: space heating, cooling, ventilation, lighting, and water heating. Two other end uses, cooking and refrigeration, are also calculated internally by the model, although they are not part of the normal FEDS output. These seven end uses, plus an "other" end use, represent the FEDS accounting for total building end use. Estimates for office equipment energy use were not provided by the FEDS model.

Estimates for the first five end uses are based on detailed building engineering simulations. Estimates for the latter two rely on parameters developed in the Regional End-Use Monitoring Program (REMP), formerly known as the End-Use Load and Consumer Assessment Program (ELCAP) study. REMP was a large end-use monitoring project sponsored by the Bonneville Power Administration. As it was designed to be used in facilities, only a general description of a building need be input for the building energy loads to be estimated interactively, relying on an extensive series of internal default values. Some of these defaults were based on data from prior CBECS, but many were based on the REMP study. For use with the CBECS, the FEDS interface was changed from interactive to batch, with the CBECS survey data supplying as many values as possible.

Besides values relating to the building characteristics, the engineering estimates also required hourly weather profiles. For each calendar month, the average temperature, humidity, and cloudiness during each hour of the day were calculated and input to the model.

Statistically Adjusted Engineering Estimates: The FEDS estimates were based on building characteristics and weather only. At the statistically adjusted engineering (SAE) stage, the engineering estimates were modified to match the observed CBECS consumption data. The basic idea behind the SAE method is simple. Let eui_{bfu} be the end-use consumption per square foot estimated by the FEDS model for building b, fuel f, and end use u, and let eui_{bf} be the total energy consumption (from the CBECS Energy Suppliers Survey) per square foot for building b and fuel f. Then a set of coefficients a_{fu} can be estimated statistically, i.e., by multiple regression, such that

$$e\hat{u}i_{bf} = \sum_u a_{fu} eui_{bfu} .$$

The coefficients adjust the FEDS engineering estimates upward or downward to match the reported energy use. The $e\hat{u}i_{bf}$ are referred to as SAE estimates. If each estimated value of a_{fu} is equal to one, the *eui*'s are the same as those calculated in the engineering model. A value other than one can reflect a variety of factors. The FEDS model assumed values for a number of engineering variables on the basis of a typical or average building. If the characteristics within the sample buildings differ on average from the assumed values, then the actual *eui*'s will diverge from the engineering *eui*'s.

The basic SAE equation stated above assumes that there is a constant bias in the engineering estimates. However, the assumption of constant bias may be inappropriate. The bias may vary along a number of dimensions. Building type, building age, occupant density, and the presence of energy-intensive activities within the building were some of the variables examined to explore the patterns of bias. A nonlinear SAE equation was developed to incorporate these items. The nonlinear framework allowed greater flexibility in the way that variables, such as building age and employment density, could interact with the engineering estimates of end-use consumption. The SAE equations were estimated separately for electricity, natural gas, fuel oil, and district heat.

The Final End-Use Estimates: Because the SAE procedure calibrated the engineering estimates to the reported data for aggregates of buildings, SAE estimates for individual buildings could still vary from the values on the CBECS Master File. For the final end-use estimates, the value on the CBECS Master File (whether reported or imputed) was prorated in proportion to the SAE estimates.

The office equipment estimate was also made after the SAE estimation by using both REMP estimates and estimates from Arthur D. Little Inc. (ADL). The REMP database contains estimates for subcomponents of "other" end-use consumption and was used to estimate the office equipment share of the "other" end-use energy consumption for the 1989 and 1992 CBECS. Included in office equipment were large computer equipment (if the CBECS data indicated the presence of a computer area with a separate air-conditioning system), personal computer equipment, and general office equipment (typewriters, copiers, cash registers, etc.). For the 1995 CBECS, the REMP computer energy consumption estimates were replaced with the more recent ADL estimates before calculating the office equipment share was calculated.

Estimation of Standard Errors

Sampling error, as described in the introduction to this appendix, is the difference between the survey estimate and the true population value due to the use of a random sample to estimate the population. This difference arises because a random subset, rather than the whole population, is observed. The typical magnitude of the sampling error is measured by the standard error of the estimate. The standard error is the root-mean-square difference between the estimate based on a particular sample and the value that would be obtained by averaging estimates over all possible samples.

If the estimates are unbiased, meaning there is no systematic error, this average over all possible samples is the true population value. In this case, the standard error is simply the root-mean-square difference between the survey estimate and the true population value. If systematic error is present, however, this bias is not included in the error measured by the standard error. Thus, the standard error tends to understate the total estimation error if there are non-negligible biases.

In principle, random errors can be attributed to the estimate by sources other than the sampling process. Such additional sources of random error include random errors by respondents and data entry staff and random unit nonresponse. To recognize these additional sources of variation, the definition of the sampling process can be expanded to include not just the selection of buildings but all steps required to obtain a set of responses. Under this expanded definition, all random errors can be regarded as sampling errors. The procedures designed to estimate the sampling error for CBECS incorporate all random components of the estimation process.

Jackknife Replication: Throughout this report, standard errors are given as percents of their estimated values, that is, as relative standard errors (RSE's). Computations of standard errors are more conveniently described, however, in terms of the estimation variance, which is the square of the standard error.

For some types of surveys, a convenient algebraic formula for computing variances can be obtained. The CBECS used a list-supplemented, multistage area sample design (See Appendix A, "How the Survey Was Conducted") of such complexity that it is virtually impossible to construct an exact algebraic expression for estimating variances. In particular, convenient formulas based on an assumption of simple random sampling, typical of most standard statistical packages, are entirely inappropriate for the CBECS estimates. Such formulas tend to give severely understated standard errors, making the estimates appear much more accurate than is the case.

The method used to estimate sampling variances for this survey was a jackknife replication method. The idea behind replication methods is to form several pseudoreplicates of the sample by selecting subsets of the full sample. The subsets are selected in such a way that the observed variance of estimates based on the different pseudoreplicates estimates the sampling variance in the overall estimate.

The k^{th} jackknife pseudoreplicate sample set is obtained by deleting all observations from one of the members in the k^{th} group and multiplying the weights on all cases in the other group members by 2 if there are 2 members in the group and by 1.5 if there are 3 members in the group. Observations in all other groups are unaffected. The k^{th} pseudoestimate is then obtained from this pseudoreplicate sample by following all the steps used to construct the full-sample estimate.

The variances are estimated from the pseudoestimates in the following way. Let X' be a survey estimate (based on the full sample) of characteristic X for a certain category of buildings. For example, X may be the total square footage of buildings using natural gas in the Midwest. Let X_k' be the pseudoestimate of X based on the k^{th} pseudoreplicate sample. The estimated variance of the full-sample estimate X' is then given by:

$$S_{X'}^{\,2} = \sum_{k=1}^{44} (X_k' - X')^2 .$$

The standard error of X' is given by:

$$S_{X'} = \sqrt{S_{X'}^{\,2}}$$

The relative standard error (percent) of X' is obtained from this standard error as:

$$RSE_{X'} = \left(\frac{S_{X'}}{X'} \right) \times 100$$

Generalized Variances: For every estimate in this report, the RSE was computed by the methods described above. This was the RSE used for any statistical tests or confidence intervals given in the text or to determine if the estimate had too much variation to publish (an RSE greater than 50 percent).

Space limitations prevent publishing the complete set of RSE's with this document. Instead, a generalized variance technique is provided by which the reader can compute an approximate RSE for each of the estimates in the main summary tables. For an estimate in the i^{th} row and j^{th} column of a particular table, the approximate RSE is given by the simple formula:

$$RSE_{i,j} = R_i C_j$$

where R_i is the RSE row factor given in the last column of row i, and C_j is the RSE column factor given at the top of column j.

The use of the row and column RSE factors is illustrated in the "Detailed Tables" section of this report..

Derivation of Row and Column Factors: The row and column factors are determined from a two-factor analysis of the table of RSEs on the basis of the model

$$\log(RSE_{i,j}) = m + a_i + b_j$$

Least-squares estimates for this model are given by:

$$m = \overline{\log(RSE)}$$

$$a_i = \overline{\log(RSE_i)} - \overline{\log(RSE)}$$

$$b_j = \overline{\log(RSE_j)} - \overline{\log(RSE)}$$

Where $\overline{\log(RSE)}$ is the mean of $\log(RSE_{i,j})$ over all rows i and columns j, $\overline{\log(RSE_i)}$ is the mean for a particular row i, and $\overline{\log(RSE_j)}$ is the mean for all rows i for a particular column j. The row and column RSE factors are then computed as

$$R_i = \log^{-1}(m + a_i) = \log^{-1}(\overline{\log(RSE_i)})$$

$$C_j = \log^{-1}(b_j) = \log^{-1}(\overline{\log(RSE_j)} - \overline{\log(RSE)})$$

The RSE row factor, R_i, is thus the geometric mean of the RSEs in row i, and the RSE column factor, C_j, is an adjustment factor with geometric mean equal to 1.0.

For a few table cells, there were no sample cases, hence, no estimate and no RSE. As a result, some of the arrays of direct estimates $RSE_{i,j}$ had a few missing values. In such cases, the formulas given above for row and column factors still apply, but only after appropriate estimates have been substituted for the missing values. In cases where a statistic was not publishable because of a large RSE or small cell sample size, the value of $RSE_{i,j}$ was set to missing and an appropriate estimate substituted so that the computed row and column factors are based only on statistics where the RSE is small enough to allow publication. Additionally, RSE column factors are not included for the median statistics found in Detailed Tables BC-2 and CE-19, or for all data in Detailed Tables EU-1 through EU-7.

Appendix C

Description of Building Types

In the Commercial Buildings Energy Consumption Survey (CBECS), buildings were classified according to principal activity, which was the primary business, commerce, or function carried on within each building. Buildings used for more than one of the activities described below were assigned to the activity occupying the most floorspace at the time of the interview. Thus, a building assigned to a particular principal activity category may have been used for other activities in a portion of its space or at some time during the year.

Each of the principal activity categories is listed alphabetically and described below. Lists of specific types of buildings included in each category are presented for clarification but are not intended to be exhaustive.

1. **Agricultural:** See **Other**.

2. **Education:** refers to buildings used for academic or technical classroom instruction. This category includes the following:

Schools:

Preschool
Elementary
Junior high
Senior high
College or university classrooms/Laboratories
Vocational school

Other activities that occur on school campuses are reported separately:

Administration (see Office/Professional)
Auditorium (see Public Assembly)
Dormitory (see Lodging)
Gymnasium (see Public Assembly)
Infirmary (see Health Care)
Library (see Public Assembly)
Museum (see Public Assembly)
School for the Mentally Retarded (see Health Care)
Stadium (see Public Assembly)
Student Union (see Public Assembly).

3. **Enclosed Shopping Center/Mall:** See **Mercantile and Service**.

4. **Food Sales:** refers to buildings used for retail or wholesale sale of food. This category includes the following:

Convenience store or market
Farmer's market, Fruit/Vegetable market
Grocery store/Supermarket
Meat/Seafood store
Retail bakery
Specialty food store.

5. **Food Service:** refers to buildings used for preparation and sale of food and beverages for consumption. This category includes the following:

Prepared-Meal Services:
Cafeteria

Carry-out Service:
Caterer
Fast-food establishment
Pizza parlor
Sandwich shop

Full-Service Restaurant:
Bar
Bar and grill
Coffee shop
Diner
Full-menu-service establishment.

6. **Health Care:** refers to buildings used as diagnostic and treatment facilities for both inpatient and outpatient care. In the tables of this report, inpatient and outpatient buildings are combined in the "Health Care" Principal Building Activity category. Excluded from this group are skilled nursing or other residential care facilities (nursing homes).

<u>Inpatient</u> facilities treat the mentally or physically ill. Buildings for overnight care are in this grouping. This category includes the following:

Medical Care Hospital:
- Chronic disease
- Ear, eye, nose, and throat
- General medical and surgical
- Maternity
- Medical infirmary (connected with an institution)
- Orthopedic
- Tuberculosis/other respiratory disease

Mental Facility:
- Mental retardation/schools for the mentally retarded
- Psychiatric

Rehabilitation Facility:
- Alcoholism
- Substance abuse/narcotics/drug addiction
- Physical therapy.

<u>Outpatient</u> care may be medical, dental, or psychiatric and involves diagnosis and treatment in which services are not required overnight. Buildings used for veterinary practices also fall into this category. This category includes the following:

Dental Clinic

Medical Clinic:
- Abortion/birth control
- Ear, eye, nose, and throat
- Emergency walk-in
- General

Mental health/psychiatric clinic

Veterinary Facilities.

7. **Hospital/Inpatient Health Services:** See **Health Care**.

8. **Hotel/Motel/Dorm, Etc.:** See Lodging.

9. **Industrial/Manufacturing:** See **Other.**

10. **Laboratory:** See **Other**.

11. **Lodging:** refers to buildings used to offer multiple accommodations for short-term or long-term residents, including nursing homes. In the tables of this report, skilled nursing and other residential care facilities are included in the "Lodging" Principal Building Activity category.

<u>Hotel/Motel/Dorm, Etc</u>.
Short-Term Residence:
- Convention hotel
- Hotel
- Inn
- Motel
- Shelter home
- Tourist home

Long-Term Residence:
- Boarding house
- Convent/monastery
- Extended Stay Hotels
- Dormitory/sorority/fraternity
- Orphanage

<u>Assisted-living elder care facilities</u> (limited medical facilities)

<u>Skilled Nursing/Other Residential Care</u> refers to buildings used as facilities which offer 24-hour nursing/medical care. This category includes the following:

- Homes for the aged
- Nursing homes.

12. **Mercantile and Service:** refers to buildings used for sales and displays of goods or services (excluding food). This category includes shopping malls and strip centers, as well as retail and service as outlined below.

Retail (other than shopping mall or strip center):
- Automobile dealers
- Building materials, garden supply stores, hardware
- Department stores
- Drugstores
- Furniture, home equipment stores and home furnishings
- Liquor stores
- Wholesale goods (except food)

Service (other than food service):
- Dry cleaner/car wash/laundry

Gasoline stations
Motor vehicle repair/service/maintenance
Multiservice establishments
Personal service
Post office.

13. **Nonrefrigerated Warehouse or Storage:** See **Warehouse and Storage**.

14. **Office:** refers to buildings used for general office space, professional offices, and administrative offices. This category includes the following:

Data Processing:
Computer center
Data entry/keypunch

Financial Office Building:
Bank
Brokerage firm
Insurance
Real estate
Securities

Professional Office Building:
Administration of an institution
Consulting
Corporate
Engineering
Law
Management
Medical
Mixed professional.

15. **Other:** refers to buildings used for activities that do not fit into any of the specifically named categories. In the tables of this report, this category includes laboratories and buildings identified as having several commercial activities that, together, represent 50 percent or more of the floorspace, but whose largest single activity is agricultural, industrial/manufacturing, or residential. This category includes the following:

Crematorium
Hangar
Public restrooms/showers
Telephone exchange
Greenhouse with retail sales of plants
Manufacturing with retail sales of products
Printing plant with retail sales.

Laboratory refers to buildings used for activities which utilize equipment for experimental testing or for analysis. This category includes the following:

Mechanical/electrical laboratory
Medical/dental laboratory
Agricultural laboratory.

16. **Outpatient Health Services/Clinic:** See **Health Care**.

17. **Public Assembly:** refers to buildings in which people gather for social or recreational activities whether in private or nonprivate meeting halls. This category includes the following:

Entertainment Building:
Archive/art gallery/exhibit hall/library/museum
Coliseum/arena (enclosed)
Concert hall
Observatory/planetarium
Night club
Radio/TV station or studio
Theater/movie house/cinema

Recreational Facility:
Amusement arcade
Bowling alley
Community centers
Gymnasium/YMCA or YWCA/indoor racket sports, recreation center/athletic facility
Indoor pool
Poolroom
Skating rink

Social/public/civic assembly:
Assembly hall
Auditorium
Convention hall
Funeral home
Lecture hall
Lodge hall
Meeting hall
Student union
Town hall

Other Enclosed Assembly Building:

Armory
Passenger terminal
Stadium.

18. **Public Order and Safety:** refers to buildings used for the preservation of law and order or public safety. This category includes the following:

Courthouse
Fire station

Jail
Penitentiary/Prison
Police station
Reformatory
Sheriff's office.

19. **Refrigerated Warehouse or Storage:** See **Warehouse and Storage.**

20. **Religious Worship:** refers to buildings in which people gather for religious activities. This category includes the following:

Chapel
Church
Mosque
Synagogue
Temple.

21. **Residential:** See **Other**.

22. **Retail (other than shopping mall or strip center):** See **Mercantile and Service**.

23. **Service (other than food service):** See **Mercantile and Service**.

24. **Skilled Nursing/Other Residential Care:** See **Lodging**.

25. **Strip Shopping Center:** See **Mercantile and Service**.

26. **Warehouse and Storage:** refers to buildings used to store goods, manufactured products, merchandise, or raw materials. In the tables of this report, both refrigerated and non-refrigerated warehouse and storage are included in the "Warehouse" Principal Building Activity category.

Refrigerated Storage refers to buildings specifically designed to store perishable goods or merchandise under refrigeration. Includes "cold storage" facilities, which store products at temperatures between 0 degrees Fahrenheit and 50 degrees Fahrenheit and "freezer" facilities, which store products at temperatures between 0 degrees Fahrenheit and 20 degrees Fahrenheit.

This category includes the following:

Cheese warehouse
Cold storage
Fur storage.

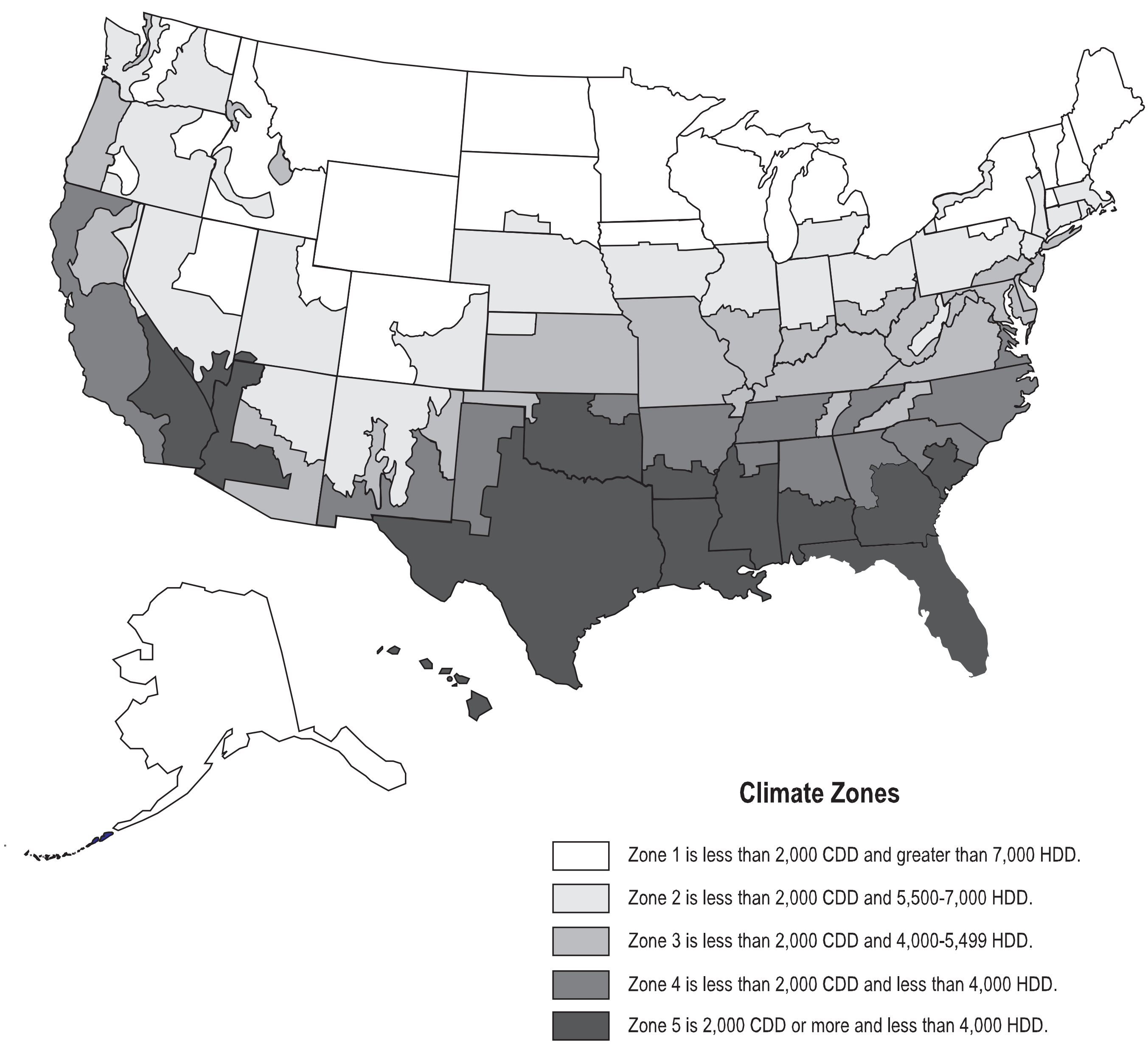
Nonrefrigerated Warehouse refers to buildings specifically designed to store perishable goods or merchandise without refrigeration.

27. **Vacant:** refers to commercial buildings in which more floorspace was vacant than was used for any single commercial activity (as defined above) at the time of interview. Thus a vacant building may have some occupied floorspace. Vacant space does not include space being maintained and ready for use.

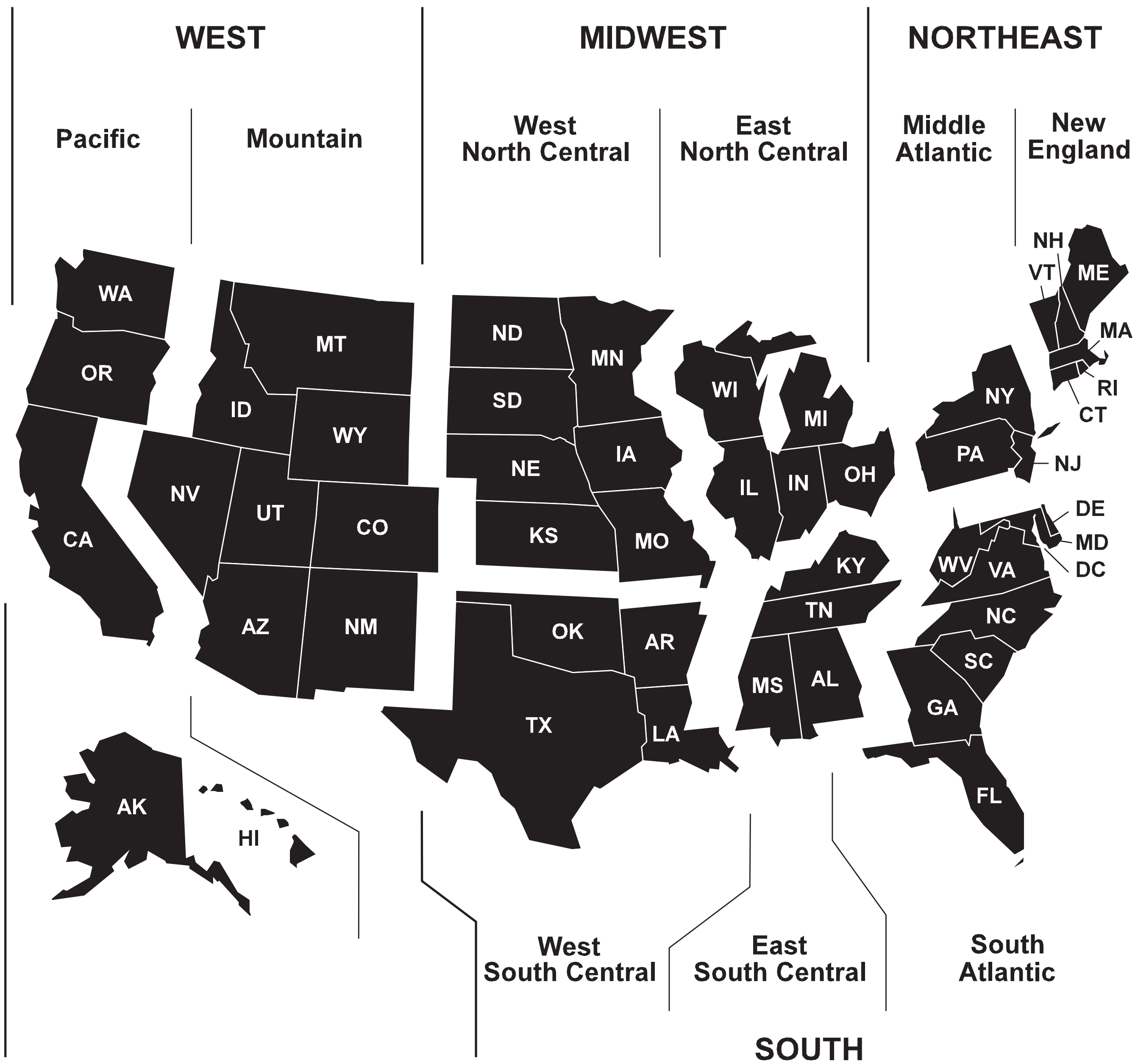
Appendix D

U.S. Climate Zones and Census Regions and Divisions Maps

U.S.Climate Zones



U.S. Census Regions and Divisions



Source: U.S. Department of Commerce, Bureau of the Census, *Statistical Abstract of the United States, 1996* (Washington, D.C., October 1996), Figure 1.

Appendix E

Metric Conversion Factors

Data in the Energy Information Administration publications are expressed in units, such as British thermal units, barrels, cubic feet, and short tons, that historically have been used in the United States. However, because U.S. activities involve foreign nations, most of which use metric units of measure, the United States is committed to making the transition to the metric system. The metric conversion factors presented in Table E1 can be used to calculate the metric-unit equivalents of values expressed in U.S. units. For example, 500 short tons are the equivalent of 453.6 metric tons (500 short tons x 0.9071847 metric tons/short tons=453.6 metric tons).

Table E1. Metric Conversion Factors

Type of Unit	U.S. Unit	Conversion Factor	Metric Unit
Mass	Short Tons	X 0.907 184 7	= Metric Tons (t)
	Short Tons Uranium Oxide (U_30_8)	X 0.769	= Metric Tons Uranium (U)
	Short Tons Uranium Fluoride (UF_6)	X 0.613	= Metric Tons Uranium (U)
	Long Tons	X 1.016	= Metric Tons(t)
	Pounds(lb)	X 0.453 592 37[a]	= Kilograms(kg)
	Pounds Uranium Oxide(lb U_3O_8)	X 0.384 645[b]	= Kilograms (Kg)
	Ounces, Avoirdupois(oz)	X 28.349 52	= Grams(g)
Volume	Barrels of Oil(bbl)	X 0.158 987 3	= Cubic Meters (m^3)
	Cubic Yards(yd^3)	X 0.765 555	= Cubic Meters (m^3)
	Cubic Feet(ft^3)	X 0.028 316 85	= Cubic Meters (m^3)
	U.S. Gallons(gal)	X 3.785 412	= Liter (L)
	Ounces, Fluid(fl oz)	X 29.573 53	= Milliliters (ml)
	Cubic Inches(in^3)	X 16.387 06	= Milliliters (ml)
Length	Miles (mi)	X 1,609,344[a]	= Kilometers (km)
	Yards (yd)	X 0.914 4[a]	= Meters (m)
	Feet (ft)	X 0.304 8[a]	= Meters (m)
	Inches (in)	X 2.54[a]	= Centimeters (cm)
Area	Acres	X 0.404 69	= Hectares (ha)
	Square Miles (mi^2)	X 2,589,988	= Square Kilometers (km^2)
	Square Yards (yd^2)	X 0.836 127 4	= Square Meters (m^2)
	Square Feet (ft^2)	X 0.092 903 04[a]	= Square Meters (m^2)
	Square Inches (in^2)	X 6.456 16[a]	= Square Centimeters (cm^2)
Temperature	Degrees Fahrenheit[c] (^oF)	X 5/9 (after subtracting 32)[a]	= Degrees Celsius (^oC)
Energy	British thermal units (Btu)	X 1,055.056	= Joules (J)
	Calories (cal)	X 4.186 8	= Joules (J)
	Kilowatthours (kWh)	X 3.6	= Megajoules (MJ)

[a]Exact Conversion.
[b]Calculated by the Energy Information Administration.
[c]To convert degrees Celsius (^oC) to degrees Fahrenheit (^oF), multiply by 9/5, then add 32.
Sources: General Services Administration, Federal Standard 376B, *Preferred Metric Units for General Use by the Federal Government* (Washington, DC, January 27, 1993), pp. 9-11, 13, and 16. National Institute of Standards and Technology, *Special Publications* 330, 811, and 814. American National Standards Institute/Institute of Electrical and Electronic Engineers, ANS/EEE Std.268-1982, pp. 28 and 29. Energy Information Administration, *Monthly Energy Review August 1993*, Appendix B, p. 161.

Appendix F

Related EIA Publications on Energy Consumption

For information on how to obtain the current publications, see the inside cover of this report. For information on later publications, contact the National Energy Information Center on (202) 586-8800. You can also go to our web site at http://www.eia.doe.gov/emeu/consumption to access reports on the commercial, manufacturing, residential, and residential transportation sectors.

In addition to the reports listed below, public-use data for the last two survey cycles for each sector can also be accessed via our Web page. To obtain public-use data for earlier years, contact the survey manager for that sector at http://www.eia.doe.gov/emeu/consumption/contacts.html.

Commercial Sector

Note: The name of the Nonresidential Buildings Energy Consumption Survey was changed to the Commercial Buildings Energy Consumption Survey, beginning with the 1989 survey. The survey name was also dropped from the report title at that time and subsequently.

Characteristics of Buildings

Commercial Buildings Characteristics 1995; August 1997, DOE/EIA-E-0109, **Electronic Only**. This report can be accessed at www.eia.doe.gov/emeu/cbecs/cb951a.html.

Commercial Buildings Characteristics 1992; April 1994, DOE/EIA-0246(92).

"Commercial Buildings Characteristics 1992," *Monthly Energy Review*, January 1994, DOE/EIA-0035(94/01).

Commercial Buildings Characteristics 1989; June 1991, DOE/EIA-0246(89).

Nonresidential Buildings Energy Consumption Survey: Characteristics of Commercial Buildings, 1986; September 1988, DOE/EIA-0246(86).

Nonresidential Buildings Energy Consumption Survey: Characteristics of Commercial Buildings, 1983; July 1985, DOE/EIA-0246(83).

Nonresidential Buildings Energy Consumption Survey: Characteristics of Commercial Buildings, 1983; A Supplemental Reference, DOE/EIA-M008.

Nonresidential Buildings Energy Consumption Survey: Fuel Characteristics and Conservation Practices; June 1981, DOE/EIA-0278.

Nonresidential Buildings Energy Consumption Survey: Building Characteristics; March 1981, DOE/EIA-0246.

Consumption and Expenditures

Commercial Buildings Consumption and Expenditures 1995; February 1998, DOE/EIA-E0318(95) **Electronic Only**. This report can be accessed at www.eia.doe.gov/emeu/cbecs/toc_ce.html. *Commercial Buildings Consumption and Expenditures 1992*; April 1995, DOE/EIA-0318(92).

Commercial Buildings Consumption and Expenditures 1992; April 1995, DOE/EIA-0318(92).

Commercial Buildings Consumption and Expenditures 1989; April 1992, DOE/EIA-0318(89).

Nonresidential Buildings Energy Consumption Survey: Commercial Buildings Consumption and Expenditures 1986; May 1989, DOE/EIA-0318(86).

Nonresidential Buildings Energy Consumption Survey: Commercial Buildings, Consumption and Expenditures 1983; September 1986, DOE/EIA-0318(83).

Nonresidential Buildings Energy Consumption Survey: 1979 Consumption and Expenditures, Part 1: Natural Gas and Electricity; March 1983, DOE/EIA-0318/1.

Nonresidential Buildings Energy Consumption Survey: 1979 Consumption and Expenditures, Part 2: Steam, Coal, Fuel Oil, LPG, and Total Fuels; December 1983, DOE/EIA-0318(79)/2.

Other Publications on the Commercial Sector

Energy End-Use Intensities in Commercial Buildings (1995 data), February 1995, DOE/EIA-E0555(95) tables only in **electronic form**. This product can be accessed at www.eia.doe.gov/emeu/cbecs/cbec-eu3.html

Energy End-Use Intensities in Commercial Buildings (1992 data), February 1995, DOE/EIA-E0555(92) tables only in **electronic form**. This product can be accessed at www.eia.doe.gov/emeu/cbecs/cbecs1d.html.

Service Report: Federal Buildings Supplemental Survey 1993, November 1995, SR/EMEU/95-02.

Energy Consumption Series— Energy End-Use Intensities in Commercial Buildings, September 1994, DOE/EIA-0555(94)/2.

"Assessment of Energy Use in Multibuilding Facilities," *Monthly Energy Review,* December 1993, DOE/EIA-0035(93/12).

Energy Consumption Series—Assessment of Energy Use in Multibuilding Facilities, August 1993, DOE/EIA-0555(93)/1.

Energy Consumption Series—User-Needs Study for the 1992 Commercial Buildings Energy Consumption Survey, September 1992, DOE/EIA-0555(92)/4.

Energy Consumption Series—Lighting in Commercial Buildings; March 1992, DOE/EIA-0555(92)/1.

Industrial Sector

Manufacturing Consumption of Energy 1994, December 1997, DOE/EIA-0512(91).

Changes in Energy Intensity in the Manufacturing Sector 1985-1991, September 1995, DOE/EIA-0552 (85-91).

Manufacturing Consumption of Energy 1991, December 1994, DOE/EIA-0512(91).

"Energy Preview: Manufacturing Energy Consumption Survey Preliminary Estimates, 1991," *Monthly Energy Review*, September 1993, DOE/EIA-0035 (93/01).

"Energy Efficiency in the Manufacturing Sector," *Monthly Energy Review*, December 1992.

Manufacturing Energy Consumption Survey: Changes in Energy Intensity in the Manufacturing Sector 1980-1988, December 1991, DOE/EIA-0552 (80-88).

Manufacturing Energy Consumption Survey: Manufacturing Fuel-Switching Capability 1988, September 1991, DOE/EIA-0515(88).

Manufacturing Energy Consumption Survey: Consumption of Energy, 1988, May 1991, DOE/EIA-0512(88).

Manufacturing Energy Consumption Survey: Energy Efficiency in Manufacturing, 1985; January 1990, DOE/EIA-0516(85).

Manufacturing Energy Consumption Survey: Fuel-Switching Capability, 1985, December 1988, DOE/EIA-0515(85).

Manufacturing Energy Consumption Survey: Methodological Report, 1985, November 1988, DOE/EIA0514(85).

Manufacturing Energy Consumption Survey: Consumption of Energy, 1985, November 1988, DOE/EIA-0512(85).

"Manufacturing Sector Energy Consumption 1985 Provisional Estimates," *Monthly Energy Review*,January 1987, DOE/EIA-0035 (87/01).

Report on the 1980 Manufacturing Industries' Energy Consumption Study and Survey of Large Combustors, February 1983, DOE/EIA-0358.

Industrial Energy Consumption, Survey of Large Combustors: Report on Alternate Fuel-Burning Capabilities of Large Boilers in 1979, February 1982, DOE/EIA-0304, GP.

Methodological Report of the 1980 Manufacturing Industries Survey of Large Combustors (EIA-463), March 1982, DOE/EIA-0306.

Other Publications on the Industry Sector

Energy Consumption Series—*Derived Annual Estimates of Manufacturing Energy Consumption 1974-1988*, August 1992, DOE/EIA-0555(92)/3.

Energy Consumption Series—*Development of the 1991 Manufacturing Energy Consumption Survey*, May 1992, DOE/EIA-0555(92)/2.

Residential Sector

Housing Characteristics

Note: The survey name was dropped from the beginning of the report title starting with the 1987 data reports.

Housing Characteristics, 1997, May 1998, DOE/EIA-E0314(97)—coming in electronic form the end of August 1998.Presently, the tables only are available and can be accessed **electronically** at http://www.eia.doe.gov/emeu/recs/ 97tblhp.html.

Housing Characteristics, 1993, June 1995, DOE/EIA-0314(93).

Housing Characteristics 1990; May 1992, DOE/EIA-0314(90), *Housing Characteristics 1987*; May 1989, DOE/EIA-0314(87).

Residential Energy Consumption Survey: Housing Characteristics 1984, October 1986, DOE/EIA-0314 (84).

Residential Energy Consumption Survey: Housing Characteristics, 1982, August 1984, DOE/EIA-0314 (82).

Residential Energy Consumption Survey Housing Characteristics, 1981, August 1983, DOE/EIA-0314 (81).

Residential Energy Consumption Survey: Housing Characteristics, 1980, June 1982, DOE/EIA-0314.

Residential Energy Consumption Survey: Characteristics of the Housing Stock and Households, 1978, February 1980, DOE/EIA-0207/2.

Residential Energy Consumption Survey: Conservation, February 1980, DOE/EIA-0207/3.

Preliminary Conservation Tables from the National Interim Energy Consumption Survey, August 1979,DOE/EIA-0193/P.

Characteristics of the Housing Stock and Households: Preliminary Findings from the National Interim Energy Consumption Survey, October 1979, DOE/EIA-0199/P.

Consumption and Expenditures

Note: The survey name was dropped from the beginning of the report title starting with the 1987 data reports. The titles were changed to *Household Energy Consumption and Expenditures 1987, Part 1: National* and *Part 2: Regional*.

Household Energy Consumption and Expenditures 1993, October 1995, DOE/EIA-0321(93).

"Household Energy Consumption and Expenditures 1990," *Monthly Energy Review*, August 1993, DOE/EIA-0035(93/08).

Household Energy Consumption and Expenditures 1990, February 1993, DOE/EIA-0321/1(90).

Household Energy Consumption and Expenditures 1990\S, DOE/EIA-0321/2(90).

Household Energy Consumption and Expenditures 1987, Part 1: National Data, October 1989, DOE/EIA-0321/1(87). Note: Energy end-use data are included in this report.

Household Energy Consumption and Expenditures 1987, Part 2: Regional Data, DOE/EIA-0321/2(87).

Residential Energy Consumption Survey: Consumption and Expenditures, April 1984 Through March 1985, Part 1: National Data, March 1987, DOE/EIA-0321/1(84).

Residential Energy Consumption Survey: Consumption and Expenditures, April 1984 Through March 1985, Part 2: Regional Data, May 1987, DOE/EIA-0321/2 (84). Note: Energy end-use data are included in this report.

Residential Energy Consumption Survey: Consumption and Expenditures, April 1982 Through March 1983, Part 1: National Data, November 1984, DOE/EIA-0321/1(82).

Residential Energy Consumption Survey: Consumption and Expenditures, April 1982 Through March 1983, Part 2: Regional Data, December 1984, DOE/EIA-0321/2(82).

Residential Energy Consumption Survey: Consumption and Expenditures, April 1981 Through March 1982, Part 1: National Data, September 1983, DOE/EIA-0321/1(81). *Residential Energy Consumption Survey: Consumption and Expenditures, April 1981 Through March 1982, Part 2: Regional Data,* October 1983, DOE/EIA-0321/2(81).

Residential Energy Consumption Survey: Consumption and Expenditures, April 1980 Through March 1981, Part 1: National Data, September 1982, DOE/EIA-0321/1(80).

Residential Energy Consumption Survey: Consumption and Expenditures, April 1980 Through March 1981, Part 2: Regional Data, June 1983, DOE/EIA-0321/2(80).

Residential Energy Consumption Survey: 1979-1980 Consumption and Expenditures, Part 1: National Data (Including Conservation), April 1981, DOE/EIA-0262/1.

Residential Energy Consumption Survey: 1979-1980 Consumption and Expenditures, Part II: Regional Data, May 1981, DOE/EIA-0262/2.

Residential Energy Consumption Survey: Consumption and Expenditures, April 1978 Through March 1979, July 1980, DOE/EIA-0207/5.

Single-Family Households: Fuel Oil Inventories and Expenditures: National Interim Energy Consumption Survey, December 1979, DOE/EIA-0207/1.

Other Publications on the Residential Sector

Energy Consumption Series—*Residential Energy Consumption Survey Quality Profile*, March 1996, DOE/EIA-0555(96)/1.

Energy Consumption Series—*Sample Design for the Residential Energy Consumption Survey*, August 1994, DOE/EIA-0555(94)/1.

Energy Consumption Series—*User-Needs Study of the 1993 Residential Energy Consumption Survey*, September 1993, DOE/EIA-0555(93)/2.

"End-Use Consumption of Residential Energy" *Monthly Energy Review*, July 1987, DOE/EIA-0035(87/07).

Residential Energy Consumption Survey: Trends in Consumption and Expenditures 1978-1984, June 1987, DOE/EIA-0482.

Residential Conservation Measures, July 1986, SR/EEUD/86/01.

*An Economic Evaluation of Energy Conservation and Renewable Energy Tax Credits,*October 1985, Service Report.

Residential Energy Consumption and Expenditures by End Use for 1978, 1980, and 1981; December 1984, DOE/EIA-0458.

Weatherization Program Evaluation, SR-EEUD-84-1, August 1984 (available from the Office of the Assistant Secretary for Conservation and Renewable Energy, Department of Energy).

Residential Energy Consumption Survey: Regression Analysis of Energy Consumption by End Use, October 1983, DOE/EIA-0431.

National Interim Energy Consumption Survey: Exploring the Variability In Energy Consumption, July 1981, DOE/EIA-0272.

National Interim Energy Consumption Survey: Exploring the Variability in Energy Consumption—A Supplement, October 1981, DOE/EIA-0272/S.

Residential Transportation Sector

Note: The survey name was dropped from the beginning of the report title starting with the 1988 data report, and the report title changed to *Household Vehicles Energy Consumption 1988*.

Household Vehicles Energy Consumption 1994, August 1997, DOE/EIA-0464(94).

Household Vehicles Energy Consumption 1991, December 1993, DOE/EIA-0464(91).

"Energy Preview: Residential Transportation Energy Consumption Survey Preliminary Estimates, 1991," *Monthly Energy Review*, January 1993, DOE/EIA-0035(93/01).

Household Vehicles Energy Consumption 1988, February 1990, DOE/EIA-0464(88).

Residential Transportation Energy Consumption Survey: Consumption Patterns of Household Vehicles 1985, April 1987, DOE/EIA-0464(85).

Residential Transportation Energy Consumption Survey: Consumption Patterns of Household Vehicles, 1983, January 1985, DOE/EIA-0464(83).

Residential Energy Consumption Survey: Consumption Patterns of Household Vehicles, Supplement: January 1981 to September 1981, February 1983, DOE/EIA-0328.

Residential Energy Consumption Survey: Consumption Patterns of Household Vehicles, June 1979 to December 1980, April 1982, DOE/EIA-0319.

Cross-Sector

Energy Consumption Measuring Energy Efficiency in the United States' Economy: A Beginning, October 1995, DOE/EIA-0555(95)/2.

Energy Consumption Series-Buildings and Energy in the 1980's, June 1995, DOE/EIA-0555(95)/1.

Energy Consumption by End-Use Sector: A Comparison of Measures by Consumption and Supply Surveys; April 6, 1990, DOE/EIA-0533.

Natural Gas: Use and Expenditures; April 1983, DOE/EIA-0382.

Public-Use Data

Note: Microdata involving the last two survey cycles for the various sector can be found on the **Consumption Homepage** at www.eia.doe.gov/emeu/page1.html. Call the National Energy Information Center on (202) 586-8800 regarding public-use data for the later survey years, such as those below.

Residential and Residential Transportation Sectors

Residential Transportation Energy Consumption Survey, 1988, Order No. PB90-501461.

Residential Energy Consumption Survey: 1987 and Residential Transportation Energy Consumption Survey, 1988, Order No. PB90-501461.

Residential Energy Consumption Survey: 1984 and Residential Transportation Energy Consumption Survey, 1985, Order No. PB87-186540.

Residential Energy Consumption Survey: 1982 and Residential Transportation Energy Consumption Survey, 1983, Order No. PB85-221760.

Residential Energy Consumption Survey: Consumption and Expenditures, 1980-1981; Monthly Billing Data, Order No. PB84-166230.

Residential Energy Consumption Survey: Housing Characteristics, 1981; Consumption and Expenditures, 1981-1982, Monthly Billing Data; Order No. PB84-120476.

Residential Energy Consumption Survey: Housing Characteristics, Annualized Consumption and Expenditures, 1980-1981, Order No. PB83-199554.

Residential Energy Consumption Survey: Household Transportation Panel Monthly Gas Purchases and Vehicle and Household Characteristics, 6/79-9/81, Order No. PB84-162452.

Residential Energy Consumption Survey: Household Screener Survey, 1979-1980, Order No. PB82-114877.

Residential Energy Consumption Survey: Household Monthly Energy Consumption and Expenditures, 1978-1979, Order No. PB82-114901.

National Interim Energy Consumption Survey (Residential), 1978, Order No. PB81-108714.

Commercial Sector

Nonresidential Buildings Energy Consumption Survey: 1986 Data, Order No. PB90-500034.

Nonresidential Buildings Energy Consumption Survey: 1979 and 1983 Data, Order No. PB88-245162.

Note: The Energy Information Administration also publishes annually the *State Energy Data Report, Consumption Estimates*, DOE/EIA-0214; the *State Energy Price and Expenditures Report*, DOE/EIA-0376; and the *Monthly Energy Review*, DOE/EIA-0035. These reports contain annual and monthly consumption information derived from EIA supply surveys.