Independent Statistics & Analysis
U.S. Energy Information Administration

Select Results from the Energy Assessor Experiment in the 2012 Commercial Buildings Energy Consumption Survey

December 2015

Independent Statistics & Analysis
www.eia.gov

U.S. Department of Energy
Washington, DC 20585

This report was prepared by the U.S. Energy Information Administration (EIA), the statistical and analytical agency within the U.S. Department of Energy. By law, EIA's data, analyses, and forecasts are independent of approval by any other officer or employee of the United States Government. The views in this report therefore should not be construed as representing those of the U.S. Department of Energy or other federal agencies.

Introduction

In 2010, the National Research Council published a report[1] on how to improve the U.S. Energy Information Administration (EIA)'s energy consumption surveys, including the Commercial Building Energy Consumption Survey (CBECS). Among the panel's recommendations was for EIA to test the feasibility of using energy auditors in tandem with, or instead of, trained survey interviewers for data collection. The panel posited that the data obtained in this experiment, even if small in scale, might help EIA to assess CBECS data quality, as well as to evaluate post data collection editing procedures and the regression model[2] that determines whether a building needs to be sent to post-interview energy supplier follow-up.

In addition to the panel's suggestions for ways to use the energy audits to improve data collection, EIA also identified a number of areas where a comparison of CBECS and energy audit data is appropriate. By observing how energy professionals record building characteristics and systems, EIA may be able to improve survey questions and concepts in the next CBECS cycle. EIA also wanted to understand the process of incorporating an energy audit into future CBECS data collections, and what the additional time spent on the audit means for respondent burden.

Our goals for this project are both data driven and procedural. First, we ask what differences exist, both quantitative and qualitative, between data collected by a trained interviewer with a computerized survey instrument, and data collected by an energy professional with a standardized paper checklist. Second, we ask whether the addition of an energy audit is desirable or feasible for future rounds of CBECS data collection. This second question weighs the potential gains in data quality with the relative costs of time, money, and respondent burden.

CBECS background

CBECS is a complex sample survey that produces the only national-level data on the characteristics and energy use in commercial buildings in the United States. The survey was first conducted in 1979 and was then conducted triennially between 1983 and 1995. Starting in 1995, it has been conducted quadrennially, with the exception of 2011 when EIA budget cuts caused a delay in data collection, postponing the tenth CBECS until 2012. The sample size for CBECS has historically ranged from 5,000 to 7,000 buildings. The target 2012 CBECS sample size was increased to improve precision and support broader uses of the data; the final responding sample for the 2012 CBECS was 6,720 buildings.

CBECS data are used for many purposes, such as: benchmarking, building design, policy planning, building code development, market research, forecasting energy consumption, and as a critical input to the Environmental Protection Agency's ENERGY STAR® models. The data are also made available to the public through tables, reports, and public use data files containing building-level records, which allow

---

[1] National Research Council. (2012*). Effective Tracking of Building Energy Use: Improving the Commercial Buildings and Residential Energy Consumption Surveys*. Panel on Redesigning the Commercial Buildings and Residential Energy Consumption Surveys of the Energy Information Administration. W.F. Eddy and K. Marton, Eds. Committee on National Statistics, Division of Behavioral and Social Sciences and Education, and Board on Energy and Environmental Systems, Division on Engineering and Physical Sciences. Washington, DC: The National Academies Press.

[2] After a building respondent supplies consumption and expenditures data, a regression model runs in the survey instrument to test whether or not the consumption is within expected bounds for a building of similar size and building activity.

users to conduct their own analyses. Before releasing public data, disclosure analysis is performed, masking certain variables, and removing names, addresses, and other geographic identifiers, so that individual buildings cannot be identified from this file.

CBECS is a two-part survey: the Buildings Survey and a follow-up Energy Suppliers Survey (ESS). In the first part, the Buildings Survey, detailed information about the buildings is collected from building owners and managers, such as building size, age, structural characteristics, operating hours, ownership, energy sources and uses, and types of energy-related equipment used. In addition, energy consumption and expenditures data for a one-year reference period are collected from building respondents whenever possible. Sometimes building respondents cannot provide these data, or the energy data fail predetermined edits; in these cases, a follow-on survey is conducted with the individual energy suppliers for the building. The ESS has historically been conducted by mail, but as of 2012 was conducted primarily as a web-based collection.

The Buildings Survey is conducted by professional interviewers using a computerized survey instrument. The interview protocol requires that the interviewer screen the building for eligibility, and then locate a respondent who is knowledgeable about energy usage in the building to provide them with a folder of information about CBECS and to set an appointment for a future interview. The interview can be conducted either in-person or by telephone. The folder includes worksheets identifying data items that may require research. Upon completion of the interview, the interviewer also scans or requests sample copies of the energy bills to be used for data editing.

Research questions

The EIA team working on the Energy Assessment experiment developed a number of research questions based on the National Research Council report and internal EIA research objectives. The main research questions we address with this analysis are:

1) What differences, both quantitative and qualitative, exist between data collected by interviewers versus that collected by assessors?
2) What are the advantages and disadvantages of each method of data collection?
3) What does *success* look like for the energy assessment project? What factors would lead EIA to incorporate this method of data collection into a future CBECS cycle?

Data collection process

As EIA began planning for the energy audit process, we consulted with an energy professional for tips and insight into the auditing process. One important insight from this meeting was to change the name of the process from an energy audit to an energy assessment (EA). The reasons for this change are two-fold. First, EIA was concerned that respondents would not want a federal agency conducting an audit on their building. Second, energy audits usually consist of an energy professional exploring a building's equipment, documents, and energy use, focusing on areas for improvement, and then making recommendations. Because EIA did not wish to endorse certain building practices or equipment, the energy professionals were instructed not to make any recommendations to building respondents about how to become more energy efficient.

Based on budget and time, EIA decided to set a target of 200 completed building EAs. To cover a variety of climates and building types, EIA selected 10 primary sampling units (PSUs), covering all five climate regions[3], with at least two PSUs per region. The 200 EAs also targeted certain primary building activities (as reported by respondents during the CBECS interview) including office, warehouse, food sales, education, food service, hospital, lodging, and non-mall retail buildings.[4] These building activities were selected based on their diverse energy intensities, among other substantive criteria of interest to the research team.

Thirteen energy assessors were trained to complete building assessments. Their experience performing building audits ranged from one to sixteen years, with a mean of seven years of experience. The assessors were given the building name, address, respondent name, and contact information. They did not have access to any other information collected during the CBECS interview to maintain the independence of the methods during data collection.

Energy assessors have a number of methods for capturing pertinent building information, most of which are individually developed. To help analyze the EA data, EIA worked with a contractor to develop a standardized paper checklist for the assessors to use during the assessment. Given time and budget constraints, a paper checklist (rather than a computerized instrument) was selected. The checklist allowed us to cover a number of the same topics captured in the CBECS data, with the addition of topics that are covered in a standard energy audit, and it was flexible enough to cover both small buildings with simple equipment and very large buildings with complex building systems. Topics covered include general building information; building envelope; heating, cooling, and ventilation systems, including controls; water heating systems; lighting systems; specialty loads; and energy use data.

Participation in the EA project was voluntary. After completing the CBECS interview, all building respondents in the selected PSUs were asked if they would like to participate in a follow-up energy assessment project. If they declined to participate, or indicated that they were not sure, they were not added to the pool of potential buildings. If they agreed to participate, the building was added to the list of potential EA buildings. Because participation was voluntary, the results from the EA data are not statistically representative of the entire sample of CBECS buildings or of any portion of the CBECS sample at smaller levels of geography.

After EA data collection was completed, the EIA research team mapped the data from the EA checklists back to the CBECS variables to compare the results obtained by the CBECS interviewer with those obtained by the energy assessor. The team attempted to map the variables with minimal editing, only using information provided by the assessor in the form of notes or attachments of additional documents (such as utility bills, equipment lists, floorplans, or images). The use of the Internet or the CBECS data during editing was strictly prohibited to maintain the independence of the methods that produced the assessment data. If an individual editor had a question about how to code an EA variable back to CBECS, the analysis group adjudicated the appropriate edited response.

---

[3] As defined by Building America: http://www.eia.gov/consumption/commercial/maps.cfm

[4] Primary building activity definitions can be found here: http://www.eia.gov/consumption/commercial/building-type-definitions.cfm

Data

At the conclusion of the CBECS interview, 1,022 building respondents were asked if they would like to participate in the follow-up EA project. Of those buildings interviewed, 554 respondents (49.5%) agreed to have the follow-up assessment completed. Of those 554 buildings that agreed, the EIA team selected 475 to be contacted by the EA contractor for an assessment. We excluded buildings with activities that were out of scope (such as vacant buildings) or that were too geographically dispersed from the rest of the sample. Overall, larger buildings were more likely to initially volunteer and more likely to actually complete an EA. Respondents from buildings in the smallest size category (1,001-5,000 square feet) were the least likely to volunteer for an EA, and less likely to complete the EA after volunteering.

Of the 475 buildings selected for the energy assessment project, 203 eligible buildings completed the assessment.[5] Each assessor conducted varying numbers of EAs, ranging from 2 to 40 completed building energy assessments, with an average of 15 completed EAs per assessor. See Figure 1 for the breakdown of completion rates by section of the checklist for the completed buildings. The assessors were fairly successful in obtaining most of the building information during their time on-site, with section completion rates between 93% and 100% for building characteristics and heating and cooling equipment. Three sections of the checklist are notable for their lower completion rates: Fan Systems, Ventilation, and Circulation Pumps. These sections of the checklist do not have direct comparisons in the CBECS questionnaire, and these data do not seem easy to obtain, even by energy professionals.

Figure 1. Checklist completion rates by topic*

Checklist Section	Buildings with section completed
General Building Information, Square Footage, Occupant Metrics, Building Activity, Schedule	100%
Principal Opaque Building Characteristics (Wall and Roof Characteristics)	100%
Principal Fenestration	100%
Lighting Characteristics	100%
HVAC: Cooling Systems (equipment information, capacity, energy sources)	99%
Energy Sources and Utility Information	98%
HVAC: Principal Heating and Cooling Equipment (year installed, major renovations)	97%
Miscellaneous Loads (Elevators, Office Equipment, Lab Equipment, Machine Shop Equipment)	95%
HVAC: Heating Systems (equipment information, capacity, energy sources)	94%
HVAC: Domestic Hot Water	94%
HVAC: Controls Systems	93%
HVAC: Fresh Air Ventilation and Exhausts	83%
HVAC: Fan System	76%
HVAC: Circulation Pumps	75%

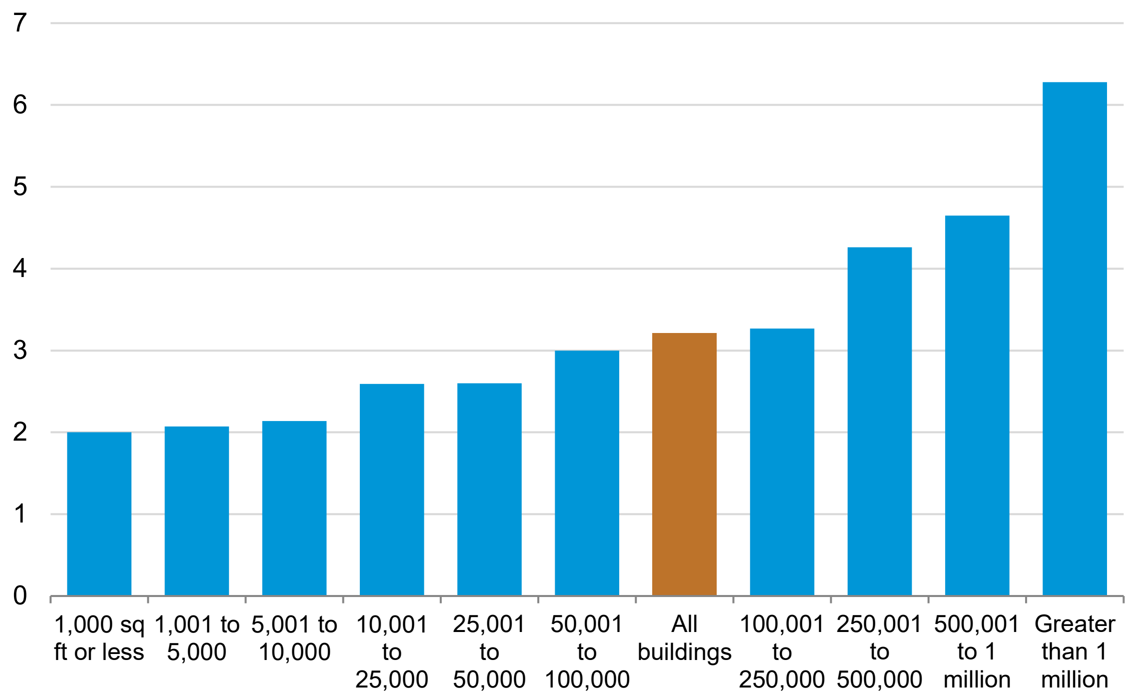
*A section is considered complete when at least one field in the section has data that is not *Don't Know*. A section coded as *Not Applicable* is considered complete.

[5] Assessors completed EAs for 206 buildings total. One building was determined to be residential, and therefore out of scope for CBECS. In two other cases, the assessors traveled to and interviewed the wrong building.

In addition to the completed checklists, assessors collected other documents with building information, such as utility bills or energy consumption printouts, copies of floorplans, equipment lists, and photographs (of the building envelope or equipment). More than half (56%) of buildings had one or more of these attachments. Of those with attachments, 57% had utility bills or consumption printouts, 59% had floorplans, 30% had equipment lists, and 44% had photos. The EIA analysts used these attachments to resolve discrepancies in the checklist data or to help with editing. While on-site, 46% of the assessors reported having access to floorplans, drawings, and other documentation.

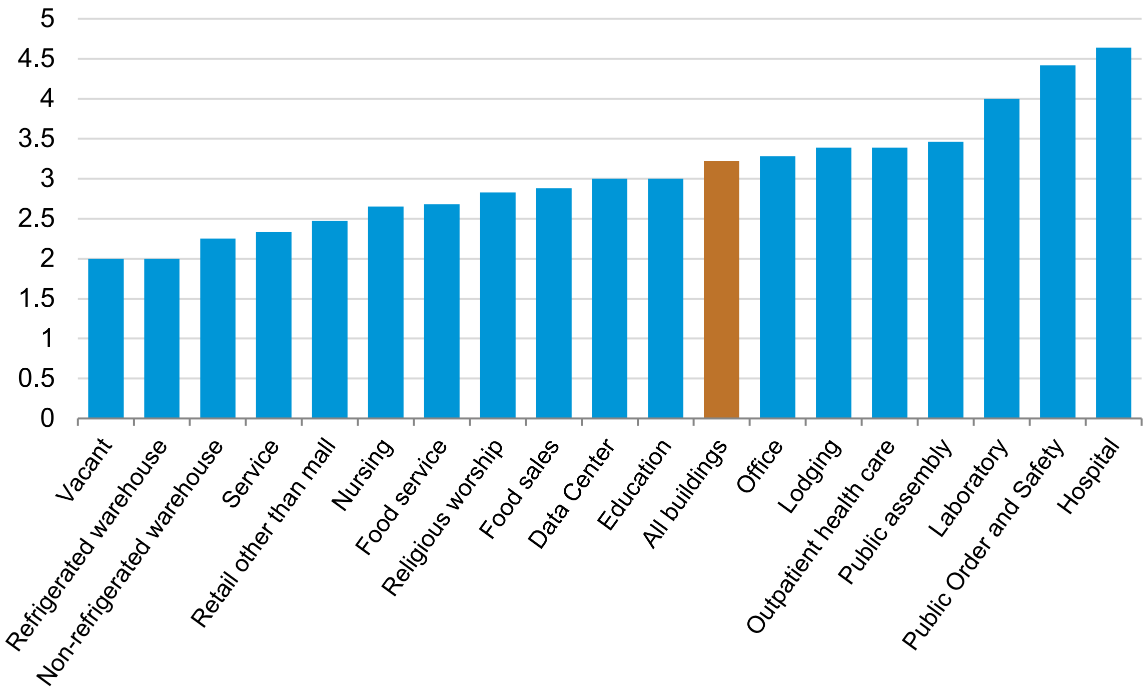
The average number of hours the assessor spent on-site to complete the assessment for all buildings was 3.2 hours. On average, it took about three contacts to set up the appointment for the building assessment, for a total of about one hour spent scheduling the EA for each building. Total time spent on-site is related to building size, as seen in Figure 2.

Figure 2. Average number of hours spent on-site by building size



Total time spent on-site appears to be less related to building activity (as reported in CBECS) than it is to building size, as seen in Figure 3. More complex buildings, such as hospitals and public order and safety buildings, took more time on-site than average, while vacant buildings and warehouses, which are usually less complex, required assessors to spend less time on-site.

Figure 3. Average number of hours spent on-site by building activity



Results

Square footage

Obtaining accurate building square footage is a high priority for the CBECS interview. Square footage is the denominator for building energy intensity, which is important for benchmarking and modeling, and it is a key input for the National Energy Modeling System (NEMS).[6]

During the CBECS interview, respondents are asked to provide an exact square footage, including finished and unfinished areas, basements, hallways, lobbies, stairways, elevator shafts, and indoor parking areas. If the respondent is unable to provide an exact square footage, they are asked to estimate the square footage and place the building into a size category. Analysts at EIA later use the square footage category to impute an exact square footage for the building. For the EAs, the same question wording was used for square footage on the checklist; however, the option to place the building into a category was not available.

One of the weaknesses of the CBECS method of recording square footage is that it is dependent on respondent reports. Respondents may recall a square footage estimate they heard earlier from real estate listings or tax records, which may not include unconditioned areas of the building or include other forms of measurement error. In addition, reports of square footage estimates have many of the

[6] For more information about the National Energy Modeling System, see http://www.eia.gov/forecasts/aeo/assumptions/, and http://www.eia.gov/forecasts/aeo/nems/documentation/

same issues as any question about large amounts, mainly rounding errors. For this reason, if the CBECS respondent cannot report exact square footage, the interviewer is instructed to enter *Don't Know* for the exact square footage and is directed to the next question, which asks for a square footage category. Even with this standardized survey protocol in place, some respondents still report rounded estimates for square footage (for example, a building is 91,400 square feet and the respondent says it's 100,000 square feet). Additionally, interviewers might not read the question as worded ("Do you know the approximate square footage of this building?") or probe for a guess ("Can you give me an estimate?").

EIA analysts anticipated that assessor reports of square footage would be more accurate because of their use of floor plans or their general ability to estimate square footage more accurately based on their experience conducting building energy audits. However, much like survey respondents, each assessor may have worked from his or her own concept of what should be included in the building square footage, despite the explicit instructions on the checklist. In the EAs, EIA also did not ask for a square footage category or any indication of whether the square footage number reported was exact or an estimate. We did, however, collect how the assessor obtained the information, either through interviewing the respondent, their own observations, or through looking at documentation.

There was a high match rate between CBECS and the EAs on square footage: 177 of the 203 buildings included in the EAs had a response for exact square footage in both the CBECS interview and the EA. Of those buildings, 52 (29%) were exact matches. Of those buildings where the square footage was an exact match, 71% had the same respondent for both the CBECS interview and the EA, and in most of those cases (80%), the assessor obtained the square footage information by asking the respondent only, not using any documents or through their own observations. Figure 4 examines the building activity for buildings with exact square footage matches. Food sales, public assembly, public order and safety, office, and lodging buildings had match rates of at least 30% in their building activity category. Non-refrigerated warehouses, outpatient healthcare, and religious worship buildings seemed to have difficulty with square footage consistency, with 20% or fewer of those buildings having exact square footage responses.

Figure 4. Buildings with exact square footage matches by CBECS Principal Building Activity (PBA)*

CBECS PBA	Matches CBECS square footage	Total cases	Percent match
Public Assembly	9	24	38%
Lodging	3	9	33%
Office	15	49	31%
Inpatient Health Care	5	17	29%
Education	8	35	23%
Retail other than mall	2	9	22%
Service	2	10	20%
Non-ref Warehouse	2	11	18%
Outpatient Health Care	1	9	11%
Food Service	0	7	0%
Food Sales	1	2	50%
Public Order and Safety	2	6	33%
Nursing	1	5	20%
Religious Worship	1	6	17%
Vacant	0	1	0%
Data Center	0	1	0%
Laboratory	0	1	0%
Refrigerated Warehouse	0	1	0%
Total	52	203	26%

*Small sample sizes are shaded

To understand if the distribution of square footage across CBECS and the EAs was comparable as a whole, a paired two-tailed *t*-test was performed to see if the null hypothesis that the difference in the two means is zero could be rejected. With a mean difference of 18,206 square feet, and a 95% confidence interval between -2,646 and 39,060 square feet, the null hypothesis that the difference between these two populations is zero cannot be rejected. This result indicates that, while the exact square footage data collected by the CBECS interviewers and the data collected by the assessors have some variation, the method itself is not contributing to a statistically significant difference across the entire distribution.

Because not all CBECS respondents are able to give an exact square footage during the CBECS interview, many provide a square footage category. To include those buildings in the EA analysis, we coded all EA reported square footage into comparable categories. See Figure 5 for a comparison of the CBECS square footage categories to the EA square footage categories. A total of 85% of buildings matched when placed into categories (in green), with an additional 12% falling within one category difference (in yellow and blue). Of those buildings that had agreement at the categorical square footage level, 66% had the same respondent for both the CBECS interview and the EA, and most of the EA data (52%) came from the assessor asking the respondent for the square footage.

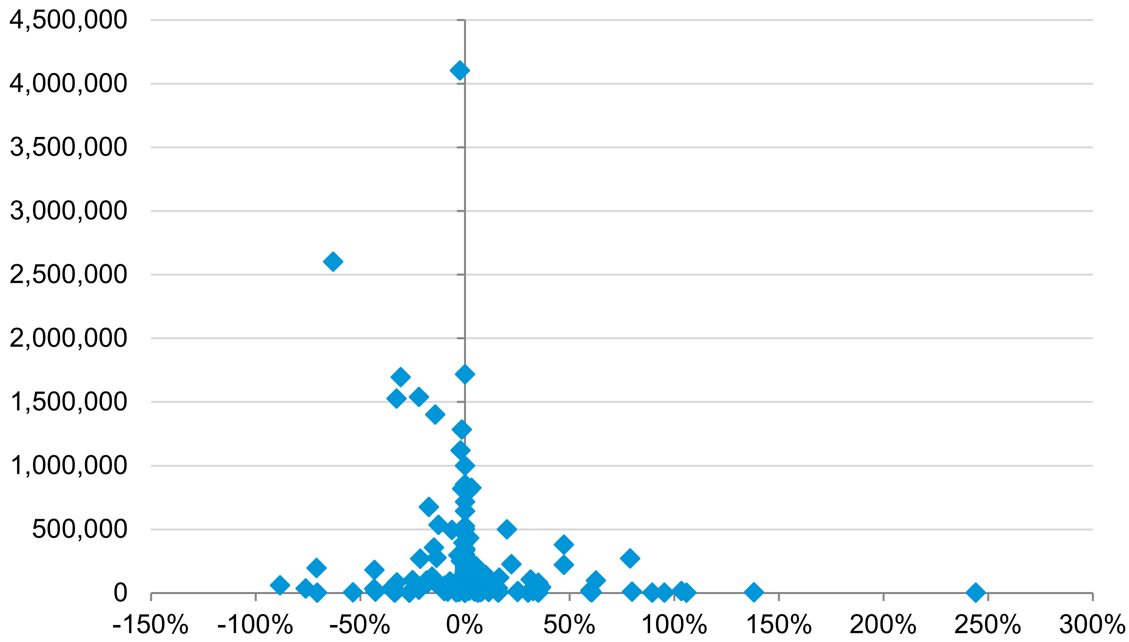
Figure 5. EA to CBECS square footage category comparison

	CBECS Reported Square Footage Category									
EA Reported Square Footage Category	**1,001-5,000**	**5,001-10,000**	**10,001-25,000**	**25,001-50,000**	**50,001-100,000**	**100,001-200,000**	**200,001-500,000**	**500,001-1 million**	**Over 1 million**	**Total**
1,000 or under	1 (0.51%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**1 (0.51%)**
1,001-5,000	20 (10.15%)	1 (0.51%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**21 (10.66%)**
5,001-10,000	1 (0.51%)	14 (7.11%)	2 (1.02%)	1 (0.51%)	1 (0.51%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**19 (9.64%)**
10,001-25,000	0 (0%)	5 (2.54%)	15 (7.61%)	2 (1.02%)	0 (0%)	1 (0.51%)	0 (0%)	0 (0%)	0 (0%)	**23 (11.68%)**
25,001-50,000	0 (0%)	0 (0%)	3 (1.52%)	16 (8.12%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**19 (9.64%)**
50,001-100,000	0 (0%)	0 (0%)	0 (0%)	1 (0.51%)	29 (14.72%)	1 (0.51%)	0 (0%)	0 (0%)	0 (0%)	**31 (15.74%)**
100,001-200,000	0 (0%)	0 (0%)	0 (0%)	0 (0%)	2 (1.02%)	27 (13.71%)	0 (0%)	2 (1.02%)	0 (0%)	**31 (15.74%)**
200,001-500,000	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	30 (15.23%)	1 (0.51%)	0 (0%)	**31 (15.74%)**
500,001-1 million	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	2 (1.02%)	10 (5.08%)	1 (0.51%)	**13 (6.60%)**
Over 1 million	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	8 (4.06%)	**8 (4.06%)**
Total	**22 (11.17%)**	**20 (10.15%)**	**20 (10.15%)**	**20 (10.15%)**	**32 (16.24%)**	**29 (14.72%)**	**32 (16.24%)**	**13 (6.60%)**	**9 (4.57%)**	**197 (100%)**

To understand the magnitude of the differences in exact square footage between the CBECS and the EA reports, we calculated the difference in square footage as a percentage of total CBECS reported square footage. The scatterplot in Figure 6 illustrates the results. The majority of buildings matched on exact square footage; these observations are clustered around the center line. Buildings with negative differences in square footage indicate that the CBECS interview had a larger square footage number than the EA. A positive difference indicates that the EA square footage was larger than the CBECS data.

Figure 6. Percentage difference between CBECS and EA square footage by CBECS square footage

CBECS reported square footage



Difference between CBECS and EA square footage as a percentage of CBECS reported square footage

Although the majority of buildings have relatively low discrepancies in square footage, it does appear that respondents in buildings with fewer than 500,000 square feet seemed to have more difficulty estimating building square footage. After looking at these results, we performed a qualitative outlier analysis, using Google Earth, CBECS interview data and comments, and Computer Audio Recorded Interviewing (CARI) information obtained during the CBECS interview to try to determine whether the CBECS interview data or EA data seemed more accurate. We looked at the buildings in the top 5% of discrepancies by square footage, where the percentage difference was between 43% and 244% of the total CBECS building square footage. The analysis had four possible outcomes:

- CBECS data were incorrect and square footage was **not** edited during the CBECS editing process
- CBECS data were incorrect and square footage **was** edited during the CBECS editing process
- The assessor estimate was wrong in the EA
- Inconclusive

For the 16 buildings included in the analysis, 6 (38%) were inconclusive, meaning we could not determine whether the CBECS respondent or the assessor incorrectly reported the square footage. An equal number of CBECS responses were deemed incorrect, but 2 of the 6 cases were corrected during the regular editing process. In 4 of the cases, (25%) it was determined that the assessor incorrectly estimated the square footage. For the assessor errors, there seemed to be two sources or error. The assessor used Google Earth to estimate the square footage themselves, and reported the footprint of the building without taking into account multiple floors. The other error was that the assessor incorrectly omitted sections of the building they did not think should be included, such as residential spaces above a commercial building, or tenant areas where they were unable to get access. For the CBECS cases, the CARI recordings revealed that in some cases the respondent was really unsure of the exact square footage and probably should have selected a square footage category instead, included parking areas that should have been excluded, or the interviewer failed to read the question text as worded, which led to confusion about what should be included in the square footage estimate.

Principal building activity

Principal building activity (PBA) is one of the most important variables collected in CBECS. Data users who rely on CBECS for benchmarking information usually use building activity as the first criterion for comparison; similarly, the Environmental Protection Agency (EPA) creates models for the ENERGY STAR® buildings program separately for each building activity.

In CBECS, the interviewer presents the respondent with a Show Card listing 18 building activities and asks if one of the activities takes up 75% or more of the floorspace in the building. If the answer is *Yes*, they record which one and then ask a follow-up question about a more detailed subcategory (the list of choices is dependent on the general building activity). Using the chosen subcategory, the survey instrument maps the correct general activity as defined by CBECS. For example, a respondent may have said their main activity was *Education*, and then chosen *Library* as the subcategory, which by the CBECS building activity definition is a public assembly building. The activity would be changed to Public Assembly. If no one activity accounts for 75% of all activity in the building, CBECS collects the top three activities, each activity's corresponding percent of floor space, and assigns a subcategory for the majority percent (or using a hierarchy based on energy intensity if there are equal maximum percentages).

The EA checklist provided spaces to record the top five activities in the building along with a list of types that almost exactly matched the CBECS general building activities[7]. Assessors recorded the corresponding percent of area served by each activity, as well as the CBECS space subcategory, listed as an addendum on the last page of the checklist. These subcategories closely matched the CBECS subcategories.

To compare the PBA classification, we mapped the 203 EA cases to a CBECS PBA and compared the unedited CBECS PBA to the EA PBA. Cases where the PBA matched in both CBECS and the EA would be considered to have high-quality PBA assignments and to demonstrate that either method could work well. For the cases that did not match, we decided that we would research to find the *correct* PBA to evaluate whether one method seemed advantageous over the other.

[7] Seventeen building activities were exact matches between CBECS and the EA. There were three minor differences: CBECS specified *Enclosed mall* as an activity, while the EAs did not, and the EA checklist included *Mall establishment activity* and *Store,* while CBECS did not. *Mall establishment category* was never used because malls were not target EA building types and *Store* was only used twice because it somewhat duplicates the *Retail* category.

Whereas the assignment of PBA is done electronically by the survey instrument in CBECS (except in cases of *other-specify*, which were reviewed by data editors at EIA), the assignment of PBA for the EAs required more intensive analyst review, for various reasons, such as: the assessors did not always provide percentages for the activities; they did not always provide subcategories, which are necessary for some activities to assign the final CBECS activity (e.g., inpatient health care vs. outpatient health care); and sometimes the subcategories did not match up with the general categories, so a judgment had to be made as to which one the assessor actually meant. In some cases it was necessary to go back to the paper checklist and other information collected by the assessors (e.g., floorplans) and look through all available information to assign the PBA. We were able to assign a PBA to all the EA cases with the information collected by the assessors.

In 78% of the cases (159/203), the PBAs matched. The building activity that had the highest match rate (considering only EA types with more than 5 cases in the sample) was nonrefrigerated warehouses, followed by lodging and then inpatient health care buildings. The hardest building activities to classify were outpatient health care, retail, and office. (Figure 7)

Figure 7. Matches of EA PBA to CBECS PBA*

EA PBA	Matches CBECS PBA	Total cases	Percent match
Nonrefrigerated warehouse	7	7	100%
Lodging	9	10	90%
Inpatient health care	12	14	86%
Public assembly	22	27	82%
Education	32	40	80%
Service	8	10	80%
Food service	7	9	78%
Office	37	48	77%
Retail (other than mall)	7	10	70%
Outpatient health care	6	12	50%
Nursing	3	3	100%
Religious worship	2	2	100%
Food sales	1	1	100%
Laboratory	1	1	100%
Refrigerated warehouse	1	1	100%
Public order and safety	4	5	80%
Vacant	0	3	0%
Total for all buildings	**159**	**203**	**78%**

*Small sample sizes are shaded

While we would have expected the match rates to be higher when an interview was part of the EA, because that mode would have most closely resembled CBECS, there did not seem to be any major differences in match rates when looking at the source of the EA data (interview, observation, and/or documents). Similarly, the match rate did not seem affected by whether the same respondent answered the CBECS interview and the EA, or by the number of activities reported.

A closer look at all 44 of the cases where the PBAs did not match showed that there was not an obvious advantage to either the CBECS interviews or the EAs in assigning the *correct* PBA. We looked at each case individually to try to determine what the PBA should be according to the CBECS definition. Resources used for this investigation included the CBECS interview, the EA case folder information, and web searches. In most cases, we were able to determine which was correct; there were six cases in which the *edited* CBECS PBA (but not the original) matched the EA PBA, an indication that in those cases, the EA accurately collected the PBA more readily than the CBECS interview. There were three cases for which either of the activities could be right; for example, the building seemed to contain both activities, and it wasn't clear from any of the available resources which was the majority activity. There were also a couple cases where we were not able to determine the correct activity or neither the CBECS nor the EA activity seemed to be correct (in one case, the CBECS edited activity seemed correct but did not match the EA activity).

Of the 39 cases where it was clear that either the CBECS or the EA PBAs was correct, it was almost evenly split–the EA was correct in 20 cases and CBECS was correct in 19 cases. The EAs better identified offices, while CBECS did better with religious worship buildings. The assessors defined some religious worship buildings as religious education buildings.

One factor that led to incorrect EA assignment of PBA was the allowance of five activities, where CBECS limits to the top three. Because the assessors were able to record a larger array of activities, this led to finer segmentation in the EAs which, in some cases, redefined the activity. There was at least one case where the building activity changed near the end of 2012, so by the time the assessment was completed, the activity had changed.

The crosswalk in Figure 8 shows the EA PBA by the CBECS PBA (original, not edited) and indicates in each cell which source was determined to be correct. It is important to note that even in the cases that do not match exactly, the activities are not that different from each other–for example, we do not see offices being identified as lodging, or education being identified as retail. For the mismatches that may seem a little odd, there is usually a good explanation. For example, there are two cases where the EA activity is office when the correct CBECS activity is inpatient health care; in both of these cases it seems very likely that the office portion is really more like medical offices or outpatient health care, but the subcategory was either not provided or was not provided correctly.

Figure 8. Crosswalk of EA PBAs to CBECS PBAs

EA PBA \ CBECS PBA	Nonref	Ldging	Inpat	Public	Eductn	Servic	Food	Office	Retail	Outpat	Nursng	Relig	Food	Lab	Refr	Pub	Data	Vacant
Nonref	7																	
Ldging		9									1 ???							
Inpat			12							2 CBed								
Public				22	1 EA			3 EA										
Eductn				1 CB	32			1 EITH				3 CB				1 CBed		1 CB
Service	1 CB					8			1 EITH									
Food				1 CBed			7	1 ???										
Office	1 CB		2 CB		1 EA			37	1 EA	1 CB		1 CB				1 EA	1 CBed	
Retail	1 EA							1 EA	7				1 EA					
Outpat			1 EA					1 EA		6	1 CB							
Nursng											3							
Relig												2						
Food													1					
Lab														1				
Refr															1			
Pub						1 EA										4		
Data																	0	
Vacant						1 CB		1 CBed										0

Each cell shows the number of cases by the data source that was determined to be correct by CBECS definition:

\# - EA and CBECS match

\# EA - EA PBA was determined to be correct

\# CB - CBECS PBA was determined to be correct

\# CBed - The edited CBECS PBA matches the EA PBA, so in these cases the EA PBA should be considered better

\# EITH - Either the CBECS or the EA PBA could be correct

\# ??? - Can't tell which is correct or neither seems correct

Operating hours and schedule

CBECS asks respondents several questions to determine the operating hours and schedule of each building. These characteristics are a major contributor to overall building energy use because occupancy is closely related to energy use for lighting, heating, cooling, and miscellaneous end uses such as office equipment.

The format of the operating hours and schedule questions for the CBECS interview is similar to the format on the EAs. CBECS first establishes that the building is not vacant and then determines if it is seasonally occupied or if it operates all year. Several subsequent questions determine if the building is open 24 hours a day, and if not, whether it is open on weekends and weekdays. Finally, CBECS asks how many hours the building is open weekly. If the respondent cannot give a direct answer, they are asked to place the total operating hours in a normal week into one of six response categories. For the EA, the assessor determines the operating hours of the building, the number of weeks open per year, the weekday schedule, the weekend schedule, and any alternate schedules. The assessor may collect this information from an interview, an observation, or a data source, but for the vast majority of cases, operating hour and schedule information was collected via an interview. Due to the similar mode of collection and similar question wordings, it was not expected that these variables would differ significantly between the CBECS interview and the EA.

To compare weekly operating hours and schedule data, five variables from the EAs were compared against five variables from the CBECS questionnaire. As expected, data collection method was not a factor for these variables because, for the three variables directly collected as part of the assessment process, more than 95% of the assessments that provided a data source listed the interview as the source of data. The first variable compared was whether or not the building was open during the week. The assessment data had 48 cases where the weekday hours were left missing, but 146 out of 156 assessment cases were said to be open during the week, compared to 178 out of 203 from CBECS. For both the interview and the assessments, nine total buildings were said to be not open during the week. However, only five specific cases matched and were said to not be open during the week in both the assessment and the interview.

The comparisons for whether the building was open on the weekend were also similar. For CBECS, this variable had more missing values, reducing the denominator to 169 cases for comparison. Figure 9 shows the percentage of buildings that were open during the week, open on the weekend, and open 24 hours a day.

Figure 9. Comparison of hours of operation – CBECS vs. EA

	Assessment Percentage	Interview Percentage	Percent of interviews where Assessment and Interview Agree
Open during the week	94% (146/156)	88% (178/203)	72% (146/203)
Open on the weekend	60% (93/156)	66% (111/169)	64% (109/169)
Open 24 hours a day	19% (38/203)	23% (45/203)	17% (43/203)

The final operating hours comparisons were made between the total weekly operating hours and the weekly hours category. Initially, the total hours were compared from the CBECS interview and the assessment. Only 15 cases had the exact same number of total hours open per week. Even using the CBECS hours categories, only 75 of 156 cases had the same response category for weekly hours.

Considering that almost all operating hours data were collected by interview in both CBECS and the EAs, and the question wordings were straightforward and very similar, it is surprising that the match rate was not higher. The lack of a similar response for total weekly operating hours is most surprising. The differences in responses are probably due to different respondents for the CBECS interview and the EAs. For example, a property manager responding to the CBECS questionnaire may state that an office building is open from 8:30 a.m. to 6 p.m. because that is when the building is open to the public and when employees are working at their desks. However, a building engineer responding to the interview portion of the energy assessment may state that the same building is open from 6 a.m. until 8 p.m. because that is when the heating and cooling systems are operational and when the building engineer is on-site.

Energy sources used

The questions determining which energy sources are used in the building and how they are used are arguably the most important sections in CBECS. Not collecting data for an energy source used by the building not only means that the supplier is never contacted, so those data are not accounted for in estimates of energy consumption and expenditures, but that end uses are also never calculated for that energy source type. If the end use is not allocated to the correct energy source, the end use is allocated to a different energy source, and EIA would underestimate the missing energy source and related uses and overestimate the reported energy source and uses.

Both the CBECS questionnaire and the EAs allow for the determination of whether or not nine different energy sources are used in the building. The method by which the energy sources used are collected is more straightforward in the CBECS interview than in the EA. The first question in the energy sources section of CBECS asks which of nine energy sources were used for any purpose in 2012. Subsequent sections on specific equipment types and end uses ask about the energy source for each use, so any original oversights should be detected later as well. The energy assessor begins by gathering utility information for the top five utility accounts. Later sections on specific equipment types and end uses also ask for the energy source for each use, but there is no section that compiles all energy sources used in the building. Despite these differences, both the CBECS questionnaire and the assessment form offer several opportunities to collect each energy source such that all energy source data should be captured. For this reason, EIA expects that the data will be very similar for energy sources used.

Figure 10 shows the number of buildings using each type of energy source and whether those buildings confirm that the energy source was used in both the CBECS and the EA results.

Figure 10. Comparison of energy sources used in CBECS and EAs

Energy Source	Used According to CBECS Questionnaire	Used According to Energy Assessment	Buildings where both Questionnaire and Assessment confirm Use
Electricity	203	196	196
Natural Gas	141	135	126
Fuel Oil, Diesel, or Kerosene	75	32	29
Bottled Gas (LPG or Propane)	11	8	4
District Steam	25	15	15
District Hot Water	9	1	1
District Chilled Water	17	7	7
Wood	1	0	0
Solar	5	11	3

With the exception of solar, the EAs recorded fewer buildings using each energy source. The results are fairly close for electricity and natural gas, but many more building cases are missed for the less common energy sources. Fuel oil reporting fares the worst, with the assessments only collecting 40% of all cases where the survey respondent reporting using the energy sources. Of the 45 mismatched cases, where the interview had fuel oil and the assessment did not, 44 of those cases had the interview reporting fuel oil used for generation. There was no field on the assessment form to record back-up generators. The other case used fuel oil for secondary heating, and fuel oil did not appear on the assessment at all. The assessor may have missed the equipment entirely, or they may have assumed it was natural gas, since the main heating fuel is natural gas. CBECS captured nine buildings that reported using district hot water, but only one of those cases was captured in the EAs. In the next two sections, the cases where the respondent reported a source are checked to find evidence of the use of that energy source to determine if the assessors are missing the source or if the respondents are erroneously reporting use of the energy source.

Space heating energy sources

Matching space heating energy sources between CBECS and the EA responses was difficult because of many places where the main heating source could be listed on the assessment spreadsheet. An attempt was made to determine the main heating energy source for each building. The total number of buildings using each main heating source was fairly consistent, although exact matches were less common (as shown in Figure 11).

Figure 11. Main space heating energy sources reported in CBECS and EAs

Main Space Heating Energy Source	Used According to CBECS Questionnaire	Used According to Energy Assessment	Buildings where both Questionnaire and Assessment confirm Use
Electricity	50	60	34
Natural Gas	103	115	90
Fuel Oil, Diesel, or Kerosene	4	12	4
Bottled Gas (LPG or Propane)	1	4	1
District Steam	22	11	11
District Hot Water	7	0	0

Cooling energy sources

Although the vast majority of cooling systems are electric, an effort was made to check the accuracy of collecting information for cooling systems that used another energy source. The energy assessment checklist allowed the option to select one of five nonelectric cooling sources: Direct Gas-Fired Desiccant Dehumidification, Indirect–Steam/Hot Water/Exhaust Air Desiccant Dehumidification, Direct-Fired Absorption Chiller, Indirect-Fired Absorption Chiller, and Indirect-Waste Heat Absorption Chiller. The energy sources for these alternative cooling sources were not directly recorded.

Only four buildings were listed by the assessor as using one of these alternative cooling systems. Three of these buildings were direct gas-fired desiccant dehumidification, but all three were listed as electric only by the CBECS respondent. The final building was reported by the assessor as having both indirect–steam/hot water/exhaust air desiccant dehumidification and a direct-fired absorption chiller. The CBECS respondent reported that the building used electricity, natural gas, and district steam for cooling, which is consistent with the EA data. Other cooling sources were reported by the CBECS respondent that did not show up as alternative cooling systems in the EAs. Five additional cases used natural gas cooling, two additional cases used district steam cooling, one case used district hot water cooling, and 17 cases used district chilled water cooling.

Building equipment

Collecting information about building heating and cooling equipment in CBECS is essential to understanding the building's overall energy consumption. This information is an input into the end-use model, which describes how energy is consumed within buildings and whether programs and policies are meeting their efficiency goals. This information also allows researchers to identify trends in heating and cooling equipment types by building type and across time. CBECS uses engineering models during the disaggregation of total energy consumption into end uses such as heating, cooling, and ventilation. These engineering models apply efficiency estimates according to the heating and cooling equipment found in each building, so without accurate information on the systems, the end uses may be allocated incorrectly.

During the CBECS interview, respondents are given a show card with seven different types of heating equipment and are asked to select all that apply. The answer categories are as follows:

1) Furnaces that heat air directly, without using steam or hot water
   (Installed inside the building, similar to a residential furnace)
2) Packaged central unit (roof mounted)
   (Self-contained unit, either unitary or built-up, that contains heating equipment and may include air-conditioning equipment)
3) Boilers inside (or directly adjacent to) the building that produce steam or hot water
   (Does not include boiler in central plant in separate building)
4) District steam or hot water piped in from outside the building
   (From a central plant in a separate building or from a utility)
5) Heat pumps (other than components of a packaged unit)
6) Individual space heaters (other than heat pumps)
   (Can be freestanding or mounted in walls, ceilings, or windows. Include heating elements in room space conditioning equipment such as Packaged Terminal Air Conditioners or PTACs.)
7) Other heating equipment

For cooling equipment, respondents are given a show card with eight possible equipment types and are asked to select all that apply. Categories are as follows:

1) Residential-type central air conditioners (other than heat pumps) that cool air directly and circulate it without using chilled water
   (Split systems that consist of an outside unit typically mounted on a slab beside the building and a separate inside cooling unit)
2) Packaged air-conditioning units (other than heat pumps)
   (Contain air-conditioning equipment (as well as fans), are typically mounted on the roof or on a slab next to the building, and may include heating equipment. Includes unitary units and built-up units.)
3) Central chillers inside (or directly adjacent to) the building that chill water for air conditioning
   (Does not include central chiller in central plant in separate building)
4) District chilled water piped in from outside the building
5) Heat pumps for cooling
6) Individual room air conditioners (other than heat pumps)
   (Installed in either walls or windows, includes what are commonly termed Packaged Terminal Air Conditioners (PTACs))
7) "Swamp" coolers or evaporative coolers
8) Other cooling equipment

After the respondent selects all of their heating and cooling equipment, they are asked a number of follow-up questions about specific equipment characteristics, types of ventilation, and maintenance. The survey tries to balance collecting enough detail to estimate equipment energy usage with the potential limits of a given respondent's knowledge about building equipment. Because CBECS samples such a diverse set of buildings, respondent knowledge about the building systems is often varied.

The CBECS building equipment section is one of the more challenging sections for respondents, so we were especially interested in comparing this data with that collected by the trained energy assessors. In the EAs, the heating and cooling equipment was collected in a very different manner than in CBECS, based on our contractor's recommendations for how assessors collect this data in the field. The EA checklist collected information on heating and cooling equipment in three sections: *HVAC: Principal Heating & Cooling Equipment*, *HVAC: Cooling Systems*, and *HVAC: Heating Systems*. Assessors began with the Principal Heating & Cooling Equipment section, which offered them five options for main equipment:

1) Roof-Top Unit
2) PTACs (packaged terminal air conditioners)
3) Heat Pumps
4) Chiller-Boiler
5) Other-Specify

It's important to note that this section captures responses for both heating and cooling equipment. In cases where a building may have a combination of different types of equipment, it is impossible to know which equipment is used for heating or cooling without looking at the subsequent heating and cooling sections.

In both of the heating and cooling systems sections, equipment is selected from two separate lists—head-end devices and terminal devices. A head-end device is the major equipment type that supplies the heated air or water/steam to heat the building or the cooled air or water to cool the building. Terminal heating and cooling devices are located in the spaces they condition. For heating equipment, the assessor had a list of the following types of head end devices:

1) Hot Water Baseboard Radiators
2) Electric Heat – Baseboard or in PTAC
3) Steam Radiators
4) Heat Pumps – Air/Water/Ground
5) Packaged Terminal Heat Pumps
6) Central Air Handlers – CAV/VAV Systems
7) Central Air Handlers
8) Duct Furnace
9) Infrared Heaters – Low/Med/High
10) Radiant Floor/Ceiling Panels
11) Underfloor Air
12) Unit Ventilators
13) Fan Coil Units
14) Cabinet Unit Heaters
15) Powered Induction Units
16) Portable Heaters
17) Fireplaces
18) Other-Specify

For heating terminal devices, the assessor had a list of the following types:

1) District Hot Water
2) Hot Water Boiler
3) Steam Boiler
4) Furnace
5) Heat Pump
6) District Steam
7) Other-Specify

For cooling equipment, the assessor had a list of the following types of head-end devices:

1) Window AC
2) Small Split AC
3) Packaged Terminal AC
4) Unitary Packaged AC
5) Custom Built Packaged AC
6) Ducted Air – CAV and VAV Systems
7) Heat Pumps – Air Source
8) Heat Pumps – Water Source
9) Heat Pumps – Ground Source
10) Packaged Terminal HP
11) Fan Coil Unit
12) Induction Unit
13) Radiant Cooling
14) Underfloor Air
15) VRF/VRV Systems
16) Swamp Coolers
17) Gas-Fired Absorption Heat Pump
18) Other-Specify

For cooling terminal devices, the assessor had the following types:

1) DX (Direct Expansion)
2) Electric Chiller
3) Absorption Chiller
4) District Chilled Water (HX)
5) Other-Specify

The EA team used these categories to try to map the EA equipment back to the original CBECS categories for comparison. For the cooling equipment, this mapping proved fairly straightforward, with direct comparisons possible by using both the information collected in the head-end and terminal equipment sections. Only six cases needed to be edited by the analysts, because of the lack of any terminal device information recorded by the assessor. To map these cases analysts relied on the original checklist and any information provided by the assessor to try to decide what type of cooling equipment was being recorded. Members of the team were not permitted to use the internet or the data collected in CBECS to determine the cooling equipment.

The heating equipment mapping proved to be more difficult. In the heating section, there is no option for a DX terminal device, making it impossible for the editing group to identify when a building had a packaged unit. In addition, if a case indicated an *other* heating equipment, the editing group reviewed the notes left by the assessor to determine the heating equipment. As a result, 70 cases required review by the editing group. The same rules applied for heating equipment as for cooling equipment: only information provided by the assessor could be used for editing, and use of the internet or CBECS data was forbidden. Cases were randomly assigned to the four members of the EA editing team to try to reduce editor bias.

After all EA heating and cooling equipment had been mapped back to the original CBECS data, we compared the EA and CBECS data by equipment type. The results for both heating and cooling equipment are in Figures 12 and 13.

Figure 12. Heating equipment agreement

Equipment Type	Used According to CBECS Questionnaire	Used According to Energy Assessment	Buildings where both Questionnaire and Assessment confirm Use
Furnace	13	36	9
Packaged Unit	105	32	29
Boiler	83	73	66
District Steam/Hot Water	30	25	23
Heat Pump	38	35	19
Individual Space Heater	48	37	14
Other	5	1	0

Figure 13. Cooling equipment agreement

Equipment Type	Used According to CBECS Questionnaire	Used According to Energy Assessment	Buildings where both Questionnaire and Assessment confirm Use
Residential-type Central Air Conditioner	43	45	16
Packaged Unit	102	73	51
Central Chiller	62	53	47
District Chilled Water	14	10	10
Heat Pump	39	41	21
Individual Room Air Conditioner	51	38	24
Swamp Cooler	7	5	3
Other	1	9	0

After comparing the heating and cooling agreement for each type of equipment, we created a summary measure for heating and cooling equipment agreement. For heating equipment, 28% of buildings had complete agreement, meaning the EA and CBECS heating equipment matched exactly for each equipment type, and an additional 31% had only one discrepancy. For cooling equipment, the EA and the CBECS data matched exactly 29% of the time, and an additional 29% had only one discrepancy. We looked more closely at buildings with more than three disagreements in heating and cooling equipment to try to understand the source of the disagreement—whether it was an error in the CBECS data, the EA data, an error made in our editing process, or we were unable to determine the source of the discrepancy. Overall, the sources of the discrepancies seemed to be tied to how equipment was captured in the EA checklist rather than actual errors in either the CBECS or EA data. There is not sufficient evidence in either the heating or cooling equipment sections to say that the CBECS or EA data is more accurate.

Discussion

After reviewing the selected results from CBECS and the EAs, we cannot say with certainty that one method of data collection is superior to the other, in terms of whether CBECS or the EAs more accurately captures key building characteristics. However, this analysis indicates the sources of errors introduced by use of each method. Some errors are more easily detected, while others require more investigation and evaluation. Easily quantifiable measures, such as building square footage, lend themselves to more straightforward analysis. For these measures, and characteristics such as principal building activity, the corroboration of CBECS data and EA data seems to indicate that both methods capture this type of data accurately. However, these data are also acquired mainly from speaking to a respondent, in which case a priming effect may come into play. Priming occurs when the same respondent has already answered similar questions, in this case during the CBECS interview, which may improve recall during subsequent interviews—such as the EAs. About 65% of the EAs were conducted with the same respondent that completed the CBECS interview.

Other data, such as energy sources used and heating and cooling equipment, are more complex, especially for larger buildings. Throughout the process of keying, editing, and mapping the EA data to the CBECS data, we learned that assessors varied in how they categorized similar equipment, which made it difficult to draw conclusions about the comparability of the CBECS and EA data for the same building. Although the assessors may have collected more in-depth information on building equipment, it was difficult to make direct comparisons to the CBECS data. The lack of standard data collection across assessors complicates our evaluation of data quality between CBECS and the EAs. Discrepancies in the data may arise from a variety of sources. They may be the result of real error on the part of the CBECS interviewer or respondent, or the EA assessor or respondent. The errors may also be keying error, the inability of the assessor to use the checklist properly, or error on the part of the EIA team to map the data correctly between the two data sources. The best improvements to each method arise from understanding the causes of specific errors and then developing strategies to reduce them at their source.

After reviewing both sets of data, we believe the following areas of the CBECS and EA process can be improved in the following ways:

- To streamline, standardize, and expedite data capture, it would be advantageous to develop an electronic EA checklist. A large amount of the EIA team's time was spent keying data, resolving discrepancies or errors on the checklist data, and editing the data to make it comparable to the CBECS data. An electronic EA checklist would eliminate the time spent keying the checklist, eliminating errors due to poor penmanship, and standardizing the data collection across assessors. The checklist would have to include space for some notes, because energy systems are not standardized across all buildings, and EIA does not want to eliminate the assessors' ability to capture unique data, if applicable.
- Implement methods to assure the application of the standard building concept in the assessments. Assessors need more training on the CBECS definition of a building. For CBECS, interviewers are trained extensively on building boundaries and on differences between the definitions of buildings, establishments, and leased versus owned areas of buildings. The assessors seemed to struggle with this definition, often noting that they were not allowed into tenant areas within a building, and thus eliminated any information from the EA checklist about these areas.
- Cognitive research needs to be conducted on the equipment sections of the CBECS interview and the assessments, specifically on heating and cooling equipment. The assessors were given a list of possible equipment for the heating and cooling sections, which EIA thought was exhaustive during the development of the checklist. However, there were still a number of write-ins and notes. These additions suggest both approaches introduce variable errors in administration of these sections.
- If we implement EAs on a portion of buildings in future CBECS data collections or conduct another research project, we recommend reducing the amount of information assessors collect. We would likely target items specifically comparable to what is collected in the CBECS survey instrument. Given the quality of data we received from this test, we specifically recommend eliminating the miscellaneous loads section (which included inventories of office, refrigeration, and industrial equipment), and information on fan systems. Assessors indicated that information on these items was difficult to gather without shutting down large, critical building systems. Both of these sections were incomplete for most buildings, and the assessors said access for this voluntary EA data was an issue.

As planning for future rounds of CBECS proceeds, we will evaluate whether or not an energy assessment component might complement, calibrate, or substantiate the standard CBECS interview process. Many of the issues we encountered with the EA process, such as lack of standardized approaches and use of the checklist across assessors, are less likely in surveys fielded by highly trained interviewers with a standard CAPI instrument. In addition, the assessors had more difficulty gaining cooperation from building respondents, even though respondents had already completed CBECS and had volunteered for the follow-up assessment.

Survey interviewers receive extensive training on gaining cooperation, a skill that is highly valued because response rates are a key performance metric. This same skill is not valued for energy assessors, because they are often invited by buildings to perform energy audits. Given the significantly higher labor costs associated with assessors as compared to interviewers, EIA would probably make only strategic use of the energy assessment technique, such as for consulting on specific sections of the survey instrument (e.g., the heating or cooling equipment section), or for specific, complex building subcategories. Use across the sample population is unlikely to be part of a future CBECS program design.

Conclusion

After completing the energy assessment experiment, we believe that we were able to achieve most of the research goals. The NAS panel specifically charged us with determining whether energy assessors should work in tandem with, or even replace, trained survey interviewers for data collection. Given the state of the data collected by the nonstandardized assessment process, which was largely uneven and incomplete, we feel the information produced by an assessment process cannot replace CBECS survey data.

Assessors are trained to seek out unique conditions of buildings, a line of inquiry that diverges from the purpose of a national benchmark survey. In the future, we believe energy assessments could be used to enhance or improve data for specific subpopulations, or to improve how we measure a concept in the survey instrument. It may be more advantageous to use EAs in the future as a separate research project, rather than as part of a production survey process. To the extent that we were able to compare the EA data to the CBECS data, we believe CBECS meets our data quality objectives. We did not find large discrepancies between the EA and CBECS data. Where we observed differences, we have gained important insight into how to improve certain sections of the CBECS instrument for the next survey cycle, such as the heating and cooling equipment.