Survey "Selfies"—Does My Home's Energy Picture Really Look that Good?[1]

Carley Murray, NYSERDA, Albany, New York
Pam Rathbun, Tetra Tech, Madison, Wisconsin

ABSTRACT

The recently completed New York Residential Baseline Study includes 2,882 telephone and Web surveys and 700 on-site inspections. These inspections were used to validate information collected over the telephone and Web using a nested sample approach. This paper measures agreement between the homeowner's self-reported perspective ("selfie") on home energy information and the information collected by the inspectors through the on-site visits at the same location.

Findings suggest that high-level information (e.g., presence or absence of certain types of equipment) is very consistent between the survey and on-site data. In addition, some measures, such as the number of personal and electronic items in the household, are challenging for both homeowners and inspectors to report. Technical details, such as the type of fuel used or whether a piece of equipment is ENERGY STAR qualified, are less accurate in self-reports than the on-site data. In other situations, such as the age of the equipment, homeowners and inspectors tend to report different information. This paper provides insight into the types of questions that homeowners may report accurately and possibly even provide better or more relevant data than on-site inspectors conducting visual observations. It also distinguishes those instances where on-site inspectors can provide more accurate and detailed data. This information can help those designing future studies to employ the most accurate approaches for collecting the data they require.

Introduction

In the coming decades, the efficiency of energy-consuming equipment and consumer behaviors are expected to undergo a transformation. Measuring this change in the future requires an understanding of the baseline conditions today. In anticipation of these upcoming changes, a statewide residential baseline study was recently conducted that included 2,882 telephone and Web surveys and 700 on-site inspections. Establishing a baseline requires accurate estimates of the existing building stock, as well as an inventory of equipment efficiency and associated energy use. Such a baseline requires an immense amount of primary data to be collected, and in some cases, validated. Facing budget constraints, program administrators seek innovative and cost-effective strategies to understand and measure these market transformations accurately.

This paper compares self-reported data on equipment and associated energy use collected from a sample of household occupants and building owners using telephone and Web surveys (the energy evaluation "selfie"), with data from a subsample of these same household occupants and building owners, using on-site observation by trained energy inspectors (the on-site data collection).

Because it may be impractical in terms of cost or time to obtain primary data from on-site data collection, studies that gather data from residential energy consumers regularly rely on self-reported survey data. The nested sample approach applied in this study for the on-site data collection provides an opportunity to assess the reliability and accuracy of the self-reported data provided by the household occupants and building owners, by comparing the characteristics of the same energy equipment collected from both sources.

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1 Any opinions expressed, explicitly or implicitly, are those of the authors and do not necessarily represent those of the New York State Energy Research and Development Authority.

Because self-report surveys depend upon a sample of respondents to represent a population, and the responses of individual respondents to provide data for each question or measure, it is always the case that survey data contain some errors. The amount of error in the survey data determine how well these data reflect the 'true' values for each measure that would be found in the population.

Research has shown that when survey questions involve established social norms, such as the widely held belief that increased energy efficiency and lower energy consumption are desirable outcomes, respondents may be motivated to respond to a survey interviewer in a way that protects their self-image or attempts to demonstrate their concern and engagement with energy efficiency issues. For example, respondents are susceptible to presenting the ideal "selfie" by overstating the energy efficiency or portraying the characteristics of their home in a way that makes them appear more energy conscious. Homeowners that lack energy efficient equipment, or feel their energy conservation efforts are not adequately captured by the survey questions, may distort their responses significantly more than homeowners for whom the energy efficiency of their equipment reflects a positive conservation image.

Recall and estimation errors also produce inaccurate self-reports. In spite of respondents' honest attempts to provide accurate information, survey questions that are conceptually difficult, require respondents to recall events over a long time frame, or request details that were never committed to memory (e.g., energy efficiency scores or ratings of equipment) can produce errors. In these instances, self-reported data may contain measurement error due to the challenges of memory recall or the respondent's estimation strategies (e.g., "I bought a new ENERGY STAR washer and dryer three years ago, and I bought the new refrigerator since then so it is similarly energy efficient").

In this paper, the primary objective is to estimate the amount of agreement between the information provided by household occupants and owners in telephone or Web surveys and data collected through on-site observation by inspectors. For questions about equipment that respondents can recall easily and accurately, the use of on-site validation should not substantially improve data quality. In fact, the effort required to gather primary data via on-site inspections may actually have a negative impact on data quality by affecting response rates and increasing respondent burden and data collection costs. On the other hand, to obtain data on equipment that are more likely to produce social desirability bias or recall/memory distortions, the differences between the self-report survey data and the on-site data should be greater. The on-site data collection by trained inspectors should provide data that are closer to the true values for these items.

The secondary goal of this paper is to understand what factors are associated with discrepancies between self-reported responses and on-site observations. From the motivational perspective, it is expected that homeowners with older or less efficient equipment will be less accurate in self-reporting reporting the age and efficiency of equipment, compared to homeowners who have newer or more efficient equipment. From a cognitive distortion perspective, it is expected that there will be more discrepancies in information that require participants to recall complex, detailed energy information or installation information from a long time ago. The results of these comparisons will inform a discussion of the tradeoffs among data collection methods in terms of cost effectiveness, sample design, and data accuracy.

Methods

The Study. The recently conducted Residential Statewide Baseline Study includes 2,882 telephone and Web surveys and a nested sample of 700 on-site inspections. Residential energy users throughout New York State were included in the scope of this study. Random samples were drawn from the major electric utilities in the state, representing 90 percent of New York State's residential households. This included existing homes (those built before 2012) and new construction (those built in 2012 and later). For the purpose of this paper, our analysis is restricted to single family housing segments that completed both an on-site data collection visit and a self-report survey by telephone or Web (N=674).

Data Collection. In this study, self-reported data was first collected from household occupants and building owners using Computer-assisted Telephone Interviewing (CATI) and Web surveys. The sample for on-site inspections was derived from a subsample of those household occupants and building owners who completed the CATI and Web surveys. Prior to the launch of the survey, the team prepared a thorough list of desired data points, determining which may be accurately collected through self-reports which required validation on-site. When more detailed information on equipment and home characteristics was required (e.g., manufacturer, model, energy consumption data), the data were collected through on-site observation by a trained inspector. The telephone and Web surveys of single family households were completed between October of 2013 and March of 2014. On-site inspections were scheduled following completion of the telephone and Web and surveys and occurred between November 2013 and April 2014.

Measures. The Residential Statewide Baseline Study asked a broad range of energy-related questions on home characteristics, equipment, and consumption. This paper focuses on a subset of these energy-related questions for which both self-report and on-site observational data were collected. Item wording and response categories from the self-reported surveys are presented in Appendix A.

Question wordings and response categories varied slightly between the self-reported surveys and on-site data collection method. The primary reason for the difference in question wording and response categories was to allow for the on-site inspector to verify information provided by the respondent in the telephone or Web and collect additional measure-level detail (e.g., greater use of "other specify" categories). Where necessary, the responses in the "other specify" categories were collapsed in this analysis to be facilitate comparison with the survey response categories.

In addition, for some equipment, the on-site inspectors could not collect independent data through observation and had to request homeowner input. This was more likely to occur for equipment such as appliances, e.g., age of the clothes washer or refrigerator. We therefore excluded these items from this analysis.

Analysis. The focus of this analysis is on how well the self-reported data matched the on-site validation data. This analysis proceeds in three steps:

(1) cross-classify raw item responses from the self-report survey and on-site data to determine overall percent agreement;

(2) consider how agreement between self-reported and on-site data is affected when question complexity increases, and cognitive distortion is more likely; and

(3) examine agreement among questions that may reflect personal values or status, where social desirability bias is more likely.

Results

Figure 1 presents the percent agreement between the survey self-report data and on-site inspector reports for selected variables. Items are presented in groupings by topic, with less complex questions at the top of the chart and more complex questions towards the bottom. Questions that simply ask whether equipment is present in the home (e.g., clothes washer, dishwasher, standalone freezer) show very high levels of agreement between homeowner self-reports and inspector observations, as high as 99%. Agreement on questions on the type of fuel available to power the home heating system, or hot water heater, are slightly lower but still at or above 90%. The ability to accurately report fuel for cooking equipment appears to be a more difficult task because stove tops and ovens may use different fuel type; agreement on fuel used for cooking falls to 78 percent.

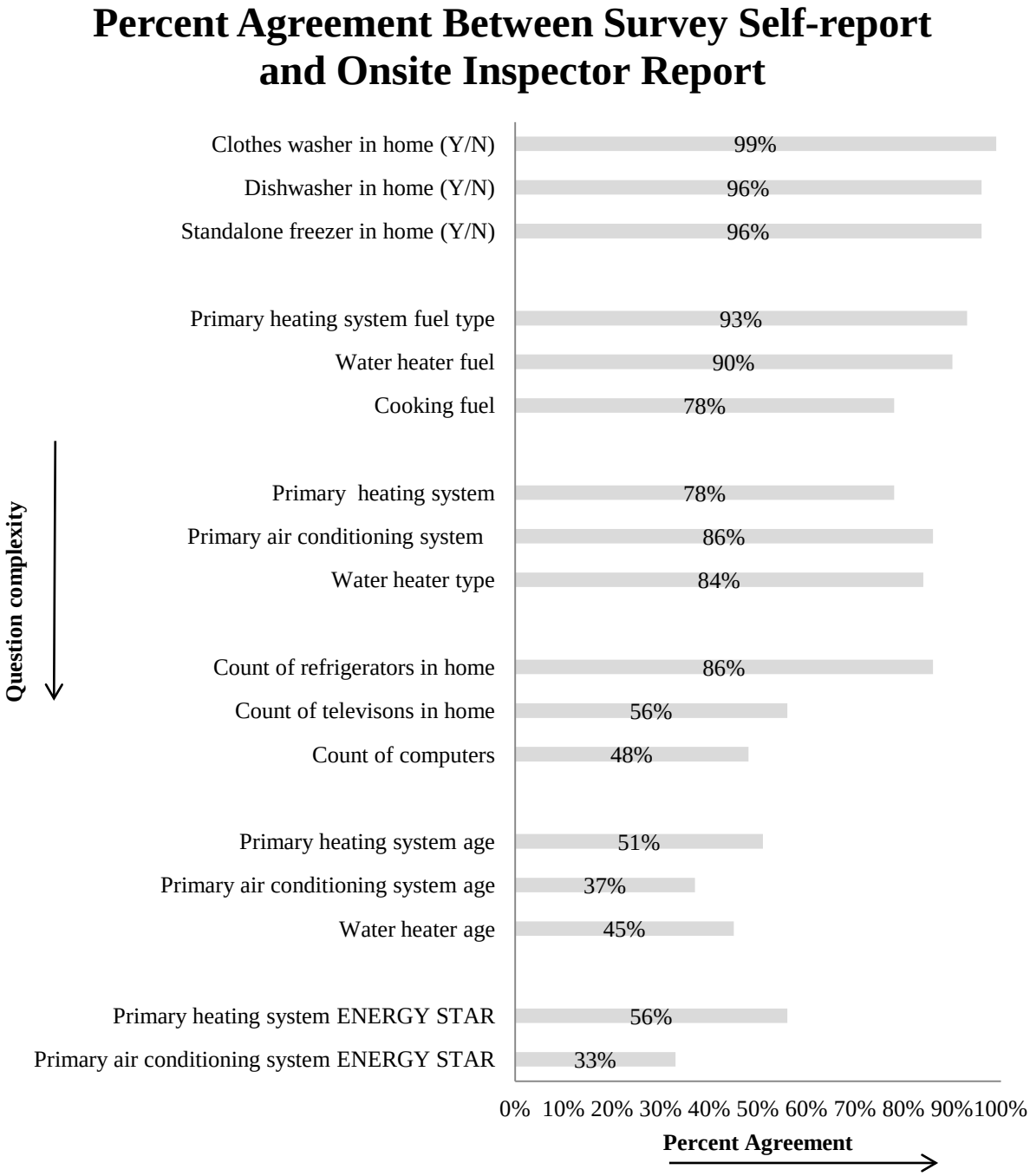


Figure 1. Percent Agreement between Survey Self-report data and On-site Inspector Validation

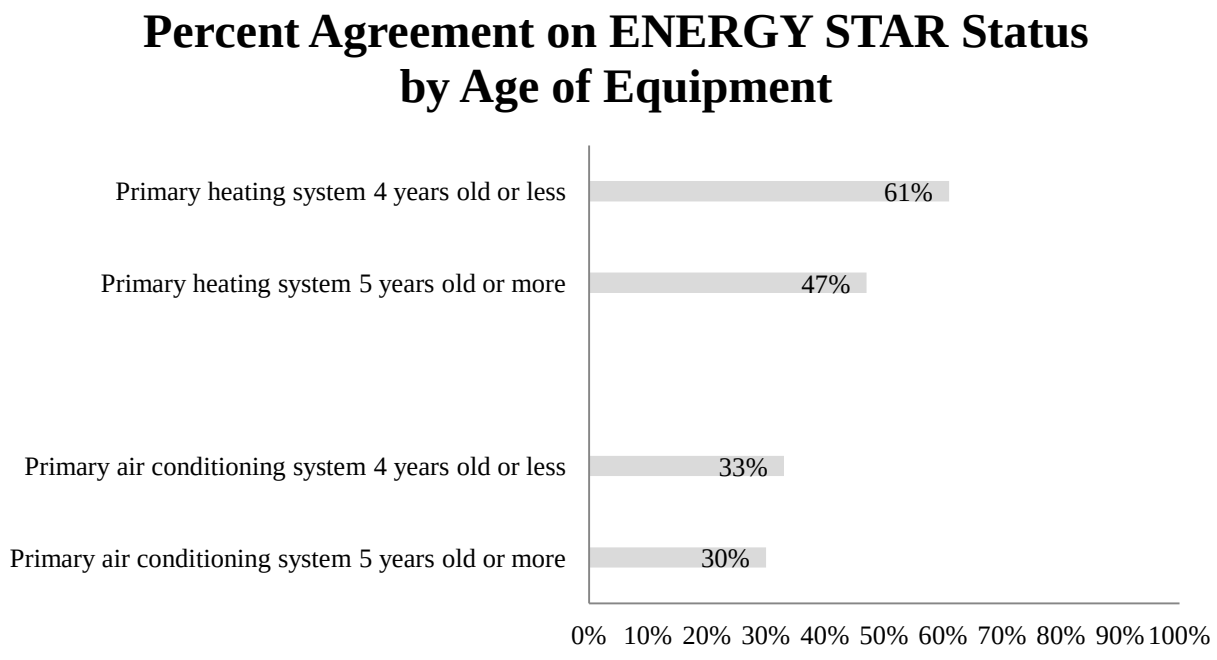
Agreement on type of primary heating system and water heating type (78% and 86%, respectively) was slightly lower than reported fuel type for these systems (93% and 90%). Self-reported and on-site observation agreement for primary air conditioning system was 86%.

Reporting the number of end-uses in a home becomes more difficult as the number of items to count increases. The number of refrigerators in the Study homes ranged from zero to four, and agreement

was 86 percent. In comparison, the range of reported televisions (zero to twelve) and computers[2] (zero to eleven) was much greater, and the level of agreement drops significantly (56% and 48%, respectively). In this case, decreased agreement between survey self-reports and on-site observations may reflect error in each mode of data collection: as the number of devices increase, it may be more difficult for individuals to accurately tally and report as a free recall survey item (i.e., unaided by a set of categories); at the same time, an inspector may not be able to readily observe and count all of the computer equipment that is located throughout the home, or kept in desk drawers or cabinets. Additionally, more equipment may be purchased or taken out of use between the time of the phone and on-site inspection.

Agreement on age of equipment drops to 51% or lower for all three items considered: primary heating system, primary air conditioning system, and water heating system. Some of this difference is likely due to the inspectors reporting age based on the date of manufacture and homeowners reporting age based on the date of purchase or installation. For the purpose of energy evaluation, the homeowner's report on age, which likely refers to equipment purchase date rather than year of manufacture, may be more useful as it will better correspond to years of actual energy use and equipment service. Moreover, inspectors cannot always identify or obtain year of manufacture information. For example, on-site records indicate that the 'age of the hot water heater' field was reported as "estimated" for more than one quarter of homes (170 of 650).

For systems less than ten years of age[3], self-reported survey data on the ENERGY STAR status of primary heating system and primary air conditioning system had relatively low levels of agreement with on-site inspector observations (56% agreement for primary heating system, 33 percent agreement for primary air conditioning system). Results presented in Figure 2 demonstrate that homeowners had higher levels of agreement with on-site inspectors regarding ENERGY STAR status when systems were less than 5 years of age (61% agreement for primary heating system) than when the systems were 5 to 10 years of age (47%), which is expected given the process to remember ENERGY STAR status is more difficult for older systems. Agreement on ENERGY STAR status is slightly higher for air conditioning units that are 0 to 4 years of age compared to units that are 5 to 10 years of age (33% vs 30%).



[2] Computers includes desktops, laptops, and tablets.

[3] If the heating or air conditioning system was ten or more years old the respondent was not asked if the system was ENERGY STAR because older systems would not meet current ENERGY STAR standards.

Figure 2. Percent Agreement on ENERGY STAR Status by Age of Equipment

This paper also explores reports of ENERGY STAR status to examine potential social desirability bias in homeowner self-reports for equipment less than 10 years old (Table 1 and 2). The odds of a primary air conditioner reported as ENERGY STAR qualified is over 5 times higher if self-reported by the homeowner compared to observed by the on-site inspector ($p < .0001$). Similarly, the odds of a primary heating system reported as ENERGY STAR is 2 times higher if self-reported by the homeowner compared to observed by the on-site inspector ($p < .0001$).

Table 1. Is Primary Air Conditioning System ENERGY STAR?

	Number ENERGY STAR	Number Not ENERGY STAR
Homeowner Self-report	239	44
On-site Inspection	94	92

Table 2. Is Primary Heating System ENERGY STAR?

	Number ENERGY STAR	Number Not ENERGY STAR
Homeowner Self-report	249	70
On-site Inspection	222	132

Discussion

Energy efficiency evaluations require an accurate understanding of energy users' equipment and equipment characteristics. This analysis shows that comparisons of self-reported survey data and on-site inspections yield high levels of agreement among simpler measures—such as the presence or absence of equipment or the general type of a piece of equipment. Greater discrepancies occur as the measurement task becomes more complex, either cognitively or technically—for example, counting more pieces of a type of equipment, recalling the age or characteristics or older equipment, or assessing the ENERGY STAR status of a piece of equipment.

Although widely used, the industry generally assumes that self-reported survey data are less reliable and less accurate than data that are observed and collected by on-site inspectors. Indeed, it is generally believed that inspectors can record the true or actual values and eliminate self-reported biases and errors. However, in some cases where there are differences, there are valid reasons, from this study and likely applicable to others, against always assuming on-site data are superior to self-reported survey data. First, the surveys and the on-site inspections were not completed simultaneously. The on-site inspections were *always* completed after the self-report surveys, and the time interval was as long as three months in some instances. During longer time intervals, the difference between the on-site observations and survey reports can reflect real change in homeowners' circumstances—e.g., homeowners may purchase new devices; replace older, less efficient equipment; store seasonal equipment; and/or discard items that are no longer being used or operating.

Second, in some instances, the homeowner may be the superior informant about some equipment or the relevant application of that equipment. For example, on-site inspectors tend to report the year of manufacture, rather than the date the equipment was first used, based on their observation. When the model year often is not available on inspection, the inspectors either estimate the year or consult with a household occupant (not necessarily the same person as the survey participant). On-site inspectors may also provide less accurate counts of personal and electronic devices, such as tablets, computers or televisions, since this equipment can be located in multiple rooms throughout a home, may not be affixed to walls, floors or other infrastructure, and may even be out of sight. Indeed, on-site observations and data

on such devices may be more accurate when the inspector actively elicits the assistance of a household occupant for help to verify their number, location, and type—i.e., asks the occupant to self-report the number and type of equipment.

However, there are measures for which on-site inspectors will provide better—more accurate and more reliable—information. In this study, we saw evidence that homeowners' reports of the ENERGY STAR status of heating and air conditioning systems were much higher than inspectors' reports. In this case, the self-reports probably reflect social desirability bias. In addition, on-site inspectors can provide more technical detail on household equipment. For example, the homeowner may simply report the equipment as a boiler. To an inspector, however, a boiler can be a steam boiler, water boiler, or a combination boiler. It is precisely these situations where on-site observations and data proves its worth. Technically expert inspectors can discern important energy efficiency distinctions among similar types of heating equipment and can report, for example, gradations in the type of fuel required per end-use. Inspectors can record information into more granular categories or provide textual responses to open-ended questions that yield broader and richer data necessary to understand a home's efficiency.

Conclusions and Recommendations

This paper provides insight into the types of questions that homeowners can report accurately and arguably provide better or more relevant data than on-site inspections. Our analysis also demonstrates those instances where on-site inspectors can provide better and richer information for these same type of questions. And on-site inspectors can certainly provide better information on technical specifications (e.g., make, model).

For future studies that employ both a survey of homeowners and on-site inspections with a subsample of these homeowners, it is recommended that special emphasis be incorporated into training the inspectors on the design of the survey and on-site inspection questions and how to use the existing response categories to ensure alignment of responses. This will facilitate direct comparisons between these two types of data.

Ultimately, program administrators must assess the primary objectives of a study, and align the objectives with a study design that fits within their budget and will yield an acceptable level of accuracy and reliability for measures, recognizing that any design will contain inherent trade-offs.

Appendix A

Below are item wording and response categories from the self-reported surveys. For the purpose of analyses, the on-site data was aggregated to match these higher level survey response categories.

- Do you have a clothes washer in your home? (Yes, No)
- Do you have an automatic dishwasher? (Yes, No)
- How many standalone freezers do you have plugged in and running in your home? (Yes = one or more; No=0)"
- What is the primary type of fuel used for heating your home? (Check one: Electricity; Natural gas from underground pipes; Propane (bottled gas); District steam; Fuel oil; Kerosene; wood; Solar; Other, specify)
- What type of fuel does your primary hot water heater use? (Check one: Electricity; Natural gas from underground pipes; Propane (bottled gas); District steam; Fuel oil; Kerosene; Solar; Other, specify)
- What type of fuel does your overs(s) with burners on top use? (Select all that apply: Electricity; Natural gas from underground pipes; Propane (bottled gas); some other fuel, specify)

- What type of fuel does your separate stove top use? (Select all that apply: Electricity; Natural gas from underground pipes; Propane (bottled gas); some other fuel, specify)
- What type of fuel does your separate oven(s) use? (Select all that apply: Electricity; Natural gas from underground pipes; Propane (bottled gas); some other fuel, specify)
- What type of primary heating system do you have in our home? (Check one: Central forced air furnace with ducts to individual rooms; Steam/hot water systems with radiators or pipes in each room (central boiler); Air source heat pump; Baseboard heat; Heating stove burning wood or coal; Fireplace; Portable electric heater; Portable kerosene heather; Solar panels; Other, specify)
- What is the primary type of air conditioning equipment you use in your home (Check one: Central air conditioning system; Room or window air conditioner; heat pump; Other, specify)
- What type of system do you use as your primary water heating system? (Check one: Stand-alone storage tank; Tankless or on demand water heater; Heat pump water heater; Part of the heating system boiler; Other specify)
- How many other refrigerators do you have plugged in and running in your home? (Record number)
- How many televisions used in your home are of each of the following types? (Count: Standard tube TVs; Flat screen plasma TVs; Flat screen LCD/LED TVs; Flat screen TV of unknown type; Rear projection TVs)
- How many of each of the following types of computer and home office equipment does your household use? (Count: Desktop computer (excluding monitor); Laptop computer; iPads, tablet computers
- About how old is your primary heating system (Check one: Less than 2 years old; 2 to 4 years old; 5 to 9 years old; 10 to 14 years old; 15 to 19 years old; 20 years old or more)
- About how old is your primary air conditioning system (Check one: Less than 2 years old; 2 to 4 years old; 5 to 9 years old; 10 to 14 years old; 15 to 19 years old; 20 years old or more)
- About how old is your primary water heating system (Check one: Less than 2 years old; 2 to 4 years old; 5 to 9 years old; 10 to 14 years old; 15 to 19 years old; 20 years old or more)
- Is your primary heating system ENERGY STAR rated (e.g., Does it have the ENERGY STAR logo on it?) (Yes, No)
- Is your primary air conditioning system ENERGY STAR rated (e.g., Does it have the ENERGY STAR logo on it?) (Yes, No)