Energy Performance Score

2008 Pilot

Findings & Recommendations Report

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Prepared for

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Prepared by

and

Energy Performance Score 2008 Pilot
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6. ATTACHMENTS

- Earth Advantage Institute Organizational Overview
- U.K. Energy Performance Certificate (EPC)
- EPS Pilot Field Technician Input Form
- EPS Pilot Homeowner Input Form
- EPS Pilot Interim Report
- EPS Score Sheet for Existing Homes
- EPS Score Sheet for New Homes
- EPS Score Sheet with Letters
- EPS Energy Analysis Report
- EPS Auditing Protocol
- EPS Database Screen Shot
- EPS Web Tender Portal Screen Shot

The above attachments and full report are available online at:

http://www.earthadvantage.org/eps.php

A copy of the report only is also available at www.energytrust.org/eps/eps_ex.html

EXECUTIVE SUMMARY

According to the Pew Center on Global Climate Change, energy used in residential, commercial, and industrial buildings produces approximately 43% of U.S. carbon dioxide (CO_2) emissions, 21% of which is from the residential sector alone. The median home in the United States is responsible for 6.2 tons per year of CO_2 emissions from electricity use. Given the magnitude of this contribution, it is essential that efforts to control climate change include an explicit focus on the building sector.

Historically, it has been difficult for homeowners to know how to evaluate the energy performance of different types of homes or the performance implications of the plethora of green building programs. What has been absent is a miles per gallon (MPG) rating for the built environment. By providing consumers with information on homes that do better than the minimum building requirements, standards and labeling can help overcome obstacles and advance building efficiency. Homeowners, municipal governments, utilities, and the real estate industry need an easy-to-understand means of comparing the performance and impact on climate change of homes in both the new and existing home sectors.

The goal of the Energy Performance Score (EPS) 2008 Pilot was to find an effective, accurate, and cost effective method and set of tools to calculate and report on a home's energy performance. The pilot drew upon the United Kingdom's Energy Performance Certificate (EPC) program that measures and reports on home energy use and associated carbon emissions. The EPC includes a score sheet graphically depicting energy use and carbon emissions and a multipage report describing energy improvements that can be made to lower energy use and costs.

In addition, the pilot considered how an MPG-type metric might apply to home energy use and sought out a metric that would meet the following criteria:

- Easily understood by the general public.
- Meaningful in different contexts to respective stakeholders.
- Applicable to new and existing homes so comparisons can be made between homes.
- Useful for indicating progress toward individual and community energy goals.
- Helpful to homeowners as a baseline against which to evaluate their own energy use.
- Consistent over time.

The Energy Performance Score for a home would use normalized values for occupancy and behavior in order to represent the annual energy use of a home under typical conditions with the caveat "actual use may vary" as is the case with MPG for cars. In this way, the EPS would be an asset rating which excludes all variability in occupant behavior from the assessment.

In order to find an accurate and cost effective method for evaluating, calculating, and scoring the energy use and carbon emissions of new and existing homes, the pilot reviewed home energy modeling software programs. While other approaches to scoring a home exist, energy modeling was determined to be the most appropriate for the goals of the EPS. Some other approaches use utility data as a starting point or for calibration, but these approaches would be hard to test for accuracy since no other generally available house-specific empirical data exists. An approach that relies on utility data would be unable to score homes that lack utility data, such as new homes, unoccupied homes, and homes with extremely unusual energy use.

Over 100 software tools were surveyed, and 4 were selected: REM/Rate, SIMPLE, and two versions of Home Energy Saver (HES). REM/Rate was selected since it was an accredited Home Energy Rating System (HERS) software and one of the best known and widely used. By contrast, SIMPLE was a newly developed program that required fewer data points, less testing, and less technical operator knowledge than REM/Rate. HES was selected on the basis of its reported accuracy and because it was an online modeling tool designed for homeowners. Of the three levels of analysis possible with HES, the pilot decided to test the middle and most complete level, which were dubbed HES-Mid and HES-Full, respectively.

It was determined that the best method for measuring the accuracy of modeling software was to compare each software's energy predictions to weather normalized utility billing data for each home. Since utility billing data includes the behavioral factors of each home, behavioral factors were also included in the modeled calculations. This means that while the EPS is an asset rating, the software testing done in the pilot was based on a comparison of operational ratings which includes occupant behaviors.

The analysis of the software program results was based on a sample of 190 homes. This sample was a subset of the 302 homes from which data was collected in Portland and Bend, Oregon, in the fall and winter of 2008. Of the 302 homes, 112 were excluded from analysis for a variety of reasons. The largest segment of those excluded (75 homes) was due to lack of complete actual use utility data. Each software tool was evaluated in terms of accuracy of energy use prediction, audit time, and ease of use.

Comparing the errors of each program, SIMPLE generally produced the most accurate results. When predicting total energy use, SIMPLE had a mean absolute percent error of 25.1% compared to HES-Full with 33.4%, REM/Rate with 43.7%, and HES-Mid with 96.6%. In other words, SIMPLE predicted energy use on average within plus or minus 25.1% of actual use.

Another means of evaluating accuracy was to look at the percentage of homes for which a program predicted well and the percentage for which it predicted poorly. Predicting well was defined as over-predicting or under-predicting by less than 25% (an absolute percent error of less than 25%). Predicting poorly was defined as over-predicting or under-predicting by more than 50%. Using these criteria, SIMPLE had essentially the same number of good estimates as HES-Full, but it also had approximately one-third as many poor results. REM/Rate had 10% fewer good predictions, but 24% more poor predictions compared to SIMPLE. In terms of offering reliable results, SIMPLE performed the best with the lowest frequency of large errors.

An in-depth review of the sample data does indicate trends whereby HES-Full and REM/Rate had a greater number of good predictions than SIMPLE for a type of energy within a subset of the sample. In nearly every cohort and for every fuel type, SIMPLE produced the fewest significant errors. This finding was somewhat surprising considering how many data points are required by each software program: HES-Full with 185 and REM/Rate with approximately 100 compared to SIMPLE with 32. Overall, SIMPLE offered consistently more accurate results, especially with older homes. Any of the software programs tested could be changed to meet the proposed standards. It is the hope of the pilot team that the EPS will spur the development or improvement of many tools as outlined in this report. However, in terms of quickly developing a tool to EPS standards, SIMPLE appears to be the most likely candidate at this time.

SIMPLE also showed the most promise for audit time and ease of use. Since data was collected for all the programs during the home audits, time comparisons for each software tool were based on the estimates of the field technicians who collected the data and entered it into each program. Based on the technicians' estimates, SIMPLE would require 1 hour to audit a home. HES-Mid was estimated to require almost 1.5 hours; HES-Full, 2 hours; and REM/Rate, almost 2.5 hours to audit the same home. Likewise, the technician's estimated data entry for SIMPLE at 14 minutes, only 3 minutes more than HES-Mid, and one-third the time of REM/Rate at 45 minutes and HES-Full at 47 minutes. These time estimates need to be tested in the field as the audit protocol for SIMPLE becomes better defined. One significant issue to be decided is the importance of blower door and duct pressurization testing both for accuracy in reporting the energy use and for determining where energy improvements need to be made for existing homes.

Calculating carbon emissions is an integral part of the EPS and completes the picture of energy use in the home by indicating the impact on greenhouse gas emissions of different fuels. The carbon score balances the fuel efficiency bias that would result from only using an energy score. In this way the carbon score helps the EPS to be a more fuel neutral approach. Homeowners were also very interested in knowing the carbon emissions associated with home energy use. On a broader level, the ability to track carbon emissions is also central to emerging energy policy at the local, state, and national levels. For these reasons, the pilot developed a methodology for calculating greenhouse gas emissions (referred to in this report as *carbon emissions*) based on the fuel types and amounts of the energy use in a home.

In addition, Earth Advantage Institute conducted a series of stakeholder surveys over the course of the pilot. These surveys solicited feedback on a range of topics, including attitudes toward home energy efficiency, the usefulness of energy auditing and analysis, comprehension of energy-related terms, score sheet preferences, and feedback from those who had a home audit during the pilot. The responses to these surveys guided the conceptual development of the EPS and were incorporated into the EPS score sheet, EPS energy analysis report, and program recommendations. The findings included the following:

- The EPS concept has considerable appeal with consumers, home improvement contractors, builders, and real estate professionals.
- The ideal price of an EPS would be $100 with a cap of $200.
- Cost is a major issue and the common language for understanding energy.
- The EPS must be presented in a clear and objective manner from a trustworthy source.
- Carbon emissions are relevant and very important to homeowners.
- Homeowners are most familiar with energy use in terms of watts and kilowatt hours.
- Homeowners want information on energy performance and where to make improvements.
- Home energy audits are perceived as useful by homeowners for a variety of reasons.
- Homeowners thought that their homes were more energy efficient than preliminary results indicated.
- Home energy auditing helps highlight the need for air and duct sealing.
- Financial incentives (from Energy Trust of Oregon in the state of Oregon) are important to making home energy upgrades about half of the time.

Based on the software analysis, research, and survey findings, the pilot team offered the following recommendations for the development of an Energy Performance Score:

1. The Energy Performance Score should be developed along two tracks: the EPS with energy and carbon scores and a performance profile of energy related elements of the home (EPS *score only*), and the EPS that additionally includes recommendations for energy upgrades (EPS *w/ upgrades*). Official EPS auditing for both tracks should be performed by trained and certified third-party auditors.

2. In order to offer a credible level of accuracy, EPS certified software programs should be able to predict energy use within 25% for 70% of homes and within 50% for 90% when compared to actual use. To this end, software should be developed to meet all the EPS requirements for accuracy and reporting. Given the analysis results, SIMPLE would be a good candidate for further refinements for a second phase of development. This should include field testing of the auditing protocol with varying levels of diagnostic testing.

3. The EPS energy score should be expressed as the total annual energy required for the house under normal conditions and be expressed in kilowatt hours per year. This score should be illustrated on a scale that also indicates the energy use of different fuels, relevant local comparisons, energy upgrades for existing homes and built to code comparisons for new homes, and community energy goals.

4. The EPS should include a carbon score that reflects the greenhouse gas emissions associated with the home's energy use. Comparisons on the carbon scale should include those listed for energy, as well as the predicted emissions if the homeowner used the most commonly subscribed renewable energy option through his or her utility or fuel provider.

5. The EPS should include an energy analysis report that includes an accounting of the annual estimated energy use and fuel costs for heating, cooling, water heating, and lights and appliances in the home, as well as the performance of the various energy-related elements in the home (e.g., walls, heating ducts, appliances). For existing homes, the report may also include recommendations for energy upgrades and the associated costs and predicted savings.

6. Ideally, the EPS will be a coordinated effort to ensure consistency of the core elements, including the EPS name and branding, and the standards for auditing, software modeling, auditor training, and reporting. There is also the need for a central database to serve as a clearinghouse for EPS scores for homeowners and homebuyers, as well as a Web tender portal through which contractors can offer estimates on energy upgrades to interested homeowners.

Energy Trust of Oregon and Earth Advantage Institute are moving ahead with the refinement of SIMPLE, as well as working with recent relevant legislation and efforts at home energy auditing in Oregon to develop and further test the EPS concept in different climate zones.

1. ENERGY PERFORMANCE SCORE PILOT OVERVIEW

Conceptual Framework

The rationale and opportunities for home energy upgrades grows every day and ranges from the global imperative to reduce carbon emissions to individual homeowner concerns over increasing energy costs. On the positive side, the United States is on the brink of directing an unprecedented amount of attention and resources to the issue of home energy performance, and the question has shifted from where to find resources to how to most effectively measure and manage them.

According to the Pew Center's Agenda for Climate Action, greenhouse gas (GHG) emissions can be addressed through labeling and standards for buildings, focusing on those that would result in significant GHG reductions through reduced energy use. By providing consumers with better information on the energy performance of homes, standards and labeling can help overcome the obstacles, such as green building brand confusion and vague greenwashing performance claims, while advancing building efficiency.

Given this context, the purpose behind the Energy Performance Score 2008 pilot was twofold. The first was to focus more attention on home energy performance by creating a common energy performance metric for stakeholders, particularly financial institutions, home performance contractors, Realtors®, and homeowners. Initially, this goal was expressed in terms of developing an easy to use metric for communicating home energy performance similar to the miles per gallon (MPG) measurement for cars.

In considering how an MPG-type metric might apply to the scoring of a home, the EPS team developed a list of important characteristics for such a metric:

- Easily understood by the general public.
- Meaningful in different contexts to respective stakeholders.
- Applicable to new and existing homes so that comparisons can be made between homes.
- Useful for indicating progress toward individual and community energy goals.
- Helpful to homeowners as a baseline against which to evaluate their own energy use.
- Consistent over time.

The second purpose of the pilot was to develop a cost effective means of auditing homes, assigning them energy performance scores, and assessing the potential impacts of energy upgrades on existing homes. The inspiration for this came, in part, from the United Kingdom's Energy Performance Certificate (EPC). Implemented as mandatory at time of sale in August 2008, Energy Performance Certificates rate the energy efficiency and carbon emissions of residential and commercial buildings and graphically depict these scores on color-coded scales. In addition to these scores, an EPC includes a multipage report describing improvements that can be made to lower energy use and costs, and to reduce carbon emissions (See Attachments for a copy of the EPC). The EPC has become one of the tools by which British homeowners assess their current homes' performance and by which homebuyers evaluate homes. Both the EPC scale and the accompanying report served as initial models as the EPS team developed the corresponding elements during the pilot.

The United Kingdom's decision to measure and report carbon emissions as part of a building's energy assessment reflects the growing interest in and need for greenhouse gas accounting. After years of delay, the impetus to create a system for measuring and monitoring carbon emissions has reached the federal and state levels in the United States. The secretary of Housing and Urban Development for the Obama administration recently expressed interest in seeing a number reflecting the energy profile of a home similar to the MPG decal for cars (Harney, 2009). By reporting a carbon score along with an energy score, the EPS will create a metric that ties home energy use to governmental, community, and individual carbon emission goals.

Goals

It was within this conceptual framework that the goals for the EPS pilot were developed:

1. Create an MPG-type metric to convey energy use and related carbon emissions for a home under normal use. This will allow contractors, Realtors, homeowners, and homebuyers to compare EPS scores to those of other homes, take action to improve scores and performance, and objectively express the upgraded energy performance of a home in a uniform way.

2. Find an accurate and cost effective method for evaluating, calculating, and scoring the energy use and carbon emissions of new and existing homes.

To achieve these goals, the EPS team developed specific objectives for the pilot:

- Review home energy audit protocols and modeling software programs to determine ones to be used in the pilot.
- Compare the results of four selected home energy audit protocols and modeling software programs against actual use data in terms of accuracy.
- Compare the selected home energy audit protocols in terms of audit time and ease of use.
- Indicate whether a home energy audit could be achieved at a reasonable cost to allow for large scale application.
- Recommend the protocols, metrics, software, and reporting for home energy audits based on these results.
- Report on findings gained through surveys, focus groups, and interviews.
- Suggest training for EPS auditors.
- Develop the parameters for an online EPS database to track results.
- Outline a Web-based portal to connect homeowners, contractors, and financing resources to streamline energy improvements.
- Survey the interest in linking the EPS to real estate listings, and to the financial, insurance, and appraisal industries.

Pilot Description

In 2007, Earth Advantage Institute (EAI) and Conservation Services Group (CSG) teamed to respond to Energy Trust of Oregon's solicitation RFP for its Home Energy Solutions program. The conceptual development of the EPS began at EAI in late 2007. Once the HES contract was awarded to CSG, work began on research and design of the EPS during 2008. Auditing of homes started in September 2008. In order to test existing home energy modeling software, a wide range of data was gathered from 302 homes in the cities of Portland and Bend, Oregon, from September to December 2008. The data on the homes was entered into a database, and each home was run through the four selected software programs (See the Selecting Energy Modeling Software section in Methodology). The energy use predicted by energy modeling software was compared with weather normalized actual energy use data collected from utility billing records. In addition, information was collected about the effort, time, and other issues involved in collecting the data. This was used as an additional lens for judging each tool's viability and efficacy.

While other approaches for scoring a home exist, energy modeling was determined to be the most appropriate for the goals of the EPS pilot. Some other approaches use utility data as a starting point or for calibration, but these approaches would be difficult to test for accuracy since no other generally available house-specific empirical data exists. An approach that relies on utility data would be unable to score homes that lack utility data, such as new homes, unoccupied homes, and homes with extremely unusual energy use. Of course, there are limitations to any given study or approach in what information can be learned. The EPS pilot limited its scope to what could be learned about the relative ability of energy modeling to predict utility bills.

Concurrent with the data collection and energy modeling software analysis, the EPS team examined the existing literature, studies, programs, metrics, and software tools in order to refine the EPS concept (See Annotated Bibliography). In addition, various stakeholders, including homeowners, Realtors, and builders, were surveyed to solicit feedback on various aspects of the EPS. The results of those surveys, interviews, and focus groups are described in the Findings section.

EPS Pilot Team

The EPS pilot was supported by Energy Trust of Oregon and Conservation Services Group (CSG), and was conducted by the nonprofit Earth Advantage Institute. EAI is a green building program provider and third-party verification entity (see Attachments for organizational overview). Earth Advantage's EPS team was overseen by Sean Penrith, executive director. David Heslam (BPI certified), the EPS program manager, performed data analysis and supervised the EAI team members who were responsible for data collection. The field technicians collecting and entering data in Portland were Casey Bradley (Certified HERS Rater, BPI trained), MacKenzie Winchel, Ryan Shanahan, and Stephen Alexander. The Bend field technicians were Matt Douglas (Certified HERS Rater) and Bill Clendenning (Certified HERS Rater). Marie Cossey was responsible for scheduling and database information management. Doug Loqa assisted with data analysis. Caitlin Weber developed the graphics. Eric Storm (Trained HERS Rater) and Beth Meredith of Living Spaces coordinated the pilot, refined the EPS concept, and compiled the final EPS report.

The EPS team's efforts have been augmented by many contributions from other people and organizations, including a number of EAI staff members. Bill Jones, director of Carbon*Advantage* at EAI, and Indigo Teiwes, an independent consultant, developed the carbon methodology. From Energy Trust of Oregon, Diane Ferington, the senior residential sector manager, provided program oversight; Brien Sipe, evaluation analyst, provided the normalized actual use data; and Sarah Castor, market research and evaluation analyst, offered liaison and analysis assistance. Portland Energy Conservation, Inc. (PECI) and CSG, working as part of Energy Trust's New Homes Program, conducted a series of focus groups for the EPS, and offered input on the integration of the EPS into Energy Trust's New and Existing Homes programs and design concepts. The report was peer reviewed and sent to stakeholders for comments.

2. METHODOLOGY

Selecting Energy Modeling Software

The process of selecting energy modeling software began by surveying existing software for accuracy, number of inputs, and ease of use. Over 100 software tools were surveyed, including those recommended by energy modeling experts, those listed on the U.S. Department of Energy's Building Energy Software Tools Directory (U.S. Department of Energy, 2009), and those analyzed in the Lawrence Berkeley National Laboratory's (LBNL) review of residential energy analysis tools (Mills, 2002). The LBNL review provides a good overview of evaluating energy modeling software, and many of its conclusions were adopted as a starting point for this pilot. As a result of this process, 15 software tools were reviewed in depth. Despite the large number of tools available, the level of inaccuracy in predicting energy use is generally high, over-predicting by up to 100%. This led the EPS team to cast the net more widely to find software tools that fit the pilot's purposes.

The Home Energy Rating System (HERS) protocol is one of the best known and most widely used energy rating systems in the United States. For this reason, the EPS team decided to use REM/Rate (an accredited HERS software) and the HERS protocol as one of the methodologies to test. The HERS Index is a rating system established by the Residential Energy Services Network (RESNET). On the HERS Index, a rating of 100 represents the energy use equivalent to a home built to the 2004 International Energy Conservation Code (IECC), and a rating of 0 is equivalent to a home with net zero energy use. A home with a HERS Index rating less than 100 is considered more energy efficient than if it were built to 2004 IECC standards, and a home scoring more than 100 is considered less efficient.

REM/Rate serves as a useful baseline since any modeling software worth recommending over current practices would have to perform more accurately and require less time than the widely recognized HERS protocol. REM/Rate entails the collection of approximately 100 data points by a rater trained in building science. The HERS auditing protocol includes blower door and duct pressurization tests, though default values are possible. It also necessitates some math skills on the part of the rater, who must enter the data into REM/Rate or other RESNET approved software. Typical audit times range from 90 minutes to 3 hours or more, depending on the size and complexity of the home.

REM/Rate is proprietary and disk-based. The software produces a wide range of outputs, including the HERS Index.

One of the conclusions of the LBNL software review was that a larger number of data inputs did not necessarily lead to greater accuracy of predicted energy use. This was echoed by other home energy professionals. Given the goal of reducing audit costs, the pilot team was interested in exploring software tools that required less data and therefore shortened audit and data entry times. For the second methodology, the EPS team selected SIMPLE, a simplified spreadsheet-based modeling program with 32 data points. SIMPLE was recently developed and submitted to the EPS team by Michael Blasnik, a nationally recognized independent consultant in energy efficiency and building science research. Initially, there was no established auditing protocol in place for SIMPLE, though the skills and knowledge required to gather the data were easily within those of a HERS rater and easily corresponded with the data gathering for REM/Rate.

SIMPLE does not require data collection or data entry for items such as the area and orientation of windows, walls, ceilings, or foundations. These are estimated by the program based on floor area. SIMPLE does not require a blower door or duct leakage test and relies on many defaults and estimates. However, in the data analysis for the pilot, blower door results were used since they were gathered for REM/Rate and were thought to be a valuable addition for accuracy, as well as for making energy upgrade recommendations.

For the third and fourth modeling software methodologies, the EPS team selected two levels of Home Energy Saver (HES), an online modeling tool developed by the U.S. Department of Energy’s Lawrence Berkeley National Laboratory. The LBNL software review indicated that HES might be more accurate than most other modeling tools. The HES program was designed for homeowners to use online, and it can be used at three levels of detail for data input. The first level uses only the zip code of the home and would not produce useful comparisons between homes within the same zip code. The second level (HES-Mid) uses 24 data points while assuming or calculating others. The third level (HES-Full) requires approximately 185 data points and is quite detailed in terms of behavior and appliance use.

Characteristics of the four selected programs are summarized in Table 2.1. The tools vary in terms of format (disk-based, Web-based, and spreadsheet-based), the level of expertise required, the specificity of the data needed, and the number of data inputs.

Tool	Format	Expertise	Specificity	Inputs
REM/Rate	Disk	Technical	Detailed	100
SIMPLE	Spreadsheet	Semi-technical	General	32
HES-Mid	Online	Nontechnical	General	24
HES-Full	Online	Semi-technical	Detailed	185

Table 2.1 Characteristics of Selected Methodologies

The Sample

From September 2, 2008, to January 19, 2009, data was collected from 302 homes: 236 in Portland, OR, and 66 in Bend, OR. While the sample from Bend was considerably smaller, the goal was to see whether there was any impact on software results in a climate that was cooler and drier than Portland's climate.

The test homes were solicited through a variety of channels and networks. The selection process was not randomized but was what is called in statistical terms a *convenience sample*, or a nonrandom sample. This sampling method did not appear to significantly affect the results of the study since the distribution of sample homes corresponded well to the age of housing stock in the areas studied. Qualifying test homes had to meet the following criteria:

- The homeowner must be present during the 2 to 3 hour audit.
- The homeowner has occupied the home for at least one year.
- The home heat source is gas or electricity.
- The home is a single-family dwelling.

The sample of homes was created using quota sampling based on the age of the homes selected. The test homes included homes from each decade with a large sample of 1920s homes due to the makeup of Portland's housing stock. Specifics about the sample used in the data analysis can be found under Accuracy of Energy Modeling Software in the Findings section.

Audit and Data Collection Protocol

The RESNET rating protocol was used as the basis of the audits. The lead field technicians in both Portland and Bend were certified HERS Raters, and the one in Portland was also BPI trained. The field technician manager was BPI certified, and the lead pilot developer successfully completed the HERS rater training.

Generally, one EAI field technician audited a home alone. Two technicians worked together for training purposes and when a home was very large, or when an extension ladder was required to reach HVAC register locations.

Simultaneous to conducting audits using the HERS protocol, the field technicians collected the data needed for the three other software programs. Home data was entered into a Field Technician Input Form during the audit that included fields for all the required REM/Rate inputs, as well as space for drawing rough plans of the home. Homeowners were asked to complete a Homeowner Input Form with information about thermostat settings, alternative heating methods, hot water use, large energy uses, past remodeling activities, and behavioral and appliance questions. The two input forms were modified and improved during the pilot. For this reason, the input forms were not consistent throughout the pilot. Discrepancies in data collection or missing data were addressed during data entry either by revisiting the home or by contacting the homeowner for nontechnical information. Copies of the Input Forms can be found in the Attachments section.

A blower door test was conducted on all homes recording the air leakage at 50 pascals. A duct pressurization test for leakage to the outside was also performed unless the home had no ducts, had no ducts in unconditioned space, or had a potentially hazardous condition, such as frayed asbestos duct tape over loose duct connections. Prior to those tests, the field technicians were asked to make educated guesses about air leakage and duct leakage, and they noted their guesses for later comparison to the actual testing results. On some homes with difficult to reach registers, a second visit with an extra field technician was required to conduct the duct pressurization test. Square foot areas for floors, walls, and ceilings were measured along with window areas. Insulation levels were visually inspected or estimated based on construction or remodel dates and given the known history of the local energy code. Information about the mechanical equipment and appliances was collected and recorded. Mechanical equipment was assumed to be operating at its stated efficiency level. Information was also gathered on house age, size, occupancy, glazing, shading, and lighting.

<u>Data Entry</u>

The field technicians entered data from the input forms into a database, and a site ID number was assigned to each home. Data that was not collected during the audit was flagged, and the home was either revisited by a field technician in the case of technical information or the homeowner was contacted for less technical information. A large number of homeowners were contacted again as a result of the initial difficulty in capturing the variety and types of data required by the different software methodologies. When appliance labels, manuals, and homeowner memory failed to provide enough information, technicians researched appliance specifications required for the modeling software.

Energy Modeling

The field technicians modeled each home with the four energy modeling software tools. The recorded results included the total annual energy use along with specific energy loads for heating, cooling, water heating, and other plug loads when available. For example, Home Energy Saver (HES) reports separate energy totals for lighting, appliances, and miscellaneous, while the other tools do not.

The EPS team developed software entry protocols, and the field technicians met weekly to ensure consistency in data entry and modeling. Records were kept for each home and for each software tool so that all results could be checked for data entry errors. Reports generated from the database helped with modeling efficiency and accuracy. Entering modeling data also provided a means of checking the accuracy of the data entry.

For reasons of efficiency and process, the technicians tended to work with one modeling software tool at a time. This allowed them to develop greater familiarity and efficiency with each tool. Unfortunately, HES was not always available online, which made time management for modeling with this tool complex.

REM/Rate has a detailed protocol that was followed by all field technicians. The Detailed input mode was used as this is how HERS ratings are calculated. The definitions of *area* and *conditioned space* were clarified with the creators of REM/Rate, Architectural Energy Corporation. Home Energy Saver was created for use by homeowners and thus the instructions and definitions are straightforward and nontechnical. SIMPLE is newly developed and does not yet have many definitions or instructions. Michael Blasnik addressed questions about the definitions of input that were not obvious.

SIMPLE provides an override section in which specific values can be used in place of generalized categories. The only override used for the main set of pilot results was the blower door test results. Duct pressurization test results were used to select from the generalized categories. Technicians also made estimates for building air leakage and duct leakage on some homes and these were used for a separate set of predicted energy results when available. Future analysis will reveal how accurate these estimates were and their effects on energy predictions.

Normalized Actual Use Data

The EPS team acknowledges that one of the potential shortcomings of comparing predicted actual use against actual use data is that this method relies on the accuracy of homeowners' reports on behavior. Another potential area for discrepancies is the methodology for normalizing the utility data for weather. Despite these limitations, normalized actual use data was still thought to offer the most useful comparison for the software results.

It is important to note that while the pilot chose to measure the accuracy of energy modeling software against actual use data, the Energy Performance Score will be a calculation of energy use based on assumptions of normalized occupant behavior. In this way, the EPS would be scoring the home independent of homeowner behavior and allow for meaningful comparisons between homes.

Energy Trust of Oregon provided weather normalized annual consumption estimates from utility data for the pilot test homes. Normalized annual consumption was reported in terms of total kilowatt hours and total therms, as well as for component parts for each fuel when possible, as described below. The data was also screened for unusual use patterns.

The normalization model used by Energy Trust runs a series of regressions for each site, allowing heating degree days (HDD) to be calculated from a temperature running from 30 to 75 degrees, and fixed at 70 degrees for cooling degree days (CDD) in the case of electric sites. The model used for each site's fuels is determined by the highest overall coefficient of determination, or R^2 statistic. Base load, heating load and/or cooling load, and total normalized annual consumption (NAC) were then determined using the long run heating degree day calculation based on the optimum reference temperature and weather station data. If the optimum NAC model failed to adequately model the effect of weather on a site's consumption (defined as an $R^2<.7$ for gas or $<.5$ for electric), a raw NAC calculation was used to arrive at an estimate of normalized annual consumption. However, the raw NAC-based estimate cannot be broken into its component parts (i.e., heating and cooling loads or base load).

Normalized Annual Consumption Calculation Models, Gas and Electric

(1) $Ui = \alpha + \beta_1 * HDDi(t) + \varepsilon$
(2) $Ui = \alpha + \beta_1 * HDDi(t) + \beta_2 * CDDi(70) + \varepsilon$
(3) (Avg(kWh/therms)/ read days)*365 = raw NAC (kWh/therms)
Definitions:
Ui : Average kWh or therm consumption per day
α : Average base load consumption per day
β_1 : Heating slope at reference temperature t
HDDi(t) : Reflects the average HDD(t) per day in interval i
β_2 : (Electric) cooling slope at reference temperature 70
CDDi(70) : (Electric) reflects the average CDD (base 70) per day in interval i
ε : An unexplained error term

All of the modeling software tested in the pilot used TMY2 (Typical Meteorological Year Version 2) weather data for calculations. However, the pilot's normalized utility data was based on weather data from the last 8 years. This means that for the Portland area, there was a 2.7% discrepancy in the HDD at a base of 65 degrees. The software's TMY2 data uses 4,456 HDD, whereas the pilot's normalization methodology used 4,337 HDD. As a result of this discrepancy, the modeling software appeared to over-predict heating energy by a corresponding amount.

Similarly, there was a 4.5% discrepancy in weather data for the Bend area for which the TMY2 data had 6,733 HDD and Energy Trust used 6,435 HDD.

Actual use data was not available for some homes in the sample. Some had opted out of sharing utility data with Energy Trust. Other homes subscribe to small electric utility companies that do not share data with Energy Trust. The homes lacking actual data were not included in the comparison of software results.

Comparing Software Results with Actual Use

In order to test the accuracy of each software tool, their results for predicted annual therms, kilowatts, and total energy use were compared with weather normalized actual energy use data for those values. Since the actual use data included occupant-specific use, each home's energy use was calculated with the software tools using occupant-specific inputs (an operational rating). Homes with significant uses of fuels other than electricity and natural gas were removed from the sample since reliable actual use data was not available in these cases.

Outliers in the sample were identified as homes with energy usage greatly under-predicted or over-predicted by all the software. It is assumed that the data collected for these homes inaccurately described the home or its occupant behavior, or the home was operating with a serious level of inefficiency due to poorly operating mechanical equipment or shell components. Examples of this include homeowners who misreported thermostat settings, or a furnace that was operating at a fraction of its stated efficiency. These outliers were reviewed to confirm that no data entry error existed and they were left in the sample for analysis.

The predicted value, mean error, and absolute error were compared for each software program's results. The distribution of the error was measured by counting the percentage of results that fell within 25% of the actual use to create a range for *good* predictions. The range of *poor* predictions was defined by counting the predictions that over- or under-predicted by more than 50% from actual use. The sample was also analyzed by cohorts of age of home, size of home, and climate zone.

Calculating EPS Energy Scores

EPS Energy Scores were also generated for each home using each software tool. The intent of an EPS energy score is to provide an assessment of a home that is independent of occupant behavior (an asset rating) in order to allow for more useful comparisons between homes. Each software tool required different data and specific protocols were established for each tool to generate EPS Energy Scores. In addition, default inputs were created for each software tool. These are detailed below.

For SIMPLE, there were four types of default values. First, the number of occupants was set based on the number of bedrooms using U.S. Census data for national averages of single family dwellings: 1 bedroom = 1.71 occupants, 2 bedrooms = 2.2, 3 bedrooms = 2.65, 4 bedrooms = 3.14, 5 or more bedrooms = 3.81. Second, the heating and cooling set points were set to 68 and 78 degrees, respectively. Third, the fields “Shower Use,” “Laundry,” “Other Hot Water Use,” “Entertainment,” “Plug Loads,” “Clothes Dryer,” and “Cooking” were all input as “Average.” Lastly, extra appliances were removed from the model. Specifically, extra refrigerators and freezers were removed, and in the energy category of “# Other Large Uses,” any large energy uses that were not attached to the home (e.g., window AC unit and dehumidifier) were removed. Appliances and equipment built in to the home (e.g., hot tub, pool heater, and pumps) were left in the model. Energy usage associated with pool pumps and heaters was based on 12 months a year for indoor pools and 3 months a year for outdoor pools.

The REM/Rate software is inherently based around the energy use of the home, as opposed to that of the homeowner, so there were very few default inputs that were needed to generate occupant-independent scores. The heating and cooling set points were 68 and 78, respectively (REM/Rate’s default values). The energy use associated with refrigerators was changed to reflect only the home’s primary refrigerator, eliminating any additional units. The “Detailed Lights and Appliances” field was not used in this study as it is not required by the HERS protocol. Therefore, those fields did not need to be changed for the purposes of generating EPS Energy Scores. No other changes were made to REM/Rate inputs.

HES takes into account many attributes of homeowner use. As a result, there were many inputs that required default entries. HES has built in default values for most input fields and default values were created for the other fields. The defaults generated by HES were used for the following data entry fields: “Water Heater Temperature,” “Moveable Window Shades,” “Stove/Oven Hours/Day,” “Dishwasher Loads/Week,” “Clothes Washer Loads/Week,” “Clothes Dryer Loads/Week,” sump pump and well pump energy usage, all entries in the “Entertainment” section, all entries in the “Home Office” section, all entries in the “Miscellaneous Kitchen” section (except for microwave), and all entries in the “Other Appliances” section.

Default values were created for other HES input fields. “Occupant Age” was based on the number of bedrooms in the home (1 bedroom = 2 occupants “Ages 14-65”; 2 bedroom = 2 occupants “Ages 14-65”; 3 bedroom = 2 occupants “Ages 14-65” and 1 occupant “Ages 6-13”; 4 bedroom = 2 occupants “Ages 14-65” and 1 occupant “Ages 6-13”; 5 or more bedrooms = 2 occupants “Ages 14-65” and 2 occupants “Ages 6-13”). The heating and cooling temperature set points were 68 and 78 degrees, respectively, along with “I leave it the same” on the weekends. No adult was assumed to be home on the weekdays. All window unit or room air conditioners were removed from the model. “Microwave Use” was set to “15 minutes/day.” If there was a hot tub, the default category selected was “Electric Spa heated 24hrs/day.” In the case of a pool, the “Pool Pump Use” was set at 24 hrs/day (3 months/year for an outdoor pool and 12 months/year for an indoor pool). If it was an indoor pool, it was assumed that there was a pool heater. All extra refrigerators and freezers were removed from the energy calculation, leaving only the primary refrigerator.

Calculating EPS Carbon Scores

While the EPS pilot uses the term *carbon* to refer to the emissions associated with energy, this is a reference to the collection of energy related greenhouse gases, which include CO_2, CH_4, and N_20. These emissions were converted into CO_2 equivalents as described in the Methodology for Calculating the Carbon Score section in Recommendations.

In order to convert energy usage into a measure of carbon emissions, the EPS team worked with carbon experts to define a methodology. The following criteria guided the methodology:

- Rigorous, logical, and simple approach
- Credible data sources
- Preference for the fewest data sources to increase the likelihood that a consistent methodology is used for information gathering
- Reasonably frequent data updates
- Potential for (simple) replication across the nation
- Linked to the utility with which the homeowner interacts
- Encourage appropriate behavioral reactions

In developing the carbon calculating methodology for electricity use, the intention was to minimize and avoid the following complications and inconsistencies whenever possible:

- The variety of renewable power programs offered by electric utilities
- Differences in methodology for assessing the greenhouse gas (GHG) footprint of power purchase agreements from one electric utility to another

See Methodology for Calculating the Carbon Score in Recommendations for a full description.

Reporting Results

Surveys, the United Kingdom's EPC progress, and anecdotal information from the field technicians all indicated that homeowners want to gain information about how to improve the energy performance of their homes. Ideally, they would like to know the cost of these upgrades and the anticipated savings.

Given that the accuracy of the modeling tools was not known until the end of the pilot, the EPS team developed an Interim EPS Report that generally outlined the energy performance of a home and recommendations for improvements. This report was provided to the homeowner.

This assessment was based on a number of factors, including the blower door and duct pressurization test results, as well as the information gathered about windows, appliances, and insulation levels. The results from the REM/Rate software were used to indicate the relative proportionality of energy use by different energy-related elements in the home. Despite later findings through software analysis that REM/Rate tended to over predict energy use, the EPS team was of the opinion that the REM/Rate results were useful enough to assign energy upgrade priorities in the Interim Report.

The Interim Reports were prepared by David Heslam, a BPI certified building analyst, envelope specialist, and remodeler with 14 years of experience performing home energy retrofits.

The Interim Report listed and described the conditions of the energy-related elements of the home with details specific to the home. Each of these elements was given a performance evaluation of *poor*, *average*, or *good*, and the priority for improvement was rated as *low* or *high*. Recommendations for energy improvements were made only for those elements with a *poor* or *average* performance level. Low cost improvements were distinguished from high cost ones on the report. A copy of the full Interim EPS Report template appears in Attachments.

Energy-Related Elements Evaluated in the Interim EPS Report

Air Leakage
Ceiling and Attic (insulation)
Heating
Cooling
Ducts
Water Heating
Lights and Appliances
Walls (insulation)
Floor Insulation
Doors
Windows

This process was useful in two respects. First, it helped some of the homeowners in the pilot understand the performance of their homes and take a greater interest in energy performance and the pilot. This was helpful in subsequent interactions, such as when requesting additional data about their home.

Second, the process highlighted the areas where data collection could be improved in order to offer more specific recommendations along with cost projections and savings. This experience helped inform the recommendations for the EPS Energy Analysis Report.

One of the goals of the next phase of this pilot is to provide each of the test homes with an EPS Score Sheet and Energy Analysis Report using the recommended software.

3. FINDINGS

Accuracy of Energy Modeling Software

Sample

The analysis of the software program results for this report was based on a sample of 190 homes. This sample was a subset of the 302 homes from which data was collected. The exclusion of audited homes from this analysis is summarized in Table 3.1. Of the 302 homes, 112 were excluded from analysis for a variety of reasons. The largest segment of those excluded (75 homes) was due to lack of complete utility billing data from which to derive actual use values. Thirteen homes were excluded because the homeowners indicated that they used significant amounts of wood heat in the past year, and one was excluded because it heated with oil. Nine homes were audited by intentionally collecting data only for the SIMPLE audit as a way to confirm audit times; these were excluded as some data for the other software programs were not available. Four homes were excluded because they used propane as cooking fuel. These alternate fuel uses were reported by homeowners during the audit even though the pilot screened homeowners for alternate fuel use before scheduling audits. Three homes had more than one unit, and 3 homes had new residents. Three other homes had recently changed the heating systems of their homes before the audit, nullifying the accuracy of the actual use data for those homes. Two homes had friable asbestos on the ductwork in such a condition that neither duct leakage nor air leakage tests could be conducted.

Homes with unusable utility data	73
Homes that reported high wood heat usage	13
Homes heated with oil	1
Homes that had SIMPLE only audits	9
Homes with incomplete information	1
Homes with reported propane usage	4
Homes that were not single-family	3
Homes with new residents	3
Homes with a mid-year oil to gas conversion	3
Homes with friable asbestos on ductwork	**2**
Homes excluded from sample	**112 Total**

Table 3.1 Attrition Table for Sample Homes

Several of the 190 homes had either very high or very low actual use when compared to the predictions from all of the software programs. Six of the homes had very high actual use. It is assumed that these houses had poor performing components, such as the heating systems, that consumed large amounts of energy that were not evident during data collection. Another 4 homes had actual use utility data that was very low compared to all of the software predictions. This may be due to misreported behavioral data from the homeowners. Removing these outliers from the sample was considered, but they were left in the sample in an effort to be representative of what auditors find in real world conditions.

Table 3.2 summarizes the year and size of the homes analyzed. The average home size in the sample was 2,027 square feet. This size was defined as living space.

Year Built	Portland	Bend	Smallest (square feet)	Largest (square feet)
Pre-1960	81	10	660	4,205
1960-1979	26	5	978	4,581
1980-1989	16	6	1,339	5,038
1990-2008	25	21	1,100	6,060

Table 3.2 Sample Homes by Year and Size

Table 3.3 compares the age distribution of homes in the sample to all homes in the two regions where audits were conducted. The 2007 data from the U.S. Census American Community Survey (U.S. Census Bureau, 2007) for all Oregon homes reflects only owner-occupied housing but should be an accurate measure of the distribution of single-family homes. The distribution of the Portland sample accurately reflects Portland housing.

The Bend sample accurately reflects the percentage of 1990 and newer homes, but the distribution of homes for the older age categories does not. Therefore, the age distribution of homes in the Bend sample is older than exists in the actual housing stock. The distribution of these Bend sample homes needs to be considered when examining results for Bend homes.

Year Built	Portland Sample Homes	% of all Portland Sample Home	All Portland Homes (2007)	% of All Portland Homes (2007)
Pre-1960	81	54.7%	87715	66.0%
1960-1979	26	17.6%	21223	16.0%
1980-1989	16	10.8%	7262	5.5%
1990-2008	25	16.9%	16772	12.6%
	Bend Sample Homes	**% of all Bend Sample Home**	**All Bend Homes (2007)**	**% of All Bend Homes (2007)**
Pre-1960	10	23.8%	1311	7.4%
1960-1979	5	11.9%	4605	25.8%
1980-1989	6	14.3%	1793	10.1%
1990-2008	21	50.0%	10108	56.7%

Table 3.3 Comparison of Sample Houses to Actual Houses by Age

Table 3.4 shows the distribution of heating fuel types for the sample and actual housing. The share of homes in the sample with electric heat is lower than it is in the Oregon housing stock. This is true for both the Portland and Bend areas.

Heating Fuel	Portland Sample Homes	% of all Portland Sample Home	All Portland Homes (2007)	% of All Portland Homes (2007)*
Gas Heat	139	93.9%	88304	66.4%
Electric Heat	8	5.4%	21681	16.3%
Gas & Electric Heat	1	0.7%	-	-
	Bend Sample Homes	**% of all Bend Sample Home**	**All Bend Homes (2007)**	**% of All Bend Homes (2007)***
Gas Heat	34	81.0%	12545	70.4%
Electric Heat	7	16.7%	3958	22.2%
Gas & Electric Heat	1	2.4%	-	-

* These percentages do not equal 100% because some homes use propane, oil, or other fuel as primary heating fuel

Table 3.4 Comparison of Sample Homes to Actual Homes by Heating Fuel Type

Results for Total Energy Use

Table 3.5 displays the summary statistics for total energy use for the 190 homes in the sample. The mean actual use was 101 MBtu and the median value was 96 MBtu. This difference was likely a result of the data including some houses with high actual use, which raised the mean actual use above the median level. This was a trend that was expected and that existed within each cohort based on size, age, and geography.

	REM/Rate	SIMPLE	HES-Mid	HES-Full
Mean Actual Use	101	101	101	101
Mean Predicted Use	133	84	157	119
Mean Error	32	-17	48	18
Mean Absolute Error	37	27	75	28
Median Absolute Error	31	21	66	23
Mean Absolute Percent Error	43.7%	25.1%	96.6%	33.4%
Median Absolute Percent Error	31.1%	24.0%	73.8%	21.8%
Percent of Homes with Accurate Prediction (less than +/- 25%)	43.2%	51.6%	19.5%	53.7%
Percent of Homes w/ Large Error in Prediction (larger than +/- 50%)	31.6%	7.9%	60.5%	21.6%

Table 3.5 Total Energy (MBtu) for 190-Home Sample

Comparing the errors of each program, SIMPLE produced results with the least mean absolute percent error. Several different measures of error are listed in the table: mean error, mean absolute error, median absolute error, mean absolute percent error, and median absolute percent error. Although each of these measures holds interest, the mean and median absolute percent errors are the most descriptive.

These mean and median absolute percent errors reflect the scope of the error relative to the mean of actual use and do so in absolute terms. Here, the term *absolute* is a mathematical function that reports any positive or negative number as a positive number. For instance, the absolute value of 25 is 25, and the absolute value of -25 is also 25. Reporting error in absolute terms does not distinguish between over-predicting versus under-predicting, and indicates the error in absolute terms. A lower mean error indicates predictions that on average are closer to the actual use values.

Focusing on these measures and looking at total energy use, SIMPLE has a mean absolute percent error of 25.1%. The closest program to SIMPLE is HES-Full with 33.4%. REM/Rate had mean absolute percent error of 43.7%. The median absolute percent error for HES-Full is slightly lower than that of SIMPLE. The relatively large difference in values between mean and median for HES-Full can be partly explained by distribution of error as described in the last two rows of Table 3.5. The large number of poor predictions raises the absolute mean error for HES-Full. This is in contrast to SIMPLE, which has fewer poor predictions, and a mean and median that are much closer together.

The last two rows of Table 3.5 display the percentage of homes for which a program predicted well and the percentage for which it predicted poorly. *Predicting well* is defined as having an absolute percent error of less than 25%. This means that the program predicted the energy use within 25%, whether it was an over-prediction or an under-prediction. The definition for *poor prediction* was an absolute percent error of more than 50%. In other words, the program was more than 50% over or under the actual use. This method of categorizing the distribution of the error was deemed more useful than a standard deviation that could be unduly influenced by a few large outliers and would not reflect some nuances of the error distribution.

Understanding how these distribution categories work, it is clear that while SIMPLE had essentially the same percentage of good estimates as HES-Full, it provided only one-third as many poor results. REM/Rate had roughly 10% fewer good predictions but 24% more poor predictions compared to SIMPLE. In terms of presenting reliable information to homeowners, the low frequency of large errors may be a significant advantage of SIMPLE.

It should be noted that HES-Mid had a mean absolute percent error of 73.8%, and 60.5% of its predictions were poor. HES-Mid performed just as poorly in comparison to the other programs for all the different cohort groups. It typically had the largest mean absolute percent error and always had the highest percentage of poor predictions. This poor performance was not surprising since the program had relatively generalized inputs. Due to this poor performance, HES-Mid will not be discussed further in this analysis section.

Another way of looking at this information is illustrated in Figure 3.1, which graphically represents the comparison of the predicted energy for each home against its actual use. Each sample home is represented by three dots, one for each software tool. The closer a dot is to the light blue line the more accurate the prediction. This figure shows REM/Rate's tendency to over-predict (dots above the line) and SIMPLE's tendency to under-predict (dots below the line). Similar graphs are shown for natural gas (Figure 3.3) and electricity use (Figure 3.4).

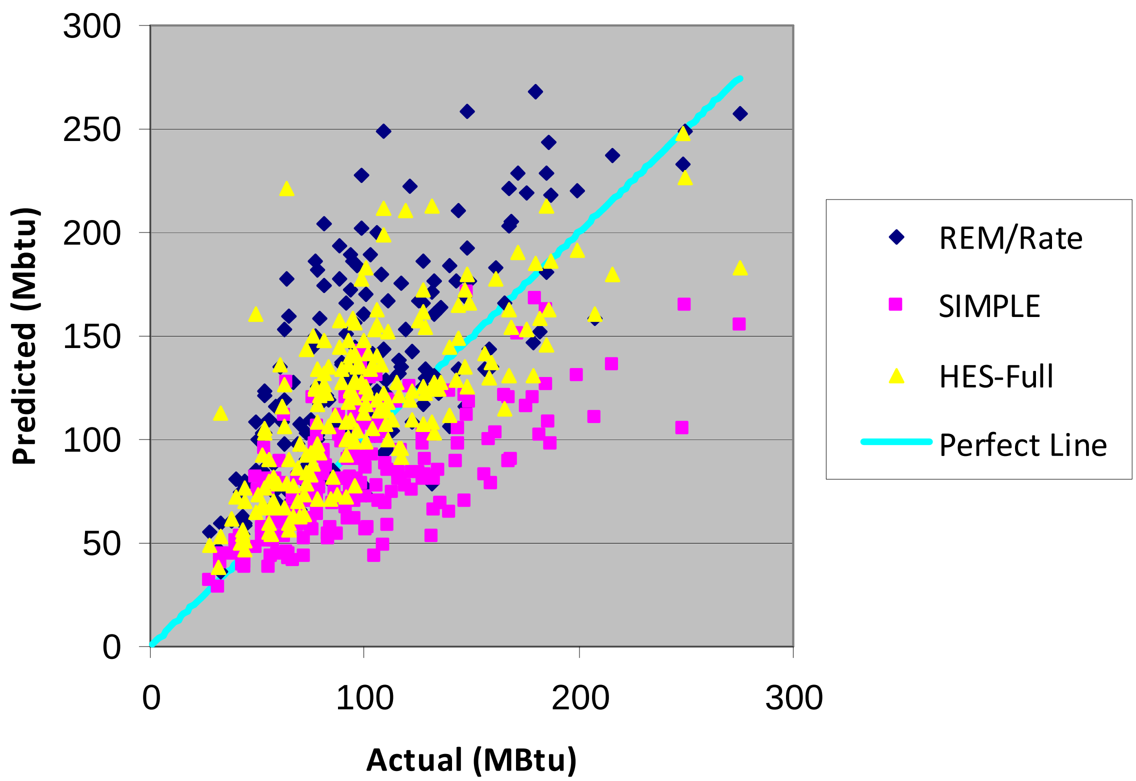


Figure 3.1 Predicted Total Energy Use vs. Weather Normalized Actual Energy Use (MBtu) (190 Homes)

Figure 3.2 illustrates the distribution of errors for total energy use. The graph shows the absolute percent error of each software tool for a given percent of homes in the sample. The line for each software tool shows its accuracy over the entire sample. The lower and flatter the line the more accurately a tool predicted total energy consumption. The mean absolute percent error for each software program is indicated with an X and the median absolute percent error is where the line for each tool crosses the 50% mark.

This chart clearly shows HES-Mid (blue line) as the least accurate since it is the highest line. SIMPLE and HES-Full are equally accurate for about 65% of homes, but then HES-Full has more errors. The quick rise after the 90% mark for all tools indicates that there are some homes for which the tools were not able to predict with any accuracy. These are likely to be the outlier homes that had issues, such as a poorly performing furnace, that the auditors were unable to observe while in the home.

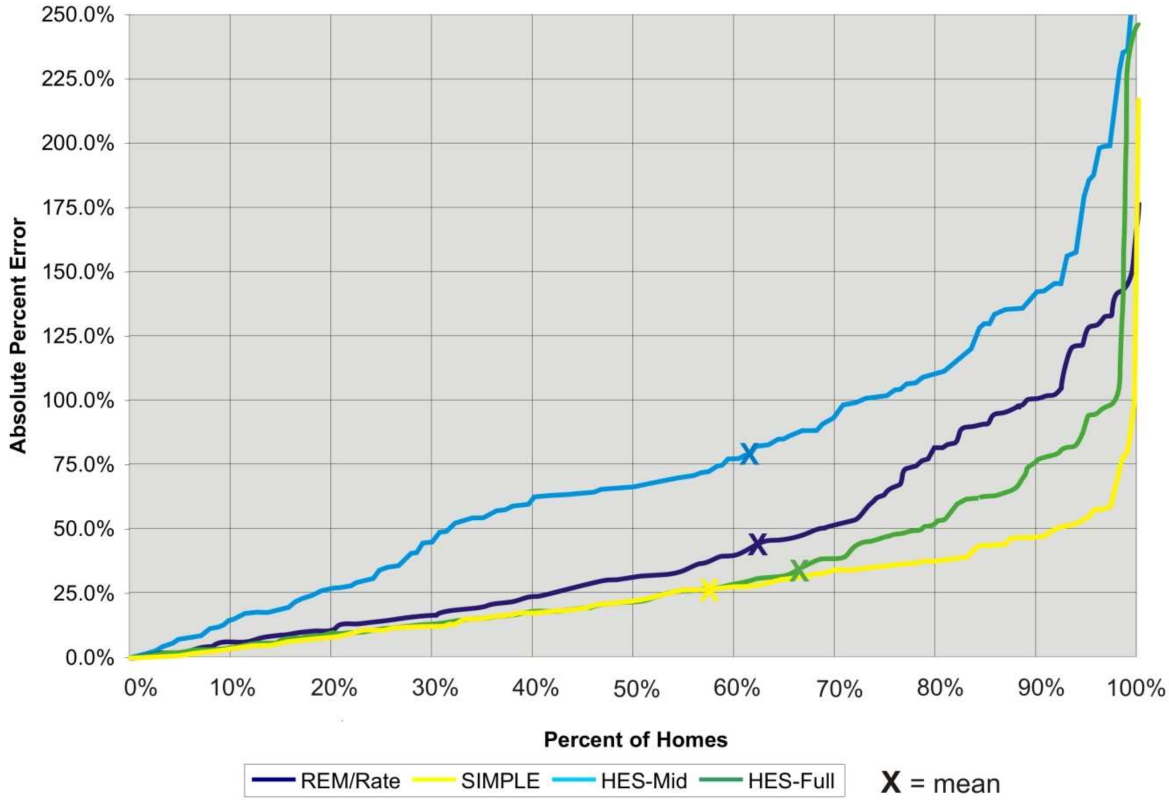


Figure 3.2 Comparison of Accuracy for Total Energy (MBtu) for 190-Home Sample

Results for Gas Use

	REM/Rate	SIMPLE	HES-Mid	HES-Full
Mean Actual Use	745	745	745	745
Mean Predicted Use	1099	625	1311	937
Mean Error	354	-120	406	192
Mean Absolute Error	387	251	701	263
Median Absolute Error	319	224	575	170
Mean Absolute Percent Error	63.7%	34.3%	123.3%	42.4%
Median Absolute Percent Error	45.9%	31.6%	100.0%	25.2%
Percent of Homes with Accurate Prediction (less than +/- 25%)	37.9%	41.6%	20.5%	53.2%
Percent of Homes w/ Large Error in Prediction (larger than +/- 50%)	45.3%	17.4%	66.8%	30.5%

Table 3.6 Total Therms for 173 Homes with Gas Heat

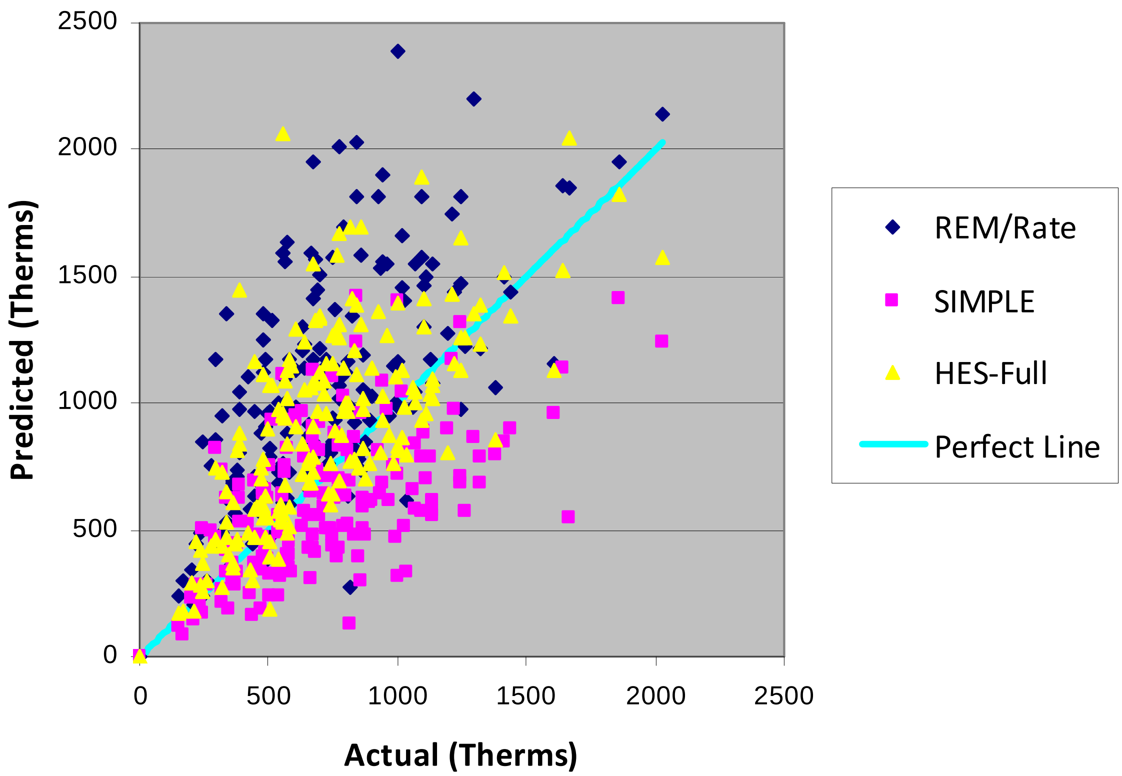


Figure 3.3 Predicted Natural Gas Use vs. Weather Normalized Actual Gas Use (Therms) (190 Homes)

Table 3.6 demonstrates results for therms that are similar to the results for total energy. HES-Full had the greatest number of accurate predictions, but SIMPLE had the least mean absolute error and the fewest poor predictions of the tools reviewed. SIMPLE had the smallest bias, as evidenced by the -120 therm mean error. The negative value indicates a tendency to under-predict while the other programs consistently over-predicted for therms. For the most part, the relative accuracy of the programs was consistent for all the cohort groups, regardless of size or age of home, or climate zone. There was a trend whereby REM/Rate had smaller errors the newer the home and the colder the climate. This trend was also apparent to a lesser extent with HES-Full. Both the number of good predictions increased and the mean absolute percent error decreased with this trend for both REM/Rate and HES-Full. SIMPLE had much less variation in its rate of errors fluctuating from 27% to 38% across all cohorts. That compares to a range of 30% to 52% for HES-Full, and 29% to 90% for REM/Rate. Size of home had a very minor effect on accuracy for SIMPLE, but as Tables 3.7 and 3.8 indicate, it had a moderate effect on REM/Rate and HES-Full as the error increased as house size decreased.

	REM/Rate	SIMPLE	HES-Mid	HES-Full
Mean Actual Use	886	886	886	886
Mean Predicted Use	1250	705	1428	1048
Mean Error	364	-181	355	162
Mean Absolute Error	412	297	752	264
Median Absolute Error	346	267	576	182
Mean Absolute Percent Error	57.8%	34.3%	112.2%	36.2%
Median Absolute Percent Error	40.4%	31.9%	83.4%	22.6%
Percent of Homes with Accurate Prediction (less than +/- 25%)	41.1%	38.9%	22.1%	54.7%
Percent of Homes w/ Large Error in Prediction (larger than +/- 50%)	40.0%	17.9%	62.1%	25.3%

Table 3.7 Total Therms for Larger-than-Median Size Homes (86 Homes)

	REM/Rate	SIMPLE	HES-Mid	HES-Full
Mean Actual Use	585	585	585	585
Mean Predicted Use	926	533	1181	811
Mean Error	342	-51	465	226
Mean Absolute Error	359	200	644	261
Median Absolute Error	295	181	564	146
Mean Absolute Percent Error	70.3%	34.2%	135.9%	49.4%
Median Absolute Percent Error	59.0%	31.4%	100.0%	31.7%
Percent of Homes with Accurate Prediction (less than +/- 25%)	34.7%	44.2%	18.9%	51.6%
Percent of Homes w/ Large Error in Prediction (larger than +/- 50%)	50.5%	16.8%	71.6%	35.8%

Table 3.8 Total Therms for Smaller-than-Median Size Homes (86 Homes)

The average house size in the larger-than-median group was 2,690 square feet, and the average size for the smaller-than-median group was 1,364 square feet. Mean actual use for the larger homes was 886 therms versus 585 therms for the smaller homes cohort.

	REM/Rate	SIMPLE	HES-Mid	HES-Full
Mean Actual Use	617	617	617	617
Mean Predicted Use	1089	643	1152	869
Mean Error	473	27	402	252
Mean Absolute Error	494	210	643	284
Median Absolute Error	430	182	578	198
Mean Absolute Percent Error	91.1%	35.8%	133.1%	52.3%
Median Absolute Percent Error	84.6%	30.9%	100.0%	41.2%
Percent of Homes with Accurate Prediction (less than +/- 25%)	22.0%	44.0%	13.2%	42.9%
Percent of Homes w/ Large Error in Prediction (larger than +/- 50%)	67.0%	23.1%	74.7%	42.9%

Table 3.9 Total Therms for Homes built before 1960 (86 Homes)

Tables 3.9 and 3.10 demonstrate how the programs tended to improve in accuracy with newer homes. It is clear from Table 3.9 that REM/Rate was not accurate in predicting therm use for houses built before 1960. The mean absolute percent error was 91.1%, and 67.0% of homes were predicted with poor results. HES-Full predicted somewhat better for this same group with a mean absolute percent error of 52.3% and with 42.9% of the homes predicted well. SIMPLE had the lowest mean absolute error at 35.8% and predicted well for 44.0% of the homes. SIMPLE still did much better at avoiding large errors at 23.1% compared to 42.9% for HES-Full and 67.0% for REM/Rate.

	REM/Rate	SIMPLE	HES-Mid	HES-Full
Mean Actual Use	808	808	808	808
Mean Predicted Use	949	538	1279	910
Mean Error	141	-269	378	102
Mean Absolute Error	199	280	660	210
Median Absolute Error	174	225	566	120
Mean Absolute Percent Error	29.4%	33.2%	98.6%	30.4%
Median Absolute Percent Error	22.7%	34.2%	65.0%	19.0%
Percent of Homes with Accurate Prediction (less than +/- 25%)	58.7%	34.8%	28.3%	63.0%
Percent of Homes w/ Large Error in Prediction (larger than +/- 50%)	17.4%	13.0%	58.7%	17.4%

Table 3.10 Total Therms for Homes Built after 1989 (41 Homes)

The number of good predictions increased for REM/Rate and HES-Full for homes built after 1989, and there were considerably fewer poor predictions for these programs. REM/Rate and HES-Full had percentage rates of good predictions for therm use that were above average for them in this sample. This was especially true for REM/Rate. REM/Rate had a mean absolute error of 29.4%, HES-Full had 30.4% and SIMPLE had 33.2%. With this cohort, SIMPLE still had the lowest number of poor predictions.

The results for all three software in predicting therm use improved in the colder climate of Bend compared to the milder climate of Portland. HES-Full had the smallest improvement and REM/Rate had the greatest improvement. SIMPLE had the lowest mean absolute percent error in both cohorts, and the fewest number of poor predictions. Part of the improved accuracy observed in the colder climate may actually be caused by another factor: age of the home. As mentioned above, the Bend sample has a large percentage of homes built after 1980. All of the programs tend to predict better for newer homes. By contrast, the Portland sample had a high percentage of homes built before 1960. All the software tended to predict worse for the older homes.

	REM/Rate	SIMPLE	HES-Mid	HES-Full
Mean Actual Use	734	734	734	734
Mean Predicted Use	1118	626	1153	917
Mean Error	384	-108	419	183
Mean Absolute Error	420	254	728	261
Median Absolute Error	364	214	591	170
Mean Absolute Percent Error	70.3%	35.3%	132.6%	42.7%
Median Absolute Percent Error	59.5%	31.6%	100.0%	23.6%
Percent of Homes with Accurate Prediction (less than +/- 25%)	33.8%	40.5%	18.9%	53.4%
Percent of Homes w/ Large Error in Prediction (larger than +/- 50%)	50.0%	19.6%	68.2%	30.4%

Table 3.11 Total Therms for Portland Area Homes (139 Homes)

	REM/Rate	SIMPLE	HES-Mid	HES-Full
Mean Actual Use	790	790	790	790
Mean Predicted Use	1018	620	1146	1018
Mean Error	228	-170	357	228
Mean Absolute Error	252	242	591	269
Median Absolute Error	174	227	508	198
Mean Absolute Percent Error	36.8%	29.9%	85.5%	41.1%
Median Absolute Percent Error	26.0%	32.7%	69.9%	31.8%
Percent of Homes with Accurate Prediction (less than +/- 25%)	52.4%	45.2%	26.2%	52.4%
Percent of Homes w/ Large Error in Prediction (larger than +/- 50%)	28.6%	9.5%	61.9%	31.0%

Table 3.12 Total Therms for Bend Area Houses (34 Homes)

For the Bend area homes, both HES-Full and REM/Rate had the percent of homes with good predictions at 52.4%, while SIMPLE did somewhat worse at 45.2% of homes. The mean absolute percent error rate of 36.8% for REM/Rate was the second lowest of any cohort group for REM/Rate. Interestingly, REM/Rate still had poor predictions for 28.6%

of the cohort. This indicates that this software tool did not accurately measure energy use for a quarter of homes in the cohort in which it performed best overall.

Results for Electrical Use

The analysis of the electrical use predictions did not provide the clear patterns of performance that were evident in the therms use. As the results in Table 3.13 indicate, SIMPLE predicted electrical use with the lowest mean rate of absolute percent error, and produced the lowest percentage of poor predictions and one of the highest percentages of good predictions, but showed a large bias toward under-prediction. Overall, the differences among the programs were not extreme, yet SIMPLE predicted electrical use the best across every cohort group.

	REM/Rate	SIMPLE	HES-Mid	HES-Full
Mean Actual Use	9426	9426	9426	9426
Mean Predicted Use	9711	7802	10451	9616
Mean Error	285	-1624	530	190
Mean Absolute Error	3304	2892	6550	3057
Median Absolute Error	2373	1902	4511	2053
Mean Absolute Percent Error	40.4%	30.3%	93.0%	36.7%
Median Absolute Percent Error	29.3%	26.4%	49.0%	27.0%
Percent of Homes with Accurate Prediction (less than +/- 25%)	43.7%	47.9%	27.9%	48.9%
Percent of Homes w/ Large Error in Prediction (larger than +/- 50%)	26.8%	18.9%	47.9%	22.6%

Table 3.13 Total Electricity (kWh) for 190-Home Sample

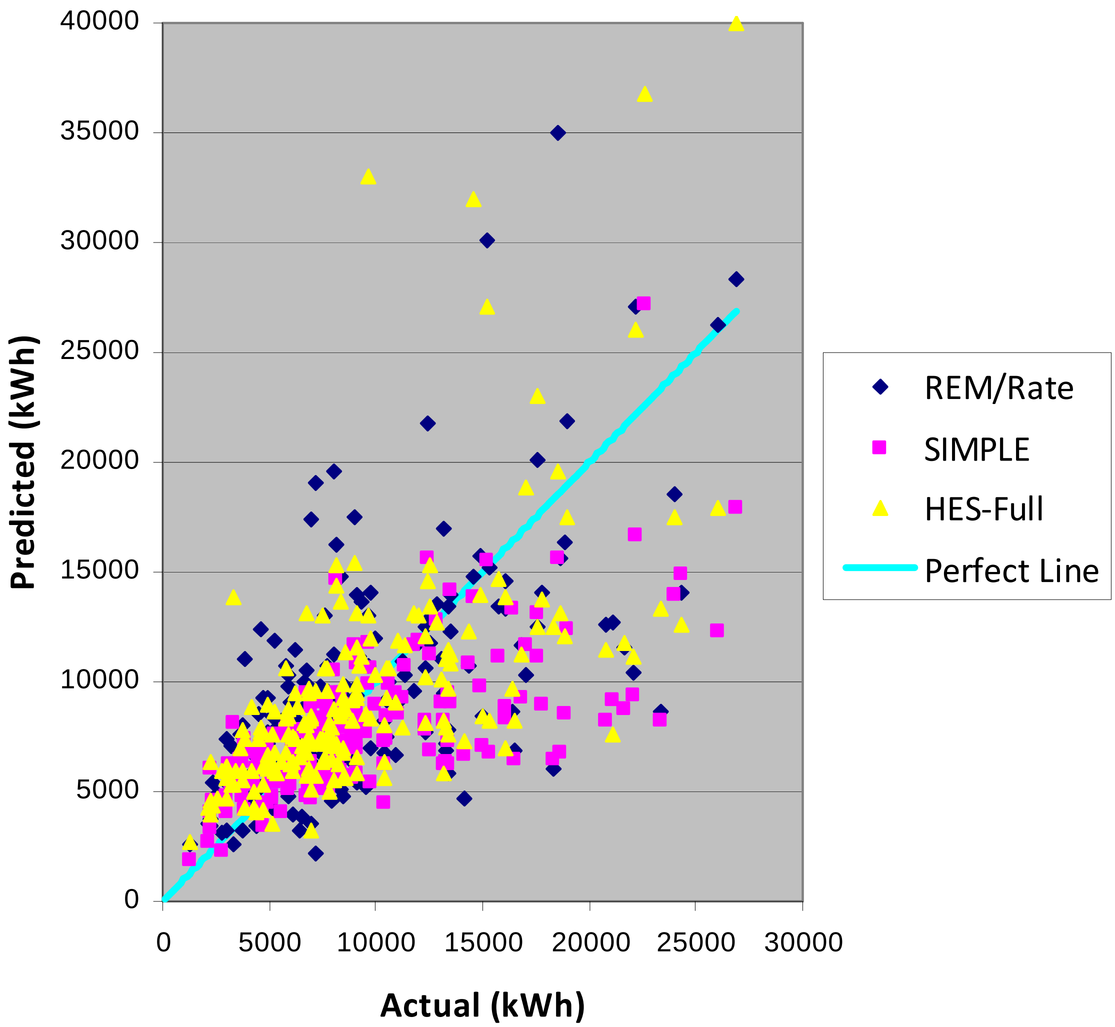


Figure 3.4 Predicted Electric Use vs. Weather Normalized Actual Electric Use (kWh) (190 Homes)

Table 3.13 includes homes with electric heating. In Table 3.14, homes heated with gas have been isolated in order to consider the ability of the software programs to calculate non-heating energy usage.

	REM/Rate	SIMPLE	HES-Mid	HES-Full
Mean Actual Use	8988	8988	8988	8988
Mean Predicted Use	8795	7277	9965	8653
Mean Error	-193	-1711	977	-335
Mean Absolute Error	3052	2858	6421	2767
Median Absolute Error	2320	1830	4120	2043
Mean Absolute Percent Error	40.1%	30.9%	96.7%	35.6%
Median Absolute Percent Error	29.8%	27.6%	49.0%	27.1%
Percent of Homes with Accurate Prediction (less than +/- 25%)	48.0%	52.6%	30.6%	53.8%
Percent of Homes w/ Large Error in Prediction (larger than +/- 50%)	29.5%	20.8%	52.6%	24.9%

Table 3.14 Total Electrical Use in kWh for Homes Heated with Gas (173 Homes)

In Table 3.14 the predictions improved marginally with the 17 electrically heated homes excluded from the sample. All three programs have the percentage of homes with good predictions slightly higher than it was for all homes. Conversely, the percentage of homes with poor results increased for each program with the 17 homes excluded. This would indicate that the programs predict electrical usage for heating better than for base load; when electric heat and base load are combined in the full sample, predictions of electrical use improve.

In evaluating the usefulness of a software tool to generate an EPS, the ability to accurately predict total energy use is very important. SIMPLE produced the best results when looking at total energy use predictions. Moreover, SIMPLE had better predictions for nearly every cohort and for both fuel types. An in-depth review of the sample data does indicate trends whereby HES-Full and REM/Rate had a greater number of good predictions than SIMPLE for a type of energy within a subset of the sample. The best example of this is the prediction of therms for homes built after 1989. But in nearly every cohort and for every fuel type, SIMPLE produced the fewest significant errors. This finding is somewhat surprising considering how much detailed information is entered into the other tools. A more in-depth review of this data could be useful in the refinement of a software tool for delivering an EPS score. Further analysis might reveal which conditions generate poor scores for the different programs and whether these reasons are systemic to the software.

These findings echo those found in other studies (Mills, 2002; Pigg & Nevius, 2000; Pigg, 2002). But as with any endeavor, additional studies to replicate these findings would be useful. While outside the scope of the pilot, another line of study would be to investigate the relative merits of other approaches such as calibrating modeled predictions with household or regional utility bill data or average savings for various energy upgrades.

Another means of evaluating the ability of the tools to deliver an EPS energy score is to compare the distributions of EPS Energy Scores. The EPS energy score distributions indicate the explanatory power of each tool. In other words, with occupant behavior input removed, does a given tool provide a range of values that match those of the population it is attempting to model?

As explained in the methodology section, the inputs for each home were modified for each tool to create an occupant-independent EPS Energy Score. All reported behavior from homeowners was changed to reflect typical or average energy use, and the number of occupants per home was based on national averages for the number of bedrooms.

Ideally, the distributions of scores would be compared to the distribution of regional energy use data that has been normalized for occupant behavior. However, this empirical data does not exist. Therefore, the next best data set is the weather normalized actual use data from the pilot’s sample, which was used to create the following comparisons.

	Actual	**REM/Rate**	**SIMPLE**	**HES-Full**
Mean Value	101	143	94	134
Quartile Distribution Values				
Minimum Value	28	37	32	49
First Quartile Value	71	102	70	105
Median Value	95	144	89	132
Third Quartile Value	122	177	115	161
Maximum Value	275	290	185	276

Table 3.15 EPS Scores for Total Energy (MBtu) for 190-Home Sample

Table 3.15 shows that the tool with the closest distribution of scores to actual use was SIMPLE. The SIMPLE quartile distribution tracked actual usage very closely from the minimum value through the third quartile. The maximum value for SIMPLE scores was well below the maximum value for actual use. This may be because the model was unable to predict well for very high usage homes, or that high usage homes cannot be modeled accurately because the usage is occupant driven or caused by mechanical failure that modeling tools cannot measure. Further research of high usage homes would allow this issue to be analyzed more fully.

A comparison of Table 3.15 and Table 3.5 shows that the mean EPS scores were all 10 to 15 MBtu higher than the predictions had been. The main factor behind this is that the time weighted thermostat settings for each homeowner were replaced with fixed thermostat settings for heating and cooling. While each program had accounted for energy saved due to setbacks, the EPS scores do not take that into account as setbacks are occupant determined. Although this change in thermostat settings to adjust from predictions to scoring did not always result in lower energy predictions, it was the case for the vast majority of homes in our sample.

Figure 3.5 is a graphic representation of the distributions described in Table 3.15. The EPS energy score distributions were divided into deciles rather than quartiles for this graph. This was to better indicate the entire distribution from minimum to maximum. The apex of each curve represents the median value for that tool. The minimum EPS energy score value is indicated by the point at which the line leaves the x-axis at the left end of the scale. The maximum value is shown as the point at which the line returns to the x-axis at the right end of the scale. It is apparent that the SIMPLE distribution closely matches that of actual use for the first 8 deciles, after which the 9th and 10th deciles of actual use stretch towards higher values. It should be reiterated that the actual use data on this graph has not been controlled for occupant behavior because this is not possible with available data. It is shown here simply to give the best available reference to actual energy use possible for the different EPS Score distributions.

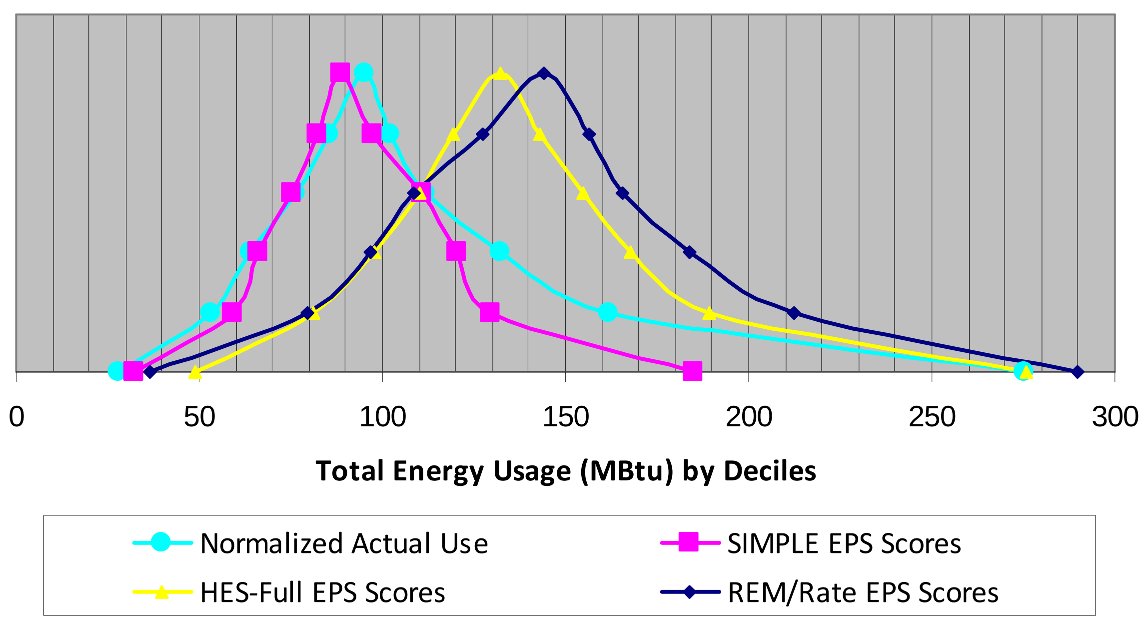


Figure 3.5 Comparative Distribution of EPS Scores (190 Homes)

Audit Time

Factors Effecting Audit Difficulty and Time

At the conclusion of 302 home audits and data entry, the field technicians were asked to describe the circumstances that added to the difficulty and time of an audit. These factors are not specific to any one tool and therefore they may vary in their applicability and impact from tool to tool. Not surprisingly, there are many parallels between these factors as illustrated in Table 3.13.

Easier and Faster	More Difficult and Time Consuming
Small house size	Large house size
Simple house geometry	Complicated house geometry Different eave lengths
Single story	Multiple stories
Conditioned basements	Combined basement and crawl spaces
Little or no remodeling	Multiple remodels
Similar windows throughout	Different window types throughout
No shading on windows	
All ducts in conditioned space	Ducted heating system Supply duct in ceilings Unusual duct blasting results
Two-person auditing team	
	Rain (difficult to record notes)
	Appliances located in attic/crawl spaces Difficult to locate appliance and mechanical equipment information Older appliances and mechanical systems with little information
Homeowner is less talkative	Homeowner is more talkative

Table 3.13 Factors Effecting Audit Difficulty and Time

Auditing protocols that require fewer of the difficult factors will inevitably take less time. Also, an auditor may use his or her time more efficiently if these factors are taken into consideration when scheduling audits.

Time Estimates for Each Tool

For each tool, field technicians were asked to estimate the time required to audit a specific sample home and run the software. They were to assume that the auditing protocol and input forms were fully developed. Their estimates are outlined in Table 3.14. The range in estimates appears to correspond to technician personality and their recorded audit times. Technicians who were particularly methodical and who took more time to audit consistently estimated longer audit and software entry times.

Tool Activity	Tech 1	Tech 2	Tech 3	Tech 4	Tech 5	Average
REM/Rate Home Audit	100	210	180	150	100	148
REM/Rate Software	45	45	45	45	45	45
					REM/Rate TOTAL	**193 mins.**
SIMPLE Home Audit	60	X	60	60	60	60
SIMPLE Software	15	X	15	7	20	14
					SIMPLE TOTAL	**74 mins.**
HES-Mid Home Audit	120	60	90	60	100	86
HES-Mid Software	15	5	15	5	15	11
					HES-Mid TOTAL	**97 mins.**
HES-Full Home Audit	120	120	90	120	150	120
HES-Full Software	60	40	45	60	30	47
					HES-Full TOTAL	**167 mins.**

Table 3.14 Estimated Time by Technician (in minutes)

Generally, the field technicians estimated that the REM/Rate audits would take the longest and the average from their estimates was 148 minutes, a half hour longer than the next longest estimate for HES-Full. The technicians also estimated that REM/Rate and HES-Full would take the longest to enter into the software, 45 and 47 minutes, respectively. This reflects the number and detailed nature of the inputs required by these tools. SIMPLE was estimated to be the fastest tool overall with a significantly faster audit time of 60 minutes and software time of 14 minutes.

Better input forms and auditing protocols might reduce audit times for all tools, though at some point, there is a limit to time savings since all the tools tested required talking with the homeowner, determining the square footage of a home, and noting information about each major appliance. Likewise, a user-friendly software interface might reduce software entry times and the time it takes to generate a home energy analysis report. With these improvements, the EPS team estimates that the total times for the tools might be reduced by 15 to 30 minutes.

Ease of Use

The field technicians were surveyed about the relative ease of using the software tools. They reported that familiarity was the most critical factor and that the more they worked with the software tools, the easier the tools were to use. None of the software tools were described as difficult. The technicians' suggestions for improvement focused on changing features that made data entry difficult and features that did not easily accommodate unusual data, especially data pertaining to conditions found in older homes.

Home Energy Saver (HES) was an online tool that was not always operating, which proved very challenging for data entry. One field technician who used HES frequently reported that it was offline 3 or 4 times a day. The full version of HES required many detailed inputs about appliances that would seemingly have little effect on the results. This led those team members who worked with it to suspect that some of the time entering the data was ultimately unnecessary.

Interestingly, the field technicians did not prefer the process of generalizing data or guessing, instead preferring specific questions with precise, preferably quantified answers. Appliance information was often not found on appliances, making the research for this information time consuming. The technicians found dropdown menus easier than fill-in blank fields. Ease of navigation, consistent language, and a good reference manual were also mentioned as helpful.

Level of Training or Expertise Required

Home energy auditing requires a certain basic set of skills and knowledge independent of the methodology:

- Friendly and reassuring people skills
- Basic math and geometry skills
- Basic building science knowledge
- Heat transfer and thermal boundaries knowledge
- Specific testing knowledge
- Familiarity with a variety of mechanical systems
- Familiarity with a variety of appliances
- Time management skills
- Carefulness and thoroughness

In general, good auditing skills transfer well from one method to another, though there are some differences in the skills needed for each of the software tools. REM/Rate required a more technical orientation and the ability to do work with complex geometry. SIMPLE required the ability to make judgments using approximations. HES-

Mid was quite simple and nontechnical, while HES-Full required a level of detail beyond even REM/Rate, though that detail was nontechnical.

See the EPS Auditor Training section in Recommendations for a description of proposed requirements for auditor education.

Survey Results

During the course of the pilot, periodic surveys of stakeholders were conducted to solicit feedback and help guide the development of the EPS. These surveys covered a range of topics including attitudes toward home energy efficiency, the usefulness of energy auditing and analysis, comprehension of energy-related terms, score card preferences, and feedback from those who had a home audit during the pilot.

The salient points found in the survey results are listed, followed by a more detailed discussion of each point.

All Stakeholders

A. The EPS concept has considerable appeal for stakeholders.
B. The ideal price of an EPS would be $100 with a cap of $200.
C. Cost is a major issue and the common language for understanding energy and making improvements.

Homeowners

D. The EPS must be presented in a clear and objective manner from a trustworthy source.
E. Carbon emissions are relevant and very important to homeowners.
F. Homeowners are most familiar with energy use in terms of watts and kilowatt hours.
G. Homeowners want information on energy performance and where to make improvements.

Homeowners who had an EPS audit during the pilot

H. Home energy audits are perceived as useful by homeowners for a variety of reasons.
I. Homeowners thought that their homes were more energy efficient than preliminary results indicated.
J. Home energy auditing helps highlight the need for air and duct sealing.
K. Financial incentives (from Energy Trust of Oregon in the state of Oregon) are important to making home energy upgrades about half of the time.
L. The Internet and talking with people are major sources of home energy information.

Realtors

M. Realtors are enthusiastic about the EPS as an option at the time of sale, but most do not want to see EPSs mandated.

Builders and Home Performance Contractors

N. While generally favorable toward the EPS, builders (particularly Home Performance [HP] contractors) expressed concerns about its specifics.

Survey Format	Respondents	Number of Respondents	Topics
Written Questionnaire	Homeowners at green home events and home shows	50	General attitudes toward energy efficiency and EPS components.
Online Survey	Homeowners living in Earth Advantage certified homes.	60	General attitudes toward energy efficiency and EPS components.
PECI-led Focus Group	Homeowners	40	General attitudes toward energy efficiency and EPS components.
Online Survey	Homeowners who had an EPS pilot audit	29	Questions about the usefulness of the audit and the Interim EPS Report.
Online Survey	Realtors	169	Realtor perceptions of buyers' and sellers' attitudes towards energy efficiency and a Realtor's view of the EPS components
Written Questionnaire Online Survey	Builders	7 50	Builder perceptions of their client's attitudes towards energy efficiency and a builders' view of the EPS components
Written Questionnaire	Green Building Professionals Green Certified Realtors	7 10	Specific questions about the EPS and feedback on score sheet graphic layout and elements
Online Survey	Home Performance Contractors	7	HP contractor perceptions of their clients' attitudes toward energy efficiency and HP contractor view of EPS components

Table 3.15 Summary of EPS Pilot Surveys

Responses from All Stakeholders

A. The EPS concept has considerable appeal for stakeholders.
The EPS is a concept that has a lot of traction with every group that was surveyed. For a homebuyer, the comparative quality of the scores is very appealing. From an existing homeowner's perspective, a report that outlines specific steps to take and the costs associated with those steps is important. Builders and Realtors interested in green homes think that the EPS has measurable value for the energy component of these homes, and the majority viewed the EPS as an opportunity to market that value.

Homebuyers
One hundred percent of homeowners surveyed said that an EPS would have some use when buying a home, with 38% indicating that it would be *so useful it should be mandatory*, 45% indicating that it would be *very useful*, and 13% saying that it would be *somewhat useful*.

Homeowners
Sixty-four percent of all homeowners wanted a customized list of energy efficiency steps with estimated costs, and 58% wanted testing of their homes' energy systems measuring the efficiency of the building, heating and cooling systems, appliances, and lighting.

Builders reported that 50% of their clients would be *very interested* in an EPS, 44% would be *somewhat interested*, and 6% would *not be interested*. Forty-five percent of builders thought that the EPS should be mandatory at the time of sale, and 55% thought that it should be optional. These builder responses reflect a client base of both new homebuyers and existing homeowners.

Builders
Ninety-one percent of builders said that they see themselves using the EPS as a competitive advantage in marketing homes. A number of them saw the EPS as a potential tool to measure and validate more energy efficient homes. This thought was expressed in the following builder comment from the survey:

> "This would allow us to put a specific dollar value on the savings offered by the sustainable features in their home from a credible third party."

Realtors
Ninety percent of Realtors said that they see themselves using the EPS as a competitive advantage in marketing homes, and 80% would like to see it on the RMLS.

B. The ideal price of an EPS audit would be $100 with a cap of $200.
In every survey administered, the majority of the respondents indicated that $100 was the preferred price, with some tolerance for pricing up to $200. If this is the public's

ceiling for cost, this has implications for the economics of the EPS, how it is structured, and what is possible. In order for the EPS to be a viable long-term and widespread tool, it will have to find a successful combination of efficiency, economies of scale, and possibly subsidies or incentives. Other options for lowering the cost burden would be to roll it into a mortgage or into home equity financing, or incentives by utility or government agencies.

C. Cost is a major issue and the common language for understanding energy and making improvements.

The cost of making energy upgrades was of main importance to people in every survey. Cost was listed consistently as the primary barrier to making energy improvements by 80% of the homeowners, a fact that was echoed by builders and Realtors. Furthermore, homeowners indicated that they wanted to know the cost of the energy improvements, as well as their returns on investment.

This is not to say that there was not significant ideological motivation expressed for conserving energy. Among green home respondents, conserving energy for environmental reasons was the second most cited reason for wanting to make energy improvements. However, costs may ultimately trump ideology when it comes to acting on motivations.

For these reasons, it is important that energy costs be included on the EPS score sheet and Energy Analysis Report when possible. Listing the dollar costs on the score sheets is problematic over the long term due to the variability of energy costs, and this must be made clear on the document. However, the costs associated with scores could eventually be dropped as members of the public learn to think in terms of energy metrics, just as they have learned to use MPG despite fluctuating fuel prices.

<u>Responses from Homeowners</u>

D. The EPS must be presented in a clear and objective manner from a trustworthy source.

One of the points to come out of the Portland Energy Conservation, Inc. focus groups was the clear need for a presentation format that was unambiguous and easy to understand. While the same level of distrust about the EPS was not evident from homeowners answering the surveys, the focus groups highlighted this potential as the participants expressed various forms of suspicion with everything from the source of the numbers to who was presenting the information.

In subsequent versions of the score sheet, these concerns were addressed by offering more explicit context and removing unfamiliar words. This care should be extended and represented consistently in all aspects of the EPS, from the promotional materials to the auditors.

This also underscored the value of having a third-party audit for official EPS scores. While it may be that the EPS protocol and software becomes universally available for the purposes of analyzing a home, it is essential that the official EPS auditing be conducted by third-party auditors so there is no question of any bias or validity of an EPS score. Given that 80% of builders and 60% of Realtors indicated that good EPS scores would positively impact the value of a property, the irrefutable objectivity of an EPS score is imperative.

Related to this were the largely negative associations many of the focus group participants had toward the term *green home* (this concept was not tested in any of the online or written surveys with homeowners). This indicates that attention must be paid to how the EPS is associated with green homes generally. There is nothing inherently green about the EPS tool, though the energy and carbon scores can undoubtedly be used to measure and motivate the green home strategy of energy efficiency. In general, it is recommended that the EPS be presented primarily as a tool for measuring home energy consumption and that it not be confused as a marker of a green home. In other words, care should be exercised in reflecting the EPS as a performance metric and not a brand or program since this causes confusion when discussing LEED-H®, ENERGY STAR®, or Earth Advantage® programs. On the other hand, an EPS can help to verify green claims or labels, while hopefully diminishing unwarranted claims and greenwashing.

E. Carbon emissions are relevant and very important to homeowners.

The term *carbon dioxide* was very familiar to the vast majority of people surveyed, and it was important to them. Over 90% of the people surveyed said that knowing the carbon emissions associated with their energy score was important to them, and only 9% of respondents said that it was not important to them.

The relevance of the carbon score is likely to grow as carbon cap and trade assigns a dollar value to carbon emissions and it becomes a greater part of economic life.

F. Homeowners are most familiar with energy use in terms of watts and kilowatt hours.

There are many units for measuring energy and some of these vary in meaning from country to country. One goal of the pilot was to find a unit of measurement that was unambiguous and that had traction with the public in order to minimize the learning necessary when introducing the EPS. While it has taken time for miles per gallon to become a common term, it may have taken even longer if the terms *miles* and *gallons* were not already familiar.

In the United States, homeowners are most frequently exposed to therms and kilowatt hours on utility bills and, less frequently, to the term million British thermal units or MBtu. Homeowners were surveyed about energy-related terms. The terms with which they were most familiar were *watts*, *kilowatt hours,* and CO_2 as demonstrated in Table 3.16.

100 watts	84%
Kilowatt hours (kWh)	80%
CO_2	80%
Carbon dioxide emissions	73%
Million Btu (MBtu)	45%
Therms	45%

Table 3.16 Homeowner Familiarity with Energy-Related Terms

G. Homeowners want information on energy performance and where to make improvements.

While the cost of making changes is the number one perceived obstacle for making energy efficiency upgrades (82%), the second most cited reason was *knowing where my home needs improvement* (47%). When asked what would help them make decisions about home energy improvements, homeowners indicated that testing and a list of improvements were important, likely because they thought of testing as the basis for creating a credible list of improvements. Sixty-four percent of respondents selected *testing the home's energy systems by measuring the efficiency of the building, the heating and cooling systems, the appliances and lighting*. Sixty one percent of respondents indicated they would like a customized list of energy efficiency steps to take with estimated costs. This was closely followed by 59% of respondents choosing *a report prioritizing the energy efficiency steps ranked by cost effectiveness*, and 58% selecting *a written report describing the efficiency level of different parts of the home*.

<u>Responses from Homeowners Who Had an EPS Audit during the Pilot</u>

H. Home energy audits are perceived as useful by homeowners for a variety of reasons.

All of the homeowners who had their homes audited as part of the pilot and responded to the survey found the audit useful: 62% reported *very useful*, 27% *somewhat useful*, and 12% *only a little useful*. The EPS team found the results positive in light of the fact that data collection was the primary focus of the audits.

The parts of the process that respondents cited as useful are listed here in order of importance: talking with the tester (85%), the blower door test (74%), and the duct pressurization test (73%). Interestingly, 70% of homeowners reported that *taking the time to consider the energy performance of their home* was a part of the usefulness of the process. In general, it seemed useful for the homeowner to be present during the testing for the time, experience, and information that this event afforded them.

I. Homeowners thought their homes were more energy efficient than the preliminary results indicated.
Homeowners participating in the pilot received an Interim EPS Report listing the energy related elements and a rating of the performance as *poor*, *average*, or *good* as described in the Reporting Results section of Methodology.

Of the test home respondents, 46% said that the audit and report revealed that their house was less efficient than they thought. Slightly fewer respondents, 39%, found that their houses were about as efficient as they thought, while 15% found that their houses were more efficient. Stated another way, it is possible that 46% of the homeowners may have overestimated the efficiency of their homes and therefore may have had little motivation to seek energy improvements without some form of feedback about their homes' energy performance.

J. Home energy auditing helps highlight the need for air and duct sealing.
In early homeowner surveys, the energy upgrades that homeowners reported performing most frequently were replacing older appliances with newer, energy efficient models (58%), installing insulation (46%), upgrading the heating and cooling system with a more efficient system (40%), and replacing single-paned windows with energy-efficient windows (40%). What was of interest was how few people reported air sealing (28%) and duct sealing (16%) given the relative cost effectiveness of these measures compared to windows. Possible barriers to air and duct sealing could include not understanding the potential impact of these measures, a lack of knowledge about how to do them, or not knowing who to hire to do the work.

In contrast to these earlier homeowner results, homeowners who had testing done on their home reported that they planned to undertake air sealing and duct sealing and wrapping much more frequently, 54% and 46%, respectively. The next most common responses were replacing incandescent bulbs with compact fluorescent bulbs (42%), installing insulation in the attic (39%), and replacing older appliances (35%). It appears that some combination of testing for air and duct tightness and the preliminary results and recommendations helped to make these upgrades a higher priority.

K. Financial incentives (from Energy Trust of Oregon in the state of Oregon) are important to making home energy upgrades about half of the time.
Energy Trust of Oregon (ETO) is the main conduit for utility funded financial incentives for energy upgrades in Oregon, and it is a major source of information about these incentives. Fifty-five percent of the homeowners who had an EPS pilot audit selected the response *they (ETO) are helpful, but are not a major factor in my decision making*, and 40% selected *they (ETO) make it possible for me to make the changes I want*. No respondents indicated that Energy Trust was not useful.

L. The Internet and talking with people are major sources of home energy information.
Eighty-two percent of the respondents reported getting information about home energy issues from the Internet and 63% from friends and talking with people. The next most reported source was from the media: newspapers, radio, magazines, and TV (59%), followed by green home events and shows (56%). Information from utility companies (48%) and books (41%) scored the lowest, but were not insignificant.

These sources are what one might expect of a green consumer who is information oriented, who relies on friends with similar values, and who approaches knowledgeable people to find information. This question was not asked of all homeowners, and so it is not known how this might differ for homeowners who may not be as focused on home energy performance as these respondents.

Responses from Realtors

M. Realtors are enthusiastic about the EPS as an option at the time of sale, but most do not want to see EPSs mandated.
Realtors reported that 63% of their homebuyers would be *extremely interested* in an EPS and 37% would be *slightly interested*. Realtors predicted that home seller interest in the EPS would be significantly less than homebuyers: 30% *very interested*, 60% *somewhat interested*, and 10% *not interested*. The different levels of interest on the part of homebuyers and sellers may give some insight as to why only 15% of Realtors thought an EPS should be mandatory while 84% thought it should be optional.

Even though some Realtors were unequivocal in their enthusiasm for the EPS in concept, there was significant concern about how a mandatory EPS might impact transactions.

On the positive side, one Realtor commented,

> "I support anything that will help to create categories in the minds of the average buyer and seller that help to distinguish more sustainable homes from less sustainable. I think the EPS is a good tool to use toward that end."

However, the following comment captures the concerns in light of the potential benefits:

> "It may create too much information for a homebuyer, confusing or scaring them if a home scores poorly. However, I know they would love it as new homeowners to see what steps they can take to move in a green direction. I do not think it would be helpful in a transaction, unless you know the home will score very well and you can market the information."

While Realtors offer useful insights into the issues that EPS scores may bring to home transactions, this will need to be weighed against the public good of informing homebuyers of the energy performance of their investments. Also, in terms of achieving community energy and carbon goals, there may be those interested in accelerating energy awareness and auditing that runs counter to the goals of some home sellers and their representatives.

Responses from Builders and Home Performance Contractors

N. While generally favorable toward the EPS, builders (particularly HP contractors) expressed concerns about its specifics.
Builders, not unlike Realtors, were generally enthusiastic about EPS as a concept, but their comments reflected concerns about the specifics of the EPS. Generally, they wanted the tool to be useful and add value to the process of home energy improvements.

The following comment captures the interest in seeing the development of a *good* tool:

> "The modeling needs to be very reliable and consistent so that it has the trust of purchasers, contractors and regulators. If it gets to that point, I think it will be an outstanding new tool."

Many builders had practical concerns about how the EPS might impact the context of their work as expressed in the following comments:

> "I'm worried about EPS scoring creating such a competitive environment for implementing efficiency improvements that it will force contractors to emphasize volume over quality work."
>
> "I think the energy rating is a good idea, but I also see it being confusing to homeowners when they are asked to duplicate the same services that a home performance contractor is selling. Also the rating could not do the homeowner any good if they hire out the work to the lowest bidder and it is not done right, such as over sizing HVAC systems, not insulating properly, and not doing the most energy savings measures. I know it is important to have an energy rating for the buyer, but what happens next is anybody's guess."

The EPS pilot team had a number of discussions with builders and contractors about these issues. The discussions were necessarily conceptual because the EPS auditing protocol and software were not yet defined. However, it is clear that the EPS tool needs to address the practical and programmatic concerns of builders and Home Performance contractors in order to be useful.

4. RECOMMENDATIONS

These recommendations are based on the software analysis, survey results, and related research conducted during the pilot. Following this summary is an extended discussion of each recommendation.

1. The Energy Performance Score should be developed along two tracks for audits: the EPS with energy and carbon scores and a performance profile of energy related elements of the home (EPS *score only*), and the EPS that additionally includes recommendations for energy upgrades (EPS *w/ upgrades*). Official EPS auditing for both tracks should be performed by trained and certified third-party auditors.

2. In order to offer a credible level of accuracy, EPS certified software programs should be able to predict energy use within 25% for 70% of homes and within 50% for 90% when compared to actual use. To this end, SIMPLE should be developed to meet all the EPS requirements for accuracy and reporting. The SIMPLE auditing protocol should be developed with varying levels of diagnostic testing and evaluated in the field.

3. The EPS energy score should be expressed as the total annual energy required for the house under normal conditions and be expressed in kilowatt hours per year. This score should be illustrated on a scale that also indicates the energy use of different fuels, relevant local comparisons, energy upgrades for existing homes and built to code comparisons for new homes, and community energy goals.

4. The EPS should include a carbon score that reflects the greenhouse gas emissions associated with the home's energy use. Comparisons on the carbon scale should include those listed for energy, as well as the predicted emissions if the homeowner used the most commonly subscribed renewable energy option through their utility or fuel provider.

5. The EPS should include an energy analysis report that includes an accounting of the annual estimated energy use and fuel costs for heating, cooling, water heating, and lights and appliances in the home, as well as the performance of the various energy-related elements in the home (e.g., walls, heating ducts, appliances). For existing homes, the report may also include recommendations for energy upgrades and the associated costs and predicted savings.

6. Ideally, the EPS will be a coordinated effort to ensure consistency of the core elements, including the EPS name and branding, and the standards for software, auditing, auditor training, and reporting. There is also the need for a central database to serve as a clearinghouse for EPS scores for homeowners and home buyers, as well as a Web tender portal through which contractors can offer estimates on energy upgrades to interested homeowners.

1 – Audits and Auditors

The Energy Performance Score should be developed along two tracks for audits: the EPS with energy and carbon scores and a performance profile of energy related elements of the home (EPS *score only*), and the EPS that additionally includes recommendations for energy upgrades (EPS *w/upgrades*). Official EPS auditing for both tracks should be performed by trained and certified third-party auditors.

Two EPS Tracks

The pilot team recommends that there be two EPS tracks. The basic level of home energy assessment would include the EPS score sheet and the Energy Analysis Report (EPS report), with the exception of the recommendations for energy upgrades sections. This is referred to as an *EPS score only* in this report. The more in-depth level would include an EPS report with a list of recommended energy upgrades and CAZ safety test results, and is referred to as an *EPS w/upgrades*. The distinction between these two levels is similar to the difference between a diagnostic home energy survey and a comprehensive home energy audit in the RESNET standards.

The EPS score only track would apply to new homes and to existing homes that do not want or need a list of upgrades. Instances of the latter include an EPS for a home after energy upgrades have been made and as part of a test-out EPS score, or to produce a score for a house sale.

If this approach is adopted, it will have implications for auditing protocol, auditor training, and pricing. The EPS score only process would require less auditor training, somewhat less audit time, and will therefore likely cost less than the EPS w/upgrades. See the outline of a preliminary auditing protocol in the Attachments.

The EPS w/upgrades track would provide a homeowner with useful recommendations for upgrades. In the cases of exceptionally poorly performing homes, it might also indicate the need for further analysis and remediation by a Home Performance contractor who could offer systemic solutions.

EPS Auditors

Third-Party Certified Auditors

In order to ensure a consistent quality of auditing and reporting for EPSs, it is recommended that there be trained and certified EPS auditors who conduct official EPS audits. A certified EPS auditor would need to successfully complete the auditor training, pass an examination, and undergo a period of proctoring as described in the EPS Auditor Training section of this report. (The distinction between training an auditor for EPS score only versus EPS w/upgrades is discussed in the EPS Auditor Training section, as well.)

In addition to being certified, an EPS auditor should not have any material interest in the energy work that will be or that has been performed on a home. These third-party certified audits would therefore remove any potential conflict of interest between performing and measuring the energy upgrades, and offer the homeowner a means of verifying the quality of the work.

It is further recommended that only the official EPS results are recorded in the EPS database that is the source of scores for homebuyers, Realtors, lenders, energy programs, and governmental agencies.

Unofficial EPS Auditing

The EPS team also recommends that EPS methodology and software be made publicly available so that anyone can use it to estimate home energy performance. These unofficial audits would be useful for contractors and design professionals in analyzing current and potential energy performance. Even curious and do-it-yourself (DIY) homeowners can use the software to better understand how different factors impact their score. These homeowner-generated scores may vary considerably from official scores due to their estimates for air and duct tightness. Ideally, such a DIY interactive tool could be offered for use on the EPS Web site, though it would be important to visually distinguish these informal scores from official EPSs.

As a cost-saving and effort-saving strategy, energy conservation programs could allow contractors to perform their own EPSs as the initial test-in score and only use a third-party certified auditor for the test-out. This method would require contractors to provide homeowners with disclosure statements regarding the potential conflicts of interest of acting as auditor and contractor for a particular home. This approach would also require a more stringent quality assurance process.

2 – Modeling Software

In order to offer a credible level of accuracy, EPS certified software programs should be able to predict energy use within 25% for 70% of homes and within 50% for 90% when compared to actual use. None of the software programs tested met these standards, though SIMPLE came the closest, as shown in Figure 4.1. Any of the software programs tested could be changed to the proposed standards. Hopefully, the EPS will spur the development or improvement of many tools as outlined in this report. However, in terms of quickly developing a tool to EPS standards, SIMPLE appears to be the most likely candidate at this time. The pilot team recommends that SIMPLE be developed to meet all the EPS requirements for accuracy and reporting. The SIMPLE auditing protocol should be developed with varying levels of diagnostic testing and evaluated in the field.

Standards for EPS Modeling Software

The results of the pilot indicate that it is possible to develop energy modeling tools that are more accurate and that require less time than current recognized standards. Much of the existing software is calibrated using the same methods as REM/Rate and likely performs similarly. The EPS team recommends that standards for certifying EPS software be established that ensure accuracy and consistency, and that offer cost-effective audit and software input times. The standards outlined in this report represent the basis for such refinement.

Critical Elements

In order to generate an EPS score sheet and report, the certified EPS software must produce results for total energy, total therms, and total kWh. It must also produce results that reflect energy use after energy upgrades and whether the home was built to code. In order to score the home and not the behavior of the household, these would be calculated assuming typical occupancy for the number of bedrooms and typical behavior. The software should incorporate the EPS carbon calculation methodology for carbon scoring and generate EPS score sheets.

In addition, the software must be able to predict the elements in the EPS energy analysis report, including energy use for heating, cooling, water heating, and other base electric loads (lighting, appliances, and plug loads). It must produce recommendations for energy upgrades along specific guidelines (to be determined in the next phase of this pilot) and be able to model the energy savings of the upgrades.

Since the EPS is measuring the house and not household behaviors, modeling software should use standard normalized assumptions for thermostat settings, hot water use, appliance use, and other plug loads. This should be based on typical behavior and the typical occupancy for the number of bedrooms in the home. Typical usage patterns should be determined from census data and other sources such as in Table 4.2.

An EPS modeling software standard should also include audit and software input times. Average audit times of less than 1 hour and average software input times of less than 30 minutes are recommended.

Accuracy

Since the EPS will be used in new and existing homes, EPS energy modeling software tools need to accurately model homes of different ages, sizes, climates, construction methods, and mechanical systems.

There are factors that must be taken into account when setting a meaningful standard for accuracy. When testing software against actual use data, the reliability of homeowner-reported use data limits the degree of certainty possible. In turn, this factor limits the ability to measure the accuracy that is possible for any given modeling software. It is more difficult to predict heating and cooling loads in milder climates because small discrepancies in the thermostat setting cause relatively large swings in the total load. There is also a need to balance the number of inputs with audit time, creating a balance between accuracy and cost.

As a starting point for a certified EPS software standard, it is recommended that modeling software be able to predict actual annual total energy use within 25% for at least 70% of a cross-section of housing stock using actual use data for comparison. Additionally, it should not make large errors in predictions for many homes. A suggested standard is that the software must predict energy use within 50% for at least 90% of homes. Figure 4.1 shows this proposed standard of accuracy (red line) in comparison to the accuracy for total energy of the four software tools tested from Figure 3.1. It may also be necessary to limit the frequency of over and under predictions, for example, to 66% in either direction to avoid consistent biases. These standards will need to be developed further to provide a fair standard regardless of the climate or fuel types used in the home. For example, these percentages may need to be eased in mild climates to account for the difficulties in predicting heating and cooling loads in those locales.

This proposed standard is a compromise between what seems possible at this time and what the public might reasonably consider to be accurate. If it is shown that even more accurate standards are reasonable, these proposed standards could be strengthened accordingly. However, the current national standard and all four software tested by the pilot fall short of this recommended standard. It is also important to note that the software tools are likely to be more accurate in calculating total energy use when behavior is normalized for typical occupancy and use, which is what the EPS score is based on.

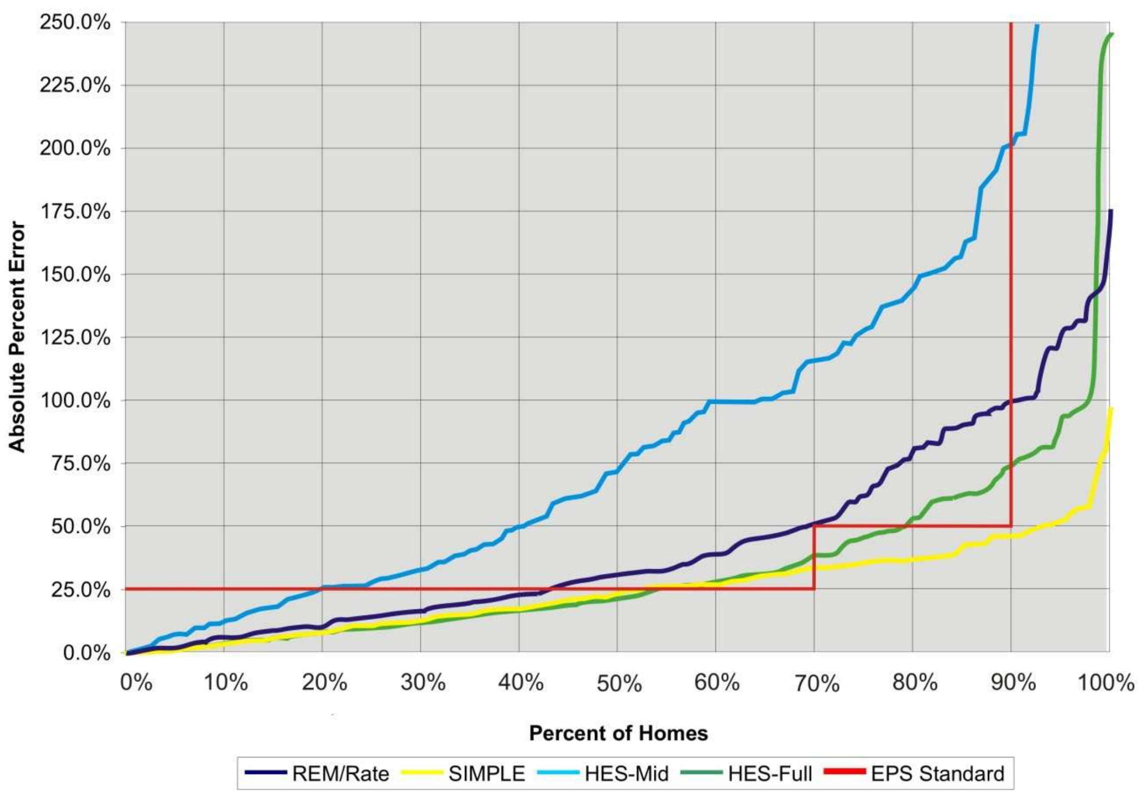


Figure 4.1 Proposed EPS Standard of Accuracy (Total Energy)

It is important to note that this recommended standard is a departure from the current national standard as established by RESNET. Rather than compare software predictions to actual use, it is current practice to compare software predictions to predictions of other software tools.

A method for testing software accuracy similar to the methodology of the EPS pilot can be established whereby software is submitted for testing. Software testing would not necessarily require additional field work if there was a standardized set of home and usage data that included multiple house configurations and climates. If more than one software tool was to be certified, discrepancies between tools could be used to manipulate reported savings by pretesting with a tool that typically over-predicts and post-testing with a tool that typically under-predicts. For this reason, it would become necessary to require the use of the same tool for before and after upgrade testing.

Recommended Modeling Software

REM/Rate performed well for 71.7% of homes built after 1989 and only performed poorly for 6.5% of this cohort. This level of performance marked the only instance a tool met the proposed EPS standard for accuracy. However, REM/Rate was inaccurate with almost a third of all homes, and it was notably less able to predict energy use in older homes. The pilot's findings are similar to results of studies by the Energy Center of Wisconsin (Pigg & Nevius, 2000; Pigg, 2002). Since one of the main goals of the EPS is to provide a universally useful tool for newer and older homes, REM/Rate is currently less than ideal. Furthermore, the longer REM/Rate audit and software input times also mean that it would likely cost more than $200 to deliver an EPS using REM/Rate.

HES-Full was generally more accurate than HES-Mid and REM/Rate, but it over-predicted energy by more than 50% for a significant number of homes. HES-Full also entailed relatively long audit and software input times. Moreover, HES was not always available online during this pilot, which means that it is unreliable as it is currently structured. HES-Mid performed poorly in all areas and cannot be recommended as a tool for the EPS.

In terms of accuracy across all ages of homes and the time required for an audit and software input, SIMPLE was the best modeling software of the tools that were tested in the pilot. It should be noted that Blasnik spent only a short time developing SIMPLE before submitting the tool for assessment in the pilot. Blasnik had originally created the program to test the assumption that fewer inputs with good algorithms could produce better results than more detailed energy modeling tools available (an assumption that proved true for the pilot tests). Consulted after the data analysis was completed, Blasnik speculated that SIMPLE could be improved along the lines outlined below within a few months.

SIMPLE might become more accurate in predicting electrical use with more specific electrical use inputs and improvements to the electrical consumption algorithms, as suggested by the correlation between house size and under-predicting electrical use. Further regression analysis of the pilot results might uncover other specific areas for improvement. It is also recommended that SIMPLE include less common features, such as second heating systems and solar electric and hot water systems.

Other improvements will broaden the utility of SIMPLE. Currently, SIMPLE uses generalized categories asking a user to select from generalizations such as *none*, *low*, *average*, or *high*. In practice, reaching this type of generalized conclusion requires greater experience or the collecting of multiple data points in order to select the appropriate generalized category. It may be more accurate and ultimately less time consuming to use the specific inputs directly for some energy uses.

SIMPLE might also be more useful as a design and evaluative tool by further developing its layers of possible inputs. Currently, there is a layer with generalized categories such as those described above, and a more specific layer available that overrides the generalized responses with things such as the actual area of the windows and walls. The second layer could be expanded to allow for more specific data entries such as number of fixtures and percent of fluorescent fixtures in the case of lighting. A third layer could be added to allow for more detailed data entry, such as a fixture count, wattage, and hours used, in order to calculate kWh per year.

With these layers, a homeowner could use the tool to either get a quick score, or use the more detailed layers to understand the impact of behavior and changes on energy use. An auditor could use the more specific input layers to capture anomalies in a home, and building designers could use these layers to test the impact of different design options on energy use.

The SIMPLE tool is quick and performed the best in the pilot. With a few adjustments, its weakness around electrical predictions could be improved. The pilot recommends that SIMPLE be developed further and tested again on an additional sample set of homes, with a more well-defined protocol, and preferably in multiple climates. Further development and testing of SIMPLE will also assure that it meets the recommended standard for accuracy and audit time and that an auditor can use it to generate an EPS for no more than $200. In addition, to make SIMPLE fit the EPS purposes, it will also need to be amended as outlined in the Standards for EPS Modeling Software section (See Attachments for SIMPLE Auditing Protocol).

<u>3 – Metrics and EPS Score Sheet</u>

The EPS energy score should be expressed as the total annual energy required for the house under normal conditions and be expressed in kilowatt hours per year. This score should be illustrated on a scale that also indicates the energy use of different fuels, relevant local comparisons, energy upgrades for existing homes and built to code comparisons for new homes, and community energy goals.

Total household energy use should be the main metric.
After surveying many existing metrics and analyzing them against the goals for the pilot, the EPS team concluded that there was a strong case for using total household energy use as the metric. The first and foremost reason is that a metric should measure what is important and what needs to be impacted. If the ultimate goal is to reduce the absolute amount of energy that a home uses, then that is what should be calculated and reported. By abstracting this metric with a rating such as the HERS Index, the energy a home uses is obscured. While consumption as a metric for residential energy use is now commonly accepted in Europe, the United States has not yet embraced this straightforward approach. By adopting consumption and not a relative scale, the discussion can focus on energy reduction in ways that have not been possible using other rating systems.

It is important to note that total household energy use must be viewed in tandem with its carbon emissions to create a comprehensive picture of home energy use. Listing energy use, based on site-used energy, and carbon emissions, based on source energy, together allows the EPS score sheet to account for the impacts of primary energy use while displaying the estimate for site energy use. Reporting both scores helps the EPS to be a fuel neutral approach that reveals the impacts of using different fuels and of fuel switching.

Total energy use allows for useful comparisons; indexes do not.
The HERS Index is one of the most popular home energy rating systems in the United States, and part of its appeal is the 0 to 100 scale. With the HERS Index, a home's rating is based on its estimated energy use relative to the estimated energy use of the home if built to 2004 IECC standards. The HERS Index is a useful tool for comparing newer homes to themselves using various benchmarks, such as whether it was built to code. However, because the rating is based on the energy use of the same home built to different standards, the rating scale for each home is unique to that home. A home scoring 82 in one place does not necessarily bear any resemblance in energy use to a home scoring 82 across the street or across the country.

Since the HERS Index rates a home relative to that home built to a specific standard, when that standard is changed, all previous ratings become obsolete. A home that received a HERS Index of 82 when the reference home was based on the 1993 MEC standards would no longer receive the same rating since the reference home has shifted to the 2004 IECC standards, and it could change again with further updates. While the lifespan of a rating is not an issue for new homes, for the EPS, significantly shortening the useful lifespan of a rating can lead to confusion about what a rating indicates at any given time. Alternatively, if not updated frequently, the index becomes outdated and less useful.

In addition to complicating comparisons between homes and making comparisons over time problematic, the HERS Index does not show the relationship between a home's energy rating and its utility bills and energy costs. By creating a score with a more direct link to the information that appears on utility bills, a homeowner can use it as a baseline from which to evaluate the impact of behavior on energy use by comparing the estimated energy use with his or her utility bills. This will allow an owner to determine whether the household's energy use is higher or lower than predicted for normal use. Other energy rating systems use a *percentage better than code* method of evaluating energy performance, such as ENERGY STAR®. These types of rating systems present a homeowner with dilemmas similar to those described for the HERS Index.

	Energy Performance Score	**HERS Index Rating**	**ENERGY STAR Rating**
Easily understood	✓	✓	✓
Shows improvement over code-built version of home	✓ local codes for new homes	✓ IECC 2004 codes	✓ 15% better than local codes
Allows for comparisons of energy use with other homes	✓	✘	✘
Scale remains the same over time	✓	✘	✘
Possible to predict utility expenses	✓	✘	✘
Easy to compare with utility bills	✓	✘	✘
Can be used to evaluate the impact of energy use behavior	✓	✘	✘

Table 4.1 The Utility of the EPS, the HERS Index, and ENERGY STAR

Table 4.1 compares the utility of the HERS Index and ENERGY STAR to the Energy Performance Score.

Measurements of total energy use allow for direct and useful comparisons between homes. Just as people have learned to compare the MPG of different cars used for different purposes, it is reasonable to assume that they will learn to compare EPSs of different homes of different sizes and even in different climates. In reality, most homebuyers only compare homes of similar size and utility.

Reporting home energy use in this straightforward manner may reveal some trends that run counter to popular perceptions. For example, one concern Realtors expressed is that the EPS may reflect negatively on older homes since older homes are not built as energy efficiently as new homes. However, since there is a strong correlation between house size and energy use, and given that many older homes are smaller than new homes, the EPS may also reflect that smaller older homes use less energy than larger energy efficient homes (Wilson & Boehland, 2005).

Energy consumption should not be measured in terms of energy use by area.
A metric that measures energy use per area (e.g., kWh/m^2, kWh/sf, or MBtu/sf) can mask total energy use and the impact home size has on energy use. A larger home can appear to have a lower rating than a smaller home, even when the smaller home uses less energy. In fact, energy use expressed by area can be misleading in terms of describing the trend in overall energy use. In the United States, energy use per square foot has decreased over the years while overall household consumption continues to climb as shown in Figure 4.2. This is a result of building more efficient but larger homes.

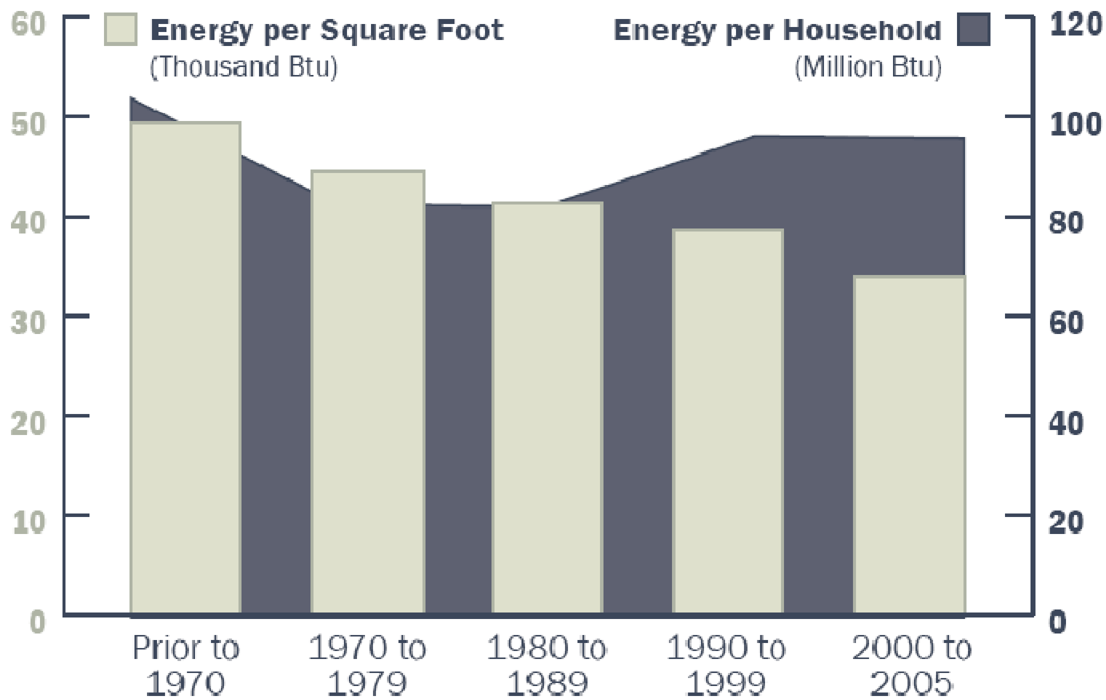


Figure 4.2 Energy per Square Foot versus Energy per Household
(Wigington, 2008; U.S. Department of Energy, 2008)

Total household energy per year does not indicate certain kinds of service.
The main service that a home is to provide is shelter from weather. Total energy per year describes this service much as MPG describes the main service of vehicles: transportation. However, the energy use metric does not indicate the number of people served by the energy consumed. Smaller homes generally house fewer people than larger homes, though this factor is somewhat offset by the trend toward smaller family size and the increase in home size (Wilson & Boehland, 2005). A one-bedroom home will likely serve one or two people, while a two-bedroom home may serve up to four people. However, the correlation between the number of bedrooms and occupancy is not

generally one to one. On average, there is only half an additional person for every additional bedroom and about 670 additional square feet, as is illustrated in Table 4.2.

Number of Bedrooms	1	2	3	4	5+
Average Number of People	1.71*	2.20*	2.65	3.14	3.81
Average Square Footage	-	1,917**	2,568	3,370	3,920

*Estimated from a known average occupancy for 1 and 2 bedroom homes. **Square footage listed is the average for 1 and 2 bedroom homes

Table 4.2 Average Number of People and Square Footage per Bedroom (U.S. EIA, 2005)

To allow for comparisons based on these kinds of service, the number of bedrooms and house square footage should be listed on the EPS score sheet so that the energy use can be seen in the context of service when required.

One-year timeframe

Several factors were considered in selecting the best time period to measure. Given that energy use varies dramatically over the course of a year, and less so year after year, using an annual total for energy best expresses how a home performs overall. Presenting energy in terms of monthly averages that divide total annual energy use by 12 can be confusing since they differ from what homeowners see on their monthly bills, which reflect monthly energy use fluctuations.

Rating the building envelope versus household behavior

Household behavior can be included or normalized when measuring energy consumption. If it is included (as for an operational rating), it communicates to a homeowner how much energy he or she uses in the home. With the right comparisons or guidelines, this can help a homeowner make choices to reduce energy consumptions. However, since the behavior of different occupants can vary dramatically for a given home, measuring household behavior masks the performance of the building. For the same reason, rating household behavior is not useful for comparing the energy use of different homes.

Another issue that was relevant to the goals of the pilot was the fact that new homes inherently do not have occupant behaviors associated with them. Therefore, calculating energy use for new homes must be based on assumptions about normal use (an asset rating).

Since one of the advantages of including household behavior is to give homeowners guidance in modifying their behavior, it is recommended that some education be added to the EPS Energy Analysis Report and the Web site that explains how homeowners can use their scores and their utility bills to determine how much their consumption is above or below what is considered normal for their homes.

Kilowatt hours (kWh) versus British thermal units (Btu)
Total annual household energy consumption could be expressed in any unit of energy, as all are convertible to the other. Ideally, the metric would be one that is already familiar to the general public to facilitate rapid adoption.

In the United States, homeowners are most frequently exposed to the terms therms and kilowatt hours on utility bills. In the pilot's surveys, 80% of homeowners were familiar with *kilowatt hour*, while *MBtu* was familiar to only 45% of the respondents. The term *therms* was familiar to 45% of respondents despite the fact that it is the metric for natural gas, which is a type of fuel found in many households. The greater familiarity with kilowatt hours over therms may be due to the fact that this term is also used in describing many consumer appliances and solar photovoltaic systems, and can be found in popular media news stories.

Currently, the United Kingdom's EPC and the European Union report home energy use in kilowatt hours.

For these reasons, kilowatt hours is likely to be more readily recognized, adopted, and used by the public as a metric for home energy use than either therms or MBtu.

Another disadvantage of MBtu is that it can mean 1,000 Btu or 1,000,000 Btu. Therefore, the even less familiar terms *MMBtu* or *million Btu* need to be used for clarity.

However, many home energy professionals report that they prefer MBtu for reporting home energy use, including some members of the EPS team. While most of them agree that all energy units are interchangeable, some express concern over possible confusion for homeowners when converting the energy of different fuels to what is commonly thought of as a measurement of electricity (i.e., kilowatt hours). Others argue that using kilowatt hours diminishes the salience of natural gas as a home energy source. It may be that the professional preference for MBtu stems from the use of British thermal units as the logical metric for heat loads, which is often the main focus in energy conservation programs.

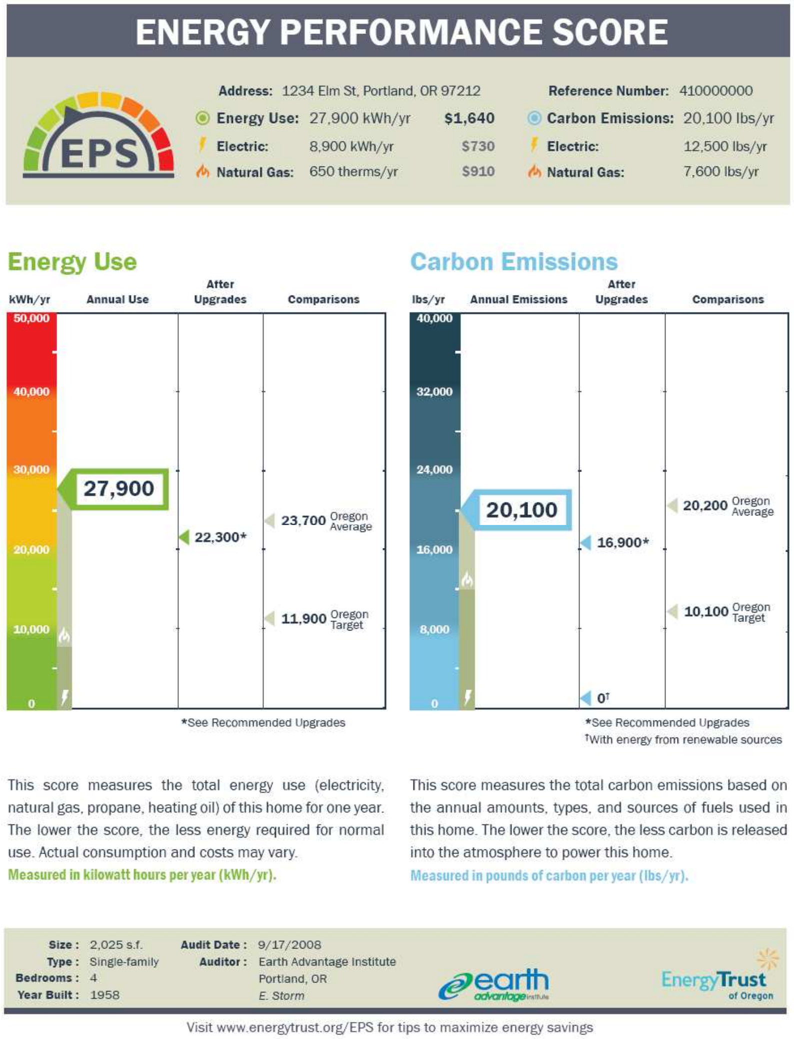
Proponents of using MBtu also argue that this metric would result in smaller and memorable numeric expressions of home energy consumption, not unlike the 0 to 100 rating systems. While this may be true, it may also serve to make this number more abstract since public understanding of Btus and MBtus is not well developed. The number may also be less impactful because it is smaller. While smaller numbers are generally easier to recall, the public does use large numbers successfully when the occasion calls for it, such as with house and car prices, and mortgage payments. Converting kilowatt hours to megawatt hours was considered to reduce the numeric complexity, but this further abstraction may decrease the impact that the number has on homeowners and may cause some confusion when comparing it to utility bills.

Taking all of these factors into account, it is recommended that an energy score be expressed in kilowatt hours per year (kWh/yr) with scores rounded to the nearest hundred. It has been suggested that rounding to the nearest thousand would better reflect the current accuracy of the modeling calculations. However, this level of rounding may obscure certain distinctions that might be meaningful and could provide useful incentives for action. Ultimately this finer level of software accuracy is desirable, which underscores the recommendation to improve the modeling software. Rather than rounding to the nearest thousand, a preferable method of indicating a more generalized score would be to use letters as described under Optional Score Sheet Elements.

To emphasize the fact that the energy and carbon scores are often comprised of different types of fuels, it is highly recommended that the component fuels all be prominently noted and graphically represented with the scores. See the EPS score sheets in the Attachments for an example.

EPS Score Sheet

The purpose of the score sheet is to graphically convey the estimated energy use and carbon emissions of a home, to indicate how these scores compare to other reference scores, and to depict the potential impact of energy upgrades on a home's EPS in the case of existing homes. It is recommended that the following elements be on any version of an EPS score sheet (See Attachments for sample EPS score sheets).



Note: The above certificate is a mock up created by Earth Advantage Institute. The version adopted and used by the New Homes program for their EPS on residential new construction homes can be found at http://www.energytrust.org/eps/. The final version to be used by Energy Trust's existing home program is not as yet defined. As such, the following recommended items may or may not be incorporated by Energy Trust.

Figure 4.3 Sample EPS Score Sheet

EPS Reference Number and Date of Issue

Official EPSs will need to be archived in a database and each EPS will need to be tracked with a unique reference number. Ideally, that EPS reference number would be based on an existing coding system that is unique to each home. The federal information processing standards codes (FIPS codes) issues state identification numbers that could be part of the reference number as a way to limit the total numbers required for a unique coding system. In order to allow for anonymity, a reference number should not use elements traceable to an address. The date that the EPS is issued could be incorporated into the code, as well as noted on the score sheet since a home may receive multiple EPSs over time. The date of issue will also help others in assessing the applicability of an EPS in cases where changes to the home have been made subsequent to the audit.

<u>Address, Type of Home, Size, Year Built, and Number of Bedrooms</u>
In addition to the address, it is important to include information that further contextualizes the EPS for those not familiar with the home. The type, size, and year built offer useful information that adds to the understanding of the score and helps to compare one home to another. The number of bedrooms indicates the potential service of the home by suggesting the number of people who could live in the home.

<u>Modeling Software Indication</u>
The EPS team recommends identifying the modeling software used to calculate the score. Given the tendency of different programs to either consistently over- or under-predict, it would be useful to be able to track which programs are producing the scores. This may play an important role if an EPS is required as a test-out after energy upgrades have been made. Energy incentive programs may require the use of the same modeling software in order to determine savings over time. This element has not yet been included in the sample EPS score sheet.

<u>Scales with Clearly Discernable Units of Measure</u>
Given the intent to convey an objective score, it is important to use an easy-to-understand and evenly distributed scale with clearly defined units of measure. The scales should be sized to accommodate the average energy use of all states. More specifically, the top end of the energy scale should be able to accommodate the state with the highest averages for energy and carbon (currently Alaska at approximately 47,000 kWh/yr and 26,700 lbs/yr), and the U.S. averages (24,800 kWh/yr and 20,400 lbs/yr) should fall near the middle of both scales. For these reasons, the sample EPS score sheet depicts a scale of 0 to 50,000 kWh/yr for energy and 0 to 40,000 lbs/yr for carbon.

<u>Energy Use</u>
The energy score is the estimated total annual energy use, and this should be highlighted on the score sheet. The amount of each fuel comprising the energy total should be reported along with the associated energy costs estimated at the time that the EPS is issued. In addition, it would be useful to indicate the amount of each fuel on the scale to reinforce the fact that the energy score is comprised of the fuels used in the home.

<u>Energy Score—After Upgrades</u>
For existing homes, the estimated energy use of the home after the recommended Energy Analysis Report upgrades have been made should be reported on the score sheet. This is calculated by modeling the home with the recommended upgrades. It needs to be determined whether this score reflects low-cost measures, high-cost

measures, or both. The pilot survey results indicated that Realtors, builders, and homeowners found energy improvements of 20% to 30% the most appealing. It is not yet known whether the recommended upgrades will indicate this level of improvement, or how the magnitude of upgrades depicted will impact homeowner decisions to make changes. A vital element for further study will be to determine how the reported scores impact home energy improvements over the long run.

Energy Score—Built to Code

Many green home programs base their home ratings on a comparison of the predicted energy use of a new home to that of the same home built to local codes for insulation, air tightness, windows type, and mechanical systems. It is therefore recommended that EPS score sheets for new homes offer a *built to code* comparison in place of *after upgrades*. This would reflect the EPS score the home would receive if it had been built to current local codes. Should programs move away from this percentage-better-than-code rating system and adopt a total energy use approach, this feature could be phased out.

Energy Score—Comparisons

To help homeowners better understand the significance of the energy and carbon scores, comparative scores are listed. In surveys, homeowners were easily overwhelmed by too many comparisons. So to be useful, the number of comparisons should be limited. Respondents were most interested in knowing how their homes compared to similar homes. At this point, the sample score sheet shows the Oregon Average since homeowner's found it of more relevance than the national average. However, it may be useful to offer comparisons with homes of a similar size and/or era, or within the same geographic region as that EPS data becomes available.

To determine the Oregon Average for energy use on the sample EPS score sheet, the total residential energy consumption for Oregon (U.S. Energy Information Administration, 2006) was divided by the number of housing units in Oregon (U.S. Census Bureau, 2009). This resulted in an average energy use of 23,700 kWh/yr. Data from a single source would be preferable and could be used to recalculate this value.

Energy Score—Oregon Target

In addition to the regional or state average, the EPS team recommends including an ambitious target that represents the energy and carbon goals for a region and shows how a home could contribute to the attainment of these broader goals. For the purposes of this pilot, this goal is called *Oregon Target*. The target consumption is based on The 2030 Challenge issued by Architecture 2030 and adopted by the American Institute of Architects and the U.S. Conference of Mayors. The 2030 Challenge calls for all new homes, buildings, and major renovations, and an equal area of existing building renovation, to reach 50% of the regional average energy use for that type of building. The 2030 Challenge also calls for increasing the reduction by 10% every 5 years toward the goal of using zero energy emitting greenhouse gases by 2030.

The 2030 Challenge aligns with the state of Oregon's carbon goal (State of Oregon, 2008) of building houses and commercial buildings that emit no carbon by 2030. To this end, the Oregon Target has been set at 11,900 kWh/yr, which is 50% of the 2006 Oregon average. The concept of the Oregon Target requires further study to ensure that it is put forward in a way that provides a positive impetus to greater energy savings. While the target needs to be established in coordination with state officials, it is strongly recommended that this type of ambitious goal be pursued.

Optional Score Sheet Elements

The elements listed here should be considered in the design of the EPS Score Sheet to increase comprehension and appeal.

<u>Color</u>

In the score sheet example in this report, the scale has been further distinguished with colors. For energy use, the scale runs from high consumption (red) to low consumption (green), and for the carbon scale the colors run from high (black) to low (sky blue).

The colors also offer a means of identifying relative performance: red and orange sound an alarm in the case of energy, while black and dark gray indicate a foul score for carbon; orange/yellow and gray/dark blue indicate caution for energy and carbon, respectively; and green indicates a positive score for energy and sky blue indicates the same for carbon. It has been indicated on the scales where these colors could appear, but these may change with further study of what energy use and carbon levels should be designated as problematic and desirable.

Another purpose of the colors is to provide an alternative means of remembering a score similar to the way the colored floors of a parking structure further distinguish the numbered levels.

<u>Letters</u>

At one point in the development of the graphics, the score sheet included letters (e.g., A, B, C) and mimicked the energy certificates found in the United Kingdom and throughout Europe. (See the example in the Attachments.) In the limited testing that was conducted, there was some indication that the association with grading might be negative. While the letters are not intended as grades per se, they do correspond to the relative energy performance with *A* signifying low energy use and *E* signifying high energy use. In this way, the letters might serve as a more effective shorthand grading system than the colors. For example, a builder could report that he only builds homes with A and B EPS scores, or a homebuyer could say to a Realtor that she only wants to look at homes with an EPS of C or better. Importantly, this use of letters allows for a rating of a home which may be more in line with the accuracy of the modeled score. The specific and therefore seemingly accurate number of kilowatts can lead people to draw false distinctions at a finer level than is warranted. As the software used for calculating

EPS scores is refined the pros and cons of rounding and letters should be considered more fully.

The Reverse Side of the EPS Score Sheet

Initially, there will likely be many questions about EPS. Therefore, in the sample EPS score sheet, the reverse side offers helpful explanatory information. Listed here and on the sample score sheet are the terms that likely require some explanation (See Attachments).

<u>Third-Party Certification</u>

There are distinctions between an EPS audit as an assessment tool, a certified audit, and a third-party certified audit that should be made clear to the users of the EPS so that they better understand the quality of the score. Only audits performed by third-party certified auditors are considered official EPS scores.

<u>Energy and Carbon Calculations</u>

In order to help homeowners and others better understand the scores, it is recommended that there be general descriptions of how the scores are calculated and the factors that influence the energy and carbon scores.

<u>Measurements</u>

As a part of the effort to increase energy literacy, the metrics used on the EPS are defined in some detail. There is an example of how the energy score is calculated combining therms and kilowatt hours, and the energy equivalents given can be used for comparing utility bill totals to the energy score

<u>Qualifying Energy Costs</u>

It is important to display energy cost to facilitate understanding and meaning, but it needs to be made clear that the costs listed on the EPS will differ somewhat from those on utility bills due to homeowner behavior and to taxes, surcharges, other fees, and rate changes.

<u>Explanation of Terms</u>

The goal was to minimize jargon and use generally familiar terms throughout the score sheet. Inevitably, there are a few terms that require explanation: after upgrades, built to code, with energy from renewable resources, Oregon Average, and Oregon Target.

<u>4 – Carbon Emissions and Calculation Methodology</u>

The EPS should include a carbon score that reflects the greenhouse gas emissions associated with the home’s energy use. While the energy score is a calculation of energy used on site, the carbon score is based on the source or primary energy that is produced in order to power the home. By tracking site and source energy, a more comprehensive energy picture is possible.

Comparisons on the carbon scale should include those listed for energy as well as the predicted emissions if the homeowner used the most commonly subscribed renewable energy option through their utility or fuel provider.

Carbon Emissions

The EPS carbon score represents the greenhouse gas emissions that are associated with the energy use of a home as explained in the Calculating the Carbon Score section. For all the same reasons elaborated for the energy score metric, it is recommended that the carbon score be an actual measurement of carbon and not an abstracted score. The carbon score calculation will be based on the energy score and its component fuels, so it should be expressed in total annual household carbon emissions.

Reporting Carbon Emissions on the Score Sheet

Since carbon emissions are a relatively new concept in the public consciousness, there is an opportunity to consider either pounds or tons as the metric. Tons of carbon is sometimes used, however there is the possible confusion between metric and imperial tons. Another factor is that while familiar, tons are less commonly experienced than pounds in daily life. Expressed in pounds, most carbon scores will be expressed in terms of thousands and tens of thousands, as will be the energy scores expressed in kilowatt hours. Whether this parallel is helpful or causes confusion is not yet known. However, the recommendation at this point is for the carbon score to be expressed in pounds per year (lbs/yr). If the trend moves strongly toward reporting carbon in tons in popular culture, then this metric may shift to reflect that.

Carbon Score—After Upgrades

For existing homes, the carbon score listed in the upgrades column reflects the change in the carbon emissions that would result if the energy upgrades recommended in the Energy Analysis Report were made. This is determined by applying the EPS carbon calculation methodology to the modeled energy use of each fuel type with the energy upgrades.

Carbon Score—Built to Code

For new homes, the carbon score listed in the built to code column reflects the change in the carbon emissions that would result if the home were built to local codes, as described in the built to code section for the energy score.

Carbon Score—Renewable Electricity

One of the more dramatic changes visible on the scale is how much the carbon score improves using energy from renewable sources. In the case of gas and electric utilities, this would be based on the most popular renewable option that they offer. This relatively easy and low-cost action on the part of homeowners offers a significant contribution toward meeting carbon emission reduction goals, and for this reason it should be shown. For heating oil, the renewable calculation is based on the highest blend of biodiesel appropriate to the heating system.

Carbon Score—Comparisons

The scores under comparisons reflect the emissions for the comparisons listed in the corresponding column for energy. They are currently the carbon scores associated with the Oregon Average energy use and the Oregon Target.

To determine the Oregon Average for carbon emissions, the EPS carbon methodology was applied to the energy consumption data for the Oregon Average. The result was an average carbon emission of 20,200 lbs/yr. The Oregon Target was then calculated to be 50%, or 10,100 lbs/yr.

Methodology for Calculating the Carbon Score

As part of the EPS pilot, a carbon calculator was developed to convert the energy score into a carbon emission score. The carbon score was based on the amount and carbon intensity for each fuel used in the home. This section describes the rationale, assumptions, and data sources for the methodology.

The carbon calculation took into account the emissions associated with the following sources:

- electricity usage
- natural gas usage
- heating oil usage
- propane usage
- onsite photovoltaic or other renewable electricity generation (representing a credit or reduction to the household's carbon calculation).

The primary data sources for these were from the U.S. Environmental Protection Agency (EPA) and the Energy Information Administration (EIA).

Electricity Based GHG Emissions

Electricity is typically the largest contributor to greenhouse gas (GHG) emissions for any given home. For the pilot, the data source for calculating the associated emissions was the Emissions and Generation Resource Integrated Database (eGRID) released by the EPA (U.S. Environmental Protection Agency, 2008). In December 2008, the EPA released the most current data, eGRID 2007, which uses 2005 data. The specific data source for the current version of the EPS is eGRID2007 Version 1.1 State File (Year 2005 Data). The EPA expects it will release 2007 data before the end of 2009 and plans on annual updates going forward. Preliminary analysis of the Oregon electricity net resources mix by the Oregon Department of Energy resulted in different carbon emissions than reported by eGrid. As the accuracy of the EPS carbon score relies on the accuracy of the underlying data, these issues should be further investigated and resolved if possible, or a more reliable database developed. The eGRID database provides information at the utility level and the regional level. The EPS pilot's recommended methodology utilizes both data sets and distinguishes between electricity generated at facilities owned or operated directly by a utility and purchased power.

Owned/Operated Electricity Generation and Associated Emissions Calculations

The eGRID database provides GHG emissions intensity data by utilities in two categories:

1. Emissions intensity of electricity generated at a facility *owned* by any given utility.
2. Emissions intensity of electricity generated at a facility *operated* by any given utility.

As there is some overlap of facilities, it is not reasonable or appropriate to combine the data. Thus, the team proposes selecting the most conservative estimate of GHG emissions. That is, selecting the higher emissions intensity figure out of option 1 and 2 above. This would ensure that emissions are not underestimated. Using the emissions associated with electrical generation bases the EPS carbon score on source energy.

Short- and Long-Term Purchased Electricity

For purchased energy, that is electricity that is not generated at facilities owned or operated by the utility, the EPS proposes calculating the associated GHG emissions using the average grid intensity for the eGRID subregion.

Challenges associated with selected methodology

Using the regional eGRID emissions intensity data associated with non-owned or non-operated electricity generation, even at the subregion level, is less than perfect because of the large geographic region covered and the variety of generation resources in each subregion. To illustrate this, consider that the neighboring states of Oregon and Washington have emissions intensity rates of 401.45 lbs/MWh and 331.11 lbs/MWh, respectively. Specifically, Oregon's emissions intensity is 21% greater than Washington's. Despite this variation, which is even greater when comparing the emissions intensity of the states of Washington and Utah, which are in the same eGRID subregion, the team proposes using eGRID average (subregion) grid intensities for calculating the GHG emissions of purchased power. This method offers the best means of meeting the pilot's requirements for credible, reliable, easily-collected, and standardized data sources and acknowledges that electricity purchases may come from a variety of sources within the subregion. It also serves to provide the incentive to utilities to improve the emissions profiles of the generation facilities that they own and operate. Lastly, while some information will be available from each utility regarding the nature and emissions profile of certain long-term power purchase agreements (for example, via Integrated Resource Plans), this information would be very difficult to extract or to treat consistently from one utility to another. Thus, for all of these reasons, the recommendation is to use average grid intensity data for non-owned or non-operated electricity generation.

Renewable Energy Programs

For renewable energy options provided to customers by utilities, the emissions associated with these programs were calculated at zero for renewable energy, and according to the above methods for any non-renewable component of the power purchase. (Some renewable power programs provide options for purchasing a fixed proportion or amount of renewable energy.) The most popular renewable power option for each utility should be used in determining the carbon score with energy from renewable sources if the utility offers multiple renewable power options. This will simplify calculations and reflect what the emissions would be if a homeowner followed suit in purchasing the most commonly selected renewable power option offered by his or her utility.

Natural Gas GHG Emissions

Emissions from natural gas usage in the home was calculated using the combustion conversion factors available in the EPA's *Unit Conversions, Emissions Factors, and Other Reference Data* published in November 2004 (Environmental Protection Agency, 2004).

When the natural gas utility offers an option for carbon neutral natural gas by means of purchasing carbon offsets equal to the homeowner's use of natural gas, the same approach for determining the carbon score with energy from renewable sources should be used as that outlined for electric renewable energy programs. The provision here is that the carbon offsets purchased meet additionality requirements, have third-party verification, and are of reasonable quality (e.g., meeting the Voluntary Carbon Standard requirements or achieving registration with the Climate Action Reserve, part of the California Climate Action Registry).

Heating Oil and Propane GHG Emissions

Emissions from the use of fossil fuel heating oil and propane in the home were calculated using the combustion conversion factors for transportation fuels available in the EIA's Voluntary Reporting of Greenhouse Gases Program (EIA Program 1605[b]) (U.S. Energy Information Administration, 2007).This data source includes propane and regular diesel emissions, as well as those associated with biodiesel (with zero emissions calculated for 100% biodiesel).

Heating systems that use residential heating oil can, without modification, use a blend of up to 20% biodiesel (B20). Heating systems that have been modified to use higher blends of biodiesel can use up to 100% biodiesel (B100). Since modifications and adjustments are required for the use of different blends beyond B20, the carbon score for energy from renewable sources can be determined by noting the mechanical equipment and the fuel mix it has been set to handle. For unmodified heating systems, the renewable source should be B20, and for modified systems, B100.

Onsite Renewable Energy Emissions Reduction

Onsite photovoltaic or other renewable electricity generation will provide a credit, or reduction, to a household's carbon calculation based on the emissions that would have been generated through the average energy mix provided by the utility. This credit will first be applied to reduce any emissions from any other fossil fuel energy resources used in the home (natural gas, heating oil, propane), with any remaining credit illustrating the amount of the home's *net positive* benefit. For example, a home could receive a negative carbon score if it was all electric and had onsite photovoltaic production greater than the home's energy use. Similarly, the value for energy from *renewable sources* would be negative in the case of an all-electric home with onsite photovoltaic production that was equal to the energy use and if the homeowner purchases renewable electricity for any grid provided energy use.

Carbon Calculation Assumptions and Data Sources

Global Warming Potential and Equivalency Calculations

The EPS pilot uses the term *carbon* to refer to the greenhouse gas emissions associated with energy. Given that the eGRID data provides CO_2, CH_4, and N_20 emissions data for each electric generating company (EGC), these emissions were converted into CO_2 equivalents using the 100 year Global Warming Potential (GWP) figures provided in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (Intergovernmental Panel on Climate Change, 2007). Note that in the past, the eGRID data used the GWPs from the Second Assessment Report. However, given that the pilot was calculating the emissions of CO_2 directly, the more current GWPs were used.

Green House Gas	100 year Global Warming Potential
CO_2	1
CH4	25
N2O	298

Table 4.3 100-Year GWPs from the IPCC AR4
from Working Group I Report,
The Physical Science Basis, p. 212.

Electric Utility Provided Data

The assumption is that each utility will be able to easily provide the answers to the following questions and that the answers will be consistently calculated/determined from one utility to the next.

1. What proportion of electricity provided to customers is derived from owned or operated generation facilities, and what proportion is derived from purchased electricity (PPAs or short-term market purchases)?

2. If there is more than one renewable power option for customers, which program is the most popular? For example, if there is a *unit* purchase program, as well as a usage-based purchase program, which one has greater customer participation (as determined by the number of participating customers)?

3. If there is more than one renewable power option for customers, what is the typical level of participation? For example, if the unit program is the most popular, do the majority of customers sign up for 1 unit, representing, for example, 100 kWh, 2 units, or more? If the usage-based program is most popular, does this provide 100% usage coverage (i.e., ensuring renewable energy is added to the grid to mitigate 100% of this customer's electricity consumption), or 50% coverage, or some other proportional coverage?

Natural Gas Utility Provided Data

The assumption is that each utility will be able to easily provide the answers to the following questions:

1. If there is more than one carbon neutral option for customers, which program is the most popular? For example, if there is a unit purchase program, as well as a usage-based purchase program such as NW Natural, which one has greater customer participation (as determined by the number of participating customers)?

2. If there is more than one carbon neutral option for customers, what is the typical level of participation? For example, if the unit program is the most popular, do the majority of customers sign up for 1 unit, representing, for example, 4 tons of GHG emissions annually, 2 units, or more? If the usage-based program is most popular, does this provide 100% usage coverage (i.e., providing GHG emission mitigation for 100% of the natural gas actually used)?

Renewable Energy Programs

In the pilot's methodology, the assumption was that there are zero GHG emissions associated with the renewable energy component of a utility's offerings. That is, if a homeowner purchases 100% renewable electricity, the assumption is that zero GHG emissions are associated with that house's electricity consumption. If a homeowner purchases 20% of a household's electricity, then there are zero GHG emissions associated with that portion of the electricity use.

Calculating Biomass and Waste GHG Emissions

With regard to electricity generated from the combustion of waste products, the eGRID data distinguishes among biomass (a fuel derived from organic matter, such as wood and paper products), agricultural waste or methane (e.g., from landfills), and fossil fuel waste streams (e.g., tires, plastics in municipal solid waste). eGRID assumes that biomass is subject to the natural carbon cycle and, therefore, does not contribute to global warming. eGRID assigns zero CO_2 emissions to generation from the combustion of all biomass because these organic materials would otherwise release CO_2 (or other greenhouse gases) to the atmosphere through decomposition, as per eGRID Technical Support Document page 7. The EPS carbon score makes carbon emissions calculations from biomass and waste feedstock based on the data provided in eGRID.

Emissions Factors for Fuels
The data source for this information was "Unit Conversions, Emissions Factors, and Other Reference Data," Environmental Protection Agency. November 2004. http://www.epa.gov/appdstar/pdf/brochure.pdf

Biodiesel Emissions Factors
The data source for this information was the Voluntary Reporting of Greenhouse Gases Program (EIA Program 1605[b]), Fuel Emission Factors (from Appendix H of the instructions to Form EIA-1605) located at www.eia.doe.gov/oiaf/1605/excel/Fuel Emission Factors.xls, for which the home/source page is http://www.eia.doe.gov/oiaf/1605/techassist.html. This data source is for the 1605 program and uses 2005 data (published in 2007), which is more updated than EIA's technical guide and primary Web link (Voluntary Reporting of Greenhouse Gases Program), which uses 2003 data published in 2005. This data source is also used by the GHG Protocol, a leading GHG methodology.

5 – EPS Energy Analysis Report

The EPS should include an energy analysis report that includes an accounting of the annual estimated energy use and fuel costs for heating, cooling, water heating and lights and appliances in the home as well as the performance of the various energy-related elements in the home (e.g., walls, heating ducts, appliances). For existing homes, the report may also include recommendations for energy upgrades and the associated costs and predicted savings.

Once again, the United Kingdom's EPC served as a guide, and the homeowner survey results confirmed that the energy analysis elements in the EPC were, in fact, of interest to homeowners in this country, as well.

There is a significant amount of information to report about the energy use of a home. In order to make that information comprehensible and useful, it is important to present it in a logical sequence that progresses from general and well-known information, to more specific and unknown information.

ENERGY ANALYSIS REPORT

Energy Performance Score **Reference Number:** 410000000 **Date:** 9/17/08

Contents

- Annual Estimated Energy Use and Fuel Costs
- Comparing Your Utility Bills with the EPS Score
- Summary of Energy Performance Related Elements
- Recommended Energy Upgrades
- Energy Upgrade Descriptions
- No- and Low-Cost Energy-Saving Strategies
- Financial Incentives

Annual Estimated Energy Use and Fuel Costs

	Current Home			After Upgrades		
	Energy	**Fuel Cost***	**Carbon**	**Energy**	**Fuel Cost***	**Carbon**
Heating	650 therms	$910.00	7,565 lbs.	488 therms	$683.00	5,680 lbs.
Cooling	0 kWh	$0.00	0 lbs.	0 kWh	$0.00	0 lbs.
Water Heating	2,907 kWh	$238.00	4,078 lbs.	2,907 therms	$238.00	4,078 lbs.
Lighting & Appliances	5,994 kWh	$492.00	8,409 lbs.	5,103 kWh	$419.00	7,179lbs.
Total (Rounded-off)	**27,900 kWh**	**$1,640.00**	**20,100 lbs.**	**22,300 kWh**	**$1,340.00**	**16,900 lbs.**

*Fuel costs are based on prices at the time the EPS is issued and do not include taxes and surcharges.

Comparing Your Utility Bills with the EPS Score

You can determine how your households's energy use compares to the estimated average use for your home by comparing the energy totals on your utility bills with the EPS.

If the totals from your utility bills are

- **similar** to the EPS, you are using an average amount of energy for your home.
- **higher** than the EPS, you are using more energy than average for your home. Reasons for this may include housing more people than average in the home, using appliances more than average, or behaviors that use more hot water, electricity, and heating than average. There may be no- and low-cost ways that you can use to save energy.
- **lower** than the EFS, you are using less energy than average for your home. Reasons for this may include housing fewer people than average in the home, using appliances less than average, or behaviors that use less hot water, electricity, or heating than average.

To calculate your actual energy use, you will need to know the amount of energy that you used for each fuel type in your home for a full year. This information is available on your utility bills. You can visit the EPS Web site to use the online calculator, or calculate the amount manually using the formulas on the back of the EPS score sheet.

Note: The above recommended pilot mock-up is not currently being used by the Energy Trust of Oregon.

Figure 4.4 First Page of Sample EPS Energy Analysis Report

Annual Estimated Energy Use and Fuel Costs

This section offers the first breakdown of the total energy score into several component parts: heating, cooling, water heating, and lighting and appliances. The pilot team also recommends including the corresponding costs and carbon for each component to enhance literacy and to help a homeowner evaluate the relative costs of the different energy components.

This analysis is repeated after upgrades as a means of indicating what energy, carbon, and cost savings are possible.

Comparing Utility Bills with the EPS Score

The EPS score can be used as a benchmark for evaluating a household's energy use. This section describes how a homeowner can do this and what the results will mean if his or her energy use is lower, the same, or higher than the EPS score. Given the relative tediousness of the calculations, a calculator tool on the EPS Web site would be helpful, and ideally the utility companies could provide a 12-month total with each bill.

Summary of Energy Performance Related Elements

This section describes the existing condition of the home at the time of the audit in regards to energy efficiency. The energy related elements of the home are divided into the following categories:

air leakage	heating
ceiling and attic	cooling
walls	ducts
floors	water heating
windows	lights and appliances

Each element is described generally for clarity, and then a specific description is given of the conditions of this element in the home. For example, *air leakage* is described briefly as *how tight your home is against air leaks*. The report then offers a more specific description of the air leaks found in the home, including specific values, such as the air changes per hour at natural conditions and a list of major leakage areas. Each element is also given a performance rating of *poor*, *average*, or *good* based on protocols defined for each element. Protocols with ranges of observable values were created for the Interim EPS Reports and will be developed further for the EPS. For elements with a variety of conditions, such as a home with multiple wall types, the rating will be based on the majority type. However, for an EPS w/upgrades, all relevant information about the elements of a home would be noted so as to more fully capture the existing conditions for the benefit of the homeowner and contractors. Technicians would be able to note unusual circumstances and safety issues requiring attention.

Recommended Energy Upgrades

This section lists recommended energy upgrades for those areas receiving a *poor* or *average* performance rating. Occasionally, some elements may receive an average rating without an upgrade suggestion. An example would be a 2x4 wall that has been insulated with blown-in cellulose. The energy performance of the wall will be average, but an improvement will not be recommended. It might be noted that more aggressive energy efficiency strategies are possible. A poor rating will always generate an upgrade recommendation. The upgrades are listed in terms of *Lower-Cost Upgrades*, which are those that typically cost less than $1,000 for a typical home, and *Higher-Cost Upgrades*, which are those that typically cost more than $1,000.

It is recommended that the suggested upgrades would result in a significant savings of energy. As found in the survey results, savings of at least 20% or 30% were considered motivating to homeowners.

The *Typical Cost Range* is based on pricing estimates from Energy Trust of Oregon and should be updated regularly. The cost ranges should be expressed for each element in a way that makes it relatively easy for a homeowner to calculate what the approximate cost would be for his or her home. For example, if attic insulation is priced per square foot, then a homeowner can multiply the square footage of his or her attic space by the prices and produce a range of cost to insulate the attic. Specifying a range of cost will give homeowners a good idea of the costs without relegating contractors to match a specific cost figure that they did not generate themselves. This is an important consideration when planning the integration of this report style into existing energy efficiency programs.

Approximate Annual Savings is based on the fuel savings as modeled by the software. A qualifying statement needs to be included that states that energy prices change frequently and that the figures given do not include taxes, fees, or surcharges.

Energy Upgrade Descriptions
The world of energy upgrades is complex and unfamiliar to most homeowners. This section is designed to briefly introduce the basics of each upgrade so as to give a homeowner a more solid understanding and basis for taking action.

No- and Low-Cost Energy Saving Strategies
These strategies are largely behavioral and can be included in the report or as a separate written document. It is recommended that these be available in written form and online to make them more accessible to people who do not use computers regularly. The list should be limited to the most impactful measures, as opposed to an exhaustive list. This section should also include local resources for additional information on home energy efficiency.

Financial Incentives
Information on where to find local, state, and federal financial incentives and tax credits is provided and includes phone numbers for those homeowners who may not have access to a computer.

6 – EPS Core Elements, Training, and Web Tender Portal

Ideally the EPS will be a coordinated effort to ensure consistency of the core elements including the EPS name and branding, and the standards for auditing, software modeling, auditor training, and reporting. There is also the need for a central database to serve as clearinghouse for EPS scores for homeowners and home buyers as well as a Web tender portal through which contractors can offer estimates on energy upgrades to interested homeowners.

Core Elements

In order to be useful to these interest groups and programs, the EPS will inevitably be adapted to fit with local and programmatic needs and goals. Utilities considering the EPS for implementation would need to realize improved savings or increased cost effectiveness compared to existing approaches. However, if the EPS is to have value across stakeholder groups and geography, there are certain core elements which will need to be clearly defined to ensure uniform adaptation of the key principles:

- Name and branding
- Software modeling and auditing protocol standards
- Reporting method, including metrics, score sheet, energy analysis report, and online interface through a Web tender portal and database

Several of these elements have been outlined in previous recommendations. In this section, EPS auditor training, the database, the Web tender portal, and linkages to other stakeholders will be delineated.

EPS Auditor Training

In order to ensure the consistency and accuracy of the EPS tool, it is necessary to define the process by which someone can become an EPS auditor and how he or she can generate an EPS score sheet and EPS report.

There currently exists home energy auditing education that offers a comprehensive training in building science, building systems, building performance analysis, and constructions practices. This knowledge is spelled out by the following three national entities:

- The Building Performance Institutes' certified Building Analyst training and standards
- The US Environmental Protection Agency and Department of Energy for the Home Performance with ENERGY STAR Program specifications
- RESNET's National Rater Training and Certifying Standard list in "RESNET Mortgage Industry National HERS Standards," Chapter 2.

The pilot team recommends a similar approach to training as outlined by RESNET for two tiers of auditor training: one for technicians conducting EPS score only audits and one for EPS w/upgrades auditors. As with RESNET, the EPS would require less training for auditors delivering an EPS score only audit. The training would entail a specific range of knowledge about home energy elements and testing equipment protocols. By RESNET standards, auditors providing comprehensive home energy audits need to be BPI certified and certified HERS raters. It is recommended that a similar approach be applied to training for EPS w/upgrades auditors. See an outline of a preliminary auditing protocol in the Attachments.

Required Background Knowledge and Skills

This section includes a summary of the required knowledge areas and is based on the language in the Residential Energy Services Network (RESNET) chapter titled, "National Standard for Home Energy Audits."

- Basics of heat transfer concepts
- Basics of building performance testing
- Basics of air distribution leakage
- Calculating gross and net areas
- Definitions/energy terminology
- Basic combustion appliance concerns
- Basics of envelope leakage, thermal bypass, thermal bridging
- Determining envelope insulation
- Presence/absence of insulation and when observable, the quality of its installation
- Recommended levels of insulation by climate zone
- HVAC: determining equipment efficiencies from model numbers or default tables
- Household appliances: determine efficiency from model numbers or vintage
- Energy units
- Measuring building dimensions
- Identification and documentation of energy audit inspected features of the home
- Basics of specifications
- Determining window and door efficiency
- Determining building orientation and shading characteristics
- Defining the thermal boundaries
- Basics of measure interaction, expected life, and bundling for optimal performance considering the house as a system and the emerging need for deep savings

In addition to this building science knowledge, any EPS auditor should be required to have the following:

- The ability to perform a building envelope leakage testing in accordance with national envelope testing standards such as ASTM E779-03 or ASTM E1827-96 (2007).
- Familiarity with duct leakage testing in accordance with ASTM E1554-07.
- Knowledge of local climate conditions and climate specific practices.

A technician who conducts EPS w/upgrades audits must also have the following skills and knowledge:

- The ability to perform combustion testing in accordance with the BPI Building Analyst Standards.
- BPI building analyst certification.

In order to verify that someone has this requisite knowledge, it is recommended that there be an entrance exam. There should be different entrance exams for EPS score only and EPS w/upgrades.

EPS Building Science Training

Soon, the goal will be to offer EPS Building Science Training to those who do not yet possess a background in home energy performance. This might be developed specifically to meet the needs of auditors who will be certified for EPS score only audits. This training should cover many of the same topics as the Building Performance Institute Building Analyst training, but should be less detailed in the areas that are not audited or analyzed with SIMPLE. The training can be offered online and supplemented with hands-on workshops in the field, minimizing the costs of training. The audience for this will include home inspectors, Realtors, and some contractors who wish to offer EPS score only as a part of their services.

EPS Specific Training

Upon passing a qualifying exam for building science knowledge and home auditing skills, one would be eligible for EPS auditor training either along the score only or w/upgrade track. The 2-day trainings should have a similar format for each track and cover content that is specific to each:

EPS score only

- Conducting an audit with protocol for EPS score only
- Using the EPS software
- Generating an EPS score sheet and report
- Visiting a site for demonstrations and to conduct an audit
- Taking a final exam for EPS score only

EPS w/upgrades

- Conducting an audit with protocol for EPS w/upgrades
- Using the EPS software
- Generating an EPS score sheet and report w/upgrades
- Visiting a site for demonstrations and to conduct an audit
- Taking a final exam for EPS w/upgrades

As is common in other home audit trainings, a mentoring or proctoring period will also be required to allow auditors to show their applied knowledge and ability to conduct EPS audits and produce EPS scores and reports.

Quality Assurance

A quality assurance (QA) program needs to be designed to operate at two levels. At the program provider level, quality assurance is required to ensure that the provider is training contractors on the EPS protocols and tools appropriately, and that accurate records are being kept on each auditor. Additional QA needs to be conducted on the work of each auditor to confirm that the EPS is being implemented correctly, that homeowners are receiving the proper documents in a timely fashion, and that records are being kept of each audit. In the case of a new EPS auditor, the first 5 to 10 audits would be reviewed by a QA contractor. After that probationary period, up to 5% of audits per year would be reviewed. This QA process should be similar to existing formats already in use in this field.

Database

An important component of the EPS is the ability of stakeholders to access EPS information online. This was not fully addressed in the pilot. To move forward, the EPS will need to establish a robust database system that serves not only as a repository for collected and modeled data points and EPS scores, but that can generate a variety of reports and link to real estate listing databases.

Desk-based databases are gradually being replaced by their *cloud* counterparts, where all data is hosted online. This will allow for scalable development and expansion of the EPS database to any interested jurisdiction.

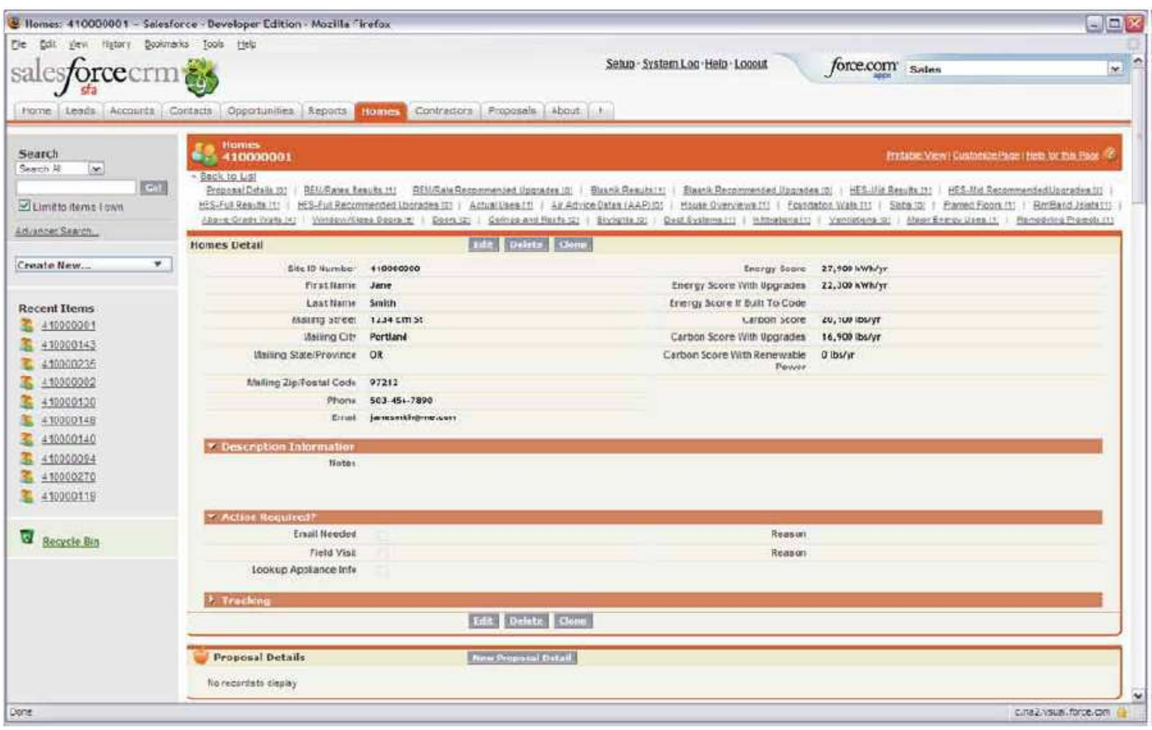


Figure 4.5 Screen Shot of SalesForce Database

SalesForce, the database system (developer version) used for the pilot, is of particular value due to the large amount of custom applications that are being developed for the software platform. SalesForce allows the creation of a public knowledge portal (PKP) that offers search capabilities (e.g., zip codes) and access to frequently asked questions while protecting the personal data of users. Linking the PKP to Google maps or Zillow will enable the public to view aggregate EPS scores for a neighborhood, city, or state.

Earth Advantage Institute hopes to encourage the adoption of the EPS concept by a national organization. The intent would be for such an organization to manage the national EPS database and the associated portals for information and contractor estimates. A full-size screen shot of the database is in the Attachments.

Online Interface – Web Tender Portal (WTP)

The parameters of an online Web tender portal were developed with the aim to provide an easy to use system for interested homeowners to receive cost estimates for recommended energy upgrades from qualified contractors. After receiving an official EPS, homeowners can choose to participate in the online estimating process and receive the information that they need to make decisions about pursuing upgrades. Online access to instant finance approval on the WTP would also facilitate the process.

Through the WTP, contractors would be able to view a subset of the EPS information and offer cost estimates for all or some of the recommended upgrades listed in the Energy Analysis Report. A homeowner would be notified via email that his or her estimates are available for review on the WTP and the owner would be free to follow up with contractors as he or she wishes. Along with the estimates, a homeowner could see a customer rating for each contractor, as well as comments posted by other consumers who have worked with that contractor. The Angie's List-type rating system of contractors would help homeowners make more informed decisions and offer an up-to-date feedback system for contractors.

Homeowners could use the WTP to schedule an official EPS audit after the contracted work is completed as a means of measuring and verifying the quality of the work performed.

In addition to assisting homeowners, the WTP would augment the work of Home Performance with ENERGY STAR contractors by providing qualified leads for work requiring their skills and knowledge. The WTP would need additional funding in order to translate the design parameters into a fully functioning tool for contractors and homeowners.

It is also recommended that the WTP be part of a larger EPS Web site that would enable all stakeholders to search for home EPSs and find locally relevant information for making energy improvements. A full-size example screen shot of the WTP is in the Attachments.

Figure 4.6 Mock Up of Tender Portal

Linkages to Stakeholders and Programs

From its inception, the EPS was designed to appeal to a variety of stakeholders:

- Homeowners and homebuyers
- Realtors and real estate listing services
- Builders
- Contractors (Home Performance and Weatherization)
- Finance, insurance, and mortgage brokers
- Utility conservation programs
- Government energy departments
- Climate policy bureaus

In order to engage with these stakeholders, there will need to be an outreach effort made to each group framing the EPS in terms that address their specific interests and needs.

Beyond these stakeholder groups, there are energy conservation programs and weatherization retrofit programs that will use the EPS. Already, the EPS has attracted national attention. The City of Seattle, City of Chicago, City of Houston, Oregon Housing and Community Services, Clinton Climate Initiative, U.S. Department of Energy, New York State Energy Research and Development Authority, and the World Business Council for Sustainable Development have expressed an interest in understanding the performance metric and its capabilities. National organizations such as U.S. DOE, EPA, RESNET, and Home Performance Council have been approached to begin a dialog about potentially adopting the EPS.

In addition, there are lessons to be drawn from European efforts to create a universal system for energy performance reporting. While Europeans are grappling with the task of establishing a mandatory system across nations, the issues that they have encountered can serve as a roadmap for the United States as it moves towards creating a more universal system of measuring and reporting home energy performance. The following is a list of elements that Europeans have either found essential or that they are in need of to ensure the quality of energy performance reporting (Maldonado, 2009):

- A sufficient number of well qualified expert auditors recognized on the basis of an exam
- A suitable electronic platform for managing the whole system
- Mandatory quality checks of issued certificates by independent experts and penalties for mistakes
- Increased quality requirements for certificates with improved recommendations
- A legal framework

<u>For Further Study</u>

The findings of this pilot are encouraging. They point to lower-cost ways of more accurately estimating a home's energy use and recommendations for improvements. In order to build on this basis and strengthen the EPS concept, Earth Advantage Institute aims to address the following in 2009:

- Provide recommendations to the developer to encourage improvements to SIMPLE.
- Develop a software testing platform that allows other tools to be assessed.
- Audit more homes to increase the data pool, and include other regions of the state and other climates to proof identified tools.
- Develop the EPS to work with 3 (triplex) and under multifamily homes.
- Conduct post-upgrade EPSs (EPS_2) on previously rated and upgraded homes, and check against actual usage changes to vet savings estimates.
- Develop the EPS data-management system.
- Pilot the streamlined and enhanced Web tender portal (graphics, password protect access, email, reporting) with contractors and homeowners.
- Identify and deliver training modules for EPS administrators and auditors/contractors.

- Develop relationship with Regional Multiple Listing Service (RMLS) to establish object linking exchange (OLE) protocol, linking the EPS database archive to RMLS database.
- Establish a mechanism for tracking the success of the EPS with respect to homeowners making efficiency upgrades and logging real savings.
- Develop a quality control protocol.
- Integrate the EPS into mortgage, refinance, and insurance products.
- Provide input on EPS marketing plan for existing homes.
- Work with energy performance organizations on refining the EPS.
- Establish an automated graphic output and report of an EPS.
- Review utility bill normalization using the new standards from NREL.
- Refine the EPS model for other climate zones.
- Investigate the relative merits of other approaches such as calibrating modeled predictions with household or regional utility bill data or average savings for various energy upgrades.

Conclusions

More accurate energy modeling software with shorter audit times is possible and needed. Despite the small pilot sample of 4 modeling software tools, the pilot found a promising software tool that offered a significantly faster and more accurate means of calculating a home's energy use than REM/Rate, the current industry standard. This challenges software developers to create better energy modeling tools.

- Modeling software should use fewer inputs and more accurate assumptions and algorithms.
- Better software testing methods should be developed that are based on accuracy relative to actual use.
- The results of such testing should be made public for each modeling software tool showing its accuracy for different types of homes.

The EPS framework combined with modeling software such as SIMPLE can provide a more accurate and affordable way to calculate a home's energy performance.

More universally useful ways of reporting performance are possible and needed. Based on feedback and pilot surveys, there are better ways to report home energy performance. Performance metrics and reporting should have the following characteristics:

- Easily understood by the general public.
- Meaningful in different contexts to respective stakeholders.
- Applicable to all homes so that comparisons can be made among homes.
- Useful for indicating progress toward energy goals for the residential building stock.
- Helpful for evaluating the impact of behavior on energy use.
- Consistent over time.

The EPS offers a new way to describe home energy performance and offers the best method for comparing homes, doing for homes what miles per gallon does for cars.

Performance standards based on consumption are needed. There is a trend shifting from prescriptive-based standards to performance-based standards.

- Performance-based standards allow greater room for creativity and innovation in home energy conservation.
- Performance-based standards make transitions easier for stakeholders when energy programs shift their standards over time.
- Measuring consumption directly incentivizes lower home energy consumption, which is the ultimate goal.

The Energy Performance Score reports annual energy use with typical occupancy and use, and therefore provides a direct connection to performance based standards and goals.

Obstacles that hinder home energy upgrades should be removed. The current system impedes connections between stakeholders and obscures important information necessary for better decisions.

- Homeowners need a sense of home performance and a prioritized list of energy improvements, as well as cost estimates and contractor referrals.
- Contractors need better assessment tools and mechanisms for connecting with interested homeowners.
- Builders and homeowners need feedback on both the energy use and carbon emissions for different energy upgrade options.
- Lenders need accurate information about home energy costs, as well as mechanisms for connecting with homeowners and builders to improve home energy performance.

The EPS as a package with a score, report, and Web site offers homeowners and professionals the tools and support they need to actualize home energy improvements in greater numbers.

It is time to rethink how home energy performance is measured and reported. Incremental energy improvements are no longer sufficient to meet the needs and goals of energy reduction in the United States. Deeper energy reductions made over shorter time periods are now crucial. This cannot be achieved through minor changes to the current methods of home energy performance auditing and reporting. The EPS pilot demonstrated that significant changes in home energy auditing are possible. Critical to making change of this magnitude is finding high leverage solutions that offer significant benefits in a number of ways. The pilot team sees the Energy Performance Score as a solution that will provide a dramatic transformation in how Americans relate to home energy, creating a universally useful, fast, and accurate miles per gallon-type rating for homes.

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This article examines some of the trends in single-family house building in the United States and provides recommendations for downsizing houses to improve quality and source efficiency.

6. ATTACHMENTS

Earth Advantage Institute Organizational Overview
U.K. Energy Performance Certificate (EPC)
EPS Pilot Field Technician Input Form
EPS Pilot Homeowner Input Form
EPS Pilot Interim Report
EPS Score Sheet for Existing Homes
EPS Score Sheet for New Homes
EPS Score Sheet with Letters
EPS Energy Analysis Report
EPS Auditing Protocol
EPS Database Screen Shot
EPS Web Tender Portal Screen Shot

The above attachments and full report are available online at:

http://www.earthadvantage.org/eps.php

A copy of the report only is also available at www.energytrust.org/eps/eps_ex.html