Asset Based Scoring for Existing Homes

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ABSTRACT

Energy Trust of Oregon has implemented and promoted an energy-use performance metric called the "Energy Performance Score (EPS)" for new construction homes and is just about to launch an EPS for existing homes. This paper explores the findings and approach taken by Energy Trust of Oregon since 2008 to research and derive a best of class asset-based metric for existing homes that meets numerous goals. Energy performance scores are "asset-based" rather than "operationally–based." "Asset-based" scores remove occupant behavior, and consider only the dwelling's physical structure, the applicable climate, and a standard set of operating parameters (e.g., thermostat settings)." By separating out behavior we can evolve to a metric that more closely resembles what a miles-per-gallon means to a consumer purchasing a car. A home's energy disclosure at time of sale and homeowner education at time of retrofit are the two "use cases" where Energy Trust sees value in having a tool for contractors to use in educating homeowners. Energy Trust's goals for a successful EPS, is to have a visual metric that:

- Has relative accuracy and consistency in predicting the home's consumption
- Is easily understood by homeowners
- Improves uptake on energy efficiency improvements
- Has ease of delivery by infrastructure (i.e. contractor acceptance)
- Provides information of value for homeowners
- Is delivered at a cost that is acceptable to homeowners
- Is fair across fuels (i.e., gas & electric) and represented in a fuel neutral perspective across different fueled homes

Introduction

As efficiency programs evolve to bring meaningful information to aid customers in better understanding their home's energy use, many efforts have been made to date.[1] An EPS is a tool for strategic engagement of customers and markets. It can be used as a tool to help contractors sell a scope of work, as a visual aid for a home buyer in comparing one home to another from an energy perspective, and as a way to educate a homeowner on their home's operating costs and its opportunity for energy efficiency improvements, but only if it can be a reliable, accepted and effective tool in the field.

Misconceptions around an EPS

It is also important to note what an EPS is not. An EPS is not a program; although it's intended to be used within energy efficiency program efforts. An EPS itself is not a certification but rather a document that discloses a home's energy consumption at a point in time given its

[1] Refer to the references for a full list of sources on the topic of home scoring and energy disclosure

asset condition at that point in time. An EPS may work collaboratively with a certification like ENERGY STAR. An EPS is not an incentive, however incentives may be tied to an EPS just as a mortgage product could be tied to an EPS value. When we first thought of incorporating EPS into our programs many contractors viewed an EPS as an alternative to Home Performance with ENERGY STAR and resisted the idea of having one. However, as we educated contractors on what an EPS is, they began to understand that it is a natural byproduct of a Home Performance level audit and can be used as a visual that demonstrates to homeowners the need for energy efficiency improvements. Today contractors are very anxious to get this tool into the market and see it as a strong sales tool. Which we can really only know when we get it deployed on existing homes. Lastly, an EPS is not a guarantee.

There are many questions that come into play when considering the deployment of such a metric.

- What is the right tool?
- How do you test accuracy of a given tool for acceptability?
- What variables of a home are required? Can we make this simple so that it doesn't cost more than $200 to deliver?
- Do you need a blower door for an initial EPS?
- Does an asset-based metric influence customer choice to install improvements?
- What does a customer relate with visually in understanding their home?
- How should the score be derived?
- Does it have efficacy in delivery in the field?
- What's the right infrastructure to deliver a score?
- What about the addition of new technologies?

First Step – Evaluate Reliable Tools

In 2008, Energy Trust undertook its first evaluative efforts in the field to vet the concept of a "miles-per-gallon" metric for a home. The original objectives were to create an MPG-type metric to convey energy use and related carbon emissions for a home under normal use that would 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. We wanted to find an accurate and cost effective method for evaluating, calculating, and scoring the energy use and carbon emissions of a home.

Out of 100 tools surveyed, four rose to the top and were then used in the field by program subcontractor Earth Advantage to inform our initial questions. The four tools at that time ranged from 1 to 2.5 hours to complete the in home audit requirements. The top findings are that:

- Complicated models with many data points were no better at forecasting energy savings than less complex models that required fewer data inputs. Similar findings occurred during Lawrence Berkeley National Labs review of software products. That is that a larger number of data inputs do not necessarily lead to greater accuracy of predicted energy use.

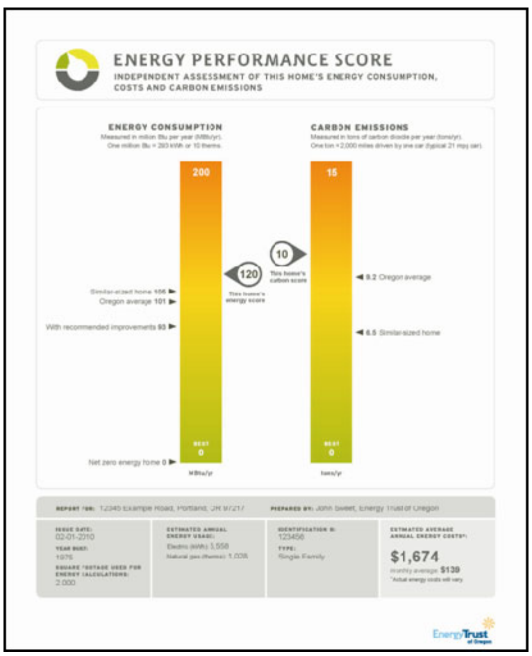
- The best performing model had an apparent error band of plus or minus 30% however we believed that a set of adjustments to the models with fewer inputs could result in a smaller error band.
- Using utility billing data to asses and compare accuracy of an asset model's forecasted energy use is flawed due to homeowner behavior being in the utility usage data.
- More tests of improved models in comparison to a standardized baseline (non-bill) should be conducted.

This effort involved the use of four models on 300 homes. The full 91 page report can be found at: http://energytrust.org/library/reports/EPS_2008_Pilot_Report.pdf .

Field Deployment of an Asset Score to Homeowners

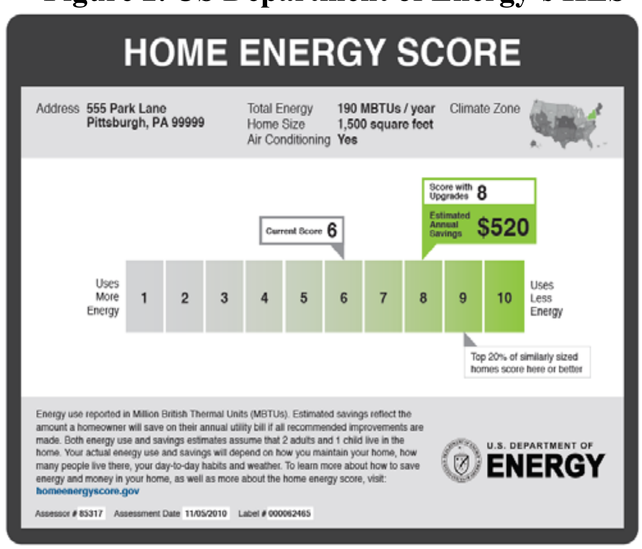
Out of this 2008 study, and after the deployment of an EPS in our new construction program, Energy Trust decided to next field test providing homeowners a score of their home during the course of a Home Energy Review (HER)[2] which is conducted by an energy advisor[3]. Homeowners who asked for an HER were randomly provided one of two forms of a *score* during this field test. One *score,* is Energy Trust's EPS (Figure 1) the other *score* is US DOE's Home Energy Score (HES) (Figure 2). In addition to the *score,* all participants received a custom recommendations report (Figure 4) which was deployed for the first time in conjunction with this field deployment of *scores.* According to our participant surveys the recommendations report was the most influential and informative collateral provided during the HER visit.

Figure 1. Energy Trust's EPS



Source: Energy Trust of Oregon

Figure 2. US Department of Energy's HES



Source: US DOE

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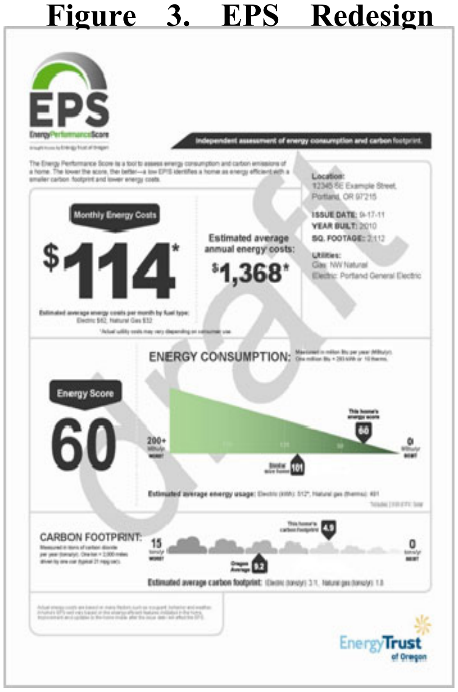
[2] A visual non-diagnostic evaluation of the home resulting in a list of recommendations and installation of CFLs and water saving devices

[3] Building Performance Institute (BPI) trained program staff

The above EPS visual (Figure 1) is what was used in the New Homes program from 2009 to April of 2012. In the course of this process Energy Trust redesigned the customer visual to address customer confusion of having a "score" with two separate scores (carbon and energy), to make more prominent the energy element, and to feature the annual operating costs of a home. Focus group research, feedback both from the new homes program staff, the EPS/HEs pilot advisors, and Energy Trust's marketing department lead to the following visual re-design of the EPS (Figure 3).

Figure 3. EPS Redesign



Source: Energy Trust of Oregon

New Visual Score

Energy Trust's redesign of the visual EPS score features a new logo, elevates the operating costs and makes more prominent the energy score.

Carbon

From focus groups and customer surveys during the pilot we found varying degrees of customer understanding of what carbon is. Having it included allows for the carbon literacy opportunity and establishes the linkage between home improvement and reduction in carbon emissions. Some focus group participants related to carbon as carbon monoxide as well. We added the "footprint" terminology and changed the depiction to be less dominant and cloud like visually in an attempt to relate carbon to air quality. Since we deliver EPS reports in varying utility scenarios Energy Trust uses the actual utility carbon based on their current resource mix and depicts carbon in an aggregate tons/yr "score" then a breakdown of the amount of carbon attributed to electric vs. natural gas is depicted underneath.

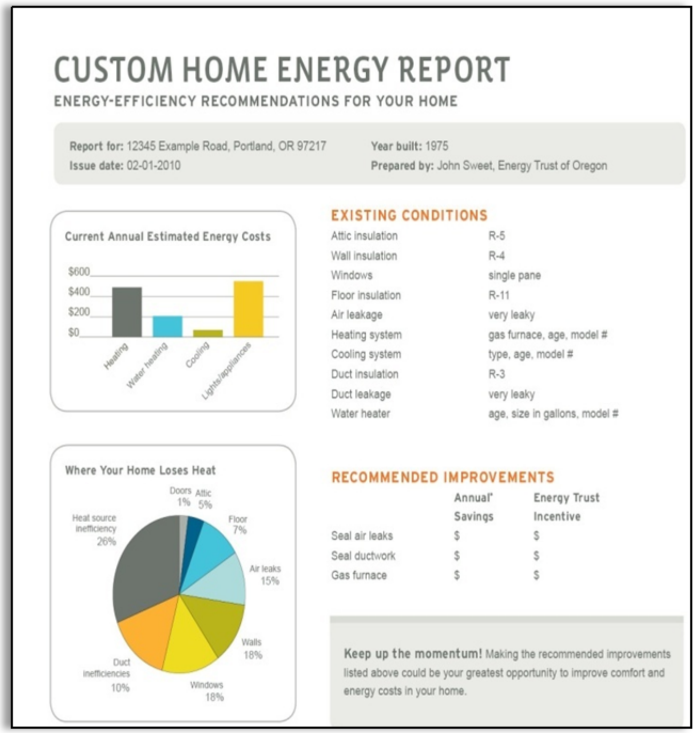
Benchmarks

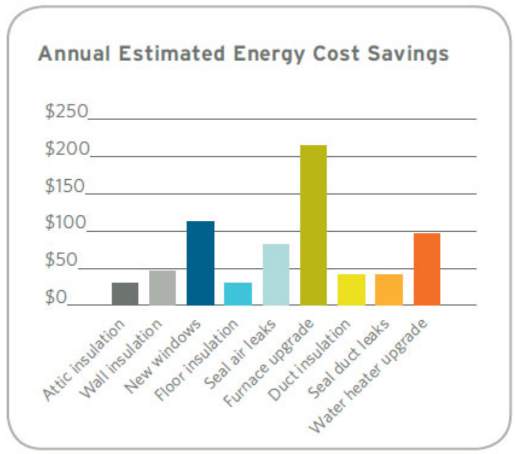
In order for an Energy Performance Score to be meaningful for a home owner, comparative benchmarks need to be used that indicate where a home falls with respect to a particular benchmark. The two benchmarks that will be used on our redesigned EPS are the average Oregon home of similar size, heating fuel, and climate zone, as well the home with improvements.

Custom Home Energy Report

We launched this version of our recommendations report for customers at the same time we deployed our EPS/HES pilot. In our focus groups and surveys we found that customers got more value from the custom energy report than the actual score sheets. This custom energy report is now provided to all customers receiving an HER by phone or in home. A control group who received only the custom energy report is used for comparative analysis with survey results and follow-through rates in order to determine if home owners who received a score were more likely to move forward with a project or do more when they did move forward.

Figure 4. Custom Home Energy Report





Backside visual based on recommendations

Source: Energy Trust of Oregon

To Blower Door or Not

In conducting these scores blower doors were not used in capturing the data points. Instead the advisor made a choice about the air leakage and assigned a value that correlates with one of five states—excellent, tight, average, leaky, or very leaky—based on a visual inspection.

Energy Trust chose not to conduct a blower door and/or duct blaster test because of the extra time and cost which violated the original cost objective of $200.[4] Second, the analysis conducted by the program around the influence of that one variable (air leakage) showed that if the advisor was completely wrong in assigning a value, the relative influence on the resulting score was nominal. Philosophically speaking if a customer chooses to then act on improvements, an actual blower door would be done and we don't want to see customers charged twice. If for purposes of an investment grade score a blower door is required, the EPS tool is established to be able to take the actual leakage value as an over ride to the assigned value.

The full detail of the 16 page survey and follow through rate results please refer to *Energy Trust Residential Home Energy Review: Analysis of Pilot Group Internet Survey Results and Energy Trust Fast Track Data*, Jennifer Stout and Steven Scott, MetaResource Group, December 2011.

Tool Comparison Study

During the second phase efforts in parallel with the delivery of scores in homes, behind the scenes Energy Trust conducted another tool comparison study on the two tools being used to deliver the pilot scores (EPS and HES) as well as SIMPLE[5], Energy Savvy[6] and Recurve[7]. Rather than comparing modeling results to actual bills, this study compared each of these tools to the regional reference tool in the Northwest, Ecotope's Simple Energy Entropy Model (SEEM). SEEM is a more detailed modeling tool that was developed to model sophisticated interactions within the structure and allows explicit examination of such parameters as duct losses and air leakage. In addition, SEEM has been tested to confirm that results match actual cases in the Pacific NW region. As a result, SEEM has been the standard tool within the Northwest region for detailed technical studies and is further explained in Chapter 5 of reference 5.

There were two data sets developed using SEEM with which to compare the other tools to. The first dataset contained a number of prototypes that were designed to examine the efficacy each tool over a diverse housing stock. Prototypes were developed for various house sizes, ages, climate zones, and heating systems resulting in 36 different prototypes. These prototypes are described below. Three prototypical buildings were designed that are roughly representative of older, moderate age and new construction.

- 1,344 square feet. Small single story over crawl space. Insulation levels typical of older homes.
- 2,200 square feet. Medium split-level w/ some second floor space over garage. First floor over crawl space. Higher insulation level typical of 1980's vintage homes.
- 2,688 square feet. Medium one story house over heated basement. Insulation level meets latest Oregon code.

[4] Since the establishment of this goal in 2008 the cost of fuel and labor has increased. A more realistic value may be $250 by today's costs.
[5] One of the tools used by Earth Advantage Institute during first phase effort that showed potential viable use
[6] Energy Savvy is the simple quick on-line audit tool used for Energy Trust's customer engagement
[7] A contractors auditing tool being used by some of Energy Trust's Home Performance Contractors

Four different equipment types were included in the prototypes used:

1. Zonal electric heat. Represents the actual thermal loads of the structure without duct losses or system inefficiencies.
2. Electric furnace, with duct losses added.
3. Gas furnace, with burner inefficiencies added.
4. Heat pump. Furnace system with heat pump. Comparison with furnace allows for assessment of how heat pump performance is modeled.

We also modeled all the prototypes in three cities (Portland, Redmond and Medford) in order to have a diversity of climates. Thus, models were run were run for each home size, heating system and location, leading to 36 cases. The second dataset was developed to compare how the various tools performed on field data collected from a test set of actual homes. For this purpose, we reviewed a group of 35 gas-heated homes and compared simulation results from each of the models and compared them to SEEM. This group of gas-heated homes was selected as representative of the current building stock in the Portland Metro region where the pilot was deployed.

Conclusions on the Tools

What we found after prototype comparison to SEEM, test home analysis and a further end use investigation is that two models appeared to be suitable for use in our market. EnergyMeasure – Home and SIMPLE as shown below. Note that the solid black diagonal line is the prototype homes modeled in SEEM (i.e., a point directly on the line represents identical results between the two modeling methods) Another successful outcome of this second tool analysis is that Energy Trust established a methodology and set prototypes that can be used to vet other tools for use in our market. This methodology could be used by other program administrators to vet model performance in a given market.

Figure 6. Energy Measure – Home

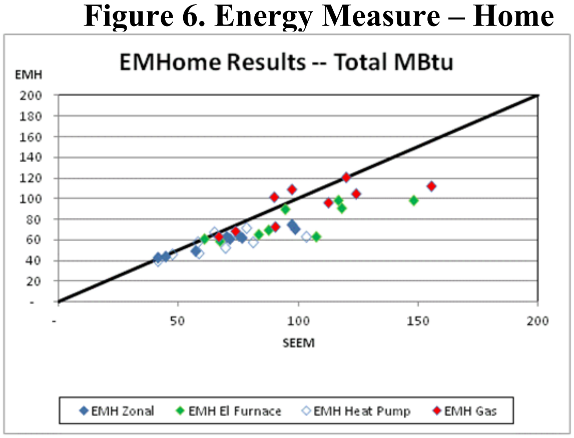
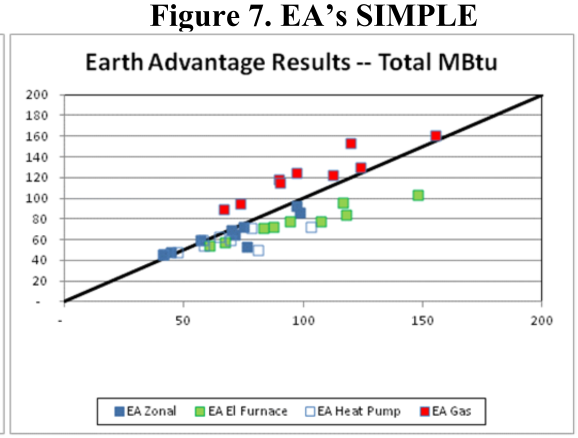


Figure 7. EA's SIMPLE



Ability to model appliance loads and cooling is less important in calculating the overall score, but it is important to note that all of the models had significantly different assumptions regarding appliance loads. For this reason the program will need to determine a methodology for contractors to consistently address appliance load assumptions as well as other factors like how livable space is defined. Defining and establishing standardization in the method and consistency in the way home characteristics are captured will result in more consistent scores being delivered in a given market. Additional conclusions regarding features of the various modeling tools based on results for end use are outlined in the full report.

It's important to note that at the time of this tool analysis (June 2011) the limited release pilot version of DOE's HES tool was used. DOE has made significant improvements to their platform since that point in time. As with most modeling tools many have been improved upon and will continue to undergo tweaks to bring them into alignment with particular technologies, programs and housing stock types.

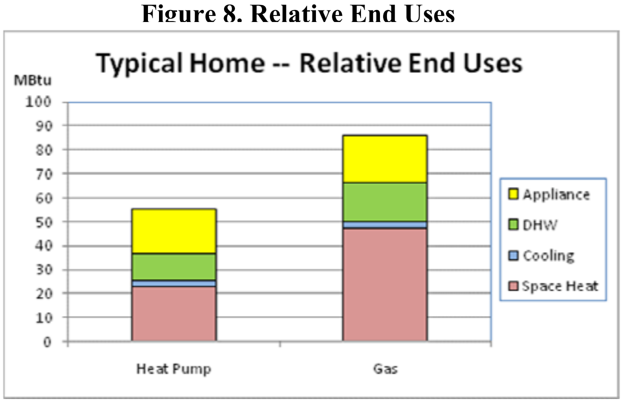
Where Are We Now?

On January 23rd, 2012, Energy Trust held an EPS stakeholder meeting in which over 100 individuals participated either in person or by phone. It was at this meeting that Energy Trust shared our top issues to resolve in order to move forward with the deployment of an EPS for existing homes. The most significant aspect for Energy Trust, which is a very relevant topic at the national level as well, is the lack of ability to present a truly fuel neutral score when using either site or source energy. This did not just present issues with Energy Trust's fuel neutrality policy, but also confused the "Save Energy, Save Money" message.

Fuel Choice Results in Different Scores

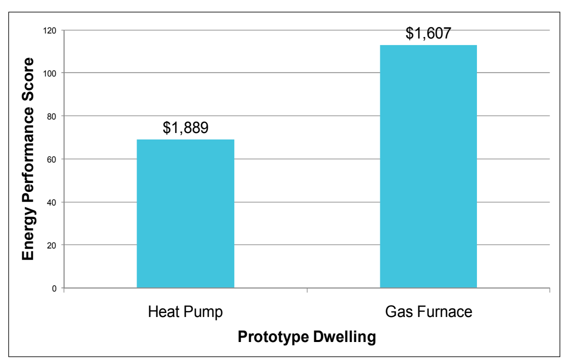
The graph to the right, from the tool analysis report, shows the very real difference in MBtu when using site energy as the output unit and comparing a gas vs. electric home, especially for existing homes where space heating contribution to the overall score is significant. Under Energy Trust's funding agreement we are mandated to be a fuel neutral organization, and using site energy for providing a score is problematic. Site–based MBtu scores favor heat pumps and source energy scores favor gas. It's also a confusing message to a consumer that a heat pump costs more to operate yet has a lower, or better, EPS score.

Figure 8. Relative End Uses



Source: Stellar Processes

Figure 9. Comparison of EPS and Annual Operating Costs



The solution described below would address both of these issues while maintaining the original intent of the EPS – a miles-per-gallon type of rating enabling consumers to compare houses, and where zero is good. Under this system, smaller and newer homes would score better (lower). While a certain amount of immersion in the details is required to convey and consider the solution we are proposing, we want to underscore two points: it would be simple to implement with any of the modeling tools being considered for generating an EPS, and it would not change the way EPS is communicated to customers.

Current Metric – Pure BTUs

Historically an EPS has been calculated by modeling the home's site-based energy usage under average operating conditions and then converting the kWh and Therms (if applicable) to MM BTU's. The total MM BTU's represents the score. Figure 10 shows the calculation of deriving a score from the usage for a typical gas furnace home and Figure 11 shows the same for the same home with a heat pump instead of a gas furnace. The difference in scores for the two fuel scores is significant.

Equation (1): Total kWh * (.003412) + Total therms * (.1) = EPS

Figure 10. Gas Furnace Home

	Usage	MM BTU Mult.[8]	MM BTUs
SPHT (Therms)	464	0.1	46
DHW (Therms)	194	0.1	19
Other (kWh)	5,996	.003412	20
EPS Score			**86**

Figure 11. Heat Pump Home

	Usage	MM BTU Mult.	MM BTUs
SPHT Electric	6,694	.003412	23
DHW Electric	3,380	.003412	12
Other Electric	6,074	.003412	20
EPS Score			**55**

Because of this bias Energy Trust staff recommends modifying the pure BTU score, creating an "adjusted" BTU metric. The following section describes a simple way to adjust the score in order to normalize for fuel source on average for typical heating systems.

New Metric – Adjusted BTUs

In order to understand the cause of the difference in the scores created with the pure BTU metric, one has to understand the on-site efficiencies of the space- and water-heating equipment being assumed by the modeling software (shown in Figure 12). For purposes of illustration, we established a rough estimate of equipment efficiencies representing the situations where

[8] These are the standard kWh and Therm MM BTU conversion factors

competing systems are most likely to be compared—when a customer is considering purchase of new space or water heating equipment.

Fuel weights, presented in Figure 13 for illustration purposes, can be created for space and water heating using the ratio of the electric equipment efficiency to gas equipment efficiency. These weights can then be applied in the calculation of the EPS as an added adjustment to normalize scores for fuel source. The factor would be used only on the electrically heated space- or water-heat of a home to bring it in alignment with a gas home.

Figure 12. Equip. Efficiency Assumptions

Assumptions	
Space Heating Efficiencies	
Heat Pump	200%
Gas Furnace	92%
Water Heating Efficiencies	
Electric	92%
Gas	65%

Figure 13. Fuel Weights

Fuel Weights	
Space Heat	217%
Water Heat	141%

Figure 14. Heat Pump Home w/ Fuel Weight

	Usage	BTU Mult.	Fuel Weight	MM BTUs
SPHT Electric	6,694	3,412	217%	46
DHW electric	3,380	3,412	141%	19
Other electric	6,074	3,412		20
EPS Score				**86**

Equation (2):
SPHT kWh*(.003412)*217%+DHW kWh*(.003412)*141%+Other kWh*(.003412) = EPS

Figure 14 shows that after the fuel weights have been applied the fuel bias has been removed from the score. Moving forward with this "adjusted" BTU metric would require agreement on the average equipment efficiencies and acknowledgement that the scores would be equal on average for typical heating systems. Energy Trust is proposing that the weights represent a comparison between the new systems we see coming into our programs. Any modeling software that is used to generate an EPS in Energy Trust territory would have to apply the weights when generating a score for a home with electric space or water heating. In addition, these fuel weights would have to be periodically reviewed to ensure a reasonable level of accuracy.

Hosting a Score and Implementation Plans

Energy Trust recognizes the demand in the market for a home energy rating system, but at the same time acknowledges there remains uncertainty as to the influence a score will have on the adoption of energy efficiency measures. We also recognize it will be new to the market and contractors may have limited experience with it or the technical ability to deploy it. For these reasons, Energy Trust is proposing a phased approach to introducing an EPS to the existing homes market. This phased approached is designed to quickly introduce an EPS into a segment of the existing homes market, while using minimal program resources, and providing a clear exit strategy for Energy Trust if the score does not gain market support.

Phase 1 involves an initial roll out of an EPS to Energy Trust customers during a comprehensive audit delivered through the existing Trade Ally Network of Home Performance Contractors. This contractor group is uniquely qualified to provide an EPS because they have been highly trained in building science and whole home energy modeling. These contractors should be able to easily incorporate the delivery of an EPS into their audits. In addition, using an established network of contractors reduces the administrative costs to Energy Trust.

Providing an EPS would be optional and there would be a fee associated with each official EPS delivered. Phase 1 is expected to start in July and last approximately one year. It is anticipated that an EPS will be delivered to 500-1000 existing homes during Phase 1. Energy Trust proposes to take on the following responsibilities in Phase 1:

- Develop modeling requirements for CSG and Earth Advantage
- Develop Fuel Weights and vet them
- Create Trade Ally addendum for contractors delivering and EPS
- Allow use of co-op trade ally development funds to help offset training cost
- Facilitate quality control and quality assurance services
- Support modifications to existing market based EPS trainings to comply
- Facilitate stakeholder engagement group to plan for Phase 2
- Conduct process evaluation and customer feedback surveys

At the end of Phase 1 Energy Trust's role and resources will be evaluated. It is important to recognize that Phase 1 of the EPS roll out does not provide a comprehensive home energy rating system for homes for the entire state of Oregon, as our service territory comprises about 80% of the population. To accomplish this goal other market actors will need to play a significant role and dedicate the necessary resources. Phase 1 will introduce a rating system into the market while minimizing Energy Trust resources necessary for implementation. Phase 1 will lay the groundwork for further development extensions as demanded by the market or public policy.

Phase 2 will involve a range of stakeholders and will require positive evaluation findings in order to maintain significant Energy Trust support. Early in Phase 1 Energy Trust will solicit interest from stakeholders to participate in a working group which will plan for Phase 2. This working group will be convened by Energy Trust through Phase 1; however, it is possible that other stakeholders may be bettered suited to serve this role in Phase 2. It is expected that this later phase will address:

- Expansion of the EPS delivery network beyond Home Performance contractors
- Inclusion of additional software tools or evolution of a single data intake platform
- Deployment of an EPS in other utility service territories
- Defining the roles that key stakeholders will play moving forward

- Identification of the appropriate entity to house EPS data at a statewide level
- What the appropriate fee structure would be for a statewide system
- The process for inclusion of EPS data within RMLS systems

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