# 2013 Report on Energy Savings and Measure Costs of Existing Homes program tracks: Standard, Home Performance, and Clean Energy Works Oregon

*Completed by Energy Trust Planning & Evaluation Group. Contributing analyses and findings reviewed by multiple independent evaluation experts as noted.*

February 14, 2014

## PURPOSE & INTRODUCTION

The purpose of this report is to provide Energy Trust of Oregon and program stakeholders a comparison of the savings and invoiced costs for three tracks within Energy Trust's Existing Homes program.

This report focuses on the three Existing Homes program tracks that provide the majority of energy savings from single-family homes.

1. Standard—stand-alone measures installed by Energy Trust trade ally contractors.
2. Home Performance—a whole-home energy-savings approach performed by Energy Trust Home Performance with ENERGY STAR trade ally contractors.
3. Clean Energy Works Oregon (CEWO)—a whole-home energy-savings approach performed by Energy Trust Home Performance trade ally contractors within CEWO's delivery model.

All three tracks receive the same cash incentives from Energy Trust for installation of qualifying measures. However, the type of energy study provided, the sales approach used, the way energy-efficiency choices are presented to the customer, the actual services provided, financing options available, and project verification services applied differ across the three tracks.

This report is informed by three analyses completed by Energy Trust and reviewed by multiple independent evaluation experts: an energy consumption analysis of utility billing data to identify savings resulting from CEWO in 2010 and 2011, a comparative analysis of savings from CEWO and the Existing Homes Standard Track, and a comparative analysis of measure costs in four Existing Homes program tracks, including CEWO, Home Performance and the Standard Track.[1] It is also informed by previous findings from evaluations of Energy Trust's Existing Homes program tracks.

This report is intended to improve our understanding of the measure costs and savings performance of each track at a time when the Existing Homes program is experiencing an array of conflicting pressures, including how to:

- Reach more customers

[1] See following documents for details on analyses and findings:
*Clean Energy Works Oregon Energy Consumption Analysis, 2010-2011*, February 11, 2014
*Comparative Analysis of Measure Costs for Existing Homes Program Tracks*, February 14, 2014
*Comparative Analysis of Savings for Existing Homes Program: CEWO and Standard Tracks,* February 14, 2014

- Achieve more savings in each home
- Support weatherization-based economic development and community "high road" goals embodied in CEWO's mission
- Achieve lower-cost savings to meet the mandate for cost-effective savings, made more challenging by current low gas costs

Throughout this report, the term "cost" refers to the amount paid by the customer to a contractor for the energy-efficiency measures installed in the home.

The cost and savings for the Standard Track have been extensively analyzed, and the results have led to:

- A conclusion that the gas portion of the Existing Homes program does not pass the Total Resource Cost (TRC) test used to determine cost-effectiveness under current analysis procedures.
- An exception from the Oregon Public Utility Commission (OPUC) to re-examine how cost-effectiveness is calculated, and to continue work to reduce program costs.

Energy Trust will present the OPUC with a proposal to reconsider cost-effectiveness methods in July 2014, and the OPUC will provide guidance through a public docket in fall 2014. Issues under discussion include how to consider such factors as comfort and related benefits to customers, the volatility of natural gas prices, discount rates used in the analysis, and whether to consider additional economic benefits to Oregon.

## BACKGROUND

Since 2003, Energy Trust has provided eligible residential customers with information, services, cash incentives and referrals to qualified trade ally contractors to support energy-efficiency upgrades in single-family homes through the Standard Track. In 2006, Energy Trust added a Home Performance with ENERGY STAR Track. In 2009, Energy Trust further expanded support for the Home Performance approach through the Clean Energy Works Portland (CEWP) pilot, and later through Clean Energy Works Oregon (CEWO). Each track is described in more detail below.

### *a. Standard Track*

Through the Standard Track of its Existing Homes program, Energy Trust supports customers completing individual energy-saving measures, whether one at a time over a span of years, or in quick succession as part of a more intensive home improvement project. Energy Trust assists eligible customers taking this measure-by-measure approach in several ways. Customers may request an in-home or phone-based "Home Energy Review" consultation with an Energy Trust energy advisor, or access an online Home Energy Profile tool for a web-based interaction. These services help customers identify and prioritize energy-saving opportunities in their homes, identify incentives available for qualifying measures, and encourage customers to connect directly with a contractor to acquire a bid for the work.

Contractors completing work in Energy Trust's Standard Track respond to consumer preference, bidding on and installing the energy-savings measure or measures requested. These contractors establish their own pricing and business practices. Energy Trust relies on

the existing contractor market, sets installation standards and provides quality assurance. Energy Trust also encourages contractors to assist customers with incentive application paperwork and offers various tools and resources to facilitate the customer's selection of a contractor.

### *b. Home Performance Track*

Home Performance with ENERGY STAR (Home Performance) helps homeowners improve the efficiency and comfort of their homes using a comprehensive, whole-house approach, while helping to protect the environment. Since 2006, Energy Trust has served as the Oregon sponsor of Home Performance with ENERGY STAR, a U.S. Department of Energy/Environmental Protection Agency joint program, and has helped develop the contractor network and market for these services in Oregon.

Home Performance contractors are specially trained and certified through the Building Performance Institute (BPI), and use diagnostic equipment to test and evaluate components of the home's interior and exterior. Energy Trust provided early development support for Home Performance including investment in contractor trainings, certification and diagnostic equipment purchase. Information gathered through home testing helps a Home Performance contractor observe how the different components of the house work together to deliver energy efficiency, comfort, safety and indoor air quality. This approach encourages national technical best practices, assists in the marketing of weatherization and equipment upgrades, and may result in the delivery of services that extend beyond energy savings.

Similar to the Standard Track, Energy Trust provides cash incentives and contractor referrals to customers, and supports the Home Performance market through quality assurance and expectations for high-quality installations practices. As the Home Performance with ENERGY STAR local sponsor, Energy Trust submits quarterly reports to the U.S. Department of Energy on activity in our service territory.

### *c. Clean Energy Works Oregon Track*

Awareness and availability of Home Performance services has grown in Oregon over time, including through the formation of CEWO, an independent nonprofit that delivers energy savings to Energy Trust through Home Performance contractors. CEWO was established in 2010 to continue a pilot program jointly developed in 2009 by the City of Portland and Energy Trust. The pilot, Clean Energy Works Portland (CEWP), fulfilled a state mandate established through Oregon legislation passed in 2009 known as the Energy Efficiency and Sustainable Technology Act (EEAST). Part of the Act was intended to demonstrate financing and loan repayment via the utility bill for residential energy-efficiency projects. The availability of on-bill repayment removed a barrier for some customers who are unable or do not prefer to pay total project costs upfront.

Federal grants through the American Recovery and Reinvestment Act (ARRA) provided funding for the CEWP pilot, and subsequently for CEWO. As an ARRA recipient, CEWO meets goals for job growth and retention, and adheres to federal reporting requirements. All projects submitted by CEWO also adhere to High Road Standards, originally established for CEWP by a number of parties including the City of Portland and Energy Trust. Such standards aim to provide employment opportunity for disadvantaged workers. They also establish wage standards for contractors to comply with Oregon's EEAST law.

Energy Trust provides its standard cash incentives for eligible energy-efficiency measures installed through CEWO Track projects. These incentives are provided directly to CEWO, which applies them as part of the customer financing packages it offers to participants.

Nationally, the cost per energy-saving measure delivered through Home Performance has been higher than the cost per savings through standard energy-efficiency program tracks that support a measure-by-measure approach. This has also been the case in Oregon with Energy Trust's Home Performance Track and CEWO Track. There are many reasons that may contribute to these cost differences, including: the broader scope of Home Performance projects, difficulty segmenting the energy measure costs and distinguishing them from costs of other services in contractor invoicing, the quality level to which the work is performed based on consumer preference, the wage requirements of EEAST and the added administrative burden for contractors to meet ARRA reporting requirements.

The growth of the Home Performance industry in Oregon has resulted in an increase of the number of whole-home weatherization projects. It has generated job growth and opportunities for businesses. Nevertheless, the higher invoiced cost per energy-saving measure, coupled with more difficult-to-measure benefits, creates a challenge for Energy Trust to show how it meets the mandate for cost-effective savings. The issue of cost-effectiveness and how benefits are valued in cost-effectiveness tests is a national issue, and is exacerbated by the current lower costs of energy, especially natural gas. Energy Trust has been working with contractors and stakeholders to review the savings and costs of its Existing Homes program tracks to identify where program offers can be maintained, given challenges with cost-effectiveness.

## KEY FINDINGS

Energy Trust Existing Homes Standard Track, Home Performance Track and CEWO Track appear to save approximately the same amount of energy per measure.[2] Average costs per measure are significantly higher in the Home Performance and CEWO Tracks.[3]

As these differences among tracks are observed, it should be noted that the Home Performance Track and CEWO Track market benefits in addition to energy cost savings for the consumer, and in the case of the CEWO Track, to provide additional social and economic benefits to Oregon that are not currently included in the TRC test. Weatherization projects can provide consumer benefits such as comfort and reduction of noise from outside, and yield positive impacts for the region's economy and for the environment. There are also preferences for different types of contractor services among consumers. As part of its High Road standards and benefits, and in alignment with the EEAST law, CEWO also requires that contractors meet wage rates higher than is typical of the industry. While these considerations are important in the overall discussion of weatherization programs, they are beyond the scope of this report.

## METHODOLOGY

[2] See *Comparative Analysis of Savings for Existing Homes Program: CEWO and Standard Tracks*

[3] See *Comparative Analysis of Measure Costs for Existing Homes Program Tracks.* Weatherization measures analyzed: ceiling insulation, wall insulation, floor insulation and air sealing.

This report draws on new analyses of the CEWO Track and previous evaluations of the Home Performance Track and Standard Track. In the evaluations cited in this analysis, energy savings estimates from program evaluations were developed using best practices based on statistical analysis of utility energy consumption data for homes. This billing analysis is the most reliable method for this type of program.

Energy Trust has utilized billing analysis, with independent review by national experts, to determine the savings impact of the Existing Homes program since its inception. Three years ago, Energy Trust began performing billing analysis for the Existing Homes program using its in-house evaluation staff instead of contracted evaluators, engaging additional independent national experts to review the evaluation design and findings. Transitioning to in-house analysis allowed Energy Trust to reduce costs for the intensive data cleaning required, while increasing the consistency of approach for data cleaning, outlier elimination, and analysis across years and program tracks. It also allowed Energy Trust to make evaluations more transparent by performing more extensive sensitivity analyses with alternative methods. To further assure continued impartiality of findings, the Energy Trust Board of Directors' Evaluation Committee engages two independent evaluation experts to review evaluations and present comments to the committee.

In alignment with this approach, the analytic methods and results cited in the report were reviewed by multiple independent experts in billing analysis and energy-efficiency cost and savings evaluation.[4] They provided comments and questions that helped refine the methodology translating to the analysis and final report. While the results form a solid basis for estimating overall savings, the available data and methods are only suitable to identify large differences in savings between the distinctive program tracks.

This report analyzes energy savings and the total installed cost of efficiency measures, including the cost of the equipment (insulation, air sealing) and installation as invoiced independently by the contractor. This is the appropriate cost for consideration in the TRC test. The TRC is the primary investment test recognized by the OPUC, and total cost of energy-efficiency measures is critical to determining whether Energy Trust is permitted, under OPUC rules, to invest ratepayer dollars. Cost data comes from the only available source: contractor invoices. This data source does present some complexities:

- Contractors, by their own account, allocate costs to different measures based on how they think they can best sell a job. Consistent trends across measures are likely to be more meaningful.
- Contractors are also known to bundle costs of some services that are not related to energy efficiency into their reported costs for measures. This may overstate costs for efficiency measures.
- Home Performance contractors delivering Home Performance Track and CEWO Track services in particular employ a "whole home" sales approach where measure costs are sold as a package, and the distinction between costs for different measures may be blurred.

[4] Independent reviewers for *Clean Energy Works Oregon Energy Consumption Analysis, 2010-2011*: Ken Keating, consultant; Tom Eckman, Conservation Resources Manager, Northwest Power and Conservation Council; Scott Pigg, Principal Researcher, Energy Center of Wisconsin; and Michael Blasnik, Principal, M Blasnik & Associates. Independent reviewers for *Comparative Analysis of Measure Costs for Existing Homes Program Tracks*: Ken Keating and Tom Eckman. Independent reviewers for *Comparative Analysis of Savings for Existing Homes Program: CEWO and Standard Tracks*: Ken Keating, Tom Eckman and Scott Pigg.

- By design, measures installed via Home Performance include additional services and approaches desired by customers. This makes the direct comparison to single measures more difficult.

The degree to which these factors explain the considerable cost differences between tracks shown in this report is beyond the scope of the report.

## SUMMARY OF COMPARATIVE ANALYSES

*Savings Comparison*

One of the aspirations for the Home Performance Track and CEWO Track is that through the extensive training and higher standards that come with Building Performance Institute certification, and are embodied in these tracks, savings per measure would be higher.

A comparative analysis of savings between CEWO and the Standard Track was performed using savings data from the 2010-2011 CEWO evaluation and a prior 2008-2009[5] evaluation of the Standard Track, the most recent impact evaluation of that track.[6] The estimated savings per measure from this comparative analysis showed savings are about the same between the two tracks in 2010 and considerably lower for CEWO in 2011. The evaluation does not provide clear reasons for these differences.

This conclusion is consistent with a prior Energy Trust comparison of Home Performance Track and Standard Track savings, which showed no clear pattern of differences in savings between the tracks. Since Home Performance and CEWO tracks both employ Home Performance contractors and procedures, it is not surprising that they have similar outcomes.

*Cost Comparison*

Average costs per measure, as reported by installation contractors, were analyzed for the Standard, Home Performance and CEWO tracks. Costs were calculated for this analysis per square foot of the home or insulation amount, as appropriate to each measure. Costs from the most recent 12 months (up to October 15, 2013) were analyzed for the comparison. Cost data for projects over a larger timespan, including the period of the CEWO savings impact evaluation (2010-2011), was used to look for trends over time. This analysis was done using participants from each of the Existing Homes tracks compared in this report, with the 5 percent highest and lowest outliers for several variables removed from each track.

The following conclusions were made:

- Reported measure costs are lowest in the Standard Track, as compared to the Home Performance and CEWO Tracks.
- Reported measure costs for the Home Performance Track are significantly higher than those in the Standard Track.

[5] http://energytrust.org/library/reports/2009_HES_gas_impact_eval.pdf
http://energytrust.org/library/reports/2008_residential_gas_impact_eval.pdf

[6] Staff believes that the cross-year comparison is appropriate for these reasons: (1) Standard Track savings have been fairly stable in recent years, and (2) results of both evaluations are adjusted for weather and changes in use among nonparticipants, so influences of factors from the particular year have been minimized. However, given the complexity of consumer energy use, comparisons would only be useful in showing significant differences in savings per measure between tracks (e.g., more than 20 percent).

- Reported CEWO Track measure costs are also significantly higher than the Standard Track.
- Costs per measure for the CEWO Track were higher than the Home Performance Track.
- Costs trends were examined for the CEWO Track and found to be fairly stable over the 2010-2013 period.
- The average cost per square foot varies the least between individual homes in the Standard Track, and varies the most for individual homes in the CEWO Track.

Energy Trust will continue to evaluate the process and savings impact of the Existing Homes program on an ongoing basis, and will continue to publish evaluation findings on its web site at www.energytrust.org/about/policy-and-reports.

# MEMO

**Date:** 2-14-2014
**To:** Board of Directors
**From:** Phil Degens, Evaluation manager
Marshall Johnson, Residential Program Manager
**Subject:** 2013 Report on Energy Savings and Measure Costs of Existing Homes program tracks: Standard, Home Performance, and Clean Energy Works Oregon

The 2013 report updates and helps refine the gas savings estimates for Clean Energy Works Oregon (CEWO) which delivers savings as part of the Existing Homes program. In addition, the report provides the program with comparative information regarding savings and measure costs in the three Existing Homes program tracks that provide the majority of energy savings from single-family homes: the Standard Track, the Home Performance with ENERGY STAR Track, and the Clean Energy Works Oregon Track.

This report is released at a time when the Existing Homes program is assessing strategies to achieve lower-cost savings to meet our mandate for cost-effective savings, while balancing support for approaches that deliver a range of benefits to motivate customers to complete energy-efficiency projects in their homes.

The Existing Homes program will:

- Incorporate the CEWO savings estimates into our reporting on Existing Homes program savings.
- Continue to coordinate with CEWO to aggregate incentives and report energy savings for eligible measures according to our Home Performance with ENERGY STAR project requirements and incentive levels.
- Continue to work with Home Performance contractors to acquire and report energy savings by providing cash incentives for eligible measures.
- Continue efforts to reduce costs for energy efficiency in existing homes, including efforts to reduce measure costs by providing customers with information about average installed costs and corresponding energy savings and related benefits.

Energy Trust staff look forward to additional guidance as part of the Oregon Public Utility Commission process to explore gas cost-effectiveness in their docket in 2014.

# Comparative Analysis of Savings for Existing Homes Program: CEWO and Standard Tracks

*Summary of comparative analysis completed by Energy Trust Planning & Evaluation Group. Analysis and findings reviewed by independent evaluation experts Tom Eckman, Conservation Resources Manager at Northwest Power and Conservation Council, Ken Keating, consultant, and Scott Pigg, Principal Researcher at Energy Center of Wisconsin.*

February 14, 2014

Due to the fact that homeowners participating in the Clean Energy Works Oregon (CEWO) Track complete more measures at once and also tend to complete a mix of measures that is more weatherization-focused than participants in the Existing Homes Standard Track, the realization rate and other results of the CEWO billing analysis are not directly comparable to the Standard Track. This billing analysis compared actual savings at the whole house level to the modeled energy savings predictions that were used in the CEWO Track in 2010 and 2011, while the Standard Track uses deemed measure-level savings that are based upon engineering estimates and prior evaluation results.

In order to make the CEWO Track savings results comparable to the Standard Track savings, an estimate of the deemed savings per home was calculated. This was done by quantifying the type and number of measures completed by the homes included in the CEWO billing analysis sample, and using the standard deemed savings rates that are used in the Standard Track of the program (and have also supplanted the previous modeled savings approach). These were used to build up an average deemed savings per home, which could then be directly compared against the savings identified by the billing analysis.

In comparing the CEWO billing analysis savings to the predicted deemed savings build up, we are able to compare the performance of measures in homes participating in the CEWO Track to the same measures completed by those participating in the Standard Track. Because this relies upon billing analysis, the savings can only be compared at the whole-house level. A more specific analysis of individual measures is not feasible, since CEWO is intended as a comprehensive weatherization path. There would not be a sufficient number of homes completing only single measures for an adequate billing analysis sample.

The results are presented below.

| Gas Savings per Home (therms) Comparison | 2010 | 2011 |
|---|---|---|
| **CEWO modeled savings** | 361 | 336 |
| **CEWO savings as identified through billing analysis** | | |
| Normalized Consumption | 225 | 125 |
| Raw Consumption | 195 | 130 |
| **Standard Track deemed savings** | 206 | 251 |

The results of this analysis show no major difference between the savings identified by the CEWO billing analysis, and those predicted by the Standard Track deemed savings approach. In 2010, the deemed savings and billing analysis have no appreciable difference. In 2011, the

billing analysis shows lower savings while the deemed savings level is higher relative to 2010. Despite this difference, there is no evidence that the comprehensive approach taken by homes participating in CEWO achieve higher levels of savings per measure than those participating in the Standard Track.

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# Clean Energy Works Oregon Energy Consumption Analysis, 2010-2011

By Phil Degens
February 11, 2014

Energy Trust of Oregon

## *Acknowledgements*

I would like to thank the many outside reviewers of this report for their extensive review and comments that helped shape the report's format and analysis. The set of independent outside reviewers that provided input were:

Scott Pigg, Principal researcher at Energy Center of Wisconsin

Michael Blasnik, Principal at M Blasnik & Associates

Tom Eckman, Conservation Resources Manager, Northwest Power Planning Council

Ken Keating, Consultant

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## Introduction

Clean Energy Works Oregon (CEWO) and its pilot program Clean Energy Works Portland (CEWP) have been operating as an on-bill financing weatherization program in Oregon since 2009. Access to financing allows homeowners to do more comprehensive weatherization projects. More than 4,300 households have availed themselves of CEWO's services and have completed weatherization projects in their gas- or electrically-heated homes. This report provides estimates of gas and electric savings generated by the program from 2010 through 2011. The program year 2009 is not analyzed since analyzing a very small number of participants (7) would not lead to reliable results.

More than 1,400 households installed energy saving measures and received services through CEWP in 2010 and CEWO in 2011. Average claimed electric savings in 2010 and 2011 (the two years with substantial numbers of participants) were about 2,000 kWh while average claimed gas savings ranged from 336 to 361 therms.

### Table 1. CEWO/CEWP kWh and Therm savings claimed, by year

| | | Electric | | Gas | |
|---|---|---|---|---|---|
| **Year** | **Total Sites** | **Average kWh Savings** | **Sites** | **Average Therm Savings** | **Sites** |
| **2009** | 7 | 389 | 5 | 426 | 7 |
| **2010** | 548 | 2,331 | 427 | 361 | 377 |
| **2011** | 866 | 1,904 | 572 | 336 | 687 |

As Table 2 shows, of the participating sites with gas accounts, nearly 85% had installed gas space heat related measures. On the other hand, only 20-26% of the participating sites with electric accounts had installed electric space heat related measures. We presume that many of these sites had gas space heat.

### Table 2. Share of space heat related measures installed in sites participating in CEWO

| **Year** | **Percent installed gas space heating measures** | **Percent installed electric space heating measures** |
|---|---|---|
| **2010** | 83% | 20% |
| **2011** | 84% | 26% |

From Tables 3 and 4, which show the number of sites participating in CEWO that installed, and average savings for, various measures, it is clear that CEWO is inspiring households to do comprehensive weatherization projects. The bulk of reported gas savings claimed are coming from shell (74%) and HVAC (16%) measures. Even though only a small proportion of the homes are electrically-heated, nearly two thirds of

reported electric savings claimed are coming from shell measures (33%) and HVAC replacements and upgrades (31%).

## Table 3. Gas measure savings claimed (therms) and sites, by year

| | 2009 | | 2010 | | 2011 | | 2009-2011 |
|---|---|---|---|---|---|---|---|
| **Measure Codes** | Average Savings per Site | Number of Sites | Average Savings per Site | Number of Sites | Average Savings per Site | Number of Sites | % of Total Gas Savings |
| **AERATOR** | 12 | 1 | 12 | 111 | 14 | 104 | 1% |
| **AIR SEALING** | 65 | 5 | 97 | 282 | 88 | 525 | 20% |
| **BOILER** | - | - | 106 | 5 | 112 | 5 | 0% |
| **CEILING INSULATION** | 111 | 6 | 99 | 258 | 82 | 489 | 18% |
| **CLOTHES WASHER** | 4 | 2 | 4 | 19 | 4 | 28 | 0% |
| **DISHWASHER** | - | - | - | - | 1 | 2 | 0% |
| **DUCT INSULATION** | 61 | 1 | 22 | 82 | 19 | 170 | 1% |
| **DUCT SEALING** | 20 | 1 | 87 | 75 | 91 | 138 | 5% |
| **ENERGY SAVER KIT** | - | - | 10 | 19 | 11 | 61 | 0% |
| **FLOOR INSULATION** | 77 | 3 | 78 | 171 | 63 | 337 | 9% |
| **GAS FURNACE RETIREMENT** | - | - | - | - | 151 | 216 | 9% |
| **GASFURNACE** | 124 | 3 | 125 | 27 | 71 | 7 | 1% |
| **KNEEWALL INSULATION** | - | - | 37 | 1 | 30 | 1 | 0% |
| **SHOWERHEAD** | 22 | 1 | 27 | 104 | 31 | 134 | 2% |
| **TANK WATER HEATER** | 17 | 1 | 70 | 12 | 25 | 44 | 1% |
| **TANKLESS WATER HEATER** | 105 | 1 | 106 | 97 | 65 | 108 | 5% |
| **WALL INSULATION** | 184 | 6 | 157 | 262 | 120 | 443 | 26% |
| **WATER HEATER SETBACK** | - | - | 7 | 11 | 7 | 36 | 0% |
| **WINDOWS** | 44 | 1 | 40 | 14 | 50 | 98 | 1% |
| **TOTAL** | 419 | 7 | 362 | 368 | 337 | 672 | 100% |

## Table 4. Electric measure savings claimed (kWh) and sites, by year

| | 2009 | | 2010 | | 2011 | | 2009-2011 |
|---|---|---|---|---|---|---|---|
| **Measure Codes** | Average Savings per Site | Number of Sites | Average Savings per Site | Number of Sites | Average Savings per Site | Number of Sites | % of Total Electric Savings |
| **AERATOR** | - | - | 237 | 90 | 170 | 138 | 2% |
| **AIR SEALING** | - | - | 1,089 | 61 | 942 | 100 | 8% |
| **CEILING INSULATION** | - | - | 1,219 | 63 | 1,033 | 97 | 8% |
| **CLOTHES WASHER** | 112 | 2 | 137 | 25 | 149 | 51 | 1% |
| **COMMISSIONING** | - | - | 375 | 16 | 375 | 8 | 0% |
| **DUCTLESS HEAT PUMP** | - | - | 4,483 | 38 | 4,878 | 48 | 19% |
| **DISHWASHER** | - | - | 93 | 1 | 85 | 5 | 0% |
| **DUCT INSULATION** | - | - | 113 | 6 | 345 | 18 | 0% |
| **DUCT SEALING** | - | - | 1,271 | 6 | 1,309 | 19 | 2% |
| **ENERGY SAVER KIT** | - | - | 197 | 35 | 190 | 98 | 1% |
| **FLOOR INSULATION** | - | - | 1,339 | 52 | 1,003 | 71 | 7% |
| **FREEZER** | - | - | 40 | 4 | 40 | 5 | 0% |
| **REFRIGERATOR** | - | - | 101 | 16 | 79 | 34 | 0% |
| **REFRIGERATOR RECYCLING** | 907 | 1 | 907 | 24 | 575 | 54 | 3% |
| **HEAT PUMP REPLACEMENT** | - | - | 7,140 | 14 | 4,537 | 18 | 9% |
| **HEAT PUMP UPGRADE** | - | - | 1,653 | 6 | 647 | 17 | 1% |
| **LIGHTING** | 329 | 2 | 465 | 281 | 543 | 277 | 14% |
| **SHOWERHEAD** | - | - | 558 | 78 | 666 | 91 | 5% |
| **SOLARPV** | - | - | 2,481 | 4 | 2,482 | 11 | 2% |
| **TANKDHW** | 156 | 1 | 1,727 | 95 | 178 | 126 | 9% |
| **WALL INSULATION** | - | - | 1,763 | 47 | 1,731 | 61 | 9% |
| **WINDOWS** | - | - | 582 | 3 | 860 | 14 | 1% |
| **TOTAL** | 584 | 2 | 2,406 | 388 | 2,098 | 454 | 100% |

## Energy Consumption Analysis Methodology

Analysis was conducted using a method similar to the PRInceton Score-keeping Method (PRISM) where average daily energy use is a function of heating requirements of the home. Weather data is matched to participants' home addresses from the one of the 11 National Oceanic and Atmospheric Administration (NOAA) weather stations that cover Energy Trust service territory. The algorithm decomposes energy use into estimated heating and base load components. To do this, an optimum "set-point" or reference temperature, is found below which energy use for heating is detected. Reference temperatures ranging from 30 to 90 degrees Fahrenheit were calculated for each gas/electric billing period and a regression was run for each of the 61 possible reference temperatures. The regression for the reference temperature with the best fit/explanatory power[1] was used to calculate the weather normalized annual consumption (NAC) using the latest typical meteorological year (TMY3) long run heating degree days. The model specifications for weather normalization are:

$$\text{Average daily consumption} = \alpha_{i1} + \beta_1 HDD_i(\tau_h) + \varepsilon_i$$
$$NAC_i = 365*\alpha_{i1} + \beta_1 LRHDD_i(\tau_h)$$

Where:

| | |
|---|---|
| $\alpha_{i1}$ = | Estimated average daily use, the "base load" in models |
| $\beta_1$= | Model predicted heating slope |
| $\beta_1 HDD_i(\tau_h)$ = | Average daily heating degree days at reference temperature $\tau_h$ |
| $\varepsilon_i$ = | Unexplained error term |
| $NAC_i$ = | Normalized annual consumption for site i |
| LRHDD= | Long-run annual heating degree days at reference temperature $\tau_h$ |

Participant savings are calculated by netting out the change in a comparison group's savings using the following equations:

$$DNAC_p = (PreNAC_p - PostNAC_p)$$
$$DNAC_c = (PreNAC_c - PostNAC_c)$$
$$Savings = DNAC_p - DNAC_c$$

## Analysis of Participant Homes with Electric or Gas Space Heating

The sites that participated in CEWO in the years 2010 and 2011 were matched to electric and gas accounts using their utility site address. These sites were then matched to the NAC regression results for the years 2009-2012.

[1] Maximum R squared.

To obtain a sample of participating sites that could be analyzed, the sites went through a series of data screens. Each screen and its impact on the sample size is shown in Table 5. Each site's gas and electric consumption is analyzed separately as measures installed through the program will impact one or the other fuel.

Attrition analysis indicates that the vast majority of participating sites could be linked with their electric and gas usage data. The two major causes of sample attrition for sites that installed gas measures were incomplete billing data (3-9% attrition), participation in other energy efficiency programs in the pre- and/or post-participation years (17-19% attrition), and no weatherization measures installed (9-10% attrition). Once these screens are imposed, most of the sites had useable weather normalization models. In the case of sites that installed electric measures, the three major causes of sample attrition were incomplete billing data (6-9% attrition), participation in other efficiency program activities in the pre- and/or post-participation years (21-27% attrition) and having no electric space heat measures installed (53-59% attrition).

## Table 5. Sample Attrition

| | 2010 Gas Sites | 2011 Gas Sites | 2010 Electric Sites | 2011 Electric Sites |
|---|---|---|---|---|
| **Total sites with savings** | **369** | **672** | **388** | **454** |
| **No matching utility account data** | (2) | (31) | (3) | (8) |
| **Total sites with positive savings and matching energy consumption** | **367** | **641** | **385** | **446** |
| **Sites with PV** | - | - | 7 | 0 |
| **Energy consumption data issues** | (8) | 33 | 10 | 21 |
| **Sites with multiple utility premises** | (2) | (3) | (4) | (9) |
| **Sites with nonresidential rate codes** | (0) | (0) | (1) | (0) |
| **Single residential utility premise per address with useable billing data (usable dataset)*** | **357** | **605** | **363** | **415** |
| **Year of measure installation is greater or less than the recognized year (when the incentive check was cut) for the measure** | (3) | (24) | (3) | (5) |
| **Also participated in the year before CEWO participation with measure savings >30 therms or 300 kWh** | (36) | (47) | (33) | (67) |
| **Also participated in the year after CEWO participation** | (24) | (51) | (44) | (47) |
| **Beginning analysis dataset (beginning dataset)*** | **294** | **483** | **283** | **296** |
| **HVAC and shell measure expected savings are outliers (less than 30 therms or 1000 kWh)** | (38) | (55) | (227) | (236) |
| **No regression with R-squared above 0.5** | (2) | (6) | (2) | (16) |
| **Negative beta (invalid relationship between temperature and energy consumption)** | (0) | (0) | (0 | (2) |

| | | | | |
|---|---|---|---|---|
| **Greater than 75% change in consumption** | (4) | (15 | (4) | (1) |
| **Participant's weather station sample size too small to generate a comparison sample** | (0) | (1) | (0) | (3) |
| **Top and bottom 2%** | (10) | (16) | (2) | (2) |
| **Final analysis dataset (final dataset)*** | **240** | **391** | **48** | **36** |

To determine the impact of the various screens on the results, we analyzed the electric and gas change in consumption using a dataset subject to few screens (larger number of observations), a moderate number of screens, and then many screens (smaller number of observations). The asterisks (*) in Table 5 above indicate the points at which this analysis was undertaken. The reason for doing this is to investigate if the imposition of these screens results in significantly different results and lead to biased results.

Tables 6 and 7 summarize the results of the analysis described above for gas and electric sites. For the gas samples the mean differs only slightly between the raw annual consumption and the changes in consumption. Changes in normalized consumption are not shown as they show a trend identical to what we see using raw annual consumption. Expected savings do go up a bit when additional screens are imposed as one would expect since one of the screens is to remove those homes with insignificant savings from gas space heating measures (>30 therms).

## Table 6. Participant gas consumption and savings, in therms

| Year | Dataset | Raw annual pre consumption | Raw annual post consumption | Change in raw consumption | S.E. of change in consumption | N | Expected savings |
|---|---|---|---|---|---|---|---|
| **2010** | Usable data | 709 | 515 | 194 | 9 | 343 | 372 |
| | Beginning | 713 | 518 | 195 | 10 | 284 | 386 |
| | Final | 716 | 493 | 223 | 10 | 240 | 436 |
| **2011** | Usable data | 588 | 451 | 138 | 7 | 580 | 347 |
| | Beginning | 580 | 439 | 141 | 8 | 464 | 362 |
| | Final | 578 | 424 | 154 | 9 | 391 | 399 |

In the case of electric consumption, applying more stringent data screens results in very different average energy usage and savings. The primary reason for this is because most of the sites did not install space heating related measures. These differences lead to separate analyses of the sites with electric space heating measures and those sites that installed only electric base load measures.

## Table 7. Participant electric consumption and savings, in kWh

| Year | Dataset | Raw annual pre consumption | Raw annual post consumption | Change in raw consumption | S.E. of change in consumption | N | Expected savings |
|---|---|---|---|---|---|---|---|
| **2010** | Usable data | 9,820 | 9,425 | 395 | 144 | 349 | 2,324 |
| | Beginning | 9,596 | 9,164 | 432 | 163 | 273 | 2,318 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Final | 14,331 | 11,995 | 2,335 | 303 | 48 | 9,140 |
| **2011** | Usable data | 9,545 | 9,392 | 153 | 156 | 386 | 2,066 |
| | Beginning | 9,219 | 9,009 | 210 | 181 | 276 | 1,621 |
| | Final | 15,448 | 13,709 | 1,740 | 640 | 36 | 6,211 |

## Comparison Group Selection

To control for non-programmatic trends and events, a comparison group is used in billing analysis. For this analysis, two comparison groups are constructed for each fuel: a stratified sample of non-participant sites and a stratified sample of future participant sites. Non-participants are defined as sites that have only one residential utility account at a unique address and that have not participated in an Energy Trust program during the analysis period. The analysis period is a three year period defined as the year prior to participation, the year during which the participant sites had measures installed, and the year after the participant sites participated in the program. Future participants are sites that participated in CEWO in the years after the analysis period and did not participate in any other Energy Trust programs during the analysis period. Future participants are believed to be more comparable and reduce issues associated with self-selection bias, as they made similar decisions to invest in a comprehensive weatherization project in subsequent years. Future participants become fewer in number in more recent years and so it is of interest to see if similar results are generated using a comparison group pulled from the general non-participant population to use in later years.

The stratification is on the base (pre-) year normalized annual consumption of each year's CEWO participant group within a specific climate zone. In this case, most of the program participation occurred within the Willamette Valley. There were not sufficient numbers of participants in other climate zones to support a separate analysis of those sites. To remove the effects of consumption outliers, those sites in the top and bottom 2% of consumption are removed. The remaining 96% of the analysis sample is grouped into quintiles[2]. The participant quintiles are used as a basis for constructing the two comparison groups. An equal number of sites are randomly selected from comparison group sites that fall within each of the consumption quintiles. In this way, each of the comparison groups has a similar mean and distribution of energy consumption in the pre-participation year.

For the non-participant group, a sample of 500 is drawn for each quintile. For the future participant group, the quintile statistics are weighted by quintile size to estimate the population mean. Tables 8 and 10 indicate that in the pre-participation period all three groups had comparable consumption.

[2] For samples with less than 100 observations, only the maximum and minimum usage sites are removed.

We first present and discuss electric savings results, and then discuss gas savings results.

## Electric Savings for Sites That Installed Electric Space Heating Measures

Table 8 shows the change in electric consumption and savings for 2010 and 2011 participants that installed electric space heating measures. On average, sites in the 2010 participant group decreased consumption by nearly 2,457 kWh. However, this estimate does not take into account non-programmatic trends. Both comparison groups also decreased their consumption during this time; non-participants reduced their consumption by 1,009 kWh and future participants reduced their consumption by 750 kWh. In 2011, participants reduced their consumption by 1,732 kWh. Only the non-participant group had a sufficient number of sites to act as a reliable comparison group and they increased their consumption by nearly 700 kWh.

### Table 8. Annual electric consumption

| Group | Average NAC (kWh) in pre-participation year | Average NAC (kWh) in post-participation year | Change in NAC | DNAC Std. Error | Sites |
|---|---|---|---|---|---|
| **2010** | | | | | |
| **Participants** | 13,475 | 11,018 | 2,457 | 303 | 48 |
| **Non-participants** | 13,867 | 12,858 | 1,009 | 68 | 2,500 |
| **Future participants** | 13,845 | 13,094 | 750 | 381 | 284 |
| **2011** | | | | | |
| **Participants** | 15,360 | 13,627 | 1,732 | 640 | 36 |
| **Non-participants** | 15,089 | 15,786 | (697) | 66 | 2,500 |
| **Future participants** | 15,486 | 14,975 | 511 | 869 | 19 |

Table 9 shows the change in raw and normalized annual consumption for the participant and comparison groups, as well as the billing analysis estimated savings (difference in the change in annual consumption for the participant and comparison groups). For the 2010 analysis the changes in consumption of both comparison groups are in the same direction and have the same relative magnitude. As the two groups are comparable, the midpoint of the two comparison groups' change in consumption is used as a basis for calculating the modest average savings of 1,577 kWh per site.

In the case of 2011, the future participant comparison group has insufficient numbers to provide reliable results and the net savings are based on a comparison with the non-participant group. In this case the savings are 2,429 kWh, for a realization rate of 39%.

It should be noted that the low estimated realization rates are likely due to overly optimistic modeled savings estimates. Expected savings were over 9,000 kWh in 2010 and close to 6,000 kWh in 2011, which is about 68% and 40% of pre-participation usage in 2010 and 2011, respectively. Usage includes space heating, but also other end uses such as water heat, appliances and plug loads which are not as influenced by CEWO

participation. So these numbers represent a much larger proportion of space heat energy use.

## Table 9. Change in electric consumption and savings (electrically-heated homes only)

| | 2010 | | | | 2011 | | | |
|---|---|---|---|---|---|---|---|---|
| | Change in normalized annual consumption (kWh) | S.E. | Change in raw annual consumption (kWh) | S.E. | Change in normalized annual consumption (kWh) | S.E. | Change in raw annual consumption (kWh) | S.E. |
| **Participants** | 2,457 | 283 | 2,335 | 303 | 1,732 | 631 | 1,740 | 640 |
| **Non-participants** | 1,009 | 66 | 594 | 68 | (697) | 219 | 260 | 66 |
| **Future participants** | 750 | 378 | 320 | 381 | 511 | 608 | 175 | 869 |
| **Savings – Non-participant comparison group** | 1,448 | 291 | 1,742 | 310 | 2,429 | 668 | 1,480 | 643 |
| **Savings – Future participant comparison group** | 1,707 | 472 | 2,015 | 486 | NA | NA | NA | NA |
| **Savings midpoint** | 1,577 | -- | 1,878 | -- | NA | -- | NA | -- |
| **Realization rate*** | 17% | -- | 21% | -- | 39% | -- | 24% | -- |

*Calculated using the midpoint of the comparison groups in 2010 and only the non-participant group in 2011 .

An analysis was also done to look at the level of savings associated with overall pre-participation electricity consumption. The goal was to determine if targeting larger users would generate larger savings. The participant sample size in both years was too small to generate reliable results or determine if there were significant trends.

## Gas Savings

A larger number of gas-heated homes participated in 2010 and 2011 compared to electrically-heated homes. Participant sites in the 2011 program year used 13% less gas in the pre-participation year than those in 2010.

### Table 10. Annual gas consumption

| Group | Average NAC (therms) in pre-participation year | Average NAC (therms) in post-participation year | Change in NAC | DNAC S.E. | Sites |
|---|---|---|---|---|---|
| **2010** | | | | | |
| **Participants** | 650 | 404 | 246 | 9 | 240 |
| **Non-participants** | 653 | 616 | 37 | 3 | 2,500 |
| **Future participants** | 652 | 602 | 50 | 13 | 540 |
| **2011** | | | | | |
| **Participants** | 566 | 420 | 146 | 8 | 391 |
| **Non-participants** | 571 | 615 | (45) | 4 | 2,500 |
| **Future participants** | 576 | 586 | (10) | 22 | 72 |

The 2010 participant group decreased its consumption by 246 therms between 2009 and 2011 (Table 12). Both comparison groups decreased their consumption by a comparable amount: 37-50 therms. The midpoint of these two groups' reduction in energy consumption is used as the baseline and results in an average savings estimate of 202 therms. In 2011, lower savings are estimated. Factors leading to this may be the lower pre-participation gas consumption of this participant group as well as the minimal increase in consumption experienced by the future participants. Non-participant and future participant samples in both 2010 and 2011 experienced changes in consumption that were in the same direction and not significantly different from one and other. This provides support for either or both of the comparison groups to provide the baseline from which savings is estimated.

Again, lower realization rates are related to the high initial estimates of savings. The expected savings were in excess of half of the households' pre-participation gas consumption (57% in 2010 and 61% in 2011). The billing analysis found that savings represented an average reduction in consumption of 32% in 2010 and 31% in 2011. In essence, a very significant reduction in consumption was achieved, just not the unrealistically high savings that were forecast.

## Table 11. Change in gas consumption and savings (gas-heated homes only)

| | 2010 | | | | 2011 | | | |
|---|---|---|---|---|---|---|---|---|
| | Change in normalized annual consumption (therms) | S.E. | Change in raw annual consumption (therms) | S.E. | Change in normalized annual consumption (therms) | S.E. | Change in raw annual consumption (therms) | S.E. |
| **Participants** | 246 | 9 | 223 | 10 | 146 | 8 | 154 | 9 |
| **Non-participants** | 37 | 3 | (4) | 3 | (45) | 4 | (33) | 2 |
| **Future participants** | 50 | 13 | (4) | 14 | (10) | 22 | (9) | 23 |
| **Savings – Non-participant comparison group** | 209 | 10 | 227 | 10 | 191 | 9 | 187 | 9 |
| **Savings – Future participant comparison group** | 196 | 16 | 227 | 17 | 156 | 23 | 163 | 24 |
| **Savings midpoint** | 202 | -- | 227 | -- | 173 | -- | 175 | -- |
| **Realization rate*** | 46% | -- | 52% | -- | 43% | -- | 44% | -- |

*Calculated using the midpoint of the comparison groups for each year.

There are definite differences in the billing analysis savings results by level of gas consumption in the year prior to participation, as seen in Table 13. For participants in 2010 and 2011, greater gas consumption was associated with greater savings, particularly in the upper three quintiles, where the average annual consumption was greater than 550-600 therms. The same trend is only seen in the 2010 comparison groups; slight increases in gas consumption were experienced across the board among the 2011 comparison group samples. In the case of gas, there is an indication that the program is obtaining greater savings from households with greater consumption and would benefit from targeting these customers to increase savings.

## Table 12. Change in consumption by quintile of pre-participation gas consumption

| | | Average pre-participation consumption (NAC) | Average participant change in consumption (DNAC) | S.E. | Average non-participant change in consumption (DNAC) | S.E. | Average future participant change in consumption (DNAC) | S.E. | Net savings by quintile (comparison groups' midpoint) | Sites |
|---|---|---|---|---|---|---|---|---|---|---|
| 2010 | Lowest Quintile | 339 | 128 | 11 | -4 | 5 | -9 | 11 | 135 | 48 |
| | 2 | 490 | 179 | 14 | 13 | 5 | 11 | 11 | 167 | 48 |
| | 3 | 611 | 238 | 16 | 44 | 6 | 47 | 12 | 193 | 48 |
| | 4 | 769 | 293 | 17 | 48 | 6 | 75 | 12 | 231 | 48 |
| | Highest Quintile | 1,042 | 391 | 24 | 83 | 6 | 126 | 18 | 287 | 48 |
| | Sample Mean | 650 | 246 | 9 | 37 | 3 | 50 | 13 | 202 | 240 |
| 2011 | Lowest Quintile | 292 | 34 | 15 | -55 | 5 | -8 | 20 | 65 | 78 |
| | 2 | 437 | 100 | 13 | -44 | 5 | -17 | 13 | 130 | 78 |
| | 3 | 547 | 133 | 19 | -58 | 14 | -42 | 25 | 183 | 79 |
| | 4 | 672 | 199 | 13 | -29 | 5 | 7 | 27 | 210 | 78 |
| | Highest Quintile | 884 | 265 | 22 | -37 | 10 | 10 | 23 | 279 | 78 |
| | Sample Mean | 566 | 146 | 8 | -45 | 4 | -10 | 22 | 173 | 391 |

## Base Load Analysis for Electric Sites

From the attrition table (Table 5), over 225 of the electric sites in each year dropped out of the analysis due to little or no space heating measures. These sites are analyzed separately since primarily base load (i.e. water heating, lighting and appliance) measures are expected to be installed. As the energy consumption is assumed to be the base load and the base load is not weather sensitive, the non-weather normalized energy consumption (raw kWh) is the usage that is analyzed. After screening the sites for data quality (i.e. number of days in a year or number of available readings in a year) and large changes in consumption, a total of 211 sites in 2010 and 206 sites in 2011 were available to be analyzed.

The electrical base load in both the CEWO participant and non-participant samples for 2010 and 2011 that were analyzed showed little movement in either of the groups for both years. The participant group did reduce their consumption on average slightly more in both years, possibly indicating modest impacts from the program (820 kWh expected savings in 2010 and 702 kWh in 2011). This impact was more pronounced in 2011 than in 2010.

### Table 13. Annual electric consumption, base load only group

| Group | Average Annualized (raw kWh) in pre-participation year | Average Annualized (raw kWh) in post-participation year | Change in Consumption | S.E. of Change | Sites |
|---|---|---|---|---|---|
| **2010** | | | | | |
| **Participants** | 8,566 | 8,314 | 252 | 168 | 211 |
| **Non-participants** | 8,651 | 8,464 | 188 | 46 | 2,500 |
| **2011** | | | | | |
| **Participants** | 8,485 | 8,008 | 476 | 170 | 206 |
| **Non-participants** | 8,512 | 8,441 | 71 | 47 | 2,500 |

### Table 14. Annual electric savings, base load only group (kWh saved/year)

| | 2010 | | 2011 | |
|---|---|---|---|---|
| | Savings | S.E. | Savings | S.E. |
| **Savings** | 64 | 174 | 406 | 177 |
| **Realization rate** | 8% | -- | 58% | -- |

## Conclusions

The results of this analysis indicate that the CEWO produced substantial gas and electric savings but that the projected savings for the retrofits were unrealistically high.

These high expected savings were likely generated by the energy simulation models used by the program. Energy Trust's experience with the Home Performance program has been that savings, especially when not bounded by the household's actual consumption, are often overestimated by many of these models in practice.[3] CEWO participants did achieve substantial gas savings in both years, lowering their gas usage by approximately 30%. This result is in line with a previous, unpublished billing analysis of CEWO that found gas usage reductions of 27%.

In regards to the weatherization of electrically-heated homes, the program realization rates were low and the estimated savings were 12% of pre-weatherization consumption in the two analysis years. This modest impact could be due to the already efficient level of homes - the average annual consumption for these homes hovered between 13,000 and15,000 kWh in the two analysis years. Electric base load measures had small estimated impacts.

CEWO has moved away from modeling energy savings with building simulation software. Many of the measure savings are now deemed and the expected savings are much lower than in the initial years of the program. In the case of gas, the results of this analysis do indicate that higher levels of savings are associated with households with above average energy consumption. With electrically-heated households the results were inconclusive due to the small participant sample.

[3]See "Efforts to Date with Modeling Tool Comparison and Summary of Key Issues" (http://energytrust.org/library/meetings/other/Jan23EPSReport.pdf), which provides a broad overview of modeling tool issues.