September 15, 2015

Measure Approval Document for Commercial Showerhead or Showerwand

Valid from January 1, 2016 to June 30, 2018

Changes in this update: Corrects cost of direct install showerwand form $28 to $35. Uses 2016 cost effectiveness calculator. This version homogenizes the language on what sectors are applicable.

End Use
Commercial hot water

Scope
Showerheads and showerwands with a flow rate of 1.75 gpm or 1.5 gpm

Program
Based on the following cost-effectiveness screening, the measures are approved for inclusion in the Existing Buildings program in both Oregon and Washington.
Not included here are: New Buildings, Multifamily, Retail, and Existing Homes showerheads are analyzed in separate documents.

The measure is expected to be applicable in the following building types:

- Hotels/motels
- Hospitals
- Schools and Public Assembly
- Offices
- Gyms/Fitness Centers

Description of the Measure
The water heating savings are calculated as the baseline energy consumption minus the efficient case energy consumption and then multiplied by the **Installation Rate**. Energy consumed to heat the water is calculated as follows: **In Situ Flow Rate** x **Usage** x **Percent Hot Water** x (1/**Water Heating Efficiency**) x conversion factors

The water and wastewater process savings are calculated as follows:

1) Determine change in water consumption between baseline and retrofit cases. For each case, water = **In Situ Flow Rate x Usage**
2) Determine electricity to process and deliver this water. Electricity = volume of water x **Water And Wastewater Energy Intensity**

Purpose of Evaluating Measure
Energy Trust is aligning its measures, where feasible, with RTF measure analysis. The RTF commercial DHW showerhead measures was last updated on July 16, 2013. At that time, the RTF concluded that pressure compensation in low flow showerheads negated the flow rate derating factor that they had been using and the Energy Trust had also incorporated into its measure analysis. As the year has already begun, Programs should use the new savings amounts beginning in 2016.

RTF calculated energy savings for fitness centers based on limited information available to them indicating 156 minutes of use per day. While a plausible estimate, RTF analysts were concerned that the number was too high, as fitness centers with the implied water heating costs would be very likely to install low flow showerheads without rebate programs. Energy Trust will use 78 minutes of use per day, which is the low end of the range from RTF's sample.

In addition, leave behind showerheads and showerwands are extended to Oregon. Energy Trust had previously offered this delivery option only in Washington. The savings are based on the delivery mechanism that the RTF identifies as Retail.

Maximum incentive amounts are calculated below, to provide the programs flexibility in setting incentives. The Existing Buildings program will record the actual incentive in a tracking spreadsheet, and may provide different incentive levels for separate delivery tracks.

BCR Calculator (link: \\Etoo.org\home\Groups\Planning\Measure Development\Commercial and Industrial\Showerhead_Commercial\bencost\ETO CEC Commercial Showerhead.xlsm)

#	Measure	Measure Life (yrs)	Savings		Incremental Costs ($)	Non-Energy Benefits (Annual $)	Maximum Incentive ($)	Utility BCR at Max Incentive	TRC BCR	Benefit Ratio	
			kWh	therms						Electric	Gas

1	Commercial Showerhead Replacement_1_75gpm_ Any Commercial Except Fitness Center_ Electric Water Heating_Retail	10	1 15	-	$28	$19	$28	2.38	7.75	100%	0%
2	Commercial Showerhead Replacement_1_75gpm_ Any Commercial Except Fitness Center_ Gas Water Heating_Retail	10	5	5.0	$28	$18	$22	1.00	5.86	13%	87 %
3	Commercial Showerhead Replacement_1_75gpm_ Any Commercial Except Fitness Center_ Any Water Heating_Retail	10	44	3.2	$28	$19	$28	1.34	6.71	68%	32 %
4	Commercial Showerhead Replacement_1_50gpm_ Any Commercial Except Fitness Center_ Electric Water Heating_Retail	10	1 78	-	$28	$28	$28	3.68	11.5 9	100%	0%
5	Commercial Showerhead Replacement_1_50gpm_ Any Commercial Except Fitness Center_ Gas Water Heating_Retail	10	8	7.7	$28	$29	$28	1.19	9.39	14%	86 %
6	Commercial Showerhead Replacement_1_50gpm_ Any Commercial Except Fitness Center_ Any Water Heating_Retail	10	67	5.0	$28	$28	$28	2.05	9.96	68%	32 %
7	Commercial Showerhead Replacement_1_75gpm_ Any Commercial Except Fitness Center_ Electric	10	1 38	-	$35	$23	$35	2.28	7.48	100%	0%

	Water Heating_Direct Install										
8	Commercial Showerhead Replacement_1_75gpm_ Any Commercial Except Fitness Center_ Gas Water Heating_Direct Install	10	6	6.0	$35	$22	$26	1.00	5.71	13%	87%
9	Commercial Showerhead Replacement_1_75gpm_ Any Commercial Except Fitness Center_ Any Water Heating_Direct Install	10	53	3.9	$35	$23	$35	1.29	6.49	68%	32%
10	Commercial Showerhead Replacement_1_50gpm_ Any Commercial Except Fitness Center_ Electric Water Heating_Direct Install	10	228	-	$35	$36	$35	3.77	11.91	100%	0%
11	Commercial Showerhead Replacement_1_50gpm_ Any Commercial Except Fitness Center_ Gas Water Heating_Direct Install	10	10	9.9	$35	$36	$35	1.22	9.36	14%	86%
12	Commercial Showerhead Replacement_1_50gpm_ Any Commercial Except Fitness Center_ Any Water Heating_Direct Install	10	87	6.4	$35	$37	$35	2.12	10.49	68%	32%
13	Commercial Showerhead Replacement_1_75gpm_	10	911	-	$28	$364	$28	18.70	121.57	100%	0%

	Fitness Center_ Electric Water Heating_Retail										
14	Commercial Showerhead Replacement_1_75gpm_ Fitness Center_ Gas Water Heating_Retail	10	43	39.5	$28	$366	$28	6.14	109.57	14%	86%
15	Commercial Showerhead Replacement_1_75gpm_ Fitness Center_ Any Water Heating_Retail	10	318	27.0	$28	$365	$28	10.12	113.27	64%	36%
16	Commercial Showerhead Replacement_1_50gpm_ Fitness Center_ Electric Water Heating_Retail	10	1,660	-	$28	$531	$28	34.08	184.14	100%	0%
17	Commercial Showerhead Replacement_1_50gpm_ Fitness Center_ Gas Water Heating_Retail	10	73	72.2	$28	$528	$28	11.11	160.32	13%	87%
18	Commercial Showerhead Replacement_1_50gpm_ Fitness Center_ Any Water Heating_Retail	10	576	49.3	$28	$531	$28	18.39	168.45	64%	36%
19	Commercial Showerhead Replacement_1_75gpm_ Fitness Center_ Electric Water Heating_Direct Install	10	1,295	-	$35	$437	$35	21.27	120.06	100%	0%
20	Commercial Showerhead Replacement_1_75gpm_ Fitness Center_ Gas Water Heating_Direct Install	10	61	56.2	$35	$438	$35	6.99	106.01	14%	86%
21	Commercial Showerhead Replacement_1_75gpm_	10	452	38.4	$35	$438	$35	11.51	110.54	64%	36%

	Fitness Center_ Any Water Heating_Direct Install										
22	Commercial Showerhead Replacement_1_50gpm_ Fitness Center_ Electric Water Heating_Direct Install	10	2,135	-	$35	$683	$35	35.06	189.47	100%	0%
23	Commercial Showerhead Replacement_1_50gpm_ Fitness Center_ Gas Water Heating_Direct Install	10	95	92.8	$35	$683	$35	11.45	165.86	14%	86%
24	Commercial Showerhead Replacement_1_50gpm_ Fitness Center_ Any Water Heating_Direct Install	10	740	63.4	$35	$682	$35	18.91	173.09	64%	36%

Measure Analysis

All measure parameters from the RTF workbooks, except for fitness center usage, as noted below:

Constant Parameters			
Parameter	**Possible Values**		**Further Explanation and Sources**
Usage (minutes per year)	Hospitality	3,509	Hospitality: [minutes per day per shower]*[annual occupancy rate]*[365 days per year] [Minutes per Day]: [1] [Annual Occupancy]: [2] Health Care: [minutes per person per day]*[clients per

	Health Care	2,528	shower]*[annual occupancy rate]*[365 days per year] [minutes per person per day]: [1] [clients per shower]: [6] [annual occupancy rate]: Northwest occupancy for hospitals and nursing facilities, by state [3]
	Commercial - Employee Shower	1,894	Commercial employee shower: professional judgment that a commercial employee shower will use one half of RTF's residential shower usage [4]
	School	2,057	School: [annual school shower water consumption] / ([number of showerheads] * [estimated flow rate]) annual school shower water consumption [5] number of showerheads [5] estimated flow rate [6]
	Any Commercial Except Fitness Center	3,029	Fitness Center: [number of showers per day] * [shower duration] / [number of showerheads] number of showers per day [7] shower duration [6]
	Fitness Center	**28,326 (differs from RTF value as explained in the section on the Purpose of Evaluating the Measure)**	[1]Gleick, P., Haasz, D., Henges-Jeck, C., Srinivasan, V., Wolff, G., Cushing, K. K., et al. (2003). Waste Not, Want Not: The Potential for Urban Water Conservation in California. Pacific Institute. Value can be found on page 5 of Appendix D of the report. A link to the appendix D: http://www.pacinst.org/reports/urban_usage/appendix_d.pdf [2]American Hotel and Lodging Association Website ((http://www.ahla.com/content.aspx?id=34706), annual Lodging Industry Profile [3] StateHealthFacts.org [4] http://rtf.nwcouncil.org/measures/res/ResShowerheads_v2_1.xlsm

		[5] Planning and Management Consultants, Ltd., Aquacraft, Inc., and John Olaf Nelson Water Resources Management. "Commercial and Institutional End Uses of Water". For the American Water Works Association. 2000. [6] Professional judgment of RTF staff [7] Phone survey of five PNW Fitness Centers conducted by RTF staff (See Usage sheet for specific value references)
Water Heating Efficiency	Electric 98% Gas 75%	Electric: DOE Test Procedure (Title 10 CFR 430 - Energy Conservation Program for Consumer Products Appendix E to Subpart B - Uniform Test Procedure for Measuring the Energy Conservation of Water Heaters, effective June 10, 1998) Gas: "Single Family 2007 Showerhead Kit Impact Evaluation". SBW Consulting; Seattle City Light. October 2008 (p.21-22)
Installation Rate	Retail 2.0gpm: 80% Retail 1.75 gpm: 75% Retail 1.5 gpm: 70%	Retail and Mail by Request: Professional judgment. Lower uptake with lower gpm for retail and mail-by-request to address concerns of lower satisfaction at lower flow rates. Direct Install: Observed in "Single Family 2007 Showerhead Kit Impact Evaluation". SBW Consulting; Seattle City Light. October 2008 [<www.seattle.gov/light/Conserve/Reports/Evaluation_14.pdf>]"SPU Showerhead/Aerator Pilot Program, Summary I: 93% of survey respondents installed and retained one or more showerheads they received. Result rounded down to 90% based on analyst assumption.

	Direct Install [all flow rates]: 90% Mail-by-Request Install [all flow rates]: 60%	
Water Heater Temperature Rise (degF)	108 to 112 degrees F, depending on flow rate.	Professional judgment based on "Energy Efficient Showerhead and Faucet Aerator Metering Study - Single Family Residences". SBW Consulting, Inc.; Puget Sound Power and Light. December 1994.
Percent Hot Water	2.5 gpm: 73% 2.0 gpm: 76% 1.75 gpm: 77% 1.5 gpm: 78%	2.5 gpm and 2.0 gpm: observed in "Single Family 2007 Showerhead Kit Impact Evaluation". SBW Consulting; Seattle City Light. October 2008 [<www.seattle.gov/light/Conserve/Reports/Evaluation_14.pdf>] Hot water percentage values for 1.75 and 1.5 gpm showerheads are extrapolated from 2.5 and 2.0 values. Lower flow rates result in higher temperature drop from showerhead to user, necessitating higher showerhead temperatures to compensate for the higher loss.
Water And Wastewater Energy Intensity (kWh/1,000 gallons)	5.29	6th Plan, accessed from the "RTF Costs and Benefits Standard Information Workbook January 2013-v1.0.xls", tab "Water and Wastewater". Value retained from 2007 analysis. For reference, national average wastewater treatment energy intensity is 1.2 kWh/1000 gallons (source: Burton, Franklin L., 1996, Water and Wastewater Industries: Characteristics and Energy Management Opportunities. (Burton Engineering) Los Altos, CA, Report CR-106941, Electric Power Research Institute Report, p.2-45) and distribution energy intensities can range from 0.5 kWh/1000 gallons to 10 kWh/1000 gallons.

Pre-conditions baseline	2.2 gpm	

Building stock shares of electric and gas water heat
The share of electric water heat is taken from the RTF workbook and is 35.1% for any commercial building, based on the 2009 CBSA. The remainder are gas water heat. The CBSA does not have a gym category, so the electric water heater market share for fitness centers is assumed to be the average of other high use building types, i.e. restaurant, hotel/motel, health, school, and university. The average from the CBSA of high use building types is 31.7%.

The conversion between electric savings calculated by the RTF and the equivalent savings for gas water heat are based on the recovery efficiencies in the RTF Standard Information Workbook. They are 1.00 recovery efficiency for electric water heat and 0.75 recovery efficiency for gas water heat.

Savings, Economics and Incentives
Measure life is 10 years, consistent with both current RTF and past Energy Trust commercial showerhead and showerwand measures.

Savings for showerwands are the same as for showerheads, though costs are higher. In order to test cost effectiveness, the showerwand costs are used to calculate the TRC. An equipment cost of $28 for showerwands was estimated by the PMC, and both Energy Trust and RTF estimate 20 minutes of labor at $20/hour for direct install. RTF estimates only $3 equipment cost for showerheads, which would clearly also be cost effective.

Non-energy benefits from reduced water use are regionally representative water and waste water costs, reduced by the value of the energy savings reported from water and waste water treatment and distribution.

Program Requirements
Showerheads and showerwands with a flow rate of 1.75 gpm or 1.5 gpm. For Existing Buildings, when the flow rate is indicated on the existing showerhead, only showerheads with a flow rate more than 2.0 gpm should be replaced.

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Reviewed by Mike Bailey

August 7, 2014

UPDATED BLESSING MEMO FOR COMMERCIAL FOODSERVICE MEASURES

July 2014 updates:

- Updated incremental costs for all measures based on Energy Star Documentation. Many measures' incremental costs are assumed to be zero
- Electric Vat Fryers and Electric Griddles had been not cost effective. They are now cost effective and newly "blessed".
- Gas and Electric Combination ovens are a new measure.

End Use: Energy Star rated electric and gas foodservice cooking equipment

Scope: These measures are proposed for existing and new commercial kitchen applications, for new use or replacement purchases.

Program: Based on the referenced analysis and associated cost-effectiveness screening, the measures described below are "blessed" on a prospective basis for inclusion in the New Buildings and Existing Buildings foodservice programs and in the PE and MF programs where these programs serve commercial kitchens.

Details:

Energy Trust contracted with the FoodService Technology Center (FSTC) in California to analyze a suite of measures for the commercial kitchens program. The analysis provides an update in savings, cost, and measure lives to the existing foodservice measures already included in the program. Additionally, it aligns our current program offerings with the recently revised Energy Star criteria for select pieces of foodservice equipment.

Savings were calculated through the FSTC testing of various pieces of baseline and Energy Star rated pieces of equipment. In many cases, the newly established Energy Star qualifications represent the previous target efficiency case over the older, less efficient ENERGY STAR product specifications. This adds support to the prior assumption that Energy Star was becoming baseline and a new tier needed to be developed. Workpapers have been written by FSTC for each piece of equipment that chronicle baseline energy use, idle energy rate, production capacity, and numerous other equipment attributes in an attempt to establish an average energy consumption rate. These baseline energy consumption rates are then compared to Energy Star energy consumption rates and the savings are calculated as the difference between the two. For the steamer measures, expected annual water savings have also been included and entered into the non-energy benefits column in the cost-effective calculator below.

Update 2013: The savings and incentive for Large Gas Fryers has been changed from per fryer to per vat. In the past, there was concern that split-vat fryers, where a single large vat has a divider and is used as 2 smaller vats, would cause confusion in the programs and result in overstating savings. However, as the programs see more true multi-vat fryers there has been a lost opportunity to claim the increased savings. The new incentive for gas fryers is cost effective at up to $1500/full size vat, although at this time the programs expect to set the incentive between $500 and $800. A full size vat is a minimum of 12 inches wide, more typically 14 or 16 inches. Each split-vat will count as one single vat. The programs will make this change at their convenience, likely the start of the 2014 program year.

Update 2014: As a result of the cost updates mentioned below, Electric Vat Fryers and Electric Griddles are now cost effective and may be included in the programs. In late 2013, Energy Star released a specification for qualifying combination ovens. Savings for combination ovens are based on the Energy Star Commercial Cooking Equipment Worksheet and assume operation at

50% in steam mode and 50% in convection mode and 360 days per year operation. This is a new measure for Energy Trust.

Costs and Incentives:

Incentives are listed in Table 1 as the maximum cost-effective incentive (defined as an incentive which makes the Utility BCR equal to 1.0 or the incremental or base cost of the measure.) **These incentives are meant to be the maximum possible incentive that a program could provide for the measure, and are NOT representative of actual incentives or incentive recommendations**. Planning recommends that the new and existing buildings programs continue to offer the same or similar incentives to each other to avoid market confusion.

Update 7/13: After finding that average installed gas fryers in the programs were 47% of the costs used in the original cost effectiveness analysis, a new cost study was performed of fryers at five online retailers and the food service equipment cost aggregator aqnet.com and compared to the costs seen by the programs in 2011 and 2012 for efficient fryers.

Update 7/14: Further cost research indicates that the cost of commercial cooking equipment is determined by many features in addition to efficiency and Energy Star models may not be more expensive than new baseline models. Energy Trust used the Energy Star Commercial Cooking Equipment Worksheet to update incremental costs. The Energy Star data indicates no incremental cost for several measures (listed as $1 in the CEC calculator to avoid errors). However, we understand that our baseline and efficient cases are not the only options available. Restaurant owners frequently purchase used equipment. Used equipment is much less expensive than new and our incentives may be necessary to move those customers to efficient equipment, therefore we will continue to offer incentives that appear to be above incremental cost. Because used equipment is highly variable, savings will continue to be based on a baseline of new non-Energy Star equipment.

Measure Life:

An estimated useful equipment life of 12 years is based on the industry-standard assumption for equipment life span and is consistent with estimates in the California Database for Energy Efficiency Resources (DEER) for commercial cooking equipment.

Table 1 – Benefit / Cost screening showing cost-effectiveness for Electric & Gas Foodservice measures

Measure #	Energy Efficiency Measure Name	Measure Lifetime	Annual Electricity Savings (kWh)	Annual Natural Gas Savings (therms)	Total Incremental Cost of Measure	Annual Non-Energy Benefits $ (if any)	MAXIMUM Potential Incentive If Measure is Cost-effective	Combined Utility System BCR	Combined TRC BCR
1	Electric Large	12	2,249		$1		$1,681	**1.0**	**1682**

	Vat Fryers / Vat								
2	Electric Griddles	12	1,860		$1		$1,331	**1.0**	**1391**
3	Electric Convection Ovens Full-Size	12	1,853		$1		$1,385	**1.0**	**1386**
4	Electric Convection Ovens Half-Size	12	1,961		$1		$1,465	**1.0**	**1466**
5	Hot Food Holding Cabinets Full Size	12	5,184		$1		$2,529	**1.5**	**3877**
6	Hot Food Holding Cabinets Half Size	12	2,592		$1		$1,499	**1.3**	**1938**
7	Electric Steam Cookers	12	2,652		$630	$1,181	$1,982	**1.0**	**20**
8	Electric Combi	12	6,139		$1		$4591	**1.0**	**4592**

	nation Ovens								
9	Gas Large Vat Fryers / Vat	12		569	$1,120		$1,502	**1.8**	**2.4**
10	Gas Griddles	12		147	$360		$688	**1.0**	**1.9**
11	Gas Convection Ovens Full-Size	12		302	$1		$1,011	**1.0**	**1012**
12	Gas Steam Cookers	12		1,308	$870	$1,181	$6,148	**1.0**	**19**
13	Gas Combination Ovens	12		290	$1		$1363	**1.0**	**1364**

Measure Requirements:

- Product must appear on the most current Energy Star criteria list under the Commercial Foodservice Equipment program or meet criteria listed in Energy Star specifications.
- Fryer vat must be a minimum of 12 inches wide. Smaller vats are likely split vats, with 2 sections constituting a single large vat.

The Cost effective screening for these measures can be found at:

E:\Planning\Cross-Program Measures\Commercial\Food Service\Cooking Equipment\Bencost\max incentive CEC Cooking Equipment 072314.xlsm

And supporting documentation can be found at:

E:\Planning\Cross-Program Measures\Commercial\Food Service\Cooking Equipment

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Reviewed by Fred Gordon

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Measure Approval Document for Commercial Hot Water Condensing Gas Boilers

End Use: Gas-fired hot water condensing boilers

Program: Based on the referenced analysis and associated cost-effectiveness screening, the measures described below are approved as cost effective on a prospective basis for inclusion in the Existing Buildings, New Buildings, and Production Efficiency programs. This document does not address residential or multifamily boilers.

Details: This measure replaces the preceding condensing boiler measure. The analysis and measure requirements were both updated, as is described in this document. This document tests boilers with 2016 avoided costs.

Program Requirements:

- Boilers must have an AFUE of 94% or greater. This is an increase from earlier measures.
- Incentives are calculated based on the size of the primary HVAC boiler(s). The size of any backup boilers shall not factor into the incentive calculation.
- Boiler system must have design return temperature appropriate to condensing functionality.

CEC of measures is attached and linked here: E:\Planning\Cross-Program%20Measures\Commercial\Heat%20&%20Cool\Boilers\2015%20update\bencost\boiler%20cec%202016.xlsm

Table 1: Cost-effectiveness calculator for condensing boiler measures

Measure	Measure Life (yrs)	Savings		Incremental Costs ($)	Maximum Incentive ($)	Utility BCR at Max Incentive	TRC BCR
		kWh	therms				
Boiler Weighted average	35	(1.38)	2.85	$10	$10	2.29	2.29
<300 kBtu/h, weighted average	35	(1.38)	2.85	$16	$16	1.48	1.48
>300 kBtu/h, <2,500 kBtu/h, weighted average	35	(1.38)	2.85	$13	$13	1.87	1.87
>2,500 kBtu/h, weighted average	35	(1.38)	2.85	$10	$10	2.29	2.29

Note: Savings, costs, and incentives listed above are on a per-kBtuh-input basis

Measure Analysis

To determine the savings for this measure, eQUEST energy simulation model runs were performed by CLEAResult using the New Buildings Program's Primary School and Small Office prototype models. These models are intended to reflect typical buildings constructed to meet the minimum requirements of the Oregon Energy Efficiency Specialty Code. The HVAC system in the models is a VAV system with hot water reheat, which is expected to be the most common application for condensing boilers incentivized through this measure. Model runs were performed using weather data for Portland, Redmond, and Astoria in order to quantify savings across the different Oregon climates.

The baseline case was modeled using a boiler heating input ratio of 1.250 (1/80%), which corresponds to the minimum requirements set forth in OEESC Table 503.2.5(5) for boilers of the sizes included in the models (the boilers in the Office model range from 247 kBtuh to 401 kBtuh and the boilers in the School model range from 1,121 kBtuh to 1,322 kBtuh, depending on climate zone). To model the condensing boiler, the heating input ratio was modified, and the boiler type was changed from "HW-BOILER" to "HW-CONDENSING". A preliminary analysis showed that 94% was the minimum efficiency for which boilers were cost effective across all sizes and building types. Therefore, savings are based on proposed model runs utilizing a boiler heating input ratio of 1.064 (1/94%). At the time of the writing of this document, the AHRI directory lists 286 natural gas hot water condensing boiler models across 26 manufacturers which have thermal efficiencies of 94% or greater, demonstrating that this level of efficiency is fairly available in the market.

To determine a single savings value to be used across all building types, a weighted average of the modeled savings was taken. Based on historical program data for condensing boiler measures, K-12 schools have accounted for 38% of therm savings, offices have accounted for 17%, college/university have accounted for 15%, and all other building types each represent 5% or less of the recorded therm savings. Primary schools are assumed to adequately represent the expected savings for boilers in an educational setting. Boilers are only used during the heating season, and so differences in annual schedules between educational levels should not significantly affect boiler savings. Primary schools are likely to have the lowest operating hours of educational levels, and so these savings should be conservative when applied across the educational sector. The results from the office model are assumed to adequately represent the average boiler savings for all other building types pursuing standard boiler incentives. Savings were also weighted based on project location, assuming that 86.6% of projects will be in the Portland climate zone, 10.3% of projects will be in the Redmond climate zone, and 3.1% of projects will be in the Astoria climate zone. Savings for each building type were tested at each size range for cost effectiveness. Those results are in Table 2.

Since there was not a dramatic difference in savings across building types, it not deemed necessary to structure the measure by building type. A weighted average based on building types of "Education" representing 53% of expected savings, and "Office and Other" representing 47% of expected savings was used for the final measure savings listed in Table 1 above.

Table 2: Savings in modeled building types (weighted by climate zone), with costs based on size and cost effectiveness with appropriate load profiles.

Measure	Sub-sector	Measure Life (yrs)	Savings		Incremental Costs ($)	Maximum Incentive ($)	Utility BCR at Max Incentive	TRC BCR
			kWh	therms				
<300 kBtu/h, Education	College	35	(1.10)	2.84	$16	$16	1.52	1.52

>300 kBtu/h, <2,500 kBtu/h, Education	College	35	(1.10)	2.84	$13	$13	1.91	1.91
>2,500 kBtu/h, Education	College	35	(1.10)	2.84	$10	$10	2.35	2.35
<300 kBtu/h, Education	School	35	(1.10)	2.84	$16	$16	1.50	1.50
>300 kBtu/h, <2,500 kBtu/h, Education	School	35	(1.10)	2.84	$13	$13	1.89	1.89
>2,500 kBtu/h, Education	School	35	(1.10)	2.84	$10	$10	2.33	2.33
<300 kBtu/h, Other (Office)	Large Office	35	(1.70)	2.86	$16	$16	1.47	1.47
>300 kBtu/h, <2,500 kBtu/h, Other (Office)	Large Office	35	(1.70)	2.86	$13	$13	1.86	1.86
>2,500 kBtu/h, Other (Office)	Large Office	35	(1.70)	2.86	$10	$10	2.29	2.29

Note: Savings, costs, and incentives listed above are on a per-kBtuh-input basis

Negative kwh savings are due to increased fan energy compared to baseline boilers. Negative savings are booked as interactive adjustments.

Incentives

Although the savings are the same across capacity ranges, the incremental costs are different. Programs may choose to structure their boiler offers with different incentives at various size ranges. If that is the case the maximum incentives below apply. If a single incentive is set for the full size range, it must be less than $10.

- <300 kBtu/h $16
- >300 kBtu/h, <2,500 kBtu/h $13
- >2,5000 kBtu/ $10

The maximum incentive is listed for reference only based on incremental cost. *This is not a proposed incentive*. Planning recommends programs set incentives well below this level.

Measure Life

The measure life is assumed to be 35 years for high efficiency boilers.

Costs

A number of different sources of incremental costs were reviewed to determine an average incremental cost for condensing boilers. The costs reviewed appear to be based on proposed efficiencies in the range of 92%-94%. The most recent sources examined were Xcel energy's condensing boiler measure, case studies from the GSA, and quotes obtained from local boiler sales reps. Two of the recent sources of incremental cost information assume boiler efficiencies of 94% or greater, and these sources are at the low end of the newest cost estimates. Therefore, the average of the gathered costs should be applicable for a 94% efficiency requirement.

Supporting Documents

Supporting documents can be found E:\Planning\Cross-Program Measures\Commercial\Heat & Cool\Boilers\2015 update
The cost effectiveness calculator can be found E:\Planning\Cross-Program Measures\Commercial\Heat & Cool\Boilers\2015 update\bencost

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Reviewed by Mike Bailey

June 17, 2015

Measure Approval Document Greenhouse Measures

Update 6/15/15 – in blue

- Latest avoided cost
- Incremental Cost update
- Thermal curtain O&M cost and measure life discussion

Update 9/18//2014

- Updated all measures
- Add Existing Buildings Washington as an applicable program
- Removed Unit Heater as it is not a current offering

Program Applicability
Based on the referenced analysis and associated cost-effectiveness screening, the measures described below are approved as cost-effective on a prospective basis for use in the following programs:

- Production Efficiency
- Existing Buildings WA

Applicability to the following building type:

- Greenhouses

TABLE 1 BCR Calculator

Energy Efficiency Measure Name	Measure Lifetime	Annual Natural Gas Savings (therms)	Total Incremental Cost of Measure	MAX Potential Incentive	Combined Utility System BCR	TRC BCR
IR Poly Film (per SF of film)	4	0.23	0.10	0.32	1.0	3.3
Thermal Curtain (Per SF of heated floor space)	10	0.41	1.17	1.19	1.0	1.3
Under Bench Heating	12	1.25	2.19	5.19	1.0	2.4

(per SF of heated floor space)						

Program requirements

IR Film Polyethylene Greenhouse cover

- Must be infrared polyethylene plastic with an anti-condensate coating.
- Must be upgrading from a non-IR cover.
- Must have a life expectancy of 4 years.
- Minimum thinness of 6 mil.

Thermal Curtain

- Must be installed above heated space and drawn closed automatically at night
- Must be designed primarily to be a heat curtain
- Must have a rated energy savings rate of 40% or higher
- Must have a minimum life expectancy of 5 years.

Under-Bench Heating

- Heating system must use hydronic heat distribution located directly on or under plant bench, on the floor or in the floor.
- Must replace unit heaters as the primary heat source
- Remaining unit heaters must be controlled to turn on only as an emergency backup

Details and Savings

All savings are based on research conducted by ICF for Energy Trust completed in 2007. The eQUEST hourly simulation tool was used to model energy consumption for a baseline greenhouse. An additional 13 scenarios were modeled representing various combinations of the energy efficiency measures. Key modeling parameters included:

- Baseline Greenhouse – Single bay, 8,192 sf, 80% efficient unit heater, no thermal curtain, no IR film
- Heating System Options – 80% efficient unit heater (baseline), 86% efficient unit heater, under bench heating system with 80% efficient hot water boiler
- Climate Zones – Willamette Valley and Bend/Redmond were modeled, but just one combination of measures was done at the Bend/Redmond climate zone. All savings are based on Willamette Valley climate zone. This results in conservative savings. Projects in the Bend/Redmond climate zone will experience 30% to 40% higher savings.

Combining these measures in the same greenhouse will yield lower savings than the sum of the individual savings, particularly the combination of IR Film and Thermal Curtain. The interactive effects were modeled and used in the measure analysis, but deemed savings assume each measure is installed independently. Energy Trust plans to revisit these savings in 2015 to align with the latest knowledge, best practices and technology in the greenhouse sector.

IR Film

IR film on inner walls reduces heating loads in greenhouses by reducing heat loss through the walls and ceiling. The greenhouse modeled had a double layer inflated polyethylene roof and walls. Both the inner and outer layers were assumed be 6 mill clear polyethylene for the baseline case. For modeling scenarios with IR film, the inner film was assumed to be IR enhanced (outer layer remained clear polyethylene).

Modelling showed the addition of IR film reduces consumption approximately 27%. In 2007, the measure savings were not adjusted for the difference between floor space and film surface area, which the incremental cost is based on and is how the measure is booked. For this update, a floor area to film area ratio of 60% was applied to correlate the savings to the film surface area. Also in

2007, the measures analysis savings assumed a 50% reduction in savings due to the belief that a large number of growers would install IR film at the in a base case. That rate of efficient base case has been reduced for this update to 16.8% based on analysis completed by Cascade Energy in 2009. In combination, these updates reduce the savings for IR film to 0.23 therms/sf of film from 0.27 therms/sf, a reduction of 15%. The new value is still higher than the 0.13 therms predicted by the DOE's Virtual Grower tool for Oregon.

Thermal Curtain
Greenhouse thermal curtains are typically designed to be deployed horizontally above the growing zone within a greenhouse. Side wall curtains, although less common, are also used. For horizontal curtains, energy is saved in three ways. First, horizontal curtains trap air above the curtain and below the roof line. This trapped air forms an insulating barrier that reduces heat losses due to conduction through the roof. Second, curtains reduce the volume of air inside the greenhouse that needs to be heated, and effectively contain the conditioned air within the desired heated space. Third, curtain fabrics are often constructed with aluminum strips or other reflective materials. These reflective curtains help reflect heat back into the greenhouse, thereby reducing the amount of radiation that escapes through the roof or side walls.

Modeling showed the impact of adding thermal curtains and IR film as separate measures to the baseline greenhouse, as well as adding both measures. Alone, the addition of a thermal curtain reduced energy consumption in the models approximately 24%, 0.41 therms/sf. This is an 16% decrease from the 2007 value of 0.49 therms/sf due to the earlier calculations referencing an incorrect table. Modeled savings was less than the savings claimed by thermal curtain manufacturers.

Under-Bench Heating
Bench heating systems are an alternative to unit heaters for keeping plant root zones warm. With under-bench heating systems, pipe or tubing is located below the bench, and hot water is circulated through the system to keep the plant beds warm. Depending on the water temperature, either plastic or metal materials can be used for the water circulation loop. Bench heating systems are known to reduce energy use compared to unit heaters because these systems offer a more efficient means of keeping plant root zones at the desired temperature. With bench systems, the volume of greenhouse air that is heated to achieve a desired root zone temperature is reduced compared to unit heaters, thereby reducing natural gas consumption. One contributing factor to the reduced natural gas consumption for under bench heating systems is that the greenhouse setpoint temperature can typically be reduced for an under bench system compared to a unit heater.

For the eQUEST modeling it was assumed that the setpoint temperature can be reduced 7° F for an under bench system, while still maintaining the same root zone. This setpoint reduction contributes to 74% gas use reduction, 1.25 therms/sf. This is a 4% increase from the 2007 memo value of 1.20 therms/sf due to the earlier memo referencing an incorrect table and including interactive effects.

Measure life

- IR film is generally sold with a 1-year or 4-year lifetime expectation, the program requires products to have a 4-year expected life. The measure life has been updated from 3 years to 4 years.
- Thermal curtain systems have can be considered in two parts, the mechanical support and control system and the curtain itself. Curtains are typically rated at 5 years, which is the typical manufacturer claim and the measure life in use in other areas. Distributers in our area indicate that 5-8 years is normal. However, the costs and baseline assumptions used in this analysis assume a new curtain system not a replacement, and include the costs of the mechanicals. Mechanical portions of the system are expected to have a life exceeding 10 years. A measure life of 10 years is used, with the assumption that an additional curtain will be purchased within that time.

- Under-bench heating systems are expected to have a measure life of 12 years, although some components, such as the boilers are expected to persist much longer.

Incentive Structure
The Production Efficiency Streamlined incentives may be updated in mid-2015. Planning suggests that Existing Buildings WA align with these levels and with any future incentive changes made by the Streamlined program. Table 1 provides maximum cost-effective incentives, *these are not suggested incentives, they are to be used as a reference only*. Incentives for these measures should not exceed applicable project cost.

- IR Polyethylene Film based on sf of film – NOT heated floor space
- Thermal Curtain based on sf of heated floor space – NOT size of curtain
- Under-Bench Heating based on sf heated floor space – NOT size of benches

Cost
Costs are averages of projects that participated in Energy Trust programs between 2010 and 2015.

- IR film costs ranged from $0.06 to $0.22 with an average cost of $0.10 per sf. Only 2 projects were over $0.20. Even the most expensive installation is cost effective. This is more than double the cost assumed by ICF at the time of the 2007 study.
- Thermal curtains ranged from $0.26 to $2.63 per sf with an average cost of $0.90. Two projects over the past 5 years have been more expensive than the limits of the cost effectiveness test. These appear to be anomalous cases of particularly small greenhouses, which did not achieve an economy of scale for labor or shipping costs. On the low end of the cost range is a project whose invoice only includes the cost of the curtain and does not include the mechanical portion of the project cost. Conversation with the suppliers indicated that curtains account for approximately 40% of project cost. The cost of a replacement curtain was assumed for year six, and the present value of that cost ($0.27) added to the initial cost of the curtain and mechanicals, for a total of $1.17. $0.36/sf higher curtain-only invoice we have available to reference.
- Under bench heating systems ranged from $0.89 to $5.00 per sf with the average cost of $2.16. All projects are within the cost effective range. This is a particularly large range because while savings are best measured on a per SF basis, the cost of the heating system is also defendant other variables such as spacing of growing benches and existing equipment on site. This range is in line with the assumptions made by ICF at the time of the study.

Supporting information
The cost effective screening for these measures is attached to this email and can be found at:
I:\Groups\Planning\Measure%20Development\Commercial%20and%20Industrial\greenhouse\greenhouse%20heating%20and%20curtains%202015%20C-E%20Calculator.xlsm

Supporting documentation, including the ICF study can be found at:
E:\Planning\EE Programs\Production Efficiency\Measures\farm\Greenhouses\IR Poly Film and heaters

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Reviewed by Mike Bailey and Fred Gordon

June 30, 2014

BLESSING MEMO FOR GREENHOUSE CONTROLLER
Updated 6/27/2014 – updates in blue

- Updated CEC with current avoided costs
- Added Existing Buildings Washington to Program Applicability
- Included Max Potential Incentive in the cost effectiveness table and discussion in Incentive Structure section

End Use
Installation of greenhouse controllers where none exist presently to coordinate multiple HVAC equipment schedules and implement night setback.

Scope
Measures are “Blessed” as cost-effective for use in the following market segments:

- Retrofit

Program Applicability
Based on the referenced analysis and associated cost-effectiveness screening, the measures described below are “blessed” as cost-effective on a prospective basis for use in the following programs:

- Production Efficiency
- Existing Buildings Washington

Within this market segment, applicability to the following building types are expected:

- Greenhouses

TABLE 1 – Table showing cost-effectiveness of installing temperature controllers in a weighted average sized greenhouse.

Measure #	Energy Efficiency Measure Name	Measure Lifetime (Maximum 70 yrs)	Annual Natural Gas Savings (therms)	Total Incremental Cost of Measure	MAX Potential Incentive	Combined Utility System BCR	Combined Societal BCR
7	Greenhouse Controller Weighted average size/schedule (per square foot)	15	0.28	$0.58	$1.64	1.0	2.9

Program requirements

- Must use a single sensor or an average of multiple sensors
- Must have a minimum of two temperature stages in a 24 hour period (i.e. allow for night setback)
- Heating and ventilation appliances must be controlled by the same sensor or same average sensor value if multiple sensors are used
- Must allow for a dead-band zone of 5°F or greater between heating and ventilation events
- Must force a delay between heating and ventilation events
- Must have the ability to temporarily override set program temperatures

- Must control all active heating devices in the given greenhouse including all fans and automated ventilation systems when applicable
- Limited to a maximum size of 15,000 sqft. per controller
- House must be heated to at least 50 degrees for 30 or more days in a year

Details
Heated greenhouses are often controlled by mechanical thermostats which are manually set to maintain the desired temperature in the greenhouse at all times. Often, there are three separate thermostats in a greenhouse controlling the heater, the ventilation fans, and the rooftop vents. This setup is problematic for two primary reasons:

1. The three thermostats can easily be out of calibration, commonly allowing the heat to be "on" while the ventilation fan is running, or an overhead vent is open.
2. The space temperature is fixed, even though plants require less heat at night.

The purpose of this measure is to offer an incentive for greenhouse controllers that operate from a single control temperature (which could come from one temperature sensor or more than one sensor where the multiple temps are averaged). These relatively simple controllers would control heaters, fans, and vents and also allow for an automatic night-setback temperature.

Savings
To determine savings from installing a greenhouse controller, three greenhouse sizes and three heating schedules were defined, based on an analysis from the Program Delivery Contractor's local greenhouse expert. They are separated out as:

Greenhouse Sizes:
Small: 20’ x 96’ (1920 ft^2)
Medium: 30’ x 96’ (2880 ft^2)
Large: 60’ x 96’ (5760 ft^2)

Heating Schedules:
Minimum: 50 degrees, January only
Medium: 65 degrees, February thru May
Maximum: 70 degrees, Year Round

Assuming the grower implemented night setback, an estimate of natural gas savings was found for each size and heating schedule. For this analysis, a 5 degree temperature difference was used to represent a reasonable set point that would not be considered detrimental to plant growth. In essence, the controller would use a time clock to automatically decide when to reduce the greenhouse temperature by 5 degrees at night, and then automatically return to the daytime set point in the morning. For this analysis, the assumption was that the temperature would be set back starting at 8pm and return to normal operating temperature at 8am.

To determine the overall expected savings given the population of greenhouses within Energy Trust’s service territory, an assumption over the mix of greenhouse sizes needs to be made. The analyst estimated that in Oregon, 30% of the greenhouses were small, 45% were medium, and 25% were large. However, because small to medium-sized greenhouses are considered the primary targets of this measure (larger greenhouses are more likely to use complex control systems) only the population of small-medium size greenhouses needed to be quantified. Based on the overall population of greenhouses within those size classes, 40% were found to be small and 60% were found to be medium.

To predict an average heating schedule for this measure, the analyst assumed from field knowledge that the distribution of greenhouse heating schedules would be around 40% heating to the minimum schedule, 35% to the medium schedule, and 25% to the maximum schedule. However, because it is more common to use smaller greenhouses for high temperature plant propagation, and then move those plants to larger (somewhat cooler) houses later on, and adjusted weighting of 58% medium heat and 42% maximum heat was used in the analysis to represent only the small to medium-sized greenhouses. For cost-effectiveness purposes, savings were still estimated for each individual greenhouse size and heating schedule, but was then also weighted by the percentages indicated above to predict what the program would typically encounter for a single measure offering across all greenhouse sizes and heating schedules.

Measure life

The equipment controller life was set at 15 years in the analysis which is consistent with the regionally accepted useful life of hardware controls for HVAC systems.

Incentive Structure

At the time of this memo, the program has an incentive of $0.03/sqft for installation of the controller. This incentive is consistent with other offerings for greenhouse controllers around the country and is cost effective, with a Utility System BCR of 54.7. The maximum cost effective incentive is $1.64, although this exceeds the expected cost of the retrofit. In the unlikely event that the programs choose to increase incentives so dramatically, incentives and bonuses must be capped at the appropriate project cost.

Cost

On average, controllers may range from $400 - $1,200 depending on the complexity of the system and the controllers’ ability to manage multiple aspects of an HVAC system, in addition to night setback. For purposes of evaluating the cost-effectiveness of this measure, the less expensive controller (multi-stage digital) was used for the smaller greenhouses where smaller, less complex HVAC systems are typically employed. The more expensive controller (Integrated type) was used for the medium sized greenhouses, which because of the larger area, may utilize more units and therefore require more complex controllers.

To obtain a single weighted average incremental cost for the measure, the costs for each controller type were then weighted by the make-up of each greenhouses size, as discussed above. Finally, in all cases an additional $500 installation cost was added to the weighted average equipment cost on a square foot basis.

Exceptions
As stated above, large greenhouses (60'x96') are excluded from this blessing. Since large greenhouses typically employ much more complex and robust control systems, they are not the target of this measure and are therefore not blessed under the analysis shown above. It should be noted that the requirement for a maximum size of 15,000 sqft per controller is meant to account for and include as eligible the cases where several small-medium sized greenhouses are "gutter connected" together. In these cases, a single controller can still adequately handle the simple operation of HVAC systems within each greenhouse. Although it is not expected to occur frequently, this type of setup is highly cost-effective because a single controller is handling a greater amount of square footage.

The cost effective screening for these measures is attached to this email and can be found at:
E:\Planning\EE Programs\Production Efficiency\Measures\farm\Greenhouses\Greenhouse Controller\Bencost\ETO C-E Calculator greenhouse controller 2014.xlsm
Supporting documentation can be found at:
\\eto-share\etoo_share\Planning\EE Programs\Production Efficiency\Measures\farm\Greenhouses\Greenhouse Controller

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September 11, 2014

Addition of Tiered Insulation Levels Blessing Memo for Prescriptive Commercial Insulation

Update 9/9/14 – updates in blue

- Add new measures for existing Roof insulation with pre-existing insulation up to R-5.
- Add new measure for existing attic insulation with pre-existing insulation up to R-19 for gas heating buildings in Washington.
- Updated to 2015 CEC avoided costs and discount rate.

End Use
Wall, roof and attic insulation for existing commercial buildings

Scope
Proposal to review deemed savings for standard prescriptive incentives currently being offered with the following minimum R-values:

- Wall R-value: 11
- Roof R-value: 11 or 20 with existing condition of R-5 or less
- Attic R-value: 19 or 38 with existing condition of R-19 or less

Measures are "Blessed" as cost-effective for use in the following market segments:

- Retrofit

Program Applicability

Based on the referenced analysis and associated cost-effectiveness screening, the measures described below are "blessed" as cost-effective on a prospective basis for use in the following programs:

- Existing Buildings including WA.
- Production Efficiency

The measure is applicable to any type of commercial or small industrial building, but will be marketed toward small to medium sized businesses no larger than 50,000ft[2]. These measures do not apply to large multi-family buildings, dormitories, assisted living facilities, etc. which typically behave more like a residential structure and have different internal loads.

TABLE 1 showing cost-effectiveness of various types of insulation for commercial/small industrial buildings depending on heating fuel type (link: E:\Planning\EE Programs\Building Efficiency\Measures\Insulation\Bencost\ETO C-E Calculator Commercial Insulation.xlsm)

Measure #	Energy Efficiency Measure Name	Measure Lifetime (Maximum 70 yrs)	Annual Electricity Savings (kWh)	Annual Natural Gas Savings (therms)	Total Incremental Cost of Measure	Annual Non-Energy Benefits $ (if any)	MAX Allowable Incentive	Combined Utility System BCR	Combined Societal BCR

1	Wall R-11 Gas Heat	40		0.16	$1.41		$1.41	**1.0**	**1.0**
2	Wall R-11 Electric Resistance	40	3.72		$1.41		$1.41	**4.7**	**4.7**
3	Wall R-11 Heat Pump	40	1.49		$1.41		$1.41	**1.9**	**1.9**
4	Roof R-11 Gas Heat	30		0.25	$0.64		$0.64	**3.1**	**3.1**
5	Roof R-11 Electric Resistance	30	5.96		$0.64		$0.64	**14.3**	**14.3**
6	Roof R-11 Heat Pump	30	2.38		$0.64		$0.64	**5.7**	**5.7**
7	Roof R-20 Gas Heat	30		0.09	$0.64		$0.64	**1.1**	**1.1**
8	Roof R-20 Electric Resistance	30	2.10		$0.64		$0.64	**5.1**	**5.1**
9	Roof R-20 Heat Pump	30	0.84		$0.64		$0.64	**2.0**	**2.0**
10	Attic R-19 Gas Heat	30		0.25	$0.90		$0.90	**2.2**	**2.1**
11	Attic R-19 Electric Resistance	30	5.79		$0.90		$0.90	**9.9**	**9.9**
12	Attic R-19 Heat Pump	30	2.32		$0.90		$0.90	**4.0**	**4.0**
13	Attic R-38 Gas Heat WA ONLY	30		0.05	$0.90		$0.90	**1.0**	**0.5**

Program requirements

- Existing partially insulated walls are not eligible for incentives under this prescriptive offering.

- Insulation projects with no existing insulation must meet the minimum R-Values of:
    1. Wall R-value: 11
    2. Roof R-value: 11
    3. Attic R-value: 19
- Insulation project with some existing insulation must meet the minimum R-Values of:
    1. Roof: R-Value 5 or less upgraded to at least 20
    2. Attic: R-Value of 19 or less upgraded to at least 38 (Washington Only)
- Projects upgrading from no insulation to the higher tiers of insulation are not eligible for both incentives (for example, a project can't apply for an incentive to go from R-0 to R-19 and then again from R-19 to R-38.
- The following is required to be submitted for incentives:
    1. Invoices
    2. Insulation specifications
- Building size shall be less than 50,000ft^2

Details
Commercial insulation has been a prescriptive measure for existing buildings and production efficiency for some time, and realizes modest uptake in the small building market where energy modeling is rarely done. An update was needed for this measure because the original analysis was done in 2001, and had little documentation and justification for savings estimates. The proposed deemed savings are based on the same minimum requirements as the previous ones: R-11 for wall and roof, and R-19 for attic, but the analysis was updated using a more integrated method of energy simulation modeling rather than the previous steady-state heat transfer analysis. In 2013 the energy models were re-run with existing insulation baselines and more insulation in the efficient case.

Savings
Savings were calculated using eQuest to simulate three (3) typical building sizes: 10,000 ft^2, 30,000 ft^2, and 50,000 ft^2. All three buildings modeled were two-story office buildings, north facing, with window to wall ratios of 40%. Infiltration rates and internal loads were based on the default values generated by eQuest for each building size. Baseline insulation values were set to ASHRAE accepted structural values, and models were run for the baseline and upgrade case using each insulation type. Simulations were also performed to compare energy savings between buildings with ducted return systems versus plenum return systems, and buildings with constant air volume (CAV) systems were compared against those with variable air volume (VAV) systems. Programmatic savings were then calculated by averaging the savings from the four different systems that were modeled over the three different building sizes together.

Natural Gas-Heated Buildings
Each building size modeled used a packaged single zone DX coil with gas furnace HVAC system, using eQuest default efficiencies. 80% heating efficiency, and a cooling EER of 9.3 were assumed.

Electrically-Heated Buildings
Electric savings for buildings using electric resistance heat were converted from gas savings estimates generated by the natural gas eQuest models. Electric savings for buildings using a heat pump system were converted from gas savings values using a COP of 2.5, and the electric resistance systems were assumed to have a COP of 1.

Several assumptions over building operation were made to keep model runs consistent and reflective of what the program has seen in the past.

- Room temperature setpoints - heating season: 72F (occupied), 69F (unoccupied)
- Room temperature setpoints - cooling season: 76F (occupied), 79F (unoccupied)
- Outside temperature for heating/cooling: 60F/65F
- Occupied Hours: Mon-Sat 8am-5pm, Sun unoccupied (40-48 hours - CBECS Table B3, Census Region, Number of Buildings and Floorspace for Non-Mall Buildings, 2003) meant to capture average building operating hours for various building types coming through the program

- Holidays: New Year's, Memorial, Independence, Labor, Thanksgiving, Day after Thanksgiving, Xmas, MLK, President's, Veterans Day
- Cooling EER: 9.3
- Gas heating efficiency: 80%
- Electric resistance COP: 1
- Heat pump COP: 2.5
- Building EUI: Determined by eQuest default values for internal loads and infiltration for office buildings
- For a zero insulation baseline condition, ASHRAE accepted R-values for structural components were used resulting in adjusted R-value baseline estimates of:
    1. Wall: R-4
    2. Attic: R-2.2
    3. Roof: R-2

Fan Savings and Cooling Penalties
As expected, model results showed that cooling energy increased in all cases with the addition of insulation, as internal heat loads are relatively constant throughout the year and essentially become trapped heat during summer months. Analysis of the 50,000 ft^2 building model revealed significant cooling energy increases with respect to the heating savings realized. It is therefore suggested that insulating buildings 50,000 ft^2 or larger are at risk for non-cost effectiveness. Because larger buildings contain more complex cooling and heating systems, and inherently contain more parameters that affect energy savings, from an implementation perspective insulation savings for these larger buildings are better served through the custom program approach.

Electric savings from reduced fan load were found when wall or attic insulation was added, and negligible savings were realized when roof insulation was added. On average, positive fan energy savings coupled with a negative cooling energy penalty resulted in an overall electric energy increase for roof and attic insulation, and a net energy decrease for wall insulation. On a sqft basis, the kWh impact is small and averages less than -0.3kWh/sqft for roof and attic insulation, and a positive 0.02kWh/sqft for wall insulation.

System Type and Return Air Path
Deemed savings were calculated by averaging the savings from the four different systems that were modeled over the three different building sizes. The four systems were a CAV duct return system, a VAV duct return system, a CAV plenum return system, and a VAV plenum return system. Results from the model showed negligible difference with respect to CAV or VAV systems in terms of fan kWh or heat savings. Therefore the system type is not expected to impact savings estimates and for purposes of the analysis, VAV and CAV systems are essentially treated the same.

Results from modeling plenum return systems versus ducted return air systems did however indicate differences in savings estimates for certain insulation cases. Most notably, savings stemming from plenum return systems were consistently higher than savings from ducted return systems, presumably because of the reduced heat loss in the unconditioned plenum space on the return air stream. The only case where this differs is with attic insulation, where only a ducted return system was used in the analysis, since it would not make sense to insulate above a drop ceiling with a plenum return. For purposes of a single deemed estimate for each insulation type, savings estimates were averaged together since the persistence of one return air path over another is not yet known. (See exceptions below)

Existing Insulation
In 2014, the models were re-run with several new scenarios using the same methods outlined above.

Baseline models were created with Roof insulation at R-5, which is the former code, and compared to an increase to R-20, which is the Oregon Code. This tiered level of insulation addition proved cost effective for all heating systems.

Baseline models were created with Attic insulation at R-11, and compared to an increase to R-38, which is the current Oregon code. The modeled baseline of R-11, corresponds to a minimum program requirement of R-19, as the program expects to see insulation levels between R-0 and R-19. R-19 was a code requirement for many years so it is expected that many buildings were built to R-19. However, it is known that in older buildings attic insulation may be damaged or otherwise degraded to have a lower effectiveness. A minimum requirement of R-19 also allows for buildings that may have differing levels of insulation in different parts of the building to participate easily. This tiered level of insulation was cost effective only for electric resistance heating. To avoid confusion, this measure will not be offered in Oregon. It will be offered in Washington where the TRC is not a requirement.

Measure life

To align with the regionally accepted lifetime for commercial weatherization measures, a lifetime of 30 years was used in the cost-effective analysis. This lifetime is shorter than for residential insulation (given a measure life of 45 years) because of the possibility of building turnover, added penetrations, and a higher chance of deterioration within a commercial setting. Measure life for wall insulation is higher than roof and attic insulation due to less chance for deterioration.

Incentive Structure

The present value of the utility benefit for each measure is indicated in the table above. The maximum incentive is the lesser of the cost of the measures or the amount of the utility benefit. The program currently plans to offer an incentive of $0.30 per square foot for all of the measures, with a $0.30 per square foot bonus in 2014, exclusive of the multifamily sector, where it is not cost effective. The expected incentive on the tiered insulation measures is $0.30 per square foot.

Cost

Data collected from Existing Buildings projects completed in program year 2011 were used in calculating the average installed cost for insulation, and were compared with vendor quotes collected over the past 2 years. In general the costs from trade allies were in very close agreement to the costs collected in FastTrack. These costs, along with the associated R-values, were averaged separately for wall, roof, and attic insulation to arrive at the values shown in the cost-effectiveness table above. Costs for projects with existing insulation is assumed to be the same as projects without insulation.

Exceptions

Although savings differences between plenum return systems and ducted return systems were found, detailed participant data does not exist to indicate which system may be more prevalent in the marketplace. For purposes of developing a single prescriptive offering, a simple average of the two return systems was made. However, because the savings impact can be large in certain cases depending on the return air system type, it is suggested that the program track this as an attribute for roof insulation measures and review the installed measures to determine if one return air system type is more prevalent and adjust the savings as necessary.

Though past program data suggests that warehouses and retail spaces make-up a significant portion of the building types that have received insulation incentives, because of historical uptake and targeted marketing efforts going forward, these measures are expected to be utilized most often in office buildings. When comparing EUI's between the three building types, warehouses exhibit the lowest EUI and therefore, the lowest savings potential, Retail has the highest EUI, and therefore the highest savings opportunity, and savings for Office buildings fall between these other two building types. Insulation was shown in a follow-up analysis to be cost-effective even at the lowest estimate of savings associated with a warehouse building. However, because very few insulation jobs occur each year, a tailored offering for different building types is not feasible for the program, and offices fall in the middle of the 3 most prevalent building types to receive this measure historically, a single deemed savings estimate associated with an office space was used in the analysis. If future work indicates that insulation jobs are becoming heavily weighted towards one particular building type, it is suggested that savings be adjusted to reflect that building type specifically instead of an average.

The higher tier of attic insulation does not pass the TRC. This measure is only blessed for use in Washington. In Washington, the WUTC has directed Energy Trust to use the Utility Cost Test as the primary determinant of cost effectiveness, and to monitor the Total Resource Cost.

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September 19. 2014

Blessing Memo for Commercial Condensing Tank Water Heaters

End Use: Commercial condensing tank gas water heaters

Program: Based on the referenced analysis and associated cost-effectiveness screening, the measures described below are "blessed" for inclusion in both Washington and Oregon for the following programs:

- New Buildings
- New Multifamily
- Existing Buildings
- Existing Multifamily

Measure History:
Condensing tank water heaters have been offered for Energy Trust's commercial and multifamily programs since 2003. However, the savings for this measure has not been reviewed or updated since that time. Previous to this update, both the New and Existing buildings programs were using savings of 0.76 therms/kBtuh capacity across all building types. Multifamily programs were using 0.644 therms/kBtuh capacity. The source of these savings and the assumed buildings mix is no longer known. At the savings that Energy Trust has been using since 2003, condensing tank water heaters were no longer cost effective when gas avoided costs dropped dramatically in 2012. This update analyses savings based on building use and water consumption and weights savings according to the building types that have participated in this offering in recent years.

Cost effectiveness

Table 1. Cost effectiveness calculator

Energy Efficiency Measure Name	Measure Lifetime	Annual Natural Gas Savings (therms)	Total Incremental Cost of Measure	MAX Potential Incentive	Combined Utility System BCR	TRC BCR
New Lodging	18	5.25	4.91	$4.66	6.0	5.7
New Restaurant	18	2.46	5.04	$4.66	2.8	2.6
New Laundry	18	6.48	4.91	$4.66	7.5	7.1
New Office & Retail & Other (Not Blessed)	18	0.38	5.66			0.4
New School	18	0.34	5.66	$2.00	1.0	0.4
New University	18	1.50	4.91	$4.66	1.7	1.6

New and Existing Multi-family	18	2.21	4.91	$4.66	2.6	2.4
Existing Buildings Weighted Average	18	1.37	5.04	$4.66	1.5	1.4

Measure Requirements:

- Gas condensing tank water heater with a thermal efficiency greater than or equal to 91%.

Savings

This analysis uses methods and spreadsheets derived for the condensing tank water heat update to break out energy savings by building use. Similar to the analysis for tankless condensing water heaters, this analysis estimates hot water consumption for various facilities such as fast-food and full service restaurants, offices, and coin-op laundry facilities, using data from a 2008 EPRI study, "Commercial Building Energy Efficiency and Efficient Technologies." The lodging sector is analyzed with floor area data from the 2003 CBECS, combined with energy use intensity data from a Lawrence Berkley National Laboratory report, "Technology Data Characterizing Water Heating In Commercial Buildings: Application To End-Use Forecasting." Multifamily water heating load data is retained from the 2003 Strategic Energy Group study. The 2009 CBSA floor space and water heat EUI are used for Schools, Universities and Other Health.

Condensing tank water heaters are cost-effective at restaurants, hotels, motels, coin operated laundries, multifamily buildings, and university buildings. Restaurants are taken to be representative of the entire food service sector, and all energy savings and incentive information in this memo regarding restaurants applies to similar businesses in the food service sector, such as groceries with food preparation areas. Lodging consists of hotels and motels. For the purposes of incentive and energy savings, hotels and motels are grouped together. Incentives and energy savings for dorms and assisted living facilities should be based on the multifamily analysis. New University is listed as a discrete measure, but the program might choose to simplify their offering by not offering it. The most likely university buildings to install this measure are likely to fall into the restaurant or multi-family categories.

Condensing tank water heaters are not cost effective in office buildings or in any building where the primary hot water end uses are hand washing in restrooms and light kitchen use.

With the updated savings and weightings, the weighted savings for Existing buildings is cost effective and existing buildings may use a simplified approach of offering the measure to any customer at the same savings rate, similar to how most prescriptive measures are offered.

The weighted savings for New Buildings was not cost effective due to a large number of participating schools and offices where water use is assumed to be low. For New Buildings, the program may offer condensing tank to the building types listed with different savings associated with each building type. A similar approach is already in use for tankless water heaters for that program. Condensing tanks are assumed to be not cost effective for most schools. The program has requested an expectation from the OPUC to retain this measure for schools, that exception may be granted on 9/30/14. If it is not granted, schools with high may use the special measures path to test for cost effectiveness. In New Buildings offices, retail stores and other commercial buildings are not eligible for condensing tank.

Measure Life

A standard measure life of 18 years is used, which is in line with existing Energy Trust measure lives for commercial water heaters and is in agreement with other regional utility programs.

Costs

And incremental cost of $4.66/kBtuh is used in cost effectiveness testing and in setting maximum incentives. This is based on research provided by PECI. An additional $100 is included per site for the addition of a condensate line, which is assumed to be a single one-time cost. Since costs are reflected on a capacity basis, buildings with higher expected installed capacity show slightly lower incremental costs as the cost of the condensate line is distributed to the larger capacity.

Incentives

Table 1 lists the maximum cost effective incentive level. *This is provided for reference only and is not a suggested incentive level.* For the measures that pass the TRC, the maximum incentive is set at that incremental cost of $4.66/kBtuh capacity. For New Schools, the maximum incentive is $2.00/kBtuh. Planning suggests the programs coordinate to set matching incentive levels whenever possible.

Exceptions

The program has requested an expectation from the OPUC to retain this measure for schools on the basis that schools with higher water use are more likely to participate than schools with average or low water use. That exception is expected to be granted on 9/30/14. If it is not granted, schools with high may use the special measures path to test for cost effectiveness. In New Buildings offices, retail stores and other commercial buildings are not eligible for condensing tank. These buildings may use the special measures path for condensing water heaters to test specialty situations, such as gyms or salons with high water use.

Supporting information

The cost effective screening for these measures is attached to this email and can be found at:
E:\Planning\Cross-Program Measures\Commercial\Water Heating\Condensing Tank Water Heater\bencost\ETO C-E Calculator condensing tank water heat 2015.xlsx
Supporting documentation, including the ICF study can be found at:
E:\Planning\Cross-Program Measures\Commercial\Water Heating\Condensing Tank Water Heater

Regarding the sharing of this document:

December 3, 2014

Updated blessing memo for Commercial and Industrial Unit heaters

Updates
- Converts legacy measure into current blessing memo format
- Align measure across programs
- Non-condensing unit heaters no longer blessed

End Use
Condensing Unit heaters

Scope
Measures are "Blessed" as cost-effective for use in the following market segments:
- Retrofit
- Replacement
- New

Program Applicability
Based on the referenced analysis and associated cost-effectiveness screening, the measures described below are "blessed" as cost-effective on a prospective basis for use in the following programs:
- Existing Buildings
- New Buildings
- Production Efficiency

Within this market segment, applicability to the following building types are expected:
- Buildings with HVAC loads in large spaces and such as gymnasiums, large retail and public assembly spaces

Green houses are not applicable.

TABLE 1 Cost Effectiveness for condensing and non-condensing unit heaters.

Energy Efficiency Measure Name	Measure Lifetime	Annual Natural Gas Savings (therms)	Total Incremental Cost of Measure	Max cost effective incentive	Combined Utility System BCR	Combined TRC BCR
Non condensing unit heaters - 86% (no longer blessed)	18	0.61	$3.26	$3.26	1.2	1.2
Condensing unit heaters - 92%	18	1.05	$5.23	$5.23	1.3	1.3

Program requirements
- Non-condensing unit heaters are no longer blessed.
- Unenclosed spaces such as outdoor seating areas or spaces open-air manufacturing spaces are not applicable. Radiant heaters are more appropriate in those areas.
- Greenhouses have different heating patterns and this measure is not applicable for them.
- Minimum thermal efficiency 92%

History
Unit heaters are legacy measures, in use by Energy Trust since 2004, although the 2004 blessing memo pre-dates our current format. They have always been a low-uptake measures.

Sometime between 2008 and 2011, the New Buildings program stopped offering non-condensing heaters and the Existing Building and Production Efficiency programs stopped offering condensing heaters. There is no remaining documentation regarding the reason for divergence between the programs. In 2014 stakeholders informed Energy Trust that there are no longer any non-condensing unit heaters available in the market that meet the 86% requirement.

For 2015 Planning suggests that programs align around the current condensing heater measure. Non condensing heaters are listed in the table above for reference only.

Cost and Savings
Incremental costs used in the cost effectiveness calculator are based on research provided to Energy Trust in 2004 by Aspen Systems, the Program Management Contractor at that time. Baseline for all sectors and situations is a code-compliant 80% thermal efficiency unit heater and 700 run hours annually.

There have been very few completed projects for these measures, creating a data set too small to look for trends or updates to pricing. Given the low uptake of this measure and the simple nature of the technology, the savings have not been updated for this memo. Savings are based on a 92% thermal efficiency, higher efficiency units will have slightly higher savings.

Incentive Structure
The maximum incentive for condensing unit heaters is $5.23/kBtu capacity. This maximum is listed for reference only and is not a suggested incentive. Historically, the incentive for condensing unit heaters has been between $1.50 and $3/kBtu.

Background information
Further information can be found here
E:\Planning\Cross-Program Measures\Commercial\Heat & Cool\Unit heaters

BRC link E:\Planning\Cross-Program Measures\Commercial\Heat & Cool\Unit heaters\bencost\unit heaters C-E Calculator Commercial 2015-4.5.xlsm

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June 18, 2015

Measure approval Document for Condensing Unit Heaters in Greenhouses

End Use
Condensing Unit heaters

Scope
Measures are "approved" as cost-effective for use in the following market segments:
- Retrofit
- Replacement
- New

Program Applicability
Based on the referenced analysis and associated cost-effectiveness screening, the measures described below are approved as cost-effective on a prospective basis for use in the following programs:
- Existing Buildings WA
- Production Efficiency

Within this market segment, applicability to the following building types are expected:
- Greenhouses only

TABLE 1 Cost Effectiveness

Energy Efficiency Measure Name	Select Natural Gas Load Profile	Measure Lifetime	Annual Natural Gas Savings (therms)	Total Incremental Cost of Measure	Max Cost-Effective Incentive	Combined Utility System BCR	TRC BCR
greenhouse condensing unit heaters (per kBtu capacity)	Space Heat	12	6.29	$11.18	$11.18	**2.3**	**2.3**

Details
Unit heaters are used to heat greenhouses, typically to maintain overnight or winter temperatures. The baseline for this measure is a standard 80% power vent or gravity fed unit heater. Condensing heaters achieve efficiencies of 90% and better. Typical applications include 1 or more unit heaters per greenhouse in the range of 180-310 kBtu input capacity. Projects are likely replace more than one heater at a time.

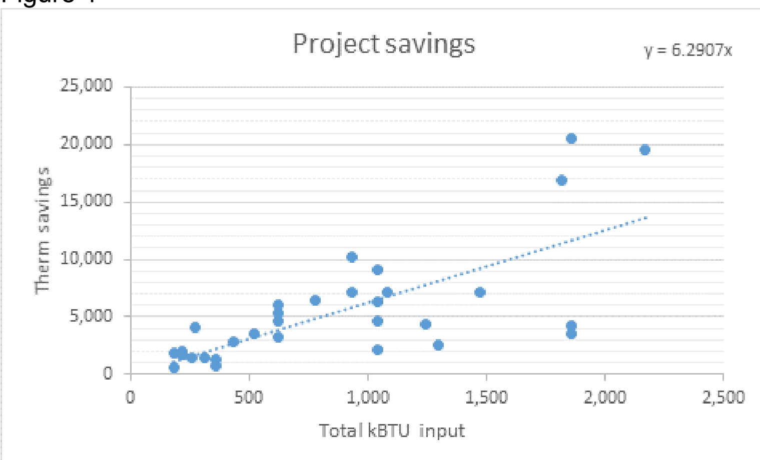
Program requirements
- Heater must be installed in a greenhouse with transparent or translucent sides and roof – this measure is not appropriate for warehouse or "indoor grow" applications which have little or no heating requirements.
- Must heat to 55 degrees or greater for a least two months per year
- Minimum greenhouse size 1,000 sq. ft

Savings
Savings for greenhouse heating depend on crop type, which influences set points, and climate so deemed savings from other regions are not suitable comparisons. Additionally, greenhouse construction also has a large impact on savings. Savings were calculated based on 32 completed greenhouse projects

that went through the PE program between 2011 and 2015. Using actual participate project information allows for a project mix representative of growers in Energy Trust territory. Savings for each of these projects was calculated using the Department of Agriculture's Virtual Grower Tool, a greenhouse energy modeling application which uses a variety of inputs including greenhouse materials, heating set points and local weather data.

While savings from these projects have not fallen perfectly along a linear path, the results do indicate a clear trend as seen in Figure 1. A best-fit line was used to generate an average savings of 6.29 therms per kBtu. Installations in new greenhouses and greenhouses with other efficiency measures in place will achieve fewer savings from condensing heaters as less heat is wasted and operating hours are less. Installations at high elevations will have higher savings.

Figure 1



Measure life
A measure life of 12 years is assumed for unit heaters, in line with unit heater measures in other applications. This is likely a conservative assumption.

Incentive Structure
Incentives will be set by the Production Efficiency program, it is expected to be in the range of $4.50/kBtu. While this measure may also be implemented by the Existing Buildings program in Washington, where EB has responsibility for greenhouses, EB is encouraged by match incentives set by PE. Incentives are to be based on the size of the condensing unit heater, in kBtus. The maximum cost effective incentive is $26/kBtu, however this is higher than the incremental cost between a standard and condensing unit heater. Since this is most often a retrofit measure, the maximum incentive listed in Table 1 is the incremental cost. *This is listed for reference only and is not a suggested incentive*.

Cost
Costs for both condensing and non condensing unit heaters were collected from the two primary manufacturers of unit heaters installed in greenhouse applications. Incremental prices range from $7 to $18 per kBtu. An average incremental cost of $11.18 was used in the cost effectives testing, representing the average incremental cost/kBtu for all sizes of the more expensive manufacturer.

Supporting Information
The cost effective screening for these measures is attached to this email and can be found at: \\ETO-SHARE\Edrive\Planning\EE%20Programs\Production%20Efficiency\Measures\farm\Greenhouses\unit%20heaters\bencost\greenhouse%20unit%20heaters%20ETO%20C-E%20Calculator%202015v2.xlsm

Supporting documentation can be found at: \\ETO-SHARE\Edrive\Planning\EE Programs\Production Efficiency\Measures\farm\Greenhouses\unit heaters

Follow up
If there is a dramatic increase in greenhouse new construction using this measure, the this measure should be re-examined to account for a different mix of typical installations.

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September 8, 2015

This measure is preliminarily approved for use with Commercial Existing Buildings for the purpose of gathering specific project data to further evaluate the measure assumptions and analysis (see program follow-up requirements below).

APPROVAL MEMO FOR PRESCRIPTIVE MODULATING BURNER AS PRELIMINARY MEASURE

End Use
Modulating burner for boiler application in commercial Existing Buildings.

Scope
Measures are approved as cost-effective for use in the following market segments:

- Replacement of burner with higher turndown ratio (5:1 or greater) for non-condensing hot water boiler
- Replacement of burner with higher turndown ratio (5:1 or greater) for condensing hot water boiler
- Replacement of burner with higher turndown ratio (5:1 or greater) for steam boiler

Modulating burners are applicable for commercial buildings with heating systems that operate on typical hours such as:

- Office Buildings
- Lodging
- Public Assembly Buildings
- Mercantile – retail Buildings
- Healthcare – Outpatient Buildings
- Grocery
- Education Buildings (K-12)

The measure is not applicable for:

- Buildings with heating system that operates on non-typical hours such as warehouse and religious worship buildings.
- Domestic water heaters
- Redundant or backup boilers

Program Applicability
Based on the referenced analysis and associated cost-effectiveness screening, the measures described below are approved as cost-effective for inclusion in:

- Existing Buildings program

Specifications for qualifying Modulating Burner are:

- Measure must be installed at facilities that have gas-boiler. Electric-only projects are not eligible for incentives from this measure
- Burner installation must be for space heating boilers

- Modulation burner installation must meet all specifications listed below:
  - Natural gas-fired
  - Hot water boiler (condensing or non-condensing type) or steam boiler
- Modulating burner installation must meet either one of the specifications below:
  - Replacement of a dual stage burner with 5-to-1 turndown ratio or higher
  - Replacement of an on-off burner with 5-to-1 turndown ratio or higher

Description of Measure

The turn down ratio is a function of the burner's capacity to match the boiler load. For example, burner with 1000 MBH input at high fire and 200 MBH input at low fire would be referred to a turn down ratio of 5:1. With the above example, if the base load remains at above 200 MBH, the burner will modulate without turning off. Cycling will not occur. However, if the base load is below 200 MBH, the burner will turn off and cycle. A boiler cycle consists of a firing interval, a post-purge, a stand-by period, a pre-purge, and a return to firing. Pre-purge and post-purge losses occur in addition to the radiation losses. In the pre-purge, the fan operates to force air through the boiler to flush out any combustible gas mixture that may have accumulated. The post-purge performs a similar function. During purging, heat is removed from the boiler as the purged air is heated. In this case, the boiler efficiency is the useful heat provided by the boiler divided by the energy input (useful heat plus losses) over the cycle duration. Frequent cycling occurs for the boiler burners that operate in an on-off mode, or for the boiler with lower turndown burner. Frequent cycling reduces the overall thermal efficiency of the boiler. Modulating burner reduces cycling losses and improves boiler efficiency.

Program requirements

- For Existing Buildings, modulating burner installation must meet the specification set forth in the Program Applicability section.
- Existing Buildings require the following to be submitted for incentives:
    1. Invoices
    2. Specifications; to include all of the following:
        - Burner maximum input rating
        - Burner turndown ratio, or burner manufacturer and model number

Program Follow-up Requirements

- The program will collect the following information for each measure and provide it to Energy Trust Planning Engineering for review after the receipt of 20 applications for this measure. This measure will stay in effect until changed (program can continue to accept and process measures during the data reporting and review process).
- Data to be collected:
    - Make, model, size (rated capacity), year of manufacture, of boiler impacted by measure
    - Description of pre-existing boiler control methodology and equipment
    - Description of new control equipment and methodology installed as a result of this measure
    - Cost of new control equipment and labor costs associated with installing and commissioning equipment
    - Site address, building type (from application list below), building sq-ft, age of building,
    - Estimate of building annual occupied hours.
    - Estimate of boiler annual operating hours – pre measure installation

Savings

The proposed deemed savings for modulating burner is 0.8 therms/year per kBtu/hour input. This reflects the average savings of installing burner with 5:1 turndown for different building types, for hot water (condensing or non-condensing) and steam gas-fired boilers.

An hourly bin analysis for Oregon climate in various cities is used. The heat load changing for each bin temperature is considered to determine the gas savings of a 5-to-1 boiler turndown as compared to a 2-to-1. The savings are based on the weighted average results from the analysis for those cities. The results indicate savings solely from the increased dynamic efficiency due to the reduced cycling losses.

The following assumptions are used in the analysis:

- Correctly-sized boilers for modulating burner applications
- Baseline: two-stage burner
- Balance points: 55°F/55°F (occupied/unoccupied)
- Condensing boiler efficiencies: 88.2% at full fire, 88.8 % at low fire based on hot water return temperature at 140°F. Ref: Lochinvar boilers Model Crest, Sync, Knight, FTXL (see the description under "*Dynamic Efficiency for Analysis*")
- Non-condensing boiler efficiencies: 84% at full fire. Ref: Parker boilers Model T300LR to T3900LR

- Steam boiler efficiencies: 80% at full fire. Ref: Parker boilers Model 102 and 103
- 3% loss in efficiency between high and low fire is based on percent excess air increase at low fire (Ref: 2008 ACEEE-proceeding: Summer Study on Energy Efficiency in Buildings), and efficiency is determined by using stoichiometric combustion analysis
- ∆T between hot water supply and hot water return: 40°F in peak heating, 5°F in mild heating
- Radiation and cycling losses: estimated by using the data from Cleaverbrooks 4-pass firetube boiler (see the description under "*Radiation and Convection Losses")*
- Load factor at high fire: 90%
- Occupancy hours: see Table 2.1 "*Building Occupancy Hours*"
- Setback during unoccupied period: 10°F lower than the occupied temperature
- Heating start/stop: one hour before/after occupancy hours
- Cities for hourly bin analysis: Portland, Newport, Bend, Pendleton, Klamath Falls
- Gas rate: $0.94/therm

Building occupancy hours are based on the data from CBECS (Commercial Buildings Energy Consumption Survey). Table 1 shows the building types being analyzed and the average occupancy hours.

Table 1 Building Occupancy Hours

Building Types	Occupied hours			Holidays/Closing
	Mon-Fri	Sat	Sun	
Office Buildings	12	0	0	All public holidays 1)
Lodging	22	22	22	
Public Assembly Buildings	11	8	6	All public holidays 1)
Education Buildings 2)	8	0	0	All public holidays 1), when classes not in session

Foot Note:

1) Public holidays include:
    - New year's day
    - Memorial Day
    - Independence day
    - Labor Day
    - Thanksgiving
    - Day after Thanksgiving
    - Christmas

2) K-12. Heating shuts down when classes are not in session

Measure Life

A standard equipment measure life of 20 years is used in the analysis to align with SEED program guidelines (http://www.oregon.gov/energy/CONS/SEED/docs/AppendixJ.pdf)

Costs

Proctor Sales provided the estimated costs for burners with 1000, 3000 and 5000 kBtu/h input rating. Table 2 below shows the installed cost of modulating burners at three different firing rates.

Table 2 – Cost of Modulating Burners

Input kBtu/h	Burner 5:1 turndown Cost
1,000	$9,890
3,000	$12,278
5,000	$13,972
Average cost	$4.02

Based on the rated input and the full cost, the weighted average of the modulating burner cost is $4.02 per kBtu/h input.

Table 3 shows the cost-effectiveness for Modulating Burner by averaging 3 different scenarios.

Table 3 Cost-Effectiveness Calculator for Modulating Burner

Measure #	Energy Efficiency Measure Name	Measure Lifetime (Maximum 70 yrs)	Annual Electricity Savings (kWh)	Annual Natural Gas Savings (therms)	Total Incremental Cost of Measure	MAX Potential Incentive If Measure is Cost-effective	Combined Utility System BCR	Combined Societal BCR
1	Average savings modulating burner Per kBtuh input capacity	20	0	0.80	$4.02	$4.02	**1.2**	**1.2**

Incentives

To be determined by program manager. Maximum incentive of $4.02 is listed for reference only based on expected average cost. This is not a suggested incentive. Incentives are not to exceed project cost.

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Analysis completed by Novi Leigh, CEM and ICF Staff

Reviewed by Paul Sklar & Jackie Goss, Energy Trust Planning Engineers and Mike Bailey, Energy Trust Engineering Manager

May 13, 2014

BLESSING MEMO FOR Commercial Dishwashers with Max incentive

UPDATE 5/12/14 –

- Re-tested measures with latest (2014) avoided costs.
- Table modified to demonstrate maximum incentive. This update allows programs to offer incentive changes and bonuses within that max incentive limits without the need to further memo revisions.
- Removed specific discussion of incentives and outdated language pertaining to earlier changes.
- Updated to current memo format

Scope
Measures are "Blessed" as cost-effective for use in the following market segments:

- Replacement
- New

Program Applicability
Based on the referenced analysis and associated cost-effectiveness screening, the measures described below are "blessed" as cost-effective on a prospective basis for use in the following programs:

- Existing Buildings
- New Buildings
- New and Existing Multi-Family (where commercial kitchens occupy a MF space, such as dormitories or nursing homes)

Within this market segment, applicability to the following building types are expected:

- Restaurants and other commercial kitchens

Saving and Cost Effectiveness
The planning department has reviewed the cost-effectiveness of Energy Star commercial dishwashers. Based on our analysis these dishwashers are blessed as cost-effective on a prospective basis. That means they are approved as cost-effective for purposes of program implementation, and we will use the savings in the attached sheet and linked sheet. These incentives are being offered under the assumption that Energy Star dishwashers have a relatively low acceptance rate in the market. All savings, incremental costs, and measure lives for these measures were estimate using the Energy Star commercial dishwasher calculator in 2009* and assume the baseline is federal code. This assumption should be reviewed as sales data becomes available.

* We elected not to take the time to update the savings analysis at this time so that we could focus our resources on screening a number of measures using the new avoided costs.

Supporting documentation can be found at:
Cost effectiveness: E:\Planning\Cross-Program Measures\Commercial\Food Service\Dishwashers\Bencost
Energy Star Calculator (basis of savings and cost): \\ETO-SHARE\Etoo_Share\Planning\Cross-Program Measures\Commercial\Food Service\Dishwashers\CDW Calc vfinalweb_EStar-partE-11-11-09.xlsx

The Existing Buildings program proposed offering incentives on under counter, single tank door/upright, and single tank conveyor models. Each of these dishwashers types are available in a high temp version (sanitizes dishes with hot water) and a low temp version (uses chemicals to sanitize dishes). Because of the energy it takes to heat the hot water the high temp Energystar dishwashers save substantially more energy than the low temp Energystar version. The cost of using chemicals to sanitize the dishes is not included in this analysis. Low temp under counter dishwashers were not blessed they did not appear to be cost effective. The link above or the attached sheet shows the screening runs for these measures.

Measure #	Energy Efficiency Measure Name	Select Business Type	Select Electric Measure Description:	Select Natural Gas Load Profile	Measure Lifetime (Maximum 70 yrs)	Annual Electricity Savings (kWh)	Annual Natural Gas Savings (therms)	Total Incremental Cost of Measure	Annual Non-Energy Benefits $ (if any)	MAX Potential Incentive If Measure is Cost-effective	Combined Utility System BCR	Combined Societal BCR
1	Under counter - high temp-Gas water heat	Other	FLAT	Hot Water	10	2,680	217	$1,000	$66	$1000	2.3	2.8
2	Under counter - high temp-Ele water heat	Other	FLAT	Hot Water	10	7,369	0	$1,000	$66	$1000	3.7	4.2
3	Single Tank Door/ Upright - High Temp-Gas water heat	Other	FLAT	Hot Water	15	5,197	405	$2,100	$123	$2100	4.8	3.4

4	Single Tank Door/ Upright - High Temp- Ele water heat	Other	FLAT	Hot Water	15	13,950	0	$2,100	$123	$2100	4.8	5.4
5	Single Tank Conveyor - Low temp - Gas hot water	Other	FLAT	Hot Water	20	0	520	$3,000	$158	$3000	1.2	1.8
6	Single Tank Conveyor - High temp - Gas hot water	Other	FLAT	Hot Water	20	7,998	508	$3,000	$154	$3000	3.6	4.3
7	Single Tank Conveyor - low temp - Ele hot water	Other	FLAT	Hot Water	20	11,228	0	$3,000	$158	$3000	3.5	4.1
8	Single Tank Conveyor - High temp - Ele hot water	Other	FLAT	Hot Water	20	18,972	0	$3,000	$154	$3000	5.9	6.5

9	Single Tank Door/ Upright - Low Temp-Gas water heat	Other	FLAT	Hot Water	15	0	554	$2,000	$168	$2000	1.5	2.4
10	Single Tank Door/ Upright - Low Temp-Ele water heat	Other	FLAT	Hot Water	15	11,969	0	$2,000	$168	$2000	4.3	5.1
Total												

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Reviewed by Fred Gordon

August 17, 2015

Measure Approval Document for Web-Enabled Thermostats for Forced Air Furnaces

End Use
Residential Space Conditioning

Scope
This measure is for single family site-built or manufactured homes that primarily heat their homes with an electric or gas forced-air furnace.

Program
Existing Homes

Description of Measure
Due to studies published in the mid-2000s indicating little or no energy savings from programmable thermostats, ENERGY STAR discontinued certification for programmable thermostats in 2009. Since that point a new generation of web-enabled thermostats has been introduced into the market. Through improved user interfaces, remote programming and adaptive setbacks utilizing advanced features to determine whether or not a home is occupied, qualified thermostats should be able to add additional setbacks into their schedule, thus savings energy even under less than ideal programming.

Measure Requirements
In order to be a qualifying web-enabled thermostat, a product must:

- Be able to connect to the internet with remote access to temperature, settings and/or schedules
- Utilize at least one automated occupancy-sensing technology (motion sensing, location services, etc.) and be able to automatically change the temperature during unoccupied periods
- Demonstrated savings **and customer satisfaction** from at least one published study or pilot program with 3rd party evaluation
- Include simple, step-by-step instructions for customer installation of the thermostat. If instructions are not included in the box, they must be easily accessible online

This memo approves the installation of thermostats qualifying under the above criteria on existing heating systems or packaged with new heating systems, and may be installed either by homeowners or by licensed contractors.

Cost-Effectiveness Table: I:\Groups\Planning\Measure Development\Residential\thermostat\bencost\ETO CEC tstat.xlsm

#	Measure	Measure Life (yrs)	Savings		Incremental Costs ($)	Maximum Incentive ($)	Utility BCR at Max Incentive	TRC BCR
			kWh	therms				
1	contractor installed web enabled tsat for	11	360	-	$100	$100	2.72	2.72

	electric forced air furnace							
2	contractor installed web enabled tsat for gas forced air furnace	11	-	35	$100	$100	1.47	1.47
3	self installed web enabled tsat for electric forced air furnace	11	331	-	$100	$100	2.50	2.50
4	self installed web enabled tsat for gas forced air furnace	11	-	32	$100	$100	1.35	1.35

Furnace Savings

From the Residential Building Stock Assessment, Oregon average gas heating load is 583 therms, and the average electric heating load is 5,992 kWh (derived from Tables 153 and 157 in the RBSA Single Family Characteristics and Energy Use report[1]). The average heating loads include both heating zone 1 and heating zone 2.

Table 1: Oregon furnace savings by fuel type

Measure	Heating Load	Savings %	Savings
Gas Furnace	583 therms	6%	35 therms
Electric Furnace	5,992 kWh	6%	360 kWh

The preliminary billing analysis[2] completed by Energy Trust Evaluation staff in July, 2015, achieved results similar to studies by NIPSCO in Gary, Indiana and Vectren in Evansville, Indiana, which ranged from 5.6% to 8.6% savings above a baseline programmable thermostat, as shown in table 2 below:

Table 2: 2010-2014 Average Heating Degree Days (base 65F)

Study	Location	HDD	% of PDX	% Savings
Baseline	Portland, OR	4,634	-	-
Vectren	Evansville, IN	4,600	99.3%	8.6%
NIPSCO	Gary, IN	5,892	127.1%	5.6%

Source: www.degreedays.net

[1] Baylon, D., Storm, P., Garaghty, K., Davis, B. 2012. *"2011 Residential Building Stock Assessment: Single-Family Characteristics and Energy Use."* Prepared for the Northwest Energy Efficiency Alliance. http://neea.org/docs/reports/residential-building-stock-assessment-single-family-characteristics-and-energy-use.pdf?sfvrsn=8

[2] Rubado, Dan. "Gas Advanced Thermostat Pilot: Billing Analysis of Gas Use", July 24, 2015. http://staffnet/Operations/PandE/_layouts/15/WopiFrame.aspx?sourcedoc=/Operations/PandE/PandE_TeamDocuments/Gast%20Tstat%20Pilot%20Billing%20Analysis%20Memo%20v2.docx&action=default

Install Rate

The 2014 Gas Thermostat Pilot yielded 415 total purchased thermostats, of which 32 were returned. This is a 92% successful install rate (383/415). This de-rating factor is used to reduce the energy savings of self-installed thermostats to account for products that are purchased but not installed or later uninstalled.

Measure Life

The California Database for Energy Efficiency Resources (DEER) lists the expected lifespan of a programmable thermostat as 11 years, up from 8 years used by the Energy Trust previously.

Costs

Retail prices for web-enabled thermostats from most major manufacturers have converged at $250. Programmable thermostats in contrast, vary widely in price from less than $25 to more than $200 based on features. Because this offering is designed for tech-savvy consumers who want a feature-rich thermostat, the baseline product should be a feature-rich programmable thermostat. The Honeywell VisionPro 8000 provides a representative product of a feature rich thermostat as it is 7-day programmable and comes either with built-in WiFi or Redlink technology. The VisionPro 8000 retails for approximately $150.

Incentives

The cost-effectiveness table lists the maximum cost-effective incentive level. This is provided for reference only and is not a suggested incentive level. For measures that pass the TRC, incentives shall be set at a level to be determined by the program as long as the total incentive does not exceed the maximum level indicated in the table.

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Reviewed by Paul Sklar & Mike Bailey

August 17, 2015

REVISED measure approval document for gas fireplaces

Measure Description
A direct vent gas fireplaces measure is currently offered in the Existing Homes, Home Performance with ENERGY STAR programs, and the small multifamily subsector of the Multifamily Existing Buildings program. In the Multifamily Existing Buildings program, fireplaces are approved only for properties where the living units are side by side, not stacked. Fireplaces for new homes are not cost-effective and not approved as a standalone measure or a component of a package used to gauge the cost-effectiveness of the EPS. This memo adds an intermittent ignition measure that includes both direct vent fireplaces and log sets in Existing Homes and New Homes.

Energy savings based on thermal efficiency
The efficiency rating is the Fireplace Efficiency score from the Canadian P4 test. Savings are calculated according to the following formula:

$$\Delta therm = hr\ x\ \frac{kBtu}{hr}\ x\ (\frac{1}{baseline} - \frac{1}{FE})$$

Hours of use: Annual 600 hours of use were extrapolated from the Energy Trust hours of use metered study for Existing Homes. A survey of participants in our New Homes Program in 2015 asked for hours of use of fireplaces. The survey response indicated 8.2 hours per week from October to March (26 weeks). If the same over-reporting phenomenon that was applied in the Existing Homes program, calculated from the difference between self-reported and metered hours of use, then the average hours of use per week in the New Homes program would be 5.4.

Heat input and average efficiency: Data is for units recognized in the program tracking database from January 1, 2014 thru July 9, 2015. The figures in table 1 are used in the thermal efficiency savings estimate.

Table 1: Updated efficient unit FE and kBtu usage

Tier	Average FE	Average kBtu	Count
70 - 74.9 FE	72.3	32,900	1,792
75+ FE	78.2	31,700	246

The number of fireplaces in the new homes market and retrofits in existing homes: The average of new home builder reported and new home occupant survey findings for number of fireplaces is applied to the new gas heated home market estimate by separating the number of New Homes from fireplace sales to Existing Homes. The hearth market in Oregon for both new and existing homes is an estimated 10,500 units annually. The size of new home market was estimated in two ways: utility account activations and the 2014 Census reported residential permits less builder reported percent of new home market heated with electricity.

Method 1 for the number of new homes (utility data): Utility customer information for NWN and CNG was screened for new residential gas account activation in 2014. Single family detached, duplex and triplex structures were included in the estimate assuming that larger structures are less likely to be candidates for hearth installations during the building process.

Method 2 for the number of new homes (census data): Census data for permits issued in Oregon during 2014 were also sourced to provide another data point for the size of the housing market. Structures with less than four units were used as the total for this estimate. The data does not distinguish between heating fuel types so the 76% estimate of new construction for new homes reported by Evergreen Economics' 2015 builder interviews was used to de-rate the permit data.

Table2: Estimate of new gas heated home market size

Data source	Total permits	Percent of new gas heated homes	Total housing units
Census 2014 permits issued for < 5 unit structures[1]	8,919	76%	6,778
UCI 2014 <4 unit gas account activations	-	-	7,278
Average	**-**	**-**	**7,028**

Method 1 for the number of fireplaces in each new home (occupant survey): To estimate the number of hearths in a new gas heated home, the new home occupant survey data is weighted based on the number of observations in the dataset yielding an estimated 0.86 hearths per new gas heated home.

Method 2 for the number of fireplaces in each new home (builder interviews): Builder interviews reported 93% of new gas heated homes have at least one fireplace, with 95% of those having one unit installed, and the remaining 5% two or more. Given the unknown number of additional units, two units are assumed for the homes with more than one installation in-line with the new home owner survey. These figures are weighted and provide an estimate of 0.98 hearths per new gas heated home.

Evenly weighting the builder reported and new home survey data yields an estimated 0.92 hearths per new gas heated home, shown in Table 3 below:

Table 3: Estimated average number of hearths in new gas heated homes

New home occupant survey				**Builder reported**		**Overall Average hearths per new home**
Number of Hearths	Count	Percent	Weight	Percent	Weight	
1	110	75%	0.75	88%	0.88	
2	8	5%	0.11	5%	0.10	
0	28	19%	0	7%	-	
Total	146	**Hearths per home**	**0.86**		**0.98**	**0.92**

[1] Census permit data site: http://www.census.gov/construction/bps/stateannual.html

Divvying up fireplaces to new homes and existing homes: Using the new gas heated home market and hearths per home figure yields an estimated 6,453 hearths in new homes, leaving an existing home market of 4,047.

Table 4: Estimated new home and existing home hearth markets

Total estimated market	10,500
2014 New Homes unit estimate	7,028
Hearths per new home	0.92
Hearth units in new homes	6,453
Existing home market	4,047

Average efficiency of fireplaces in new homes: Table 5 below shows the distribution of efficiency levels for hearths found in new homes. Mid-points for the efficiency bin are sourced from incented units in the program tracking database for the 65+ FE units. Verifier data is used for the sub-65 efficiency levels rather than the mid-point of the bin. These figures are used to estimate the weighted FE score for the comparison region for the manufacturer and distributor reported 2014 unit sales and to remove the estimated new home thermal efficiency distribution from the total market estimate.

Table 5: Efficiency bin mid points

FE efficiency bin	Verifier sourced percent in bin	Estimated new home unit distribution	FE point estimate	FE point estimate source
75+	0%	-	78.2	2014-July 2015 average FE
70-74	2%	129	72.3	2014-July 2015 average FE
65-69	6%	387	67.5	2014 average FE
50-64	90%	5,808	55.8	New home verifier data
0-49	2%	129	45	New home verifier data
Total	**100%**	**6,453**	**56.6**	

Method 1 for the average efficiency of fireplaces in Existing Homes (manufacturer baseline): The efficiency distribution found by the verifiers (shown above in table 5) is applied to the new home hearth unit estimate and then subtracted from the manufacturer reported distribution of units for the entire market. The resulting average thermal efficiency for Existing Homes based on manufacturer data is 65.5 FE.

Table 6: Manufacturer weighted baseline

Manufacturer reported comparison region in 2014				Verifier sourced distribution removed	
Efficiency bin	Bin midpoint	Manufacturer reported 2014 distribution	Units in market	Less new homes	Weighted FE
75+	78.2	2%	210	210	4.1
70-74	72.3	9%	945	844	15.1

65-69	67.5	23%	2,415	2,012	33.6
50-64	55.8	62%	6,510	695	9.6
0-49	45.0	4%	420	286	3.2
Totals	**-**	**100%**	**10,500**	**4,047**	**65.5**

Method 2 for the average efficiency of fireplaces in Existing Homes (distributor baseline): The distributor baseline estimates follows the same procedure as the manufacturer data shown in table 6 with one deviation due to a lack of 2014 distributor reported units in the 70-74 FE bin. Subtraction of the new home efficiency distribution (shown in table 5) would result in a negative weighting for the 70-74 bin. To mitigate a negatively weighted efficiency bin the new home unit estimate is subtracted from the next less efficient bin until the entire new home unit estimate has been removed from the total market estimate. The resulting average thermal efficiency for Existing Homes based on distributor data is 54.3 FE.

Table 7: Distributor weighted baseline

Distributor reported comparison region in 2014				Verifier sourced distribution removed	
Efficiency bin	Bin midpoint	Distributor reported 2014 distribution	Units in market	Less new homes	Weighted FE
75+	78.2	3%	315	315	6.1
70-74	72.3	0%	-	-	-
65-69	67.5	4%	420	-	-
50-64	55.8	80%	8,400	2,501	34.5
0-49	45.0	13%	1,365	1,231	13.7
Totals	**-**	**100%**	**10,500**	**4,047**	**54.3**

Manufacturer and distributor reported data are weighted equally to provide a new thermal efficiency baseline for existing homes of 59.9 FE.

Energy savings based on intermittent ignition system

Intermittent ignition savings are calculated by multiplying the heat input by the number of hours the pilot would otherwise be on. The heat input of the pilot light is 1000 Btu/h, based on the DOE Technical Support Document for the federal standard. The hours are 8760 minus the hours the fireplace is in operation.

The baseline for the intermittent ignition system is the Eastern Washington market, where distributors surveyed in the market transformation study sold 46% of their product without intermittent ignition systems. An estimated 40% of the difference between the comparison region and our service territory, where 9% of products are sold without intermittent ignition systems, was attributed by the authors of the study to regional differences. The result is 32% of intermittent ignition systems can be influenced by our incentive, and that is the NTG ratio for the savings that we would claim for a retail or customer incentive (0.46-0.4*(0.46-0.11) = 0.32). The NTG will be applied to the working savings for reporting, but in accordance with Energy Trust practice is not used for the cost effectiveness calculation in this analysis.

NTG: Note that the Program is considering a midstream delivery model, with the baseline for each distributor calculated from the previous year's sales. In that case, the working savings would be multiplied by the number of additional units that each distributor sold above the previous year's baseline. It is not necessary to apply the NTG ratio to the midstream savings model, for that reason.

Even though these savings are based on the ignition system, it will be super important to record the thermal efficiency of all of the fireplaces, as potential market transformation savings will be based on direct vent fireplaces with thermal efficiency of 65 or better, while log sets with intermittent ignition systems will get program savings.

Energy savings based on on-demand ignition system.
The heat input of the pilot light is 1000 Btu/h, based on the DOE Technical Support Document for the federal standard. There are a total of 4368 hours in the heating season (from October 1 to March 31).

The on-demand pilot light allows the homeowner to shut down the fireplace, including the pilot light, when it is not in use, though it can be overridden by thermostat or remote control to extinguish the pilot light only after five consecutive days not in use. In the absence of other data, the default mode is assumed to be shutting off the fireplace after five consecutive days of it not being used.

Metered data used to determine hours of use included some on demand fireplaces. Superb statistical work by Energy Trust evaluators produced an average number of hours in excess of the five day lag time that an on demand fireplace would remain off during the heating season. This additional 372 hours off time is added to the savings for on demand ignition systems.

Weighting of different ignition systems: 13% of the models on the NRCAN product list are on demand. Intermittent ignition system savings are blended with the on demand savings based on that proportion of products in the market. In addition, the market transformation study also indicated that about 20% of products with intermittent ignition systems could be switched to standing pilot mode. The measure analysis deducts this percentage from the ignition system savings.

Measure Cost
Tax credits are available through ODOE. They are $350 for 70-74 FE fireplaces and $550 above 80 FE. **However, the tax credits are new this year, and Energy Trust has no information on their uptake. Although it may become necessary to subtract the tax credit from the incremental cost in future years, this measure analysis does not do so**.

The DOE Technical Support Document for the rulemaking process gives the incremental production cost of the electronic controls and starter as $28 for vented fireplaces and $70 for vented log sets. This analysis takes the higher number and applies a 50% contractor mark-up, which is also applied to the fireplace equipment cost below.

Incremental costs of $25 for thermal efficiency are taken from the median prices in the 2013 Cadmus market assessment between the 60 to 64FE baseline and the 70FE and above efficient case and given the same 50% mark-up from wholesale to retail costs that was applied to the ignition system. Costs for thermal efficiency for new homes are from the median price between the 55FE baseline and the 70FE efficient case. Thermal efficiency savings are not cost effective in new homes.

Cost Effectiveness Calculator: \\Etoo.org\home\Groups\Planning\Measure Development\Residential\fireplace\bencost\ETO CEC fireplace 2016.xlsm

Measure	Measure Life (yrs)	Savings		Incremental Costs ($)	Non-Energy Benefits (Annual $)	Maximum Incentive ($)	Utility BCR at Max Incentive	TRC BCR
		kWh	therms					
Fireplace ignition system	20		64	$105	$0	$105	3.81	3.81
Existing Homes fireplace thermal efficiency from 70 to 74 FE	20		57	$38	$0	$38	9.49	9.49
Existing Homes fireplace thermal efficiency at 75 FE and above	20		74	$38	$0	$38	12.48	12.48
New Homes fireplace thermal efficiency from 70 to 74 FE	20		18	$1,113	$0	$1,113	2.98	0.10
New Homes fireplace thermal efficiency at 75 FE and above	20		22	$1,113	$0	$1,113	3.65	0.12

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Reviewed by Mike Bailey & Fred Gordon

September 4, 2014

Blessing Memo for condensing gas furnaces in two tiers for Northwest Natural Washington Service Territory

End Use

Gas furnace

Scope

Condensing furnaces in two tiers:

- AFUE 90%-94.9%
- AFUE 95%+

Program

Based on the referenced analysis, the measure described below is "blessed" on a prospective basis for inclusion in the Home Energy Savings and Multifamily Existing Buildings programs for properties with four or fewer living units in Northwest Natural's Washington service territory. The building stock for multifamily properties with four or fewer living units tends to be row houses or garden style apartments of two stories or less, having separate attic spaces, and individual entrances. For those reasons, we believe that the thermal properties for this subsector of the multifamily market is largely similar to detached single family homes in Washington. Furnaces in renter occupied properties in Oregon and Savings Within Reach are expected to have higher savings and are blessed separately, as the housing stock for Clark County, Washington is newer.

Description of the Measure

AFUE 90%+ gas furnaces operate in the condensing range, transferring more of the heat available in the moisture vapor in the exhaust gases to the circulating warm air.

Purpose of Evaluating Measure

This memo defines gas savings and maximum incentive for two furnace efficiency tiers in Northwest Natural Washington service territory.

Program Requirements

Condensing gas furnace installations must have a minimum AFUE of 90% and be located within Northwest Natural Washington service territory.

BCR Calculator attached and linked: E:\Planning\EE Programs\Home Energy Savings\HOUSE TYPES AND measures\single family\furnaces\Washington\bencost\SW WA Furnaces ETO C-E Calculator Residential 2015- 4.5.xlsx

Project	Measure Lifetime (Maximum 70 yrs)	Annual Gas Savings, therm	Total Cost	Max ETO Incentives	Utility System PV of Benefits	Societal PV of Benefits	Combined Utility System BCR	Combined Societal BCR
90-94.9% AFUE gas furnace	25	60.7	$500	$424	**$424**	**$424**	**1.00**	**0.8**
95%+ AFUE gas furnace	25	80.7	$950	$563	**$563**	**$563**	**1.00**	**0.6**

Note: this table uses 2015 avoided costs

Measure Analysis

Annual savings for 90%+ AFUE condensing gas furnaces range from 65 to 78 therms, with an average of 71 therms, based on the 2006-2009 impact evaluation estimates for the Oregon program.

This memo uses the multiple variable model estimates assuming that it more closely resembles potential load reductions from a newer housing stock in NW Natural Washington service territory. The model includes interactive effects from multiple measure installation, which diminish the per measure savings due to reduction in overall gas usage from such measures as weatherization.

Savings

Based on these findings, furnace savings in existing single family dwellings can be estimated using the following equation:

*Estimated multiple variable therm savings = (Efficient AFUE – 80% Baseline) * 5.14*

Northwest Natural Washington 2012-April 2014 incented gas furnace installation AFUE and estimated savings

Furnace efficiency tier	**Weighted average AFUE**	**Therm savings relative to baseline**
AFUE 90% to 94.9%	91.8%	60.7
AFUE 95%+	95.7%	80.7

Savings, Economics and Incentives

Incremental costs for furnaces can vary widely depending on manufacturer, product features and efficiency levels. Market research conducted in April 2014 collected a number of contractor bids for gas furnaces with a variety of options and efficiency levels. The study found that very high AFUE rated furnaces frequently featured ECM blowers and multi-stage burner controls associated with higher prices, but were not pre-requisites of furnaces achieving the higher range of AFUE ratings.

Cost effectiveness screening uses the economy bids. These bids are more competitive bids, as they are for models with fewer of those features that increase cost, but do not improve energy savings. The difference in contractor bids has a wide range, with one price quote showing no cost difference between a AFUE 80 and a AFUE 90 furnace, while another set of bids showed a nearly $1000 difference between a AFUE 80 and a AFUE 92 furnace. Incremental costs between economy bids by each contractor for 80 AFUE, 90 AFUE, and 95 AFUE furnaces were compared with the bids from the same contractor, in order to minimize the non-energy related differences between models. The median cost increment was $500, which is used in the cost effectiveness analysis. The median difference between a AFUE 80 and AFUE 95 was $950.

The maximum cost effective incentive for furnace from 90 to 94 AFUE is $424 and the maximum incentive for furnaces 95 AFUE and better is $563. Neither tier passes the Total Resource Cost test. However, the Washington Utilities and Transportation Commission has allowed such measures in the efficiency portfolio, provided that the incentive passes the Utility Cost Test and the portfolio passes the TRC. The Commission will monitor the effect of such measures on the Total Resource Cost of the efficiency program as a whole.

Measure life of 25 years, consistent with Energy Trust gas furnace measures since 2005 based on research on furnace age at retirement conducted in British Columbia (Natural Gas Furnace Market Assessment, August, 2005, Haybart and Hewitt).

October 6, 2015

Measure approval for Living Wise Kits

Valid dates: January 1, 2016 to December 31, 2016

End User: Oregon schools in the service territory of Energy Trust electric utilities

Scope: Living Wise Kit including a 1.75 gpm showerhead, a 1.5 gpm kitchen aerator, a 1.0 gpm bath aerator, and two 9.3W omnidirectional LEDs (60W equivalent).

Description of the Measure

Living Wise Kits provide educational materials and energy and water saving equipment to elementary school classes. Classroom activities demonstrate how LEDs use less energy than incandescent bulbs. The materials also explain how reducing water consumption by using low flow showerheads and aerators conserves valuable resources and uses less energy for water heating. After participating in the classroom activities, students have the opportunity to perform energy and water consumption related experiments at home, and to install the LEDs, showerhead, and aerators, with parents or other adult supervision.

Purpose of Evaluating Measure

This memo updates the installation rates and water heating fuel splits, based on the spring 2015 report from RAP

Program Materials Include:

- Student Guide
- Student Workbook
- Program Introduction Letter to Parent/Guardian
- Home Survey (Scantron Form)
- Certificate of Achievement
- "Get Wise" Wristband
- Teacher Guide
- State Education Standard Correlation Chart
- Supplemental Activities
- Spanish Translated Materials
- Electricity Poster for classroom
- Water Poster for classroom
- Natural Gas Poster for classroom
- Teacher Program Evaluation Form
- Self-Addressed Postage-Paid envelope
- Teacher Incentive Flyer
- Thank-you card to teachers
- Product Installation Instructions (English & Spanish)
- Natural Resource Fact Chart
- Reminder Stickers & Magnet Pack
- Student Incentive Postcard
- Parent/Guardian Comment Card

Living Wise Kit

- Two 9.3W Omnidirectional **A19** LEDs
- One High-Efficiency Showerhead (1.75 gpm Niagara chrome)
- One Kitchen Aerator (1.5 gpm Flip & Swivel)

• One Bathroom Faucet Aerator (1.0 gpm w/ Locking Mechanism)
• One Digital Thermometer (0 degrees to 212 degrees)
• One Flow Rate Test Bag
• Toilet Leak Detector Tablets

BCR Calculator (linked and attached): \\Etoo.org\home\Groups\Planning\Measure Development\Residential\Living Wise Kits\bencost\ETO CEC Living Wise Kit 2016.xlsm

#	Measure	Measure Life (yrs)	Savings		Incremental Costs ($)	Non-Energy Benefits (Annual $)	Maximum Incentive ($)	Utility BCR at Max Incentive	TRC BCR
			kWh	therms					
1	LED - 1st lamp	12	10		$7.00	$0.85	$6.87	1.00	2.07
2	LED - 2nd lamp	12	8		$7.00	$0.86	$6.07	1.00	1.96
3	showerhead - 1.75 gpm ELE water heat	15	134		$4.50	$14.71	$114.62	1.00	60.58
4	kitchen faucet aerator - 1.5 gpm ELE water heat	15	59		$2.05	$6.53	$50.88	1.00	59.02
5	bathroom faucet aerator - 1.0 gpm ELE water heat	15	71		$1.35	$7.85	$61.14	1.00	107.70
6	showerhead - 1.75 gpm GAS water heat	15	5	5.8	$4.50	$14.71	$34.12	1.00	42.69
7	kitchen faucet aerator - 1.5 gpm GAS water heat	15	2	2.6	$2.05	$6.53	$15.14	1.00	41.59
8	bathroom faucet aerator - 1.0 gpm GAS water heat	15	3	3.1	$1.35	$7.85	$18.20	1.00	75.89

LED Measure Analysis
This memo follows the methodology used to calculate LED savings in the retail lighting memo. The hours of use are 1.9 hours, based on information from a study done by The Cadmus Group in 2010 for the California Public Utility Commission and adapted by the RTF. The 9.3 W lamp replaces the average

general purpose lamp for the 750 to 1049 lumen category, which includes CFL, incandescent, and halogen lamps. The baseline wattage is 35.9, based on the 2014 Lighting Shelf Space Survey.

This memo models the baseline without the 45 lm/W standard intended to go into effect in 2020. Should the standard take effect, the savings will be trued-up, using an average of the pre-2020 and post-2020 savings, weighting accorded to the extent of the measure life that occurs before and after the cut-off. The savings would be 4.5 kWh per year for the first omnidirectional LED and 4.0 kWh per year for the second omnidirectional LED.

Heating energy added to the load by the replacement of incandescent lamps by LEDs is approximately 2.3 kWh per year for electric space heat for the first LED lamp and approximately 0.09 therms for gas space heat. The second LED lamp is installed just a little less frequently, and the electric space heat interaction is 2.0 kWh per year, and the gas space heat interaction is 0.07 annual therms. The electric heating interaction is subtracted from the working savings in the cost-effectiveness table above. Heating interaction for gas space heat appears as a negative number in the non-energy benefits in the table above. Surveys from the Living Wise Kits from the first half of 2015 showed an installation rate of 65% for the first LED and 57% for the second LED.

The present value of the cost of the future purchases of the less-efficient and shorter-lived bulbs that are alternatives to LEDs were added in the Non-Energy Benefit column. The average operating life for the baseline blend of incandescent, halogen, and CFL is 5.18 years and the average cost of a replacement is $4.82. Therefore, any lamp other than an LED would need to be replaced 1.3 times during the life of the measure, not counting the initial replacement.

Measure life for LEDs is 12 years, consistent with the retail LED blessing memo.

Aerator Measure Analysis
This memo follows the general methodology used to calculate energy savings for aerators adopted from Energy Saver Kit. Daily use is 2.5 minutes per faucet per day at 50% of the maximum flow and 104˚F delivery temperature. Baseline flow rates were collected by CSG, during Home Energy Reviews. The existing stock of kitchen aerators averaged 2.71 gpm in single family homes, and bath aerators were 2.48 gpm. A 35% installation rate was indicated by surveys from the Living Wise Kits from the first half of 2015.

Measure life for aerators is 15 years, consistent with past Living Wise Kit analysis.

Water system pumping has an additional electrical energy savings of 5.29 kWh per 1000 regardless of the water heating fuel. ETO uses a blended water and sewer rate from four cities and towns to calculate the non-energy benefit of reducing water consumption. The rate is $14.24 per 1000 gallons, after removing the portion of the rate attributable to water system pumping. The change in water volume annually includes both cold and hot water and is calculated by multiplying the change in flow rate, the minutes of faucet use, and the installation rate.

Showerhead Measure Analysis
This memo follows the methodology used to calculate energy savings for showerheads adopted from Energy Saver Kits. The ratio of locating low flow showerheads in primary showers, which are used more than secondary showers, remains 67% in primary shower and 33% in secondary shower, as does the length of the average shower at 7.84 minutes. The number of people per household has been updated

to 2.57 in single family households and 1.8 in multifamily households according to the 2009 American Community Survey. The installation rate for showerheads is 36%, based on surveys from the Living Wise Kits from the first half of 2015.

Water system pumping energy and the non-energy benefit of reduced water consumption are treated the same for showerheads as described above for aerators.

Measure life for showerheads is 15 years, consistent with past Living Wise Kit analysis.

Water heating fuel
The split in water heating fuel from surveys from the first half of 2015 was 45.83% electric and 46.98% gas.

Costs and incentives
The incremental costs in the table above are representative of costs that the program has negotiated with vendors in recent years. However, the maximum incentives for showerheads and aerators are far and away greater than the incremental cost, and should never be paid in the real world. The maximum incentives are indicated here to prove that these measures are cost effective and to allow the program to calculate and meet cost effectiveness and levelized cost targets. **The cost of the whole kit is $46.25, including education materials with which savings are not associated, but which are necessary for delivery of the measures. The whole cost is well within the sum of the maximum incentives.**

Additional Information on Savings and Baseline assumptions used in this analysis:
The NW Power Council Regional Technical Forum (RTF) has concluded that the planned 2020 Federal efficiency standard may impact the savings from residential lighting measures, by upgrading the efficiency of the baseline. Because less efficient baseline incandescent and halogen bulbs have short lives, if an LED is not installed due to the program, these baseline bulbs are likely to be impacted by the 2020 standard during expected lifetime of 2016 lighting measures.

Energy Trust has decided not to implement this RTF standard for 2016. The reasons are several:

- BPA has elected to delay implementation of the standard's impacts until 2017, because of limitations on program changes in their contracts with retail utilities. Because Energy Trust's program is closely coordinated with BPA's, it would be confusing to the market and contractors if Energy Trust used different numbers than the BPA in 2016.
- Some BPA staff and contractors are collecting data on the impact of standards in the lighting market. This data may change the assumptions used in the RTF's analysis.
- Past Federal standards have been changed at the last minute by acts of Congress, creating uncertainty about the probability that the current standard will actually go into effect.
- Programs help influence that outcome by influencing market acceptance, which influences people who talk to Congress. Thus by continued program incentive efforts help to make the actual implementation of the future standard more likely.

Energy Trust will review this decision in 2016 planning for the 2017 program.

document and the attached economic and engineering analyses, but if so, please ensure that it is no longer identified as an Energy Trust document. Energy Trust makes no representations or warranties about the suitability of the documents for any particular use and disclaims all express and implied warranties with regard to the documents, including warranties of non-infringement, merchantability or fitness for a particular purpose.

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Reviewed by Mike Bailey

September 15, 2015

Revision: Adds multifamily below 4 living units. No other changes.

Approval Memo for 0.67EF or 0.70EF Gas Storage Water Heater

Valid dates: January 1, 2016 to December 31, 2016

End Use: Gas storage water heaters sold to retailers, water heater contractors, and homeowners

Scope: Gas storage water heaters with an Energy Factor greater than or equal to 0.67.

Program: New or Existing Single Family Homes, as well as New or Existing Manufactured Homes, **and for properties in the Multifamily Existing Buildings program with 2-4 living units.**

Description of the Measure
Gas storage water heater designs which may be used to improve the efficiency to 0.67EF are increased insulation and improved flue baffles, electronic ignition, and/or an electromechanical flue damper. These options may be combined with power venting at additional cost. Power vented models are included in this measure but very little uptake is expected for them, as a result of the cost. This measure does not include condensing water heaters or tankless water heaters which have an EF greater than 0.80.

Purpose of Re-Evaluating Measure
A federal standard became effective in April 16, 2015, which requires an EF of 0.60 for a gas storage water heater with a 50 gallon storage capacity.

BCR Calculator: (link: \\Etoo.org\home\Groups\Planning\Measure Development\Residential\gas storage water heat\bencost\ETO CEC gas storage water heat.xlsm)

Measure	Measure Life (yrs)	Savings		Incremental Costs ($)	Non-Energy Benefits (Annual $)	Maximum Incentive ($)	Utility BCR at Max Incentive	TRC BCR
		kWh	therms					
gas storage water heat 67EF	13		23	$200	$0	$103	1.00	0.51
gas storage water heat 70EF	13		31	$430	$0	$141	1.00	0.33

Measure Analysis
The gas water heater baseline is derived from a study Michael Blasnik completed for the Energy Trust in 2009. The study found that the average household water heating energy use was 218 therms. This analysis uses this estimate as a baseline for energy use.

Savings, Economics, and Incentives
With an improvement from 0.60 EF to 0.67 EF, the water heater will use 23 fewer therms. Models with an EF of 0.70 will save 31 therms.

There is considerable variability in the cost of the water heaters. Recent quotes ranged from a $200 incremental cost for a 0.67 EF unit to $430 incremental cost for a 0.70 EF unit. If it is not already available, an electrical connection has an additional cost of approximately $150. Retrofit installations for which an electrical connection is not already available are not included in this analysis, as the additional cost of electrical work will likely preclude the installations in those sites. The new construction scenario or a retrofit installation in which an electrical connection is available is shown in the cost effectiveness calculator above.

The maximum cost effective incentive for a 0.67EF model is $97. The maximum cost effective incentive for a 0.70EF model is $132.

The lifetime of this measure is 13 years, from the DOE Technical Support Document for the federal standard.

Energy Trust requested an exception for this measure to continue despite a TRC below 1, and was granted permission by the OPUC in UM 1622 on the basis that inclusion of the measure will increase market acceptance and lead to reduced costs. The exception cites Energy Trust's expectation "that with implementation of a range of upstream tactics to improve sales, some of which are being developed in concert with other programs across the country, there will be greater market acceptance of high efficiency gas water heaters and costs will go down." **In August, 2015, Energy Trust notified the OPUC that the TRC continues to be below 1 and was given an extension until the end of 2016.**

Program Requirements
Gas storage water heaters with an Energy Factor greater than or equal to 0.67 and Energy Star approved qualify for this measure. Power vent models also qualify for this measure.

Exclusions
Condensing units, whether storage or tankless, are excluded from these measures. Currently, the only residential tank condensing models available are very expensive or lack a flame retention guard. Manufacturers have created a category of "hybrid" gas water heaters between tankless and storage, that have a greater than 2 gallon tank and a greater than 75 kBtu/hr burner. Field testing of the hybrids is needed to determine their energy savings potential. These are also excluded from this measure.

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Reviewed by Mike Bailey

October 1, 2015

MEASURE APPROVAL DOCUMENT FOR 2016 NW NATURAL WASHINGTON NEW HOMES ENERGY PERFORMANCE SCORE

Program

- New Homes Washington

Scope

Energy Performance Score (EPS™) Measures are approved for new gas heated single family construction in Washington.

Background

The New Homes EPS program in SW Washington utilizes the Oregon EPS certification framework to establish performance criteria for its incentive structure. The EPS is a compliance method that allows builders to select a custom combination of measures that exceed Washington residential energy code. The EPS provides flexibility when designing buildings enabling builders and raters to compare multiple packages to find the feasible cost-effective options for builders.

Program Requirements

- All projects entering the new homes program via the SW WA EPS track will be simulated using REM/Rate modeling software with results from the Fuel Summary Report entered into the EPS calculator for determination of incentives, savings and overall EPS rating
- Homes must be heated with gas
- Builders are required to work with a RESNET® accredited HERS provider

Cost-Effectiveness

Table 1 below presents the benefit cost ratios for the pathways modeled for SW WA EPS homes, as well as a weighted average of all pathways based on the 2015 distribution of EPS homes in Oregon to simulate anticipated activity in Washington.

In Washington, Energy Trust does not claim electric savings. The benefits of the electric savings are used in the TRC test, **but not in the utility test**. Aside from pathway 1, these measures do not pass the TRC individually or as a weighted average. These measures are only approved for use in Washington. In Washington, the Washington Utilities and Transportation Commission (WUTC) has directed Energy Trust to use the Utility Cost Test as the primary determinant of cost effectiveness, and to monitor the Total Resource Cost. Preliminary analysis shown to the WUTC in August 2015 with EPS measures under a 1.0 TRC was approved to be included in the 2016 program year. There is a long history of new home programs leading to market transformation, by increasing building acceptance of advanced practices, leading to lower costs and enhanced building codes. As a result the long term cost-effectiveness is likely to be far better than that shown here. Energy Trust will track the electric savings as unclaimed savings and coordinate with electric utilities in the area as needed. All electric savings use a conservative 10 year measure life with a ventilation fan load profile when converting to present value TRC benefits.

Table 1: EPS Pathway Benefit Cost Ratios

Measure	Measure Life (yrs)	Savings kWh	Savings therms	Incremental Costs ($)	Non-Energy Benefits (Present Value $)	Maximum Incentive ($)	Utility BCR at Max Incentive	TRC BCR
SWWA EPS Path 1	25	NEB	79	$671	$119	$600	1.00	1.07
SWWA EPS Path 2	31	NEB	120	$1,292	$124	$1,033	1.00	0.90
SWWA EPS Path 3	35	NEB	200	$2,932	$412	$1,814	1.00	0.76
SWWA EPS Path 4	38	NEB	243	$8,078	$537	$2,288	1.00	0.35
SWWA EPS Path 5	39	NEB	271	$9,136	$544	$2,583	1.00	0.34
Weighted SWWA EPS Pathways	30	NEB	123	$1,721	$209	$1,045	1.00	0.73

Savings
To obtain an estimate of the energy savings and the resulting EPS score, the program has elected to use REM/Rate™ to model both the expected baseline as well as each home entering the program. As an energy modeling tool, REM/Rate has been shown to be reasonably accurate on a national level in evaluating the expected energy performance of new homes. To account for regional differences that exist outside of the REM/Rate calculation methodology a specialized calculator tool was developed to adjust outputs from REM/Rate and tailor them to Pacific Northwest conditions. These adjustment factors more accurately reflect the consumption and savings seen in the Northwest.

To calculate savings over a defined baseline, a home is modeled in REM/Rate using installed components and performance testing results. REM/Rate calculates the energy consumptions of the home using the installed components/improvements and simultaneously calculates the consumption of a User Defined Reference Home (UDRH) which uses the specifications of the baseline code home as a comparison baseline to the modeled home. Consumption outputs from the code and improved homes are then entered into the EPS calculator tool. The difference between code and improved home cases determines the savings to be claimed by the program, which is then converted to MBtus to calculate the overall EPS score for the home.

Modeled pathways use Washington State code as the baseline and then the most frequent gas equipment and shell upgrades observed in the Oregon EPS program to estimate savings thresholds.

Non-Energy Benefits are included in the cost effectiveness calculator in Table 1 and are based on Energy Trust approved water savings from one 1.75 GPM showerhead installation in pathways 3 through 5 as well as the non-claimed electric savings as demonstrated in Table 2.

Table 2: Modeled Pathway kWh Savings, kWh Present Value Equivalent and Water Related Non-Energy Benefits

	Path 1	Path 2	Path 3	Path 4	Path 5

Modeled kWh savings	200	208	357	568	579
Present value of kWh savings	$119	$124	$213	$338	$345
Present value of water Non-Energy Benefits			$199	$199	$199
Total Non-Energy Benefits for TRC	**$119**	**$124**	**$412**	**$537**	**$544**

Details

Minimum requirements for each path are listed in Table 3 below.

Table 3: Detailed Upgrades Modeled by Pathway Compared to 2012 Washington Code (Improvements from Code in Bold)

	Code Gas	Path 1	Path 2	Path 3	Path 4	Path 5
Slab	R-5 break R-10 2' under	R-5 break R-10 2' under	R-5 break R-10 2' under	R-5 break R-10 2' under	R-5 break R-15 4' under	R-5 break R-15 4' under
Framed Floor	R-30 (U-0.034)	R-30 (U-0.034)	R-30 (U-0.034)	**R-38 (U-0.028)**	**R-38 (U-0.028)**	**R-38 (U-0.028)**
Basement Wall	R-21 Int. (U-0.054)	R-21 Int. (U-0.054)	R-21 Int. (U-0.054)	R-21 Int. (U-0.054)	R-20 Cont	R-20 Cont
Wall	R-21 int. (U-0.054)	R-21 int. (U-0.054)	**R-21 Adv or R-23 Int. (U-0.051)**	**R-21 Adv or R-23 Int. (U-0.051)**	**U-0.035**	**U-0.035**
Window	U-0.30 SHGC 0.30	U-0.30 SHGC 0.30	U-0.30 SHGC 0.30	**U-0.28 SHGC 0.28**	**U-0.25 SHGC 0.26**	**U-0.22 SHGC 0.25**
Ceiling	R-49	R-49	R-49	**R-49 + R-21 Heel**	**R-49 + R-21 Heel**	**R-60 Adv.**
Water Heater	0.82 EF Tankless	0.82 EF Tankless	0.82 EF Tankless	0.82 EF Tankless	0.82 EF Tankless	0.82 EF Tankless
Furnace	78 AFUE	**92 AFUE**	**95 AFUE**	**95 AFUE**	**96 AFUE**	**96 AFUE**
Duct Location	Attic	Attic	Attic	**Inside**	**Inside**	**Inside**
Duct Insulation	R8	R-8	R-8	n/a	n/a	n/a
Duct Leakage	4% CFM_{25}/CFA	4% CFM_{25}/CFA	4% CFM_{25}/CFA	40 CFM_{50}	40 CFM_{50}	40 CFM_{50}
Infiltration	5 ACH50	5.0 ACH50	**4.0 ACH 50**	**3.0 ACH 50**	**2.5 ACH50**	**2.0 ACH 50**
Mechanical Ventilation	Exhaust, standard efficiency 24 hours 40 watts	**High Efficiency Exhaust** **(2.857 CFM/watt)**	**High Efficiency Exhaust** **(2.857 CFM/watt)**	**High Efficiency Exhaust** **(2.857 CFM/watt)**	**HRV** **(75% SRE 1.25 CFM/w)**	**HRV** **(80% SRE 1.25 CFM/w)**
Lights and Appliances	75%	75%	75%	75%	100% and ESTAR Appliances	100% and ESTAR Appliances
Other	x	x	x	Low flow fixtures	Low flow fixtures	Low flow fixtures
	Therm Savings	79	117	189	253	288

kWh Savings	200	208	357	568	579
Mbtu Savings	9	12	20	27	31
% Better-Gas Only	13.30%	19.80%	31.50%	43.40%	48.70%
% Better Than Code-Whole Home	10.30%	15.00%	23.90%	33.10%	37.00%
Incremental Cost	$671	$1,292	$2,941	$8,086	$9,144

Measure life

REMRate aggregates end use savings together, and does not provide outputs by specific end-uses components. To estimate weighted measure lives by modeled pathway, some simplifying assumptions have been used to allocate savings to specific end use measure lives based on 2015 Oregon distribution of pathways. To simplify this analysis, furnace savings are assumed to be identical across all pathways despite AFUE increasing with the higher pathways. Domestic water heating savings are based on one 1.75 gallon per minute showerhead installation in a new home with the associated Energy Trust therm savings and measure life for paths 3 through 5. The remaining savings are associated with insulation and new home air sealing standalone measure lives of 45 years. These simplifications do not impact total savings, but could impact measure life. Weightings are shown in Table 4.

Table 4: Pathway Weighted Measure Lives Based on Modeled End Use Savings

End use	Measure life	Path 1	Path 2	Path 3	Path 4	Path 5	Weighted Path
Heating - Gas Furnace	25	79	79	79	79	79	
Domestic Water Heating	15			8.2	8.2	8.2	
Shell Measures	45		38	102	166	201	
Oregon distribution of pathways		48%	24%	23%	4%	1%	100%
Total therms		**79**	**117**	**189**	**253**	**288**	**123**
Weighted Average Measure Life		**25**	**31**	**35**	**38**	**39**	**30**

Costs

Costs in Table 1 are based on a variety of sources for individual improvements in the modeled pathways. Within each pathway costs for measures requiring a treated area are weighted using the following distribution of home sizes which are based on the observed data for new home construction within the Oregon EPS program, shown in table 5 below.

Table 5: Modeled Home Size Within Pathways for Weighting Costs

Square Footage	Distribution
1,380	15%
2,129	35%
2,509	35%
2,852	10%
3,602	5%

Specific end-use cost sources came from the following sources with a brief discussion of assumptions employed in the analysis.

Gas Furnaces

- All pathways use data from 2014 Energy Trust funded research, which interviewed contractors regarding installation costs for both code furnaces and high efficiency models. Energy Trust SharePoint link.

ENERGY STAR® Exhaust fans Pathways 1 through 3

- Survey of supplier catalogs from 2009. While dated, small ENERGY STAR ventilation fans contribute $44 to incremental cost and the technology has not changed significantly over time.

Heat Recovery Ventilators Pathways 4 & 5

- Builder reported costs from the Northwest Energy Efficiency Alliance's Next Step Home Pilot. Two builders' reported incremental costs for units with 70-75% sensible recovery efficiency.

Low Flow Fixtures

- Includes one 1.75 GPM showerhead with savings, costs and non-energy benefits sourced from Energy Trust measure approval document. Energy Trust SharePoint link.

Weatherization and Windows

- Shell measures and window incremental costs were sourced from the Northwest Power and Conservation Council's 6th Power Plan for new construction measures, appendix G:
    - https://www.nwcouncil.org/media/6311/SixthPowerPlan_Appendix_G.pdf.
- Wall insulation costs for pathways 4 and 5 – Advanced wall insulation – were reported from four builders in the Next Step Home pilot from a code baseline of a 2x6 frame using fiberglass insulation.
- Air sealing costs for pathways 1 through 3 use RTF sourced costs. Weatherization – Single Family ResSFWx_v3_4.xlsx 'CostData&Analysis tab' row 31.
- Air sealing for pathways 4 and 5 are based on five builder reported costs from the Northwest Energy Efficiency Alliance's Next Step Home Pilot targeting an infiltration level of 2.0 ACH from a code baseline of 5.0 ACH 50.

Lighting

- Improvements from the 75% ENERGY STAR requirement to 100% for pathways 4 & 5 are assumed to be CFLs, as builders are assumed to use the lowest cost option for improvements. The RTF has estimated incremental costs for whole home lighting improvements on a number of occasions for Oregon, which is assumed to have a similar socket count as new homes in Southwest Washington.
    - An analysis for Oregon's 2012 ENERGY STAR new homes specification from the RTF stating $17 to replace the remaining 25% of sockets in a home (Link, slide 20, RTF workbook: EStarLighting_ExistingFY10v1_5.xls) with ENERGY STAR qualified lighting from a 75% baseline.

Incentive Structure

Table 1 lists the maximum cost effective incentive level. *This is not a suggested incentive and is to be used by the program as a reference only*. For REM/Rate modeled homes that have savings which fall between the defined pathways a “sliding scale” approach will be used to estimate the savings to be claimed by the program and the incentive level to be paid.

Expiration

This offering is approved for homes built to the 2012 Washington residential building code. When codes are updated, this offering must be updated as well.

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