NW Natural 2019
Energy Efficiency Plan

Table of Contents

1 SUMMARY

The following plan outlines how NW Natural plans to save 375,513 therms across its energy efficiency programs. These savings are expected to cost $3,169,493.

2018 EE Plan Summary		Annual Therms Goal	Annual Cost
Incentive Program	Commercial Program	147,481	$988,187
	Residential Programs	221,714	$1,442,877
Low Income	WA-LIEE	6,318	$149,328
Market Transformation	NEEA	N/A	$184,101
Pilots & Trial Programs	Pilots & Trial Programs	TBD	$315,000
Evaluation	Evaluation	N/A	$90,000
	EE Plan Total	**375,513**	**$3,169,493**

2 PART I – Background

2.1 History

Northwest Natural, dba NW Natural ("NW Natural" or "Company"), began offering its current energy efficiency programs to Washington customers on October 1, 2009. The Washington Utilities and Transportation Commission's ("WUTC's") Order No. 04 in the Company's 2008 rate case, docketed as UG-080546, directed the Company to create and begin offering a program.

The Company's energy efficiency programs were developed and continue to evolve under the direction and oversight of the Energy Efficiency Advisory Group ("EEAG") which is comprised of interested parties to the Company's 2008 rate case.

The Company began using Energy Trust of Oregon ("Energy Trust") as the delivery arm for its Oregon energy efficiency incentive program in 2003. Since the Company's Washington service territory is contiguous with its Oregon territory, it made sense in 2009 to have Energy Trust extend the boundaries of the Oregon incentive program offerings into Washington.

As agreed to in UG-080546, Energy Trust implemented the Company's incentive program for one pilot year. During this time, the EEAG monitored the program's performance and assessed whether Energy Trust should be the ongoing incentive program implementer. On May 25, 2011, NW Natural made a compliance filing in UG-080546 wherein it stated the EEAG's opinion to allow Energy Trust to continue delivering the Company's energy efficiency incentive programs in Washington. On June 8, 2011, Public Counsel separately filed a letter supporting this decision.

2.2 Oversight

The EEAG includes representatives from NW Natural, Energy Trust of Oregon ("Energy Trust"), Washington Utilities and Transportation Commission ("WUTC") Staff, Public Counsel, Alliance of Western Energy Consumers ("AWEC") (formerly Northwest Industrial Gas Users), The Energy Project, and the NW Energy Coalition.

2.3 Program Delivery

The Company's programs are currently delivered to customers through partnerships and contracts with third parties.

The incentive program is offered through Energy Trust. Energy Trust is an independent, nonprofit organization dedicated to helping utility customers save electric and gas energy. Energy Trust was formed in 2002 in response to Oregon legislation that restructured electric utilities[1] for multiple reasons, including allowing non-residential

[1] SB 1149, codified as ORS 757.612, mandated the creation of an independent entity capable of providing demand side management services to utility customers.

customers to purchase their electricity from providers other than the utility and reassigning the responsibility for demand side management from utility operations to Energy Trust.

The Washington Low Income program (WA-LIEE) including outreach and delivery is provided through local community action agencies. The local community action agencies are Clark County Community Action Agency serving Clark County and Washington Gorge Action Programs serving Klickitat and Skamania Counties.

Market Transformation efforts are a regional collaborative effort administered by the Northwest Energy Efficiency Alliance ("NEEA") with funding from multiple utilities.

2.4 Energy Efficiency Programs Offered

2.4.1 Incentives Program

2.4.1.1 Residential Program Description

Residential programs in southwest Washington acquire cost-effective gas savings by engaging with builders and homeowners. This program engages with builders to increase energy efficiency of newly constructed homes through incentives, education, trade and program ally support and quality assurance. For single-family and small multifamily homeowners, incentives are available for the following energy saving efforts:

- efficient space heating and controls
- water heating
- insulation
- windows
- water conservation and behavioral actions
- education
- trade ally support
- financing with repayment through utility bills
- market interventions

Specific measure offerings and details are as listed in Appendix 1 and Appendix 2.

There are four tracks within the Residential Incentive program, Home Retrofit (Standard), Multifamily, Mid-stream (distributor and retail) and EPS New Construction (new homes).

2.4.1.2 Residential Standard Track (Existing Home Retrofit)

Residential customers with gas heated homes are offered incentives for cost-effective weatherization measures and certain efficient gas appliances. Customers are encouraged to work with Trade Allies to ensure they are being provided accurate energy efficiency information and access to the most efficient equipment and services. On-line home energy reviews are also available wherein an energy use estimation tool identifies incentives

and qualifying insulation and weatherization measures that could be installed to improve the efficiency of customers' homes.

2.4.1.3 Residential Multifamily Track

Residential customers in multifamily buildings are offered a specialized subset of the Residential Standard Track incentives. Due to the usage profile of Multifamily buildings, there are unique measures within this sub sector. Condos, townhomes, duplexes, triplexes and fourplexes and stacked (2-4) units qualify for incentives for the approved measures.

2.4.1.4 Residential Mid-stream (Supply Chain) and Products Track

Mid-stream focuses efforts and incentives toward distributors to encourage them to stock and promote the sale of efficient equipment to contractors and residential customers. The Products strategy focuses on retail engagement to promote efficient natural gas appliances and fixtures.

2.4.1.5 EPS New Homes Track

The EPS New Homes program encourages builders to construct homes to an energy efficiency standard that is at least 10% better than Washington building code. EPS is a trademarked name of an energy performance scoring tool that aims to highlight the benefits of energy-efficient newly built homes. The Company offers an energy performance score that rates the efficiency of a home and measures it against similar-sized homes built to 2015 Washington State Residential Energy Code. Qualifying new homes must also meet new construction Best Practice criteria established by the EPS New Construction (homes) Program. The compliance of all new homes is verified through an inspection process and homes are issued a score, called an EPS, upon completion.

2.4.1.6 Commercial Program Description

The Commercial program provides natural gas energy-efficiency solutions for new and existing commercial buildings. Commercial customers of NW Natural in Washington can receive incentives for qualifying energy-efficient upgrades and retrofits. The program incentivizes select measures in existing and new commercial buildings, including office buildings, restaurants and other foodservice buildings, dormitory and assisted living facilities, greenhouses and multifamily structures. Specific measure offerings and details are as listed in Appendix 1 and Appendix 2.

The Washington Existing Buildings program consists of two tracks, custom and standard.

2.4.1.7 Commercial Custom Track

The Custom Track acquires gas savings through incentivizing energy efficient capital projects and operations and maintenance upgrades in complex and non-standard situations. Program Management Contractor account managers and engineering firms identify and promote customer opportunities. The custom track also pursues opportunities in retro commissioning, which features targeted incentives for operations and maintenance improvements such as controls or HVAC adjustments.

2.4.1.8 Commercial Standard track

The Commercial Standard track provides incentives for standard measures with predetermined (deemed) savings for buildings of all sizes and across all commercial market sectors. The program promotes measures through customer outreach and cultivation of trade ally contractors.

2.4.1.9 Commercial New Construction track

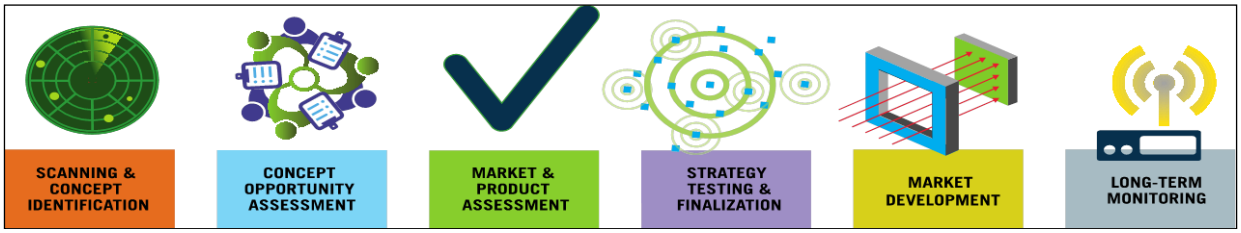
In 2019 this track is being called out separately from the Existing Building Standard track for the first time. While there are no New Construction specific offerings, there has been enough new construction activity in the Company's territory to continue to track and identify the resulting savings. Future efforts may expand support and measures offered to New Construction through building owners and expanded trade allies such as architects and system engineers.

2.4.2 Low Income

Under NW Natural's low-income energy efficiency program, agencies administering the program leverage other funding sources with WA-LIEE dollars to provide whole-house weatherization services to qualifying customers. Program details are available in the Company's Schedule I, "Washington Low Income Energy Efficiency Program (WA-LIEE)."

2.4.3 Market Transformation

The Company views the regional gas market transformation initiative led by the Northwest Energy Efficiency Alliance (NEEA) as a necessary investment in the future of gas demand side management (DSM) and as an enduring component of regional power planning. NEEA's primary work on behalf of the Pacific Northwest is focused on two strategic goals: 1) bring energy efficient emerging gas technologies to market, and 2) create the market conditions that will accelerate and sustain the market adoption of energy efficient emerging gas technologies. NEEA uses a stage-gate approach to manage its work. Below are the six phases that a technology would go through to fully achieve the two goals and result in a sustained market change that provides gas savings.



Prior to the market development phase, NEEA works on:

- Scanning for new technologies (shown in the graphic above as "scanning and concept identifications")
- Researching and assessing both the market and technology conditions and savings potential (through the concept opportunity assessment and market and product assessment stages)

- Developing and testing the market intervention strategy for the technology and developing cost effectiveness models which produce long term cost effectiveness metrics and energy savings forecasts (both part of strategy testing and finalization)

The purpose of these phases is to develop additional efficiency measures and strategies over the long-term that will further the cost-effectiveness and reliability of savings and programs by acquiring savings at market scale. At each stage, the assessment of the potential for long-term cost-effective savings is refined**.** NEEA does not typically forecast savings associated with these earlier phases. These first four phases (of the graphic) are where most of the activity has been in the early years of the NEEA gas collaborative. Significant savings begin in the fifth stage, Market Development.

2.4.4 Pilots & Trial Programs

The company offers pilots from time to time to test and evaluate new program or measure opportunities. Pilots should have defined objectives or purposes and will be limited in duration.

The company may also pursue trial programs and effort to take advantage of time sensitive opportunities, drive program uptake or to adaptively manage existing programs.

2.5 Cost Effectiveness Standards

2.5.1 UCT: Utility Cost Test

The Company utilizes the UCT to evaluate the cost effectiveness of the incentive program. The UCT measures the present value of the energy savings in relation to the net costs incurred by the incentive program, including incentive costs and excluding any net costs incurred by the participant. The UCT measures utility benefits divided by utility costs where each is defined as follows:

Utility Benefits are:
The value of gas energy saved based on the Company's avoided costs. The Company's avoided costs include the following values:

- Gas Price Forecasts
- Supply and Distribution Capacity Costs
- Washington State Carbon Policy Adder
- Risk Reduction Value
- 10% Power Act Credit

Utility Costs are:

- Incentives paid to, or for the benefit of, the participant
- Administrative costs
- Evaluation, verification, and monitoring

2.5.2 TRC: Total Resource Cost Test

The Company will continue to monitor and report how the portfolio fares using the Total Resource Cost (TRC) Test. The TRC includes all quantifiable costs and benefits regardless of who accrues them. This includes participant and others' costs. The TRC Test a calculation of total present value of total resource benefits divided by total resource costs when each is defined as follows:

Total Resource Benefits include:

- The value of gas energy saved based on the Company's avoided costs. The Company's avoided costs include the following values:
  - Gas Price Forecasts
  - Supply and Distribution Capacity Costs
  - Washington State Carbon Policy Adder
  - Risk Reduction Value
  - 10% Power Act Credit
- Non-energy benefits as quantified by a reasonable and practical method
- The 10% conservation preference adder

Total Resource Costs are:

- Administrative costs
- Evaluation, verification, and monitoring
- The participant's remaining out-of-pocket costs for the installed cost of the measures after incentives and Federal tax credits

2.5.3 NSPM: National Standard Practice Manual

The Company may investigate the opportunities provided by NSPM methodology, such as the Resource Value Test (RVT), which is "intended to provide a comprehensive framework for assessing the cost-effectiveness of energy efficiency resources." Any change to Cost Effectiveness test will be vetted through the EEAG process.

2.5.4 Levelized Cost Metric

The levelized cost is the present value of the total net cost of a measure over its economic life, converted to equal annual payments. The levelized cost calculation starts with the incremental capital cost of a given measure or package of measures. The total cost is amortized over an estimated measure lifetime using the discount rate established in the Company's most current IRP. The annual net measure cost is then divided by the annual net energy savings (therms) from the measure application (again relative to a standard technology) to produce the levelized cost estimate in dollars per therm saved, as illustrated in the following formula.

$$LevelizedCost = \frac{Net\ Annual Cost(\$)}{Net\ Annual Savings}$$

The levelized cost of an energy efficiency measure is cost-effective if it is less than the average levelized costs of other supply-side options. A cost-effective threshold is established in the Company's most current IRP and further refined through the BCR test.

2.5.5 Avoided Cost

The avoided cost calculation used in the 2019 EE Plan includes new updated assumptions, including a new natural gas price forecast (as outlined in the 2018 Integrated Resource Plan (IRP)) https://www.nwnatural.com/uploadedFiles/NW%20Natural%202018%20IRP.pdf) and hedge value of demand side management. Also new to these avoided costs are supply capacity costs based on new peak-day coincident factors developed by NW Natural, replacing most of the peak-day factors previously sourced from the Northwest Power and Conservation Council (NWPCC) and distribution capacity costs based on new peak-hour coincident factors developed by NW Natural, replacing the use of peak-day factors sourced from the NWPCC. The avoided costs also include new values for: 1) expected impact to natural gas customers from national carbon policy, and 2) expected impact of incremental carbon policy from Washington State. Avoided costs were updated at the beginning of the 2018 calendar year for use in 2019 measure and program planning. These values were used in the 2018 IRP and are described in chapter four of the 2018 IRP. The most recent avoided costs are used to retroactively review the cost-effectiveness of the current 2018 program year.

The Company will adaptively manage and make improvements to the avoided cost calculation methodology as necessary. Continuing work on the avoided cost calculation further refines the true avoided cost for Washington customers by identifying how energy savings on peak help avoid or delay investment in capacity resources.

2.6 Program Evaluation, Monitoring and Verification

2.6.1 Impact Evaluations

Annual savings reported by the Company are based on the assumed gross savings for each measure. The assumed savings is consistent with the most current impact studies performed on the programs and measures. The Company or third parties are utilized to perform impact studies used to validate the engineering assumptions used in setting bi-annual gas conservation targets. Impact evaluations of residential measures typically include analysis of a group of customers' energy usage data before and after a measure is installed (i.e., billing analysis). Non-residential measures receive a combination of engineering review of key algorithms and parameters, a document review of project files and specific building-level model inputs, and site visits to verify operational patterns and installation practices that affect savings estimates.

Savings from all measures are evaluated on a regular basis by the program implementer based on accepted practice, program activity, staff resources and evaluation priorities (unless sample sizes based on participation rates are not statistically significant.) From the impact evaluation, a determination is made by the Company if evaluated savings are

consistent with assumed savings. If they are not, the deemed savings values are "adjusted" by the program implementer to reflect the relevant evaluation findings. The adjustment of savings is accomplished through a combination of savings realization adjustment factors (SRAF) and through updating the deemed savings values expressed in the measure approval documents (MADs). A link to the Impact Evaluation as well as a short summary of the results will be provided in the quarterly report following the report's release.

2.6.2 Process Evaluations

The Company or program delivery contractor may, as appropriate, contract with a third party evaluation contractor to perform process evaluations on a subset or all energy efficiency programs, WA-LIEE, pilots, and other efforts offered. The third party evaluation contractor studies the programs and reports on the processes employed for each program with recommendations for improvement. A link to process evaluations, as well as short summaries of the results, will be provided in quarterly or annual reports following the Process Evaluation Report's release.

2.7 Process for Program Changes

The Company considers if incentive program year changes are needed when reviewing Unit Energy Savings (UES) Measure List (Appendix 1) prior to filing the Plan each year. If the UES Measure List needs an offering added, changed, or removed, the Company will revise this Plan to make requested program modifications when it makes its annual advice filing, submitted no later than December 1, to revise the performance metrics and budget that are also included in this Plan. This does not preclude the Company from filing to revise Schedule G or its EE Plan or Appendices at any time during the year.

Advice filings revising or adding measures will include:

1) A measure-level benefit-cost ratio ("BCR") calculation as outlined in Section 2.5 "Cost Effectiveness".

2) For new measures, a summary of the vetting of a measure before it is introduced as a program offering. The EEAG will be given the opportunity to review all tariff filings before they are filed. The Company will generally give the EEAG ten business days to review a draft filing. The EEAG's review process will not be less than five business days.

3) New programs proposed mid-cycle will include a program-specific plan addressing the possible need for program-specific metrics.

4) For Pilots previously budgeted or with no additional budget impact, no filing will be required. The EEAG will be given the opportunity to review the offering before implementation if not previously outlined in the "Pilot

Program" section. The Company will include summary notes in the appropriate report following the completion of any Pilots.

Not all advice filings must include the EE Plan. The EE Plan will only be included when it is being revised.

The Company will work to resolve issues with EEAG members before filing. If the EEAG cannot agree and recommend approval of a filing, the Company may still choose to make the filing with the WUTC with the understanding that EEAG members may intervene in that public proceeding.

2.8 Annual Schedule for Program Planning

By November 15 of each year, the Company will provide the EEAG with the following proposals for the next program year, which will subsequently be filed with the WUTC in a new docket. The Company will file to this docket all the required reporting for the program year, including a link to the Purchased Gas Adjustment (PGA) filing wherein program costs are recovered.

Budget

The Company provides in this plan a total estimated budget for the program year. The budget presents expected expenditures by program and customer class. The budget component comprised of incentives and direct customer benefit shall be considered a soft cap and may be exceeded in order to acquire available cost effective savings or facilitate low income projects. Notification should be made to the EEAG prior to exceeding incentive targets.

The budget forecast is based on the best information available at the time of filing. As the year progresses, budgeted dollars may be reallocated among the various programs and/or measures and/or new offerings that are submitted to the WUTC.

The Company may provide the necessary funding for program administration and delivery as appropriate, including reserves. The amounts dispersed in one year are the sum of all funds forecasted to be needed for that program year, adjusting for any unspent or uncommitted funds previously dispersed.

Metrics

The Company proposes performance metrics each year that will address the following:

- Total program costs
- Projected therm savings consistent with most recent IRP
- Average levelized cost for measures
- Projected homes to be weatherized in the WA-LIEE program

The Company expects that Utility Cost Test (UCT) at the portfolio level should be greater than 1.0 and will report compliance to this in the Annual Report.

The Company will present the EEAG with the next year's budget and performance metrics before making a tariff filing with the WUTC to modify this plan so that it incorporates the next year's projected costs and metrics accordingly. This filing will be made annually not later than December 1 for a January 1 effective date.

2.8.1 Reporting Schedule

2.8.1.1 Program Year Schedule

January 1	Start of program year
April 25	Annual report for previous program year is filed.
Second Quarter	NW Natural check in with County agencies regarding WA-LIEE progress and performance. Understand any necessary changes and report to EEAG.
May 25	Q1 report on January 1 through March 31 of current year
August 25	Q2 report on April 1 through June 30 and YTD
October 1	Tariff filing submitted for program cost recovery.
November 1	Requested effective date of program cost recovery filing.
November 15	Share next year's budget range, funding schedule, and proposed performance metrics with EEAG no later than this date
November 25	Q3 report on July 1 through September 30 and YTD
November 30	Latest date to file EE Plan for next program year
January 1	Start of next program year; new EE Plan effective

Quarterly

The Company will report on its program on a calendar year basis. Quarterly reports will be provided to the EEAG and filed with the WUTC.

Annual

An annual report will be due annually by the following April 25th after the end of the program year.

EEAG Review

The EEAG will meet either in person or by teleconference to review the annual report and as requested if additional meetings are needed.

2.9 Content of Reports

The quarterly reports will include:

1. Quarterly progress toward annual program metrics
2. A breakdown of costs by program and customer sector
3. A reporting on percentage of program costs spent on customer incentives
4. The funding paid to date by the Company

5. A status report on market transformation efforts, spending, and activity
6. The Q2 report will include a 6 month check in on WA-LIEE
   - program year costs
   - homes served
   - estimated total therms saved per home
   - total therm savings to-date
7. The quarterly report following the annual release of the impact and process report will include a link to that report and a short summary of the findings (if evaluations were performed)

The annual report will include the following:

1. Budget compared to actual results by program
2. Cost-effectiveness calculations results as defined in Section 2.5 and outlined by Program in Part II of this plan
3. Measure level participation (units installed and savings) under the incentive program
4. Reporting on achievement of metrics
5. A status report on NEEA market transformation efforts, spending, and activity
6. An overview of the Company's year-end review of program delivery expenses and transactions
7. Evaluation results (if performed)
8. Pilot results/metrics (if performed)
9. WA-LIEE program results including:
   - total program year costs
   - homes served
   - estimated total therm savings
   - average therms saved per home

2.10 Annual Program Budget Guidelines

Budgets

Forecasted program costs for the next calendar year will be reviewed annually in November when metrics are also proposed for the following program year.

Actual Costs

Each year, the Company will file its annual report by April 25 which will detail costs and acquisitions for the previous program year. This filing will trigger the EEAG's review of the energy efficiency program including Incentive, WA-LIEE, Market Transformation, Pilots, and other program expenses.

2.11 Cost Recovery

Incentive program, Market Transformation, Low Income, Pilot, Evaluation and all other Energy Efficiency related expenses are deferred and later amortized for recovery from applicable customers on an equal cents per margin basis as established annually in the temporary rate adjustments, Schedules 215 and 230, respectively. The Company will

annually submit a stand-alone filing concurrent with its PGA filing, for cost recovery of its energy efficiency program expenses for the prior calendar year. That annual filing will include the following information:

- Background on the Company's energy efficiency programs and cost recovery
- A copy of the prior program year's annual report as outlined in section 2.9 "Content of Reports" of this Plan
- The total dollar amount the Company is seeking to recover
- The total incremental dollar impact that the proposed rate change will have on average residential and commercial customer monthly bills
- Total average monthly bill of proposed rate for applicable customers
- Work papers demonstrating the analysis behind the collection rate

The Company also includes a message on applicable customers' monthly bills stating how much of their current monthly bill represents costs collected to pay for the residential and commercial energy efficiency programs.

3 PART II – 2019 Plan

3.1 Current-Year Program Drivers

With the success of the Company's incentive program efforts in 2018, the 2019 strategy will continue with a few additional offerings and enhancements.

Residential

2019 Strategic Focus

- Expand participation
- Work effectively across the supply chain to support more targeted approaches to cost effective measure adoption
- Identify opportunities for program design changes, operational efficiencies in incentive processing, trade ally management, quality assurance, consolidated measure analysis and submissions processes across multiple sectors
- Continue to work with NW Natural to ensure alignment on goals of program delivery, outreach tactics and marketing strategies

2019 Activities—Ongoing and New

Advance the viability, relevance and performance of programs.

- Utilize the five-year measure savings tool to continually inform 2-year forecast and support strategic planning
- Work with NW Natural to ensure compliance to Washington Utilities and Transportation Commission regulatory requirements and to provide robust and accurate reporting

Increase customer participation and awareness of energy efficiency and renewable energy benefits

- Reassess Energy Saver Kit fulfillment and plan for changes to the current free kit offer in mid-2019. Assess the opportunity to develop a marketplace solution to engage customers and offer access to low-cost or no-cost energy savings products
- Increase savings from emerging savings opportunities such as smart thermostats through instant coupon and direct installation offers
- Continue to support the trade ally experience through customized in-person engagements
- Engage and participate in trade industry associations including Clark County HVAC Trade Association, Clark County Rental Association and Building Industry Association of Clark County
- Collaborate with Clark PUD on direct install of smart thermostats for low-income customers
- Launch a rental gas furnace offer to home retrofit and multifamily programs
- Continue to increase customer participation and awareness of multifamily incentive through trade ally and property management engagement

- Continue to coordinate with NW Natural to facilitate stakeholder and trade ally relationships that drive participation and awareness
- Across the supply chain, expand the use of customized program designs and promotional tactics for heating and water heating system replacements (i.e. lead generation marketing)
- Program lead and conducted EPS New Construction field quality assurance, including coordination with verifiers to maintain quality assurance and quality control procedures

Commercial

2019 Strategic Focus

- Strategic direction will be consistent with 2017 and 2018. The program will maintain existing tracks, market channels, market engagement activities and operational processes.
- Develop new strategies beyond 2019, including work on new measures and pilots and new construction options
- Continue to develop new standard offerings to streamline the process for customers and trade allies who are too busy to pursue custom projects. This will include new offerings and changing some existing custom offerings to standard offerings.
- Track savings projections by track to proactively identify anticipated savings and budget impacts at a more tactical level over the next two to three years
- Utilize utility and project tracking data to improve forecasting methodologies to achieve higher confidence factors for savings and budget
- Increase outreach, technical services and other support to small- to medium-sized and rural commercial customers and trade allies

2019 Activities—Ongoing and New

Increase the flexibility and adaptability of Energy Trust

- Identifying custom measures that can be converted to prescriptive measures allowing for adaptability of frequently used measures
- Identify new pilots to increase savings opportunities for 2020.

Advance the viability, relevance and performance of programs

- Organize the trade ally and outreach team to effectively reach all prospective and eligible small business customers
- Perform market analysis to identify remaining market potential available to all tracks of the program
- Identify new approach to direct install that can support Existing Buildings in Washington
- Explore and utilize other market channels such as buy-down programs to more effectively deliver program elements such as restaurant equipment

Increase customer participation and awareness of energy efficiency. Identify additional ways to serve minority and underserved markets such as rural communities and tribes.

- Diversify program participation through increased outreach to small- to medium-sized businesses and trade allies
- Continue collaboration with like-minded organizations such as Northwest Energy Efficiency Alliance (NEEA), Bonneville Power Administration (BPA) and the Regional Technical Forum (RTF) to identify opportunities for new measures, strategies and delivery channels
- Increasing the portfolio of measures that are delivered midstream
- Work with outreach and trade ally staff to create more tailored pieces for specific offerings, customer segments and contractor trades
- Continue trade ally segmentation efforts, optimizing support depending on trade, program knowledge and participation and regional services
- Provide sales support to trade allies to help them build program incentives into their business models to further energy efficiency
- Build the technical knowledge of outreach staff on the value proposition of energy-efficient equipment choices
- Increase activity of delivery contractor's market channel subject matter experts and trade ally coordinators to provide focused support for delivery contractor's account managers working in Washington
- Form an outreach subgroup focused on small business market penetration to coordinate with trade allies to identify and serve appropriate target-market small businesses.

Low Income

The Company's Low Income program relies on partners to find and complete projects. Referral and funding challenges have slowed partner project delivery. In 2019 the Company plans to continue to adaptively manage the program and test additional program support approaches for growth and to support future partner success.

3.2 Incentive Program Metrics and Budget

The 2019 Incentive Program Metrics are: Total Cost, Levelized Cost, UCT and total therm savings.

- The **total costs:** Costs estimated to achieve all cost effective therms for the incentive programs being offered as determined in the Company's 2016 Integrated Resource Plan ("IRP").

The program's primary goal is to meet system demand with the least cost conservation as required per WAC 480-90-238(1). The therm savings target is aligned with the demand-side management targets for the programs offered as identified in the Company's 2016 IRP. From a quarterly perspective, savings are anticipated as follows: Q1: 10%; Q2: 10%; Q3: 25%; and Q4: 55% of the annual total.

- **Average levelized cost** for the incentive program portfolio of measures will not exceed $0.65 per therm.

This metric is unchanged from last year. The profile of the Company's Washington service territory makes it harder to reduce the averaged levelized cost per therm than it would be in an area with more industrial customers since therm savings are acquired more cost effectively for bigger customers than for residential customers.

- The **UCT** at the incentive program portfolio level is greater than 1.0.

The UCT shall be calculated as prescribed in Section 2.5. A value greater than 1.0 demonstrates that the benefits received are greater than the costs. This test is applied at the portfolio level.

3.2.1 Therm Savings by Incentive Program

Incentive Program	2019	Annual Therms Goal
Commercial Programs	Existing Buildings - Standard	32,766
	Existing Buildings - Custom	44,100
	New Buildings - Standard	70,616
	Commercial Total	**147,481**
Residential Programs	Existing Homes Retrofit	135,425
	Mid-stream - Distributor and Retail	9,896
	Multifamily	7,279
	EPS New Construction	69,114
	Residential total	**221,714**
	Total savings	**369,195**

3.2.2 Expenses by Incentive Program

Incentive Program	Budgeted Expenditures		
Commercial Programs	Existing Buildings - Standard	$	199,465
	Existing Buildings - Custom	$	337,476
	New Buildings - Standard	$	403,152
	Commercial administration	$	48,093
	Commercial Total	**$**	**988,187**
Residential Programs	Existing Homes Retrofit	$	659,511
	Mid-stream: Distributor and Retail	$	85,200
	Residential Multifamily	$	64,853
	EPS New Construction	$	563,101
	Residential Administration	$	70,211
	Residential total	**$**	**1,442,876**
	Total Expenditures	**$**	**2,431,063**

3.2.3 Incentives by Incentive Program

Incentive Program		Incentives Budget		Percent incentives
Commercial Programs	Existing Buildings - Standard	$	98,699	49%
	Existing Buildings - Custom*	$	200,068	59%
	New Buildings - Standard	$	183,299	45%
	Commercial Total	**$**	**482,066**	**49%**
Residential Programs	Existing Homes Retrofit	$	323,017	49%
	Mid-stream: Distributor and Retail	$	48,099	56%
	Residential Multifamily	$	20,561	32%
	EPS New Construction	$	382,959	68%
	Residential total	**$**	**774,636**	**54%**
	Total Incentives	**$**	**1,256,703**	**52%**

3.2.4 Incentive Program Cost Effectiveness

The goal of the Company's incentive program is to acquire cost-effective gas therm savings. The portfolio of energy efficiency Incentive programs will be deemed cost-effective if, at the end of the program year, the program portfolio passes the Utility Cost Test (UCT) by having a benefit-to-cost ratio of one or more.

3.3 Low Income Metrics and Budget

The WA-LIEE program will strive to weatherize **18** homes. A breakout of costs and therm savings estimates is reflected in table 2 below:

3.3.1 Low Income Performance Targets

WA-LIEE		Annual Therm Savings
WA-LIEE	WA-LIEE total @ 18 homes	6,318
	Total Low Income savings	**6,318**

3.3.2 Low Income Budget

WA-LIEE			Budget
WA-LIEE @ 18 homes	WA-LIEE Measures	$	109,440
	WA-LIEE Agency Administration (15%)	$	16,416
	Health / Safety	$	18,000
	WA-LIEE application processing admin (5% cap)	$	5,472
	WA-LIEE Total	**$**	**149,328**

The WA-LIEE 2019 goal for Clark County program is in line with expected 2018 performance due to lack of matching funds from state and federal agencies. Efforts initiated in 2018 in coordination with the Energy Project will encourage the weatherization of gas homes in the Company's outlying service areas.

As outlined in Schedule I, there is a measure funding cap per home of $6,080 with an additional 15% allowable for agency administrative costs plus a $1,000 cap on heath/safety work. The Company is allowed up to 5% for processing administration.

The Company is exploring additional program efforts and engaging in outreach activities to drive additional program participation in 2019.

3.3.3 Low Income Cost Effectiveness

The goal of the Low Income program is primarily to address underserved markets and customers that do not have access to the energy efficiency incentive programs. WA-LIEE leverages funds provided by other state, federal and local agencies. Those leveraged funds also utilize Savings to Investment (SIR) tests.

3.4 Gas Market Transformation Metrics and Budget

The Company will continue its participation with NEEA in 2019. The NEEA budget is on track and in line with the 5 year business plan. Actual expenditures are based on invoiced totals arising from the actual progress of NEEA during the year.

3.4.1 Market Transformation Budget

Market Transformation			Budget
NEEA	2019 NW Natural Washington Allocation	$	184,101
	NEEA Total	**$**	**184,101**

3.4.2 Market Transformation Energy Savings

Given the nature of Market Transformation work, there is high investment in the beginning and the bulk of the savings are delivered in the long-term, this is true for NEEA's electric portfolio as well. The bulk of the natural gas technologies NEEA is exploring that have high savings opportunities are pre-commercialized and therefore will not be market ready for quite some time. Much of NEEA's work is focused on bringing them to market faster, but this is yet another reason why the energy savings are a few years away.

There are no savings forecasted for the Natural Gas Business Plan (2015-2019). The Company hopes and expects to see savings from a continued NEEA effort beyond 2019.

3.4.3 Market Transformation Cost Effectiveness

NEEA programs will be tracked and any associated savings will be reported separately. It has been discussed with the EEAG that these programs are not likely or expected to contribute savings this early in development. The Company acknowledges that this practice of excluding market transformation from total cost effectiveness analysis is in no way precedent setting, and should the Company make any future requests for the unique treatment of costs and savings, such requests will be evaluated by the EEAG and WUTC at that time, and on a case-by-case basis.

3.5 Pilots & Trial Programs Metrics and Budgets

The Company plans to investigate and initiate opportunities to further strengthen the suite of offerings through a number of pilot projects and temporary or test programs. These programs and offerings are often referred to as "Pilots" but some may be temporary program structures or supporting efforts to enhance and drive existing offerings. The Company's EEAG will be briefed as progress is made and budgets are provided in Section 3.5.1 to outline expected expenditures.

Low Income Furnace Tune-ups

Low income weatherization is a whole home holistic effort. Some qualified customers cannot be reached or served in a timely manner but have equipment that is inoperable or a safety risk. In an effort to serve these customers the company is proposing $500 per furnace to the local weatherization agency to provide Furnace Tune Ups for approximately 30 homes.

Low Income Program Adjustment

The Company is aware of efforts by other utilities and agencies within Washington to enhance Low Income Weatherization programs. The company continues to seek ways to support our partners and increase the number of homes served in its territory. In 2019 the company will mimic the new program models adopted by other gas utilities through a temporary program. In addition to the existing WALIEE offering, partner agencies will be eligible for an additional indirect administration assistance plus an increase weatherization project cap up to the State's Matchmaker grant cap. The result is $5,508 additional, per project, with a total 2019 goal of at least 18 homes.

New School Construction

Preliminary results from the Company's 2018 New School study show modeling can help the program and schools realize additional cost effective savings. With a fixed number of bonds and new schools in the pipeline within the Company's service area, this temporary program support would offer modeling assistance of $5,000-7,000 per school to help push schools beyond current energy efficiency offerings.

Low Income Thermostat

The Company plans to partner with the local Consumer Owned Utility, Clark Public Utilities (CPU), in a direct to consumer thermostat program. CPU has allocated nearly $2M and selected several vendors through a public bidding and procurement process to provide direct install thermostats and LED bulbs in low income households. The Company is looking to leverage those efforts to enable qualified gas customers to also participate. The costs are estimated to be approximately $300 per home for installation.

Strategic Energy Management

Clark Public Utilities (CPU) and BPA are initiating a Strategic Energy Management (SEM) Pilot for commercial customers. The CPU's SEM Pilot participants are also customers of the Company. In continued efforts to partner with Clark Public Utilities and support customers, the Company will look to engage where possible. While there are no plans for direct financial support or to be an official participant of the SEM efforts, the Company and Company's Implementer(s) may provide technical support, engagement and resources as deemed appropriate in support of these efforts, any resulting Custom Projects and potential future SEM efforts that may result in therm savings.

3.5.1 Pilot & Trial Program Budget

Pilots & Trial Programs		Budget	
	Low Income Furnace Tune Ups	$	15,000
	Low Income Program Adjustment	$	100,000
	School New Construction	$	100,000
	Low Income Thermostat Direct Install	$	100,000
	Pilot Total	**$**	**315,000**

3.5.2 Pilot Energy Savings

Pilot programs will be tracked and any associated savings will be reported separately. It has been discussed with the EEAG that these programs may not all contribute savings.

3.5.3 Pilot Cost Effectiveness

Pilots will generally be excluded from total cost effectiveness but project by project tests may be performed. The Company acknowledges that this practice of excluding pilot costs from total cost effectiveness analysis is in no way precedent setting, and should the Company make any future requests for the unique treatment of costs and savings, such requests will be evaluated by the EEAG and WUTC at that time, and on a case-by-case basis.

3.6 Loans and On-The-Bill Repayment Services

The Company will continue to provide access to a low-interest, unsecured financing offer to residential homeowners who heat their homes with natural gas. The program lender will originate loans granted for the purposes of purchasing and installing conservation and energy efficiency measures incented by the existing homes program, and the Company will provide billing and remittance services to the program lender by placing the loan repayment fee on the participating customers' monthly gas bill. Customers who obtain a loan with on-the-bill repayment services will receive a loan repayment charge itemized as "Energy Upgrade Loan" on their monthly bill for natural gas service. This will be reflected for the term of the loan or until the loan has been paid off, transferred, or otherwise discharged or removed from the bill in accordance with the terms and conditions of the Company's service agreement. The Company will lead and manage the coordination of activities between the program lender, the program management contractor, and the Company. More information can be found in Appendix 5.

3.7 Evaluation Activities and Budget

In 2010 the Company hired Navigant for a two part study on the Company's Washington Energy Efficiency program. The first part was a benchmark study to evaluate how the pilot program compared to other programs in Washington and the second part was an evaluation of how the Company should proceed with turning the pilot into a full-fledged program. Over the past 7 years the Company's program, as well as the other Washington

programs, have evolved and matured. The Company plans to hire a third party to perform a three part study in 2019. Phase one will provide another benchmark of the program. Phase two will explore areas for enhancement within the Company's current program offering. Phase three will investigate opportunities to grow the Company's Energy Efficiency efforts through new program offerings, sectors or other efforts.

The Company will utilize a bid process and a proposed Scope of Work for the three phases mentioned which will be available to the EEAG.

3.7.1 Evaluation Budget

Evaluation Work		Budget	
Evaluation	Program baseline	$	30,000
	Areas of enhancement	$	30,000
	Program growth opportunities	$	30,000
	Evaluation Total	**$**	**90,000**

4 PART III – Appendices

These Appendices are for reader reference and additional background or context unless specifically referenced in the body of the Company's Plan.

4.1 Appendix 1: UES Measure Lists

Measure List

2019 change	PROGRAM CODE	Measure Group	Measure Code	Measure Description	Load Profiles	2019 Load Profile	Measure Life	Incentive per Quantity	Incremental (TRC) Cost per Quantity	Savings (kWh) per Quantity	Savings (Therms) per Quantity	2019 WA-Only GAS AC per measure	Estimated Max Incentive (2019 AC)	Notes	Other NEB (Annual $)	UCT BCR at Max Incentive (2019 AC v1.1)	UCT BCR at Incentive Level (2019 AC v1.1)	TRC BCR (2019 AC v1.1)	2019 Levelized Cost ($.64% Discount Rate)	MAD #
New Measure	Home Retrofit	AERATOR	BYOKAER5BGWA	Build Your Own Kit - SW WA, .5gpm Bath Aerator Gas	RESDHWG	DHW	15	$1.35	$1.35		1.8	$11.19	$1.35		$5.30	8.29	8.29	47.33	$0.08	27
Savings Change	Home Retrofit	AERATOR	BYOKAER10BGWA	Build Your Own Kit - SW WA, 1.0gpm Bath Aerator Gas	RESDHWG	DHW	15	$1.35	$1.35		1.1	$6.84	$1.35	Savings Change	$3.39	5.07	5.07	30.04	$0.12	27
New Measure	Home Retrofit	AERATOR	BYOKAER1KGWA	Build Your Own Kit - SW WA, 1.0gpm Kitch Aerator Gas	RESDHWG	DHW	15	$1.85	$1.85		2.9	$18.03	$1.85		$7.12	9.75	9.75	48.02	$0.06	27
Savings Change	Home Retrofit	AERATOR	BYOKAER1SKGWA	Build Your Own Kit - SW WA, 1.5gpm Kitch Aerator Gas	RESDHWG	DHW	15	$1.85	$1.85		1.4	$8.71	$1.85	Savings Change	$3.47	4.71	4.71	23.36	$0.13	27
No change	Home Retrofit	CEILINGINSULATE	INSCEILGZ1	SF Attic Insulation/SQFT, Gas Heat, Zone 1 2014	GEXSPHT	Res Heating	45	$0.25	$0.83		0.06	$1.25	$0.83		$0.00	1.51	5.01	1.51	$0.26	58
No change	Home Retrofit	THERMOSTAT	SMARTSTATGOT	Smart Thermostat - Gas Only Territory	GEXSPHT	Res Heating	11	$50.00	$100.00		32	$247.94	$100.00		$1.83	2.48	4.96	2.63	$0.19	153
No change	Home Retrofit	OTHER	SEASSAVEFURNWA	Seasonal Savings - Winter Furnaces, Washington	GEXSPHT	Res Heating	1	$3.00	$3.00		16	$13.15	$3.00		$2.86	4.38	4.38	5.29	$0.20	173
No change	Home Retrofit	FLOORINSULATE	INSFLRGHZ1	SF Floor Insulation/SQFT, Gas Heat, Zone 1 2014	GEXSPHT	Res Heating	45	$0.30	$1.60		0.04	$0.84	$0.84		$0.00	1.00	2.78	0.52	$0.46	58
No change	Home Retrofit	GASFIRE	GASHRTH7074	Gas Hearth 70-74 FE	GEXSPHT	Res Heating	20	$150.00	$0.01		5.14	$700.09	$150.00		$0.00	4.67	4.67	70008.91	$0.25	29
No change	Home Retrofit	GASFIRE	GASHRTH75	Gas Hearth 75+ FE	GEXSPHT	Res Heating	20	$250.00	$47.00		6.32	$860.81	$250.00		$0.00	3.44	3.44	18.32	$0.33	29
No change	Home Retrofit	GASFURNACE	HEGASFURN95PLUS	Gas Furnace SW WA 95%+ AFUE	GEXSPHT	Res Heating	25	$200.00	$990.00		92	$1,467.94	$990.00	new offer for 2019		1.48	7.34	1.48	$0.16	23
New Measure	Home Retrofit	GASFURNACE	HESGASFURNRENTALWA	Gas Furance - Rentals 90%+ AFUE	GEXSPHT	Res Heating	25	$550.00	$986.00		92	$1,467.94	$986.00		$6.20	1.49	2.67	1.57	$0.45	23
No change	Home Retrofit	KNEEINSULATE	INSKWGHZ1	SF Knee Wall Insulation/SQFT, Gas Heat, Zone 1 2014	GEXSPHT	Res Heating	45	$0.30	$1.39		0.05	$1.04	$1.04		$0.00	1.00	3.48	0.75	$0.37	58
Savings, Incentive Change	Home Retrofit	SHOWERHEAD	BYOKSHWR150WA	Build Your Own Kit, 1.5 gpm Showerhead Gas	RESDHWG	DHW	15	$6.00	$6.00		9.9	$61.56	$6.00	Savings Change	$18.56	10.26	10.26	41.02	$0.06	27
Savings, Incentive Change	Home Retrofit	SHOWERHEAD	BYOKSHWR175WA	Build Your Own Kit, 1.75 gpm Showerhead Gas	RESDHWG	DHW	15	$6.00	$6.00		8.2	$50.99	$6.00	Savings Change	$15.32	8.50	8.50	33.89	$0.07	27
Savings, Incentive Change	Home Retrofit	SHOWERWAND	BYOKWAND150GWA	Build Your Own Kit, 1.5 gpm Shower wand Gas	RESDHWG	DHW	15	$11.00	$11.00		12.2	$75.86	$11.00	Savings Change	$22.86	6.90	6.90	27.56	$0.09	27
Savings, Incentive Change	Home Retrofit	SHOWERWAND	BYOKWAND175GWA	Build Your Own Kit, 1.75 gpm Shower wand Gas	RESDHWG	DHW	15	$11.00	$11.00		7.9	$49.12	$11.00	Savings Change	$14.77	4.47	4.47	17.82	$0.14	27
No change	Home Retrofit	WINDOWS	WINDOWS27G	Windows - GAS - U <= .27	GEXSPHT	Res Heating	45	$4.00	$4.36		0.48	$10.02	$4.36		$0.00	2.30	2.51	2.30	$0.51	28
No change	Home Retrofit	WINDOWS	WINDOWS2830G	Windows - GAS - U .28-.30	GEXSPHT	Res Heating	45	$1.75	$1.11		0.2	$4.18	$2.68		$0.00	1.56	2.39	3.76	$0.54	28
No change	Home Retrofit	TANKLESS	WAGASTANKLESS	Tankless Water Heater, Gas .82 $125, 2016	RESDHWG	DHW	20	$200.00	$1,834.00		74.2	$586.37	$586.37		$0.00	1.00	2.93	0.32	$0.23	197
New Measure	Home Retrofit	THERMOSTAT	DITSTATGFACWA	Direct Install Thermostat - Gas Furnace w/ AC	GEXSPHT	Res Heating	11	$270.00	$300.00		35	$271.18	$271.18	Max incentive as placeholder	$3.78	1.00	1.00	1.01	$0.96	222
No change	midstream	GASFIRE	GASHRTHPLELE25	Gas hearth-Electronic ignition $25, retailer/distributor incent	GEXSPHT	Res Heating	20	$25.00	$108.00		5.6	$76.27	$76.27		$0.00	1.00	3.05	0.71	$0.38	29
No change	midstream	GASFIRE	GASHRTHPLELE30	Gas hearth-Electronic ignition $30, retailer/distributor incent	GEXSPHT	Res Heating	20	$30.00	$108.00		5.6	$76.27	$76.27		$0.00	1.00	2.54	0.71	$0.45	29
New Measure	Midstream	TANKDHW	ESGASDHWWA	ENERGY STAR Storage Water Heater	RESDHWG	DHW	13	$100.00	$215.00		25.7	$140.47	$140.47	Max incentive as placeholder	$4.71	1.00	1.40	0.85	$0.43	102
Savings, Incentive Change	EPS New Construction	SHOWERHEAD	WASHW15	NWNWA 1.5 gpm Retail Showerhead	RESDHWG	DHW	15	$8.50	$8.50		7.2	$44.77	$8.50		$13.50	5.27	5.27	21.06	$0.12	26
Savings, Incentive Change	EPS New Construction	SHOWERHEAD	WASHW16	Washington Retail Showerhead, 1.6 gpm	RESDHWG	DHW	15	$8.50	$8.50		5.5	$34.20	$8.50		$10.32	4.02	4.02	16.10	$0.16	26
Savings, Incentive Change	EPS New Construction	SHOWERHEAD	WASHW175	NWNWA 1.75 gpm Retail Showerhead	RESDHWG	DHW	15	$8.50	$8.50		3.6	$22.38	$8.50		$6.79	2.63	2.63	10.58	$0.24	26
Savings, Incentive Change	EPS New Construction	SHOWERHEAD	WASHW20	NWNWA 2.0 gpm Retail Showerhead	RESDHWG	DHW	15	$8.50	$8.50		1.4	$8.71	$8.50		$2.57	1.02	1.02	4.03	$0.61	26
No change	EPS New Construction	EPS	SWWAEPS1	SWWA EPS Path 1 - 2018	1GHNACG	Res Heating	34	$250.00	$ 949.00		80	$1,507.14	$949.00		$12.85	1.59	6.03	1.79	$0.21	145
No change	EPS New Construction	EPS	SWWAEPS2	SWWA EPS Path 2 - 2018	1GHNACG	Res Heating	39	$450.00	$ 2,463.00		142	$2,829.01	$2,463.00		$14.56	1.15	6.29	1.24	$0.20	145
No change	EPS New Construction	EPS	SWWAEPS3	SWWA EPS Path 3 - 2018	1GHNACG	Res Heating	41	$650.00	$ 6,437.00		258	$5,232.05	$5,232.05		$52.03	1.00	8.05	0.94	$0.16	145
No change	EPS New Construction	EPS	SWWAEPS4	SWWA EPS Path 4 - 2018	1GHNACG	Res Heating	42	$850.00	$ 8,519.00		293	$5,989.93	$5,989.93		$53.58	1.00	7.05	0.80	$0.18	145
No change	Multifamily	THERMOSTAT	SMARTSTATGOT	Smart Thermostat - Gas Only Territory	GEXSPHT	Res Heating	11	$50.00	$100.00		32	$247.94	$100.00		$1.83	2.48	4.96	2.63	$0.19	153
No change	Multifamily	GASFURNACE	HEGASFURN95PLUS	Gas Furnace SW WA 95%+ AFUE	GEXSPHT	Res Heating	25	$200.00	$990.00		92	$1,467.94	$990.00			1.48	7.34	1.48	$0.16	23
No change	Multifamily	GASFIRE	GASHRTH7074	Gas Hearth 70-74 FE	GEXSPHT	Res Heating	20	$150.00	$0.01		5.14	$700.09	$150.00		$0.00	4.67	4.67	70008.91	$0.25	29
No change	Multifamily	GASFIRE	GASHRTH75	Gas Hearth 75+ FE w/ele ignition	GEXSPHT	Res Heating	20	$250.00	$47.00		6.32	$860.81	$250.00		$0.00	3.44	3.44	18.32	$0.33	29
No change	Multifamily	TANKISSDHW	WAGASTANKLESS	SWWA Gas Tankless Water Heater	RESDHWG	DHW	20	$200.00	$1,834.00		74.2	$586.37	$586.37		$0.00	1.00	2.93	0.32	$0.23	197
No change	Multifamily	WINDOWS	WINDOWS27G	Windows - GAS - U <= .27	GEXSPHT	Res Heating	45	$4.00	$4.36		0.48	$10.02	$4.36		$0.00	2.30	2.51	2.30	$0.51	28
No change	Multifamily	WINDOWS	WINDOWS2830G	Windows - GAS - U .28-.30	GEXSPHT	Res Heating	45	$1.75	$1.11		0.2	$4.18	$2.68		$0.00	1.56	2.39	3.76	$0.54	28
No change	Existing Multifamily Washington	THERMOSTAT	SMARTSTATGOT	Smart Thermostat - Gas Only Territory	GEXSPHT	Res Heating	11	$50.00	$100.00		32	$247.94	$100.00			2.48	4.96	2.48	$0.19	153
New Measure	Existing Multifamily Washington	THERMOSTAT	DITSTATGFACWA	Direct Install Thermostat - Gas Furnace w/ AC	GEXSPHT	Res Heating	11	$212.00	$236.00		27.5	$213.07	$213.07	Max incentive, placeholder	$2.97	1.00	1.01	1.00	$0.96	222
New Measure	Existing Multifamily Washington	GASFURNACE	HESGASFURNRENTALWA	Gas Furnance - Rentals 90%+ AFUE	GEXSPHT	Res Heating	25	$550.00	$986.00		92	$1,467.94	$986.00	placeholder	$6.20	1.49	2.67	1.57	$0.45	23

				total incentive w/ bonus	Forecasted add	Savings (Therm	Forecasted additional savings resulting from bonus
Bonus	TANKLESSDHW	TANKLESSBONUS	300	12	74.2	$890.00	
Bonus	EPS	Lowincome VERF	Varies - bonus amount = $250	20	Varies	Varies	

Measure Code	Measure Description	Load Profile	2019 Load Profile	Measure Life	Incentive per Quantity	Incremental (TRC) Cost per Quantity	Savings (Therms) per Quantity	2019 WA-Only GAS AC per measure	Estimated Max Incentive (2019 AC)
AERATORGONLY0P5	Aerator - Gas Hot Water - Bathroom 0.5 GPM or less	RESDHWG	DHW	10	$ 3.00	$ 8.66	19.1	$81.80	$8.66
AERATORGONLYK1P5	Aerator - Gas Hot Water - Kitchen 1.5 GPM or less	RESDHWG	DHW	10	$ 5.00	$ 8.66	7.9	$33.83	$8.66
	Aerator - Gas Water Heat - Bathroom 0.5 GPM or less - Leave Behind	RESDHWG	DHW	10	$ 2.00	$ 2.00	14.9	$63.81	$2.00
	Aerator - Gas Hot Water - Kitchen 1.5 GPM or less - Leave Behind	RESDHWG	DHW	10	$ 2.00	$ 2.00	6.1	$26.13	$2.00
	Steam Trap Low Pressure, High Use	GEXPRO	Com Heating	6	$ 0.90	$ 0.90	1	$4.86	$0.90
	Steam Trap Medium Presure High Use	GEXPRO	Com Heating	6	$ 0.50	$ 0.50	1.9	$9.24	$0.50
	Steam Trap Low Pressure, Low Use	GEXPRO	Com Heating	6	$ 0.90	$ 0.90	0.6	$2.92	$0.90
	Steam Trap Medium Presure Low Use	GEXPRO	Com Heating	6	$ 0.50	$ 0.50	1.1	$5.35	$0.50
	Steam Trap Dry Cleaner	GEXPRO	Flat	6	$ 0.40	$ 0.40	0.3	$0.70	$0.40
BEWASHGASPART	Commercial Clothes Washer-Gas Water Heat - commercial laundry	GEXPRO	Clotheswasher	7	$ 65.00	$ 425.00	32	$83.81	$83.81
COMBOOVGASWA	Gas Combination Ovens	GNEWPRO	Com Cooking	12	$ 750.00	$ 1.00	277	$1,875.64	$1,878.00
GASSTEAMCOOK	Steam Cooker - Gas	GNEWPRO	Com Cooking	12	$ 1,850.00	$ 2,270.00	865	$5,857.15	$2,270.00
GFBOIL2500	Boiler > 2,500 kBtuh input	GEXSPHT	Com Heating	35	$ 8.00	$ 10.00	2.85	$57.69	$10.00
GFBOIL300	Boiler < 300 kBtuh input	GEXSPHT	Com Heating	35	$ 10.00	$ 16.00	2.85	$57.69	$16.00
GFBOIL3002500	Boiler ≥ 300, ≤ 2,500 kBtuh input	GEXSPHT	Com Heating	35	$ 9.00	$ 13.00	2.85	$57.69	$13.00
GREENIRPOLY	Infrared (IR) polyethylene greenhouse cover	GEXSPHT	Com Heating	4	$ 0.32	$ 0.10	0.23	$0.77	$0.32
GREENTHCUR	Thermal Curtains Installed on Greenhouses	GEXPRO	Com Heating	10	$ 0.30	$ 1.17	0.41	$3.20	$1.19
GREENUNDERBENCH	Under-bench heating Green house	GEXSPHT	Com Heating	12	$ 1.05	$ 2.19	1.25	$11.58	$2.19
GRNCNTRL	Greenhouse controllers	GEXSPHT	Com Heating	15	$ 0.10	$ 0.58	0.28	$3.21	$0.58
INSATTICGWA	Attic Insulation - Gas heating	GEXSPHT	Com Heating	30	$ 0.60	$ 0.90	0.25	$4.71	$0.90
INSROOFGR5R20	Roof Insulation R-5 to R-20 gas heat	GEXSPHT	Com Heating	30	$ 0.30	$ 0.64	0.09	$1.70	$0.64
INSROOFGWA	Roof Insulation - Gas heating	GEXSPHT	Com Heating	30	$ 0.60	$ 0.64	0.25	$4.71	$0.64
INSWALLGWA	Wall Insulation - Gas heating	GEXSPHT	Com Heating	40	$ 0.60	$ 1.41	0.16	$3.41	$1.41
MFSTEAMTRAPWA	Multifamily Steam Traps	GEXPRO	Res Heating	6	$ 100.00	$ 100.00	99	$440.52	$100.00
NCBVD	Boiler Vent Damper	GEXSPHT	Com Heating	12	$ 1,000.00	$ 1,500.00	270	$2,501.02	$1,000.00
NCCONVOVENWA	Convection Oven - Gas - Full Size	GEXPRO	Com Cooking	12	$ 315.00	$ 388.00	107	$724.53	$388.00
NCDHWCONDMF	MF Domestic Tank Water Heaters	GEXPRO	DHW	18	$ 3.25	$ 3.25	3.2	$23.23	$3.25
NCDHWCONDWA	Domestic Tank Water Heaters	GEXPRO	DHW	18	$ 3.00	$ 3.92	2.2	$15.97	$3.92
NCIRGASFRY2014	Gas Fryer	GEXPRO	Com Cooking	12	$ 1,000.00	$ 1,290.00	431	$2,918.42	$1,290.00
	Gas Single Rack Oven	GEXPRO	Com Cooking	12	$ 2,500.00	$ 1.00	995	$6,737.41	$3,000.00
	Gas Double Rack Oven	GEXPRO	Com Cooking	12	$ 5,000.00	$ 1.00	1689	$11,436.68	$6,000.00
	Commercial Tankless Water Heaters ≥200 kBtu/h	GEXPRO	DHW	15	$ 1.00	$ 1.46	0.9	$5.60	$1.46
	Multifamily Tankless Water Heaters ≥200kBtu/h	GEXPRO	DHW	15	$ 2.25	$ 1.24	0.7	$4.35	$2.45
NEW	Greenhouse condensing unit heaters	GEXSPHT	Com Heating	12	$ 5.00	$ 11.18	6.29	$58.26	$11.18
NEW	Commercial Showerhead Replacement 1.50gpm Any Commercial Except Fitness Center Gas Water Heating	GEXPRO	DHW	10	$ 7.00	$ 7.14	8	$34.26	$7.14
NEW	Commercial Showerhead Replacement 1.50gpm Fitness Center Gas Water Heating	GEXPRO	DHW	10	$ 7.00	$ 7.14	71	$304.08	$7.14
	Commercial Showerhead Replacement 1.75gpm Any Commercial Except Fitness Center Gas Water Heating	GEXPRO	DHW	10	$ 7.00	$ 7.14	5	$21.41	$7.14
	Commercial Showerhead Replacement 1.75gpm Fitness Center Gas Water Heating	GEXPRO	DHW	10	$ 7.00	$ 7.14	46	$197.01	$7.14
PIPEINSLN	Pipe Insulation - Hot water - Pipe Diameter > 1.5"	GEXPRO	DHW	15	$ 2.00	$ 18.40	4	$24.87	$18.40
PIPEINSLN	Pipe Insulation - Hot water - Pipe Diameter ≤ 1.5"	GEXPRO	DHW	15	$ 2.00	$ 18.40	4	$24.87	$18.40
PIPEINSLN	Pipe Insulation - Low-Pressure Steam (< 15 psig) - Pipe Diameter > 1.5"	GEXPRO	Flat	15	$ 4.00	$ 18.40	9.3	$51.24	$18.40
PIPEINSLN	Pipe Insulation - Low-Pressure Steam (< 15 psig) - Pipe Diameter ≤ 1.5"	GEXPRO	Flat	15	$ 4.00	$ 18.40	9.3	$51.24	$18.40
PIPEINSLN	Pipe Insulation - Med-Pressure Steam (15–200 psig) - Pipe Diameter > 1.5"	GEXPRO	Flat	15	$ 6.00	$ 14.57	5	$27.55	$14.57
PIPEINSLN	Pipe Insulation - Med-Pressure Steam (15–200 psig) - Pipe Diameter ≤ 1.5"	GEXPRO	Flat	15	$ 6.00	$ 14.57	5	$27.55	$14.57
RADHEATMODWA	Radiant Heater, Modulating	GEXSPHT	Com Heating	20	$ 7.00	$ 8.46	3.8	$55.38	$8.46
RADHEATNONMODWA	Radiant Heater, Non-Modulating Infrared Natural Gas-Fired Radiant Heater	GEXSPHT	Com Heating	20	$ 5.50	$ 7.05	2.93	$42.70	$7.05

Measure Code	Measure Description	Load Profile	2019 Load Profile	Measure Life	Incentive per Quantity	Incremental (TRC) Cost per Quantity	Savings (Therms) per Quantity	2019 WA-Only GAS AC per measure	Estimated Max Incentive (2019 AC)
STCONHITEMPGASWA	Dishwasher - Single Tank Conveyor - gas high temp	RESDHWG	Flat	20	$ 900.00	$ 2,050.00	280	$1,969.45	$1,969.45
STCONLOTEMPGAS	Dishwasher - Single Tank Conveyor - gas low temp	RESDHWG	Flat	20	$ 900.00	$ 1.00	545	$3,833.38	$3,835.00
STDRUPLOTEMPGAS	Dishwasher - Single Tank Door/Upright - gas low temp	RESDHWG	Flat	15	$ 550.00	$ 662.00	675	$3,719.11	$662.00
STDUPHITEMPGASWA	Dishwasher - Single Tank Door/Upright - gas high temp	RESDHWG	Flat	15	$ 825.00	$ 995.00	461	$2,540.01	$995.00
	Dishwasher - Multi Tank Conveyor - High Temp - Gas Water Heat	RESDHWG	Flat	20	$ 800.00	$ 970.00	1063	$7,476.86	$970.00
	Dishwasher - Multi Tank Conveyor Low Temp Gas Water Heat	RESDHWG	Flat	20	$ 800.00	$ 970.00	786	$5,528.51	$970.00
	Dishwasher - Pot Pan Utensil - High Temp Gas Water Heat	RESDHWG	Flat	10	$ 350.00	$ 1,710.00	138	$521.58	$521.58
	Dishwasher - Undercounter - Low Temp gas water heat	RESDHWG	Flat	10	$ 195.00	$ 234.00	106	$400.63	$234.00
THERMRADVAL	Thermostatic Radiator Valves (TRVs), central hydronic or steam systems only (MF only)	GEXSPHT	Res Heating	15	$ 100.00	$ 215.00	55	$584.87	$215.00
NEW	Multifamily Commercial Clothes Washer Common Areas	RESDHWG	Clotheswasher	11	$ 65.00	$ 425.00	24	$95.31	$95.31
BOCINCENTIVE1	BOC - Building Operations Manager Certificate, Level 1	GEXPRO	Flat	3	$ 600.00	$ 600.00	759	$908.15	$600.00
BOCINCENTIVE2	BOC - Building Operations Manager Certificate, Level 2	GEXPRO	Flat	3	$ 600.00	$ 600.00	759	$908.15	$600.00
New (No code yet)	Cooler Doors	GEXSPHT	Com Heating	15	$ 100.00	$ 375.00	45	$516.09	$375.00
New (No code yet)	Manufacturer-Installed Rooftop Unit Controls - Demand Control Ventillation controls on new RTUs, All New and Existing Buildings on Commercial Rate, including Multifamily	GEXSPHT	Com Heating	15	$ 29.00	$ 38.00	21	$240.84	$38.00
New (No code yet)	Multifamily HVAC Hot Water Condensing Gas Boilers <300 kbtu/h	GEXSPHT	Res Heating	35	$ 10.00	$ 16.00	4.1	$78.23	$16.00
New (No code yet)	Multifamily HVAC Hot Water Condensing Gas Boilers ≥300 kbtu/h, ≤2,500 kbtu/h	GEXSPHT	Res Heating	35	$ 9.00	$ 13.00	4.1	$78.23	$13.00
New (No code yet)	Multifamily HVAC Hot Water Condensing Gas Boilers >2,500 kbtu/h	GEXSPHT	Res Heating	35	$ 8.00	$ 10.00	4.1	$78.23	$10.00
	WA Existing or New MF Customer Purchased Kitchen Aerator 1.50 gpm	RESDHWG	DHW	15	$ 5.00	$ 5.00	2.2	$13.68	$5.00
	WA Existing or New MF Customer Purchased Kitchen Aerator 1.0 gpm	RESDHWG	DHW	15	$ 5.00	$ 5.00	4.6	$28.60	$5.00
	WA Existing or New MF Customer Purchased Bathroom Aerator 1.0 gpm	RESDHWG	DHW	15	$ 5.00	$ 5.00	2.2	$13.68	$5.00
	WA Existing or New MF Customer Purchased Bathroom Aerator 0.5 gpm	RESDHWG	DHW	15	$ 5.00	$ 5.00	3.5	$21.76	$5.00
	WA Existing or New MF Leave Behind Kitchen Aerator 1.50 gpm	RESDHWG	DHW	15	$ 5.00	$ 5.00	2.2	$13.68	$5.00
	WA Existing or New MF Leave Behind Kitchen Aerator 1.0 gpm	RESDHWG	DHW	15	$ 5.00	$ 5.00	4	$24.87	$5.00
	WA Existing or New MF Leave Behind Bathroom Aerator 1.0 gpm	RESDHWG	DHW	15	$ 5.00	$ 5.00	1.8	$11.19	$5.00
	WA Existing or New MF Leave Behind Bathroom Aerator 0.5 gpm	RESDHWG	DHW	15	$ 5.00	$ 5.00	2.7	$16.79	$5.00
	WA Customer Purchase MF Gas 1.50 gpm Showerhead	RESDHWG	DHW	15	$ 7.00	$ 7.14	13.5	$83.94	$7.14
	WA Customer Purchase MF Gas 1.50 gpm Showerwand	RESDHWG	DHW	15	$ 7.00	$ 7.14	9.9	$61.56	$7.14
	WA Leave Behind MF Gas 1.50 gpm Showerhead	RESDHWG	DHW	15	$ 7.00	$ 12.00	10.1	$62.80	$12.00
	WA Leave Behind MF Gas 1.50 gpm Showerwand	RESDHWG	DHW	15	$ 7.00	$ 28.00	7.4	$46.01	$28.00
	WA Customer Purchase MF Gas 1.75 gpm Showerhead	RESDHWG	DHW	15	$ 7.00	$ 7.14	9.8	$60.94	$7.14
	WA Customer Purchase MF Gas 1.75 gpm Showerwand	RESDHWG	DHW	15	$ 7.00	$ 7.14	4.3	$26.74	$7.14
	WA Leave Behind MF Gas 1.75 gpm Showerhead	RESDHWG	DHW	15	$ 7.00	$ 12.00	7.4	$46.01	$12.00
	WA Leave Behind MF Gas 1.75 gpm Showerwand	RESDHWG	DHW	15	$ 7.00	$ 28.00	3.2	$19.90	$19.90
New (No code yet)	Multifamily Condensing Tankless Water Heater ≤199 kbtu/h	RESDHWG	DHW	15	$ 300.00	$ 320.00	82	$509.87	$320.00
New (No code yet)	New Refrigerated Cases with Doors in Convenience Stores/Small Grocery	GEXSPHT	Com Heating	15	$ 35.00	$ 206	18.9	$216.76	$206.25
New (No code yet)	New Refrigerated Cases with Doors in Medium Grocery	GEXSPHT	Com Heating	15	$ 35.00	$ 206	36.8	$422.04	$206.25
New (No code yet)	New Refrigerated Cases with Doors in Large Grocery	GEXSPHT	Com Heating	15	$ 35.00	$ 206	33.7	$386.49	$206.25

4.2 Appendix 2: Measure Approval Documents

I. New Commercial for 2019
   a. Building Operator Certificate
   b. Commercial Aerators
   c. Commercial Clothes Washers
   d. Commercial Condensing Tank Water Heaters
   e. Commercial Condensing Tankless Water Heaters ≥ 200 kBtu/h
   f. Commercial Dishwashers and Dish Machines
   g. Commercial Steam Traps
   h. Direct Install Showerheads and Shower Wands
   i. Food Service Cooking Measures
   j. New Cooler Cases with Doors
   k. Radiant Infrared Heaters
   l. Residential and Multifamily Aerators
   m. Thermostatic Radiator Valves in Multifamily

II. New Residential for 2019
   a. Direct Install Smart Thermostats with Funding Partners
   b. Energy Saver Kits
   c. Condensing Gas Furnaces in SW Washington
   d. Residential Gas Storage Water Heaters
   e. Retail Showerheads and Shower Wands

Measure Approval Document for Building Operator Certificate

Valid Dates
10/22/18 – 12/31/19

End Use or Description
Training for building operators in commercial, industrial, and existing multifamily buildings.

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

- Building Tune-up and Operations (BTO) Program
- Existing Multifamily

Within these programs, applicability to the following building types or market segments or other program tracks are expected:

- Existing Multifamily – Assisted Living
- Existing Multifamily – Market Rate

Purpose of Re-Evaluating Measure
Measure is being updated to explicitly approve Washington measures as well as electric only in Oregon. In addition, the MAD now shows the two levels of certification available, although no difference in savings is claimed. No changes are made to the calculations for the BTO measure. The analysis for Existing Multifamily is based on the BTO measure and is modified for energy use intensities of the sector.

Cost Effectiveness
Table 1 Cost Effectiveness Calculator Oregon

Measure	Sector	Sub-sector	Electric Load Profile	Gas Load Profile	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Electric Allocation	% Gas Allocation
BOC Level 1 in BTO	Commercial	Other	Process	Flat	3	14,603	759	$600	$0.00	$600	4.109	4.109	76%	24%
BOC Level 1 in BTO Electric Only	Commercial	Other	Process	Flat	3	14,603		$600	$0.00	$600	3.111	3.111	100%	0%
BOC Level 2 in BTO	Commercial	Other	Process	Flat	3	14,603	759	$600	$0.00	$600	4.109	4.109	76%	24%
BOC Level 2 in BTO Electric Only	Commercial	Other	Process	Flat	3	14,603		$600	$0.00	$600	3.111	3.111	100%	0%
BOC Level 1 in Multifamily	Commercial	Other	Process	Flat	3	6,391	332	$600	$0.00	$600	1.798	1.798	76%	24%
BOC Level 1 in Multifamily Electric Only	Commercial	Other	Process	Flat	3	6,391		$600	$0.00	$600	1.362	1.362	100%	0%
BOC Level 2 in Multifamily	Commercial	Other	Process	Flat	3	6,391	332	$600	$0.00	$600	1.798	1.798	76%	24%
BOC Level 2 In Multifamily Electric Only	Commercial	Other	Process	Flat	3	6,391		$600	$0.00	$600	1.362	1.362	100%	0%

Table 2 Cost Effectiveness Calculator Washington

Measure	Sector	Sub-sector	Gas Load Profile	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Other NEB (Annual $)	ELE Bill Savings (Annual $)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR
BOC Level 1 in BTO WA	Commercial	Other	FLAT	3	0	759	600.0	$0.00	$0.00	$0.00	$600	1.51	1.51
BOC Level 2 in BTO WA	Commercial	Other	FLAT	3	0	759	600	$0.00	$0.00	$0.00	$600	1.51	1.51

Requirements
- Building electricity and gas, if applicable, must be provided by Energy Trust sponsored utilities

- For Multifamily properties
    1. Heating for dwelling units must be served by central system
    2. Total square footage of building must be greater than 70,000 sq. ft.
- Individual Building Operators are not allowed to receive additional training incentives within 3 years of their first training.

Baseline

This measure uses

1. Existing Condition

Baseline is existing condition where building operator does not receive BOC. It does not appear that Multifamily building operators are commonly obtaining the training in the absence of an incentive. From 2015 to the present, only 7 Multifamily building operators received the training in Oregon. While the exact number of eligible properties is not known, it is known that there are over 600 Multifamily properties with over 100 units, in Multnomah County alone. With this in mind, it is highly likely that less than 5% of eligible Multifamily building operators have received the training, prior to the incentive being established.

Measure Analysis

NEEA's second Building Operator Certificate Expansion Initiative Market Progress Evaluation Report provides data on the average area for which a builder operator is responsible and the savings achieved as a percentage of energy consumption. The Commercial Building Stock Assessment provides Energy Intensity Indices. Savings are the product of the three factors. Because each operator is modelled as having separate control of an area of the building, savings may be booked for additional operators in the same building. Though the areas for which multiple building operators are responsible overlap when they work in the same building, the average area is calculated by dividing the overall building area by the number of operators.

The average regional commercial energy intensity indices are 14.1 kWh per year per square foot and 0.34 annual therms per square foot. The average area for which a non-BOC operator is responsible, from the NEEA report, is 72,935 square feet. The non-BOC operator is the candidate for future training, so that area is used, rather than the area operated by someone who has received BOC training. Percentage savings are based on the difference in expected savings from a certified and non-certified operator, **1.42%** of electric energy consumption and **3.06%** of natural gas consumption from the second Market Progress and Evaluation Report (page 36). Therefore, per operator savings are **14,603** kWh per year and **759** annual therms in the BTO program.

There are two levels of training available, Level 1 and Level 2. No differentiation in savings is made between the two levels. It is understood that while a Building operator may elect to take the second level of training in order to maintain Building Operator Certification, Energy Trust will not incentivize or claim savings for overlapping training periods.

While electric savings are expected for any Washington trainings, NEEA claims these savings and so they should not be claimed as a non-energy benefit for bill savings.

The Multifamily BOC savings are calculated differently, because there is less comprehensive energy use intensity data from the Regional Building Stock Assessment (RBSA). In order to scale the savings for Multifamily, the energy use intensity (EUI) for the Multifamily and Commercial sectors was determined. The ratio of these two values was applied to the BTO savings to determine Multifamily specific savings:

$$\Delta E_{MF} = \frac{EUI_{MF}}{EUI_{COMM}} * \Delta E_{COMM}$$

The EUI's were determined from the Residential Energy Consumption Survey (RECS) and Commercial Building Energy Consumption Survey (CBECS). The data for these two data sources is nationwide and data analysis was required to obtain a region specific value. For Multifamily, the data was filtered on the following values:

1. Region – AK,CA, HI, OR, WA
2. Climate – Less than 2,000 CDD and 4,000 – 5,499 HDD
3. Building Style – Apartment in building with 5+ units

Filtering on this many attributes reduced the samples size considerably. In order to maintain the robustness of the estimate, it was averaged with the EUI for Multifamily buildings with 5+ units nationwide.

The CBECS uses different attributes, so the data was only filtered for the Pacific Census Division.

A summary of the results is provided below:

Name	Value
MF EUI (kBtu / sq ft)	45
COMM EUI (kBtu / sq ft)	104
MF EUI / COMM EUI	44%

Lastly, multiplying the BTO savings values by .44 yields Multifamily specific savings of 6,391 kWh and 332 therms.

Comparison to RTF or other programs

Measure is not offered by RTF or other regional programs.

Measure Life

Measure life is three years, consistent with other operations and maintenance measures.

Cost

An incremental cost of $600 is used for cost effectiveness. As discussed above, very few multifamily participants have opted for the training for the training without an incentive. While the incremental cost is not an exact value, the follow up section discusses plans for future improvements.

Incentive Structure

The maximum incentives listed in Table 1 are for reference only and are not suggested incentives. Incentives will be structured per building operator certificate.

Follow-Up

Measure should be updated with most recent values from CBSA, RBSA if applicable, RECS, and CBECS. If any additional research is performed by NEEA, the results should be included. Future analysis should examine whether the savings from MPER #1 or MPER #2 are more appropriate. In the next analysis it is of utmost importance to justify why the incentive is appropriate as an incremental cost for the full program.

Supporting Documents

The cost effective screening for these measures is attached and can be found along with supporting documentation at: I:\Groups\Planning\Measure Development\Commercial and Industrial\Whole Building and Controls\Builder Operator Certificate

Building Operator Certification 2019-v1

References

BOC-Expansion Initiative Market Progress Evaluation Report #2 Final Report

Version History and Related Measures

Table 3 Version History

Date	Version	Reason for revision
8/12/15	137.X	First release
9/17/15	137.X	Corrected CEC error
6/19/18	137.2	Added Multifamily
10/22/18	137.3	Added level 2 certification, Washington and electric only measures.

Approved & Reviewed by

Kenji Spielman
Planning Engineer

Mike Bailey PE
Engineering Manager Planning

Disclaimer

Measure Approval Document for Thermostatic Radiator Valves in Multifamily

Valid Dates
1/1/2019 – 12/31/2021

End Use or Description
Thermostatic Radiator Valves (TRV) reduce load and avoid overheating areas of buildings with central steam or hydronic heating.

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

- Existing Multifamily
- Existing Buildings in Washington, where that program serves multifamily buildings

Within these programs, the measure is applicable to the following cases:

- Retrofit (Assumes existing condition baseline)

Purpose of Re-Evaluating Measure
Washington Multifamily added to this update. Retest cost effectiveness. No changes to costs, savings or maximum incentives.

Cost Effectiveness
Table 1 Cost Effectiveness Calculator Oregon

Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR
Thermostatic Radiator Valve	15	55	$215.00	$215.00	1.5	1.5

Table 2 Cost Effectiveness Calculator Washington

Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR
Thermostatic Radiator Valve	15	55	$215.00	$215.00	2.7	2.7

Requirements
- Multifamily buildings with central steam heating systems where thermostatic valves are not already in place, typically these buildings were built prior to 1995.
- Thermostatic valves or other zonal controls are considered baseline in new construction steam systems so this measure is not applicable to NBM.

Details

Steam systems in pre-1995 buildings are typically single zone systems. Steam boilers are controlled by a single thermostat or a timer, and heat is produced at all radiators on the system whenever the boiler is on. This can lead to over-heated areas of the building, which cause residence to be uncomfortable, open windows or run fans wasting further energy. Thermostatic radiator valves reduce load by allowing radiators to turn off while the boiler is still producing steam. TRVs provide temperature control by allowing steam to bypass a radiator based on a temperature set point. Typically, TRVs require a tool or specific knowledge to adjust and are set up at install to comfortable temperature. Some models may allow for easier control and thus the savings will be somewhat based on user behavior. However, radiator valves are essentially off-switches, they cannot keep a boiler running longer hours or at times not specified by the boiler controls. Thermostatic radiator valves cannot increase heating load.

Thermostatic radiator valves are an established technology in use with newer steam systems. The MF program occasionally sees this measure in custom projects where an older building's steam system is being upgraded. Due to the cost of ATAC studies, the program has not promoted this technology to smaller buildings or buildings not researching other steam upgrades. As a prescriptive measure, the program expects much higher uptake of this measure.

Baseline

This measure uses an Existing Condition Baseline.

The baseline is existing condition which is a radiator without a thermostatically controlled valve.

Measure Analysis

The savings were determined by averaging savings values from Multifamily custom project studies. These studies were performed between 2011 and 2014. It is very challenging to utilize engineering analysis to predict savings, as there are many variables which influence the energy savings.

Savings

Savings for thermostatic radiator valves vary with the size of a building, the radiators per square foot, and the boiler efficiency. A review of 4 custom studies in the BEM program found that savings vary with the distribution of radiators in the space. Savings ranged from 26 to 105 therms per installed thermostatic valve. The average savings are 55 therms per valve. Savings are based on a set point of 72 degrees and assume a boiler set point of 78 degrees.

Measure Life

The measure life is 15 years, in line with other HVAC measures. Manufacturers claim an expected life of 15 – 20 years.

Cost

The median project cost in the Multifamily program between 2011 and 2014 was $215 per TRV which includes installation.

Non Energy Benefits

There are non-quantifiable non energy benefits of increased tenant comfort. This is mainly due to avoiding the need to open windows during times of overheating.

Incentive Structure

The maximum incentives listed in Table 1 and Table 2 are for reference only and are not suggested incentives. Incentives will be structured per thermostatic radiator valve and should not exceed project cost.

SRAF

Typical program SRAF rates apply.

Follow-Up

Any studies or pilots on the technology should be reviewed for incorporation into the analysis.

Supporting Documents

The cost effective screening for these measures is attached and can be found along with supporting documentation at: I:\Groups\Planning\Measure Development\Commercial and Industrial\Commercial HVAC\thermostatic radiator valves

45 Thermostatic Radiator Valves_CEC

Version History and Related Measures

Table 3 Version History

Date	Version	Reason for revision
3/4/14	45.1	Introduce measure
5/18/18	45.2	Add Washington. Update cost effectiveness

Table 4 Related Measures

Measures	MAD ID
Multifamily steam traps	40

Approved & Reviewed by

Jackie Goss, PE
Sr. Planning Engineer

Mike Bailey PE
Engineering Manager Planning

Disclaimer

This Energy Trust document and its attachments may be used by you or shared, at no cost, with other parties who are interested in our work and analyses. Should you or anyone with whom this document is

shared, have suggestions for improvement of our work, please let us know. You may modify this 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.

Measure Approval Document for Residential and Multifamily Aerators

Valid Dates
January 1, 2019 – December 31, 2021

End Use or Description
Installation of aerators by a contractor, PMC, or multifamily builder, at a Home Energy Review (HER) in Oregon. In Washington for qualifying commercial rate multifamily as customer purchased and installed low flow aerators. In Washington the measures are also approved for leave behind program for qualifying commercial rate multifamily customers.

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

- Existing Buildings (Washington Existing and New Multifamily)
- Existing Single Family
- Existing Manufactured Homes
- New Multifamily Buildings
- Existing Multifamily

Within these programs, applicability to the following building types or market segments or other program tracks are expected:

- Detached single family homes
- Townhomes
- Multifamily buildings (low-rise, mid-rise, and high-rise)
- Dorms
- Assisted living

Within these programs, the measure is applicable to the following cases:

- Retrofit
  - Existing Multifamily
- New
  - New Multifamily Buildings
- Replacement
  - Washington Multifamily, Existing Single Family, Existing Manufactured Homes, Washington Multifamily

Purpose of Re-Evaluating Measure
This update incorporates the RTF v1.1 Aerator analysis which corrects some errors from the previous analysis, mainly around daily water use.

Cost Effectiveness
Table 1 Cost Effectiveness Calculator Oregon

Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Electric Allocation	% Gas Allocation
SF Kitchen Aerator 1.5 GPM ELE	15	63	0.0	$5.00	$8.28	$5.00	9.24	27.28	100%	0%
SF Kitchen Aerator 1.5 GPM Gas	15	2	2.8	$5.00	$8.28	$5.00	2.92	20.95	12%	88%
SF Kitchen Aerator 1.5 GPM Partial Territory Gas	15	0	2.8	$5.00	$8.49	$5.00	2.58	21.08	0%	100%
SF Kitchen Aerator 1 GPM ELE	15	134	0.0	$5.00	$17.71	$5.00	19.76	58.33	100%	0%
SF Kitchen Aerator 1 GPM GAS	15	5	5.9	$5.00	$17.71	$5.00	6.23	44.80	12%	88%
SF Kitchen Aerator 1 GPM Partial Territory Gas	15	0	5.9	$5.00	$18.16	$5.00	5.51	45.07	0%	100%
MH Kitchen Aerator 1.5 GPM ELE	15	61	0.0	$5.00	$8.01	$5.00	8.94	26.39	100%	0%
MH Kitchen Aerator 1.5 GPM GAS	15	2	2.7	$5.00	$8.01	$5.00	2.82	20.27	12%	88%
MH Kitchen Aerator 1.5 GPM Partial Territory Gas	15	0	2.7	$5.00	$8.22	$5.00	2.49	20.39	0%	100%
MH Kitchen Aerator 1 GPM ELE	15	130	0.0	$5.00	$17.14	$5.00	19.12	56.44	100%	0%
MH Kitchen Aerator 1 GPM GAS	15	5	5.7	$5.00	$17.14	$5.00	6.03	43.35	12%	88%
MH Kitchen Aerator 1 GPM Partial Territory Gas	15	0	5.7	$5.00	$17.57	$5.00	5.33	43.61	0%	100%
MF Kitchen Aerator 1.5 GPM ELE	15	73	0.0	$5.00	$9.67	$5.00	10.79	31.85	100%	0%
MF Kitchen Aerator 1.5 GPM GAS	15	3	3.2	$5.00	$9.67	$5.00	3.40	24.47	12%	88%
MF Kitchen Aerator 1.5 GPM Partial Territory Gas	15	0	3.2	$5.00	$9.92	$5.00	3.01	24.61	0%	100%
MF Kitchen Aerator 1 GPM ELE	15	136	0.0	$5.00	$17.95	$5.00	20.03	59.12	100%	0%
MF Kitchen Aerator 1 GPM GAS	15	5	6.0	$5.00	$17.95	$5.00	6.32	45.41	12%	88%

Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Electric Allocation	% Gas Allocation
MF Kitchen Aerator 1 GPM Partial Territory Gas	15	0	6.0	$5.00	$18.41	$5.00	5.59	45.68	0%	100%
SF Bathroom Aerator 1 GPM ELE	15	38	0.0	$5.00	$5.97	$5.00	5.54	18.54	100%	0%
SF Bathroom Aerator 1 GPM GAS	15	2	1.7	$5.00	$5.97	$5.00	1.78	14.78	14%	86%
SF Bathroom Aerator 1 GPM Partial Territory Gas	15	0	1.7	$5.00	$6.12	$5.00	1.53	14.87	0%	100%
SF Bathroom Aerator 0.5 GPM ELE	15	59	0.0	$5.00	$9.42	$5.00	8.73	29.24	100%	0%
SF Bathroom Aerator 0.5 GPM GAS	15	3	2.6	$5.00	$9.42	$5.00	2.80	23.31	14%	86%
SF Bathroom Aerator 0.5 GPM Partial Territory Gas	15	0	2.6	$5.00	$9.66	$5.00	2.42	23.45	0%	100%
MH Bathroom Aerator 1 GPM ELE	15	41	0.0	$5.00	$6.48	$5.00	6.01	20.13	100%	0%
MH Bathroom Aerator 1 GPM GAS	15	2	1.8	$5.00	$6.48	$5.00	1.93	16.04	14%	86%
MH Bathroom Aerator 1 GPM Partial Territory Gas	15	0	1.8	$5.00	$6.65	$5.00	1.66	16.14	0%	100%
MH Bathroom Aerator 0.5 GPM ELE	15	64	0.0	$5.00	$10.22	$5.00	9.48	31.73	100%	0%
MH Bathroom Aerator 0.5 GPM GAS	15	3	2.8	$5.00	$10.22	$5.00	3.04	25.30	14%	86%
MH Bathroom Aerator 0.5 GPM Partial Territory Gas	15	0	2.8	$5.00	$10.48	$5.00	2.62	25.45	0%	100%
MF Bathroom Aerator 1 GPM ELE	15	60	0.0	$5.00	$9.53	$5.00	8.83	29.58	100%	0%
MF Bathroom Aerator 1 GPM GAS	15	3	2.6	$5.00	$9.53	$5.00	2.83	23.58	14%	86%
MF Bathroom Aerator 1 GPM Partial Territory Gas	15	0	2.6	$5.00	$9.77	$5.00	2.45	23.72	0%	100%
MF Bathroom Aerator 0.5 GPM ELE	15	93	0.0	$5.00	$14.71	$5.00	13.65	45.69	100%	0%
MF Bathroom Aerator 0.5 GPM GAS	15	4	4.1	$5.00	$14.71	$5.00	4.38	36.42	14%	86%
MF Bathroom Aerator 0.5 GPM Partial Territory Gas	15	0	4.1	$5.00	$15.09	$5.00	3.78	36.64	0%	100%
NBM Kitchen Aerator 1.5 GPM ELE	15	55	0.0	$5.00	$7.27	$5.00	8.113	23.952	100%	0%
NBM Kitchen Aerator 1.5 GPM GAS	15	2	2.4	$5.00	$7.27	$5.00	2.560	18.398	12%	88%
NBM Kitchen Aerator 1.5 GPM Partial Territory Gas	15	0	2.4	$5.00	$7.46	$5.00	2.264	18.507	0%	100%
NBM Kitchen Aerator 1 GPM ELE	15	118	0.0	$5.00	$15.55	$5.00	17.348	51.214	100%	0%
NBM Kitchen Aerator 1 GPM GAS	15	4	5.2	$5.00	$15.55	$5.00	5.474	39.339	12%	88%
NBM Kitchen Aerator 1 GPM Partial Territory Gas	15	0	5.2	$5.00	$15.95	$5.00	4.840	39.572	0%	100%
NBM Bathroom Aerator 1 GPM ELE	15	57	0.0	$5.00	$8.99	$5.00	8.341	27.925	100%	0%
NBM Bathroom Aerator 1 GPM GAS	15	2	2.5	$5.00	$8.99	$5.00	2.676	22.260	14%	86%
NBM Bathroom Aerator 1 GPM Partial Territory Gas	15	0	2.5	$5.00	$9.22	$5.00	2.309	22.394	0%	100%
NBM Bathroom Aerator 0.5 GPM ELE	15	89	0.0	$5.00	$14.18	$5.00	13.152	44.034	100%	0%
NBM Bathroom Aerator 0.5 GPM GAS	15	4	3.9	$5.00	$14.18	$5.00	4.219	35.101	14%	86%
NBM Bathroom Aerator 0.5 GPM Partial Territory Gas	15	0	3.9	$5.00	$14.54	$5.00	3.641	35.312	0%	100%

Table 2 Cost Effectiveness Calculator Washington

Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	Other NEB (Annual $)	ELE Bill Savings (Annual $)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR
WA MF Customer Purchased Kitchen Aerator 1.5 GPM	15	2.2	$5.00	$5.30	$0.00	$5.30	$5.00	2.69	13.23
WA MF Customer Purchased Kitchen Aerator 1 GPM	15	4.6	$5.00	$11.33	$0.00	$11.33	$5.00	5.76	28.29
WA MF Customer Purchased Bathroom Aerator 1 GPM	15	2.2	$5.00	$6.55	$0.00	$6.55	$5.00	2.75	15.78
WA MF Customer Purchased Bathroom Aerator 0.5 GPM	15	3.5	$5.00	$10.33	$0.00	$10.33	$5.00	4.33	24.88
WA MF Leave Behind Kitchen Aerator 1.5 GPM	15	2.2	$5.00	$5.28	$0.00	$5.28	$5.00	2.69	13.20
WA MF Leave Behind Kitchen Aerator 1 GPM	15	4.0	$5.00	$9.81	$0.00	$9.81	$5.00	4.99	24.49

WA MF Leave Behind Bathroom Aerator 1 GPM	15	1.8	$5.00	$5.20	$0.00	$5.20	$5.00	2.18	12.53
WA MF Leave Behind Bathroom Aerator 0.5 GPM	15	2.7	$5.00	$8.04	$0.00	$8.04	$5.00	3.37	19.36

Requirements

- For Multifamily direct install and WA MF Leave Behind, retrofitted aerator must be of lesser flow rate than existing
- Washington customer purchased as well as leave behind program participant must be an existing building program qualifying customer, with natural gas water heating, served by an Energy Trust eligible utility
- Water heating fuel must be provided by an Energy Trust Utility
- For customer purchased aerators the program will specify a minimum number of aerators to purchase

Baseline

This measure uses a:

- Inefficient Market Baseline
  - Multifamily Direct Install
  - WA MF Leave Behind
- Full Market Baseline
  - SF
  - MH
  - NBM
  - WA MF Customer Purchased

The existing condition baseline was determined using RBSA II data for rated flow rates of aerators by housing type.

The Multifamily direct install program screens projects to ensure the replacement aerator is of lesser flow rate than existing. In the case of bathroom aerators, the screening criteria is greater than 1.0 GPM while the kitchen aerators criteria is greater than 1.5 GPM. RBSA data excluded from these performance bins were excluded to create an inefficient market baseline.

Table 3 Kitchen Baseline Flow Rate

		Flow Rate (GPM)	Baseline Weight
Kitchen	**SF**	2.2	46%
		2	15%
		1.8	14%
		1.5	25%
		1	0%
	MH	2.2	46%
		2	15%
		1.8	14%
		1.5	25%
		1	0%
	MF DI / WA Leave Behind	2.2	61%
		2	20%
		1.8	19%
		1.5	0%
		1	0%
	NBM / WA Customer Purchased	2.2	46%
		2	15%
		1.8	14%
		1.5	25%
		1	0%

Table 4 Bathroom Baseline Flow Rate

		Flow Rate (GPM)	Baseline Weight
Bathroom	**SF**	2.2	36%
		2	28%
		1.8	1%
		1.5	28%
		1	6%
		0.5	0%
	MH	2.2	36%
		2	28%
		1.8	1%
		1.5	28%
		1	6%
		0.5	0%
	MF DI / WA Leave Behind	2.2	38%
		2	30%
		1.8	1%
		1.5	31%
		1	0%
		0.5	0%
	NBM / WA Customer Purchased	2.2	36%
		2	28%
		1.8	1%
		1.5	28%
		1	6%
		0.5	0%

Measure Analysis

Constant Volume Water Usage

In this analysis, water usage is broken up in two categories: constant volume and constant duration usage. Constant volume usage is unaffected by the flow rate of the faucet. This includes actions such as filling pots. Constant duration usage is affected by the flow rate of the faucet. It assumes that the user will use the faucet for the same duration, regardless of flow rate. This leads to energy and water savings from a reduced flow aerator. Research is needed to better understand these factors, but the RTF estimated the following values:

Table 5 Constant Duration Water Usage

	Kitchen	**Bathroom**
% of usage that is constant duration	50%	75%

Baseline Water Usage

Table 6 Summary of Baseline Water Usage

	Kitchen	**Bathroom**
Hot water gallons per capita, per day	3.6	1.3
Mixed Water Temperature (deg F)	93	86

% Hot Water	53%	44%
Total gallons per capita, per day	6.8	2.9

Baseline hot water usage was referenced from SBW studies on Single Family and Multifamily usage[12]. In order to determine the total water usage, the fraction of hot water to total water usage was required. This value was determined from a study by Cadmus[3] on mixed water temperatures of kitchen and bathroom faucets. This simple calculation is shown below:

$$V_{total} = \frac{V_{hot}}{\phi_{hot}} = \frac{2.7}{.53} = 5.1$$

This analysis deviates from the RTF analysis with respect to occupancy values. We find it more appropriate to use 2015 American Community Survey Census data, whereas the RTF uses RBSA II data.

Table 7 Occupancy Data

	ACS	RBSA II
Single Family	2.74	2.59
Manufactured Homes	2.44	2.44
Multifamily	2.11	1.81

RBSA II data is also used to determine the number of faucets per home.

Table 8 Faucets per Home

	Kitchen	**Bathroom**
Single Family	1.08	2.56
Manufactured	1.00	2.10
Multifamily Residence	1.00	1.31
Total	1.06	2.32

The analysis assumes a throttling rate (percentage of full faucet flow) of 50% which is consistent with the previous ETO analysis.

Efficient Water Usage

As discussed previously, this analysis breaks down the water usage into constant volume and constant duration usage. Due to this approach, the constant volume usage is equivalent in the baseline and efficient cases. The constant duration usage in the efficient case is calculated as the product of base case flow duration (in minutes) and rated flow rate.

Miscellaneous

Table 9 Misc. Water Heating

	Gas	**Electric Resistance**	**Electric Heat Pump**
Water Heater Recovery Efficiency	0.75	1.00	1.65
Water Heater Temp Increase	75	75	75
kWh/gallon		0.184	0.111
therms/gallon	0.0084		

Delivery Channels

In Oregon, the measure is only offered through the direct install track. A 90% installation rate is used. In Washington customer purchase aerators are assumed to be installed at the same rate as retail showerheads, 80% and the leave behind measures are at 60%, also following showerheads. The installation rates are from RTF Aerators v1.0 and Showerheads v3.1 workbooks.

[1] SBW Consulting, 1994. "Energy Efficient Showerhead and Faucet Aerator Metering Study: Single Family Residences. Final Report." SBW Report Number 9414 for Puget Sound Power and Light.
[2] SBW Consulting, 1994. "Energy Efficient Showerhead and Faucet Aerator Metering Study: Multifamily Residences. Final Report." SBW Report Number 9408 for Bonneville Power Administration.
[3] Cadmus and Opinion Dynamics for the Michigan Evaluation Working Group, 2013. "Showerhead and Faucet Aerator Meter Study."

Comparison to RTF or other programs

The analysis is in agreement with the RTF with the exception of the following factors:

- Occupancy
  - 2015 ACS Census Data uses instead of RBSA II
- MF Baseline Flow Rate
    - 1.0 GPM bathroom and 1.5 GPM kitchen aerators excluded from baseline due to screening
- 90% installation rate for direct install
- 80% installation rate for customer purchased
- 60% installation rate for leave behind
- RTF uses 10 year measure life, while this is 15 years

Measure Life

The measure life is 15 years which is in agreement with other water saving devices.

Cost

Costs for Oregon direct install aerators are equal to incentives mutually agreed-upon by PMC and Energy Trust Program staff taking into account both product and labor costs. Washington costs are unchanged from the previous MAD.

Non Energy Benefits

The reduced water consumption NEB from aerator devices is calculated using water rates net of embedded electricity in Oregon for gas and electric territories, and total water rates without removing embedded energy for Oregon gas only territory. Washington uses the combined rate of water including embedded energy use for waste water treatment

- Oregon full territory $13.30/1,000 gallons
- Oregon gas only territory $13.64/1,000 gallons
- Washington $10.90/1,000 gallons

Incentive Structure

The maximum incentives listed in Table 1 and Table 2 are for reference only and are not suggested incentives. Incentives will be structured per aerator.

Follow-Up

Several of the factors in the analysis had a high degree of uncertainty or were based off older studies. All of the major variables in the analysis should be reviewed to see if better data sources have emerged. All updates to the RTF analysis should be reviewed at the next update. The water heater recovery efficiency for both gas and electric water heaters should be reexamined.

Review possibly changing measure life to 10 years to be consistent with RTF. Not changed at this time due to lack of data.

Supporting Documents

The cost effective screening for these measures is attached and can be found along with supporting documentation at:
I:\Groups\Planning\Measure Development\Residential\Res Water Reduction\aerator

Residential Aerators 2019-v1.1 V

Version History and Related Measures

Table 10 Version History

Date	MAD Version	Reason for revision
2005	x	Direct install aerator introduced
11/12/07	x	Update direct install existing condition assumptions for multifamily and single family shower heads and aerators.
10/19/10	x	Leave behind aerators approved for multifamily and single family. Separates savings between kitchen and bath aerators
10/21/10	x	Adds additional flow rates to leave behind multifamily and single family aerators.
11/5/10	x	Multifamily direct install update, includes combined bath/kitchen aerator measure
4/28/11	x	Multifamily direct install in gas-only territory with partner PUDs, includes aerators, showerheads and other hot water measures
6/22/11	x	Add shower wands to gas-only territory direct install
8/5/11	x	Single family direct install aerators
9/29/11	x	Update single family direct install to include Home Energy Review track
11/21/11	x	Language clarifications
8/15/14	25.x	Combine single family and multifamily direct install MADs combined for both showerheads and aerators in all territories. Update flow rates based on RBSA data. Update to 2011 RTF assumptions. Includes more flow rates and aerators.
8/26/14	25.x	Corrected error regarding % hot water in prior version
4/15/15	51.x	Split MAD 25, combine single and multifamily direct install aerators into a single MAD. Direct install showerheads now listed in MAD 157. MAD 25 retired.
4/19/16	51.1	Add new small multifamily as an applicable program
5/1/17	51.2	And Washington multifamily, customer purchase track
8/29/18	51.3	Incorporate RTF v1.0 analysis
10/9/18	51.4	Correct savings and NEBs due to RTF error in baseline per capita flow rates

Table 11 Related Measures

Measure	MAD ID
Leave-behind showerheads, wands and aerators in single family Washington only	43
Commercial aerators	1
Energy Saver Kit (includes aerators)	27
Living Wise Kit (includes aerators)	30
Carry Home Savings Kit (includes aerators)	154
Direct install and Washington showerheads	157

Approved & Reviewed by

Kenji Spielman

Planning Engineer

Mike Bailey PE

Engineering Manager Planning

Disclaimer

This Energy Trust document and its attachments may be used by you or shared, at no cost, with other parties who are interested in our work and analyses. Should you or anyone with whom this document is shared, have suggestions for improvement of our work, please let us know. You may modify this 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.

Measure Approval Document for Radiant Infrared Heaters

Valid Dates
1/1/2019-12/31/2021

End Use or Description
Use of direct-fired radiant heaters to heat large open areas.

Program Applicability
Based on the referenced analysis and associated cost-effectiveness screening, the measures described below are approved for use in the following programs in Oregon and Washington:

- Existing Buildings
- New Buildings
- Production Efficiency

Within these programs, applicability to the following building types or market segments or other program tracks are expected:

- Gymnasiums
- Warehouses
- Manufacturing Buildings
- Other buildings with large rooms and high ceilings

Within these programs, the measure is applicable to the following cases:

- New
- Retrofit

Purpose of Re-Evaluating Measure
This is a major update, including review of baseline and proposed equipment, space and setpoint assumptions as well as review and revision of analysis and costing. Analysis updated to include climate zones outside of Portland metro that were not included in prior measure evaluation. Both savings and costs are reduced.

Cost Effectiveness
Cost effectiveness of radiant heaters in Oregon and Washington is demonstrated in Table 1 and Table 2, including the incremental savings between modulating and non-modulating heaters.

Table 1 Cost Effectiveness Calculator, Oregon, per kBtu/h

Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Ele	% Gas
Infrared Radiant Heaters, non-modulating	20	2.50	2.93	$7.05		$7.05	3.5	3.5	9%	91%
Infrared Radiant Heaters, modulating	20	2.44	3.80	$8.46		$8.46	3.7	3.7	7%	93%
Infrared Radiant Heaters, non-modulating - gas only	20		2.93	$7.05	$0.19	$7.05	3.2	3.6	0%	100%
Infrared Radiant Heaters, modulating - gas only	20		3.80	$8.46	$0.20	$8.46	3.5	3.8	0%	100%
Difference between modulating and non-modulating	20		0.87	$1.41		$6.73	1.0	4.8	0%	100%

Table 2 Cost Effectiveness Calculator, Washington, per kBtu/h

Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR
Infrared Radiant Heaters, non-modulating	20	2.50	2.93	$7.05	$0.19	$7.05	6.1	6.4
Infrared Radiant Heaters, modulating	20	2.44	3.80	$8.46	$0.19	$8.46	6.5	6.8
Difference between modulating and non-modulating	20	0	0.87	$1.41	$0.00	$8.46	1.5	9.0

Requirements
Infrared Radiant Heater installation must meet all specifications listed below:

- Facility has qualifying gas service. Electric-only projects are not eligible for incentives from these measures.
- Low intensity type discharge
- Natural gas-fired
- Non-condensing type
- Positive pressure (“standard”) systems
- Only indoor areas qualify for incentives due to building code requirements for outdoor installations.
- Areas greater than 20,000 sq ft are excluded from the incentive due to installation complexity and cost and savings variability.

Details
Radiant infrared heaters are an efficient alternative to convective type gas-fired unit heaters in buildings with spaces with high ceilings, such as gymnasiums and warehouses. They reduce heat loss from thermal stratification along the height of the building and require only a minimal

amount of fan energy for combustion purposes, as opposed to a convection-based system, which must force the warm air to its destination. With a forced air system, heat escapes as doors are opened and the system must reheat the quantity of air that has escaped as if from a cold startup. However, with infrared heat the floor acts as a reservoir. When doors are opened, the slab loses very little of its heat and when the doors close, this mass acts as a heat sink to continue warming the surrounding air.

The primary design characteristics which distinguish various models of infrared heaters are:

- Modulating, dual stage, or single stage burners
- Condensing or non-condensing
- Low-intensity or high-intensity burners
- Vacuum or positive pressure heaters

Modulating Burners

An advanced feature of low-intensity infrared tube heaters is modulating burners, which optimize combustion by pre-programmed burner controls that adjust both fuel and air, modulating burner input rate with outdoor air temperature to match the heating system's fuel input to the building's heat requirement. Modulation of the burners-in-series occurs by varying the pressure and adjusting gas and combustion air equally which ensures proper combustion.

Due to the higher costs and savings associated with this type of equipment, it was analyzed separately and is a discrete measure meriting higher incentives over a non-modulating infrared heater.

Vacuum and Positive Pressure Systems

The main difference between a vacuum style heater and a positive pressure tube heater is that the vacuum style heater burner box is under a negative instead of a positive pressure. A vacuum pump located at the end of the system pulls gases down the tube and may be installed as a condensing or non-condensing system. Vacuum-style infrared heater systems may have up to six burners, commonly vented by a single vacuum pump which results in fewer roof or sidewall penetrations, making these installations advantageous when multiple heaters are needed. However vacuum-based systems use more electricity due to the vacuum pump.

Because of the additional electricity along with multi-venting possibilities, vacuum style heaters are not well suited for a prescriptive offering. They are therefore excluded from this measure approval as they are better served in the custom program track.

Condensing vs. Non-Condensing Units

Condensing systems typically allow for longer system lengths and higher system thermal efficiency. However, a non-condensing system more efficiently utilizes the highly emissive black coating on the radiant tubes at a more reasonable equipment cost. Although thermal efficiencies are greater with condensing systems, a vacuum pump is needed for better heat distribution with these longer system lengths resulting in higher electricity usage compared to a non-condensing type.

Because condensing units are a discrete choice over non-condensing units, the increase in savings between the two types is expected to be not cost-effective. Condensing units were not analyzed with this update. Therefore, condensing units are excluded from this prescriptive measure approval.

Baseline

This measure uses a code baseline.

The baseline system is a gas-fired unit heater that meets the minimum code efficiency requirements of 80% E_c (combustion efficiency).

Measure Analysis

An hourly bin analysis for Portland, Bend and Astoria climates were used with the appropriate convection heat transfer coefficient for each bin temperature to determine the gas and electric savings of an infrared radiant heater compared to a typical convective type gas fired unit heater. The analysis solely considers the heat loss through the building envelope, by considering it as a slab, and does not attempt to account for interactive effects between heat losses and the internal loads such as lighting, plug load, pumps, fans, solar gains and miscellaneous equipment.

A fully weatherized building is assumed to isolate the effects of radiant heat on the slab, and uses the following assumptions in the steady state heat transfer analysis:

- Room temperature setpoints - heating season: 68°F (occupied), 65°F (unoccupied)
- Outside temperature when heating starts: 60°F
- Convective gas-fired unit heater efficiency: 80%
- Gas fired radiant heater efficiency – non-condensing, non-modulating: 80%
- Gas fired radiant heater efficiency – non-condensing, modulating: 80%
- Ceiling height: 18 ft
- ACH: 0.35

The analysis shows that even though baseline equipment efficiency levels are essentially the same as the target equipment efficiency levels, gas savings are significant. In addition, because the fan in a radiant system is solely used for combustion purposes as opposed to a convective unit which must move the air to condition the space, significant electric savings are realized as well. For modulating infrared units, it is assumed that the unit functions at 75% capacity when the hourly heating load is <30% of the maximum hourly capacity.

Savings calculations assume the baseline and proposed units will be in operation when there is a difference in temperature between the outside air temperature and the room temperature setpoints regardless of occupancy status. Previous analysis assumed the unit to be off when the building is unoccupied even if there is a difference in temperature. The occupied set point temperature is less than the prior analysis.

Savings

Analysis on building sizes of 3,000, 5,000, 10,000, 20,000, 30,000 and 50,000 sq ft were conducted. Applications of radiant heat in spaces larger than 20,000 sq ft were excluded from the final weighted savings estimation as they were found to be inappropriate for a prescriptive measure. Such applications can be expected to require additional design elements (e.g. condensing/non-condensing, single/multi burner, positive/negative pressure, complex gas piping) which will vary costs and are better candidates for a custom measure analysis approach.

The savings presented in Table 1 and Table 2 are based on weighting the prevalence of projects in New Buildings across three climate zones, as shown in Tables 3 and 4. A straight average was used for the four building sizes appropriate to this measure.

Table 3 Non-Modulating Unit Savings Analysis per kBtu/h

Location		3,000 ft²	5,000 ft²	10,000 ft²	20,000 ft²	30,000 ft²	50,000 ft²
Redmond	Ele (kWh)	2.78	1.78	0.95	0.50	0.34	0.20
10.3%	Gas (therms)	3.37	2.99	2.53	2.13	1.92	1.68
Portland	Ele (kWh)	4.72	3.00	1.60	0.83	0.56	0.34
86.6%	Gas (therms)	3.73	3.27	2.70	2.21	1.96	1.66
Astoria	Ele (kWh)	5.25	3.34	1.78	0.93	0.63	0.38
3.1%	Gas (therms)	4.38	3.83	3.17	2.60	2.31	1.98
Weighted	Ele (kWh)	4.53	2.89	1.54	1.03	0.54	0.33
Weighted	Gas (therms)	3.71	3.25	2.70	2.05	1.96	1.68
Average	**Ele (kWh)**	**2.50**					
Average	**Gas (therms)**	**2.93**					

Table 4 Modulating Unit Savings Analysis per kBtu/h

Location		3,000 ft²	5,000 ft²	10,000 ft²	20,000 ft²	30,000 ft²	50,000 ft²
Redmond	Ele (kWh)	2.78	1.78	0.95	0.50	0.34	0.20
10.3%	Gas (therms)	4.43	3.99	3.45	2.98	2.73	2.46
Portland	Ele (kWh)	4.72	3.00	1.60	0.83	0.56	0.34
86.6%	Gas (therms)	4.60	4.10	3.48	2.95	2.67	2.35
Astoria	Ele (kWh)	5.25	3.34	1.78	0.93	0.63	0.38
3.1%	Gas (therms)	5.63	5.00	4.26	3.64	3.31	2.95
Weighted	Ele (kWh)	4.53	2.89	1.54	0.80	0.54	0.33
Weighted	Gas (therms)	4.62	4.11	3.50	2.97	2.70	2.38
Average	**Ele (kWh)**	**2.44**					
Average	**Gas (therms)**	**3.80**					

Measure Life

A standard equipment measure life of 20 years was used in the analysis and aligns with estimates from the Oregon Department of Energy assumptions used in their SEED program. Additionally, since there are few moving parts, equipment life of a radiant system is expected to surpass that of conventional convective air systems. A measure life of 20 years therefore appears conservative when compared with other technologies where maintenance of moving parts may become more of an issue over time

Cost

Values for cost estimation were obtained from the Overhead and Profit (O&P) values for infrared gas fired units as well as gas fired unit heaters found in RS Means 2018. The O&P costs add 10% to the bare material costs, labor costs, overhead and equipment costs. Unit heaters under 30 MBH were excluded from the cost calculations due radiant heaters sizing data. Incremental costs were calculated based on a $/MBH average for both non-modulating and modulating infrared heaters.

Incentive Structure

Incentive basis is heater capacity (kBtu/h). *The maximum incentives listed in Table 1 and Table 2 are for reference only and are not suggested incentives.* The maximum difference between incentives for modulating and non-modulating should not exceed the max incentive listed as for the difference between the measures, which is based on the utility value of the incremental savings.

SRAF

Typical program SRAF rates will apply.

Follow-Up

Costs are significantly lower than reported in the last major update of this measure, which may be a result of wider acceptance of this measure. Promoting a higher tier of efficiency may become necessary to alleviate any free ridership issues from greater market acceptance of this measure.

Supporting Documents

The cost-effectiveness screening for these measures is attached and can be found along with supporting documentation at:
I:\Groups\Planning\Measure Development\Commercial and Industrial\Commercial HVAC\radiant heaters

117_IR Heater_OR-WA-CE C

Radiant_Heater_Analysis_non_condens

Version History and Related Measures

Energy Trust has been offering radiant heaters for many years. These measures predate our current measure approval process and record retention destruction dates. Table 5 may be incomplete, especially for approvals before 2013.

Table 5 Version History

Date	Version	Reason for revision
4/4/12	117.1	Radiant heaters approved
7/19/18	117.2	Update savings and costs with new set points and climate zones.

Approved & Reviewed by

Jackie Goss, PE
Sr. Planning Engineer

Mike Bailey PE
Engineering Manager Planning

Disclaimer

This Energy Trust document and its attachments may be used by you or shared, at no cost, with other parties who are interested in our work and analyses. Should you or anyone with whom this document is shared, have suggestions for improvement of our work, please let us know. You may modify this 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.

EnergyTrust of Oregon

Measure Approval Document for New Cooler Cases with Doors

Valid Dates

1/1/2018-12/31/2020

Description

Installation of new vertical medium-temperature grocery display cases with doors, instead of open cases.

Program Applicability

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

- Existing Buildings
- New Buildings

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

- Convenience Stores
- Grocery Stores
- Big Box Retail Stores with Grocery Sections

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

- New
- Replacement

Cost Effectiveness

Table 1 Cost Effectiveness Calculator Oregon

Measure	Measure Life (years)	Savings (kWh/lf)	Savings (therms/lf)	Incremental Costs ($/lf)	Non Energy Benefits ($/lf)	Maximum Incentive ($/lf)	UCT BCR at Max Incentive	TRC BCR	% Electric Allo-cation	% Gas Allo-cation
Cooler Doors in Convenience, Electric Heating	15	412	0	$206		$206	1.41	1.41	100%	0%
Cooler Doors in Medium Grocery, Electric Heating	15	458	0	$206		$206	1.56	1.56	100%	0%
Cooler Doors in Large Grocery, Electric Heating	15	733	0	$206		$206	2.50	2.50	100%	0%
Cooler Doors in Convenience, Gas Heating	15	277	18.9	$206		$206	1.46	1.46	65%	35%
Cooler Doors in Medium Grocery, Gas Heating	15	196	36.8	$206		$206	1.68	1.68	40%	60%
Cooler Doors in Large Grocery, Gas Heating	15	494	33.7	$206		$206	2.61	2.61	65%	35%
Cooler Doors in Convenience, Gas Heating, Gas only	15		18.9	$206	$21.89	$106	1.00	1.67	0%	100%
Cooler Doors in Medium Grocery, Gas Heating, Gas only	15		36.8	$206	$15.48	$206	1.01	1.82	0%	100%
Cooler Doors in Large Grocery, Gas Heating, Gas only	15		33.7	$206	$38.96	$190	1.00	2.98	0%	100%

Table 2 Cost Effectiveness Calculator Washington

Measure	Measure Life (years)	Savings (kWh/lf)	Savings (therms/lf)	Incremental Costs ($/lf)	Non Energy Benefits ($/lf)	Maximum Incentive ($/lf)	UCT BCR at Max Incentive	TRC BCR	% Electric Allo-cation	% Gas Allo-cation
Cooler Doors in Convenience, Gas Heating	15		18.9	$206	$21.37	$114	1.00	1.59	0%	100%
Cooler Doors in Medium Grocery, Gas Heating	15		36.8	$206	$15.11	$206	1.08	1.81	0%	100%
Cooler Doors in Large Grocery, Gas Heating	15		33.7	$206	$38.02	$203	1.00	2.83	0%	100%

Requirements

- This measure is applicable to the purchase of new remote commercial refrigerated medium temperature display cases with doors in new construction or existing buildings when additional cases are added or existing cases are replaced.
- Self-contained condensing unit display cases are not eligible for this measure.
- Refurbished cases are not eligible for this measure.

Details

Warm air and moisture from the sales floor (infiltration) are responsible for 70-80% of the refrigeration load on open vertical refrigerated display cases. Adding doors greatly reduces this infiltration, thereby reducing the load on the refrigeration system resulting in energy savings. In addition to refrigeration savings, there are interactive effects with the store's heating and cooling systems leading to heating savings, and a cooling penalty.

Measure Analysis

The baseline is a new vertical medium temperature remote commercial refrigerated display case without doors.

Savings were calculated to include savings/penalties associated with the following components: decreased load on refrigeration system due to decrease in infiltration from the sales floor, interactions with the building heating, and interactions with building cooling.

The infiltration savings is calculated as the difference between the case load without doors and with doors multiplied by the estimated full load refrigeration hours based on building type and region divided by the code minimum EER (12.85) for a medium temperature remote commercial refrigeration display case[i]. The EFLH hours estimates were derived using hourly reports produced using the GrocerSmart eQUEST models. Hourly reports were generated for the building refrigeration load, heating load, and cooling load. The sum of all hourly loads was divided by the peak annual load to determine the annual equivalent full load hours. Separate models were used representing Convenience Stores, Small Grocery, Medium Grocery, and Large Grocery. Cases with doors are assumed to have 75% lower infiltration loads and 55% lower conduction loads than cases without doors, resulting in overall loads for cases with doors, 27% of those for cases without doors[ii].

The building heating savings is calculated as the difference between the case load without doors and with doors multiplied by the estimated full load heating hours based on building type and region divided by the code minimum heating efficiency for either a gas fired furnace or an electric heat pump system.

The building cooling penalty is calculated as the difference between the case load without doors and with doors multiplied by the estimated full load cooling hours based on building type and region divided by the code minimum air conditioner efficiency.

Savings were reported separately based on the following categories:

1. Building type: convenience stores and small grocery stores (modeled to represent <14,000 SF), medium grocery stores (≥14,000 SF, <75,000 SF), and large grocery stores (≥75,000 SF with non-grocery spaces)
2. Type of building heat: electric or natural gas
3. Energy Trust region: Portland, Eugene, Astoria, Medford, and Pendleton.

Savings calculations are included in the workbook called: "NB Medium Temperature Case Doors Calculator_07252017.xlsx".

Self-contained refrigerated cases were excluded from this analysis. A leading display case manufacturer informed the program that due to the new 2017 DOE energy efficiency requirements for refrigerated cases, they do not currently offer a self-contained medium temperature case that has doors.

Savings are reported separately for different store sizes/types, as the savings between different store types showed relatively high variation. Savings are averaged across different weather locations, as the savings between different locations showed relatively low variation. The combined savings and analysis of differences between store sizes and locations can be found in the "NB Medium Temperature Case Doors Sorted Savings_07252017.xlsx" spreadsheet. Final savings are shown in Table 1.

Comparison to RTF or other programs

The RTF's cooler door retrofit measure of doors onto existing cases is currently inactive.

Energy Trust's Existing Buildings program has a cooler door retrofit measure (MAD ID 47) based on the RTF's now-inactive measure (workbook v1.0)[iii]. Both costs and savings are expected to be lower for new cases than for retrofits. The lower savings are partially due to differences in calculation methods, and partially due to the assumption of higher efficiency refrigeration equipment. Energy Trust's retrofit measure does not differentiate by store type.

Measure Life

The measure life is 15 years, consistent with other standard grocery refrigeration measures in Energy Trust and RTF programs.

Cost

A leading display case manufacturer was surveyed and it was estimated that the average incremental cost of purchasing a remote commercial medium temperature vertical case with doors compared to one without doors was $206.25/linear foot of case.

Non Energy Benefits

In Energy Trust's gas-only territory, where Energy Trust cannot incent or claim electric savings, electric bill savings experienced by customers are calculated as non-energy benefits.

Incentive Structure

The maximum incentives listed in Table 1 and Table 2 are for reference only and are not suggested incentives. Note that in gas-only territory, maximum incentives are lower than in full-service or electric-only territory and differ by grocery size and between Oregon and Washington. This measure is applicable to the grocery Market Solutions offering. New Buildings incentives must be set such that projects receiving a the highest Market Solutions bonus do not exceed the maximum incentives.

Incentives will be structured per linear foot of case.

Follow-Up

Minimum efficiency for commercial refrigeration equipment is defined by federal standards, documented in 10 CFR 431.66. This measure should be revised when commercial refrigeration equipment standards are revised.

Supporting Documents

The cost effective screening for these measures is attached and can be found along with other supporting documents at:
I:\Groups\Planning\Measure Development\Commercial and Industrial\Grocery\cooler doors\New coolers

NB Medium Temperature Case D

Version History and Related Measures

Table 3 Version History

Date	Version	Reason for revision
8/11/17	201.1	Approve cooler doors for new cases.

Table 4 Related Measures

Measures	MAD ID
Cooler Door Retrofits	47
Grocery Market Solutions	161

Approved & Reviewed by

Jackie Goss, PE
Sr. Planning Engineer

Mike Bailey PE
Engineering Manager - Planning

Disclaimer

This Energy Trust document and its attachments may be used by you or shared, at no cost, with other parties who are interested in our work and analyses. Should you or anyone with whom this document is shared, have suggestions for improvement of our work, please let us know. You may modify this 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.

[i] DOE federal standard electronic code of federal regulations Subpart C 2017 references AHRI standard 1200 (I-P)-2010 for the EER of remote commercial display cases.
[ii] Faramarzi, Ramin T., B.A. Coburn and R. Sarhadian, 2002. *Performance and Energy Impact of Installing Glass Doors on an Open Vertical Deli/Dairy Display Case*. ASHRAE Transactions, AC-02-7-2, pp 673-679.
[iii] https://rtf.nwcouncil.org/measure/walk-inreach-door-retrofit

Measure Approval Document for Commercial Foodservice Cooking Measures

Valid Dates
January 1, 2019 to December 31, 2021

End Use or Description
ENERGY STAR rated electric and gas foodservice cooking equipment

Program Applicability
Based on the referenced analysis and associated cost-effectiveness screening, the measures described below are approved for use in the following programs where commercial kitchens are served:

- Existing Buildings
- New Buildings
- Multifamily
- Production Efficiency

Within these programs, applicability to the following building types or market segments are expected where commercial kitchens are present in:

- Full and quick service restaurants, including those in mixed use buildings such as hotels or casinos.
- Penitentiaries
- Hospitals
- Grocery stores
- Schools

Within these programs, the measure is applicable to the following cases:

- New
- Replacement

Purpose of Re-Evaluating Measure
This update adjusts savings and costs based on the latest ENERGY STAR standards. Additionally, savings are revised to account for lower hours of use than in the past version.

Gas griddles and electric half-size convection ovens are no longer approved in Oregon. Hot food holding cabinets no longer differentiated by size.

Rack ovens were inadvertently left out of version 101.2. This is a small update to include them.

Cost Effectiveness
Table 1 Cost Effectiveness Calculator Oregon

Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR
Electric Fryers	12	2,610	0	$276	$0	$276	5.7	5.7
Electric Griddles	12	1,572	0	$860	$0	$860	1.1	1.1
Electric Convection Ovens Full-Size	12	1,620	0	$388	$0	$388	2.5	2.5
Hot Food Holding Cabinets Any Size	12	1,415	0	$680	$0	$680	1.3	1.3
Electric Steam Cookers Any Size	12	13,061	0	$3,400	$1,993	$3,400	2.3	7.7
Electric Combination Oven Any Size	12	5,229	0	$1	$0	$3,157	1.0	3157
Gas Fryers	12	0	431	$1,290	$0	$1,290	1.2	1.2
Gas Convection Ovens Full-Size	12	0	107	$388	$0	$388	1.0	1.01
Gas Steam Cookers Any Size	12	0	865	$2,270	$1,993	$2,270	1.4	9.50
Gas Combination Oven Any Size	12	0	277	$1	$0	$1,016	1.0	1016
Rack Oven – Single Rack	12	0	995	$1	$0	$3,000	1.2	3647
Rack Oven – Double Rack	12	0	1,689	$1	$0	$6,000	1.0	6188

Table 2 Cost Effectiveness Calculator Washington

Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR
Gas Fryers	12	0	431	$1,290	$0	$1,290	2.3	2.3
Gas Griddles	12	0	103	$1,250	$0	$696	1.0	0.6
Gas Convection Ovens Full-Size	12	0	107	$388	$0	$388	1.9	1.9
Gas Steam Cookers	12	0	865	$2,270	$1,901	$2,270	2.6	9.7
Gas Combination Oven	12	0	277	$1	$0	$1,878	1.0	1878
Rack Oven - Single Rack	12	0	995	$1	$0	$3,000	2.2	6740
Rack Oven - Double Rack	12	0	1689	$1	$0	$6,000	1.9	11436

Requirements

- Fryer vat can be standard vat or large vat and must be a minimum of 12 inches wide.
- Convection ovens must be capable of accommodating standard full-size sheet pans measuring 18 x 26 x 1 inch to be considered full size.
- Single Rack ovens must be capable of accommodating one removable single rack of standard sheet pans measuring 18 x 26 x 1 inch.
- Double Rack ovens must be capable of accommodating two removable single racks of standard sheet pans measuring 18 x 26 x 1 inch or one removable double-width rack.
- Product must appear on the most current ENERGY STAR criteria list under the Commercial Foodservice Equipment program and meet criteria listed in ENERGY STAR specifications.

Table 3 ENERGY STAR Specifications 2018

Equipment	ENERGY STAR Version Number
Standard Vat Fryers	3.0
Griddles	1.2
Convection Ovens	2.2
Combination Ovens	2.2
Rack Ovens	2.2
Hot Food Holding Cabinets	2.0
Steam Cookers	1.2

Baseline

This measure uses an inefficient market baseline.

The Savings Calculator for ENERGY STAR Certified Commercial Kitchen Equipment utilizes non-qualifying equipment models, based on EPA and Food Service Technology Center (FSTC) research, as the inefficient market baseline. This measure analysis utilizes the default assumptions in the calculator.

Measure Analysis

Measure savings are determined by the Savings Calculator for ENERGY STAR Certified Commercial Kitchen Equipment outputs. The ENERGY STAR defaults for equipment specifications were utilized for all usage types. The sited sources for this data are as follows:

- Food Service Technology Center (FSTC) research on available models, dated 2009 and 2011
- EPA research on available models, dated 2013 (ovens only)
- Fisher Nickel Calculator (ovens only)
- ENERGY STAR specifications

Gas steam cookers were evaluated at a variety of sizes and the savings were averaged.

The 2015-2016 Existing Buildings Impact Evaluation found hours of use were overestimated for several sampled projects, particularly schools. To address that, high-usage and low-usage scenarios have been separately evaluated with a weighted average applied based on historical data for commercial food service measures. To determine how to define high usage vs low usage, a survey was sent to contacts from previous commercial kitchen participants to determine actual hours of equipment use. All responses with operation hours less than 12 hrs/day, which is the ENERGY STAR default, were assumed to be low usage and were averaged.

High-usage

ENERGY STAR's default values are utilized for sizing and hours of use.

- All measures 365 days/yr
- Griddles, ovens, steam cookers – 12 hrs/day
- Hot food holding cabinets – 15 hrs/day
- Fryers – 16 hrs/day

Low-usage

ENERGY STAR's default values are utilized for sizing, with no adjustments to quantity of food prepared due to the difficulty validating any estimate. Hours of for all measures are the average of survey respondents for non-restaurant market types:

- 197 days/yr
- 5.8 hrs/day

Weighting

The assumptions for high and low usage were entered into the Savings Calculator for ENERGY STAR Certified Commercial Kitchen Equipment separately and the results were then entered into the Cost Effectiveness Calculator. A weighted average was then applied at a rate of 77% for restaurants and 23% for non-restaurants to provide the final savings for all measures.

Comparison to RTF

RTF offers only electric food service cooking equipment, all in Planning or Small Saver status. There are several key differences between RTF and Energy Trust. RTF uses a full market baseline, which discounts savings due to prevalence of ENERGY STAR equipment in the marketplace, while Energy Trust use an inefficient market baseline and applies free-ridership in SRAFs. Rather than using the ENERGY STAR calculator, RTF does custom engineering calculations and on the equipment they offer. Additionally, RTF differentiates a variety of sizes for all equipment, while Energy Trust simplifies most equipment to be an average of all sizes.

For consistency with our gas equipment, Energy Trust uses ENERGY STAR calculator and assumptions for all equipment rather than mixing RTF and ENERGY STAR methods. In all cases, RTF's inclusion of market prevalence is the biggest source of difference. Other notable differences include:

- Electric fryers, our savings are notably higher than RTF, primarily because RTF assumes 40% less food cooked per day than ENERGY STAR assumes.
- Electric Hot Food Holding Cabinets, our savings are notably lower than RTF, because RTF assumes lower idle energy use that ENERGY STAR specifies.

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. This is also the default measure life used in the Savings Calculator for ENERGY STAR Certified Commercial Kitchen Equipment. The ENERGY STAR calculator sites FSTC research on available models in 2009 as the source for a 12 year measure life.

Cost

The Savings Calculator for ENERGY STAR Certified Commercial Kitchen Equipment determines incremental equipment cost as the difference between an ENERGY STAR and non-ENERGY STAR model. The resources for these costs are sited as coming from EPA research using Auto Quotes, dated July 2016. ENERGY STAR's default cost values are utilized for all measures, with the exception of standard vat fryers and hot food holding cabinets. Fryers and hot food holding cabinets are important measures to the Existing Buildings program and a regional analysis of past project cost and distributor surveys provided local cost information.

For measures where the ENERGY STAR calculator indicates a negative incremental cost, $1 is used in cost effectiveness testing. 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 continue to offer incentives that appear to be above incremental cost.

Incentive Structure

The maximum incentives listed in Table 1 and Table 2 are for reference only and are not suggested incentives. Standard incentives should be set to accommodate any known or potential bonuses without exceeding the maximum incentives. Currently, the New Buildings Program offers bonuses up to 20% on cooking equipment through various Market Solutions packages.

Incentives will be structured per item, not to exceed invoice cost.

For measures where the ENERGY STAR calculator indicates no incremental cost, $1 is used in cost effectiveness testing. In these cases, the maximum incentive is set to the maximum incentive that passes the utility cost test, or low end of expected cost of equipment, whichever is lower. In these cases, planning suggest incentives be well below the maximum.

Non-Energy Benefits

ENERGY STAR rated steamers save about 135,000 gallons of water annually. This is included as a non-energy benefit. Combination ovens also save water, though the ENERGY STAR calculator does not quantify how much, so it is not included in our analysis.

Follow-Up

Oregon Energy Efficiency codes are expected to be updated and be effective fall of 2019. If updated energy codes require ENERGY STAR cooking equipment, this MAD must be revised to exclude programs or projects that are subject to the code.

Measures should be reviewed on a regular basis for changes to Energy Star specifications and federal standards.

Supporting Documents

The cost effective screening for these measures and the ENERGY STAR calculators are attached and can be found along with supporting documentation at: I:\Groups\Planning\Measure Development\Commercial and Industrial\Food Service\Cooking Equipment


CEC_OR-WA 2019 v1.1 Commercial Foc


commercial_kitchen _equipment_calculat


commercial_kitchen _equipment_calculat

References

Savings Calculator for ENERGY STAR Certified Commercial Kitchen Equipment (2017)

Version History and Related Measures

Energy Trust has been offering ENERGY STAR food service cooking equipment for many years. These measures predate our measure approval documentation and record retention practices. Table 4 may be incomplete, particularly for offerings approved before 2013.

Table 4 Version History

Date	Version	Reason for revision
4/7/05	x.x	Revise gas fryer measures
4/8/05	x.x	Approve gas griddles
12/12/05	x.x	Approve electric hot food holding cabinets and steam cookers
3/22/07	x.x	Revise gas fryer savings, add gas convection oven
10/14/09	101.x	Merge several cooking approvals into single document, revise all savings and costs, remove electric griddles and electric fryers.
7/16/13	101.x	Update fryer costs
9/23/13	101.x	Change format to include maximum incentives
8/7/14	101.1	Update costs. Add electric griddles, electric fryers, electric combination ovens and gas combination ovens. Add multifamily and production efficiency as applicable programs.
7/9/2018	101.2	Update hours of use and latest Energy Star specifications. Cost updates
7/25/18	101.3	Add rack ovens

Table 5 Related Measures

Measures	MAD ID
Commercial Dishwashers	35
Commercial Ice Machines	90
Venthood Controls Prescriptive	122
Venthood Controls Calculator	184
Restaurant Market Solutions	158
Grocery Market Solutions	161
Retail Market Solutions	160
Primary Schools Market Solutions	165

Approved & Reviewed by

Jackie Goss, PE
Sr. Planning Engineer

Mike Bailey PE
Engineering Manager Planning

Disclaimer

This Energy Trust document and its attachments may be used by you or shared, at no cost, with other parties who are interested in our work and analyses. Should you or anyone with whom this document is shared, have suggestions for improvement of our work, please let us know. You may modify this 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.

Measure Approval Document for Direct Install Showerheads and Shower Wands

Valid Dates
1/1/2019 – 12/31/2019

End Use or Description
Low flow showerheads and shower wands by direct install in Oregon single and multifamily. In Washington, the customer purchased measure is in qualifying commercial rate multifamily entities as customer purchased and installed low flow showerheads and wands. For the leave-behind offering in Washington, the PMC (upon approved contract from Energy Trust) performs a walkthrough survey of eligible facilities to identify potential energy saving opportunities. As part of this offering, the PMC may recommend and provide high efficiency showerheads and/or shower wands at no cost for installation at the facility.

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

- Existing Multifamily
- Existing Homes
- Multifamily in Washington, limited to sites that qualify for participation under the existing buildings program

Within these programs, the measure is applicable to the following cases:

- Retrofit

Purpose of Re-Evaluating Measure
Alignment with RTF Showerhead v3.1 workbook savings methodology

Cost Effectiveness
Table 1 Cost Effectiveness Calculator Oregon

Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Electric Allocation	% Gas Allocation
SF Direct Install 1.75 GPM Showerhead Any Electric	15	287	0	$12	$29.27	$12.00	17.61	44.17	100%	0%
SF Direct Install 1.75 GPM Showerhead Full Territory Gas	15	8	12.8	$12	$29.27	$12.00	5.46	32.02	9%	91%
SF Direct Install 1.75 GPM Showerhead Partial Territory Gas	15	0	12.8	$12	$30.02	$12.00	4.97	32.20	0%	100%
SF Direct Install 1.50 GPM Showerhead Any Electric	15	372	0	$12	$37.89	$12.00	22.79	57.17	100%	0%
SF Direct Install 1.50 GPM Showerhead Full Territory Gas	15	10	16.6	$12	$37.89	$12.00	7.07	41.45	9%	91%
SF Direct Install 1.50 GPM Showerhead Partial Territory Gas	15	0	16.6	$12	$38.85	$12.00	6.43	41.68	0%	100%
SF Direct Install 1.75 GPM Shower Wand Any Electric	15	285	0	$28	$29.01	$28.00	7.48	18.76	100%	0%
SF Direct Install 1.75 GPM Shower Wand Full Territory Gas	15	8	12.7	$28	$29.01	$28.00	2.32	13.60	9%	91%
SF Direct Install 1.75 GPM Shower Wand Partial Territory Gas	15	0	12.7	$28	$29.75	$28.00	2.11	13.68	0%	100%
SF Direct Install 1.50 GPM Shower Wand Any Electric	15	415	0	$28	$42.28	$28.00	10.90	27.35	100%	0%

Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Electric Allocation	% Gas Allocation
SF Direct Install 1.50 GPM Shower Wand Full Territory Gas	15	12	18.5	$28	$42.28	$28.00	3.38	19.83	9%	91%
SF Direct Install 1.50 GPM Shower Wand Partial Territory Gas	15	0	18.5	$28	$43.36	$28.00	3.07	19.94	0%	100%
MH Direct Install 1.75 GPM Showerhead Any Electric	15	333	0	$12	$33.96	$12.00	20.43	51.25	100%	0%
MH Direct Install 1.75 GPM Showerhead Full Territory Gas	15	9	14.9	$12	$33.96	$12.00	6.34	37.16	9%	91%
MH Direct Install 1.75 GPM Showerhead Partial Territory Gas	15	0	14.9	$12	$34.83	$12.00	5.76	37.37	0%	100%
MH Direct Install 1.50 GPM Showerhead Any Electric	15	411	0	$12	$41.88	$12.00	25.20	63.20	100%	0%
MH Direct Install 1.50 GPM Showerhead Full Territory Gas	15	12	18.4	$12	$41.88	$12.00	7.82	45.82	9%	91%
MH Direct Install 1.50 GPM Showerhead Partial Territory Gas	15	0	18.4	$12	$42.95	$12.00	7.11	46.08	0%	100%
MH Direct Install 1.75 GPM Shower Wand Any Electric	15	330	0.0	$28	$33.57	$28.00	8.66	21.71	100%	0%
MH Direct Install 1.75 GPM Shower Wand Full Territory Gas	15	9	14.7	$28	$33.57	$28.00	2.69	15.74	9%	91%
MH Direct Install 1.75 GPM Shower Wand Partial Territory Gas	15	0	14.7	$28	$34.43	$28.00	2.44	15.83	0%	100%
MH Direct Install 1.50 GPM Shower Wand Any Electric	15	449	0.0	$28	$45.77	$28.00	11.80	29.60	100%	0%
MH Direct Install 1.50 GPM Shower Wand Full Territory Gas	15	13	20.1	$28	$45.77	$28.00	3.66	21.46	9%	91%
MH Direct Install 1.50 GPM Shower Wand Partial Territory Gas	15	0	20.1	$28	$46.94	$28.00	3.33	21.58	0%	100%
MF Direct Install 1.50 GPM Showerhead Any Electric	15	340	0.0	$12	$34.61	$12.00	20.82	52.23	100%	0%
MF Direct Install 1.50 GPM Showerhead Full Territory Gas	15	10	15.2	$12	$34.61	$12.00	6.46	37.87	9%	91%
MF Direct Install 1.50 GPM Showerhead Partial Territory Gas	15	0	15.2	$12	$35.50	$12.00	5.87	38.08	0%	100%
MF Direct Install 1.50 GPM Shower Wand Any Electric	15	250	0.0	$28	$25.47	$28.00	6.57	16.47	100%	0%
MF Direct Install 1.50 GPM Shower Wand Full Territory Gas	15	7	11.2	$28	$25.47	$28.00	2.04	11.94	9%	91%
MF Direct Install 1.50 GPM Shower Wand Partial Territory Gas	15	0	11.2	$28	$26.12	$28.00	1.85	12.01	0%	100%

Table 2 Cost Effectiveness Calculator Washington

Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Electric Allocation	% Gas Allocation
WA Customer Purchase MF Gas 1 75 GPM Showerhead	15	0	9.8	$7.14	$13.80	$7.14	6.43	25.65	0%	100%
WA Customer Purchase MF Gas 1 50 GPM Showerhead	15	0	13.5	$7.14	$18.91	$7.14	8.81	35.15	0%	100%
WA Customer Purchase MF Gas 1 75 GPM Shower Wand	15	0	4.3	$7.14	$6.04	$7.14	2.82	11.23	0%	100%
WA Customer Purchase MF Gas 1 50 GPM Shower Wand	15	0	9.9	$7.14	$13.92	$7.14	6.48	25.86	0%	100%
WA Leave Behind MF Gas 1 75 GPM Showerhead	15	0	7.4	$12.00	$13.80	$12.00	5.10	16.54	0%	100%
WA Leave Behind MF Gas 1 50 GPM Showerhead	15	0	10.1	$12.00	$18.91	$12.00	6.99	22.66	0%	100%
WA Leave Behind MF Gas 1 75 GPM Shower Wand	15	0	3.2	$28.00	$6.04	$26.78	1.00	3.10	0%	100%
WA Leave Behind MF Gas 1 50 GPM Shower Wand	15	0	7.4	$28.00	$13.92	$28.00	2.20	7.15	0%	100%

Requirements

- In Oregon, direct installation of showerheads by a contractor, PMC, or program ally
- In Washington the customer purchase measure requires a PMC determined minimum (currently 10 but subject to change) number of showerheads and/or shower wands must be purchased by a customer through a vendor or Trade Ally that has not discounted the product through participation in Energy Trust's retail showerhead offering
- Washington retail as well as leave behind participation is limited to multifamily properties that qualify for services through the Existing Buildings program on a commercial gas rate with gas water heat
- Water heating fuel must be provided by an Energy Trust Utility

Details

Low flow water devices save energy by reducing the volume of water that needs to be heated. Additionally, energy savings are generated from the treatment reduction on the wastewater and water treatment plants.

Baseline

This measure uses

- Modified Existing Condition (OR MF)
- Existing Condition (SF, MH, WA MF)

The Oregon Existing Multifamily program uses modified existing condition baseline because properties screen for flow rates greater than the efficient flow rate. This screening occurs beforehand in the form of a phone call, as well as during the direct install thought on-site verification. Therefore, the baseline is adjusted so that it does not include these efficient devices.

The Residential Programs and Washington Multifamily do not perform as extensive testing and therefore use an existing condition baseline to account for efficient products.

Table 3 Distribution of Showerhead and Wand Flow Rates for Oregon

			Rated Flow Rate						
Type	Home Type	Data Source	>2.5 GPM	2_50 GPM	2_00 GPM	1_80 GPM	1_75 GPM	1_60 GPM	1_50 GPM
Direct Install	SF - Any Device	RBSA I	44%	34%	6%	0%	11%	0%	5%

			Rated Flow Rate						
Direct Install	OR MF - Showerhead	ETO Field Test	31%	31%	16%	0%	22%	0%	0%
Direct Install	OR MF - Shower wand	ETO Field Test	3%	35%	25%	0%	38%	0%	0%
Direct Install	WA MF - Showerhead	ETO Field Test	29%	29%	15%	0%	21%	0%	6%
Direct Install	WA MF - Shower wand	ETO Field Test	2%	26%	19%	0%	28%	0%	26%
Direct Install	MH - Any Device	RBSA I	66%	18%	4%	0%	2%	0%	9%

Measure Analysis

Savings analysis is based on a modified version of the RTF's and commercial and residential showerhead workbook v3.1.[1]

The RTF uses the following equations to develop unit energy consumptions, UECs, for each water heater technology, flow rate of showerhead/wand and housing type:

1. [Water consumption] = [rated flow rate (gallons/minute)] x [in use flow adjustment] x [# of events/yr] x [event duration (minutes/event)]
2. [End-use Energy consumption] = [water consumption] x [mixed hot water energy intensity (kWh/gallon)]
3. [Embedded water/waste water energy consumption] = [water consumption] x [water/waste water energy intensity (kWh/gallon)]

Table 4 through Table 6 describe the various inputs used to estimate individual UECs for all combinations of measure types, with specific inputs and outputs presented in Table 7 and Table 8. UECs are then combined with baseline existing condition data from Table 3 to generate a common energy consumption from which specific UECs for flow rates can be subtracted to generate unit energy savings, or UESs, discussed in the savings section (Table 10).

Table 4 below presents the inputs to estimate energy intensity of water heating by various technologies. Recovery energy (RE) for electric resistance and gas storage water heaters are sourced from the RTF standard information workbook, SIW.[2] Heat pump water heater recovery efficiency of 200% is an RTF judgement. Remaining values are RTF input assumptions and calculations.

Table 4 Water Heater Recovery Energy, Temperature Rise and Energy Intensities by Water Heater Type and Fuel

Water Heating Type	RE	Water Heater delta T	Effective delta T of mixed hot water for shower	Specific Heat of Water (kWh/gallon/degF)	Specific Heat of Water (therms/gallon/degF)	Energy Intensity (kWh/gallon)	Energy Intensity (therms/gallon)
Electric Resistance	1.00	75	52.5	0.0024		0.128	
Electric HPWH	2.00	75	52.5	0.0024		0.064	
Gas	0.75	75	52.5		0.0001		0.0058

Table 5 below presents the in-situ multipliers for the various flow rate categories in addition to the estimate length of shower associated with each rated flow rate (1.6 gpm device duration deviated substantially from 1.5 and 1.75 gpm devices, 8.4 minutes, and instead uses an average of the two flow rates, 9.03 minutes).[3] 90% is the multiplier used by the RTF while 1.5 gpm devices used in-situ rates found in a 2016 Energy Trust field study on 1.5 gpm devices.[4]

Values above 2.5 gpm are based on RBSA I measured findings divided by an in-situ rate of 90% to estimate a rated flow value.

Table 5 Flow Rate In-situ adjustments and Shower Event Duration by Rated Flow Rate

Rated Flow Rate Category	Rated flow rate (gpm)	In situ adjustment	duration (minutes/event)
>2.5 GPM	3.67	90%	7.39
2.50 GPM	2.50	90%	8.20

[1] RTF Commercial and Residential Showerheads v3.1
[2] RTF Standard information workbook v2.6 (current SIW version as of this publication date is v3.2, but values remain the same).
[3] Aquacraft, Inc. Residential End Uses of Water
[4] Energy Trust Multifamily Showerhead Study Report

2.00 GPM	2.00	90%	8.37
1.80 GPM	1.80	90%	8.72
1.75 GPM	1.75	90%	8.86
1.60 GPM	1.60	90%	9.03
1.50 GPM	1.50	88% (81% for wands)	9.21

Table 6 describes the inputs used to generate people per showerhead. RBSA I data specific to Oregon provides average and total showerheads per housing type (single family, manufactured home, multifamily), while 2015 American Community Survey, ACS, data is used to source Oregon occupancy per housing type, and gas heated homes only for the Southwest Washington service territory. Given the ACS does not collect water heating fuel, gas heated homes are used as a proxy for occupants per housing type in homes with gas water heating.

RBSA I data is extremely limited for SW Washington resulting in the use of the Oregon RBSA I distribution of total showerheads to create a weighted average occupant per showerhead for both Oregon and Washington.

Table 6 Showerheads per Dwelling, Total Showerheads and Occupancy per Housing Type

	SF	MH	MF	Weighted Avg
Oregon total # of showerheads (RBSA I)	**2,030,706**	**283,035**	**269,610**	**-**
Oregon average # of showerheads per residence (RBSA I)	1.7	1.65	1.21	1.65
Occupants per dwelling 2015 OR ACS	2.47	2.44	2.11	2.43
Occupants per shower Oregon	***1.45***	***1.48***	***1.75***	***1.48***
Total Oregon shower events (at 250 events per person/yr)	***362***	***369***	***436***	***371***
Washington				
Occupants per gas dwelling 2015 SW WA ACS	2.98	2.13	2.34	2.82
Occupants per shower SW Washington	***1.75***	***1.29***	***1.94***	***1.72***
Total Washington shower events (at 250 events per person/yr)	***437***	***322***	***484***	***430***

Table 7 below illustrates the combined inputs used to generate UECs by water heater type, flow rate, measure type and housing type for a limited number of flow rates. Energy Trust specific costs of water per gallon have been added as well (separate values are used for Oregon and Washington).

Table 7 Examples of Combined Inputs used for Oregon Single Family Showerhead Unit Energy Consumption Calculation

Showerhead Water Heater Type and Flow Rate	Rated Flow Rate (gpm)	In use flow adjustment	Frequency for SF (events/yr)	Event duration (minutes/event)	End-use energy intensity (kWh or therms/gallon)	Water/ waste water energy intensity (kWh/gallon)	Energy Trust OR water/waste water cost, net of energy cost ($/gallon)
Electric Resistance 1.75 GPM	1.75	90%	362	8.9	0.128	0.0037	$0.013
Electric Resistance 1.50 GPM	1.50	88%	362	9.2	0.128	0.0037	$0.013
Electric HPWH 1.75 GPM	1.75	90%	362	8.9	0.064	0.0037	$0.013
Electric HPWH 1.50 GPM	1.50	88%	362	9.2	0.064	0.0037	$0.013
Gas 1.75 GPM	1.75	90%	362	8.9	0.0058	0.0037	$0.013
Gas 1.50 GPM	1.50	88%	362	9.2	0.0058	0.0037	$0.013

Table 8 Shows the UEC values based on the inputs from Table 7.

Table 8 Examples of Unit Energy Consumption Outputs

Showerhead Water Heater Type and Flow Rate	Water Consumption (gallons/year)	Primary Energy Consumption		Embedded Water/Waste Water		In use flow rate (gpm)
		Annual Energy Consumption (kWh/yr)	Annual Energy Consumption (therms/yr)	Annual Energy Consumption (kWh/yr)	Energy Trust water/ Waste Water cost ($/yr)	
Electric Resistance 1.75 GPM	5,607	719	0	21	$74.58	1.58
Electric Resistance 1.50 GPM	4,888	626	0	18	$65.01	1.32
Electric HPWH 1.75 GPM	5,607	359	0	21	$74.58	1.58
Electric HPWH 1.50 GPM	4,888	313	0	18	$65.01	1.32
Gas 1.75 GPM	5,607	0	33	21	$74.58	1.58
Gas 1.50 GPM	4,888	0	28	18	$64.01	1.32

Table 9 Shows the split used between standard electric resistance storage and heat pump water heaters. This value is an RTF judgement and was made after RBSA I and prior to RBSA II data being available. These values enable one common electric water heating baseline UEC.

Table 9 Electric Water Heater Weighting

Housing Type	Electric Resistance	Electric HPWH
Any Electric Any home	98%	2%
Any Electric SF	98%	2%
Any Electric MF	98%	2%
Any Electric MH	98%	2%

Savings

Table 10 Illustrates the calculation of UESs for Oregon electric showerhead measures in the direct install track. An installation rate of 90% is applied to savings in all sectors. For formatting reasons water/wastewater is shortened to W/WW

Table 10 Example of Unit Energy Savings Calculation for Oregon Direct Install Electric Showerheads

			Base Case - RUL					Efficient Case					Savings and NEBs, Install Rates Applied			
Territory	Water Heating Type	Flow Rate - Efficient Case	Energy DHW (kWh/yr)	Energy DHW (therms/yr)	Water (gallons/yr)	Energy W/WW (kWh/yr)	Energy Trust W/WW cost ($/yr)	Energy DHW (kWh/yr)	Energy DHW (therms/yr)	Water (gallons/yr)	Energy W/WW (kWh/yr)	Energy Trust W/WW cost ($/yr)	Install Rate	Total kWh savings (DHW+WW/yr)	Final therm savings	Final NEBs
Full Territory	Any Electric	1_75 GPM	1,022	0	8,053	30	$107.10	711	0	5,607	21	$74.58	90%	287	-	$29.27
Full Territory	Gas	1_75 GPM	0	47	8,053	30	$107.10	0	33	5,607	21	$74.58	90%	8	12.8	$29.27
Partial Territory	Gas	1_75 GPM	0	47	8,053	30	$107.10	0	33	5,607	21	$74.58	90%	0	12.8	$30.02

In Washington, since the measure is customer-installed, a 60% installation rate is used.

Comparison to RTF or other programs

- RTF uses full regional RBSA I results exclusively, this analysis uses Oregon specific RBSA I data when available (e.g., Oregon specific avg. number of showerheads and total number of showerheads per dwelling type).
- Occupancy data is sourced from 2015 1-year American Community Survey samples rather than RBSA I data. Sample sizes are larger and the data is more recent than RBSA I.
- ACS data for all occupants, including those under 6, are used, compared to the RTF's 6+ criteria for both occupancy and estimated shower events per person per year.
  - Using the 6+ criteria for both occupancy and shower events compounds the reduction annual shower frequency.
- In-situ flow rates for 1.5 gpm showerheads and wands use Energy Trust's 2016 multifamily field test de-ratings of 88% and 81%, respectively, rather than the RTF's standard 90% for all flow types.
- Savings are calculated for 1.6 and 1.8 gpm devices used by Energy Trust programs in addition to the 1.5, 1.75 and 2.0 gpm calculated by the RTF.
- OR MF removes 1.50 GPM units from baseline due to pre and on-site screening.
- Energy Trust uses a 15 year measure life, in contrast to the RTF's assumption of 10 years.

Measure Life

Measure life is 15 years, consistent with other Energy Trust measures for water-saving devices.

Cost

Costs for Oregon direct install showerheads and shower wands are equal to incentives mutually agreed-upon by PMC and Energy Trust Program staff taking into account both product and labor costs. Washington costs for customer purchase measures are retail costs based on cost analysis done for MAD#77 Commercial Showerheads.

Non Energy Benefits

Reduced water consumption from low flow devices is used as a NEB in the analysis.

Combined water rates net of embedded electricity are used in Oregon for gas and electric territories, and total water rates without removing embedded energy for Oregon gas only territory. Washington uses the combined rate of water, also without removing embedded energy use for waste water treatment.

- Oregon full territory $13.30/1,000 gallons
- Oregon gas only territory $13.64/1,000 gallons
- Washington $10.90/1,000 gallons

Incentive Structure

The maximum incentives listed in Table 1 and Table 2 are for reference only and are not suggested incentives. Incentives will be structured per showerhead or shower wand.

Follow-Up

Inputs most likely to change:

- Potential occupancy per dwelling type updates from American Community Survey (this MAD uses 2015 data)
- Measure life should be re-examined
- RTF's current showerhead workbook, v3.1, sunsets in August 2019 and revisions are likely to include RBSA II data. New RBSA II inputs would likely include:
  - Distribution of flow rates by housing type
  - New electric resistance/heat pump water heater splits
  - New gas storage and instantaneous water heater splits
  - Showerheads/wands per dwelling and total fixture counts (for dwelling weighting)

Washington leave behind is likely distinct enough as a deliver channel that it should have its own MAD in the future.

Supporting Documents

The cost effective screening for these measures is attached and can be found along with supporting documentation at: I:\Groups\Planning\Measure Development\Residential\Res Water Reduction\showerhead\direct install

CEC 157 DI SH and SW 2019.xlsx

References

https://rtf.nwcouncil.org/measure/showerheads

Version History and Related Measures

Table 11 Version History

Date	Version	Reason for revision
x	X	Direct install of showerheads introduced.
9/16/09	X	Shower wands approved for direct install in single family.
3/02/10	157.x	Direct install of single family showerheads at the time of Home Energy Review.
7/30/10	X	Shower wands approved for direct install in multifamily.
10/13/10	77.x	Introduce commercial sector-wide showerhead approval in single document, including direct install in multifamily.
11/01/10	77.x	Clarified descriptions of New Buildings program tracks.
8/05/11	157.x	Update costs.
11/30/12	157.x	Updates uninstall rates.
3/27/14	157.x	Add maximum incentive.
8/15/14	157.x	Combine single family and multifamily direct install MADs. Update flow rates based on RBSA data. Update to 2011 RTF assumptions. Includes more flow rates and aerators.
8/26/14	157.x	Corrected error regarding % hot water in prior version
11/3/14	77.x	Update flow rate assumptions based on RBSA data. Multifamily direct-install and leave-behind included on commercial showerhead MAD ID 77.
9/15/15	77.x	Updated costs. Multifamily direct-install removed from commercial showerhead MAD ID 77.
11/12/15	157.x	Multifamily and residential direct install MADs combined. Updated for 2015 RTF assumptions, direct install aerators removed from MAD ID 157, combined with MAD ID 51.
10/5/16	157.1	Update multifamily savings based on 2016 flow rate study.
5/1/17	157.2	Added Washington Multifamily customer purchased track
9/12/17	157.3	Updated occupancy values, water and embedded energy rates, SF shower wand analysis update.
8/10/18	157.4	Alignment with RTF Showerhead v3.1 workbook savings methodology

Table 12 Related Measures

Measures	MAD ID
Retail showerheads and wands	26
Leave-behind showerhead and wands single family Washington only	43
Commercial showerheads	77
New Homes showerheads and wands	131
New buildings and New Multifamily showerheads	144
Retail shower wands, additional sizes	156
Energy Saver Kit (includes showerheads and wands)	27
Living Wise Kit (includes showerhead)	30
Carry Home Savings Kit (includes showerhead)	154
Community Event and Utility Give Away (includes showerhead)	155
Direct install and Washington Aerators	51

Approved & Reviewed by

Kenji Spielman
Planning Engineer

Mike Bailey PE
Engineering Manager Planning

Disclaimer

This Energy Trust document and its attachments may be used by you or shared, at no cost, with other parties who are interested in our work and analyses. Should you or anyone with whom this document is shared, have suggestions for improvement of our work, please let us know. You may modify this 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.

Measure Approval Document for Commercial Showerheads and Shower Wands

Valid Dates
January 1, 2019 to December 31, 2019

End Use or Description
Commercial water heating energy savings for showerheads and shower wands with a flow rate of 1.75 gpm or 1.5 gpm.

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

- Existing Buildings

Savings are based on the delivery mechanism that the RTF identifies as Retail, whereby the precondition flow rate is not a measure identifier.

Within these programs, applicability to the following building types or market segments or other program tracks are expected:

- Fitness Centers
- Any commercial except Fitness Centers (weighted average of Hospitality, Retail, Healthcare, Schools, Offices)

Within these programs, the measure is applicable to the following cases:

- New
- Replacement

Cost Effectiveness
The following tables show the results of the cost effectiveness analysis for Oregon and Washington.

Table 1 Cost Effectiveness Calculator Oregon

Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Electric Allocation	% Gas Allocation
Commercial Showerhead Replacement 1.75gpm Any Commercial Except Fitness Center Electric Water Heating	10	111	0	$7.14	$14.49	$7.14	7.79	24.00	100%	0%
Commercial Showerhead Replacement 1.75gpm Any Commercial Except Fitness Center Gas Water Heating	10	4	5	$7.14	$14.49	$7.14	2.36	18.57	11%	89%

Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Electric Allocation	% Gas Allocation
Commercial Showerhead Replacement 1.50gpm Any Commercial Except Fitness Center Electric Water Heating	10	172	0	$7.14	$21.03	$7.14	12.00	35.53	100%	0%
Commercial Showerhead Replacement 1.50gpm Any Commercial Except Fitness Center Gas Water Heating	10	5	8	$7.14	$21.03	$7.14	3.62	27.16	11%	89%
Commercial Showerhead Replacement 1.75gpm Fitness Center Electric Water Heating	10	1,042	0	$7.14	$135.46	$7.14	72.84	224.45	100%	0%
Commercial Showerhead Replacement 1.75gpm Fitness Center Gas Water Heating	10	35	46	$7.14	$135.46	$7.14	22.06	173.67	11%	89%
Commercial Showerhead Replacement 1.50gpm Fitness Center Electric Water Heating	10	1,605	0	$7.14	$196.67	$7.14	112.17	332.29	100%	0%
Commercial Showerhead Replacement 1.50gpm Fitness Center Gas Water Heating	10	51	71	$7.14	$196.67	$7.14	33.82	253.93	11%	89%
Commercial Showerhead Replacement 1.75gpm Any Commercial Except Fitness Center Gas Water Heating partial territory	10	0	5	$7.14	$14.83	$7.14	2.10	18.69	0%	100%
Commercial Showerhead Replacement 1.50gpm Any Commercial Except Fitness Center Gas Water Heating partial territory	10	0	8	$7.14	$21.53	$7.14	3.23	27.33	0%	100%
Commercial Showerhead Replacement 1.75gpm Fitness Center Gas Water Heating partial territory	10	0	46	$7.14	$138.72	$7.14	19.60	174.85	0%	100%
Commercial Showerhead Replacement 1.50gpm Fitness Center Gas Water Heating partial territory	10	0	71	$7.14	$201.40	$7.14	30.24	255.65	0%	100%

Table 2: Cost Effectiveness Calculator Washington

Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR
Commercial Showerhead Replacement 1.75gpm Any Commercial Except Fitness Center Gas Water Heating	10	5	$7.14	$13.99	$7.14	2.94	17.60
Commercial Showerhead Replacement 1.50gpm Any Commercial Except Fitness Center Gas Water Heating	10	8	$7.14	$20.30	$7.14	4.53	25.83
Commercial Showerhead Replacement 1.75gpm Fitness Center Gas Water Heating	10	46	$7.14	$130.78	$7.14	27.48	164.62
Commercial Showerhead Replacement 1.50gpm Fitness Center Gas Water Heating	10	71	$7.14	$189.87	$7.14	42.40	241.51

Requirements

- Installation of showerheads and showerwands with a flow rate of 1.75 gpm or 1.5 gpm.
- PMC determined minimum (currently 10 but subject to change) number of showerheads and/or shower wands must be purchased by a customer through a vendor or Trade Ally that has not discounted the product through participation in Energy Trust's retail showerhead offering
- Water heating fuel is supplied by a participating utility

Baseline

This measure uses a Code Baseline.

The market baseline flowrate matches the Showerheads_RTFv3.1 calculator workbook for showerheads and showerwands with a nominal flowrate equal to 2.5 gpm. The reduced baseline in-situ flowrate of 2.2 gpm reflects the findings from a March 2017 CLEAResult study of actual measured flowrates in multifamily applications in Energy Trust of Oregon territory. The CLEAResult report confirms the results of previous showerhead in-situ flowrate tests conducted by SBW for Seattle City Light in 2007 and solidifies the assumption in the RTF calculations.

The RTF's previously approved (2013) commercial calculations assumed 98% for electric water heater efficiency. This value was updated in 2016 to 100% for residential calculations. The updated cost-effectiveness calculations now use 100% for commercial applications. Steady state efficiency for electric water heaters changed from 98% to 100%.

Measure Analysis

The water heating savings are calculated as the baseline energy consumption minus the efficient case energy consumption. Energy consumed to heat the water is calculated as follows:

$$Water\ heating\ energy = In\ situ\ flow\ rate\ x\ Usage\ x\ \%\ hot\ water\ x\ \left(\frac{1}{water\ heating\ efficiency}\right) x\ conversion\ factors$$

The electric and gas savings per gallon of water is calculated as shown here:

$$kWh\ savings = \left(\frac{kWh}{gallon}\right) x\ annual\ usage\ (min)\ x\ flow\ rate\ (gpm)$$

$$therm\ savings = \left(\frac{therms}{gallon}\right) x\ annual\ usage\ (min)\ x\ flow\ rate\ (gpm)$$

The terms kWh/gallon and therms/gallon are calculated as shown here:

$$\frac{kwh}{gallon} = Delta\ T\ (°F)\ x\ 0.00244 \frac{kWh}{gal \cdot °F}\ x \frac{1}{electric\ water\ heater\ efficiency}$$

$$\frac{therms}{gallon} = Delta\ T\ (°F)\ x\ 0.0000833 \frac{therms}{gal \cdot °F}\ x \frac{1}{gas\ water\ heater\ efficiency}$$

Wastewater treatment plants requires energy for all the pumps and other processes. Water thus has embedded energy and any reduction in water usage will enjoy a savings in embedded energy. The previous equations do not account for savings due to embedded energy reduction from reduced water usage. The following equation shows the energy savings contribution of this embedded energy.

$$kWh\ embedded\ energy\ savings = 0.00368 \frac{kWh}{gal}\ x\ water\ savings\ (gal)$$

Finally, the total electric energy savings is simply:

$$Total\ kWh\ savings = kWh\ savings + kWh\ embedded\ energy\ savings$$

Comparison to RTF or other programs

Measure reportable savings are determined using the Showerheads_RTFv3.1 calculator workbook. The value for electric water heating efficiency is adjusted to reflect noted errata by RTF in commercial savings calculations.

The Commercial employee shower minutes/yr were not updated per the RTF noted errata for three reasons:

- The individual sector 'Commercial office – employee shower' category is not directly included in the measure offering
- The impact to weighted average savings of the Hospitality, Retail, Healthcare, Schools, Offices sectors that make up the 'Any commercial except Fitness Centers' category is insignificant and does not affect measure cost effectiveness
- The current calculation ignores the number of employees per showerhead and assumes an arbitrary 50% reduction in annual minutes as a fraction of residential usage

The hours of use for fitness centers uses the most conservative value from the survey.

Measure Life

Measure life is 10 years, which is consistent with the current RTF and past Energy Trust commercial showerhead and showerwand measures.

Cost

Costs were determined with the same approach used in the RTF calculator, i.e. online shopping queries to obtain average costs for each flowrate category. This approach is to conduct online searches for the phrase "Showerhead 1.5 gpm", then sort the results by price and record the 10 lowest prices (excluding used items). This sequence was repeated for 1.75 and 2.50 gpm showerheads. The RTF cost estimates were obtained on June 6, 2013. These cost estimates were updated on June 15, 2018. The decision to use the 10 lowest prices instead of the previous 20 assumes that prices beyond the 10^{th} lowest price reflect aesthetic design features and should be excluded in incremental cost analysis.

Non-Energy Benefits

Non-energy benefits are based on regionally representative water and waste water costs. They represent the value of the energy savings reported from water and waste water treatment and distribution (net of embedded electricity). These values are in alignment with Oregon and Washington combined water and waste water rates.

- Fresh water rate, $/1000 gal
- Fresh Water Embedded Energy, kWh/1000 gal
- Effective Electricity Rate, $/kWh
- Fresh Water Rate, net of Embedded Electricity, $/1000 gal

The value of the non-energy benefits for combined water rate, net of embedded electricity, is $14.17/1000 gal in Oregon. For partial territory measures the value of combined water rate, $14.51/1000 gal in Oregon and $13.68/1000 gal in Washington is used.

Incentive Structure

The maximum incentives listed above in
Table 1 and **Error! Reference source not found.** are for reference only and are not suggested incentives.

Follow-Up

Measures should be reviewed on a regular basis to correlate with any newer versions of the RTF Savings Calculator.

Supporting Documents

The cost effective screening for these measures is attached and can be found along with supporting documentation at:
I:\Groups\Planning\Measure Development\Commercial and Industrial\Commercial showerheads and aerators\showerhead_Commercial

CEC 77 Commercial
Retail Showerheads

Version History and Related Measures

Table 3 Version History

Date	Version	Reason for revision
2/28/2013	77.x	First release
11/3/2014	77.x	Aligning variables with RTF
3/16/2015	77.x	Updating with newer RTF assumptions
9/15/2015	77.1	Corrects DI costs and updates sectors
8/10/2018	77.2	Updates water costs, water heater efficiency

Table 4 Related Measures

Measures	MAD ID
Retail Showerheads and Showerwands	26
Energy Saver Kits	27
WA Leave Behind Showerhead and Showerwand	43
New Homes Showerheads and Showerwands	131
New Buildings Showerheads	144
Direct Install Showerheads and Showerwands	157

Approved & Reviewed by

Kenji Spielman
Planning Engineer

Mike Bailey PE
Engineering Manager Planning

Disclaimer

This Energy Trust document and its attachments may be used by you or shared, at no cost, with other parties who are interested in our work and analyses. Should you or anyone with whom this document is shared, have suggestions for improvement of our work, please let us know. You may modify this 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.

Measure Approval Document for Commercial Steam Traps

Valid Dates

January 1, 2019 to December 31, 2021

End Use or Description

Steam traps are components of central steam systems, used primarily for space heating, but also for process uses. Failed open traps release steam from the steam system, resulting in water and heat loss.

Program Applicability

Based on the referenced analysis and associated cost-effectiveness screening, the measures described below are approved for use in the following programs:

- Existing Buildings in Oregon and Washington

Within these programs, applicability to the following building types or market segments or other program tracks are expected:

- Healthcare facilities
- Correctional facilities
- Dry cleaners / laundry facilities
- K-12 schools
- College campuses
- Office buildings
- Hotels / lodging

Purpose of Re-Evaluating Measure

This update expands applicability to a range of building types. The prior measures were only approved for K-12 schools and dry cleaners.

Savings and incentives are now based on steam trap capacities rather than per trap.

Cost Effectiveness

Table 1 Cost Effectiveness Calculator Oregon, per lb/hr capacity of repaired/replaced trap

Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR
Steam Trap - Low Pressure, High Use	6	1.0	$0.9	$0.90	2.2	2.2
Steam Trap - Medium Pressure, High Use	6	1.9	$0.5	$0.50	7.7	7.7
Steam Trap - Low Pressure, Low Use	6	0.6	$0.9	$0.90	1.3	1.3
Steam Trap - Medium Pressure, Low Use	6	1.1	$0.5	$0.50	4.4	4.4
Steam Trap - Dry Cleaner	6	0.3	$0.4	$0.40	1.3	1.3

Table 2 Cost Effectiveness Calculator Washington, per lb/hr capacity of repaired/replaced trap

Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR
Steam Trap - Low Pressure, High Use	6	1.0	$0.9	$0.90	5.4	5.4
Steam Trap - Medium Pressure, High Use	6	1.9	$0.5	$0.50	18.5	18.5
Steam Trap - Low Pressure, Low Use	6	0.6	$0.9	$0.90	3.2	3.2
Steam Trap - Medium Pressure, Low Use	6	1.1	$0.5	$0.50	10.7	10.7
Steam Trap - Dry Cleaner	6	0.3	$0.4	$0.40	1.8	1.8

Requirements

- Must repair or replace existing steam trap
- Steam trap must be installed in a commercial building utilizing natural gas fired steam boiler fueled by a participating gas utility.
- With the exception of dry cleaning facilities, all steam traps in the system must be tested for failure status (failed open, failed closed or working) prior to replacement and only failed open traps replaced.

Steam traps are classified according to hours of use and steam pressure into following four categories with the following definitions:

- Low pressure systems have steam pressure of 15 psig or less.
- Medium pressure systems have steam pressure between 15 psig and 100 psig.
- High usage systems include facilities that operate 24X7. For example, in-patient hospitals, penitentiaries, hotels, etc.
- Low usage systems, include facilities that operate less than 24X7. For example, K-12 schools, universities, offices, etc.

Baseline

This measure uses an existing condition baseline.

Baseline equipment in dry cleaners is a mix of failed and not failed steam traps. Baseline equipment in other facilities is failed open steam traps.

Measure Analysis

Savings for the Steam Trap Replacement measures were analyzed by ICF's engineering team using Armstrong's steam loss calculation method.

Savings are a result of reducing steam leaks from the system. The estimated steam leak rate per trap is a function of orifice size, pressure and hours of use. The savings are normalized to the rated trap capacity (lbs/hr). The rated trap capacity can be obtained from manufacturer's specification sheets given the make/model, orifice size, and differential pressure of the steam trap.

This savings analysis utilizes Armstrong's method for steam loss[i]. Armstrong's method is adapted from Masonelian's calculation based on field and test data which showed light condensate loads in drip and tracer applications and higher condensate loads in process applications[1]. This results in different savings per application type, which are then each multiplied by a population factor[ii] to find the final savings per trap.

$$Savings\ \left(\frac{therms}{yr}\right)$$

$$= FP\ x\ FS\ x\ CV\ x\ \sqrt{\Delta P\ x\ (Pi + Po)}\ x\ Latent\ heat\ of\ vaporization\ \left(\frac{btu}{lb}\right) x\ 10^{-5}\left(\frac{therms}{btu}\right) x\ \frac{hours\ of\ operation\ \left(\frac{hrs}{yr}\right)}{Boiler\ efficiency\ (\%)}$$

Where:

- FP (Population Factor)
  - Drip and tracer = 25%
  - Coil and process = 75%
- FS (Service Factor acting to account for differences in steam flow by application type)
  - $FS_{Process}$ = 0.9
  - FS_{Drip} = 1.4
- CV (Flow Co-efficient) = $22.1\ x\ diameter\ (in)^2$
  - Diameter is steam pipe orifice diameter with the following ranges considered:
    - Low pressure range: 1/8 in. – ½ in.
    - Medium pressure range: 1/8 in. – ¼ in.
- $\Delta P = P_i - P_o$
  - P_i = Inlet pressure (psia)
    - Low pressure range: 16.7 psia – 29.7 psia
    - Medium pressure range: 64.7 psia – 114.7 psia
  - P_o = Outlet pressure (psia) assumed at 14.7 psia
- Latent Heat of Vaporization:
  - Low-Pressure Steam (<15 psig): 956 btu/lb
  - Medium-Pressure Steam (15-200 psig): 884 btu/lb
- Hours of operation:
  - High use = 4,380 hrs/yr
  - Low use = 2,514 hrs/yr
- 80% boiler efficiency

Dry cleaning / laundry facilities:

$$Savings\ \left(\frac{therms}{yr}\right) = \left(Process\ savings\ \left(\frac{therms}{yr}\right) + Drip\ savings\ \left(\frac{therms}{yr}\right)\right) x\ 27\%$$

The following assumptions were made in determining savings for dry cleaning and laundry facilities:

- Medium steam pressure system
- Orifice size of 1/8 in.
- System use 2,514 hr/yr
- 27% of traps assumed failed open, though all traps are replaced. [iii]

[1] Drip applications remove condensate formed in steam lines. Tracer applications use steam-filled tube to raise the temperature of pipe contents. Coil and Process applications remove condensate and air at heat transfer process, such as at radiators or heat exchangers.

All other facilities:

$$Savings\ \left(\frac{therms}{yr}\right) = Process\ savings\ \left(\frac{therms}{yr}\right) + Drip\ savings\ \left(\frac{therms}{yr}\right)$$

Usage at other facility types vary, so savings are based on capacity, hours of use and steam pressure.

Normalizing the Calculation Results

The savings per trap were normalized to provide a therms savings by capacity (lb/hr). Typical steam trap capacities were determined based on the orifice size, maximum operating pressure (PMO), and differential pressure using steam trap sizing charts in the Watson McDaniel catalog[iv]. Once the capacity was determined for the range of traps considered, the savings were divided by the capacity to determine a ratio. The traps with the same inlet pressure (low vs medium) and hours of use resulted in similar values. The ½ inch orifice sizes for low pressure steam systems were removed from this analysis, as they were high outliers in both hours of use categories. Averages were then calculated to determine savings based on capacity and pressure. Table 3 shows how this process was completed based on the steam trap sizes considered.

Table 3 Steam trap savings and costs with averages

Steam Pressure	Orifice Size *in*	Δ P *psia*	Savings per Trap *therms*	Capacity *lbs/hr*	Savings Ratio *therms/ lb/hr*	Cost Estimate *$/trap*	Cost Ratio *$/lb/hr*	Savings Average *Therms/ lb/hr*	Cost Average *$/lb/hr*
High Use									
Low	1/8	2	147	190	0.8	$448	$2.36	1.0	$0.94
	1/3	2	917	1140	0.8	$678	$0.60		
	1/2	2	2,348	2300	1.0	$743	$0.32		
	1/8	15	478	400	1.2	$448	$1.12		
	1/3	15	2,987	2100	1.4	$678	$0.32		
Med	1/8	50	1,080	670	1.6	$551	$0.82	1.9	$0.49
	1/4	50	4,320	2600	1.7	$843	$0.32		
	1/8	100	1,950	860	2.3	$551	$0.64		
	1/4	100	7,799	3600	2.2	$843	$0.23		
Low Use									
Low	1/8	2	84	190	0.4	$448	$2.36	0.6	$0.94
	1/3	2	526	1140	0.5	$678	$0.60		
	1/2	2	1,348	2300	0.6	$743	$0.32		
	1/8	15	274	400	0.7	$448	$1.12		
	1/3	15	1,714	2100	0.8	$678	$0.32		
Med	1/8	50	620	670	0.9	$551	$0.82	1.1	$0.49
	1/4	50	2,480	2600	1.0	$843	$0.32		
	1/8	100	1,119	860	1.3	$551	$0.64		
	1/4	100	4,477	3600	1.2	$843	$0.23		
Dry Cleaning Facilities									
Med	1/8	50	167.38	670	0.2	$295	$0.44	0.3	$0.39
	1/8	100	302.18	860	0.4	$295	$0.34		

Comparison to other programs

Energy Trust's Multifamily program has an offering for replacement of failed traps in multifamily buildings as approved in MAD 40. The multifamily offering is structured per trap replaced rather than by trap capacity.

The Production Efficiency program has an offering for replacement of all steam traps, whether failed or operating correctly as approved in MAD 200, assuming a 16.3% failure rate. Savings and costs are higher for industrial steam trap replacement due differences in calculation methods, larger sizes and higher hours of use.

Measure Life

Six years is used based on a 2007 study by ICF. This is consistent across the Energy Trust's steam trap offerings.

Cost

Several vendors were interviewed to provide costing estimates. The vendors mentioned that costs vary based on customer type, number of traps replaced, size, pressure and other factors. The information provided included ranges of installed costs for steam trap replacements, which included demo and removal of existing steam traps as well as testing costs.

Equipment cost estimates were given as:

- low pressure: $70-$365
- medium pressure: $173-$465

Labor hour estimates were given as 1.5 hours per trap installed at a rate of $150 per hour. Some customers would likely do the installation utilizing in-house labor, while others would hire installers. To verify that the measure is cost effective utilizing contracted labor, installation costs as indicated above have been applied to all trap sizes.

The testing cost is estimated at $25 per trap tested. The cost of this testing is distributed over the replaced traps, with the assumption of 16.3% failed open per the SoCal Gas Steam Trap Work paper. Dry cleaning facilities do not have a testing cost included because the program design is to replace all steam traps.

The costs were normalized to determine a cost/lb/hr capacity. Table 3 shows the cost per kBtu/h at the example sizes and averages for this calculation.

Non Energy Benefits

Replacing failed open steam traps will result in reduced steam loss, and water savings. The benefits of water savings are not quantified in the analysis.

Incentive Structure

The maximum incentives listed in Cost Effectiveness
Table 1 *and Table 2 are for reference only and are not suggested incentives.* Incentives will be structured per steam trap capacity (lbs/hr), not to exceed project cost.

Follow-Up

Costing data for steam traps varied between sources and may need to be updated based on applications received. Program to collect cost per steam trap (not including labor or testing) and record in PT for further evaluation.

Since for dry cleaners and laundromats, incentives are expected to cover a large portion of project costs, a limit on the frequency that a participant may use this offering may need to be put in place if repeat participants become excessive.

Supporting Documents

The cost effective screening for these measures and analysis files are attached and can be found along with supporting documentation at: I:\Groups\Planning\Measure Development\Commercial and Industrial\Process Equipment\steam traps\

OR-WA-CE Calculator-2019-v1.1

Steam Trap Estimated Savings_fi

Version History and Related Measures

Energy Trust has been offering commercial steam trap replacements for many years. These offerings predate our current measure approval documentation and record retention practices. Table 4 may be incomplete, particularly for offers approved prior to 2013.

Table 4 Version History

Date	Version	Reason for revision
12/03/07	42.x	Approve steam trap replacements in dry cleaners and laundries.
05/17/10	42.x	Revise dry cleaner steam trap offering, direct install/testing by program staff.
12/02/10	42.x	Combined schools and dry cleaners into same document. Schools savings based on pilot results. Revised dry cleaner offering to allow both direct install and standard program approach.
04/09/14	42.1	Removed direct install options and testing incentives.
7/19/18	42.2	Savings revised. No longer based on studies or pilot results, but engineering calculation methods Update units to per capacity from per trap. Add building types. Changed dry cleaner savings to replace all.

Table 5 Related Measures

Measures	MAD ID
Industrial Steam Trap Replacements	200
Multifamily Steam Trap Replacements	40

Approved & Reviewed by

Jackie Goss, PE
Sr. Planning Engineer

Mike Bailey PE
Engineering Manager Planning

Disclaimer

This Energy Trust document and its attachments may be used by you or shared, at no cost, with other parties who are interested in our work and analyses. Should you or anyone with whom this document is shared, have suggestions for improvement of our work, please let us know. You may modify this 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.

[i] Armstrong Theoretical Steam Loss Calculations
[ii] SDG&E Work paper Revision 0 (June 15, 2012)
[iii] SoCal Gas Steam Trap Work paper Revision G (2006)
[iv] Watson McDaniel Product Catalog, 2015

Measure Approval Document for Commercial Dishwashers and Dish Machines

Valid Dates
January 1, 2019 to December 31, 2021

End Use or Description
Dishwashers and Dish Machines in Commercial Kitchens

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

- Existing Buildings
- New Buildings
- Production Efficiency
- Multifamily

Within these programs, applicability to the following building types or market segments or other program tracks are expected:

- Restaurants and other commercial kitchens

Within these programs, the measure is applicable to the following cases:

- New
- Replacement

Purpose of Re-Evaluating Measure
The measure is being re-evaluated to align with the updated 2017 ENERGY STAR Commercial Kitchen Equipment calculator.

High temperature under-counter dishwashers with gas water heat are no longer cost effective and no longer approved in Oregon. Pot, Pan and Utensil type dishwashers and under-counter low temperatures dishwashers are now included.

Requirements

- Dishwashers and Dish Machines must be approved by ENERGY STAR v2.0

Cost Effectiveness
Cost effectiveness is demonstrated in Table 1 and Table *2*.

Table 1: Cost Effectiveness Calculator Oregon

Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Ele	% Gas
Under Counter - Low Temp - Elec WH	10	2,594		$234	$209	$234	5.6	12.8	100%	0%
Stationary Single Tank Door - Low Temp - Elec WH	15	16,499		$662	$1,332	$662	18.5	40.4	100%	0%
Single Tank Conveyor - Low Temp - Elec WH	20	13,906		$1	$1,076	$3,309	4.0	27417	100%	0%
Multi Tank Conveyor - Low Temp - Elec WH	20	19,214		$970	$1,552	$970	18.8	39.9	100%	0%
Under Counter - High Temp - Elec WH	10	3,194		$2,025	$89	$1,617	1.0	1.2	100%	0%
Stationary Single Tank Door - High Temp - Elec WH	15	12,014		$995	$579	$995	8.9	15.3	100%	0%
Single Tank Conveyor - High Temp - Elec WH	20	9,303		$2,050	$352	$2,050	4.3	6.6	100%	0%
Multi Tank Conveyor - High Temp - Elec WH	20	27,754		$970	$1,334	$970	27.1	45.3	100%	0%
Pot, Pan, and Utensil - High Temp - Elec WH	10	3,356		$1,710	$174	$420	4.0	1.8	100%	0%
Under Counter - Low Temp - Gas WH	10	54	106	$234	$209	$234	1.5	8.6	8%	92%
Stationary Single Tank Door - Low Temp - Gas WH	15	346	675	$662	$1,332	$662	5.1	27.0	8%	92%
Single Tank Conveyor - Low Temp - Gas WH	20	863	545	$1	$1,076	$3,309	1.2	18366	20%	80%
Multi Tank Conveyor - Low Temp - Gas WH	20	403	786	$970	$1,552	$970	5.3	26.5	7%	93%
Stationary Single Tank Door - High Temp - Gas WH	15	978	461	$995	$579	$995	2.9	9.2	25%	75%
Single Tank Conveyor - High Temp - Gas WH	20	2,603	280	$2,050	$352	$2,050	2.0	4.3	59%	41%
Multi Tank Conveyor - High Temp - Gas WH	20	2,332	1,063	$970	$1,334	$970	8.9	27.1	25%	75%
Pot, Pan, and Utensil - High Temp - Gas WH	10	45	138	$1,710	$174	$420	1.1	1.1	5%	95%
Under Counter - Low Temp - Gas Only	10		106	$234	$219	$234	1.4	8.9	0%	100%
Stationary Single Tank Door - Low Temp - Gas Only	15		675	$662	$1,393	$662	4.7	27.6	0%	100%
Single Tank Conveyor - Low Temp - Gas Only	20		545	$1	$1,171	$3,309	1.0	18813	0%	100%
Multi Tank Conveyor - Low Temp - Gas Only	20		786	$970	$1,623	$970	4.9	27.1	0%	100%
Stationary Single Tank Door - High Temp - Gas Only	15		461	$995	$671	$995	2.1	9.5	0%	100%
Single Tank Conveyor - High Temp - Gas Only	20		280	$2,050	$567	$1,700	1.0	4.5	0%	100%
Multi Tank Conveyor - High Temp - Gas Only	20		1,063	$970	$1,553	$970	6.6	27.8	0%	100%
Pot, Pan, and Utensil - High Temp - Gas Only	10		138	$1,710	$182	$420	1.0	1.1	0%	100%

Table 2: Cost Effectiveness Calculator Washington

Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Ele	% Gas
Under Counter - Low Temp - Gas WH	10	0	106	$234	$208.88	$234	1.7	8.4	0%	100%
Stationary Single Tank Door - Low Temp - Gas WH	15	0	675	$662	$1,328.56	$662	5.6	25.6	0%	100%
Single Tank Conveyor - Low Temp - Gas WH	20	584	545	$1	$1,117.72	$3,835	1.0	17038	0%	100%
Multi Tank Conveyor - Low Temp - Gas WH	20	0	786	$970	$1,547.24	$970	5.7	24.5	0%	100%
Under Counter - High Temp - Gas WH	10	1,471	71	$2,025	$202.23	$269	1.0	0.9	0%	100%
Stationary Single Tank Door - High Temp - Gas WH	15	827	461	$995	$641.31	$995	2.6	9.0	0%	100%
Single Tank Conveyor - High Temp - Gas WH	20	2,511	280	$2,050	$544.05	$1,970	1.0	4.1	0%	100%
Multi Tank Conveyor - High Temp - Gas WH	20	1,986	1,063	$970	$1,483.54	$970	7.7	25.8	0%	100%
Pot, Pan, and Utensil - High Temp - Gas WH	10	0	138	$1,710	$173.29	$523	1.0	1.1	0%	100%

Baseline

This measure uses an inefficient market baseline.

The baseline for this measure reflects existing equipment per ENERGY STAR Commercial Dishwasher Specification v2.0[1]. Baseline specifications build on equipment performance data provided to ENERGY STAR by industry stakeholders, and combined research efforts on available models conducted in 2013 by the EPA and Food Service Technology Center (FSTC).

Savings and Measure Analysis

Savings are calculated using ENERGY STAR methodology and assumptions from the 2017 Commercial Kitchen Equipment Calculator[2]. Major operating assumptions in common for all equipment types are included in Table 3. Gas water heaters are assumed to be 80% efficient and electric water heaters are assumed to be 98% efficient.

Table 3: ENERGY STAR v2.0 Operational Assumptions for Commercial Dishwashers

Machine Type	Average daily operation (hours)	Days per year	Racks washed per day
Under Counter	18	365	75
Stationary Single Tank Door	18	365	280
Single Tank Conveyor	18	365	400
Multi Tank Conveyor	18	365	600
Pot, Pan, and Utensil	18	365	280

Electric power is saved in the water treatment process when water is saved. In electric territory, this is added to electric savings at a rate of 3.68kwh/1000 gal. In non-electric territory, this is included in the non-energy benefits associated with water savings.

Table 4 Dishwasher Savings Summary

			Water (thousand gallons)	Gas (therms)	Electricity (kWh)	Embedded Energy Savings (kWh)	Total kWh
Electric Water Heat	**Low Temperature**	**Under Counter**	14.8	0	2540	54	2594
		Stationary Single Tank Door	94.0	0	16153	346	16499
		Single Tank Conveyor	75.9	0	13626	279	13906
		Multi Tank Conveyor	109.5	0	18811	403	19214
	High Temperature	**Under Counter**	6.3	0	3171	23	3194
		Stationary Single Tank Door	40.9	0	11863	150	12014
		Single Tank Conveyor	24.8	0	9212	91	9303
		Multi Tank Conveyor	94.2	0	27408	347	27754
		Pot, Pan, and Utensil	12.3	0	3311	45	3356
Gas Water Heat	**Low Temperature**	**Under Counter**	14.8	106	0	54	54
		Stationary Single Tank Door	94.0	675	0	346	346
		Single Tank Conveyor	75.9	545	584	279	863
		Multi Tank Conveyor	109.5	786	0	403	403
	High Temperature	**Under Counter**	6.3	71	1471	23	1494
		Stationary Single Tank Door	40.9	461	827	150	978
		Single Tank Conveyor	24.8	280	2511	91	2603
		Multi Tank Conveyor	94.2	1063	1986	347	2332
		Pot, Pan, and Utensil	12.3	138	0	45	45

Comparison to RTF

The RTF does not currently have a commercial dishwasher UES.

Measure Life

Equipment measure life falls between 10 and 20 years depending on equipment type and temperature category and is grounded in EPA/FSTC research on available models conducted in 2013.

Cost

The ENERGY STAR Certified Commercial Kitchen Equipment calculator defines incremental equipment cost as the difference between an ENERGY STAR and non-ENERGY STAR certified model. The resources for these costs are cited as EPA research using Auto Quotes, dated 2016 for high/low temperature under counter/single door, and 2012 for all other types. The ENERGY STAR incremental costs are used to evaluate measure cost-effectiveness. The under counter, high temp, gas water heat measure is not cost effective. Regional costs for this measure are not conclusive as well and hence the analysis continued with the ENERGY STAR costing.

Non Energy Benefits

Non-energy benefits are based on reduced water usage and are quantified with regionally representative water and wastewater costs. They represent the value customer bill savings reported from water and wastewater treatment and distribution.

The value of the non-energy benefits for combined water rate, net of embedded electricity, is $14.48/1000 gal in Oregon. For partial territory measures, where embedded energy is not claimed, the value of combined water rate, $14.82/1000 gal in Oregon and $14.13/1000 gal in Washington is used.

Incentive Structure

The maximum incentives listed in Table 1 and Table 2 are for reference only and are not suggested incentives. Standard incentives should be set to accommodate any known or potential bonuses without exceeding the maximum incentives. Currently, the New Buildings Program offers bonuses up to 20% on dishwashers through various Market Solutions packages. Incentives will be structured per item, not to exceed invoice cost.

[1] https://www.energystar.gov/products/commercial_food_service_equipment/commercial_dishwashers/key_product_criteria
[2] https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0ahUKEwir3f-n1pXcAhWnqlQKHXoCBw0QFghdMAA&url=https%3A%2F%2Fwww.energystar.gov%2Fsites%2Fdefault%2Ffiles%2Fasset%2Fdocument%2Fcommercial_kitchen_equipment_calculator.xlsx&usg=AOvVaw2FrqT6Vjmb3c8271IrF05L

For measures where the ENERGY STAR calculator indicates a negative incremental cost, $1 is used in cost effectiveness testing. 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 may continue to offer incentives that appear to be above incremental cost.

Maximum incentives are set such that they equipment type has the same maximum incentive regardless of fuel. Maximum incentives are different between Oregon and Washington.

SRAF

Typical program SRAFs apply.

Follow-Up

Measures should be reviewed on a regular basis to correlate with any newer versions of the savings calculator for ENERGY STAR Certified Commercial Kitchen Equipment or updates to federal standards or ENERGY STAR specifications.

Supporting Documents

The cost effective screening and a modified copy of the ENERGY STAR calculator for these measures is attached and can be found along with supporting documentation at:
I:\Groups\Planning\Measure Development\Commercial and Industrial\Food Service\Commercial Dishwashers


OR-WA-CE Calculator-Commerc

commercial_kitchen _equipment_calculat

Version History and Related Measures

Energy Trust has been offering commercial dishwashers for many years. These offers predate our current measure approval documentation process and record retention policies. Table 5 may be incomplete, particularly for offers approved prior to 2013.

Table 5 Version History

Date	Version	Reason for revision
3/21/2008	35.x	Approve Energy Star commercial dishwashers
6/04/2008	35.x	Add additional dishwasher configurations
5/13/2014	35.1	Update maximum incentives
7/17/18	35.2	Revise savings and cost to Energy Star v2.0

Table 6 Related Measures

Measures	MAD ID
Commercial Food Service Cooking Equipment	101
Commercial Ice Machines	90
Venthood Controls Prescriptive	122
Venthood Controls Calculator	184
Restaurant Market Solutions	158
Grocery Market Solutions	161
Retail Market Solutions	160
Primary Schools Market Solutions	165

Approved & Reviewed by

Jackie Goss, PE
Sr. Planning Engineer

Mike Bailey PE
Engineering Manager Planning

Disclaimer

This Energy Trust document and its attachments may be used by you or shared, at no cost, with other parties who are interested in our work and analyses. Should you or anyone with whom this document is shared, have suggestions for improvement of our work, please let us know. You may modify this 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.

Measure Approval Document for Commercial Condensing Tankless Water Heaters ≥ 200 kBtu/h

Valid Dates
January 1, 2019 – December 31, 2021

End Use or Description
High efficiency, condensing, tankless water heater or water supply boiler installed in a commercial or multifamily building.

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

- Existing Buildings
- Existing Multifamily
- New Buildings
- New Multifamily
- Production Efficiency

Within these programs, the measure is applicable to the following cases:

- New
- Replacement

Purpose of Re-Evaluating Measure
Costs and savings have been updated. Maximum incentives have been reduced due to lower incremental costs. Additional building types have been added.

Cost Effectiveness
Savings and cost effectiveness for approved building types are demonstrated for Oregon and Washington in Table 1 and Table 2. Savings for additional up-approved building types are included in supporting documents.

Table 1 Cost Effectiveness Calculator Oregon, per kBtu/h

Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR
Tankless ≥ 200 kBtu/h - Office	15	0.7	$1.24	$1.24	2.6	2.6
Tankless ≥ 200 kBtu/h - Schools	15	0.9	$1.24	$1.24	3.5	3.5
Tankless ≥ 200 kBtu/h - Hotel/Motel	15	1.1	$2.15	$2.15	2.4	2.4
Tankless ≥ 200 kBtu/h - Restaurant	15	0.3	$1.24	$1.24	1.1	1.1
Tankless ≥ 200 kBtu/h - Commercial Gym	15	0.7	$1.24	$1.24	2.5	2.5
Tankless ≥ 200 kBtu/h - Coin Laundry	15	3.2	$1.24	$1.24	12.0	12.0
Tankless ≥ 200 kBtu/h - All Commercial	15	0.9	$1.46	$1.46	2.7	2.7
Tankless ≥ 200 kBtu/h - Multifamily	15	0.7	$2.45	$2.45	1.4	1.4

Table 2 Cost Effectiveness Calculator Washington, per kBtu/h

Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR
Tankless ≥ 200 kBtu/h - Office	15	0.7	$1.24	$1.24	3.4	3.4
Tankless ≥ 200 kBtu/h - Schools	15	0.9	$1.24	$1.24	4.7	4.7
Tankless ≥ 200 kBtu/h - Hotel/Motel	15	1.1	$1.24	$2.15	3.2	3.2
Tankless ≥ 200 kBtu/h - Restaurant	15	0.3	$2.45	$1.24	1.4	1.4
Tankless ≥ 200 kBtu/h - Multifamily	15	0.7	$1.24	$2.45	1.9	1.9
Tankless ≥ 200 kBtu/h - Commercial Gym	15	0.7	$1.24	$1.24	3.3	3.3
Tankless ≥ 200 kBtu/h - Coin Laundry	15	3.2	$1.24	$1.24	16.0	16.0
Tankless ≥ 200 kBtu/h - All Commercial	15	0.9	$1.46	$1.46	3.6	3.6
Tankless ≥ 200 kBtu/h - Multifamily	15	0.7	$1.24	$2.45	1.9	1.9

Requirements

For tankless commercial gas water heaters and hot water supply boilers:

- Condensing, tankless-type water heaters and hot water supply boilers used to supply domestic hot water
    - Installed equipment must not provide building space heating
- Integral tank volume <10 gal
- Must have a minimum 92.0% thermal efficiency rating
- Must have a minimum capacity of 200 kBtu/h

Programs may choose to use the weighted average savings for all building types, or the building-specific applications. Programs may not use average savings for some types and specific for others as that would not conform to the weighted average scheme. If programs choose to use weighted average savings, installation in additional building types is approved. If programs choose to apply the measure by building type, the measure for each building type can be made to areas of multi-use sites for hot water systems that provide dedicated service to that area and additional building type requirements are listed in Table 3. For example, a university building with a cafeteria that has a dedicated hot water system could use the Restaurant building type. However, it may be advisable, at a program's discretion, to require additional review or a custom or special measure for these cases.

Table 3 Requirements by Building Type

Building Type	Requirements
Office	Must be > 5,500 sq ft
Commercial Gym	Must have shower facilities
Multifamily	Must have a shared central DHW system

Baseline

This measure uses a Code Baseline.

The baseline equipment is a commercial tankless water heater or hot water supply boiler with an 80% thermal efficiency rating.

Savings

Analysis began with 14 of the 16 available DOE Energy Plus prototype building models described in the document *Enhancements to ASHRAE Standard 90.1 Prototype Building Models*[1]. Table 2.2 in that document was used to determine annual water use, tank volumes and total capacities used in the models. Energy Plus performance summary output files for the ASHRAE 90.1-2010 version models were accessed to determine annual hot water consumption and building areas.

Building-level savings are calculated using building type annual hot water use derived from Energy Plus prototype buildings, 80% baseline efficiency, measure case of 92% efficiency, and assumed 90°F temperature rise. Building-level savings were normalized based on equipment capacity.

Normalize savings to tankless capacity

An additional step was necessary to convert the assumed Energy Plus models' storage-type DHW system capacities to a capacity appropriate to tankless systems. The conversion method used is presented in Chapter 7, section 7.7, *Sizing to Maximum Load* of the in the US Department of Energy document, *Technical Support Document (TSD): Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Commercial Water Heating Equipment* [2] (TSD). Conversion factors, assumed demand periods, and additional detail for this conversion are presented in Appendix 7B of the TSD and summarized below.

[1] US Department of Energy, S. Goel, et al. April, 2014, Document # PNNL-23269

[2] US Department of Energy, Navigant Consulting, Inc.and Pacific Northwest National Laboratory. April 18, 2016, *Technical Support Document (TSD): Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Commercial Water Heating Equipment* . (Docket ID: EERE-2014-BT-STD-0042, available at https://www.regulations.gov/docket?D=EERE-2014-BT-STD-0042).

$$Q_{in,adjust} = (Adj_{tankless} \times y \times dT \times Vol \times Tank_u / GD_{hr} + Adj_{tankless} \times Q_{in}) \times C_p \times 1kBtu/h / 1000Btu/h$$

Where:

$Q_{in,adjust}$ =	Adjusted tankless capacity, kBtu/h
$Adj_{tankless}$ =	Tankless adjustment factor, developed from the modified Hunter's curve to adjust the sizing methodology for water heaters with storage to suit water heaters without storage, shown in Table 4
y =	Specific weight of water, 8.20lb/gal
dT =	Assumed change in inlet temperature from the equipment's set-point, 90°F
Vol =	Volume of water in the tank in gallons, shown in Table 4
$Tank_u$ =	Tank utilization the fraction of hot water in the tank that is usable before the dilution by cold water lowers the temperature below an acceptable level, assumed 70%
GD_{hr} =	Demand period for building type in hours, shown in Table 4
Q_{in} =	Input capacity of the equipment, Btu/h, shown in Table 4
C_p =	Specific heat of water, 1.0 Btu/lb/°F

Table 4 summarize the assumptions used to determine the tankless capacity necessary to serve the model buildings as well as the results.

Table 4 Modeled Tank Properties, Assumptions and Tankless Capacities for Each Building Type

DOE Prototype or Other Building Type	Modeled WH total volume (gal)	Modeled WH total capacity (kBtu/h)	Demand Period (hr)	Tankless adjustment factor	Required tankless capacity (kBtu/h)
Small Office*	40	41	1	1.58	97
Medium Office	100	100	1	1.58	240
Large Office	300	300	1	1.58	719
Stand-alone Retail*	40	40	1	1.58	96
Strip Mall*	40	41	1	1.58	97
Primary School	200	200	1	1.58	479
Secondary School	600	600	1	1.58	1438
Outpatient Health Care*	200	200	1	1.58	479
Hospital*	600	900	1	3.49	4764
Small Hotel	300	500	2	3.49	2196
Large Hotel	900	900	2	3.49	3952
Quick Service Restaurant	100	100	1	6.98	1059
Full Service Restaurant	200	200	1	6.98	2117
High-Rise Apartment	600	600	1	2.25	2047
Commercial Gym	NA				744
Coin Laundry	NA				924

*Building types analyzed but later removed from consideration.

In the case of the two non-DOE prototype buildings analyzed, Commercial Gym and Coin Laundry, selected information from MAD 212 was used as a basis for generating annual hot water consumption, total capacity, and building areas. MAD 212 capacities for these buildings represent tankless systems, so the capacities were not altered as for the Energy Plus building types. Information regarding typical coin

laundry square footage and typical number of washing machines - 20 washing machines per 1,000 square feet - was determined from multiple internet resources.

Many of the DOE prototype-based results were combined where appropriate to reduce complexity and better represent building classifications likely to be more familiar to the market (e.g., quick service and full-service restaurant building type results were combined into the Restaurant type). Table 5 presents the map between analyzed building types and final, measure building types. Savings and incremental costs are averaged for these groupings.

Table 5 Building Type Mapping

DOE Prototype or Other Building Type	Savings (therm/ kBtu/h)	Incremental Cost ($/kBtu/h)	Measure Building Type	Measure Savings (therm/ kBtu/h)	Measure Incremental Cost ($/kBtu/h)
Medium Office	0.36	$1.24	Office	0.68	$1.24
Large Office	1.01	$1.24			
Primary School	0.48	$1.24	Schools	0.94	$1.24
Secondary School	1.41	$1.24			
Small Hotel	0.37	$1.24	Hotel/Motel	1.11	$2.15
Large Hotel	1.84	$3.06			
Quick Service Restaurant	0.23	$1.24	Restaurant	0.28	$1.24
Full Service Restaurant	0.33	$1.24			
High-Rise Apartment	0.74	$3.06	Multifamily	0.74	$2.45
Gym	0.67	$1.24	Gym	0.67	$1.24
Coin Laundry	3.19	$1.24	Coin Laundry	3.19	$1.24

A weighted average was determined to cover all commercial building types based on project data from both Existing Building and New Buildings from 2016 and 2017 based on prevalence of the condensing tank water heater measure. The weightings are shown in Table 6. Multifamily is not included in the weighted average because of its large market share and because it is offered through different programs.

Table 6 Weighted Averaging Across Building Types

	Weighting	Savings (therm/kBtu/h)	Incremental Cost ($/kBtu/h)	Weighted Savings (therm/kBtu/h)	Weighted Cost ($/kBtu/h)
Office	14%	0.7	$1.24	0.10	$0.18
Schools	40%	0.9	$1.24	0.38	$0.49
Health Care	4%	0.3	$2.15	0.01	$0.08
Hotel/Motel	20%	1.1	$2.15	0.23	$0.44
Restaurant	17%	0.3	$1.24	0.05	$0.21
Commercial Gym	2%	0.7	$1.24	0.02	$0.03
Coin Laundry	2%	3.2	$1.24	0.08	$0.03
Weighted Average				**0.85**	**$1.46**

Measure Life

A measure life of 15 years is assumed for this measure, which may be conservative for systems with hot water boilers. This is consistent with the MAD 212, Commercial Condensing Tankless Water Heaters <200 kBtu/h.

Cost

The US DOE document titled *Technical Support Document (TSD): Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Commercial Water Heating Equipment* is the primary cost information source for this measure. The TSD is a supporting document to the US DOE document, *2016-05-31 Notice of proposed rulemaking, Energy Conservation Program: Energy Conservation Standards for Commercial Water Heating Equipment*.[3] Chapter 6 of the TSD presents costing formulas for baseline hot water heating equipment and above-code efficiency equipment, Equations 6.8 and 6.9, respectively, presented as Figure 1.

Figure 1: Technical Support Document Formulas for Calculating Consumer Costs Based on Manufacturing Costs and Assumed Markups

$$CPP_{BASE} = COST_{MFG} \times (MU_{MFG} \times MU_{BASE} \times Tax_{SALES}) = COST_{MFG} \times MU_{OVERALL\_BASE}$$

Eq. 6.8

$$CPP_{STD} = COST_{MFG} \times MU_{OVERALL\_BASE} + \Delta COST_{MFG} \times (MU_{MFG} \times MU_{INCR} \times Tax_{SALES})$$
$$= CPP_{BASE} + \Delta COST_{MFG} \times MU_{OVERALL\_INCR}$$

Eq. 6.9

Where:

CPP_{STD} = commercial consumer equipment price for models meeting new energy conservation standards,
CPP_{BASE} = commercial consumer equipment price for baseline models,
$COST_{MFG}$ = manufacturer cost for baseline models,
$\Delta COST_{MFG}$ = change in manufacturer cost for more-energy-efficient models,
MU_{MFG} = manufacturer markup,
MU_{INCR} = incremental replacement or new home channel markup,
Tax_{SALES} = sales tax (replacement applications only),
$MU_{OVERALL\_BASE}$ = baseline overall markup (equipment of manufacturer markup, baseline replacement or new home channel markup, and sales tax), and
$MU_{OVERALL\_INCR}$ = incremental overall markup.

The cost equations in Figure 1 use manufacturing production costs ($COST_{MFG}$) values that are estimated in Chapter 5 of the TSD, referred to there as Manufacturer's Production Costs (MPC) for both tankless water heaters and hot water supply boilers. These are presented in Figure 2.

[3] The docket for the proposed rulemaking, including a pdf of the TSD, can be accessed at https://www.regulations.gov/docket?D=EERE-2014-BT-STD-0042.

Figure 2: TSD Manufacturer Production Costs

Table 5.10.3 MPC and MSP Estimates for Gas-Fired Tankless Water Heaters, 250,000 Btu/h Input Capacity

Thermal Efficiency	MPC (2014$)	MSP (2014$)
80%	$629.67	$913.81
82%	$638.62	$927.95
84%	$647.38	$941.25
92%	$790.45	$1,149.43
94%	$804.87	$1,170.05
96%	$824.45	$1,201.86

Table 5.10.4 MPC and MSP Estimates for Gas-Fired Hot Water Supply Boilers, 399,000 Btu/h Input Capacity

Thermal Efficiency	MPC (2014$)	MSP (2014$)
80%	$1,182.00	$1,742.35
82%	$1,205.56	$1,779.30
84%	$1,411.17	$2,073.31
92%	$2,671.86	$3,862.92
94%	$2,826.90	$4,084.63
96%	$2,981.94	$4,306.34

Values for the overall mark-ups, $MU_{overall\_base}$ and $MU_{overall\_incr}$ for the base case and incremental (more efficient) equipment used in the equation in Figure 1 are given for replacement and new construction markets in Tables 6.8.1 and 6.8.3 of the TSD. Sales tax is included in the overall markups. To find appropriate markups for Energy Trust use, 1.0716 was divided into each term to remove sales tax. Table 7 summarizes final markup values used.

Table 7: Markup Values Excluding Sales Tax

Heater type	$MU_{base,ave}$	$MU_{incr,ave}$
Tankless	2.99	1.92
Hot Water Supply Boiler	3.13	1.96

Incremental costs are calculated using the 80% baseline and 92% efficient case MCPs in Figure 2 and the markups in Table 7. Costs are assigned to building types based on the likelihood of whether a hot water supply boiler or water heater would be installed. Only the Hospital, Large Hotel, and High-rise Apartment are expected to have hot water supply boilers installed. For these building types, a weighted average likelihood of 70% for tankless water heaters and 30% for hot water supply boilers is assumed. The 70/30 split is based on discussions with trade allies and New Buildings Program data. Incremental costs for hot water heaters, hot water supply boilers, and the 70/30 weighted incremental cost are presented in Table 8.

Table 8: Final Incremental Costs

Heater Type	Incremental Costs ($/kBtu/h)
Tankless	$1.24
Hot Water Supply Boiler	$7.32
Weighted Tankless/Boiler	$3.06

Incentive Structure

The maximum incentives listed in Table 1 and Table 2 are for reference only and are not suggested incentives. Standard incentives should be set to accommodate any known or potential bonuses without exceeding the maximum incentives. Currently, the New Buildings Program offers bonuses up to 20% on water heating equipment through various Market Solutions packages.

Incentives will be structured per kBtu/h capacity.

Follow-Up

There are indications that design choices between the two technologies may be driven by different factors for retrofit vs new construction. Consideration and research into these factors would be beneficial in determining if separate measures might better suit the market.

The weighted averages of savings by building type are based on tank water heaters, which have more data available at this time. Building types should be re-weighted at next update using up to date information. If additional building types participate with more than 5% of savings, that type should be included in the next update.

Supporting Documents

The cost effectiveness screening and analysis for these measures is attached and can be found along with supporting documentation at: I:\Groups\Planning\Measure Development\Commercial and Industrial\Commercial Water Heating\gas tankless water heat\Commercial and MF greater than 200

OR-WA-CEC-2019-v 1.1_CondTankless_a

Commercial Condensing Tankles

Version History and Related Measures

Energy Trust has been supporting commercial tankless water heaters and hot water supply boilers for many years. Past measures predate our approval and records retention processes. Table 9 may be incomplete, especially for measures approved before 2013.

Table 9 Version History

Date	Version	Reason for revision
2004	86.x	Approve various gas commercial measures including water service boilers
4/6/2011	72.1	Introduce commercial tankless for commercial and multifamily. Requirement is 94% efficient.
7/31/2018	72.2	Update savings based on modeled buildings. Add building types. Change efficiency requirement to 92%.

Table 10 Related Measures

Measures	MAD ID
Commercial & Multifamily Condensing Tank Water Heater	21
Multifamily Condensing Tankless Water Heater >200 kBtu	196
Commercial Condensing Tankless Water Heater >200 kBtu	212
Multifamily Condensing HVAC Boiler	147
Commercial Condensing HVAC Boiler	88

Approved & Reviewed by

Jackie Goss, PE
Sr. Planning Engineer

Mike Bailey PE
Engineering Manager Planning

Disclaimer

Measure Approval Document for Commercial Condensing Tank Water Heaters

Valid Dates
Jan 1, 2019 – December 31, 2021

End Use or Description
High efficiency, condensing, storage-type water heater installed in a commercial setting.

Program Applicability
Based on the referenced analysis and associated cost-effectiveness screening, the measures described below are approved for use in the following programs in Oregon and Washington:

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

Within these programs, the measure is applicable to the following cases:

- New
- Replacement

Purpose of Re-Evaluating Measure
Costs and savings have been updated. Additional building types have been added.

Cost Effectiveness
Savings and cost effectiveness for approved building types are demonstrated for Oregon and Washington in Table 1 and Table 2.

Table 1 Cost Effectiveness Calculator Oregon, per kBtu/h

Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR
Tank Water Heater - Office	18	2.2	$5.44	$5.44	2.3	2.2
Tank Water Heater - Schools	18	1.6	$3.92	$3.92	2.2	2.2
Tank Water Heater - Health Care	18	1.7	$3.25	$3.25	2.8	2.8
Tank Water Heater - Hotel/Motel	18	2.2	$1.49	$1.49	8.2	8.2
Tank Water Heater - Restaurant	18	3.8	$6.20	$6.20	3.4	3.4
Tank Water Heater - Commercial Gym	18	1.0	$2.51	$2.51	2.2	2.2
Tank Water Heater - Coin Laundry	18	3.9	$1.83	$1.83	11.8	11.8
Tank Water Heater - All Commercial Buildings	18	2.2	$3.92	$3.92	3.2	3.2
Tank Water Heater - Multi-Family	18	3.2	$3.25	$3.25	5.5	5.5

Table 2 Cost Effectiveness Calculator Washington, per kBtu/h

Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR
Tank Water Heater - Office	18	2.2	$5.44	$5.44	3.0	3.0
Tank Water Heater - Schools	18	1.6	$3.92	$3.92	2.9	2.9
Tank Water Heater - Health Care	18	1.7	$3.25	$3.25	3.7	3.7
Tank Water Heater - Hotel/Motel	18	2.2	$1.49	$1.49	10.7	10.7
Tank Water Heater - Restaurant	18	3.8	$6.20	$6.20	4.4	4.4
Tank Water Heater - Commercial Gym	18	1.0	$2.51	$2.51	2.9	2.9
Tank Water Heater - Coin Laundry	18	3.9	$1.83	$1.83	15.4	15.4
Tank Water Heater - All Commercial Buildings	18	2.2	$3.92	$3.92	4.1	4.1
Tank Water Heater - Multi-Family	18	3.2	$3.25	$3.25	7.2	7.2

Requirements

- Condensing, storage-type water heaters
- Tank volume ≥10gal (additional storage-only tanks may be present)
- Capacity of greater than 75,000 Btu/h

- Must have a minimum 94.0% thermal efficiency rating as determined by testing methods in the Code of Federal Regulations, Appendix A to Subpart G of Part 431—Uniform Test Method for the Measurement of Thermal Efficiency and Standby Loss of Gas-Fired and Oil-Fired Storage Water Heaters and Storage-Type Instantaneous Water Heaters.
- Energy Factor (EF) or Uniform Energy Factor (UEF) ratings do not conform to the savings estimation methodology and are therefore not eligible.

Additional building type requirements are listed in Table 3.

Table 3 Requirements by buildings type

Building Type	Requirements
Office >5,500 sqft	Must be >5,500sqft
Commercial Gym	Must have shower facilities
Multi-Family	Must have a shared central DHW system

Existing Buildings and New Buildings Programs may choose to use the weighted average savings for all building types, or the building-specific applications. Programs may not use average savings for some types and specific for others as that would not conform to the weighted average scheme. If programs choose to apply the measure by building type, application of the building types can be made to areas of multi-use sites for hot water systems that provide dedicated service to that area. For example, a multi-story university building with a ground floor cafeteria that has a dedicated hot water system for that floor could use the restaurant building type incentives and savings. Similarly, water heaters serving kitchens within hotels may be better represented by the restaurant building type than the hotel building type. However, it may be advisable, at a program's discretion, to require additional review or a custom or special measure for these cases.

Baseline

This measure uses a code baseline.

Baseline equipment is storage type, 80% thermal efficiency water heater.

Savings

Savings are generated by two factors:

1) Efficiency gains – savings generated by efficiency improvement over an 80% baseline as applied to annual hot water use. This portion of total savings is directly proportional to use.
2) Improved standby losses – AHRI standby loss data in Btu/h for condensing and non-condensing storage type water heaters was analyzed and showed that high efficiency units had significantly improved standby loss performance compared to 80% efficient units.

Annual hot water use values are used to determine efficiency savings, whereas building type tank volumes are used to determine standby losses specific to each building type.

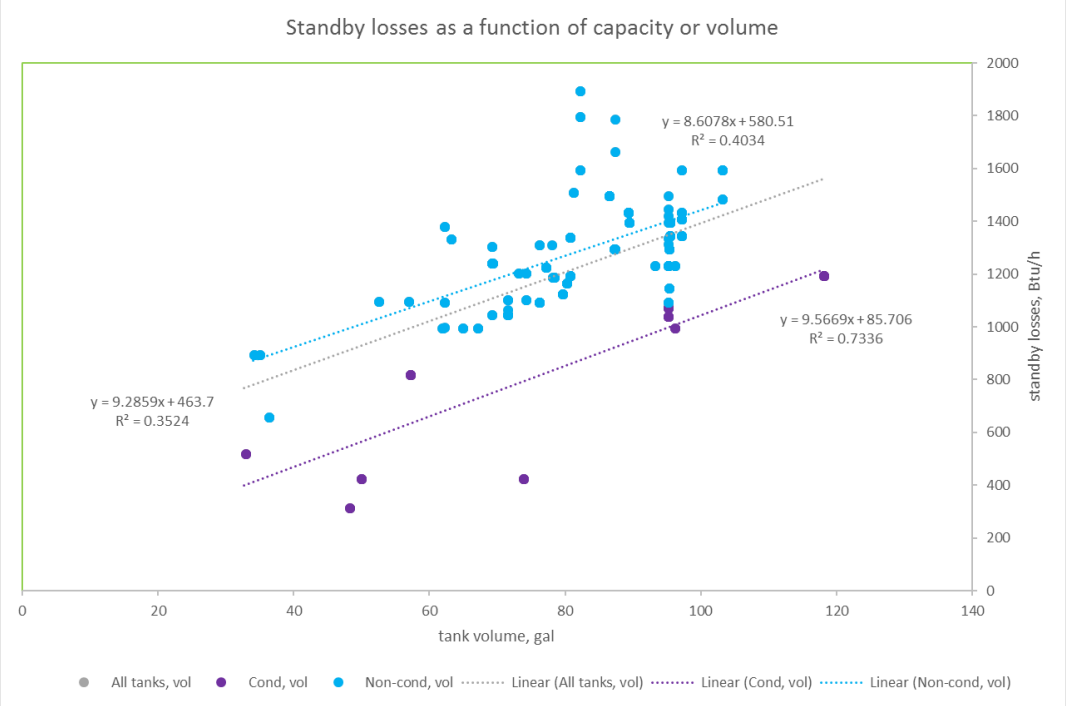
Savings Due to Efficiency Gains

Efficiency savings are calculated using building type annual hot water use, an 80% baseline efficiency, a measure case 94% efficiency, and assumed 90°F temperature rise.

Savings Due to Improved Standby Losses

Condensing water heaters generally have much better standby losses as shown in Figure 1. AHRI data shows standby losses correlate very closely with tank volume, which is to be expected. Equal tank volume in the base and measure cases is assumed. Average baseline and efficient standby loss rates are individually calculated using a corresponding volume-standby loss correlation equation and defined total building tank volume. Annual losses are found by multiplying the loss rate by 8760 hr/year for the baseline and measure cases. Savings are then found by taking the difference in baseline and measure case losses. Figure 1 shows standby loss data and presents the linear, loss-volume correlation equations used.

Figure 1 Standby Losses



Measure Analysis

Analysis began with 14 of the 16 available DOE Energy Plus prototype building models described in the document *Enhancements to ASHRAE Standard 90.1 Prototype Building Models*[1]. Table 2.2 in that document was used to determine tank volumes and total capacities. Energy Plus html performance summary output files for the ASHRAE 90.1 2010 version models were accessed to determine annual hot water consumption and building areas.

In the case of the two non-DOE prototype buildings analyzed, Commercial Gym and Coin Laundry, selected information from MAD 212 was used as a basis for generating annual hot water consumption, total capacity, and building areas. Information regarding typical coin laundry square footage and typical number of washing machines, 20.0 washing machines per 1,000 sqft, was determined from several internet resources.

[1]US Department of Energy, S. Goel, et al. April, 2014, Document # PNNL-23269

Assumptions regarding building sizes and water heater characteristic are summarized in Table 4.

Table 4 Area, Hot Water Use, and Total Capacities for Complete Building Type Set

DOE Prototype Or Other Building Type	Building area (ft2)	WH total volume (gal)	WH total capacity (kBtu/h)
Small Office*	5,500	40	41
Medium Office	53,628	100	100
Large Office	498,588	300	300
Stand-alone Retail*	24,962	40	40
Strip Mall*	22,500	40	41
Primary School	73,960	200	200
Secondary School	210,887	600	600
Outpatient Health Care	40,946	200	200
Hospital	241,351	600	900
Small Hotel	43,200	300	500
Large Hotel*	122,120	900	900
Quick Service Restaurant	2,500	100	100
Full Service Restaurant	5,500	200	200
High-Rise Apartment	84,360	600	600
Commercial Gym	7076	600	744
Coin Laundry	2000	600	924

*-Building types analyzed but later removed from consideration.

The two Retail and Small Office building types were excluded later in the analysis process due to poor cost effectiveness, low hot water use, and because the ~40 kBtu/h capacities put the water heaters in the residential water heater category. Commercial units of this size are generally not seen in the market and would usually not have a thermal efficiency rating. The Large Hotel type were not included in the prescriptive measure because annual water use seemed disproportionately high in comparison to other building types.

Many of the DOE prototype-based results were combined where appropriate to reduce complexity and better represent building types likely to be more familiar to the market (e.g., quick service and full-service restaurant building type results were combined into the Restaurant type). Table 5 presents the map between, analyzed building types and final, measure building types. Savings for additional building types are included in supporting documents.

Table 5 Building Type Mapping

DOE Prototype Or Other Building Type	Savings (therm/ kBtu/h)	Incremental Cost ($/kBtu/h)	Measure building type	Averaging method	Savings (therm/ kBtu/h)	Incremental cost ($/kBtu/h)
Medium Office	1.35	$7.80	Office >5,500 sqft	simple average	2.22	$5.44
Large Office	3.09	$3.07				
Primary School	1.61	$4.59	Schools	simple average	1.58	$3.92
Secondary School	1.55	$3.25				
Outpatient Health Care	1.17	$4.59	Health Care Hospital	simple average	1.66	$3.25
Hospital	3.07	$3.25				
Small Hotel	3.46	$3.07	Hotel/ Motel	NA	2.2	$1.49
Quick Service Restaurant	3.21	$7.80	Restaurant	simple average	3.78	$6.20
Full Service Restaurant	4.35	$4.59				
High-Rise Apartment	3.23	$3.25	Multi-Family	NA	3.23	$3.25
Gym	1.00	$2.51	Gym	NA	1.00	$2.51
Coin Laundry	3.89	$1.83	Coin Laundry	NA	3.89	$1.83

A weighted average was determined to cover all building types except multifamily based on project data from both Existing Building and New Buildings from 2016 and 2017. The weightings are shown in Table 6. Multifamily is not included in the weighted average because of its large market share and because it is offered through different programs.

Table 6 Weighted Averaging Across Building Types

	Weighting	Savings (therm/kBtu/h)	Incremental Cost ($/kBtu/h)	Weighted Savings (therm/kBtu/h)	Weighted Cost ($/kBtu/h)
Office	14%	2.2	$5.44	0.32	$0.79
Schools	40%	1.6	$3.92	0.64	$1.56
Health Care	4%	1.7	$3.25	0.06	$0.12
Hotel/Motel	20%	2.2	$1.49	0.45	$0.31
Restaurant	17%	3.8	$6.20	0.64	$1.05
Commercial Gym	2%	1.0	$2.51	0.02	$0.06
Coin Laundry	2%	3.9	$1.83	0.09	$0.04
Weighted Average				**2.23**	**$3.92**

Measure Life

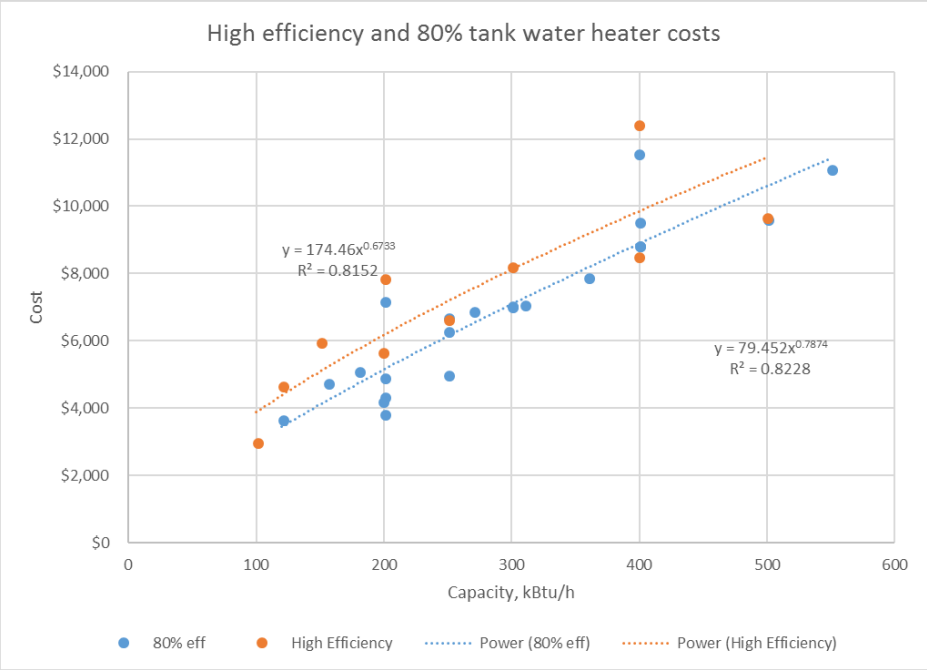
The measure life of 18 years from the previous version of the measure has been maintained.

Cost

The cost data comes from three manufacturer's models with a variety of capacities and volumes. Most costs were found on internet sites and one set from discussions with a distributor. Figure 2 is a graphical representation of the data including cost-capacity correlation equations used to determine baseline and measure case costs for each building type.

The incremental cost per kBtu/h is less at higher tank sizes, leading to variable incremental cost between building types.

Figure 2 Water Heater Costs



Incentive Structure

The maximum incentives listed in Table 1 and Table 2 are for reference only and are not suggested incentives. Standard incentives should be set to accommodate any known or potential bonuses without exceeding the maximum incentives. Currently, the New Buildings Program offers bonuses up to 20% on water heating equipment through various Market Solutions packages.

Incentives will be structured per kBtu/h capacity.

SRAF

Typical program SRAF rates apply.

Follow-Up

A newer class of water heating equipment, residential-duty commercial water heaters (>75kBtu/h ≤105kBtu/h and <120 gallons), is currently included in federal code, but appears to not be fully implemented and has apparently stalled coincident with the recent change in federal administration. Various aspects of this measure will be impacted if/when the residential-duty commercial water heater rules are fully implemented. This equipment class, along with residential water heaters, are required to meet a uniform energy factor (UEF) minimum rating value. Determining UEF is done via a federal efficiency testing method using one of 4 draw patterns chosen according to a storage type water heater's First Hour Rating (FHR) (CFR §430.32(d)). UEFs determined from different draw pattern tests are not comparable. Currently no mention of UEF is made for AHRI-listed hot water heaters meeting the definition for the class; those models list only thermal efficiency in the AHRI commercial gas fired water

heater database. It is expected that UEF values will be published for the class at some point and this class will be used in commercial settings.

Program data for two NC high schools gave some indication that the Energy Plus total building tank volumes may be slightly undersized, and capacities potentially undersized by more than half. However, not enough data was collected to deviate from the Energy Plus assumptions, and the ASHRAE 90.1 Prototype Enhancements document states that significant effort was expended to match the modeled values to real buildings and to Chapter 50 of ASHRAEs HVAC Applications guide. Collecting additional similar data for this and other actual building types may be useful for fine-tuning the measures.

Supporting Documents

The cost effectiveness screening for these measures is attached and can be found along with supporting documentation at: I:\Groups\Planning\Measure Development\Commercial and Industrial\Commercial Water Heating\condensing tank water heat


OR-WA-CEC-2019-v 1.1_CondTankV4.xls:


Commercial Condensing Tank W

Version History and Related Measures

Energy Trust has been offering condensing tank water heaters for many years. These offers predate our measure approval process and record retention policies. Table 7 may be incomplete, particularly for approvals prior to 2013.

Table 7 Version History

Date	Version	Reason for revision
12/23/2003	87.x	Approve various commercial gas measures including condensing tank water heaters.
3/14/2012	x.x	Approve various multifamily gas water heaters including condensing tank water heaters.
9/19/2014	21.1	Update savings. Base measure on building type. Merge multifamily and commercial approvals into single document.
7/13/2018	21.2	Update savings and costs, Add additional building types.

Table 8 Related Measures

Measures	MAD ID
Commercial Condensing Tankless Water Heaters and Boilers >200 kBtu/h	72
Commercial Condensing Tankless Water Heaters <200 kBtu/h	212
Multifamily Condensing Tankless Water Heaters <200 kBtu/h	196

Approved & Reviewed by

Jackie Goss, PE
Sr. Planning Engineer

Mike Bailey PE
Engineering Manager Planning

Disclaimer

This Energy Trust document and its attachments may be used by you or shared, at no cost, with other parties who are interested in our work and analyses. Should you or anyone with whom this document is shared, have suggestions for improvement of our work, please let us know. You may modify this 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.

Measure Approval Document for Commercial Clothes Washers

Valid Dates
1/1/2018 – 12/31/2020

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

- Existing Buildings
- New Buildings
- New Multifamily
- Existing Multifamily
- Residential (where residential serves small multifamily with shared laundries)

Within these programs, the measure is expected to be primarily in:

- Commercial facilities with laundry loads such as lodging and hospitals
- Laundromats
- Multifamily with shared laundry rooms

Within these programs, the measure is applicable to the following cases:

- New
- Replacement

Purpose of Re-Evaluating Measure
Update for new expiration dates, avoided costs and water rates and maximum incentives. Savings are updated based on Energy Trust's 2017 value for the embedded energy in water savings.

Cost Effectiveness
Table 1 Cost Effectiveness Calculator Oregon

Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Non-Energy Benefits (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Electric Allocation	% Gas Allocation
Commercial laundry ≥ MEF 2.2	7	460	26	$425	$152	$209	1.00	2.62	75%	25%
Commercial laundry ≥ MEF 2.2 - Electric only	7	1,027	0	$425	$152	$347	1.00	2.94	100%	0%
Commercial laundry ≥ MEF 2.2 - Gas only territory	7	0	32	$425	$180	$67	1.00	2.68	0%	100%
Multifamily clothes washer in common area ≥ MEF 2.2	11	624	5	$425	$106	$354	1.00	2.98	95%	5%
Multifamily clothes washer in common area ≥ MEF 2.2 - Electric only	11	752	0	$425	$106	$405	1.00	3.10	100%	0%
Multifamily clothes washer in common area ≥ MEF 2.2 - Gas only territory	11	0	24	$425	$126	$78	1.00	2.75	0%	100%

Table 2 Cost Effectiveness Calculator Washington

Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Non-Energy Benefits (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Electric Allocation	% Gas Allocation
Commercial laundry ≥ MEF 2.2 - Gas only territory	7	0	32	$425	$169	$71	1.00	2.43	0%	100%
Multifamily clothes washer in common area ≥ MEF 2.2 - Gas only territory	11	0	24	$425	$108	$80	1.00	2.23	0%	100%

Requirements
- ENERGY STAR (v7.1) front load commercial clothes washer
- Hot water fuel must be provided by an Energy Trust utility

Details
Commercial clothes washers are soft mount, generally 30 pounds of capacity or less. They wash many loads per day as they are in a commercial setting, or they are in the common areas of multifamily buildings and used by several families. Commercial clothes washers are rated by their Modified Energy Factor (MEF) which is an efficiency metric with units of ft^3/kwh/cycle. It combines mechanical energy used by the washer, water heating, and energy required to remove moisture content after the spin cycle. Another efficiency metric used by ENERGY STAR is the Water Factor (WF), which is the gallons of water per cycle per unit volume of laundry. ENERGY STAR commercial clothes washers have MEF $\geq$ 2.2 and WF $\leq$ 4.5.

Savings and Baseline
The baseline is shown in Table 3.

Table 3 Baseline Washer Categories

Washer Category	Market Share
Top Load MEF 1.60 to 2.19	71.6%
Top Load MEF 2.20 and greater	0%
Front Load MEF 2.00 to 2.19	3.6%
Front Load MEF 2.20 and greater	24.9%

While this measure requires that hot water fuel must be provided by an Energy Trust participating utility, the savings are weighted assuming the fuel splits in Table 4, which shows the percentage of equipment that is assumed to be electric. Laundromat, lodging, and hospital fuel splits are based on 2012 CBSA: Regional Building Characteristics Summary (Table A6) and the total number of commercial dryers in the database. Multifamily fuel splits are based on 2011 RBSA.

Table 4 Assumed percentage of electric water heat and electric dryers in full and partial service territories

	Dual Fuel Territory		Gas Only Territory		Electric Only Territory	
	Water heat	Dryer	Water heat	Dryer	Water heat	Dryer
Commercial	22%	77%	0%	77%	100%	100%
Multifamily	87%	74%	0%	74%	100%	100%

All savings are due to reduced water usage and reduced dryer energy. The washer itself does not use less electricity per cycle than a standard washer. Savings are based on the following assumptions:

- 1,095 cycles per year are used for multifamily and 1,497 cycles per year are used for the commercial sector referenced from 2014 US DOE Technical Support Document (TSD) for commercial clothes washers.
- Electric water heating efficiency is 98% and gas water heating efficiency is 75% in agreement with DOE TSD.
- Per TSD, average washer load is 13.50 lbs of dry clothes per load
- 50% of fresh water remains in moisture content of clothes per Bevan study "Two Case Studies Describe Significant of Energy Embedded in Water"

Cost

Incremental costs are referenced from the 2014 US DOE TSD for commercial clothes washers.

Comparison to RTF or other programs

Analysis is heavily based on RTF Commercial Clothes Washer v4.4 measure.

Measure Life

Measure life is taken from RTF analysis which uses 7 years for commercial applications and 11 years for multifamily applications. The RTF references the 2014 U.S. DOE TSD for commercial clothes washers.

Non Energy Benefits

Non-energy benefits due to water savings are determined using most recent Energy Trust rates, net of embedded electricity which is included as electricity savings.

In gas only territory, electric bill savings (from electric dryers) and electric embedded water savings are included as non energy benefits.

A maintenance cost ($19 and $30) is included as a negative non-energy benefit corresponding to RTF assumptions regarding regular maintenance of commercial washing machines.

Incentive Structure

The maximum incentives listed in Table 1 and Table 2 are for reference only and are not suggested incentives. Incentives will be structured per clothes washer.

Follow-Up

This measure should be updated following any changes to federal standards or ENERGY STAR specifications. Maintaining alignment with the RTF is preferred. Costs should be updated at the next revision. Consider splitting measure by water heating fuel rather than by territory at next revision.

Supporting Documents

The cost effective screening for these measures is attached and can be found along with supporting documents at: I:\Groups\Planning\Measure Development\Commercial and Industrial\Commercial Appliances\clothes washer

Commercial Clothes Washer CEC.xlsx

References

U.S. DOE's 2010-01-19 Commercial Clothes Washers Final Rule Technical Support Document: Chapter 8. Life-Cycle Cost and Payback Period Analysis http://www.regulations.gov/#!documentDetail;D=EERE-2012-BT-STD-0020-0036

RTF Commercial Clothes Washers https://rtf.nwcouncil.org/measure/clothes-washers

Version History and Related Measures

Energy Trust has been supporting commercial clothes washers for many years. This measure predates our current measure approval and record retention policies. Table 5 may be incomplete, particularly for activities prior to 2013.

Table 5 Version History

Date	Version	Reason for revision
6/27/2005	x	Approve commercial clothes washers for multifamily and laundromats. MEF>1.8
12/08/2006	x	Change incentives
3/09/2007	x	Update measure to MEF>2.0
3/06/2009	x	Update measure to align with CEE tier II specifications. MEF ≥ 2.0 WF ≤ 6.0. Blend Multifamily and laundromat savings
3/10/2009	x	Add partial territory clarifications and correct errors
11/06/2015	89.x	Update for ENERGY STAR 7.1. Split analysis for multifamily and commercial settings, add additional commercial building types. Weights water and dryer fuels. MEF >2.2.
1/22/2016	89.1	Adds residential new homes small multifamily as applicable program
9/19/17	89.2	Update water NEBs and embedded energy, maximum incentives.

Table 6 Related Measures

Measures	MAD ID
Multifamily in-unit clothes washers	152

Approved & Reviewed by

Jackie Goss, PE
Sr. Planning Engineer

Mike Bailey PE
Engineering Manager Planning

Disclaimer

April 6, 2015

UPDATED Measure Approval for Aerators in Commercial Buildings

End Use
Commercial service water heating

Scope
Faucet aerators in offices, hotels, motels, hospitals, restaurants, and other commercial buildings. Savings for single family and multifamily homes, as well as dorms and assisted living facilities are described in a separate document.

Program
Based on the following analysis and cost/benefit calculations, the measures described below are approved for inclusion in the Building Efficiency and New Building Efficiency programs in Oregon and Washington.

Description of the Measure
Aerators reduce the amount of water heating energy by restricting the flow rate of water at the faucet.

Purpose of Evaluating Measure
This memo adds leave behind measures and calculates the maximum cost effective incentive.

BCR Calculator (link: I:\Groups\Planning\Measure Development\Commercial and Industrial\aerator_Commercial\ETO CEC commercial aerator.xlsm)

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 Incentive If Measure is Cost-effective	Combined Utility System BCR	Combined Societal BCR
1.5 gpm aerator electric water heat	10	183		$8.66	$28	$8.66	**11.8**	**37.1**
1.5 gpm aerator gas water heat	10	10	7.9	$8.66	$28	$8.66	**3.8**	**29.1**
1.0 gpm aerator electric water heat	10	296		$8.66	$48	$8.66	**19.1**	**62.4**

1.0 gpm aerator gas water heat	10	18	13.5	$8.66	$48	$8.66	**6.6**	**49.8**
0.5 gpm aerator electric water heat	10	420		$8.66	$68	$8.66	**27.1**	**88.4**
0.5 gpm aerator gas water heat	10	25	19.1	$8.66	$68	$8.66	**9.3**	**70.6**
Leave behind 1.5 gpm aerator electric water heat	10	143		$8.66	$22	$8.66	**9.2**	**28.8**
Leave behind 1.5 gpm aerator gas water heat	10	8	6.1	$2.00	$22	$2.00	**12.9**	**97.9**
Leave behind 1.0 gpm aerator electric water heat	10	230		$2.00	$38	$2.00	**64.5**	**210.1**
Leave behind 1.0 gpm aerator gas water heat	10	14	10.5	$2.00	$38	$2.00	**22.1**	**167.8**
Leave behind 0.5 gpm aerator electric water heat	10	326		$2.00	$53	$2.00	**91.3**	**297.7**
Leave behind 0.5 gpm aerator gas water heat	10	20	14.9	$2.00	$53	$2.00	**31.3**	**237.7**

Measure Analysis

Many of the data points used by the current commercial aerator measures remain the same, including state and federal standards, mixing temperature at the faucet, and the

average efficiency of water heaters. Faucets assumed to be on for 13 minutes per day on weekdays.

The lodging and health cate subsectors will experience different total hot water loads, depending on their occupancy rates. Occupancy rates for the lodging sector are 80% and occupancy rate for the healthcare sector are 70%.

It is likely that offices will continue to be the majority of new buildings in which aerators are installed. Therefore, the energy savings, combined across the entire sector, are calculated from a mix of 50% office building, 25% lodging, and 25% health care. The distribution of buildings in which aerators are installed may change significantly, and the actual distribution should be examined in future years.

The install rate for leave behind measures is assumed to be 70%, based on similar install rates for leave behind showerheads.

Savings, Economics and Incentives
The cost of an aerator is between $1 and $2, plus 20 minutes of labor at $20 per hour. Measure life remains 10 years. The incentives listed in the calculator are the maximum cost effective incentives based on the utility test. However, the maximum costs and incentives for the showerheads are far and away greater than the actual cost of the showerhead, and should never, ever be paid in the real world. They 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.

Additional electrical energy savings result from reduced system pumping by the water utility. Water system pumping has an additional electrical energy savings of 5.29 kWh per 1000 gallons. 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. Water rates are slightly less in Vancouver, WA, where water savings are calculated at a rate of $9.81 per 1000 gallons.

Program Requirements
Faucet aerators with a maximum rated flow of 1.5 gpm or 1.0 gpm in either kitchen or bathroom or a faucet aerator with a maximum rated flow of 0.5 gpm in a bathroom sink.

warranties with regard to the documents, including warranties of non-infringement, merchantability or fitness for a particular purpose.

Paul Sklar, E.I.
Planning Engineer

Energy Trust of Oregon
421 SW Oak St., Suite 300
Portland, OR 97204

503.445.2947 DIRECT
503.546.6862 FAX
energytrust.org

reviewed by Fred Gordon

Measure Approval Document for Direct Install Smart Thermostats with Funding Partners

Valid Dates
September 25, 2018 – December 31, 2020

Description
This MAD approves the professional installation of qualified web-enabled thermostats installed in Oregon as part of the Portland General Electric Residential Thermostats DI Program (RTDIP) or installed in SW Washington where copayments are provided by a utility, community-based organization or low-income agency as described in this document.

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

- Residential Program
- Existing Multifamily Program

Within these programs, the measure is applicable to the following cases:

- Retrofits

Details
This approval document does not approve a specific, prescriptive installation scenario, but instead specifies the range of incentives that Energy Trust can provide as long as the funding partner organization provides support such that the remaining cost to Energy Trust and the customer does not exceed the maximum cost-effective level indicated in the CEC tables below. Each heating system/cooling system combination provides a different level of savings, thus the max residual copayment for each type of heating system is different.

Energy Trust expects each partner to have unique costs, funding and installation parameters. This approval document therefore requires that Energy Trust staff review each proposed application of these measures to ensure compliance with OPUC direction on measures utilizing other funding sources. **At the time of publication, only the PGE RTDIP and SW Washington applications are being approved by this MAD.**

Cost Effectiveness
The cost effectiveness tables below demonstrate several cost scenarios for each heating system type. Each specific program that utilizes this approval document will have different costs. For each heating system type, the highlighted rows indicate the max remaining cost after co-funding that is approved as cost effective by this approval document. Other rows are included for reference.

Table 1 Cost Effectiveness Calculator Oregon – Single Family

Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Cost ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Elec	% Gas
SF Gas Furnace w/Copayment, $400 Remaining	11	17	35.0	$400	$0.00	$149	1.00	0.37	7%	93%
SF Gas Furnace w/Copayment, $300 Remaining	11	17	35.0	$300	$0.00	$149	1.00	0.50	7%	93%
SF Gas Furnace w/Copayment, $200 Remaining	11	17	35.0	$200	$0.00	$149	1.00	0.74	7%	93%
SF Gas Furnace w/Copayment, $149 Remaining	11	17	35.0	$149	$0.00	$149	1.00	1.00	7%	93%
SF Gas Furnace w/Copayment, $100 Remaining	11	17	35.0	$100	$0.00	$100	1.49	1.49	7%	93%
SF Gas Furnace w/Central AC w/Copayment, $400 Remaining	11	46	35.0	$400	$0.00	$162	1.00	0.40	15%	85%
SF Gas Furnace w/Central AC w/Copayment, $300 Remaining	11	46	35.0	$300	$0.00	$162	1.00	0.54	15%	85%
SF Gas Furnace w/Central AC w/Copayment, $200 Remaining	11	46	35.0	$200	$0.00	$162	1.00	0.81	15%	85%
SF Gas Furnace w/Central AC w/Copayment, $162 Remaining	11	46	35.0	$162	$0.00	$162	1.00	1.00	15%	85%
SF Gas Furnace w/Central AC w/Copayment, $100 Remaining	11	46	35.0	$100	$0.00	$100	1.62	1.62	15%	85%
SF Electric Furnace w/Copayment, $400 Remaining	11	360	0.0	$400	$0.00	$239	1.00	0.60	100%	0%
SF Electric Furnace w/Copayment, $300 Remaining	11	360	0.0	$300	$0.00	$239	1.00	0.80	100%	0%
SF Electric Furnace w/Copayment, $239 Remaining	11	360	0.0	$239	$0.00	$239	1.00	1.00	100%	0%
SF Electric Furnace w/Copayment, $200 Remaining	11	360	0.0	$200	$0.00	$200	1.19	1.19	100%	0%
SF Electric Furnace w/Copayment, $100 Remaining	11	360	0.0	$100	$0.00	$100	2.39	2.39	100%	0%
SF Electric Furnace w/Central AC w/Copayment, $400 Remaining	11	389	0.0	$400	$0.00	$258	1.00	0.65	100%	0%
SF Electric Furnace w/Central AC w/Copayment, $300 Remaining	11	389	0.0	$300	$0.00	$258	1.00	0.86	100%	0%
SF Electric Furnace w/Central AC w/Copayment, $258 Remaining	11	389	0.0	$258	$0.00	$258	1.00	1.00	100%	0%
SF Electric Furnace w/Central AC w/Copayment, $200 Remaining	11	389	0.0	$200	$0.00	$200	1.29	1.29	100%	0%
SF Electric Furnace w/Central AC w/Copayment, $100 Remaining	11	389	0.0	$100	$0.00	$100	2.58	2.58	100%	0%
SF Heat Pump w/Copayment, $400 Remaining	11	594	0.0	$400	$0.00	$364	1.00	0.91	100%	0%
SF Heat Pump w/Copayment, $363 Remaining	11	594	0.0	$363	$0.00	$363	1.00	1.00	100%	0%
SF Heat Pump w/Copayment, $300 Remaining	11	594	0.0	$300	$0.00	$300	1.21	1.21	100%	0%
SF Heat Pump w/Copayment, $200 Remaining	11	594	0.0	$200	$0.00	$200	1.82	1.82	100%	0%
SF Heat Pump w/Copayment, $100 Remaining	11	594	0.0	$100	$0.00	$100	3.64	3.64	100%	0%

Table 2 Cost Effectiveness Calculator Oregon – Multifamily

Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Elec	% Gas
MF Gas Furnace w/Copayment, $400 Remaining	11	13	27.5	$400	$0.00	$117	1.00	0.29	7%	93%
MF Gas Furnace w/Copayment, $300 Remaining	11	13	27.5	$300	$0.00	$117	1.00	0.39	7%	93%
MF Gas Furnace w/Copayment, $200 Remaining	11	13	27.5	$200	$0.00	$117	1.00	0.59	7%	93%
MF Gas Furnace w/Copayment, $117 Remaining	11	13	27.5	$117	$0.00	$117	1.00	1.00	7%	93%
MF Gas Furnace w/Copayment, $100 Remaining	11	13	27.5	$100	$0.00	$100	1.17	1.17	7%	93%
MF Gas Furnace w/Central AC w/Copayment, $400 Remaining	11	36	27.5	$400	$0.00	$132	1.00	0.33	18%	82%
MF Gas Furnace w/Central AC w/Copayment, $300 Remaining	11	36	27.5	$300	$0.00	$132	1.00	0.44	18%	82%
MF Gas Furnace w/Central AC w/Copayment, $200 Remaining	11	36	27.5	$200	$0.00	$132	1.00	0.66	18%	82%
MF Gas Furnace w/Central AC w/Copayment, $133 Remaining	11	36	27.5	$133	$0.00	$132	1.00	1.00	18%	82%
MF Gas Furnace w/Central AC w/Copayment, $100 Remaining	11	36	27.5	$100	$0.00	$100	1.32	1.32	18%	82%
MF Electric Furnace w/Copayment, $400 Remaining	11	282	0.0	$400	$0.00	$187	1.00	0.47	100%	0%
MF Electric Furnace w/Copayment, $300 Remaining	11	282	0.0	$300	$0.00	$187	1.00	0.62	100%	0%
MF Electric Furnace w/Copayment, $200 Remaining	11	282	0.0	$200	$0.00	$187	1.00	0.94	100%	0%
MF Electric Furnace w/Copayment, $188 Remaining	11	282	0.0	$188	$0.00	$187	1.00	1.00	100%	0%
MF Electric Furnace w/Copayment, $100 Remaining	11	282	0.0	$100	$0.00	$100	1.87	1.87	100%	0%
MF Electric Furnace w/Central AC w/Copayment, $400 Remaining	11	306	0.0	$400	$0.00	$203	1.00	0.51	100%	0%
MF Electric Furnace w/Central AC w/Copayment, $300 Remaining	11	306	0.0	$300	$0.00	$203	1.00	0.68	100%	0%
MF Electric Furnace w/Central AC w/Copayment, $203 Remaining	11	306	0.0	$203	$0.00	$203	1.00	1.00	100%	0%
MF Electric Furnace w/Central AC w/Copayment, $200 Remaining	11	306	0.0	$200	$0.00	$200	1.01	1.01	100%	0%
MF Electric Furnace w/Central AC w/Copayment, $100 Remaining	11	306	0.0	$100	$0.00	$100	2.03	2.03	100%	0%
MF Heat Pump w/Copayment, $400 Remaining	11	467	0.0	$400	$0.00	$286	1.00	0.71	100%	0%
MF Heat Pump w/Copayment, $300 Remaining	11	467	0.0	$300	$0.00	$286	1.00	0.95	100%	0%
MF Heat Pump w/Copayment, $286 Remaining	11	467	0.0	$286	$0.00	$286	1.00	1.00	100%	0%
MF Heat Pump w/Copayment, $200 Remaining	11	467	0.0	$200	$0.00	$200	1.43	1.43	100%	0%
MF Heat Pump w/Copayment, $100 Remaining	11	467	0.0	$100	$0.00	$100	2.86	2.86	100%	0%

Table 3 Cost Effectiveness Calculator Washington – Single Family

Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Elec	% Gas
SF Gas Furnace w/Copayment, $400 Remaining	11	17	35.0	$400	$1.37	$271.03	1.00	0.71	0%	100%
SF Gas Furnace w/Copayment, $300 Remaining	11	17	35.0	$300	$1.37	$271.03	1.00	0.94	0%	100%
SF Gas Furnace w/Copayment, $282 Remaining	11	17	35.0	$282	$1.37	$271.03	1.00	1.00	0%	100%
SF Gas Furnace w/Copayment, $200 Remaining	11	17	35.0	$200	$1.37	$200.00	1.36	1.41	0%	100%
SF Gas Furnace w/Copayment, $100 Remaining	11	17	35.0	$100	$1.37	$100.00	2.71	2.82	0%	100%
SF Gas Furnace w/Central AC w/Copayment, $400 Remaining	11	46	35.0	$400	$3.78	$271.03	1.00	0.75	0%	100%
SF Gas Furnace w/Central AC w/Copayment, $350 Remaining	11	46	35.0	$350	$3.78	$271.03	1.00	0.86	0%	100%
SF Gas Furnace w/Central AC w/Copayment, $300 Remaining	11	46	35.0	$300	$3.78	$271.03	1.00	1.00	0%	100%
SF Gas Furnace w/Central AC w/Copayment, $250 Remaining	11	46	35.0	$250	$3.78	$250.00	1.08	1.21	0%	100%
SF Gas Furnace w/Central AC w/Copayment, $200 Remaining	11	46	35.0	$200	$3.78	$200.00	1.36	1.51	0%	100%
SF Gas Furnace w/Central AC w/Copayment, $150 Remaining	11	46	35.0	$150	$3.78	$150.00	1.81	2.01	0%	100%
SF Gas Furnace w/Central AC w/Copayment, $100 Remaining	11	46	35.0	$100	$3.78	$100.00	2.71	3.01	0%	100%
SF Gas Furnace w/Central AC w/Copayment, $50 Remaining	11	46	35.0	$50	$3.78	$50.00	5.42	6.03	0%	100%

Table 4 Cost Effectiveness Calculator Washington – Multifamily

Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Elec	% Gas
MF Gas Furnace w/Copayment, $400 Remaining	11	13	27.5	$400	$1.07	$212.95	1.00	0.55	0%	100%
MF Gas Furnace w/Copayment, $300 Remaining	11	13	27.5	$300	$1.07	$212.95	1.00	0.74	0%	100%
MF Gas Furnace w/Copayment, $223 Remaining	11	13	27.5	$223	$1.07	$212.95	1.00	1.00	0%	100%
MF Gas Furnace w/Copayment, $200 Remaining	11	13	27.5	$200	$1.07	$200.00	1.06	1.11	0%	100%
MF Gas Furnace w/Copayment, $100 Remaining	11	13	27.5	$100	$1.07	$100.00	2.13	2.22	0%	100%
MF Gas Furnace w/Central AC w/Copayment, $400 Remaining	11	36	27.5	$400	$2.97	$212.95	1.00	0.59	0%	100%
MF Gas Furnace w/Central AC w/Copayment, $300 Remaining	11	36	27.5	$300	$2.97	$212.95	1.00	0.79	0%	100%
MF Gas Furnace w/Central AC w/Copayment, $236 Remaining	11	36	27.5	$236	$2.97	$212.95	1.00	1.00	0%	100%
MF Gas Furnace w/Central AC w/Copayment, $200 Remaining	11	36	27.5	$200	$2.97	$200.00	1.06	1.18	0%	100%
MF Gas Furnace w/Central AC w/Copayment, $100 Remaining	11	36	27.5	$100	$2.97	$100.00	2.13	2.37	0%	100%

Exceptions

On August 30, 2018, the OPUC granted a two-year exception for the Portland General Electric, PGE, direct install measure "DI DR Thermostat Gas FAF + AC" under the "minor measures" approval process as described below. This exception is only for installations as a part of Portland General Electric's residential thermostat direct install program.

The measure exception was granted based on these criteria:

- D: improves participation in a cost-effective program by providing consistency with other program offerings, namely, homes with air conditioning that are heated with electric furnaces and electric heat pumps
- F: as part of a pilot program intended for a limited number of customers.

Due to Energy Trust listing as the primary reason for the exception being tied to an offering from PGE's Demand Response pilot program and the uncertainty of this measure's impact the OPUC is concerned about the interrelated and apparently mutual dependent nature of these offerings and the risks attendant to ratepayers. As a condition of this exception the OPUC will also require that:

1. Energy Trust to lead a joint workshop with PGE for Staff and stakeholders to educate interested parties about how Energy Trust's energy efficiency measures were designed and being implemented as a complement to PGE's demand response programs within six months of this authorization. The workshop should explain the interrelated nature of cost-effectiveness using actual program data from both programs – without compromising confidentiality - and highlight design principles so that other utilities can begin to design DR programs that leverage Energy Trust incentives.
2. Energy Trust to produce a report with PGE to update the Commission on how this measure is performing and what has been learned from Energy Trust's participation with the PGE Demand Response pilot program within one year of this authorization

This exception is good for two years or until the measure becomes > 5% of the Program's savings or the TRC drops. The exception will expire a few months before the MAD expires. Non cost effective measures must be discontinued at that time unless further exceptions are approved.

Requirements

- The only allowed delivery channel in Oregon is the PGE Residential Thermostat Direct Install Program, a demand reduction pilot. Installations are also allowed in NW Natural Washington's service territory with or without co-funding provided they do not exceed costs and incentives in the CEC tables above.
- Thermostats must be on the Smart Thermostat qualified products list.
- Cost of the installation minus copayment cannot exceed the incremental value indicated in the highlighted rows of the CEC tool.
- In cases where a funding partner is providing support above the minimum cost-effectiveness levels highlighted in the CEC, the total co-funding amount plus the total incentive amount cannot exceed the total project cost.

Baseline

This measure uses an Existing Condition Baseline.

The baseline for this measure is an existing programmable or manual thermostat. Thermostats will be installed by contractors, so there is reasonable certainty that homes will not have a pre-existing qualified thermostat as it is assumed a funding partner would not pay for the installation of a second qualified thermostat.

This baseline condition is different than in MAD 153, which uses an inefficient market baseline. Because the actual thermostats that make up the baseline in both scenarios are similar, however, the savings remain transferrable between analyses.

Savings and Measure Analysis

Where not otherwise specified, sources for this analysis are derived from the Retail Web-Enabled Thermostats MAD (#153).

Table 5 Single Family Savings

HVAC System	Heating Savings		Cooling Savings	Total kWh	Total Therms
	kWh	Therms	kWh	kWh	Therms
Gas Furnace with CAC	17	35.0	30	46	35.0
Gas Furnace (no CAC)	17	35.0	0	17	35.0
Electric Furnace with AC	360	0	30	389	0
Electric Furnace (no CAC)	360	0	0	360	0
Heat Pump	594	0	n/a (included in other savings)	594	0

Table 6 Multifamily Savings

HVAC System	Heating Savings		Cooling Savings	Total kWh	Total Therm
	kWh	Therms	kWh	kWh	Therms
Gas Furnace with CAC	13	27.5	23	36	27.5
Gas Furnace (no CAC)	13	27.5	0	13	27.5
Electric Furnace with AC	282	0	23	306	0
Electric Furnace (no CAC)	282	0	0	282	0
Heat Pump	467	0	n/a (included in other savings)	467	0

Baseline loads for heating and cooling

For single family homes, the average annual heating loads are derived from the 2011 RBSA.[1] The average heating loads for Oregon homes are 5,992 kWh and 583 therms for electric and gas heated homes, respectively. These values include both heating zone 1 and heating zone 2 and are used for electric furnace and gas furnace heated homes in this analysis. The heating load for heat pump homes is backed out from the savings numbers and percentages stated in the follow up billing analysis from the 2013/2014 Nest thermostat pilot.[2]

Cooling loads are less well established, however the same Nest pilot evaluation found 200 kWh of cooling usage while the 2016 summer Seasonal Savings[3] billing analysis 787 kWh of Portland summer cooling load. Due to the large difference between these values, this analysis uses the average of these two loads.

For multifamily dwelling units, the average annual heating load for electrically heated units is derived from the RTF's Connected Thermostat measure analysis[4]. To determine the annual heating load for multifamily gas heated units, the ratio of the multifamily electric heating load to the single family electric heating load was calculated and applied to the single family average gas heating load of 583 therms. The electric heating ratio was found to be 0.79 which resulted in a multifamily average gas heating load of 458 therms.

[1] 2011 RBSA: Single Family Characteristics and Energy Use. Ecotope, 2012. https://neea.org/resources/2011-rbsa-single-family-characteristics-and-energy-use
[2] *Evaluation of Nest Thermostat Heat Pump Control Pilot*. Apex Analytics, 2014. https://www.energytrust.org/wp-content/uploads/2016/12/Nest_Pilot_Study_Evaluation_wSR.pdf
[3] *Nest Thermostat Seasonal Savings Pilot Evaluation.* Apex Analytics, 2017. https://www.energytrust.org/wp-content/uploads/2017/12/Energy-Trust-of-Oregon-Nest-Seasonal-Savers-Pilot-Evaluation-FINAL-wSR.pdf
[4] *RTF Connected Thermostats.* https://rtf.nwcouncil.org/measure/connected-thermostats

Heating savings

This measure utilizes a 6% savings rate, sourced from the Retail Web-Enabled Thermostats MAD (#153) for homes with electric or gas furnaces, however homes with heat pumps will use the savings value from the 2014 Nest thermostat pilot billing analysis of 594kWh, an assumed 12% savings.

Cooling savings

Homes with cooling controlled by the web-enabled thermostat may experience additional savings. As one of the primary use-cases of this measure will be electric utility demand-response programs, homes with central AC will likely make up a larger fraction of participants than exist in the general population.

Where the equipment to cool is present, cooling savings will be assumed to be the same as heating savings, at 6% of the cooling load. This is currently an Energy Trust engineering judgement. Thermostat manufacturer's report higher summer savings percentages than this in other regions, however there is currently a lack of strong evidence for a higher level of savings in the Pacific NW.

Fan Savings

For gas heated homes, the runtime of the furnace fan will be reduced and will generate electrical savings. The average annual fan energy usage is derived from the Regional Technical Forum's (RTF) Residential Single Family Existing HVAC and Weatherization analysis. Since gas furnace fan savings are achieved through runtime reduction, savings are also assumed to be 6%, which is in agreement with the heating load savings. Fan savings are only calculated for heating zone 1 in order to take a conservative approach.

Fan savings are not included in electric measures as runtime reduction kWh savings are already included in the overall heating loads and usage reductions.

Install rate

Because all thermostats will be direct-installed by a contractor or other professional installer, a 100% installation rate will be used.

Comparison to RTF and other offerings

This MAD deviates from the RTF primarily in that Energy Trust uses a longer measure life than the RTF, includes gas heated measures, and utilizes pilot results for heat pump savings rather than percentage-based savings. The RTF also splits savings by heating zone, while Energy Trust simply blends all zones together.

This offer differs from the standard retail smart thermoset measure in several ways. First, the retail measure (MAD 153) chooses to blend all electric heating systems together due to uncertainties in heating system reporting. This measure specifies professionally installed thermostats, so there is a greater certainty in heating system of the home. Second, the retail measure uses the average device cost of a programmable thermostat as the baseline cost, whereas this measure specifies a range of costs based on the specific program to which this measure is being applied. This MAD is non-prescriptive, while other Energy Trust thermostat offers have been only prescriptive.

Measure Life

This measure uses an 11-year measure life, consistent with other Energy Trust thermostat measures.

Costs

Costs for each thermostat install will vary based on the detail of co-funding agreements. The actual cost for specific program efforts will be used the application of measure.

Costs for this analysis start $450 per installation, which is an estimate sourced from one utility demand-response program. The cost recorded in each line of the CEC is the difference between this assumed full cost and the level of funding partner support. The highlighted rows in in table demonstrate the maximum cost approved for participation in this measure.

Non Energy Benefits

In Washington, unclaimed electric savings are included as non-energy benefits.

Incentive Structure

The maximum incentives listed in
Table 1 through **Error! Reference source not found.** are for reference only and are not suggested incentives.

Incentives will be determined individually for each specific application of this offering as the level of copayment will vary between programs, changing the incentives that Energy Trust can pay. In no cases should the combination of the copayment and Energy Trust dollars exceed the total project cost or the incentive listed in the highlighted row.

SRAF

No free-ridership SRAF will be used for this measure as it is a direct installation service. Programs supported by this MAD would not exist at scale without Energy Trust incentives.

Follow-Up

- As of September 2018, Energy Trust has engaged the OPUC to discuss how other funding streams (e.g., community based organizations in-kind labor, rate payer based low income funds, federal funds) should be handled in TRC calculations. Should the OPUC approve additional funding streams, this MAD will be amended to reflect additional eligible delivery mechanisms.
- Cooling usage is still a relatively uncertain aspect of NW energy usage. As such, this measure should receive follow up if more definitive cooling loads become available via evaluation activities or other research.
- Any program desiring to run the program with partner copayment levels that do not meet or exceed the cost-effectiveness thresholds in the CEC may require a new OPUC exception request for the specific scenario under consideration.
- Single family homes with a gas furnace and central AC are allowed under an OPUC exception I:\Groups\Planning\Measure Development\Residential\Res HVAC\thermostat\web enabled thermostat\co funded\bencost, with the further understanding that there may be incidental inclusion of small multifamily properties. If a utility or other partner agency begins to specifically target gas multifamily dwellings and does not contribute enough to bring the costs below the cost in the highlighted rows, an additional exception request will be needed.

Supporting Documents

The cost effective screening for these measures is attached and can be found along with supporting documentation at:
I:\Groups\Planning\Measure Development\Residential\Res HVAC\thermostat\web enabled thermostat\co funded\bencost

222 cofunded DI Thermostats - CEC.xl

Version History and Related Measures

Table 7 Version History

Date	Version	Reason for revision
9/25/2018	222.1	Creation of direct install smart thermostats with copayments for PGE direct install demand reduction program in Oregon, and installations in in SW Washington with or without co-funding.

Table 8 Related Measures

Measures	MAD ID
Retail Web-Enabled Thermostats	153
Automated Thermostat Optimization	173
Strip heat lock out for heat pumps	19
Contractor installed thermostats on heat pumps	148

Approved & Reviewed by

Jackie Goss, PE
Sr. Planning Engineer

Mike Bailey PE
Engineering Manager Planning

Disclaimer

Measure Approval Document for Energy Saver Kits

Valid Dates
January 1, 2019 – December 31, 2019

End Use or Description
Energy Saver Kits

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

- Residential

Purpose of Re-Evaluating Measure

- Showerheads and wands
    - Updated RTF analysis is being incorporated for savings and non-energy benefits.
- Aerators:
    - Recently completed RTF analysis is being incorporated into this MAD for savings.
- LED measures:
    - Updated market analysis on baselines is being used to adjust savings, incremental costs and non-energy benefits.

Cost Effectiveness

Table 1 Cost Effectiveness Calculator Oregon

Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Electric Alloc.	% Gas Alloc.
By Request Showerhead - Full Territory Any Electric 1.75 GPM	15	177	0.0	$6.00	$17.99	$6.00	21.65	54.30	100%	0%
By Request Showerhead - Full Territory Any Electric 1.50 GPM	15	212	0.0	$6.00	$21.60	$6.00	25.99	65.20	100%	0%
By Request Showerhead - Full Territory Gas 1.75 GPM	15	5	7.9	$6.00	$18.02	$6.00	6.73	39.44	9%	91%
By Request Showerhead - Full Territory Gas 1.50 GPM	15	6	9.5	$6.00	$21.63	$6.00	8.07	47.33	9%	91%
By Request Showerhead - Partial Territory Gas 1.75 GPM	15	0	7.9	$6.00	$18.48	$6.00	6.12	39.66	0%	100%
By Request Showerhead - Partial Territory Gas 1.50 GPM	15	0	9.5	$6.00	$22.19	$6.00	7.34	47.60	0%	100%
By Request Shower Wand - Full Territory Any Electric 1.75 GPM	15	150	0.0	$11.00	$15.25	$11.00	10.01	25.11	100%	0%
By Request Shower Wand - Full Territory Any Electric 1.50 GPM	15	240	0.0	$11.00	$24.40	$11.00	16.02	40.17	100%	0%
By Request Shower Wand - Full Territory Gas 1.75 GPM	15	5	7.7	$11.00	$17.47	$11.00	3.56	20.85	9%	91%
By Request Shower Wand - Full Territory Gas 1.50 GPM	15	7	11.7	$11.00	$26.62	$11.00	5.42	31.78	9%	91%
By Request Shower Wand - Partial Territory Gas 1.75 GPM	15	0	7.7	$11.00	$17.92	$11.00	3.23	20.97	0%	100%
By Request Shower Wand - Partial Territory Gas 1.50 GPM	15	0	11.7	$11.00	$27.30	$11.00	4.93	31.96	0%	100%
By Request General Purpose and Three-Way 250 to 1049 lumens	12	4.6	0	$2.91	$0.10	$2.91	1.00	1.31	100%	0%
By Request Reflectors and Outdoor 250 to 1049 lumens	12	3.8	0	$2.38	$0.15	$2.38	1.00	1.59	100%	0%
By Request Bathroom Aerator 1 GPM ELE	15	26	0.0	$1.35	$4.13	$1.35	14.20	47.55	100%	0%
By Request Bathroom Aerator 1 GPM GAS	15	1	1.1	$1.35	$4.13	$1.35	4.56	37.90	14%	86%
By Request Bathroom Aerator 1 GPM Partial Territory Gas	15	0	1.1	$1.35	$4.24	$1.35	3.93	38.13	0%	100%
By Request Kitchen Aerator 1.5 GPM ELE	15	32	0.0	$1.85	$4.24	$1.85	12.78	37.73	100%	0%
By Request Kitchen Aerator 1.5 GPM Gas	15	1	1.4	$1.85	$4.24	$1.85	4.03	28.98	12%	88%
By Request Kitchen Aerator 1.5 GPM Partial Territory Gas	15	0	1.4	$1.85	$4.35	$1.85	3.57	29.15	0%	100%

Table 2 Cost Effectiveness Calculator Washington

Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	Other NEB (Annual $)	ELE Bill Savings (Annual $)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR
WA By Request Showerhead - Partial Territory Gas 1.75 GPM	15	8.2	$6.00	$15.32	$0.00	$15.32	$6.00	8.49	33.88
WA By Request Showerhead - Partial Territory Gas 1.50 GPM	15	9.9	$6.00	$18.56	$0.00	$18.56	$6.00	10.29	41.06
WA By Request Shower Wand - Partial Territory Gas 1.75 GPM	15	7.9	$11.00	$14.77	$0.00	$14.77	$11.00	4.47	17.82
WA By Request Shower Wand - Partial Territory Gas 1.50 GPM	15	12.2	$11.00	$22.86	$0.00	$22.86	$11.00	6.91	27.58
WA By Request Bathroom Aerator 1 GPM Partial Territory Gas	15	1.1	$1.35	$3.39	$0.00	$3.39	$1.35	5.26	30.23
WA By Request Kitchen Aerator 1.5 GPM Partial Territory Gas	15	1.4	$1.85	$3.47	$0.00	$3.47	$1.85	4.77	23.45

Requirements

- The maximum number of products distributed in each kit shall be determined by program staff in consultation with Energy Trust Planning.
- In gas only service territory, showerheads and aerators should only be distributed to customers with gas water heating.
- Lighting products should not be distributed in gas only service territory.
- In electric only service territory, showerheads and aerators should only be distributed to customers with electric water heat.
- Each household should not receive a kit more often than once every two years, with reasonable and agreed upon exceptions, such as residency changes or alterations or additions in kit product content.
- Bulbs must be ENERGY STAR qualified or meet the ENERGY STAR specification.

Baseline

Showerheads, wands and aerators:

- Existing Condition – Inefficient Market Baseline

LED measures:

- Full Market Baseline

Describe baseline and how it was determined

Showerheads and wands:

- RBSA I data specific to Oregon was used to determine a weighted average flow rate for single family, manufactured homes and multifamily dwellings. Flow rates are then weighted by housing type based on surveys conducted in 2018 by Energy Trust.

Aerators:

- Uses RBSA II data specific to Oregon to determine a weighted average flow rate for single family, manufactured homes and multifamily dwellings. Flow rates are then weighted by housing type based on surveys conducted in 2018 by Energy Trust.

LEDs:

- LED bulbs have a dramatically longer life than other bulbs on the market. To account for this, Energy Trust has adopted a modified version of the RTF Residential Lighting workbook. The workbook models a shift in the baseline energy usage over time as inefficient bulbs burn out and are replaced. Each bulb type has an assumed life in years, based on rated hours and expected hours of use, rounded to the nearest year, with a minimum life of one year. It is assumed that when a bulb burns out it will be replaced at the current market share of all products. The market replacement assumption is a change from previous RTF analysis, which assumed that half the bulbs were replaced like for like, half at the market rate. Much more detailed description of the methodology is available on the RTF website[1].

Measure Analysis

Table 3 and Table 4 are used for multiple kit components and are referenced in the specific measure component sections.

[1] https://rtf.nwcouncil.org/measure/residential-lighting

Table 3 Installation Rates from 2018 ESK Survey

Kit Component	Net Install Rate
A-lamps	**71%**
Reflectors	**73%**
Shower wands	**61%**
Showerheads	**55%**
1.75 gpm	***58%***
1.50 gpm	***53%***
Kitchen Aerators	**49%**
Bath Aerators	**59%**

Table 4 Kit Recipient Housing Type Distribution from 2018 ESK Survey

	Percent (n=200)	Percent excluding refused (n=197)	Oregon housing units	Housing Category	Percent
Single family detached	79%	81%	64%	Single Family	64%
Single family attached	4%	4%	5%	Multifamily	28%
Duplex, triplex or fourplex	6%	6%	7%		
Apartment or condominium with >=5 units	5%	5%	16%		
Manufactured or mobile home	5%	5%	8%	Manufactured Home	8%
Refused	2%				

Savings

Showerheads and shower wands
Savings analysis is based on a modified version of the RTF's and commercial and residential showerhead workbook v3.1.[2]

The RTF uses the following equations to develop unit energy consumptions, UECs, for each water heater technology, flow rate of showerhead/wand and housing type:

- [Water consumption] = [rated flow rate (gallons/minute)] x [in use flow adjustment] x [# of events/yr] x [event duration (minutes/event)]
- [End-use Energy consumption] = [water consumption] x [mixed hot water energy intensity (kWh/gallon)]
- [Embedded water/waste water energy consumption] = [water consumption] x [water/waste water energy intensity (kWh/gallon)]

[2] RTF Commercial and Residential Showerheads v3.1

Table 5 through Table 7 describe the various inputs used to estimate individual UECs for all combinations of measure types, with specific inputs and outputs presented in Table 8 and Table 9.

UECs are then combined with existing distributions of flow rates by housing types from Table 11 to generate a weighted existing baseline energy consumption from which specific UECs for flow rates can be subtracted to generate unit energy savings, or UESs, discussed in Table 12. These values are then multiplied by the installation rates found in Table 3 and weighted based on the housing type distribution found in Table 4.

Table 5 below presents the inputs to estimate energy intensity of water heating by various technologies. Recovery energy (RE) for electric resistance and gas storage water heaters are sourced from the RTF standard information workbook, SIW.[3] Heat pump water heater recovery efficiency of 200% is an RTF judgement. Remaining values are RTF input assumptions and calculations.

Table 5 Water Heater Recovery Energy, Temperature Rise and Energy Intensities by Water Heater Type and Fuel

Water Heating Type	RE	Water Heater delta T	Effective delta T of mixed hot water for shower	Specific Heat of Water (kWh/gallon/degF)	Specific Heat of Water (therms/gallon/degF)	Energy Intensity (kWh/gallon)	Energy Intensity (therms/gallon)
Electric Resistance	1.00	75	52.5	0.0024		0.128	
Electric HPWH	2.00	75	52.5	0.0024		0.064	
Gas	0.75	75	52.5		0.0001		0.0058

Table 6 below presents the in-situ multipliers for the various flow rate categories in addition to the estimate length of shower associated with each rated flow rate (1.6 gpm device duration deviated substantially from 1.5 and 1.75 gpm devices, 8.4 minutes, and instead uses an average of the two flow rates, 9.03 minutes).[4] 90% is the multiplier used by the RTF while 1.5 gpm devices used in-situ rates found in a 2016 Energy Trust field study on 1.5gpm devices.[5]

Values above 2.5 gpm are based on RBSA I measured findings divided by an in-situ rate of 90% to estimate a rated flow value.

Table 6 Flow Rate In-situ adjustments and Shower Event Duration by Rated Flow Rate

Rated Flow Rate Category	Rated flow rate (gpm)	In situ adjustment	duration (minutes/event)
>2.5 GPM	3.67	90%	7.39
2.50 GPM	2.50	90%	8.20
2.00 GPM	2.00	90%	8.37
1.80 GPM	1.80	90%	8.72
1.75 GPM	1.75	90%	8.86
1.60 GPM	1.60	90%	9.03
1.50 GPM	1.50	88% (81% for wands)	9.21

[3] RTF Standard information workbook v2.6 (current SIW version as of this publication date is v3.2, but values remain the same).
[4] Aquacraft, Inc. Residential End Uses of Water
[5] Energy Trust Multifamily Showerhead Study Report

Table 7 describes the inputs used to generate people per showerhead. RBSA I data specific to Oregon provides average and total showerheads per housing type (single family, manufactured home, multifamily), while 2015 American Community Survey, ACS, data is used to source Oregon occupancy per housing type, and gas heated homes only for the Southwest Washington service territory. Given the ACS does not collect water heating fuel, gas heated homes are used as a proxy for occupants per housing type in homes with gas water heating.

RBSA I data is extremely limited for SW Washington resulting in the use of the Oregon RBSA I distribution of total showerheads to create a weighted average occupant per showerhead for both Oregon and Washington.

Table 7 Showerheads per Dwelling, Total Showerheads and Occupancy per Housing Type

	SF	MH	MF	Weighted Avg
Oregon total # of showerheads (RBSA I)	**2,030,706**	**283,035**	**269,610**	**-**
Oregon average # of showerheads per residence (RBSA I)	1.7	1.65	1.21	1.65
Occupants per dwelling 2015 OR ACS	2.74	2.44	2.11	2.64
Occupants per shower Oregon	***1.61***	***1.48***	***1.75***	***1.61***
Total Oregon shower events (at 250 events per person/yr)	***402***	***369***	***436***	***402***
Washington				
Occupants per gas dwelling 2015 SW WA ACS	2.98	2.13	2.34	2.82
Occupants per shower SW Washington	***1.75***	***1.29***	***1.94***	***1.72***
Total Washington shower events (at 250 events per person/yr)	***437***	***322***	***484***	***430***

Table 8 below illustrates the combined inputs used to generate UECs by water heater type, flow rate, measure type and housing type for a limited number of flow rates. Energy Trust specific costs of water per gallon have been added as well (separate values are used for Oregon and Washington).

Table 8 Examples of Combined Inputs used for Oregon Single Family Showerhead Unit Energy Consumption Calculation

Showerhead Water Heater Type and Flow Rate	Rated Flow Rate (gpm)	In use flow adjustment	Frequency for SF (events/yr)	Event duration (minutes/event)	End-use energy intensity (kWh or therms/gal.)	Water/ waste water energy intensity (kWh/gal.)	Energy Trust OR water/waste water cost, net of energy cost ($/gal.)
Electric Resistance 1.75 GPM	1.75	90%	402	8.9	0.128	0.0037	$0.013
Electric Resistance 1.50 GPM	1.50	88%	402	9.2	0.128	0.0037	$0.013
Electric HPWH 1.75 GPM	1.75	90%	402	8.9	0.064	0.0037	$0.013
Electric HPWH 1.50 GPM	1.50	88%	402	9.2	0.064	0.0037	$0.013
Gas 1.75 GPM	1.75	90%	402	8.9	0.0058	0.0037	$0.013
Gas 1.50 GPM	1.50	88%	402	9.2	0.0058	0.0037	$0.013

Table 9 Shows the UEC values based on the inputs from Table 8.

Table 9 Examples of Unit Energy Consumption Outputs

Showerhead Water Heater Type and Flow Rate	Water Consumption (gallons/year)	Primary Energy Consumption		Embedded Water/Waste Water		
		Annual Energy Consumption (kWh/yr)	Annual Energy Consumption (therms/yr)	Annual Energy Consumption (kWh/yr)	Energy Trust water/ Waste Water cost ($/yr)	In use flow rate (gpm)
Electric Resistance 1.75 GPM	5,607	719	0	21	$74.58	1.58
Electric Resistance 1.50 GPM	4,888	626	0	18	$65.01	1.32
Electric HPWH 1.75 GPM	5,607	359	0	21	$74.58	1.58
Electric HPWH 1.50 GPM	4,888	313	0	18	$65.01	1.32
Gas 1.75 GPM	5,607	0	33	21	$74.58	1.58
Gas 1.50 GPM	4,888	0	28	18	$65.01	1.32

Table 10 Shows the split used between standard electric resistance storage and heat pump water heaters. This value is an RTF judgement and was made after RBSA I and prior to RBSA II data being available. These values enable one common electric water heating baseline UEC.

Table 10 Electric Water Heater Weighting

Housing Type	Electric Resistance	Electric HPWH
Any Electric Any home	98%	2%
Any Electric SF	98%	2%
Any Electric MF	98%	2%
Any Electric MH	98%	2%

Table 11 contains the flow rate distributions by housing type from RBSA I and the multifamily field tests of flow rates for showerheads and wands. Single family and manufactured home rates are sourced from RBSA I data. Multifamily savings calculations are based on the blended showerhead and wand flow rates based on the distribution of units installed in the 2016 program year (72% showerhead, 28% wand).

Table 11 RBSA I and Multifamily Field Test Distribution of Showerhead/Wand Flow Rate Distributions by Housing Type

Home Type	Rated Flow Rate						
	>2.5 GPM	2_50 GPM	2_00 GPM	1_80 GPM	1_75 GPM	1_60 GPM	1_50 GPM
By Request Any home - Any Device	43%	32%	7%	0%	11%	0%	7%
By Request SF - Any Device	44%	34%	6%	0%	11%	0%	5%
By Request MF - Showerhead	29%	29%	15%	0%	21%	0%	6%
By Request MF - Shower wand	2%	26%	19%	0%	28%	0%	26%
By Request MF - Any Device (blended flow rate)	19%	28%	16%	0%	23%	0%	12%
By Request MH - Any Device	66%	18%	4%	0%	2%	0%	9%

Table 12 Illustrates the calculation of water energy UESs for Oregon electric showerhead measures. The existing baseline distribution (Table 11) is used to generate baseline UEC values for each housing type in the analysis, while the distribution of kits by housing type (Table 4) is used to weight home type specific

analysis into a series or UECs for any home type. UECs calculated for each flow rate are subtracted from the baseline UEC to estimate the UES values for electric and gas water heating energy, waste water energy and water usage.

Table 12 Example of Unit Energy Savings Calculation for Oregon ESK Electric Showerhead Water Heater Savings

Measure Type	DHW Energy (kWh/yr)					
	SF UEC	MH UEC	MF UEC	Weighted UEC	Baseline UEC	UES
Any Home By Request Any Electric_>2.5 GPM	1,246	1,145	1,353	1,268	1,020	-
Any Home By Request Any Electric_2_50 GPM	941	864	1,021	957	1,020	-
Any Home By Request Any Electric_2_00 GPM	769	706	835	782	1,020	237
Any Home By Request Any Electric_1_80 GPM	720	662	782	733	1,020	287
Any Home By Request Any Electric_1_75 GPM	711	654	772	724	1,020	296
Any Home By Request Any Electric_1_60 GPM	664	610	720	675	1,020	345
Any Home By Request Any Electric_1_50 GPM	620	570	673	631	1,020	389
Single Family Electric Baseline	1,022	1,014	1,021	1,020	-	-

The final step in calculating the UESs is the installation rate of the showerheads, shown in Table 3. These rates are applied to DHW, waste water and non-energy benefit values to determine final estimated savings.

Aerators

Analysis is based on a modified version the RTF's analysis of Aerators v1.1[6]. RBSA II data is used to estimate unit energy consumptions for kitchen and bath aerators based on the field data for housing types and flow rates. This analysis uses all data for existing conditions which assumes that existing low flow aerators may be replaced with new devices.

Table 13 RBSA II Baseline Usage by Housing Type and Flow Rate

End Use	Home Type	Rated Flow Rate (gpm)	Baseline Weight
Kitchen	SF	2.2	46%
Kitchen	SF	2	15%
Kitchen	SF	1.8	14%
Kitchen	SF	1.5	25%
Kitchen	SF	1	0%
Kitchen	MH	2.2	46%
Kitchen	MH	2	15%
Kitchen	MH	1.8	14%
Kitchen	MH	1.5	25%
Kitchen	MH	1	0%
Kitchen	MF	2.2	46%

End Use	Home Type	Rated Flow Rate (gpm)	Baseline Weight
Bathroom	SF	2.2	36%
Bathroom	SF	2	28%
Bathroom	SF	1.8	1%
Bathroom	SF	1.5	28%
Bathroom	SF	1	6%
Bathroom	SF	0.5	0%
Bathroom	MH	2.2	36%
Bathroom	MH	2	28%
Bathroom	MH	1.8	1%
Bathroom	MH	1.5	28%
Bathroom	MH	1	6%

[6] RTF Aerators workbook v1.1 https://rtf.nwcouncil.org/measure/aerators.

End Use	Home Type	Rated Flow Rate (gpm)	Baseline Weight
Kitchen	MF	2	15%
Kitchen	MF	1.8	14%
Kitchen	MF	1.5	25%
Kitchen	MF	1	0%
Kitchen	Any	2.2	46%
Kitchen	Any	2	15%
Kitchen	Any	1.8	14%
Kitchen	Any	1.5	25%

End Use	Home Type	Rated Flow Rate (gpm)	Baseline Weight
Bathroom	MH	0.5	0%
Bathroom	MF	2.2	36%
Bathroom	MF	2	28%
Bathroom	MF	1.8	1%
Bathroom	MF	1.5	28%
Bathroom	MF	1	6%
Bathroom	MF	0.5	0%
Bathroom	Any	2.2	36%
Bathroom	Any	2	28%
Bathroom	Any	1.8	1%
Bathroom	Any	1.5	28%
Bathroom	Any	1	6%

Constant Volume Water Usage

In this analysis, water usage is broken up in two categories: constant volume and constant duration usage. Constant volume usage is unaffected by the flow rate of the faucet. This includes actions such as filling pots. Constant duration usage is affected by the flow rate of the faucet. It assumes that the user will use the faucet for the same duration, regardless of flow rate. This leads to energy and water savings from a reduced flow aerator. Research is needed to better understand these factors, but the RTF estimated the following values:

Table 14 Constant Duration Water Usage

	Kitchen	**Bathroom**
% of usage that is constant duration	50%	75%

Baseline Water Usage

Baseline hot water usage was referenced from SBW studies on Single Family and Multifamily usage[7,8]. In order to determine the total water usage, the fraction of hot water to total water usage was required. This value was determined from a study by Cadmus[9] on mixed water temperatures of kitchen and bathroom faucets, the simple calculation is shown below:

$$V_{total} = \frac{V_{hot}}{\phi_{hot}} = \frac{2.7}{.53} = 5.1$$

[7] SBW Consulting, 1994. "Energy Efficient Showerhead and Faucet Aerator Metering Study: Single Family Residences. Final Report." SBW Report Number 9414 for Puget Sound Power and Light.
[8] SBW Consulting, 1994. "Energy Efficient Showerhead and Faucet Aerator Metering Study: Multifamily Residences. Final Report." SBW Report Number 9408 for Bonneville Power Administration.
[9] Cadmus and Opinion Dynamics for the Michigan Evaluation Working Group, 2013. "Showerhead and Faucet Aerator Meter Study."

This analysis deviates from the RTF analysis with respect to occupancy values. We find it more appropriate to use 2015 American Community Survey Census data, whereas the RTF uses RBSA II data.

Table 15 Occupancy Data

	ACS	RBSA II
Single Family	2.74	2.59
Manufactured Homes	2.44	2.44
Multifamily	2.11	1.81

RBSA II data is also used to determine the number of faucets per home.

Table 16 Faucets per Home

	Kitchen	Bathroom
Single Family	1.08	2.56
Manufactured	1.00	2.10
Multifamily Residence	1.00	1.31
Total	1.06	2.32

The analysis assumes a throttling rate (percentage of full faucet flow) of 50% which is consistent with the previous ETO analysis.

Savings from pumping energy are calculated at 3.68 kWh per 1,000 gallons for full territory measures. For the measures the water savings are valued as non-energy benefits at the water rate net of embedded energy ($13.30 in Oregon). For partial territory measures water non-energy benefits are calculated at the full rate for Oregon ($13.64) and Washington ($10.90).

Install rates based on a survey conducted by Energy Trust in 2018 are used to adjust the savings. These values can be found in Table 3.

Table 17 Oregon Kit Aerator Measures

Row Labels	Sum of Weighted Electric Savings	Sum of Weighted Gas Savings	Sum of Weighted OR NEBs
OR By Request Bathroom Aerator 1 GPM ELE	26	-	$4.13
OR By Request Bathroom Aerator 1 GPM GAS	1	1.1	$4.13
OR By Request Bathroom Aerator 1 GPM Partial Territory Gas	-	1.1	$4.24
OR By Request Kitchen Aerator 1.5 GPM ELE	32	-	$4.24
OR By Request Kitchen Aerator 1.5 GPM Gas	1	1.4	$4.24
OR By Request Kitchen Aerator 1.5 GPM Partial Territory Gas	-	1.4	$4.35

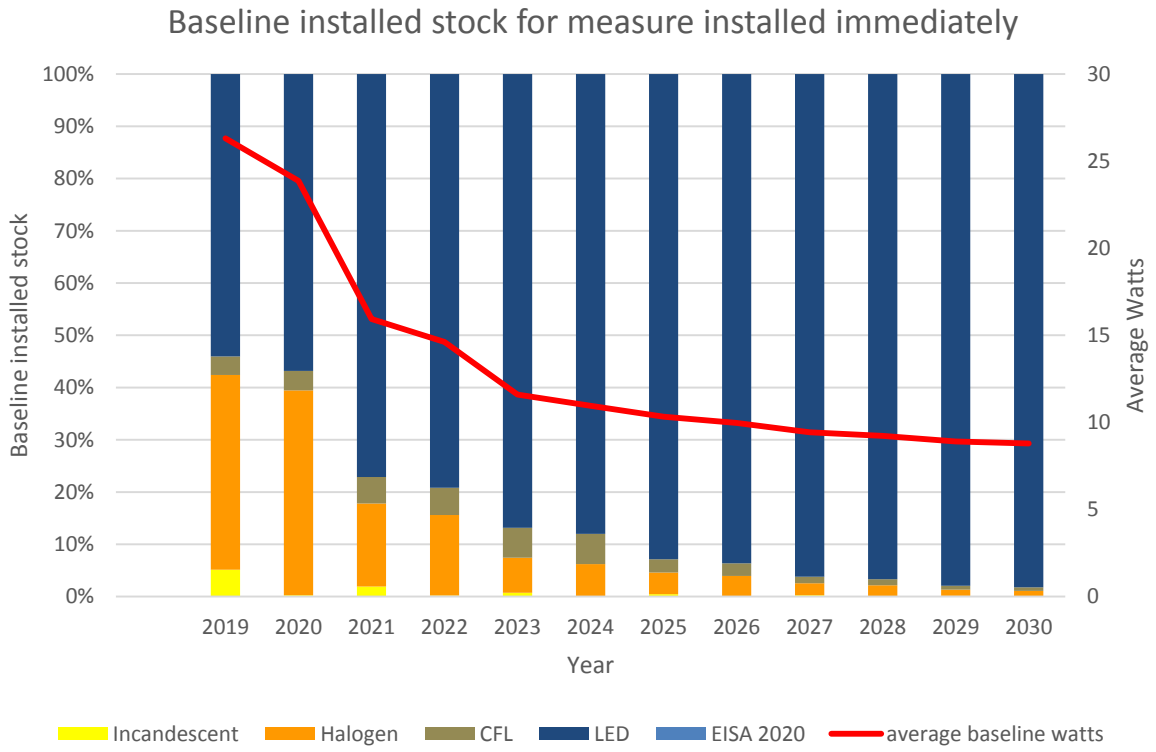
Table 18 Washington Kit Aerator Measures

Row Labels	Sum of Weighted Electric Savings	Sum of Weighted Gas Savings	Sum of Weighted WA NEBs

WA By Request Bathroom Aerator 1 GPM Partial Territory Gas	0	1.1	$3.39
WA By Request Kitchen Aerator 1.5 GPM Partial Territory Gas	0	1.4	$3.47

LEDs

Figure 1 Example baseline wattage



Measure Analysis

The primary data source to determine market share is NEEA's regional market survey. This annual survey combines Nielsen sales data with a shelf survey of retailers across the region. A key component of the NEEA report is the Chain Logic analysis created by BPA[10]. While the full report has yet to be released at this time, NEEA shared preliminary results. These include an adjustment to retailer shares from previous reports, resulting in slightly lower market share of LEDs than previously assumed.

For brevity, the full explanation of the savings analysis is not included here, but a high level overview is provided here.

Steps in the RTF process:

- The analysis is based on NEEA shelf survey data
- Lumens are normalized in each lumen bin across technology types
- The baseline is calculated for each individual measure differentiating for:

[10] https://www.bpa.gov/EE/Utility/research-archive/Documents/Momentum-Savings-Resources/Chain_Logic_Presentation.pdf

  - Bulb type
  - Lumen bin
  - Delivery channel
  - End use
  - Hours of use
- The lifetime savings are determined by calculating the baseline in each individual year of the measure life for each individual measure, to which the efficient product is compared.
- Similar methodology is used to calculate savings for stored bulbs as well as avoided replacement costs.

In 2020, Phase 2 of the Energy Security and Independence Act (EISA) is scheduled to come into effect, prohibiting the sale of inefficient bulbs. A full discussion on EISA is outside the scope of this MAD, but the main considerations are summarized below.

- 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.
- Successful implementation of EISA will, to some degree, depend on market acceptance which programs support.

The RTF tool is designed to calculate savings in two periods, before and after EISA comes into effect. Post EISA the RTF assumes that all incandescent and halogen bulbs would be replaced with a minimally EISA compliant bulb. The Energy Trust version of the RTF tool removes the EISA assumptions, making the calculation methodology the same in both time periods.

Savings

Savings for lighting measures are the difference in wattage between the efficient LED and the shifting market baseline in each calculated year multiplied by the average wattage of the efficient LED. We do not include HVAC interactive effects as the overall impact is small and the increased need for heating is generally offset by a decreased need for cooling.

The RTF tool creates two distinct savings periods, pre-EISA and post EISA. For the purposes of cost-effectiveness testing for Energy Trust, final savings are a weighted average of savings estimated in each period based on their relative length of time within the 12-year measure life.

- HVAC interaction penalties are not captured in the savings analysis at this time. Table 19 shows the savings values before and after the HVAC interaction, full measure life average savings are used in this analysis.
- Installation rates identified in Table 3 from the 2018 ESK survey are then used to estimate final savings and non-energy benefit values.

Table 19 Kit LED Component Savings Summary

Measure Name	Initial Installation Rate	Full measure life average (kWh)	Full measure life average Interaction (kWh)	Net Savings	Annualized lamp replacement savings (2017$)
By request General Purpose and Three-Way 250 to 1049 lumens	71%	**4.64**	-0.50	4.1	$0.10
By request Reflectors and Outdoor 250 to 1049 lumens	73%	**3.79**	-0.41	3.4	$0.15

The major changes from the RTF analysis, include:

- The RTF workbook has been modified to make no assumptions about EISA, to make no cost projections and to keep all dollar figures in 2017 the year they were collected.

Comparison to RTF or other programs

Showerheads and wands:

- RTF uses full regional RBSA I results exclusively, this analysis uses Oregon specific RBSA I data when available (e.g., Oregon specific avg. number of showerheads and total number of showerheads per dwelling type).
- Occupancy data is sourced from 2015 1-year American Community Survey samples rather than RBSA I data. Sample sizes are larger and the data is more recent than RBSA I.
- ACS data for all occupants, including those under 6, are used, compared to the RTF's 6+ criteria for both occupancy and estimated shower events per person per year.
  - Using the 6+ criteria for both occupancy and shower events compounds the reduction annual shower frequency.
- In-situ flow rates for 1.5 gpm showerheads and wands use Energy Trust's 2016 multifamily field test de-ratings of 88% and 81%, respectively, rather than the RTF's standard 90% for all flow types.
- Savings are calculated for 1.6 and 1.8 gpm devices used by Energy Trust programs in addition to the 1.5, 1.75 and 2.0 gpm calculated by the RTF.
- RTF assumes a 10-year measure life.
- Similar analysis is used across all Energy Trust residential and multifamily (new/existing) programs.

Aerators:

- RTF uses full regional RBSA II results exclusively, this analysis uses Oregon specific RBSA II data when available (e.g., Oregon specific avg. number of showerheads and total number of showerheads per dwelling type).
- Occupancy data is sourced from 2015 1-year American Community Survey samples rather than RBSA II data. Sample sizes are larger and the data is more recent than RBSA II.
- ACS data for all occupants, including those under 6, are used, compared to the RTF's 6+ criteria for both occupancy and estimated shower events per person per year.
  - Using the 6+ criteria for both occupancy and shower events compounds the reduction annual shower frequency.
- RTF assumes a 10-year measure life.
- Similar analysis is used across all Energy Trust residential and multifamily (new/existing) programs.

LED Lamps:

- For purposes of measure analysis, EISA 2020 is ignored.
- Non-energy benefits do not include the benefit of avoided purchases of LEDs in the future.
- HVAC interactive effects are ignored.

Measure Life

Showerheads, wands and aerators

- Measure life is assumed to be 15 years, consistent with other Energy Trust measures for water-saving devices.

LED lamps

- Due to the uncertainty of the lifetime of the new LED products the lifetime is capped at 12 years in accordance with RTF methodology, regardless of hours of use.

Cost

Costs reflect the per-item cost of the product, handling and shipping to a consumer. These represent both the incremental cost and the incentive level in Cost Effectiveness

Table 1 and Table 2.

Non Energy Benefits

Water Devices
Reduced water consumption from low flow devices is used as a NEB in the analysis.

Combined water rates net of embedded electricity are used in Oregon for gas and electric territories, and total water rates without removing embedded energy for Oregon gas only territory. Washington uses the combined rate of water including embedded energy use for waste water treatment

- Oregon full territory $13.30/1,000 gallons (rate is net of embedded energy)
- Oregon gas only territory $13.64/1,000 gallons
- Washington $10.90/1,000 gallons

LED Lamps
The NEBs associated with these measures are the prevented need to purchase new bulbs based on the longer life of the LED lamps. The avoided equipment cost to purchase replacement bulbs follows the baseline replacement methodology used for savings. One major change between the RTF and Energy Trust's analysis is in relation to the avoided purchase of an LED in the future. Previously the cost of LEDs was included in the avoided future purchases. However, in much the same way that LED market share is blended into the baseline to account for free-ridership, the avoided need to purchase an efficient product is not considered a benefit that Energy Trust should claim. By removing the costs from these purchases Energy Trust is preventing claiming non-energy benefits from the efficient choice that a customer would have made without program intervention.

Incentive Structure

The maximum incentives listed in

;t Effectiveness

e 1 Cost Effectiveness Calculator Oregon

	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	I
erhead - Full Territory Any Electric 1.75 GPM	15	177	0.0	$6.00	$17.99	$6.00	
erhead - Full Territory Any Electric 1.50 GPM	15	212	0.0	$6.00	$21.60	$6.00	
erhead - Full Territory Gas 1.75 GPM	15	5	7.9	$6.00	$18.02	$6.00	
erhead - Full Territory Gas 1.50 GPM	15	6	9.5	$6.00	$21.63	$6.00	
erhead - Partial Territory Gas 1.75 GPM	15	0	7.9	$6.00	$18.48	$6.00	
erhead - Partial Territory Gas 1.50 GPM	15	0	9.5	$6.00	$22.19	$6.00	
er Wand - Full Territory Any Electric 1.75 GPM	15	150	0.0	$11.00	$15.25	$11.00	
er Wand - Full Territory Any Electric 1.50 GPM	15	240	0.0	$11.00	$24.40	$11.00	
er Wand - Full Territory Gas 1.75 GPM	15	5	7.7	$11.00	$17.47	$11.00	
er Wand - Full Territory Gas 1.50 GPM	15	7	11.7	$11.00	$26.62	$11.00	
er Wand - Partial Territory Gas 1.75 GPM	15	0	7.7	$11.00	$17.92	$11.00	
er Wand - Partial Territory Gas 1.50 GPM	15	0	11.7	$11.00	$27.30	$11.00	
al Purpose and Three-Way 250 to 1049 lumens	12	4.6	0	$2.91	$0.10	$2.91	
tors and Outdoor 250 to 1049 lumens	12	3.8	0	$2.38	$0.15	$2.38	
om Aerator 1 GPM ELE	15	26	0.0	$1.35	$4.13	$1.35	
om Aerator 1 GPM GAS	15	1	1.1	$1.35	$4.13	$1.35	
om Aerator 1 GPM Partial Territory Gas	15	0	1.1	$1.35	$4.24	$1.35	
n Aerator 1.5 GPM ELE	15	32	0.0	$1.85	$4.24	$1.85	
n Aerator 1.5 GPM Gas	15	1	1.4	$1.85	$4.24	$1.85	
n Aerator 1.5 GPM Partial Territory Gas	15	0	1.4	$1.85	$4.35	$1.85	

le 2 Cost Effectiveness Calculator Washington *and Table* 2 *are for reference only and are not gested incentives.* Incentives will be structured per device (e.g., showerhead/wand, aerator or LED p).

AF

gram and measure SRAFs are not applied to Energy Saver Kit components.

low-Up

werhead inputs most likely to change:

Potential occupancy per dwelling type updates from American Community Survey (this MAD uses 2015 data).

RTF's current showerhead workbook, v3.1, sunsets in August 2019 and revisions are likely to include RBSA II data. New RBSA II inputs would likely include:

- Distribution of flow rates by housing type.
- New electric resistance/heat pump water heater splits.
- New gas storage and instantaneous water heater splits.
- Showerheads/wands per dwelling and total fixture counts (for dwelling weighting).

- Measure life should be re-assessed.

Aerator inputs most likely to change:

- Potential occupancy per dwelling type updates from American Community Survey (this MAD uses 2015 data).
- Savings values could change significantly if new data should emerge on constant duration vs. constant flow values.
- Measure life should be re-assessed.

Lighting inputs most likely to change:

- Energy Trust researches the lighting market baseline every six months.
- Review changes to RTF analysis and pending EISA 2020 implementation.

Supporting Documents

The cost effective screening for these measures is attached and can be found along with supporting documentation at: I:\Groups\Planning\Measure Development\Residential\Res Kits\Energy Saver Kit

ESK 2019-v1.1.xlsx

Version History and Related Measures

Table 20 Version History

Date	Version	Reason for revision
2/28/2013	27.X	New kitchen aerator flow rate
11/1/2013	27.X	Updated costs
8/26/2014	27.X	Updated baseline, sink water temperature
11/7/2014	27.X	RBSA and RTF alignment, LEDs replace CFLs
9/22/2015	27.X	RBSA and RTF alignment on showerhead and LED costs and savings
10/11/2016	27.X	Updating savings, installation rates for 2017 program year, added 1.5 gpm showerhead
6/13/2017	27.2	Updating savings, household occupants, showerhead/wand baseline flow rates, aerator usage duration, aerator annual occupancy days, installation rates for 2017 program year based on new form design, added 1.5 gpm shower wand, new incremental costs
6/21/2017	27.3	Fixed error in incremental costs for shower wands
10/5/2017	27.4	Updated avoided costs, lighting savings for 2018
10/24/2018	27.5	Updated avoided costs and savings for all kit components for 2019

Table 21 Related Measures

Measures	MAD ID
Single family direct install lighting	16
Multifamily direct install lighting	139
Direct Install Showerheads and Shower wands	157
Retail lighting	140
Retail showerheads and shower wands	26
Residential aerator	51

Approved & Reviewed by

Kenji Spielman
Planning Engineer

Mike Bailey PE
Engineering Manager Planning

Disclaimer

This Energy Trust document and its attachments may be used by you or shared, at no cost, with other parties who are interested in our work and analyses. Should you or anyone with whom this document is shared, have suggestions for improvement of our work, please let us know. You may modify this 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.

Measure Approval Document for Condensing Gas Furnaces in SW Washington

Valid Dates
January 1, 2019 – December 31, 2020

End Use or Description
High efficiency gas furnace in southwest Washington

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

- Residential – Home Retrofit
- Existing Multifamily
    - 2-4 units and side by side structures

Within these programs, the measure is applicable to the following cases:

- Replacement (Assumes inefficient baseline)

Purpose of Re-evaluating measure
Updated savings and costs using simplified savings calculation including fan savings and more recent costs.

Cost Effectiveness
Cost effectiveness is shown in Table 1. Savings and cost effectiveness for each tier as well as for the weighted average of the tiers are shown, to allow the program flexibility in designing the offer.

Southwest Washington is a gas-only service territory for Energy Trust and electric savings are not claimed by Energy Trust. Customer's expected electric bill savings are considered a non-energy benefit in the cost effectiveness calculation.

Table 1 Cost Effectiveness Calculator Washington

Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	ELE Bill Savings – NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR
90% to 94.9% AFUE Gas Furnace	25	64	72	$521	$5.22	$521	2.2	2.3
95%+ AFUE Gas Furnace	25	76	92	$990	$6.20	$990	1.5	1.6
90%+ AFUE Gas Furnace	25	76	92	$986	$6.20	$986	1.5	1.6

Requirements

- Installed in Washington only
- 90% or greater AFUE
- Program can elect to use individual 90%-94% AFUE and 95%+ AFUE tiers or a single 90% or greater tier, but not both to avoid skewing the weighting.

Baseline

This measure uses code baseline of 80% AFUE.

Guidance from the Washington Energy Efficiency Advisory Group in April 2018 indicated the use of an 80% AFUE code baseline is appropriate for Washington's regulatory environment.

Savings

Gas Savings

Gas savings can be estimated using the following equation:

$$therm\ savings\ = baseline\ heating\ therms - \left(\frac{baseline\ heating\ therms\ *\ baseline\ AFUE}{efficient\ AFUE}\right)$$

Table 2 shows normalized annual consumption for single family gas heated dwellings in the southwest Washington service territory based on a comprehensive 2012 analysis. Weighted baseline heating loads for gas homes in the territory is 557 therms.

Table 2 NW Natural Washington 2012 Market Profile Single Family Normalized Annual Consumption Usage Statistics

Age Range	Properties	Base Load	Heating Load	Total Load
Pre-1940	2,074	166	509	602
1940-1960	3,022	160	498	584
1960-1980	3,315	199	580	692
1980-1992	4,720	196	574	686
1992-Present	36,834	206	560	754
Total	49,965	**Weighted Heating Load**	**557**	

Table 3 shows the estimated therm savings by tier based on the weighted heating load of 557 therms for southwest Washington and an 80% AFUE baseline.

Table 3 Average AFUE by Tier and Therm Savings Estimate

Efficiency tier	Distribution of Units	Weighted average AFUE	Therm savings relative to baseline
90% to 94.9% AFUE Gas Furnace	1%	92%	71.9
95%+ AFUE Gas Furnace	99%	96%	92.1
90%+ AFUE Gas Furnace Blended		96%	91.9

Electric Savings

Fan energy savings are due to reduced fan runtimes, or lower fan speeds, needed to maintain set point temperatures with a more efficient furnace. Estimated Fan runtime savings:

$$Fan\ kWh\ savings\ = \frac{(therm\ savings\ *\ 100{,}000Btu/therm)}{input\ Btu/h}\ *\ fan\ input$$

Average furnace fan savings by tier are shown below in Table 4. Input kBtuh is sourced from 2016-2017 Energy Trust incented furnaces while fan input energy of 0.53 kW is based on RTF SEEM modeling of electric forced air furnaces.[1]

Table 4 Furnace Fan Electric Savings Estimate

Efficiency tier	Distribution of Units	Fan kW	Average of Furnace kBtu/h Input	Fan kWh Savings
90% to 94.9% AFUE Gas Furnace	1%	0.53	60.0	63.6
95%+ AFUE Gas Furnace	99%	0.53	64.1	76.1
90%+ AFUE Gas Furnace Blended		0.53	64.1	76.0

Measure Life

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).

Cost

Market research conducted in April 2014 collected a number of contractor bids for gas furnaces with a variety of options and efficiency levels for both economy and premium products. The study found that very high AFUE rated furnaces frequently featured ECM blowers and multi-stage burner controls

[1] RTF Single Family Existing HVAC and Weatherization SEEM runs - February 2016 – Tab 'SEEMoutput'

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. Incremental costs between economy bids by each contractor for 80%, 90%, 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 an 80% and 95% AFUE was $950.

Table 5 below shows costs by tier from the original study and adjusted to 2017 $s using the GDP deflator found in the RTF standard information workbook.[2]

Table 5 Costs by Tier

Tier	Distribution of Units	Cost Survey (2014 $s)	2017 $s for CE Screening
90% to 94.9% AFUE Gas Furnace	1%	$500	$521
95%+ AFUE Gas Furnace	99%	$950	$990
90%+ AFUE Gas Furnace		$946	$986

Comparison to other programs or offerings

This analysis shares a number of similarities to MAD 22, gas furnaces for rentals, moderate income track and small multifamily in Oregon.

- Both analyses use identical savings estimation methods but with different baseline heating loads, average AFUEs and furnace capacities as inputs.
- Costs are sourced from the same contractor supplied bids in 2014 used in MAD 22 for Oregon rentals, moderate income and small multifamily.

Incentive Structure

The maximum incentives listed in Table 1 are for reference only and are not suggested incentives.

Incentives will be paid per gas furnace installation.

SRAF

Free-ridership rates do not currently apply in the southwest Washington service territory.

Follow-Up

Parts of this measure most likely to change:

- When blended measure is used, proportion of 90-94.9% and 95%+ AFUE units may shift over time, necessitating updates to savings and costs.

[2] RTF Standard Information Workbook v3.2

Supporting Documents

The cost effective screening for these measures is attached and can be found along with supporting documentation at:

I:\Groups\Planning\Measure Development\Residential\Res HVAC\furnace\nwn WA furnaces

SW WA Gas Furnace - CEC 2019-

Version History and Related Measures

Table 6 Version History

Date	Version	Reason for revision
1/1/2009	23.x	Approve 90%+ AFUE furnaces in SW WA.
9/4/2014	23.1	Add two tiers: 90-94.9% & 95%+ AFUE
5/22/2018	23.2	Ppdate savings analysis and add fan savings value, update cost.

Table 7 Related Measures

Measures	MAD ID
Gas furnace in small multifamily, rentals and Savings Within Reach in Oregon	22
Rental furnace pilot (inactive, merged with MAD 22)	24
Avista Residential gas furnace (inactive)	193
Commercial condensing furnaces in Multifamily as centralized heating	203

Approved & Reviewed by

Jackie Goss, PE

Sr. Planning Engineer

Mike Bailey PE

Engineering Manager Planning

Disclaimer

Measure Approval Document for Residential Gas Storage Water Heaters

Valid Dates
January 1, 2018 – December 1, 2020

End Use
ENERGY STAR gas storage water heaters sold to retailers, water heater contractors, builders and homeowners.

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

- Residential
- Existing Multifamily, buildings with 2-4 units and side by side structures

Within these programs, the following situations are expected:

- New
- Replacement

Purpose of Re-Evaluating Measure
This update merges tiers and simplifies requirements to support the UEF ratings/test procedure change and removes non-energy benefits associated the Residential Energy Tax Credits (RETC) and better reflects the program design shift to a retail and midstream offerings.

Cost Effectiveness
Cost effectiveness for gas tank water heaters is shown in Tables 1 and 2.

Table 1 Cost Effectiveness Calculator Oregon

Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	NEBs (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR
ENERGY STAR Storage Water Heater	13	25.7	$215	$5.34	$103	1.00	0.72

Table 2 Cost Effectiveness Calculator Washington

Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	NEBs (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR
ENERGY STAR Storage Water Heater	13	25.7	$215	$4.71	$104	1.00	0.68

Exceptions
On 11/8/2017 Energy Trust received an exception through the minor exception process to offer ENERGY STAR gas storage water heaters in Oregon based on the following UM 551 criteria.

B. inclusion of the measure is expected to lead to reduced cost of the measure. Early indications suggest the retail strategy is driving lower incremental cost units. Similar results are expected for the distributor channel.

The PUC requires that the exception expire on 13/31/2020 or when the measure becomes more than 5% of the program's savings or when a new MAD is produced with a lower cost effectiveness.

Measure level cost effectiveness is not required in Washington.

Program Requirements

- Gas storage water heaters must be approved by ENERGY STAR
- Power vent models qualify for this measure, but power vent is not a requirement.
- Condensing storage and tankless units are *excluded* from these measures.
- 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. Further testing of the hybrids is needed to determine their energy savings potential. These are *excluded* from this measure.

Details

In 2015, new federal energy efficiency standards for water heaters went into effect. These standards increased the minimum EF rating to 0.60 for a 50 gallon water heater. ENERGY STAR efficiency specifications for gas storage water heaters remained unchanged with a minimum qualifying EF of 0.67. In 2017, ENERGY STAR updated their specifications for gas water heaters to establish UEF qualification criteria. ENERGY STAR is not requiring recertification of existing units, only newly produced models will need to meet new UEF specifications. Existing models will continue to be ENERGY STAR approved. Throughout 2018 and perhaps beyond, there will be water heaters on the market with a mix of EF and UEF ratings, which would create a complex set of participation requirements if one or the other were used to specify requirements. ENERGY STAR will be the qualifying criteria for this measure to avoid that confusion.

Savings and Baseline

Beginning in mid-2017, all new water heaters are required to be tested under the UEF test protocol. DOE also allows current models with EF ratings to be mathematically converted to UEF in the short term. UEF ratings differ from EF ratings, but the difference is not consistent across models due to underlying differences between the test procedures. More study is required to understand the impacts of the UEF test protocols including how this change impacts savings calculations. For 2018 Energy Trust will maintain the existing savings methodology, however tiering will be removed as it is not possible to determine the tier of a water heater from its UEF rating.

Savings for gas storage water heaters are based on an estimated water heating energy consumption of 218 therms for a baseline, 0.60 EF gas water heater. This figure is a result of the 2009 draft study by Michael Blasnik and Associates, on contract for Energy Trust of Oregon. The savings for equipment with higher Energy Factors are calculated using the following equation:

$$Savings\ (therms) = 218\ therms * \left(1 - \frac{baseline\ EF}{efficient\ EF}\right)$$

The average energy factor of water heaters participating in the program in recent years is 0.68 EF. This results in an average energy savings of 25.7 therms.

Costs

Existing Homes Program median incremental cost data from 2011-2015 was blended with 2016-2017 retail program median incremental costs to determine incremental cost for high efficiency gas water heaters. These values were normalized to 2017 dollars using the RTF GDP deflator to ensure comparability. Sales tax was removed from Washington project costs. Installed cost information was not available for 0.60 EF units from program historical data. To estimate incremental costs for the 2011-2015 Existing Homes data, program data from a retired 0.62-0.66 EF unit measure was used as a proxy for a 0.60 EF baseline installation. Baseline costs for the retail data set were sourced from the models available in two primary home improvement stores via their websites. Incremental costs listed in Table 3 are blended together in the cost effectiveness tables.

Table 3 Incremental Costs for 2011-2015 Existing Homes program data

Efficiency Tier	Count	Median Cost	Average Energy Factor	Incremental Cost From Baseline
0.63 EF Baseline Proxy	277	$1,189	0.63	-
ENERGY STAR qualified	2,009	$1,407	0.68	$219

Table 4 Incremental Costs for 2016-2017 Retail program data

Efficiency Tier	Count	Median Cost	Average Energy Factor	Incremental Cost From Baseline
Baseline	60	$548	0.62	-
ENERGY STAR qualified	148	$715	0.68	$167

Non-Energy Benefits

Warranty Benefit

Retail research revealed that qualifying atmospherically drafted ENERGY STAR units, which make up the majority of the products, have significantly longer warranty lives than baseline units (typically 12 years instead of 6 or 9 years). Extended coverage offers a financial benefit to consumers who purchase qualifying equipment. Given that warranties are typically provided by manufacturers, retail water heater data was used to estimate the typical warranties for program qualifying equipment that is installed by contractors as well.

To estimate the benefit associated with the longer warranty lengths research conducted by Lawrence Berkeley National Laboratory on water heater stock over time was used.[i] The analysis used a Weibull distribution to model the turnover for water heaters over time. Modeled parameters determine the shape of the distribution as well as the speed at which equipment is estimated to fail. In addition, the LBNL analysis used a three year delay in their function to model units being replaced under warranty. This analysis removes this delay and instead uses the average length of warranties for qualifying and non-qualifying equipment.

The warranty benefit is estimated as the percent of units surviving relative to the baseline equipment's warranty. In the case of power vented units the warranty is actually a penalty, due to its shorter duration. Each qualifying equipment type's retail cost unit is multiplied by the relative fraction surviving relative to the baseline to calculate the lifetime warranty benefit. At the end of the average qualifying atmospheric unit's warranty 59% are estimated to be surviving relative to 44% at the end of the baseline warranty length. Multiplying the difference in survival rate by the qualifying units' retail cost yields a $107 benefit. This approach also yields a $62.77 penalty when comparing qualifying power vented units to baseline equipment due to shorter warranty on power vented equipment.

Table 5 Warranty Lengths and Unit Cost by Venting Configuration and Efficiency Tier at Retail for Gas Storage Water Heaters

Venting Configuration	Average Warranty Length (Years)	Failure Percent Relative to Baseline	Average Retail Unit Cost	Warranty Benefit
Non-ENERGY STAR	7.7	-	-	-
Atmospheric 0.67+ EF	10.7	15%	$709	$107
Power vented 0.67+ EF	6.5	-7%	$916	-$62

To calculate an annual non-energy benefit, the value of the warranty benefit or penalty is annualized over its warranty life. To create an annualized benefit or penalty, the present value of the units is taken based on a discount rate of 4.3% in Oregon and 5.53% in Washington and the average warranty length for that piece of equipment. These values are then weighted by the share of program-incented water heaters that are power or atmospherically vented, not on efficiency tiers. The final weighted annual warranty non-energy benefit is $5.34 in Oregon and $4.71 in Washington as shown in Table 6.

Table 6 Weighted Warranty Non-Energy Benefit by Venting Configuration

Venting Configuration	Weight In Program	Warranty Benefit At Year Of Failure	Present Value Of Warranty Benefit (Oregon)	Annualized (Oregon)	Present Value Of Warranty Benefit (Washington)	Annualized (Washington)
Atmospheric 0.67+ EF	85%	$107.47	$68.49	$6.99	$60.42	$6.16
Power vented 0.67+ EF	15%	-$61.89	($39.44)	($4.02)	($34.79)	($3.55)
Weighted annual warranty NEB				**$5.34**		**$4.71**

Residential Energy Tax Credit

All Oregon state tax credits for residential efficiency expired at the end of 2017. No tax credits are included in this analysis.

Midstream Adjustment Factors

For midstream water heater sales, Energy Trust will use the Distributor Sales Allocation Tool (DSAT) and Retail Sales Allocation Tool (RSAT) to allocate the savings and incentives from each unit sold by participating distributors and retailers to the appropriate utilities. DSAT and RSAT outputs were used to calculate an adjustment factors for midstream savings to account for expected leakage – units recognized in the midstream water heater program but installed in non-Energy Trust territory. Because all gas utilities in Oregon and SW Washington participate with Energy Trust, leakage for gas midstream water heaters to non-Energy Trust territory is expected to be near zero. For more information on the DSAT and RSAT methodology, refer to the DSAT documentation in supporting documents.

Measure Life

The lifetime of this measure is 13 years, from the DOE Technical Support Document for the 2015 federal standards change.

Incentive Structure

The maximum incentives listed in Table 1 and Table 2 are for reference only and are not suggested incentives.

Incentives are likely to vary by program and sales channel and may be paid to retailers, distributors, contractors, end customers or home builders. Midstream incentives may be passed through or kept by retail channels or distributers.

Follow-Up

As more water heater data from the midstream and retail program becomes available such as costs and model EF and UEF specifications, this measure should be reevaluated as necessary.

The current savings methodology and the impacts of the UEF test procedures should be revisited when information is available. Energy Trust currently lacks a method to determine savings as a function of UEF, which will be necessary if higher efficiency tiers will be targeted in the future.

Supporting Documents

The cost effective screening for these measures is attached and can be found along with supporting documentation at:
I:\Groups\Planning\Measure Development\Residential\Res Water Heating\gas storage water heat

Gas Storage DHW 2018 CE_9_20_2017.›

DSAT and RSAT methods:
I:\Groups\Planning\Measure Development\Residential\Res Water Heating\heat pump water heater\DSAT

ENERGY STAR Water Heater Specifications:
https://www.energystar.gov/products/spec/residential_water_heaters_specification_version_3_0_pd

Version History and Related Measures

Energy Trust has been incentivizing gas water heaters for many years and the offering has evolved over time and predates our record retention and measure approval practices. Table 7 shows the measure history since 2010 when 0.67 EF was introduced as an efficiency tier in our residential program and may be incomplete for activities prior to 2013.

Table 7 Version History

Date	Version	Reason For Revision
5/26/10	102.x	Introduce 0.67 EF water heaters for existing and manufactured homes
5/27/10	102.x	Include small multifamily homes in prior approval.
6/2/10	102.x	Include condensing tank units.
8/10/10	102.x	Included distributor incentive.
1/6/12	102.x	Update cost and incentives.
6/19/12	102.x	Update approval to include maximum incentive.
9/2/15	102.x	Update savings due to federal standard influence of baseline. Removes condensing units.
9/15/15	102.x	Includes small multifamily.
2/16/16	102.x	Includes the products program.
12/30/16	102.1	Update costs and non-energy benefits.
11/8/17	102.2	Updated costs, NEBs. Change qualifying criteria to ENERGY STAR. Clarifies mid-stream program design.

Table 8 Related Measures

Water Heating Measures	MAD ID
Residential and existing small multifamily heat pump water heaters	52
New small multifamily heat pump water heaters	176
New homes and small multifamily tankless water heaters	178
Commercial condensing tank water heaters	21
Commercial tankless water heaters	72

Approved & Reviewed by

Jackie Goss, PE
Sr. Planning Engineer

Mike Bailey PE
Engineering Manager Planning

Disclaimer

This Energy Trust document and its attachments may be used by you or shared, at no cost, with other parties who are interested in our work and analyses. Should you or anyone with whom this document is shared, have suggestions for improvement of our work, please let us know. You may modify this 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.

[i]James D. Lutz, Asa Hopkins, Virginie Letschert, Victor H. Franco, and Andy Sturges . Using National Survey Data to Estimate Lifetimes of Residential Appliances.

https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0ahUKEwjtmfa5-63PAhUK02MKHZI2B6UQFgghMAA&url=https%3A%2F%2Fpublications.lbl.gov%2Fislandora%2Fobject%2Fir%253A157288%2Fdatastream%2FPDF%2Fdownload%2Fcitation.pdf&usg=AFQjCNFmN6Mdlvs9kS10fGHANQnhY5baTw

Measure Approval Document for Retail Showerheads and Shower Wands

Valid Dates

January 1, 2019 to December 31, 2019

End Use or Description

Low flow showerheads and shower wands reduce water heating energy consumption by reducing the amount of water used for showering events.

Program Applicability

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

- Residential –Midstream Retail

Within these programs, the measure is applicable to the following cases:

- Replacement using a full retail market baseline

Purpose of Re-Evaluating Measure

- Alignment with RTF showerhead v3.1 workbook savings methodology
- Incorporation of Oregon and SW Washington measure suites into one MAD

Cost Effectiveness

Table 1 Cost Effectiveness Calculator Oregon

Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Non-Energy Benefits (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Electric	% Gas
Retail Showerhead - Full Territory Any Ele 2.00 GPM	15	29	0.0	$8.50	$2.94	$8.50	2.49	6.3	100%	0%
Retail Showerhead - Full Territory Any Ele 1.80 GPM	15	69	0.0	$8.50	$7.00	$8.50	5.95	14.9	100%	0%
Retail Showerhead - Full Territory Any Ele 1.75 GPM	15	76	0.0	$8.50	$7.76	$8.50	6.59	16.5	100%	0%
Retail Showerhead - Full Territory Any Ele 1.60 GPM	15	116	0.0	$8.50	$11.78	$8.50	10.01	25.1	100%	0%
Retail Showerhead - Full Territory Any Ele 1.50 GPM	15	151	0.0	$8.50	$15.42	$8.50	13.10	32.8	100%	0%
Retail Showerhead - Full Territory Gas 2.00 GPM	15	1	1.3	$8.50	$2.94	$6.58	1.00	4.5	9%	91%
Retail Showerhead - Full Territory Gas 1.80 GPM	15	2	3.1	$8.50	$7.00	$8.50	1.85	10.8	9%	91%
Retail Showerhead - Full Territory Gas 1.75 GPM	15	2	3.4	$8.50	$7.76	$8.50	2.04	12.0	9%	91%
Retail Showerhead - Full Territory Gas 1.60 GPM	15	3	5.2	$8.50	$11.78	$8.50	3.10	18.2	9%	91%
Retail Showerhead - Full Territory Gas 1.50 GPM	15	4	6.8	$8.50	$15.42	$8.50	4.06	23.8	9%	91%
Retail Showerhead - Partial Territory Gas 2.00 GPM	15	0	1.3	$8.50	$3.01	$5.98	1.00	4.6	0%	100%
Retail Showerhead - Partial Territory Gas 1.80 GPM	15	0	3.1	$8.50	$7.18	$8.50	1.68	10.9	0%	100%
Retail Showerhead - Partial Territory Gas 1.75 GPM	15	0	3.4	$8.50	$7.96	$8.50	1.86	12.1	0%	100%
Retail Showerhead - Partial Territory Gas 1.60 GPM	15	0	5.2	$8.50	$12.08	$8.50	2.82	18.3	0%	100%
Retail Showerhead - Partial Territory Gas 1.50 GPM	15	0	6.8	$8.50	$15.81	$8.50	3.69	24.0	0%	100%
Retail Shower Wands - Full Territory Any Ele 2.00 GPM	15	28	0.0	$22.95	$2.82	$20.35	1.00	2.2	100%	0%
Retail Shower Wands - Full Territory Any Ele 1.80 GPM	15	68	0.0	$22.95	$6.89	$22.95	2.17	5.4	100%	0%
Retail Shower Wands - Full Territory Any Ele 1.75 GPM	15	75	0.0	$22.95	$7.64	$22.95	2.40	6.0	100%	0%
Retail Shower Wands - Full Territory Any Ele 1.60 GPM	15	115	0.0	$22.95	$11.66	$22.95	3.67	9.2	100%	0%
Retail Shower Wands - Full Territory Any Ele 1.50 GPM	15	191	0.0	$22.95	$19.44	$22.95	6.11	15.3	100%	0%
Retail Shower Wands - Full Territory Gas 2.00 GPM	15	1	1.2	$22.95	$2.82	$6.31	1.00	1.6	9%	91%
Retail Shower Wands - Full Territory Gas 1.80 GPM	15	2	3.0	$22.95	$6.89	$15.42	1.00	3.9	9%	91%
Retail Shower Wands - Full Territory Gas 1.75 GPM	15	2	3.3	$22.95	$7.64	$17.11	1.00	4.4	9%	91%
Retail Shower Wands - Full Territory Gas 1.60 GPM	15	3	5.1	$22.95	$11.66	$22.95	1.14	6.7	9%	91%
Retail Shower Wands - Full Territory Gas 1.50 GPM	15	5	8.5	$22.95	$19.44	$22.95	1.90	11.1	9%	91%
Retail Shower Wands - Partial Territory Gas 2.00 GPM	15	0	1.2	$22.95	$2.89	$5.74	1.00	1.6	0%	100%

Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Non-Energy Benefits (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Electric	% Gas
Retail Shower Wands - Partial Territory Gas 1.80 GPM	15	0	3.0	$22.95	$7.06	$14.02	1.00	4.0	0%	100%
Retail Shower Wands - Partial Territory Gas 1.75 GPM	15	0	3.3	$22.95	$7.84	$15.56	1.00	4.4	0%	100%
Retail Shower Wands - Partial Territory Gas 1.60 GPM	15	0	5.1	$22.95	$11.96	$22.95	1.03	6.7	0%	100%
Retail Shower Wands - Partial Territory Gas 1.50 GPM	15	0	8.5	$22.95	$19.93	$22.95	1.72	11.2	0%	100%

Table 2 Cost Effectiveness Calculator Washington

Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Non-Energy Benefits (Annual $)	ELE Bill Savings (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR
Retail Showerhead - WA Partial Territory Gas 2.00 GPM	15	0	1.4	$8.50	$2.57	$0.00	$8.50	1.01	4.02
Retail Showerhead - WA Partial Territory Gas 1.80 GPM	15	0	3.3	$8.50	$6.13	$0.00	$8.50	2.40	9.58
Retail Showerhead - WA Partial Territory Gas 1.75 GPM	15	0	3.6	$8.50	$6.79	$0.00	$8.50	2.66	10.61
Retail Showerhead - WA Partial Territory Gas 1.60 GPM	15	0	5.5	$8.50	$10.32	$0.00	$8.50	4.04	16.11
Retail Showerhead - WA Partial Territory Gas 1.50 GPM	15	0	7.2	$8.50	$13.50	$0.00	$8.50	5.28	21.08
Retail Shower Wands - WA Partial Territory Gas 2.00 GPM	15	0	1.3	$22.95	$2.47	$0.00	$8.21	1.00	1.43
Retail Shower Wands - WA Partial Territory Gas 1.80 GPM	15	0	3.2	$22.95	$6.03	$0.00	$20.06	1.00	3.49
Retail Shower Wands - WA Partial Territory Gas 1.75 GPM	15	0	3.6	$22.95	$6.69	$0.00	$22.25	1.00	3.87
Retail Shower Wands - WA Partial Territory Gas 1.60 GPM	15	0	5.5	$22.95	$10.21	$0.00	$22.95	1.48	5.91
Retail Shower Wands - WA Partial Territory Gas 1.50 GPM	15	0	9.1	$22.95	$17.02	$0.00	$22.95	2.47	9.84

Requirements

- Rated flows between 1.5 and 2.0 gallons per minute
- Showerheads and shower wands must be WaterSense® certified.

Baseline

This measure uses:

- Full Retail Market Baseline

These measures assume that a consumer who purchases a showerhead or wand at retail has already made the decision to purchase a product and whose flow rate options are limited to those available in store (and legally allowed by code, ≤2.5 GPM), with the prevalence of products assumed to reflect the relative sales at the various flow rates.

The RTF conducted a simple web-survey of regional Home Depot products available in-store on June 5, 2016. The survey included products available in-store in the Portland area, and are used for the Oregon and Southwest Washington service territories. Product counts and distributions for Portland are presented below in Table 3.

Table 3 Retail Distribution of Showerhead and Wand Flow Rates for Oregon

	Rated Flow Rate						
Home Type	**>2.5 GPM**	**2.50 GPM**	**2.00 GPM**	**1.80 GPM**	**1.75 GPM**	**1.60 GPM**	**1.50 GPM**
Web Survey n	0	8	26	0	0	0	1
Web Survey distribution	0%	23%	74%	0%	0%	0%	3%

Measure Analysis

Savings analysis is based on a modified version of the RTF's and commercial and residential showerhead workbook v3.1.[1]

The RTF uses the following equations to develop unit energy consumptions, UECs, for each water heater technology, flow rate of showerhead/wand and housing type:

1. [Water consumption] = [rated flow rate (gallons/minute)] x [in use flow adjustment] x [# of events/yr] x [event duration (minutes/event)]
2. [End-use Energy consumption] = [water consumption] x [mixed hot water energy intensity (kWh/gallon)]
3. [Embedded water/waste water energy consumption] = [water consumption] x [water/waste water energy intensity (kWh/gallon)]

Table 4 through Table 6 describe the various inputs used to estimate individual UECs for all combinations of measure types, with specific inputs and outputs presented in Table 7 and Table 8. UECs are then combined with baseline market data from Table 3 to generate a common market energy consumption from which specific UECs for flow rates can be subtracted to generate unit energy savings, or UESs, discussed in the savings section (Table 10).

Table 4 below presents the inputs to estimate energy intensity of water heating by various technologies. Recovery energy (RE) for electric resistance and gas storage water heaters are sourced from the RTF standard information workbook, SIW.[2] Heat pump water heater recovery efficiency of 200% is an RTF judgement. Remaining values are RTF input assumptions and calculations.

Table 4 Water Heater Recovery Energy, Temperature Rise and Energy Intensities by Water Heater Type and Fuel

Water Heating Type	RE	Water Heater delta T	Effective delta T of mixed hot water for shower	Specific Heat of Water (kWh/gallon/degF)	Specific Heat of Water (therms/gallon/degF)	Energy Intensity (kWh/gallon)	Energy Intensity (therms/gallon)
Electric Resistance	1.00	75	52.5	0.0024		0.128	
Electric HPWH	2.00	75	52.5	0.0024		0.064	
Gas	0.75	75	52.5		0.0001		0.0058

Table 5 below presents the in-situ multipliers for the various flow rate categories in addition to the estimate length of shower associated with each rated flow rate (1.6 gpm device duration deviated substantially from 1.5 and 1.75 gpm devices, 8.4 minutes, and instead uses an average of the two flow rates, 9.03 minutes).[3] 90% is the multiplier used by the RTF while 1.5 gpm devices used in-situ rates found in a 2016 Energy Trust field study on 1.5gpm devices.[4]

Values above 2.5 gpm are based on RBSA I measured findings divided by an in-situ rate of 90% to estimate a rated flow value.

Table 5 Flow Rate In-situ adjustments and Shower Event Duration by Rated Flow Rate

Rated Flow Rate Category	Rated flow rate (gpm)	In situ adjustment	duration (minutes/event)
>2.5 GPM	3.67	90%	7.39
2.50 GPM	2.50	90%	8.20
2.00 GPM	2.00	90%	8.37
1.80 GPM	1.80	90%	8.72
1.75 GPM	1.75	90%	8.86
1.60 GPM	1.60	90%	9.03
1.50 GPM	1.50	88% (81% for wands)	9.21

Table 6 describes the inputs used to generate people per showerhead. RBSA I data specific to Oregon provides average and total showerheads per housing type (single family, manufactured home, multifamily), while 2015 American Community Survey, ACS, data is used to source Oregon

[1] RTF Commercial and Residential Showerheads v3.1
[2] RTF Standard information workbook v2.6 (current SIW version as of this publication date is v3.2, but values remain the same).
[3] Aquacraft, Inc. Residential End Uses of Water
[4] Energy Trust Multifamily Showerhead Study Report

occupancy per housing type, and gas heated homes only for the Southwest Washington service territory. Given the ACS does not collect water heating fuel, gas heated homes are used as a proxy for occupants per housing type in homes with gas water heating.

RBSA I data is extremely limited for SW Washington resulting in the use of the Oregon RBSA I distribution of total showerheads to create a weighted average occupant per showerhead for both Oregon and Washington.

Table 6 Showerheads per Dwelling, Total Showerheads and Occupancy per Housing Type

	SF	MH	MF	Weighted Avg
Oregon total # of showerheads (RBSA I)	**2,030,706**	**283,035**	**269,610**	**-**
Oregon average # of showerheads per residence (RBSA I)	1.7	1.65	1.21	1.65
Occupants per dwelling 2015 OR ACS	2.74	2.44	2.11	2.64
Occupants per shower Oregon	***1.61***	***1.48***	***1.75***	***1.61***
Total Oregon shower events (at 250 events per person/yr)	***402***	***369***	***436***	***402***
Washington				
Occupants per gas dwelling 2015 SW WA ACS	2.98	2.13	2.34	2.82
Occupants per shower SW Washington	***1.75***	***1.29***	***1.94***	***1.72***
Total Washington shower events (at 250 events per person/yr)	***437***	***322***	***484***	***430***

Table 7 below illustrates the combined inputs used to generate UECs by water heater type, flow rate, measure type and housing type for a limited number of flow rates. Energy Trust specific costs of water per gallon have been added as well (separate values are used for Oregon and Washington).

Table 7 Examples of Combined Inputs used for Oregon Single Family Showerhead Unit Energy Consumption Calculation

Showerhead Water Heater Type and Flow Rate	Rated Flow Rate (gpm)	In use flow adjustment	Frequency for SF (events/yr)	Event duration (minutes/event)	End-use energy intensity (kWh or therms/gal.)	Water/ waste water energy intensity (kWh/gal.)	Energy Trust OR water/waste water cost, net of energy cost ($/gal.)
Electric Resistance 1.75 GPM	1.75	90%	402	8.9	0.128	0.0037	$0.013
Electric Resistance 1.50 GPM	1.50	88%	402	9.2	0.128	0.0037	$0.013
Electric HPWH 1.75 GPM	1.75	90%	402	8.9	0.064	0.0037	$0.013
Electric HPWH 1.50 GPM	1.50	88%	402	9.2	0.064	0.0037	$0.013
Gas 1.75 GPM	1.75	90%	402	8.9	0.0058	0.0037	$0.013
Gas 1.50 GPM	1.50	88%	402	9.2	0.0058	0.0037	$0.013

Table 8 Shows the UEC values based on the inputs from Table 7.

Table 8 Examples of Unit Energy Consumption Outputs

		Primary Energy Consumption		Embedded Water/Waste Water		
Showerhead Water Heater Type and Flow Rate	Water Consumption (gallons/year)	Annual Energy Consumption (kWh/yr)	Annual Energy Consumption (therms/yr)	Annual Energy Consumption (kWh/yr)	Energy Trust water/ Waste Water cost ($/yr)	In use flow rate (gpm)
Electric Resistance 1.75 GPM	5,607	719	0	21	$74.58	1.58
Electric Resistance 1.50 GPM	4,888	626	0	18	$65.01	1.32
Electric HPWH 1.75 GPM	5,607	359	0	21	$74.58	1.58
Electric HPWH 1.50 GPM	4,888	313	0	18	$65.01	1.32
Gas 1.75 GPM	5,607	0	33	21	$74.58	1.58
Gas 1.50 GPM	4,888	0	28	18	$65.01	1.32

Table 9 Shows the split used between standard electric resistance storage and heat pump water heaters. This value is an RTF judgement and was made after RBSA I and prior to RBSA II data being available. These values enable one common electric water heating baseline UEC.

Table 9 Electric Water Heater Weighting

Housing Type	Electric Resistance	Electric HPWH
Any Electric Any home	98%	2%
Any Electric SF	98%	2%
Any Electric MF	98%	2%
Any Electric MH	98%	2%

Savings

Table 10 Illustrates the calculation of water energy UESs for Oregon electric showerhead measures at retail. The retail baseline distribution (Table 3) is used to generate baseline UEC values for each housing type in the analysis, while total showerhead counts found in RBSA I are used to weight UECs for each flow rate and housing type into a series or UECs for any home type. Finally, UECs for eligible flow rates (1.5 through 2.0 gpm) are subtracted from the baseline UEC to estimate the final UES values for electric and gas water heating energy, waste water energy and water usage.

Table 10 Example of Unit Energy Savings Calculation for Oregon Retail Electric Showerheads

Measure Type	Retail Baseline Distribution	DHW Energy (kWh/yr)					
		SF UEC	MH UEC	MF UEC	Weighted UEC	Baseline UEC	UES
Retail - Any Electric >2.5 GPM	0%	1,246	1,145	1,353	1,246	**804**	-
Retail - Any Electric 2.50 GPM	23%	941	864	1,021	941	**804**	-
Retail - Any Electric 2.00 GPM	74%	769	706	835	769	**804**	35
Retail - Any Electric 1.80 GPM	0%	720	662	782	721	**804**	83
Retail - Any Electric 1.75 GPM	0%	711	654	772	712	**804**	92
Retail - Any Electric 1.60 GPM	0%	664	610	720	664	**804**	140
Retail - Any Electric 1.50 GPM	3%	620	570	673	620	**804**	184
Retail - Any Electric Baseline	**-**	**804**	**739**	**873**	**804**	**804**	**-**
RBSA I Showerhead weight		2,030,706	283,035	269,610			
RBSA I Showerhead Distribution Percent		79%	11%	10%			

The final step in calculating the UESs is the installation rate of the showerheads. Table 11 below shows the RTF judgment based install rates by flow type. 1.6 and 1.8 gpm devices are assigned identical rates to the original RTF measure types. These rates are applied to DHW, waste water and non-energy benefit, NEB, values to determine final estimated savings.

Table 11 Installation Rates by Retail Showerhead and Wand Flow Rate

Delivery Mechanism	2.00 GPM	1.80 GPM	1.75 GPM	1.60 GPM	1.50 GPM	Notes
Retail	80%	80%	80%	80%	80%	RTF judgment

Comparison to RTF or other programs

While much of this MAD's analysis replicates the RTF's approach, there are a number of specific differences:

Comparison to RTF:

- RTF uses full regional RBSA I results exclusively, this analysis uses Oregon specific RBSA I data when available (e.g., Oregon specific avg. number of showerheads and total number of showerheads per dwelling type).
- Occupancy data is sourced from 2015 1-year American Community Survey samples rather than RBSA I data. Sample sizes are larger and the data is more recent than RBSA I.
- ACS data for all occupants, including those under 6, are used, compared to the RTF's 6+ criteria for both occupancy and estimated shower events per person per year.
  - Using the 6+ criteria for both occupancy and shower events compounds the reduction annual shower frequency.
- In-situ flow rates for 1.5 gpm showerheads and wands use Energy Trust's 2016 multifamily field test de-ratings of 88% and 81%, respectively, rather than the RTF's standard 90% for all flow types.
- Savings are calculated for 1.6 and 1.8 gpm devices used by Energy Trust programs in addition to the 1.5, 1.75 and 2.0 gpm calculated by the RTF.
- RTF assumes a 10 year measure life.

Comparison to other Energy Trust programs:

- Retail showerheads in this analysis use the RBSA I total showerhead counts by dwelling types to weight the savings between dwelling types. Direct install showerheads/wands use savings specific to the housing type where the installation is taking place. Kit, or by request, showerheads use Energy Trust process evaluations survey responses to develop weighted savings for all housing types.

Measure Life

Measure life is assumed to be 15 years, consistent with other Energy Trust measures for water-saving devices.

Cost

Retail costs are based on the 25th percentile of manufacturer suggested retail price for showerheads and wands offered by retailers participating in the 2017 program. The 25th percentile is used to account for the large variety of features unrelated to energy efficiency that retail products may include. This approach mirrors the RTF cost methodology with the exception that the RTF does not differentiate between showerheads and wands in their cost collection methodology. Cost by product type used in this cost effectiveness screening:

- Showerhead $8.50
- Shower wand $22.95

Non Energy Benefits

Reduced water consumption from low flow devices is used as a NEB in the analysis.

Combined water rates net of embedded electricity are used in Oregon for gas and electric territories, and total water rates without removing embedded energy for Oregon gas only territory. Washington uses the combined rate of water including embedded energy use for waste water treatment

- Oregon full territory $13.30/1,000 gallons (net embedded energy)
- Oregon gas only territory $13.64/1,000 gallons
- Washington $10.90/1,000 gallons

Incentive Structure

The maximum incentives listed in Table 1 and Table 2 are for reference only and are not suggested incentives. Incentives will be structured per showerhead sold at retail.

Follow-Up

Inputs most likely to change:

- Potential occupancy per dwelling type updates from American Community Survey (this MAD uses 2015 data)
- Retail product mix by flow rate

- RTF's current showerhead workbook, v3.1, sunsets in August 2019 and revisions are likely to include RBSA II data. New RBSA II inputs would likely include:
  - Distribution of flow rates by housing type
  - New electric resistance/heat pump water heater splits
  - New gas storage and instantaneous water heater splits
  - Showerheads/wands per dwelling and total fixture counts (for dwelling weighting)
- Measure life should be re-evaluated, especially should further data emerge
- Incremental cost of shower wands, as using the 25th percentile may not be appropriate

Supporting Documents

The cost effective screening for these measures is attached and can be found along with supporting documentation at: I:\Groups\Planning\Measure Development\Residential\Res Water Reduction\showerhead

CEC 26 Retail Showerheads and W

Version History and Related Measures

Table 12 Version History

Date	Version	Reason for revision
2005	26.x	Introduction of retail showerheads
2007-2009	26.x	Various updates
8/21/2014	26.x	Incorporation of 2011 RBSA I data, align more with RTF
7/25/2017	26.1	Combining MAD 156, updating flow rates and occupancies.
1/3/2018	26.2	Adding 1.8 gpm measures
6/22/2018	26.3	Extending eligibility date, updated costs, full alignment with RTF savings methodology, merging OR/WA measure suites to one MAD.

Table 13 Related Measures

Measures	MAD ID
Additional Retail Shower Wands	156
Direct Install Showerheads and Shower Wands	157
Energy Saver Kit	27
Living Wise Kit	30
Carry Home Savings Kit	154
Community Event and Utility Giveaway	155
New Buildings showerheads (new multifamily)	144

Approved & Reviewed by

Kenji Spielman
Planning Engineer

Mike Bailey PE
Engineering Manager Planning

Disclaimer

4.3 Appendix 3: On-the-bill Repayment

Residential Loans and On-The-Bill Repayment Services: Description of On-the-Bill Repayment Services

The Company assists in marketing a low-interest financing offer to residential homeowners who heat their homes with gas heat. The program lender will originate loans granted for the purposes of installing conservation and energy efficiency measures incented by the existing homes program, and the Company will provide billing and remittance services to the program lender by placing the loan repayment fee on the customers' monthly gas bill. Customers who obtain a loan with On-the-Bill Repayment Services will receive a loan repayment charge separately itemized as "Energy Upgrade Loan" on their monthly bill for natural gas service. This will be reflected for the term of the loan or until the loan has been paid off, transferred, or otherwise discharged or removed from the bill in accordance with the terms and conditions of the Company's service agreement.

Program Lender

Craft3, a non-profit community development financial institution (CDFI) lender, will act as the program lender, under the terms and conditions of a service agreement with Energy Trust. Craft3 received a grant from the State Of Washington's Clean Energy Revolving Loan Fund[2] for the purpose of providing financing to Washington residents for the purpose of installing energy efficiency measures. The intent of this offering is to facilitate the acquisition of cost-effective natural gas savings while extending the benefit of the State Of Washington's Clean Energy Revolving Loan Fund to natural gas ratepayers in Southwest Washington.

Loan

The loan offerings through Craft3 that will qualify for On-the-Bill Repayment Services must fit the following parameters:

- Loans must be granted to residential homeowners who use natural gas as their primary heating fuel.
- Loan amounts must be used to install conservation and energy efficient measures incented under NW Natural's existing homes program.
- Loan Amount:
  - Loan amounts must be no less than $2,500 and no more than $15,000.
- Term of loan:
  - Loans up to $7,500 to have a max term of 7 years,
  - Loans between $7,500-$15,000 up to 15 years.
- The program has a fixed interest rate at 4.49%. Contingent on market conditions, Craft3 may at a later date revise the interest rate offer for future customers, not to

[2] *See* http://www.commerce.wa.gov/Programs/Energy/Office/Pages/Clean-Energy-Funds.aspx

exceed 5.49%. Under all circumstances rates will be fixed and consistent for any qualifying customer.

- Loans will be unsecured.
- No penalty for early repayment.
- Craft3 may assess a financing fee of $100 for loans between $2,500-$7,500, $200 for loans between $7,500-$15,000
    - Fees may be financed as an addition to the loan balance
- At least 51% of the loan must be for costs that are directly attributable to the commissioning and installation of the qualifying measure(s), costs incurred to comply with applicable building code, mechanical code, or other pertinent regulations, or costs incurred to meet any technical specifications established by the Energy Trust. Whereas 49% of the loan may be allocated toward non-qualifying energy measures such as cooling.

Terms and Conditions

1. The Company will directly bill Energy Trust or Craft3 for ongoing administrative costs, including costs associated with loan setup, loan termination and other incremental activities related to accounting and processing of bill payments.
2. The business relationship and the services exchanged between Energy Trust and the Company shall be in accordance with an executed Service Agreement. The Energy Trust will act as the program manager of this offering.
3. The provision of On-the-Bill Repayment Services will in no way conflict with the Company's compliance to WAC 480-90, Washington Administrative Code (WAC).
4. A Customer's decision to enter into a loan agreement with Craft3 will not affect his/her ability to establish credit with the Company; it will have no impact on the amount that a Customer may be required to pay on deposit for Natural Gas utility service; and it will have no effect on a Customer's ability to receive reliable natural gas service. The Company will communicate this in writing to customers who participate in this loan program.
5. By entering into a loan agreement with Craft3, the customer will be responsible to remit the monthly loan repayment amount to NW Natural with his/her monthly bill payment for natural gas services.
6. NW Natural is not a party to the loan agreements and has no financial interest in these loans.
7. Monthly payments received from customers participating in this program will be allocated to the customers' account in accordance with Rule 4 of this the Company's Tariff.
8. The Company will not disconnect gas service to a customer for non-payment of loan repayment charges.
9. NW Natural is solely a billing agent for Craft3. Participating Customers must acknowledge that the Company shall be held harmless for any liability resulting from

contractors' actions with regard to installation of energy efficiency measures resulting from this program.

10. NW Natural has no responsibility to collect charges, penalties, or fees beyond the remitting to Craft3 the loan repayment collections the Company receives from Customers in accordance with the services described herein.
11. Craft3 is responsible to tell the Company how much to bill per month for each loan and how many months each customer should be billed. The Company is not responsible for any information provided by Craft3.
12. The Company will not a) accept loan pay-offs, b) issue refunds on loan payments, c) offer payment arrangements on loan amounts due, or d) allow energy assistance to be applied to loan balances.
13. Craft3 must obtain a signed consent form from participating Customers that states that the Customer agrees to allow the Company to provide Craft3 with Customer-specific bill payment information.
14. Craft3 must obtain signed documentation from the Customer that certifies that the Customer has been made aware of the Company's limited role in the loan repayment process.
15. Craft3 must provide the Company with a toll-free customer service phone number to which the Company will refer Customers who have questions or concerns about their loan. The Company is not responsible for Customer questions and disputes related to the loan or the Customer's perceived or real experience related to any portion of the loan or energy efficiency measures.
16. The Company will provide Customers with an overview of the loan product. Specific terms and conditions of the loan will be provided by Craft3.
17. A Customer with a loan open at the time he/she sells his/her home may either pay the loan off at the time of the sale; or if the new homeowner is willing to assume the loan and is able to pass the Craft3's credit requirements, the new homeowner may assume the remaining balance of the loan.
18. If a Customer with a loan refinances his/her mortgage, Craft3 will work with the Customer. A fee may be assessed if Craft3 subordinates its lien to the new mortgage lender.