NW Natural 2020
Energy Efficiency Plan

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1 SUMMARY

The following plan outlines how NW Natural plans to save 345,811 therms across its energy efficiency programs. These savings are expected to cost $3,004,777.

2020 EE Plan Summary		Annual Therms Goal	Annual Cost
Incentive Program	Commercial Program	111,413	$889,420
	Residential Programs	227,918	$1,675,333
Low Income	WA-LIEE	6,480	$156,624
Market Transformation	NEEA	N/A	$117,648
Regional Collaboration	RTF	N/A	$10,100
Pilots & Trial Programs	Pilots & Trial Programs	TBD	$155,652
	EE Plan Total	**345,811**	**$3,004,777**

2 PART I – Background

2.1 History

Northwest Natural Gas Company, 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") 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.

The Washington Utilities and Transportation Commission's ("WUTC's") Order No. 06 in the Company's 2018 rate case, docketed as UG-181053 amended the reporting requirements and review timelines related to the program. Order 06 (UG-181053) also addressed the Company's cumulative deferral balance which will be amortized over a four-year period, November 1, 2019, through October 31, 2023.

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 Residential and Commercial 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 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.

Regional collaborative efforts funded from multiple utilities include Market Transformation administered by the Northwest Energy Efficiency Alliance ("NEEA") and technical collaborative efforts through the Northwest Power and Conservation Council's Regional Technical Forum ("RTF").

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.

[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.

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

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 (standard and custom)

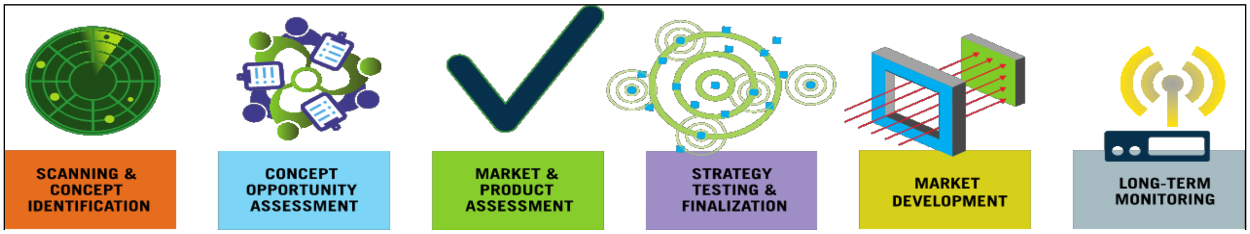
In 2020 the Commercial Program will provide standard, prescriptive measure offerings for new commercial buildings and will also provide a custom, modeled approach for some appropriate projects. New construction has continued to be an important market segment for savings acquisition. Through this work the program has expanded its effort to work directly with development design teams to ensure efficiency is being considered with equipment selection and design elements. A custom approach will allow for smaller building features and elements to be considered in the overall efficiency plan for a newly built structure. The program team will work with new construction design teams to determine the best efficiency options as well as the best program approach to influence and capture all efficiency opportunities.

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 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, as it pertains to gas energy efficiency, 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 is 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 Integrated Resource Plan ("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.

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

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

Avoided costs were updated at the beginning of the 2018 calendar year for use in 2019 measure and program planning and these same values have carried into planning for 2020. These values were used in the 2018 IRP and are described in chapter four of the 2018 IRP.
(https://www.nwnatural.com/uploadedFiles/NW%20Natural%202018%20IRP.pdf

Avoided cost values are based on assumptions including the natural gas price forecast outlined in the 2018 IRP and hedge value of demand side management. Also included in 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.

Current avoided costs also include previously estimated values for:

1) Expected impact to natural gas customers from national carbon policy, and
2) Expected impact of incremental carbon policy from Washington State.

The most recent avoided costs were used to retroactively review the cost-effectiveness of the 2018 program year. Moving forward, new avoided cost values will be calculated for 2021 measure planning. These updated values will also be used to retroactively screen 2019 program results because these values will best represent the current value of 2019 savings to the Company.

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 Annual report.

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 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.

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.

The Company will give the EEAG twenty days to review a draft filing.

2.8 Annual Schedule for Program Planning

By November 11 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 1st	Start of program year
January 28th	1st Quarter check in with EEAG
April 28th	2nd Quarter check in with EEAG
June 1st	Annual report for previous program year is filed
July 28th	3rd Quarter check in with EEAG
October 20th	4th Quarter check in with EEAG and EE Plan kickoff
November 1st	Requested effective date of program cost filing
November 10th	Share EE Plan with EEAG
January 1st	Start of next program year; new EE Plan effective

Quarterly

The Company will report on its program on a calendar year basis. Quarterly calls will be hosted by the Company to discuss progress towards its annual EE Plan goals.

Annual
An annual report will be due annually by the following June 1st 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 invited to participate in quarterly calls.

2.9 Content of Report

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 June 1 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, Regional Technical Forum Pilot, Evaluation and all other Energy Efficiency expenses related to Schedule 215 are forecasted for the twelve month period beginning each November 1st. Any differences between the forecast and actual dollars spent during the twelve months will be deferred and either credited or surcharged to customers based on over or under collection through rates. Schedule 230 costs will be deferred and later amortized for recovery from applicable customers on an equal percent of margin basis as established annually. The Company will annually submit a stand-alone filing concurrent with its PGA filing, for cost recovery of its energy efficiency program forecast under Schedule 215 and historical expenses for the prior calendar year on Schedule 230.

3 PART II – 2020 Plan

3.1 Current-Year Program Drivers

With the success of the Company's incentive program efforts in 2019, the 2020 strategy will continue with a few additional offerings and enhancements.

2019 Washington Energy Legislation

The Company will continue to track outcomes of relevant laws passed during Washington's 2019 Legislative Session, including the Department of Commerce's Appliance Standards Rulemaking. Results of such activities may impact the portfolio of efficiency incentives (e.g., appliances and fixtures) offered across various Residential and Commercial tracks in the future.

Residential

Overall, 2019 market dynamics are expected to continue into 2020. The Washington new construction market volume is expected to remain constant in 2020. Builder participation will remain strong, and the program expects to maintain its current market share of 45%. Gas savings are decreasing slightly in new construction due to the impact of the increased air infiltration baseline. The saving acquisition cost for gas homes remains consistent.

As the Southwest Washington housing stock matures, and existing HVAC systems need replacement, gas furnaces are expected to continue as a large savings opportunity. The multifamily market in Southwest Washington continues to be strong, and these properties are considered an opportunity despite low program uptake. Single-family rental homes continue to be challenging to serve due to property management and ownership structures, awareness of Energy Trust offerings and limited financial case for efficiency improvement. A decrease in showerhead unit sales is expected based on year-over-year trends, which creates risk with partners, such as Bonneville Power Administration, that support these promotions.

2020 Residential Key Activities

a. Prepare home builders for a 2020 Washington code update to drive 2021 savings through the EPS new construction track.

b. Continue to engage residential HVAC market actors to align program strategies and provide incentives for efficient gas HVAC equipment. Develop market promotions that drive low-cost installations across customer types.

c. Work with residential weatherization market actors to promote increased insulation incentives to encourage broader customer adoption.

d. Continue to develop and expand relationships with distributor partners to expand sales of efficient fireplaces and gas tank water heaters to contractors and builders.

e. Expand the installed base of smart thermostats, through instant coupon promotions, downstream incentives, direct installations, and through increasing incentive from $50 to $100. Leverage installed base of smart thermostats to achieve additional savings through enhanced control of customer thermostats.

f. Implement distributing instant saving devices at no cost to customers through community partnerships and event participation.

g. Continue to develop targeted marketing and communications strategies to drive leads to contractors, highlight special midstream promotions, and expand reach and engagement with general audiences and in specific regions or communities.

h. Prepare for discontinuation of retail showerheads.

i. Leverage a final year of Energy Saver Kits as a tool to engage new participants, while developing new approaches to optimize and personalize the customer experience.

j. Evaluate new measures, including advanced windows.

k. Assess the multifamily market in Southwest Washington and revise the strategy to gain better market participation in efforts to serve diverse customer profiles.

l. Expand co-funding of thermostats, water heating and HVAC equipment to include low-income agencies, community-based organizations and partner utilities with a goal of maximizing benefit streams across partners.

m. Continue to support the trade ally experience through customized in-person engagements and lead generation campaigns.

Residential 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

Residential Activities—Ongoing

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-2020. 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
- 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 to lead, and conduct EPS New Construction field quality assurance, including coordination with verifiers to maintain quality assurance and quality control procedures

Commercial

The strong economy coupled with ongoing construction labor shortages continue to divert commercial customers' attention away from energy efficiency projects, and tariffs are increasing costs and risk to customers. Recently passed Washington school bond measures have led to significant retrofit and new construction activity that is expected to continue for the next few years. Working with design and construction teams has allowed the program to explore custom modeled savings approaches to ensure no savings opportunities are left behind. Savings from boilers, which have been a key contributor of commercial savings for both new and existing buildings, will be about 64% lower per boiler as a result of a new evaluation.

Commercial Savings Realization Adjustment Factors (SRAFs)

Starting with the 2019 EE Plan, Savings Realization Adjustment Factors or SRAFs have been applied to the commercial savings as a means of adjusting the deemed, gross savings to more accurately reflect the findings of recent program impact evaluations. SRAFs will again be applied to 2020 savings goals and reported savings. The commercial program will be applying the following SRAFs to the associated program track; Existing Buildings (standard and custom), 0.81; New Buildings (standard and custom), 0.90. The application of SRAFs helps to ensure that savings are reported in alignment with what utilities should expect in terms of a reduction of load. This is meant to provide a conservative savings value to support IRP goals.

The program also updates engineering assumptions associated with measures as the Measure Approval Documents or MADs expire. Not all MADs are updated every year, so the application of SRAFs is meant to provide program savings adjustment that might be outside of the scheduled MAD update process. With this 'belt and suspenders' approach, the program is helping to ensure that savings are not over-reported.

The impact of the SRAFs and measure engineering updates is noteworthy. Between 2010 and 2018 the Washington efficiency programs reported gross, working savings. The commercial program has been experiencing a steady incline of customer participation and savings acquisition with 2017 Commercial goal at 156,525 and therms saved at 154,866, in 2018 Commercial goal at 160,000 and therms saved at 161,632. In 2019, the working savings goal was 170,016, however with the application of the SRAF is reduced to 147,481. In 2019, engineering assumptions on 19 commercial Measure Approval Documents were updated for 2020 delivery. Amongst these was a roughly 65% reduction in deemed savings for commercial boilers which has been a prominent measure for the WA portfolio. As a result, the total working gross savings commercial goal calculated at 134,799. With the application of the 2020 SRAFs, these savings are then reduced to 111,413.

Thus, despite maintained diverse and strong customer participation and program activity, the 2020 goal is much lower then what industry market trends and actual program activity might suggest.

2020 Commercial Key Activities

a. Offer a range of standard measures, including restaurant equipment, insulation, water heaters and boilers.
b. Expand offerings for new commercial buildings through a custom, modeled-efficiency approach. This program offering will provide more savings opportunities in new buildings that are otherwise not covered by prescriptive measures but when coupled together, provide significant savings. Interactive effect also considered with custom approach which helps to ensure accurate reporting of savings.
c. Continue to focus outreach activities on low-income housing through the Vancouver Housing Authority and other local agencies.
d. Increase outreach and promotion of Building Operator Certification to capital improvement project teams.
e. Participate in local, community-focused events, including chambers and business associations.
f. Expand regional involvement and cross program collaboration in outlying rural areas, support Clark County's Green Business program activities, seek out sponsorships, training and outreach with local chambers and business organizations, and increase collaboration with the Washington Green Schools program.
g. Review NEEA window film pilot findings for applicability to Existing Buildings.
h. Launch new marketing campaigns targeted to smaller, rural and minority-owned businesses.
i. Investigate a new boiler calculator tool.

j. Ensure that NW Natural objectives for Washington are addressed through the process of rebidding Existing Buildings and Existing Multifamily contracts.
k. Collaborate with Clark Public Utility District and NW Natural to explore offering Strategic Energy Management.

Commercial Strategic Focus

- Strategic direction will build off 2019 program. The program will maintain existing tracks, market channels, market engagement activities and operational processes, while also adding a commercial construction New Buildings – Custom track.
- Develop new strategies beyond 2020, 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

Commercial Activities—Ongoing

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 opportunities to increase savings for 2021.

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 NEEA, the Bonneville Power Administration BPA and the 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 2020 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 2020 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 most recently acknowledged 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 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		Annual Therms Goal
Commercial Programs	Existing Buildings - Standard	50,666
	Existing Buildings - Custom	38,491
	New Buildings - Standard	17,980
	New Buildings - Custom	4,275
	Commercial Total	**111,413**
Residential Programs	Existing Homes Retrofit	131,244
	Mid-stream - Distributor and Retail	9,192
	Multifamily	993
	EPS New Construction	86,490
	Residential total	**227,918**
	Total savings	**339,331**

3.2.2 Expenses by Incentive Program

Incentive Program		Budgeted Expenditures
Commercial Programs	Existing Buildings - Standard	$ 319,980
	Existing Buildings - Custom	$ 343,721
	New Buildings - Standard	$ 119,907
	New Buildings - Custom	$ 72,041
	Commercial administration	$ 43,771
	Commercial Total	**$ 899,420**
Residential Programs	Existing Homes Retrofit	$ 716,336
	Mid-stream: Distributor and Retail	$ 76,693
	Residential Multifamily	$ 8,020
	EPS New Construction	$ 797,307
	Residential Administration	$ 76,977
	Residential total	**$ 1,675,333**
	Total Expenditures	**$ 2,574,753**

Expenditures include Incentives and Delivery

3.2.3 Incentives by Incentive Program

Incentive Program		Incentives Budget	Percent incentives/expenditures
Commercial Programs	Existing Buildings - Standard	$ 119,845	37%
	Existing Buildings - Custom*	$ 188,060	55%
	New Buildings - Standard	$ 48,747	41%
	New Buildings – Custom*	$ 54,250	75%
	Commercial Total	**$ 410,902**	**46%**
Residential Programs	Existing Homes Retrofit	$ 263,666	37%
	Mid-stream: Distributor and Retail	$ 47,488	62%
	Residential Multifamily	$ 3,153	39%
	EPS New Construction	$ 585,743	73%
	Residential total	**$ 900,050**	**54%**
	Total Incentives	**$ 1,310,952**	**51%**

*Commercial Custom Studies included in Custom Track

- Percent Incentives is calculated by dividing budgeted incentives by total budgeted expenditures

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.

2020 Utility Cost Test and Total Resource Cost Test benefit/cost ratios by program

Program	Utility Cost Test benefit/cost ratio	Total Resource Cost Test benefit/cost ratio
Commercial programs	1.6	1.2
Residential Programs	1.8	1.0
Total NW Natural Washington Efficiency Program Portfolio	**1.7**	**1.0**

- Values based on forecasted measure quantities and savings

3.3 Low Income Metrics and Budget

The WA-LIEE program will strive to weatherize **19** 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 @ 19 homes	6,480
	Total Low Income savings	**6,480**

3.3.2 Low Income Budget

WA-LIEE		Budget
WA-LIEE	WA-LIEE Measures	$ 115,520
	WA-LIEE Agency Administration (15%)	$ 17,328
	Health / Safety	$ 19,000
	WA-LIEE application processing admin (5% cap)	$ 5,776
	WA-LIEE Total	**$ 157,624**

The WA-LIEE 2020 goal for Clark County program is in line with expected 2019 performance. Efforts initiated in 2019 in coordination with the Energy Project will encourage the weatherization of gas homes in the Company's outlying service areas and will continue in 2020.

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 continuing pilot program efforts and engaging in outreach activities to drive additional program participation in 2020 and have a set target of completing a home in Klickitat or Skamania Counties.

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 Ratio (SIR) tests.

3.4 Gas Market Transformation Metrics and Budget

The Company will continue its participation with NEEA in 2020-2024. 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	2020-2024 NW Natural Washington Allocation	$ 588,239
	2020 NEEA Total	**$ 117,648**

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.

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 to continue to offer $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 and began offering an adjustment in 2019. The company continues to seek ways to support our partners and increase the number of homes served in its territory. In 2020 the company will continue to operate 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 2020 goal of at least 18 homes in Clark County and at least one completion in the remaining service territory.

Low Income Thermostat

In 2019 the Company partnered 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 continue this partnership and leverage the ongoing efforts to enable qualified gas customers to also participate. The Company plans to test additional outreach and marketing to increase uptake and refer customers to the Weatherization program. The costs are estimated to be approximately $305 per home for installation with an estimate of 100 installs and some funding for communication efforts.

3.5.1 Pilot & Trial Program Budget

Pilots & Trial Programs		Budget
	Low Income Furnace Tune Ups	$ 15,000
	Low Income Program Adjustment	$ 105,652
	Low Income Thermostat Direct Install	$ 35,000
	Pilot Total	**$ 155,652**

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 Northwest Power and Conservation Council - Regional Technical Forum (RTF)

In 2020 the Company has agreed to support the work of the Regional Technical Forum's 2020-2024 Business Plan. The work of the RTF will assist the Company in developing and acquiring cost-effective conservation, conservation research and evaluating conservation investments.

3.6.1 RTF Budget

RTF		Budget
	RTF 2020 Work Plan – NWN WA	$ 10,100
	RTF Total	**$ 10,100**

3.7 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 3.

3.8 Evaluation Activities

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. The Company continues to evaluate the need for a program-level outside evaluation.

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

2020 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 Q	Savings (Therms) per Quantity	2019 WA-Only GAS AC per measure	Estimated Max Incentive (2020 v1.2 AC)	Notes	Other NEB (Annual $)	UCT BCR at Max Incentive (20	UCT BCR at Incentive Lev	TRC BCR (2020 AC v1.2)	2019 Levelized Cost (5.64% Discount Rate)	MAD #
Discontinued	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		$3.39	5.07	5.07	30.04	$0.12	27
Discontinued	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	BYOKAER15KGWA	Build Your Own Kit - SW WA, 1.5gpm Kitch Aerator Gas	RESDHWG	DHW	15	$1.85	$1.85		1.4	$8.71	$1.85		$3.47	4.71	4.71	23.36	$0.13	27
Savings, Incentive Change	Home Retrofit	CEILINGINSULATE	INSCEILGZ1	SF Attic Insulation/SQFT, Gas Heat, Zone 1 2014	GEXSPHT	Res Heating	45	$0.60	$1.46	0.20	0.07	$1.55	$1.46		$0.01	1.06	2.58	1.34	$0.50	58
Discontinued	Home Retrofit	CEILINGINSULATE	RNTINSCEILGHZ1	Rental Attic Insulation, Gas Heat - Zone 1	GEXSPHT	Res Heating	45	$0.50	$1.46	0.20	0.07	$1.55	$1.46		$0.01	1.06	3.09	1.34	$0.42	58
Savings, Incentive Change	Home Retrofit	FLOORINSULATE	INSFLRGHZ1	SF Floor Insulation/SQFT, Gas Heat, Zone 1 2014	GEXSPHT	Res Heating	45	$0.60	$2.07	(0.02)	0.042	$0.88	$0.88		$0.01	1.00	1.46	0.45	$0.88	58
Discontinued	Home Retrofit	FLOORINSULATE	RNTINSFLRGHZ1	Rental Floor Insulation, Gas Heat - Zone 1	GEXSPHT	Res Heating	45	$0.40	$2.07	(0.02)	0.042	$0.88	$0.88		$0.01	1.00	2.19	0.45	$0.59	58
No change	Multifamily	GASFIRE	GASHRTH7074	Gas Hearth 70-74 FE	GEXSPHT	Res Heating	20	$150.00	$0.01		51.4	$700.09	$0.01		$0.00	70008.91	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		63.2	$860.81	$47.00		$0.00	18.32	3.44	18.32	$0.33	29
No change	Home Retrofit	GASFIRE	GASHRTH7074	Gas Hearth 70-74 FE	GEXSPHT	Res Heating	20	$150.00	$0.01		51.4	$700.09	$0.01		$0.00	70008.91	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		63.2	$860.81	$47.00		$0.00	18.32	3.44	18.32	$0.33	29
No change	Multifamily	GASFURNACE	HESGASFURNRENTALW	Gas Furnance - 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	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	Home Retrofit	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	Home Retrofit	GASFURNACE	HESGASFURNRENTALW	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
Discontinued	Home Retrofit	KNEEINSULATE	INSKWGHZ1	SF Knee Wall Insulation/SQFT, Gas Heat, Zone 1 2014	GEXSPHT	Res Heating	45	$0.30	$2.52	0.08	0.052	$1.09	$1.09		$0.02	1.00	3.62	0.61	$0.36	58
Savings update, cost	Home Retrofit	OTHER	SEASSAVEFURNWA	Seasonal Savings - Winter Furnaces, Washington	GEXSPHT	Res Heating	1	$3.00	$3.00	35	16	$13.15	$3.00		$0.00	4.38	4.38	5.29	$0.20	173
Savings, Incentive Change	Home Retrofit	SHOWERHEAD	BYOKSHWR150WA	Build Your Own Kit, 1.5 gpm Showerhead Gas	RESDHWG	DHW	15	$12.00	$2.52	0.080454691	0.052	$0.32	$0.32		$0.02	1.00	0.03	0.24	$23.20	27
Savings, Incentive Change	Home Retrofit	SHOWERHEAD	BYOKSHWR175WA	Build Your Own Kit, 1.75 gpm Showerhead Gas	RESDHWG	DHW	15	$12.00	$2.52	0.080454691	0.052	$0.32	$0.32		$0.02	1.00	0.03	0.24	$23.20	27
Savings, Incentive Change	Home Retrofit	SHOWERWAND	BYOKWAND150GWA	Build Your Own Kit, 1.5 gpm Shower wand Gas	RESDHWG	DHW	15	$16.00	$2.52	0.080454691	0.052	$0.32	$0.32		$0.02	1.00	0.02	0.24	$30.94	27
Savings, Incentive Change	Home Retrofit	SHOWERWAND	BYOKWAND175GWA	Build Your Own Kit, 1.75 gpm Shower wand Gas	RESDHWG	DHW	15	$16.00	$2.52	0.080454691	0.052	$0.32	$0.32		$0.02	1.00	0.02	0.24	$30.94	27
Savings Change	Multifamily	TANKLESS	WAGASTANKLESS	SW WA Gas Tankless Water Heater	RESDHWG	DHW	20	$200.00	$1,834.00		76	$600.59	$600.59	Savings Change	$0.00	1.00	3.00	0.33	$0.22	197
Savings, Incentive Change	Multifamily	THERMOSTAT	SMARTSTATGOT	Smart Thermostat - Gas Only Territory	GEXSPHT	Res Heating	11	$100.00	$170.00	42	31.8	$246.39	$170.00	Savings change, incentive increase		1.45	2.46	1.61	$0.39	153
New Measure	Multifamily	THERMOSTAT	SMARTSTATGOTIC	Smart Thermostat Instant Coupon - Gas Only Territory	GEXSPHT	Res Heating	11	$100.00	$170.00	42	31.8	$246.39	$170.00			1.45	2.46	1.61	$0.39	153
Savings, Incentive Change	Multifamily	THERMOSTAT	SMARTSTATGOT	Smart Thermostat - Gas Only Territory	GEXSPHT	Res Heating	11	$100.00	$170.00	42	31.8	$246.39	$170.00	Savings change, ince	$1.83	1.45	2.46	1.70	$0.39	153
Savings, Incentive Change	Home Retrofit	THERMOSTAT	SMARTSTATGOT	Smart Thermostat - Gas Only Territory	GEXSPHT	Res Heating	11	$100.00	$170.00	42	31.8	$246.39	$170.00	Savings change, ince	$0.01	1.45	2.46	1.61	$0.39	153
New Measure	Home Retrofit	THERMOSTAT	SMARTSTATGOTIC	Smart Thermostat Instant Coupon - Gas Only Territory	GEXSPHT	Res Heating	11	$100.00	$170.00	42	31.8	$246.39	$170.00			1.45	2.46	1.61	$0.39	153
No change	Multifamily	THERMOSTAT	DITSTATGFACWA	Direct Install Thermostat - Gas Furnace w/ AC	GEXSPHT	Res Heating	11	$213.07	$213.07	36	27.5	$213.07	$213.07	Max incentive, plac	$0.00	1.00	1.00	1.11	$0.96	222
No change	Home Retrofit	THERMOSTAT	DITSTATGFACWA	Direct Install Thermostat - Gas Furnace w/ AC	GEXSPHT	Res Heating	11	$271.18	$271.18	46	35	$271.18	$271.18	Max incentive as pl	$0.00	1.00	1.00	1.11	$0.96	222
Discontinued	Home Retrofit	WALLINSULATE	INSRJGHZ1	SF Rim Joist Insulation/SQFT, Gas Heat, Zone 1 2014	GEXSPHT	Res Heating	45	$0.30	$2.52	0.08	0.052	$1.09	$1.09		$0.02	1.00	3.62	0.61	$0.36	58
Savings, Incentive Change	Home Retrofit	WALLINSULATE	INSWALLGHZ1	SF Wall Insulation/SQFT, Gas Heat, Zone 1 2014	GEXSPHT	Res Heating	45	$0.60	$2.52	0.08	0.052	$1.09	$1.09		$0.02	1.00	1.81	0.61	$0.71	58
Discontinued	Home Retrofit	WALLINSULATE	RNTINSWLLGHZ1	Rental Wall Insulation, Gas Heat - Zone 1	GEXSPHT	Res Heating	45	$0.50	$2.52	0.08	0.052	$1.09	$1.09		$0.02	1.00	2.17	0.61	$0.59	58
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	$1.11		$0.00	3.76	2.39	3.76	$0.54	28
New Measure	Home Retrofit	AERATOR	LBAER10BGWA	Leave Behind - SW WA, 1.0gpm Bath Aerator Gas	RESDHWG	DHW	15	$1.35	$1.35		1.1	$6.84	$1.35		$3.39	5.07	5.07	30.04	$0.12	27
New Measure	Home Retrofit	AERATOR	LBAER15KGWA	Leave Behind - SW WA, 1.5gpm Kitch Aerator Gas	RESDHWG	DHW	15	$1.85	$1.85		1.4	$8.71	$1.85		$3.47	4.71	4.71	23.36	$0.13	27
New Measure	Multifamily	AERATOR	LBAER10BGWA	Leave Behind - SW WA, 1.0gpm Bath Aerator Gas	RESDHWG	DHW	15	$1.35	$1.35		1.1	$6.84	$1.35		$3.39	5.07	5.07	30.04	$0.12	27
New Measure	Multifamily	AERATOR	LBAER15KGWA	Leave Behind - SW WA, 1.5gpm Kitch Aerator Gas	RESDHWG	DHW	15	$1.85	$1.85		1.4	$8.71	$1.85		$3.47	4.71	4.71	23.36	$0.13	27
New Measure	Home Retrofit	SHOWERHEAD	LBSHWR150WA	Leave Behind - SW WA, 1.5 gpm Showerhead Gas	RESDHWG	DHW	15	$12.00	$2.52	0.080454691	0.052	$0.32	$0.32		$0.02	1.00	0.03	0.24	$23.20	27
New Measure	Home Retrofit	SHOWERHEAD	LBSHWR175WA	Leave Behind - SW WA, 1.75 gpm Showerhead Gas	RESDHWG	DHW	15	$12.00	$2.52	0.080454691	0.052	$0.32	$0.32		$0.02	1.00	0.03	0.24	$23.20	27
New Measure	Multifamily	SHOWERHEAD	LBSHWR150WA	Leave Behind - SW WA, 1.5 gpm Showerhead Gas	RESDHWG	DHW	15	$12.00	$2.52	0.080454691	0.052	$0.32	$0.32		$0.02	1.00	0.03	0.24	$23.20	27
New Measure	Multifamily	SHOWERHEAD	LBOKSHWR175WA	Leave Behind - SW WA, 1.75 gpm Showerhead Gas	RESDHWG	DHW	15	$12.00	$2.52	0.080454691	0.052	$0.32	$0.32		$0.02	1.00	0.03	0.24	$23.20	27
New Measure	Home Retrofit	SHOWERWAND	LBWAND150GWA	Leave Behind - SW WA, 1.5 gpm Shower wand Gas	RESDHWG	DHW	15	$16.00	$2.52	0.080454691	0.052	$0.32	$0.32		$0.02	1.00	0.02	0.24	$30.94	27
New Measure	Home Retrofit	SHOWERWAND	LBWAND175GWA	Leave Behind - SW WA, 1.75 gpm Shower wand Gas	RESDHWG	DHW	15	$16.00	$2.52	0.080454691	0.052	$0.32	$0.32		$0.02	1.00	0.02	0.24	$30.94	27
New Measure	Multifamily	SHOWERWAND	LBWAND150GWA	Leave Behind - SW WA, 1.5 gpm Shower wand Gas	RESDHWG	DHW	15	$16.00	$2.52	0.080454691	0.052	$0.32	$0.32		$0.02	1.00	0.02	0.24	$30.94	27
New Measure	Multifamily	SHOWERWAND	LBWAND175GWA	Leave Behind - SW WA, 1.75 gpm Shower wand Gas	RESDHWG	DHW	15	$16.00	$2.52	0.080454691	0.052	$0.32	$0.32		$0.02	1.00	0.02	0.24	$30.94	27
New Measure	Multifamily	CEILINGINSULATE	INSCEILGZ1	SF Attic Insulation/SQFT, Gas Heat, Zone 1 2014 MF	GEXSPHT	Res Heating	45	$0.60	$1.46	0.20	0.07	$1.55	$1.46		$0.01	1.06	2.58	1.34	$0.50	58
New Measure	Multifamily	FLOORINSULATE	INSFLRGHZ1	SF Floor Insulation/SQFT, Gas Heat, Zone 1 2014 MF	GEXSPHT	Res Heating	45	$0.60	$2.07	(0.02)	0.042	$0.88	$0.88		$0.01	1.00	1.46	0.45	$0.88	58
New Measure	Multifamily	WALLINSULATE	INSWALLGHZ1	SF Wall Insulation/SQFT, Gas Heat, Zone 1 2014 MF	GEXSPHT	Res Heating	45	$0.60	$2.52	0.08	0.052	$1.09	$1.09		$0.02	1.00	1.81	0.61	$0.71	58

			total Incentive w/ bonus	Forecasted additic	Savings (Therms) per Quantity	Forecasted additional savings resulting from bonus
Bonus	TANKLESSDHW	TANKLESSBONUS	300	12	74.2	890
Bonus	WAEPS	LowIncome_VERF	Varies - bonus amount = $250	20	Varies	Varies
Bonus	HEGASFURN95PLUS	FURNACEBONUSWA	300	50	92	4600
Bonus	HESGASFURNRENTALWA	FURNACEBONUSWA	650	10	92	920
Bonus	WAEPS	SWEDASSIST	Varies	12	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	$ 2.00	$ 2.71	14	$59.96	$2.71
AERATORGONLYK1P5	Aerator - Gas Hot Water - Kitchen 1.5 GPM or less	RESDHWG	DHW	10	$ 5.00	$ 7.00	7	$29.98	$7.00
	Aerator - Gas Water Heat - Bathroom 0.5 GPM or less - Leave Behind	RESDHWG	DHW	10	$ 2.00	$ 2.00	10	$42.83	$2.00
	Aerator - Gas Hot Water - Kitchen 1.5 GPM or less - Leave Behind	RESDHWG	DHW	10	$ 5.00	$ 2.00	5	$21.41	$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
GREENIRPOLY	Infrared (IR) polyethylene greenhouse cover	GEXSPHT	Com Heating	4	$ 0.10	$ 0.10	0.23	$0.77	$0.10
GREENTHCUR	Thermal Curtains Installed on Greenhouses	GEXPRO	Com Heating	10	$ 1.17	$ 1.17	0.41	$3.20	$1.17
GREENUNDERBENCH	Under-bench heating Green house	GEXSPHT	Com Heating	12	$ 2.19	$ 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
New (No code yet)	Roof Insulation R5 or less to R30	GEXSPHT	Com Heating	25	$ 1.00	$ 2.05	0.09	$1.53	$1.53
New (No code yet)	Roof Insulation R0 or less to R15	GEXSPHT	Com Heating	25	$ 0.50	$ 2.05	0.43	$7.31	$2.05
New (No code yet)	Roof Insulation R0 or less to R30	GEXSPHT	Com Heating	25	$ 1.00	$ 2.05	0.51	$8.67	$2.05
New (No code yet)	Attic Insulation R0 to R25	GEXSPHT	Com Heating	30	$ 0.60	$ 0.95	0.14	$2.64	$0.95
New (No code yet)	Wall Insulation R0 to R20	GEXSPHT	Com Heating	30	$ 0.60	$ 1.38	0.19	$3.58	$1.38
New (No code yet)	Attic insulation Gas Heat WA (R0-R11 starting condition)	GEXSPHT	Res Heating	45	$ 1.46	$ 1.46	0.074		
New (No code yet)	Wall insulation Gas Heat WA	GEXSPHT	Res Heating	45	$ 1.09	$ 2.52	0.052		
New (No code yet)	Floor insulation Gas Heat WA	GEXSPHT	Res Heating	45	$ 0.88	$ 2.07	0.042		
MFSTEAMTRAPWA	Multifamily Steam Traps	GEXPRO	Res Heating	6	$ 100.00	$ 100.00	99	$440.52	$100.00
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	DHW Pipe Insulation	GEXPRO	DHW	15	$ 4.00	$ 18.40	4.4	$27.36	$18.40
PIPEINSLN	Commercial MPS Pipe Insulation	GEXPRO	Flat	15	$ 12.00	$ 18.40	9.4	$51.79	$18.40
PIPEINSLN	Commercial Heating HW Pipe Insulation	GEXPRO	Flat	15	$ 4.00	$ 18.40	5.7	$31.41	$18.40
PIPEINSLN	Commercial LPS Pipe Insulation	GEXPRO	Flat	15	$ 8.00	$ 18.40	9.3	$51.24	$18.40
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
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
	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 - Existing Buildings	GEXPRO	Flat	3	$ 1,600.00	$ 1,895.00	1877	$2,245.85	$1,895.00
BOCINCENTIVE2	BOC - Building Operations Manager Certificate, Level 2 - Existing Buildings	GEXPRO	Flat	3	$ 1,600.00	$ 1,895.00	1877	$2,245.85	$1,895.00
	BOC - Building Operations Manager Certificate, Level 1 - Multifamily	GEXPRO	Flat	3	$ 400.00	$ 1,895.00	316	$378.10	$378.10
	BOC - Building Operations Manager Certificate, Level 2 - Multifamily	GEXPRO	Flat	3	$ 400.00	$ 1,895.00	316	$378.10	$378.10
New (No code yet)	Cooler Doors	GEXSPHT	Com Heating	15	$ 100.00	$ 316.32	39	$447.27	$316.32
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)	Condensing Boiler - New Multifamily (per 100 SF)	GEXSPHT	Res Heating	35	$ 2.00	$ 3.98	0.77	$14.69	$3.98
New (No code yet)	Condensing Boiler - New Commercial (per 100 SF)	GEXSPHT	Com Heating	35	$ 2.00	$ 7.35	0.74	$14.98	$7.35
New (No code yet)	Condensing Boiler - Existing Multifamily (per kBtu/h) - WA	GEXSPHT	Res Heating	35	$ 3.25	$ 8.93	2.23	$42.55	$8.93
New (No code yet)	Condensing Boiler - Existing Buildings (per kBtu/h) - WA	GEXSPHT	Com Heating	35	$ 3.25	$ 8.93	1.03	$20.85	$8.93
	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	$ 3.00	$ 5.00	2.2	$13.68	$5.00
	WA Existing or New MF Customer Purchased Bathroom Aerator 0.5 gpm	RESDHWG	DHW	15	$ 3.00	$ 5.00	3.5	$21.76	$5.00

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)
	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	$ 3.00	$ 5.00	1.8	$11.19	$5.00
	WA Existing or New MF Leave Behind Bathroom Aerator 0.5 gpm	RESDHWG	DHW	15	$ 3.00	$ 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	132	$820.77	$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
New (No code yet)	Conveyor Broilers <22" wide conveyor - gas only	GNEWPRO	Com Cooking	12	$ 2,015.00	$ 2,523	1145	$7,753.11	$2,523.00
New (No code yet)	Conveyor Broilers 22-28" wide conveyor - gas only	GNEWPRO	Com Cooking	12	$ 2,515.00	$ 3,146	1933	$13,088.87	$3,146.00
New (No code yet)	Conveyor Broilers >28" wide conveyor - gas only	GNEWPRO	Com Cooking	12	$ 2,925.00	$ 3,659	3161	$21,403.99	$3,659.00
Gas OD 1/12 HP	Domestic hot water recirculation controls - On demand		DHW	12	$ 300.00	$ 388	139.5	$707.39	$388.00
Gas OD 1/6 - 1/4 HP	Domestic hot water recirculation controls - On demand		DHW	12	$ 1,200.00	$ 2,198	279 - 353.4		$0.00
Gas OD 1/2 - 5 HP	Domestic hot water recirculation controls - On demand		DHW	12	$ 1,900.00	$ 2,198	424	$2,150.06	$2,150.06
Gas AQ 1/12 HP	Domestic hot water recirculation controls - Aquastat		DHW	12	$ 100.00	$ 108	22	$111.56	$108.00
Gas AQ 1/6 - 1/4 HP	Domestic hot water recirculation controls - Aquastat		DHW	12	$ 200.00	$ 1,000	44 - 55.8		$0.00
Gas AQ 1/2 - 5 HP	Domestic hot water recirculation controls - Aquastat		DHW	12	$ 300.00	$ 1,000	67	$339.75	$339.75
Gas LRN 1/12 HP	Domestic hot water recirculation controls - Learning		DHW	12	$ 100.00	$ 206	22	$111.56	$111.56
Gas LRN 1/6 - 1/4 HP	Domestic hot water recirculation controls - Learning		DHW	12	$ 200.00	$ 1,000	44 - 55.8		$0.00
Gas LRN 1/2 - 5 HP	Domestic hot water recirculation controls - Learning		DHW	12	$ 300.00	$ 1,000	67	$339.75	$339.75
New (No code yet)	Outdoor Pools - condensing pool heater - per SF		Flat	10	$ 3.50	$ 3.52	1.1	$4.16	$3.52
New (No code yet)	Indoor Pools - condensing pool heater - per SF		Flat	10	$ 2.35	$ 2.35	0.68	$2.57	$2.35
	DCKV - gas heat		Com Heating	15	$ 750.00	$ 2,188	142	$1,628.54	$1,628.54
	DCKV - gas heat - custom new and retrofit calculator		Com Heating	15	n/a	n/a	n/a		
New (No code yet)	Furnace, 91%, Multifamily		Res Heating	18	$ 1.50	$ 8.66	0.51	$6.37	$6.37
New (No code yet)	Furnace, 95%, Multifamily		Res Heating	18	$ 2.00	$ 12.30	0.9	$11.25	$11.25
New (No code yet)	Furnace, 98%, Multifamily		Res Heating	18	$ 3.00	$ 14.92	0.39	$4.87	$4.87
New (No code yet)	3/4" DHW pipe insulated to 1.5"		Res Heating	15	$4.00	$ 12.99	2.3	$24.46	$12.99
New (No code yet)	1" DHW pipe insulated to 1.5"		Res Heating	15	$4.00	$ 13.61	2.8	$29.78	$13.61
New (No code yet)	2" DHW pipe insulated to 2"		Res Heating	15	$4.00	$ 16.86	4.9	$52.11	$16.86
New (No code yet)	3" DHW pipe insulated to 2"		Res Heating	15	$4.00	$ 20.02	6.9	$73.37	$20.02
New (No code yet)	4" DHW pipe insulated to 2"		Res Heating	15	$4.00	$ 23.13	8.7	$92.52	$23.13
New (No code yet)	3/4" LPS (<15 psig) pipe insulated to 1.5"		Res Heating	15	$4.00	$ 12.99	1.7	$18.08	$12.99
New (No code yet)	1" LPS (<15 psig) pipe insulated to 1.5"		Res Heating	15	$4.00	$ 13.61	2.1	$22.33	$13.61
New (No code yet)	2" LPS (<15 psig) pipe insulated to 2"		Res Heating	15	$4.00	$ 16.86	3.7	$39.35	$16.86
New (No code yet)	3" LPS (<15 psig) pipe insulated to 2"		Res Heating	15	$4.00	$ 20.02	5.2	$55.30	$20.02
New (No code yet)	4" LPS (<15 psig) pipe insulated to 2"		Res Heating	15	$4.00	$ 23.13	6.5	$69.12	$23.13
	Modulating Burner		Com Heating	20	$ 9.50	$ 9.50	1.4	$20.40	$9.50
	EF 0.82+/UEF 0.81+ Tankless Gas Water Heater		Res Heating	20	$ 601.00	$ 1,838	76	$1,035.15	$1,035.15
	Restaurant - CTWH 199 kBtu/h		DHW	15	$ 320.00	$ 320	152	$945.13	$320.00
	Coin-op Laundry - CTWH 199 kBtu/h		DHW	15	$ 320.00	$ 320	481	$2,990.84	$320.00
	Gym/Fitness Center- CTWH 199 kBtu/h		DHW	15	$ 320.00	$ 320	100	$621.80	$320.00
	Schools- CTWH 199 kBtu/h		DHW	15	$ 320.00	$ 320	89	$553.40	$320.00
	SF SWWA DI Tstat gFAF w/CAC - Comp Funding		Res Heating	11	$ 271.00	$ 301	35	$271.18	$271.18
	SF SWWA DI Tstat gFAF - Comp Funding		Res Heating	11	$ 271.00	$ 282	35	$271.18	$271.18
	MF SWWA DI Tstat gFAF w/CAC - Comp Funding		Res Heating	11	$ 213.00	$ 237	27.5	$213.07	$213.07
	MF SWWA DI Tstat gFAF - Comp Funding		Res Heating	11	$ 213.00	$ 222	27.5	$213.07	$213.07

4.2 Appendix 2: Measure Approval Documents

Measure Approval Document for Automatic Conveyor Broilers

Valid Dates
4/15/2019 – 12/31/2021

End Use or Description
Automated conveyor broilers cook food by direct and indirect contact with gas-fired flames. Energy Efficient broilers consume both less gas and less electricity than their baseline counterparts.

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:
- Foodservice

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

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 Allo	% Gas Allo
Conveyor Broilers <22" wide conveyor	12	7,144	1,145	$2,523	$0.00	$2,523	4.0	4.0	50%	50%
Conveyor Broilers 22-28" wide conveyor	12	6,403	1,933	$3,146	$0.00	$3,146	4.2	4.2	35%	65%
Conveyor Broilers >28" wide conveyor	12	23,849	3,161	$3,659	$0.00	$3,659	8.5	8.5	55%	45%
Conveyor Broilers <22" wide conveyor - ELECTRIC ONLY	12	7,144	0	$2,523	$865.07	$2,523	2.0	5.1	100%	0%
Conveyor Broilers 22-28" wide conveyor - ELECTRIC ONLY	12	6,403	0	$3,146	$1,459.92	$3,146	1.4	5.7	100%	0%
Conveyor Broilers >28" wide conveyor - ELECTRIC ONLY	12	23,849	0	$3,659	$2,387.78	$3,659	4.6	10.6	100%	0%
Conveyor Broilers <22" wide conveyor - GAS ONLY	12	0	1,145	$2,523	$534.11	$2,523	2.0	4.0	0%	100%
Conveyor Broilers 22-28" wide conveyor - GAS ONLY	12	0	1,933	$3,146	$478.75	$3,146	2.7	4.1	0%	100%
Conveyor Broilers >28" wide conveyor - GAS ONLY	12	0	3,161	$3,659	$1,783.09	$3,659	3.9	8.3	0%	100%

Table 2 Cost Effectiveness Calculator Washington

Measure	Measure Life (years)	Unclaimed Savings (kWh)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR
Conveyor Broilers <22" wide conveyor	12	7,144	1,145	$2,523	$550.08	$2,523	3.07	4.94
Conveyor Broilers 22-28" wide conveyor	12	6,403	1,933	$3,146	$493.06	$3,146	4.16	5.50
Conveyor Broilers >28" wide conveyor	12	23,849	3,161	$3,659	$1,836.38	$3,659	5.85	10.14

Requirements
- Broiler must be an automatic conveyor with catalyst and an input rate less than 80 kBtu/h or a dual stage or modulating gas valve with a capability of throttling the input rate below 80 kBtu/h.
- Implementation and installation requirements: Must be installed under a Type I Hood
- Broilers fueled by an alternate fuel such as propane may be considered with the electric only territory measure.

Details
Typical conveyor broilers operate at a constant input rate maintaining average cavity temperatures between 600°F and 700°F. The temperature is regulated by a gas manifold pressure adjustment. Constant input rate broilers do not differentiate between cooking and idle operation – the broiler operates at the same rate throughout the day.

Advanced automatic conveyor broilers utilize a dual-stage gas valve which reduces the input rate during cooking conditions to prevent flare ups, and also cycle gas burners on/off to maintain cooking cavity temperature. Broilers utilizing a catalyst on top of their cooking cavity reduce emissions and further insulate the cavity, resulting in lower input rates needed to maintain cooking temperatures. Advanced automatic conveyor broilers also use active airflow management techniques to recirculate hot air inside the cavity, resulting in lower gas input rates needed to maintain cooking temperatures.

Most popular automatic conveyor broilers fall into three categories based on their energy usage:
- 1-2 lane wide broilers with conveyor belt width less than 22 inches
- 3 lane wide broilers with conveyor belt width greater than 22-28 inches
- 4 lane wide broilers with conveyor belt width greater than 28 inches

Baseline
This measure uses a Full Market Baseline.

Baseline equipment will be an automatic conveyor broiler meeting the performance specifications outlined in Southern California Gas's Workpaper[1], which is the source of much of the measure analysis. There are no federal guidelines for this type of cooking equipment. We assume the efficient equipment has little to no market share. Baseline broiler is assumed to be an automatic conveyor broiler capable of maintaining a temperature above 600°F with a tested idle rate greater than:

- 40kBtu/h for a belt narrower than 22"
- 60kBtu/h for a belt between 22 and 28"
- 70kBtu/h for a belt wider than 28"

Savings and Measure Analysis

Daily equipment energy use for both standard and efficient conveyor broiler types is determined using Equation 1 below provided by the SCG Workpaper. Electric and gas energy savings for each broiler size category results from reduced preheat, idle, and full load cooking energy rates for efficient equipment over standard equipment.

Automatic conveyor broiler energy consumption has been measured through laboratory testing as well as field verification. Field gas and electric sub metering data provides broiler hours of operation and broiler operating mode data.[1] ASTM F2239-10 is an industry standard method for testing the performance of conveyor broilers. The test method evaluates the energy consumption and cooking performance of conveyor broilers through characterizing the broiler preheat, idle and cooking in terms of gas and electric energy consumption. These laboratory test values are then used to populate an energy model by applying operating hours.

Broiler operating hours are determined by:

- Restaurant open hours
- Operation surveys stating how many minutes before opening the broiler gets turned on and off
- Sub metered field data

Broiler annual energy consumption depends on the following factors:

- Broiler hours of operation
- Broiler preheat time and energy
- Broiler idle rate
- Broiler cooking rate

$$E_{daily} = \frac{W}{PC} \times \left(q_{gas,h} + q_{elec,h}\right) + \left(q_{gas,i} + q_{elec,i}\right) \times \left(t_{on} - \frac{W}{PC} - \frac{n_p \times t_p}{60}\right) + n_p \times E_p \qquad Eq. 1$$

Where:

- E_{daily} = Daily energy consumption (Btu/day)
- W = pounds of food cooked per day (lbs)
- PC = Production capacity (lbs/hr)
- $q_{gas,h}$ = heavy load cooking gas energy rate (Btu/hr)
- $q_{elec,h}$ = heavy load cooking electric energy rate (kW*)
- $q_{gas,i}$ = idle gas energy rate (Btu/hr)
- $q_{elec,I}$ = idle electric energy rate (kW*)
- t_{on} = total time the appliance is on per day
- n_p = number of preheats per day
- t_p = duration of preheat
- E_p = preheat energy (Btu)

*convert to Btu

Comparison to other offerings.

Operating hours for broilers are based on SCG research at quick serve and large restaurants. These hours do not match those used for other cooking equipment offerings, which assume 23% of installations happen in schools or other buildings with significantly lower hours of operation.

Non-Energy Benefits

In single-fuel territories, customer bill savings for out of territory fuel are listed as non-energy benefits.

Measure Life

The estimated useful life of 12 years is based on the 2017 DEER EUL of commercial cooking equipment.

Cost

Incremental costs between baseline and proposed equipment are used. The installation costs are assumed to be the same for the baseline and energy efficient conveyor broilers. The cost of purchasing an automatic conveyor broiler usually includes delivery, installation and setup costs if purchased directly from the factory or an authorized retailer. In other cases, broiler delivery and installation costs can be up to $1000. This cost is used for both proposed and baseline labor estimates.

The SCG study gathered costs for energy efficient broilers from manufacturers. Broilers researched were distributed into the three belt width categories. Models that fell in the same category were averaged together. With not all model size options available with both single and dual belt controls, the cost for both models was extrapolated based on the cost premium of the dual belt model over the single belt option. Then the pricing was averaged for both models to achieve the measure costs. Baseline equipment cost data were not unavailable for sizes other than the 4-lane conveyor width model. Estimated costs were derived by using the same percentage cost premium over the energy efficient broiler for the 4-burger wide model for the smaller 2 and 3 burger width models.

Incentive Structure

The maximum incentives listed in ***Error! Reference source not found.*** *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.

SRAF

Standard program SRAFs apply to this measure.

1. SoCalGas. (2017). *Commercial Conveyor Broilers* (Whitepaper No. WPSCGNRCC171226A_Rev00)

Follow-Up

Should they be released, Federal guidelines for conveyor broilers will be considered for the next update.

If broilers become a common measure in the schools market or similar situation with reduced hours, analysis should be updated to account for lower hours of operation in that setting.

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\Food Service\Cooking Equipment\broilers

OR-WA-CEC-2020-v
1.1 - 233.2 Automati

Version History and Related Measures

Table 3 Version History

Date	Version	Reason for revision
4/5/2019	233.1	Introduce conveyor broiler measures
4/5/2019	233.2	Update valid dates for immediate launch.
4/16/19	233.3	Correct requirements regarding venthood types

Table 4 Related Measures

Measures	MAD ID
Commercial Foodservice Cooking Measures	101
Restaurant Market Solutions Offering (MSO)	158

Approved & Reviewed by

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Energy Trust of Oregon

Measure Approval Document for Building Operator Certification

Valid Dates
1/1/2020 – 12/31/2022

End Use or Description
Training for building operators in commercial and multifamily buildings though the Building Operator Certification (BOC) program.

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
- 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
- Large Commercial Buildings

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

Purpose of Re-Evaluating Measure
This update includes adjustments to savings based on the findings of NEEA's latest Building Operator Certificate Expansion Initiative Market Progress Evaluation Report (MPER) #3 released on 8/24/15. as well as including participant data collected by Energy Trust during 2016 – 2018 program years.

Incremental costs are updated to reflect the full cost of the BOC training. Maximum incentive is updated.

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	% Ele. Allo.	% Gas Allo.
BOC in Existing Buildings	3	63,142	1,877	$1,895	$0.00	$1,695	7.8	7.8	82%	18%
BOC in Multifamily	3	10,636	316	$1,895	$0.00	$1,695	1.2	1.2	80%	20%
BOC Electric-heat Existing Buildings	3	63,142	0	$1,895	$0.00	$1,695	6.4	6.4	100%	0%
BOC Gas-only in Existing Buildings	3	0	1,877	$1,895	$4,720.84	$1,695	1.4	9.1	0%	100%
BOC Electric-heat in Multifamily	3	18,046	0	$1,895	$0.00	$1,638	1.0	1.0	100%	0%
BOC Gas only in Multifamily	3	0	316	$1,895	$795.20	$413	1.0	1.5	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
BOC in Existing Buildings	3	63,142	1,877	$1,895	$4,861.93	$1,895	2.5	9.4
BOC in Multifamily	3	10,636	316	$1,895	$818.96	$809	1.0	1.6

Requirements
Participation Requirements
- Participant must operate a building where primary space heating fuel is provided by eligible utility
- Participants may not receive incentive and Energy Trust will not claim savings for both level 1 and level 2 certification within three years
- For Multifamily properties
  - Heating for dwelling units must be served by central system
  - Total square footage of building must be greater than 70,000 sq. ft.

Program Tracking Requirement
- Building square footage will be tracked
- Building primary heating system type will be tracked

Details
Total per-operator gas and electric savings are the product of savings percentage estimates, commercial gas and electric energy intensities, and an estimated average number of square feet served per operator. 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 in the population.

Baseline
This measure uses an existing condition baseline, in which a building operator did not receive BOC.

Savings and Measure Analysis
NEEA released the Building Operator Certificate Expansion Initiative Market Progress Evaluation Report (MPER) #3 on 8/24/15. NEEA's third Market Progress Evaluation Report characterizes BOC related energy savings as a percentage of total energy consumption. The 2014 Commercial Building Stock Assessment provides Energy Use Indices (EUI) data informing the percentage savings. MPER #3 estimated savings per operator increased based on 2014 CBSA data, which show that the total larger tier building population significantly increased by about 50%, while the smaller tier building population doubled. The change results in a considerable increase in both building operator population and the average square footage served per operator, certified or not. For non-certified building operators, the report recommends 432,768 sq. ft., but notes 286,000 sq. ft. as a conservative option. For non-BOC-credentialed operators, the report lists 77,721 sq. ft.

Energy Trust program data for BOC incentive recipients collected from 2016 – 2018 show an average square footage served equal to 183,861 sq. ft. Using program average is a more conservative estimate and is functionally equal to the average of 286,000 and 77,721 sq. ft reported by NEEA. This is a safe assumption compared to the report estimate of 12% penetration in OR and WA. Based on that 181,861 sq. ft. is used in commercial savings calculations.

The average regional commercial EUIs from MPER #3 are 15.5 kWh per year per square foot and 0.40 annual therms per square foot. Percentage savings are based on the difference in expected savings from a certified and non-certified operator, 2.24% of electric energy consumption and 2.58% of natural gas consumption from the third Market Progress and Evaluation Report (page 37). Therefore, per operator savings are 63,142 kWh per year and 1,877 annual therms in the Existing Buildings program.

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 EUI for the Multifamily and Commercial sectors was determined. The ratio of these two values was applied to the Existing Buildings savings to determine Multifamily specific savings:

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

The EUIs 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 regionally specific value. For Multifamily, the data was filtered on the following values:

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

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

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

The Multifamily program requires a BOC recipient is responsible for a building of at least 70,000 square feet. Multiplying the Existing Buildings EUIs by 44% yields Multifamily-specific electric and gas EUIs of 6.78 kWh/sq. ft. and 0.18 therms/sq. ft., respectively. These EUIs are multiplied by 70,000 square feet and by the savings percentages from MPER #3.

Resulting Multifamily-specific dual fuel savings are 10,636 kWh and 316 therms.

The CBSA electric EUI estimates include both electric only and dual fuel buildings, so it is likely that the combined EUI of electric and gas buildings is an overestimate of total energy use. For this reason, savings in electric-only buildings use the same EUI estimates as dual fuel buildings. This is likely an underestimate, but it was not feasible to estimate separate electric EUIs. Savings in electric-only multifamily buildings are the sum of initially projected electric savings, and therm savings converted into additional kWh savings using an 80% gas efficiency offset. Resulting multifamily-specific electric-only savings are 18,056 kWh. This conversion was done because otherwise the measure does not look cost effective when we have reason to believe it is. Justifications include the electric only EUI underestimate as well as the expectation that for Multifamily only the average square footage per BOC operator will be greater than the 70,000 square foot program minimum.

Comparison to RTF or other programs

This measure is not offered by RTF or other regional programs but is still tracked by NEEA. Programs are required to track BOC participant and associated savings and report them to NEEA to avoid regional double counting.

Measure Life

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

Cost

The full BOC training cost is currently $1,895 per level.

Non Energy Benefits

Non-energy benefits are claimed based on the electric savings realized for BOC certificants located in gas-only territory.

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 BOC certificant (Level 1 or 2). Note that maximum incentives are less for multifamily participants in gas-only territory.

Follow-Up

Measure should be updated in accordance with program data and any published NEEA BOC-E MPER results.

The multifamily EUI used in both gas and electric savings projections is based on CBECS and RECS data, since RBSA data lacks sufficient EUI data. The commercial EUI used in multifamily calculations is based on CBSA data, which accounts for the population of electric-only buildings in its approach. Multifamily electric-only savings are assumed to be conservative in this update, in that the program expects few electric-only buildings to apply for this incentive, and those that do are expected to be larger than 70,000 square feet and thus realize higher savings.

For the next update, this assumption should be revisited and adjusted using any regional building consumption data that supersedes that used in this 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\Whole Building and Controls\Builder Operator Certificate

137 Building Operator Certificatic

References

BOC-Expansion Initiative Market Progress Evaluation Report #3 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	137.1	Corrected CEC error
6/19/18	137.2	Added Multifamily
8/1/2019	137.3	Updated savings based on MPER #3 and 2016-2018 program data, updated incremental costs

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EnergyTrust of Oregon

Measure Approval Document for Condensing HVAC Boilers in Multifamily and Commercial Buildings

Valid Dates

1/1/2020 through 12/31/2022

End Use or Description

Gas-fired hot water condensing boilers for HVAC use.

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
- 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

The measures have been reanalyzed to align with code updates. In the anticipated 2019 OEESC (ASHRAE 90.1 2016), boilers under 300 kBtu/h will be required to have an AFUE of 82%, up from the 2014 OEESC requirement of 80%.

The unit of measure has been updated to an option for per square foot of area served by the boiler(s) in addition to per installed capacity (kBtu/h) in order to address evaluation concerns around oversized and back-up systems.

Costs and maximum incentives have been updated.

This MAD combines commercial and multifamily condensing boiler MADs 88 and 147.

Cost Effectiveness

Table 1 Cost Effectiveness Calculator Oregon

Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Maximum Incentive ($)	Utility BCR at Max Incentive	TRC BCR
Condensing Boiler – New Multifamily (per kBtu/h capacity)	35	(1.67)	1.499	$8.93	$8.93	2.5	2.5
Condensing Boiler - New Multifamily (per 100 SF)	35	(0.87)	0.770	$4.61	$4.61	2.5	2.5
Condensing Boiler – New Commercial (per kBtu/h capacity)	35	(1.03)	0.696	$8.93	$8.93	1.0	1.0
Condensing Boiler – New Commercial (per 100 SF)	35	(1.19)	0.737	$9.23	$9.23	1.0	1.0
Condensing Boiler - Existing Multifamily (per kBtu/h capacity)	35	(2.23)	2.215	$8.93	$8.93	3.7	3.7
Condensing Boiler - Existing Multifamily (per 100 SF)	35	(1.32)	1.288	$5.24	$5.24	3.7	3.7
Condensing Boiler - Existing Buildings (per kBtu/h capacity)	35	(1.33)	1.029	$8.93	$8.93	1.5	1.5
Condensing Boiler - Existing Buildings (per 100 SF)	35	(2.57)	1.839	$17.11	$17.11	1.4	1.4

Table 2 Cost Effectiveness Calculator Washington

Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Maximum Incentive ($)	Utility BCR at Max Incentive	TRC BCR
Condensing Boiler – New Multifamily (per kBtu/h capacity)	35	(1.59)	1.510	$8.93	$8.93	3.2	3.0
Condensing Boiler – New Multifamily (per 100 SF)	35	(0.71)	0.675	$3.98	$3.98	3.2	3.0
Condensing Boiler – New Commercial (per kBtu/h capacity)	35	(1.00)	0.724	$8.93	$8.93	1.6	1.5
Condensing Boiler – New Commercial (per 100 SF)	35	(0.94)	0.627	$7.35	$7.35	1.7	1.6
Condensing Boiler - Existing Multifamily (per kBtu/h capacity)	35	(2.12)	2.230	$8.93	$8.93	4.8	4.5
Condensing Boiler - Existing Multifamily (per 100 SF)	35	(1.06)	1.117	$4.47	$4.47	4.8	4.5
Condensing Boiler - Existing Buildings (per kBtu/h capacity)	35	(1.36)	1.031	$8.93	$8.93	2.3	2.2
Condensing Boiler - Existing Buildings (per 100 SF)	35	(2.37)	1.627	$15.54	$15.54	2.1	1.9

Requirements

- Minimum 94% efficiency (either AFUE or thermal efficiency)
- Per kBtu/h capacity measures must not include redundant, lagging or backup boilers
- For new construction projects, the load to be served by the efficient equipment must meet the 94% efficiency requirement. Back up equipment that isn't expected to be in regular service is NOT required to meet this efficiency requirement.
    - Verification of areas served by the boiler is required for the per-area-savings measures.
- Only boilers for HVAC uses qualify.

- Boilers used for DHW or pool heating do not qualify
- Boilers (aka “heat adders”) serving the water loops in water-source heat pump (WSHP) systems are not eligible for this measure.
- Boiler system must have design return temperature appropriate to condensing functionality.
- This measure may not be used in conjunction with the modulating boiler burner measure since this analysis assumes (but does not require) boilers are modulating.

Details

Past evaluations finding have found that back up and redundant boilers have been included in participating projects. This issue has been addressed for New Buildings by changing the unit of measure to be per square foot served by the boiler (rounded to 100 sf increments to accommodate limits on thousandths place digits per Therm savings values in databases). By normalizing to served building square footage and utilizing it as the unit basis for the measure, New Buildings is claiming savings on the buildings expected load rather than the installed capacity, which often includes back-up units. Existing Buildings, Existing Multifamily and Production Efficiency must ensure their program design and program material prevent back up, lagging and redundant boilers from participating or use the per square foot unitization.

Baseline

This measure uses a Code Baseline.

Energy Trust assumes that typical installations in new and existing buildings would be code minimum efficiency with modulating burners.

Code efficiency requirements vary by boiler capacity as shown in Table 3. Boiler projects in New Buildings and Existing Buildings were used to determine occurrence in the each of the size categories <300 kBtu/h, 300-2,500 kBtu/h, and >2,500 kBtu/h. A weighted average was used to arrive at the “blended” baseline 80.2% efficiency used in the energy use analysis.

Table 3 Boiler Size Occurrence for Past Projects

Size Category	Code Efficiency	% of total projects
<300 kBtu/h	82%	8%
300-2,500 kBtu/h	80%	81%
>2,500 kBtu/h	80%	10%
Weighted Average	**80.2%**	

Measure Analysis

For the New Construction measures hourly heating load output was extracted from DOE prototype models (ASHRAE 90.1-2016)[1] for the following available building types: High-rise Apartment, Mid-rise Apartment, Hospital, Large Hotel, Small Hotel, Large Office, Medium Office, Small Office, Quick Service Restaurant, Full Service Restaurant, Stand-alone Retail, Strip Mall, Primary School, Secondary School, and Warehouse. For replacement measures hourly heating load output was extracted from the ASHRAE 90.1-2004 DOE prototype models[2], using the High-rise and Mid-rise Apartment building types for Existing Multifamily and the Hospital, Large Hotel, Small Hotel, Large Office, Medium Office, Quick Service Restaurant, Full Service Restaurant, Stand-alone Retail, Strip Mall, Primary School, Secondary School, and Warehouse building types for Existing Buildings. Industrial sites were not analyzed due to low expected volume, but Production Efficiency may use the measures designed for Existing Buildings. Each of these models was simulated with weather data for three climate zones (Portland, Redmond, and Astoria).

Hourly heating load output represents the heating load to be produced by the boiler plant. An 8,760 spreadsheet analysis was developed where this hourly load data served as the input to performance curves for both a standard (90.1-2016 equivalent) boiler and a high-efficiency condensing boiler. Curve output at each hour was used to determine boiler input power for a standard boiler and a high-efficiency boiler. Savings is the difference in summed input power of the standard boiler minus the high-efficiency boiler, and then normalized (by either kBtu/h capacity or square feet). Other inputs to the curve include part load ratio and return water temperatures. A weighted average of building and regional participants was used to determine a single commercial value. Both baseline and efficient boilers are assumed to have modulating burners.

Savings

Savings were calculated for each building type. Then a weighted average was calculated based on building type weightings shown in Table 4 and project location weightings shown in Table 5 (derived from historical program participation).

Table 4 Building Type Weightings

Building Type	Weighting Value
Hospital	2.21%
Hotel	2.76%
Office	33.70%
Restaurant	0.83%
Retail	1.10%
School	57.18%
Warehouse	2.21%

Table 5 Location Weightings

Climate Zone	Weighting Value
Portland*	65.0%
Redmond	31.0%
Astoria	4.0%

*Washington savings are for the Portland zone only

Negative kWh savings are generated due to the presence of a combustion fan in condensing boilers and no fan in the baseline, non-condensing boilers. Negative electric savings are included in cost effectiveness testing, but do not subtract from annual savings achievements.

Measure Life

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

[1] U.S. Department of Energy. (2018, October 24). 90.1-2016 Commercial Prototype Building Models. Retrieved from https://www.energycodes.gov/development/commercial/prototype_models.
[2] U.S. Department of Energy. (2018, October 24). 90.1-2004 Commercial Prototype Building Models. Retrieved from https://www.energycodes.gov/development/commercial/prototype_models.

Cost

Several information sources were investigated including RSMeans Online, internet searches, federal cost information, California's Database for Energy Efficient Resources (DEER), and Energy Trust Existing Buildings boiler project cost records. Ultimately, incremental costs used in this measure come from the three following sources:

1) Final Rule: Energy Conservation Standards for Commercial Packaged Boilers. (Final Rule),[3]
2) The Technical Support Document (TSD)[4] to the Final Rule, and
3) an internet search of several distributor/retail websites.

Boiler costs in the <300 kBtu/h and 300-2,500 kBtu/h ranges were determined by performing internet searches of several online retail and distributor websites. Cost data on larger units was not available online. A total of 28 prices were found for units ranging from 55-850 kBtu/h. Incremental cost per kBtu/h input for boilers with capacity of <300 kBtu/h is $13.58 while that for boilers in the capacity range of 300-2,500 kBtu/h is $8.00.

Cost data for boilers >2,500 kBtu/h was found in the Final Rule and TSD. Table IV.5 in the Final Rule explicitly lists Manufacturer Selling Prices (MSP) for baseline equipment as well as incremental prices for several efficiencies above the baseline. In the TSD, MSP is not the cost seen by the final customer. Markup factors (specified by State) must be applied to MSP values to determine final customer costs; the factors are explained in Chapter 6 of the TSD. To calculate the incremental cost for the purposes of testing cost effectiveness, the Table IV.5 incremental MSP of $31,917 for a 94% efficient, 3,000 kBtu/h unit has been adjusted by a markup of 1.163 (OR) and 1.62 (WA). This results in per-kBtu/h incremental costs of $13.66 and $13.64, for Oregon and Washington, respectively.

Incremental costs were normalized to $/kBtu/h for each of three boiler size classes: <300 kBtu/h, 300-2,500 kBtu/h, and >2,500 kBtu/h. These were then combined into a weighted average incremental cost for all boilers using the same weights as were used for the blended baseline efficiency.

Table 6 Weighting incremental costs

Boiler size class	% of total projects	Source	Oregon		Washington	
			IC/kBtu/h	**weighted IC**	**IC/kBtu/h**	**weighted IC**
<300 kBtu/h	8%	Internet costs, 2019	$13.58	$1.09	$13.58	$1.09
300-2500 kBtu/h	81%	Internet costs, 2019	$8.00	$6.48	$8.00	$6.48
>2,500 kBtu/h	10%	TSD, table IV.5	$13.66	$1.37	$13.64	$1.36
Weighted Average				**$8.93**		**$8.93**

To determine incremental cost in $/sqft, boiler capacity per modeled building area for each building type and climate zone model combination was calculated. The average of those values was then multiplied by the final $/kBtu/h incremental costs. The result is an incremental cost in $/sqft normalized to the modeled boiler capacities and building areas.

Incentive Structure

The maximum incentives listed in Table 1 *and Table 2 are for reference only and are not suggested incentives.*

Incentives may be structured per square feet of conditioned floor space or per kBtu/h capacity of the boiler equipment. Programs that use per kBtu/h measures must maintain requirements preventing back up or lagging boilers from participation.

SRAF

Negative savings for electricity are listed as SRAF components.

Follow-Up

Current indications are that Oregon will be adopting ASHRAE 90.1 2019 in October of 2020. A review of the new code will be required to determine if another update to the condensing boiler measures will be warranted for projects approved under the 2020 code.

There is a concern that code may not be the most appropriate baseline for this measure and that it is more suitable to a market baseline. Programs have committed to market assessment research with results incorporated into the next update. This should include market baseline efficiencies and prevalence of modulating burners in new boilers.

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\boilers\Condensing hot water boiler

Boilers OR-WA-CE Calculator-2020-v1.2 | Summary_Existing.xlsx | Summary_New Construction.xlsx

Version History and Related Measures

Energy Trust has been offering boiler measures for many years. These measures predate our measure approval documentation process and record retention schedules. Table 7**Error! Reference source not found.** may be incomplete, particularly for measures approved prior to 2013.

[3] Office of Energy Efficiency and Renewable Energy, Department of Energy (12/28/2016). Energy Conservation Standards for Commercial Packaged Boilers; Final Rule. https://www.energy.gov/eere/buildings/downloads/issuance-2016-12-28-energy-conservation-program-energy-conservation-1.

[4] Office of Energy Efficiency and Renewable Energy, Department of Energy (12/9/2016). Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Commercial Packaged Boilers. https://www.regulations.gov/document?D=EERE-2013-BT-STD-0030-0083.

Table 7 Version History

Date	Version	Reason for revision
12/23/2003	88.x	Hot water boilers approved for commercial and multifamily applications.
10/30/2008	88.x	Multifamily boilers removed from MAD 88 due to differing loads.
6/23/2009	88.x	All new savings calculations. Base savings and incentive on boiler capacity. Recombine multifamily and commercial boilers into MAD 88.
6/9/2014	88.x	Add maximum incentives.
2/11/2015	88.x	Add Production Efficiency.
8/26/2015	88.1	Commercial Boilers separated from Multifamily. New commercial analysis based on building modeling and 94% efficiency requirement.
10/06/2015	147.1	Multifamily boilers separated from other commercial boilers. New analysis based on building modeling and 94% efficiency requirement. Measure life increased to 35 years.
4/01/2017	147.2	Add Washington to Multifamily. Clarifies requirements for larger sizes.
6/30/2019	88.2	Recombine multifamily and commercial boilers into a single MAD. MAD 147 will be retired. Separates new and existing buildings into separate measures. Updated baseline for 2019 code update, updated cost. Unitized to sqft.

Table 8 Related Measures

Measures	MAD ID
Modulating boiler burners and controls	142
Process hot water boiler calculator tool	226
Commercial condensing tankless water heaters	72
Pool Heaters	238

Approved & Reviewed by

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Disclaimer

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Measure Approval Document for Commercial Insulation

Valid Dates
1/1/2020 – 12/31/2022

End Use or Description
This document describes electricity and gas savings resulting from the installation of below-deck insulation on flat roofs where there was none previously, or where only a small amount of insulation was present, and cavity insulation in attic and walls where there was none previously. Consideration of cases involving damaged or missing roof insulation are also included, since commercial roof insulation upgrades are often considered at the same time as roof repairs or replacements.

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
- Production Efficiency

Purpose of Re-Evaluating Measure
This measure is reevaluated to align savings and cost estimates with 2020 Oregon Energy Efficiency Specialty Code (OEESC) requirements, industry current best practices, and applicability to relevant market segments and customer types.

The update for version 68.2 differentiates savings by heating and cooling zone, changes insulation requirements and clarifies use in single-fuel territories.

Version 68.3 corrects copy/paste errors in Tables 1-3 the led to mismatches between measure descriptions and their properties. No changes to the CEC.

Requirements
- Damaged or missing insulation claimed as providing no insulating value (R-0) for purposes of claiming the 'no existing insulation' baseline condition must be prequalified and documented by the installation contractor.
- Walls existing condition must contain no insulation. Existing partially insulated walls are not eligible for incentives under this prescriptive offering.
- Customers in heating zone 3 can use the measures designed for heating zone 2.
- Customers in cooling zone 3 may use the measures designed for cooling zone 2.
- If cooling zone is unknown, use measures designed for cooling zone 1 which represent that majority of Energy Trust's customers.
- In heating zone 1, gas-only customers are no eligible for Roof Insulation - R5 or less to R15. These customers must insulate to R30.
- Customers in electric-only territory with propane or other heat fuels may use the electric-only measures listed Table 4.
- Washington customers must have gas heat.
- The following is required to be submitted for incentives:
  - Invoices
  - Insulation R-value specifications
  - Primary heating system and fuel
  - Building Type

Cost Effectiveness
Cost effectiveness is demonstrated in Table 1 through Table 5. Table 1 includes buildings that use electric as the primary heat source, either electric resistance or heat pump. These measures must be in a participating electric utility. Table 2 includes gas-heated buildings in Energy Trust's dual-fuel territory. Table 3 includes gas-heated buildings in Energy Trust's gas-only territory. Table 4 includes buildings with gas or other heat in Energy Trust's electric-only territory. These are expected to be rare and would include customers on non-qualified gas rate schedules, transport gas customers or customers that heat with propane. Table 5 includes buildings that heat with gas in Washington, which is gas-only territory.

Table 1 Cost Effectiveness Calculator Oregon – Electric heat

#	Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max	TRC BCR	% Elec	% Gas
4	HZ1, CZ1 - Roof Insulation - R5 or less to R15 - heat pump	25	1.99		$2.05		$2.05	1.3	1.3	100%	0%
5	HZ1, CZ2 - Roof Insulation - R5 or less to R15 - heat pump	25	2.08		$2.05		$2.05	1.4	1.4	100%	0%
6	HZ2, CZ1 - Roof Insulation - R5 or less to R15 - heat pump	25	2.75		$2.05		$2.05	2.4	2.4	100%	0%
7	HZ1, CZ1 - Roof Insulation - R5 or less to R15 - elec resistance	25	3.43		$2.05		$2.05	3.0	3.0	100%	0%
8	HZ1, CZ2 - Roof Insulation - R5 or less to R15 - elec resistance	25	3.53		$2.05		$2.05	3.0	3.0	100%	0%
9	HZ2, CZ1 - Roof Insulation - R5 or less to R15 - elec resistance	25	5.16		$2.05		$2.05	4.4	4.4	100%	0%
13	HZ1, CZ1 - Roof Insulation - R5 or less to R30 - heat pump	25	2.47		$2.05		$2.05	1.7	1.7	100%	0%
14	HZ1, CZ2 - Roof Insulation - R5 or less to R30 - heat pump	25	2.59		$2.05		$2.05	1.7	1.7	100%	0%
15	HZ2, CZ1 - Roof Insulation - R5 or less to R30 - heat pump	25	3.52		$2.05		$2.05	3.0	3.0	100%	0%
16	HZ1, CZ1 - Roof Insulation - R5 or less to R30 - elec resistance	25	4.27		$2.05		$2.05	3.7	3.7	100%	0%
17	HZ1, CZ2 - Roof Insulation - R5 or less to R30 - elec resistance	25	4.39		$2.05		$2.05	3.8	3.8	100%	0%
18	HZ2, CZ1 - Roof Insulation - R5 or less to R30 - elec resistance	25	6.66		$2.05		$2.05	5.7	5.7	100%	0%
22	HZ1, CZ1 - Roof Insulation - R0 to R15 - heat pump	25	11.73		$2.05		$2.05	7.9	7.9	100%	0%
23	HZ1, CZ2 - Roof Insulation - R0 to R15 - heat pump	25	12.28		$2.05		$2.05	8.2	8.2	100%	0%
24	HZ2, CZ1 - Roof Insulation - R0 to R15 - heat pump	25	15.45		$2.05		$2.05	13.3	13.3	100%	0%
25	HZ1, CZ1 - Roof Insulation - R0 to R15 - elec resistance	25	20.48		$2.05		$2.05	17.6	17.6	100%	0%
26	HZ1, CZ2 - Roof Insulation - R0 to R15 - elec resistance	25	21.03		$2.05		$2.05	18.1	18.1	100%	0%
27	HZ2, CZ1 - Roof Insulation - R0 to R15 - elec resistance	25	28.87		$2.05		$2.05	24.8	24.8	100%	0%
31	HZ1, CZ1 - Roof Insulation - R0 to R30 - heat pump	25	13.46		$2.05		$2.05	9.0	9.0	100%	0%
32	HZ1, CZ2 - Roof Insulation - R0 to R30 - heat pump	25	14.05		$2.05		$2.05	9.4	9.4	100%	0%
33	HZ2, CZ1 - Roof Insulation - R0 to R30 - heat pump	25	17.55		$2.05		$2.05	15.1	15.1	100%	0%
34	HZ1, CZ1 - Roof Insulation - R0 to R30 - elec resistance	25	23.93		$2.05		$2.05	20.6	20.6	100%	0%
35	HZ1, CZ2 - Roof Insulation - R0 to R30 - elec resistance	25	24.51		$2.05		$2.05	21.1	21.1	100%	0%
36	HZ2, CZ1 - Roof Insulation - R0 to R30 - elec resistance	25	33.15		$2.05		$2.05	28.5	28.5	100%	0%
40	HZ1, CZ1 - Attic Insulation - R0 to R25 - heat pump	30	5.00		$0.95		$0.95	8.1	8.1	100%	0%
41	HZ1, CZ2 - Attic Insulation - R0 to R25 - heat pump	30	5.20		$0.95		$0.95	8.5	8.5	100%	0%
42	HZ2, CZ1 - Attic Insulation - R0 to R25 - heat pump	30	6.81		$0.95		$0.95	14.1	14.1	100%	0%
43	HZ1, CZ1 - Attic Insulation - R0 to R25 - elec resistance	30	7.83		$0.95		$0.95	16.3	16.3	100%	0%
44	HZ1, CZ2 - Attic Insulation - R0 to R25 - elec resistance	30	8.04		$0.95		$0.95	16.7	16.7	100%	0%
45	HZ2, CZ1 - Attic Insulation - R0 to R25 - elec resistance	30	11.91		$0.95		$0.95	24.7	24.7	100%	0%
49	HZ1, CZ1 - Wall Insulation - R0 to R20 - heat pump	30	5.61		$1.38		$1.38	6.3	6.3	100%	0%
50	HZ1, CZ2 - Wall Insulation - R0 to R20 - heat pump	30	5.80		$1.38		$1.38	6.5	6.5	100%	0%
51	HZ2, CZ1 - Wall Insulation - R0 to R20 - heat pump	30	7.64		$1.38		$1.38	11.0	11.0	100%	0%
52	HZ1, CZ1 - Wall Insulation - R0 to R20 - elec resistance	30	9.45		$1.38		$1.38	13.5	13.5	100%	0%
53	HZ1, CZ2 - Wall Insulation - R0 to R20 - elec resistance	30	9.63		$1.38		$1.38	13.8	13.8	100%	0%
54	HZ2, CZ1 - Wall Insulation - R0 to R20 - elec resistance	30	14.03		$1.38		$1.38	20.1	20.1	100%	0%

Table 2 Cost Effectiveness Calculator - Gas Heat in dual fuel territory

#	Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max	TRC BCR	% Elec	% Gas
1	HZ1, CZ1 - Roof Insulation - R5 or less to R15 - gas heat	25	0.84	0.07	$2.05		$2.05	1.2	1.2	62%	38%
2	HZ1, CZ2 - Roof Insulation - R5 or less to R15 - gas heat	25	0.93	0.07	$2.05		$2.05	1.2	1.2	64%	36%
3	HZ2, CZ1 - Roof Insulation - R5 or less to R15 - gas heat	25	0.84	0.12	$2.05		$2.05	1.4	1.4	50%	50%
10	HZ1, CZ1 - Roof Insulation - R5 or less to R30 - gas heat	25	1.03	0.09	$2.05		$2.05	1.4	1.4	62%	38%
11	HZ1, CZ2 - Roof Insulation - R5 or less to R30 - gas heat	25	1.15	0.09	$2.05		$2.05	1.5	1.5	64%	36%
12	HZ2, CZ1 - Roof Insulation - R5 or less to R30 - gas heat	25	1.03	0.15	$2.05		$2.05	1.8	1.8	48%	52%
19	HZ1, CZ1 - Roof Insulation - R0 to R15 - gas heat	25	4.76	0.43	$2.05		$2.05	6.7	6.7	61%	39%
20	HZ1, CZ2 - Roof Insulation - R0 to R15 - gas heat	25	5.32	0.43	$2.05		$2.05	7.2	7.2	63%	37%
21	HZ2, CZ1 - Roof Insulation - R0 to R15 - gas heat	25	4.76	0.66	$2.05		$2.05	8.2	8.2	50%	50%
28	HZ1, CZ1 - Roof Insulation - R0 to R30 - gas heat	25	5.14	0.51	$2.05		$2.05	7.6	7.6	58%	42%
29	HZ1, CZ2 - Roof Insulation - R0 to R30 - gas heat	25	5.72	0.51	$2.05		$2.05	8.1	8.1	61%	39%
30	HZ2, CZ1 - Roof Insulation - R0 to R30 - gas heat	25	5.14	0.76	$2.05		$2.05	9.1	9.1	48%	52%
37	HZ1, CZ1 - Attic Insulation - R0 to R25 - gas heat	30	2.74	0.14	$0.95		$0.95	7.8	7.8	73%	27%
38	HZ1, CZ2 - Attic Insulation - R0 to R25 - gas heat	30	2.95	0.14	$0.95		$0.95	8.2	8.2	74%	26%
39	HZ2, CZ1 - Attic Insulation - R0 to R25 - gas heat	30	2.74	0.25	$0.95		$0.95	9.5	9.5	60%	40%
46	HZ1, CZ1 - Wall Insulation - R0 to R20 - gas heat	30	2.56	0.19	$1.38		$1.38	5.6	5.6	65%	35%
47	HZ1, CZ2 - Wall Insulation - R0 to R20 - gas heat	30	2.74	0.19	$1.38		$1.38	5.9	5.9	67%	33%
48	HZ2, CZ1 - Wall Insulation - R0 to R20 - gas heat	30	2.56	0.31	$1.38		$1.38	6.9	6.9	53%	47%

Table 3 Cost Effectiveness Calculator Oregon – Gas heat in Gas Only Territory

#	Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max	TRC BCR	% Elec	% Gas
59	HZ2, CZ1 - Roof Insulation - R5 or less to R15 - gas heat - gas only	25		0.12	$2.05	$0.06	$1.49	1.0	1.2	0%	100%
60	HZ1, CZ1 - Roof Insulation - R5 or less to R30 - gas heat - gas only	25		0.09	$2.05	$0.08	$1.12	1.0	1.1	0%	100%
61	HZ1, CZ2 - Roof Insulation - R5 or less to R30 - gas heat - gas only	25		0.09	$2.05	$0.09	$1.12	1.0	1.2	0%	100%
62	HZ2, CZ1 - Roof Insulation - R5 or less to R30 - gas heat - gas only	25		0.15	$2.05	$0.08	$1.95	1.0	1.5	0%	100%
63	HZ1, CZ1 - Roof Insulation - R0 to R15 - gas heat - gas only	25		0.43	$2.05	$0.36	$2.05	2.7	5.2	0%	100%
64	HZ1, CZ2 - Roof Insulation - R0 to R15 - gas heat - gas only	25		0.43	$2.05	$0.40	$2.05	2.7	5.5	0%	100%
65	HZ2, CZ1 - Roof Insulation - R0 to R15 - gas heat - gas only	25		0.66	$2.05	$0.36	$2.05	4.1	6.7	0%	100%
66	HZ1, CZ1 - Roof Insulation - R0 to R30 - gas heat - gas only	25		0.51	$2.05	$0.38	$2.05	3.2	6.0	0%	100%
67	HZ1, CZ2 - Roof Insulation - R0 to R30 - gas heat - gas only	25		0.51	$2.05	$0.43	$2.05	3.2	6.3	0%	100%
68	HZ2, CZ1 - Roof Insulation - R0 to R30 - gas heat - gas only	25		0.76	$2.05	$0.38	$2.05	4.7	7.5	0%	100%
69	HZ1, CZ1 - Attic Insulation - R0 to R25 - gas heat - gas only	30		0.14	$0.95	$0.20	$0.95	2.1	5.6	0%	100%
70	HZ1, CZ2 - Attic Insulation - R0 to R25 - gas heat - gas only	30		0.14	$0.95	$0.22	$0.95	2.1	5.9	0%	100%
71	HZ2, CZ1 - Attic Insulation - R0 to R25 - gas heat - gas only	30		0.25	$0.95	$0.20	$0.95	3.8	7.3	0%	100%
72	HZ1, CZ1 - Wall Insulation - R0 to R20 - gas heat - gas only	30		0.19	$1.38	$0.19	$1.38	2.0	4.2	0%	100%
73	HZ1, CZ2 - Wall Insulation - R0 to R20 - gas heat - gas only	30		0.19	$1.38	$0.21	$1.38	2.0	4.4	0%	100%
74	HZ2, CZ1 - Wall Insulation - R0 to R20 - gas heat - gas only	30		0.31	$1.38	$0.19	$1.38	3.3	5.5	0%	100%

Table 4 Cost Effectiveness Calculator Oregon – Gas or other heating fuels in Electric Only Territory

#	Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max	TRC BCR	% Elec	% Gas
77	HZ1, CZ1 - Roof Insulation - R5 or less to R15 - gas heat - elec only	25	0.84		$2.05	$0.05	$1.47	1.0	1.1	100%	0%
78	HZ1, CZ2 - Roof Insulation - R5 or less to R15 - gas heat - elec only	25	0.93		$2.05	$0.05	$1.63	1.0	1.2	100%	0%
79	HZ2, CZ1 - Roof Insulation - R5 or less to R15 - gas heat - elec only	25	0.84		$2.05	$0.09	$1.47	1.0	1.4	100%	0%
86	HZ1, CZ1 - Roof Insulation - R5 or less to R30 - gas heat - elec only	25	1.03		$2.05	$0.07	$1.81	1.0	1.4	100%	0%
87	HZ1, CZ2 - Roof Insulation - R5 or less to R30 - gas heat - elec only	25	1.15		$2.05	$0.07	$2.02	1.0	1.5	100%	0%
88	HZ2, CZ1 - Roof Insulation - R5 or less to R30 - gas heat - elec only	25	1.03		$2.05	$0.12	$1.81	1.0	1.7	100%	0%
95	HZ1, CZ1 - Roof Insulation - R0 to R15 - gas heat - elec only	25	4.76		$2.05	$0.32	$2.05	4.1	6.4	100%	0%
96	HZ1, CZ2 - Roof Insulation - R0 to R15 - gas heat - elec only	25	5.32		$2.05	$0.32	$2.05	4.6	6.9	100%	0%
97	HZ2, CZ1 - Roof Insulation - R0 to R15 - gas heat - elec only	25	4.76		$2.05	$0.50	$2.05	4.1	7.7	100%	0%
104	HZ1, CZ1 - Roof Insulation - R0 to R30 - gas heat - elec only	25	5.14		$2.05	$0.39	$2.05	4.4	7.2	100%	0%
105	HZ1, CZ2 - Roof Insulation - R0 to R30 - gas heat - elec only	25	5.72		$2.05	$0.39	$2.05	4.9	7.7	100%	0%
106	HZ2, CZ1 - Roof Insulation - R0 to R30 - gas heat - elec only	25	5.14		$2.05	$0.58	$2.05	4.4	8.6	100%	0%
113	HZ1, CZ1 - Attic Insulation - R0 to R25 - gas heat - elec only	30	2.74		$0.95	$0.10	$0.95	5.7	7.5	100%	0%
114	HZ1, CZ2 - Attic Insulation - R0 to R25 - gas heat - elec only	30	2.95		$0.95	$0.10	$0.95	6.1	7.9	100%	0%
115	HZ2, CZ1 - Attic Insulation - R0 to R25 - gas heat - elec only	30	2.74		$0.95	$0.19	$0.95	5.7	8.9	100%	0%
122	HZ1, CZ1 - Wall Insulation - R0 to R20 - gas heat - elec only	30	2.56		$1.38	$0.14	$1.38	3.7	5.3	100%	0%
123	HZ1, CZ2 - Wall Insulation - R0 to R20 - gas heat - elec only	30	2.74		$1.38	$0.14	$1.38	3.9	5.6	100%	0%
124	HZ2, CZ1 - Wall Insulation - R0 to R20 - gas heat - elec only	30	2.56		$1.38	$0.24	$1.38	3.7	6.5	100%	0%

Table 5 Cost Effectiveness Calculator Washington – Gas heat only

#	Measure	Measure Life (years)	Not claimed Savings (kWh)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max	TRC BCR
1	HZ1, CZ1 - Roof Insulation - R5 or less to R15 - gas heat	25	0.84	0.07	$2.05	$0.06	$1.21	1.0	1.0
2	HZ1, CZ2 - Roof Insulation - R5 or less to R15 - gas heat	25	0.93	0.07	$2.05	$0.07	$1.21	1.0	1.1
3	HZ2, CZ1 - Roof Insulation - R5 or less to R15 - gas heat	25	0.84	0.12	$2.05	$0.06	$2.01	1.0	1.4
4	HZ1, CZ1 - Roof Insulation - R5 or less to R30 - gas heat	25	1.03	0.09	$2.05	$0.08	$1.50	1.0	1.2
5	HZ1, CZ2 - Roof Insulation - R5 or less to R30 - gas heat	25	1.15	0.09	$2.05	$0.09	$1.50	1.0	1.3
6	HZ2, CZ1 - Roof Insulation - R5 or less to R30 - gas heat	25	1.03	0.15	$2.05	$0.08	$2.05	1.3	1.8
7	HZ1, CZ1 - Roof Insulation - R0 to R15 - gas heat	25	4.76	0.43	$2.05	$0.37	$2.05	3.6	5.9
8	HZ1, CZ2 - Roof Insulation - R0 to R15 - gas heat	25	5.32	0.43	$2.05	$0.41	$2.05	3.6	6.2
9	HZ2, CZ1 - Roof Insulation - R0 to R15 - gas heat	25	4.76	0.66	$2.05	$0.37	$2.05	5.5	7.8
10	HZ1, CZ1 - Roof Insulation - R0 to R30 - gas heat	25	5.14	0.51	$2.05	$0.40	$2.05	4.3	6.8
11	HZ1, CZ2 - Roof Insulation - R0 to R30 - gas heat	25	5.72	0.51	$2.05	$0.44	$2.05	4.3	7.1
12	HZ2, CZ1 - Roof Insulation - R0 to R30 - gas heat	25	5.14	0.76	$2.05	$0.40	$2.05	6.4	8.9
13	HZ1, CZ1 - Attic Insulation - R0 to R25 - gas heat	30	2.74	0.14	$0.95	$0.21	$0.95	2.7	5.9
14	HZ1, CZ2 - Attic Insulation - R0 to R25 - gas heat	30	2.95	0.14	$0.95	$0.23	$0.95	2.7	6.2
15	HZ2, CZ1 - Attic Insulation - R0 to R25 - gas heat	30	2.74	0.25	$0.95	$0.21	$0.95	5.0	8.1
16	HZ1, CZ1 - Wall Insulation - R0 to R20 - gas heat	30	2.56	0.18	$1.38	$0.20	$1.38	2.4	4.5
17	HZ1, CZ2 - Wall Insulation - R0 to R20 - gas heat	30	2.74	0.18	$1.38	$0.21	$1.38	2.4	4.6
18	HZ2, CZ1 - Wall Insulation - R0 to R20 - gas heat	30	2.56	0.31	$1.38	$0.20	$1.38	4.3	6.3

Baseline

This measure uses an existing condition baseline.

The baseline conditions for these measures are the result of consideration of Existing Buildings program data collected between 2011 – 2019 for roof, attic, and wall insulation projects across Oregon and SW Washington. For example, many flat roof insulation projects involve an assessment of the existing insulation, which may reveal insulation that is damaged, missing, or made from a material no longer used. In addition, commercial attic spaces are often uninsulated. These cases fall into one of three categories:

1) The existing insulation is effective, but barely. When originally installed, the insulation was effective, but is now compressed or damaged resulting in effectiveness of R-5 or less.
2) The insulation is compressed or damaged and not effective; essentially R-0
3) There is no existing insulation; R-0

Savings and Measure Analysis

Projected annual savings are the result of whole building simulations performed using EnergyPlus v8.8.0. Simulations were performed using DOE models constructed to represent existing commercial reference buildings constructed in or after 1980[i]. 15 building types were simulated with varying insulation R-values to reflect progress toward code level insulation of commercial roofs, attics, and walls; see Figure 1. Models were simulated using TMY3 weather files in seven cities across Oregon. Locations include: Baker City, Medford, North Bend, Pendleton, Portland, Redmond, and Salem.

Table 5.5-4 *Building Envelope* Requirements for Climate Zone 4 (A,B,C)*

Opaque Elements	*Nonresidential*		*Residential*		*Semiheated*	
	Assembly Maximum	Insulation Min. *R-Value*	Assembly Maximum	Insulation Min. *R-Value*	Assembly Maximum	Insulation Min. *R-Value*
Roofs						
Insulation entirely above deck	U-0.032	R-30 c.i.	U-0.032	R-30 c.i.	U-0.093	R-10 c.i.
Metal building[a]	U-0.037	R-19 + R-11 *Ls* or R-25 + R-8 *Ls*	U-0.037	R-19 + R-11 *Ls* or R-25 + R-8 *Ls*	U-0.082	R-19
Attic and other	U-0.021	R-49	U-0.021	R-49	U-0.034	R-30
Walls, above Grade						
Mass	U-0.104	R-9.5 c.i.	U-0.090	R-11.4 c.i.	U-0.580	NR
Metal building	U-0.060	R-0 + R-15.8 c.i.	U-0.050	R-0 + R-19 c.i.	U-0.162	R-13
Steel-framed	U-0.064	R-13 + R-7.5 c.i.	U-0.064	R-13 + R-7.5 c.i	U-0.124	R-13
Wood-framed and other	U-0.064	R-13 + R-3.8 c.i. or R-20	U-0.064	R-13 + R-3.8 c.i. or R-20	U-0.089	R-13
Wall, below Grade						
Below-grade wall	C-0.119	R-7.5 c.i.	C-0.092	R-10 c.i.	C-1.140	NR

* The following definitions apply: c.i. = *continuous insulation* (see Section 3.2), FC = filled cavity (see Section A2.3.2.5), *Ls* = *liner system* (see Section A2.3.2.4), NR = no (insulation) requirement.

Figure 1 ASHRAE 90.1 - 2016 Building Envelope Requirements

Table 6 lists the reference building models and associated measures they are expected and were used to quantify savings for. There are not restrictions on which building types may use any of the measures.

Table 6 Reference Models and Associated Measures

Building Type	Floor Area (ft^2)	Roof	Attic	Wall
Full Service Restaurant	5,500		x	x
Hospital	241,351	x		
Large Hotel	122,120	x		x
Large Office	498,588	x		x
Medium Office	53,628	x		x
Primary School	73,960	x		x
Quick Service Restaurant	2,500		x	x
Secondary School	210,887	x		x
Small Hotel	43,200		x	
Small Office	5,500		x	
Stand-alone Retail	24,962	x		x
Strip Mall	22,500	x		x
Supermarket	45,000	x		x
Warehouse	52,045	x		x

Savings were grouped by city according to RTF climate zones to determine average annual savings estimates for heating and cooling zones 1 and 2; see Table 7. The resulting savings include values for the following groups:

- Heating Zone 1; Cooling Zone 1
- Heating Zone 1; Cooling Zone 2
- Heating Zone 2; Cooling Zone 1

Table 7 RTF Heating and Cooling Zones by City

City	Heating Zone	Cooling Zone
Baker City	2	1
Medford	1	2
North Bend	1	1
Pendleton	1	2
Portland	1	1
Redmond	2	1
Salem	1	1

For electrically heated buildings, projected gas savings were converted to electric savings to represent both heat pump and electric resistance primary heating systems. For electric resistance heating, gas savings in therms per square foot were converted directly to kWh savings per square foot. For electrically heated buildings using heat pumps, therm savings per square foot were converted to kWh saving per square foot using air-source heat pump HSPF of 7.7, sourced from the RTF standard information workbook v4.1[ii].

Measure Life

Insulation measure life will follow per SB1149 measure life guidelines[iii]

- Roof insulation will use 25 years
- Attic insulation will use 30 years
- Wall insulation will use 30 years

Cost

Historical project costs gathered during program years 2014 – 2018 were used to update retrofit costs per square foot of insulation area for roofs, attics, and walls.

Non Energy Benefits

Out of territory energy savings are included as non-energy benefits using Energy Trust's blended commercial rates. Propane savings are assumed to be equivalent to out of territory gas NEBs.

Incentive Structure

The maximum incentives listed in Tables 1 through 5 are for reference only and are not suggested incentives. Incentives will be structured per square foot of insulation.

SRAF

Existing Buildings program SRAFs apply to this measure.

Follow-Up

Recent Oregon Energy Efficiency Specialty Code (OEESC) changes align non-residential envelope requirements with ASHRAE 90.1. For 2020, requirements align with 90.1-2016. For 2021, OEESC will align with 90.1-2019. Changes to envelope requirements are not expected in 90.1-2019. This measure is for the retrofit of existing buildings which are not required to meet code envelope requirements. However, this measure intends to incentivize customer progress toward code required insulation. Based on that, we recommend updating this measure to include appropriate incremental improvements as progress toward code level insulation, as requirements change.

If differentiation by heating and cooling zones becomes burdensome, a revision will be needed to blend the measures.

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 Weatherization\insulation

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Version History and Related Measures

Energy Trust has been offering commercial insulation measures for many years. These predate our measure approval documentation and record retention policies. Table 8 may be incomplete, particularly for measures approved prior to 2012.

Table 8 Version History

Date	Version	Reason for revision
2003	x	Introduce commercial insulation measures for gas heated buildings
9/24/08	x	Add measures for electric heated buildings
4/4/12	68.x	Update savings and costs for Wall, Attic and Roof insulation.
9/9/14	68.x	Add measures for roof and attic insulation with pre-existing insulation.
9/11/14	68.1	Add Washington attic insulation
7/11/19	68.2	Revise savings and costs. Differentiate by heating and cooling zones. Change minimum insulation levels
9/26/19	68.3	Corrects copy/paste errors in Tables 1-4. No change to actual measure definitions.

Table 9 Related Measures

Measures	MAD ID
Commercial Pipe Insulation	91
Multifamily Insulation	110

Approved & Reviewed by

Jackie Goss, PE
Sr. Planning Engineer

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[i] Existing Commercial Reference Buildings Constructed In or After 1980
[ii] RTF Standard Information Workbook v 4.1
[iii] SB1149 Program Guidelines; Appendix A

Energy Trust of Oregon

Measure Approval Document for Commercial & Industrial Pipe Insulation

Valid Dates

January 1st, 2020 to December 31st, 2022

End Use or Description

This measure describes energy savings that result from insulating previously uninsulated hot water or steam piping. This measure is available for low pressure and medium pressure steam (LPS, MPS) distribution systems, Domestic Hot Water (DHW), and heating hot water applications.

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
- Production Efficiency

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

- Retrofit

Purpose of Re-Evaluating Measure

This update includes

- Clarification between domestic hot water and heating hot water uses.
- Commercial steam system costs and savings were re-weighted based on a strait average of pipe sizes
- Domestic hot water savings are re-weighed across building sizes and pipe sizes

Cost Effectiveness

Table 1 Cost Effectiveness Calculator Oregon, per linear foot

Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR
DHW Pipe Insulation	15	4.4	$18.40	$18.40	1.4	1.4
Commercial MPS Pipe Insulation	15	9.4	$18.40	$18.40	4.0	4.0
Commercial Heating HW Pipe Insulation	15	5.7	$18.40	$18.40	2.4	2.4
Commercial LPS Pipe Insulation	15	9.3	$18.40	$18.40	4.0	4.0
Industrial LPS Pipe Insulation	10	27.5	$18.40	$18.40	5.4	5.4
Industrial MPS Pipe Insulation	10	45.5	$18.40	$18.40	9.0	9.0

Table 2 Cost Effectiveness Calculator Washington, per linear foot

Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR
DHW Pipe Insulation	15	4.4	$18.40	$18.40	1.5	1.5
Commercial MPS Pipe Insulation	15	9.4	$18.40	$18.40	5.9	5.9
Commercial Heating HW Pipe Insulation	15	5.7	$18.40	$18.40	3.6	3.6
Commercial LPS Pipe Insulation	15	9.3	$18.40	$18.40	5.8	5.8
Industrial LPS Pipe Insulation	10	27.5	$18.40	$18.40	5.6	5.6
Industrial MPS Pipe Insulation	10	45.5	$18.40	$18.40	9.3	9.3

Requirements

- Must not have any existing insulation to be eligible for incentive.
- All Service Jacketing (ASJ) will be required for indoor pipe insulation projects, and aluminum jacketing for outdoor piping insulation projects to maintain the life of the insulation.
- Table 3 shows required insulation thickness based on nominal pipe diameter, and steam pressure classifications.

Table 3 Minimum insulation thickness

	Pipe Diameter	
Fluid	**≤ 1.5"**	**> 1.5"**
Domestic Hot Water	1.5”	2”
Heating Hot Water	1.5”	2”
Low Pressure Steam (< 15 psig)	1.5”	2”
Med Pressure Steam (15-200 psig)	1.5”	2”

Baseline

This measure uses an existing condition baseline.

The baseline is uninsulated schedule 40 steel pipe.

Measure Analysis

Savings were based on a 2010 ICF study conducted on behalf of the Energy Trust of Oregon. The study analyzed the impact of pipe insulation in commercial and industrial applications. A bare pipe baseline was used to describe sites that had missing, severely deteriorated, or uninsulated piping. Several different applications and their associated operating hours and fluid temperatures were looked at, assumptions for the analysis are listed in Table 4.

Table 4 Input Parameter Summary

Input Parameter	Value	Units
Boiler Efficiency	80%	N/A
Thermal conductivity, steel pipe (k)	314.4	Btu-in/hr-ft^2-F
Thermal conductivity, insulation (k)	0.29	Btu-in/hr-ft^2-F
Ambient Temperature	70	°F
DHW Supply/Return Temperature	130/124	°F
Medium-pressure Steam Supply/Return Temperature	338/212	°F
Heating System Supply/Return Temperature	180/160	°F
Low-pressure Steam Supply/Return Temperature	250/212	°F
Emissivity of steel and insulation	0.8	N/A

The analysis assumes that 90% of pipes will be located indoors and 10% will be located outdoors. Savings were determined by using heat transfer engineering equations to model a horizontal pipe with internal fluid flow along with empirical relations for the necessary heat transfer coefficients. The following equation was used to determine heat loss from the pipe:

$$q = \frac{Q}{L} = \frac{\pi \Delta T}{R_1 + R_{pipe} + R_{ins} + R_2}$$

where

q = Energy loss per length of pipe (Btu/hr/ft)

Q = Energy loss (Btu/hr)

L = Pipe length (ft)

ΔT = Temperature difference between fluid and air ($T_{fluid} - T_{air,}$) (°F)

The R values in the denominator represent the thermal resistance factors that impede the flow of heat. R values vary and be solved for with physical properties and heat transfer coefficients.

R1 = Thermal resistance due to convection between fluid and inside pipe surface

Rpipe = Thermal resistance due to conduction through pip

Rins = Thermal resistance due to conduction through insulation

R2 = Thermal resistance due to convection and radiation at the exterior insulation surface.

The heat loss for bare and insulated pipes were calculated and used to find the incremental heat loss per hour. Using the heat loss rate, the savings were determined by multiplying the heat loss by the operating hours and dividing by the assumed boiler efficiency. Table 5 lists the assumed operating hours for the different applications.

Table 5 Operating Hours

Application	Operating Hours
Small Commercial DHW	2,500 hours
Small Commercial Medium Pressure Steam	2,200 hours
Large Commercial DHW	6,500 hours
Large Commercial Heating	2,900 hours
Large Commercial Low Pressure Steam	2,900 hours
Industrial Low Pressure Steam	8,400 hours
Industrial Medium Pressure Steam	8,400 hours

Table 503.2.8 in the 2010 Oregon Energy Efficiency Specialty Code was used to develop target insulation levels for each case based on the expected fluid type and pipe size. After feedback on the difficultly of installing code level insulation, the requirements were adjusted to deviate slightly. Since existing buildings and production efficiency are not subject to code level requirements for insulation, this adjustment will not violate code and will ideally result in more eligible applications.

Savings were calculated for pipe diameters of 1”, 2”, 3”, and 4” for each application. The average savings from the different pipe sizes and supply/return piping were taken for each application and are displayed in Tables 1 and 2. This was done so that contractors will not have to distinguish the direction of flow during installation, and projects with multiple pipe sizes will not have differing incentive rates.

For small and large commercial DHW applications, the savings were averaged so that the program will not have to discern what constitutes a small versus a large commercial building. DHW savings in small buildings are not cost effective, but the average savings are cost effective. The operating hours, were the only variance between the two applications, mitigating the impact of combining these applications.

Comparison to other programs

This MAD exists alongside MAD 111 – Multifamily Pipe Insulation. Both draw from the same analysis and methodology though savings differ primarily due to differences in hours of operation.

Measure Life

The 2007 ASHRAE Handbook assigns a 20 year measure life to modeled insulation, and a 2005 DEER Database report referencing CALMAC data lists 15 years for pipe wrap. Although pipe insulation in high traffic areas would likely deteriorate faster than these estimates, the program assumes that OSHA requirements would already require pipe insulation (especially on steam systems) to be installed in these high exposure areas. Therefore, the vast majority of insulation installed through the existing buildings program is expected to be done on piping found in low traffic areas, above ceiling spaces, or in wall cavities. A measure life of 15 years for commercial pipe insulation was used as a conservative estimate in the cost-effectiveness screening.

For industrial applications, a measure life of 10 years was used to screen for cost-effectiveness to account for the more frequent change out of process piping and expected re-insulation.

In both sectors, because insulation is rarely maintained and could potentially become damaged earlier than the equipment it is connected to would need replacement, (particularly in the case of boilers) the program will require installing ASJ on indoor piping and aluminum jacketing on outdoor piping to ensure savings realization for the life of the measure.

Cost
Cost averages were estimated based off contractor proposals gathered for the ICF report in 2010. The data collected was averaged to determine cost based off pipe diameter. The averages were weighted using the assumption that 90% of the installed insulation would be indoors and the 10% would be outdoors requiring aluminum jacketing.

Load Profiles
The measures serving DHW will use a hot water gas load profile. Measures serving HVAC loads with use commercial heating gas load profile. Industrial measures will use flat gas load profile.

Incentive Structure
The maximum incentives listed in Table 1 and ***Error! Reference source not found.*** *are for reference only and are not suggested incentives.* Incentives will be structured per linear foot of insulation.

SRAF
Existing Buildings and Industrial Program SRAFs apply to these measures.

Follow-Up
For the next update costs should be reviewed and adjusted to reflect any market changes.

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\Process Equipment\pipe insulation

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91 - Commercial Pipe

References
1) ICF (2010). Impact of Pipe Insulation on Natural Gas Consumption – Commercial and Industrial Applications. (ICF Report No. 201902D) Bellevue, WA.

Version History and Related Measures
Energy Trust has been offering pipe insulation measures for many years. These offering predate our measure approval documentation process and our record retention timelines. Table 6 may be incomplete, particularly for measures approved prior to 2013.

Table 6 Version History

Date	Version	Reason for revision
2010	91.x	Introduce pipe insulation measures
11/17/2010	91.1	Change insulation thickness requirements
5/30/2019	91.2	Separate measures for insulation on domestic hot water and heating hot water pipes. Re-weight DHW and commercial steam savings.

Table 7 Related Measures

Measures	MAD ID
Commercial Insulation	68
Multifamily Pipe Insulation	111
Condensing Tank Water Heaters	21
Commercial Condensing tankless >199 kBtu	72
Hot Water HVAC Boilers	88
Modulating Boiler Burners	142
Commercial Steam Traps	42
Industrial Steam Traps	200

Approved & Reviewed by

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Measure Approval Document for Commercial Showerheads and Shower Wands

Valid Dates
January 1, 2020 to December 31, 2020

End Use or Description
This measure describes 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 for use in the following programs:
- Existing Buildings

Within these programs, applicability to the following building types or market segments or other program tracks are expected:
- Any commercial except fitness (Hospitality, Retail, Healthcare, Schools, Offices)
- Fitness Centers

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

Purpose of Re-Evaluating Measure
This is an administrative update, with no changes to savings or costs. Measures were re-tested with the latest avoided costs and the expiration date was extended through 2020.

While the Regional Technical Forum (RTF) measure this analysis is based upon was updated in 2019, there was insufficient time to adequately update the analysis to represent Energy Trust territory.

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	% Ele Allo	% Gas Allo
Showerhead 1.75gpm Any Commercial Except Fitness Center Electric Water Heating	10	111	0	$7.14	$14.49	$7.14	8.9	24.9	100%	0%
Showerhead 1.75gpm Any Commercial Except Fitness Center Gas Water Heating	10	4	5	$7.14	$14.49	$7.14	2.8	18.9	11%	89%
Showerhead 1.50gpm Any Commercial Except Fitness Center Electric Water Heating	10	172	0	$7.14	$21.03	$7.14	13.6	36.9	100%	0%
Showerhead 1.50gpm Any Commercial Except Fitness Center Gas Water Heating	10	5	8	$7.14	$21.03	$7.14	4.4	27.7	10%	90%
Showerhead 1.75gpm Fitness Center Electric Water Heating	10	1,042	0	$7.14	$135.46	$7.14	82.8	232.9	100%	0%
Showerhead 1.75gpm Fitness Center Gas Water Heating	10	35	46	$7.14	$135.06	$7.14	26.6	176.2	11%	89%
Showerhead 1.50gpm Fitness Center Electric Water Heating	10	1,605	0	$7.14	$196.67	$7.14	127.6	345.5	100%	0%
Showerhead 1.50gpm Fitness Center Gas Water Heating	10	51	71	$7.14	$196.67	$7.14	40.7	258.7	10%	90%
Showerhead 1.75gpm Any Commercial Except Fitness Center Gas Water Heating partial territory	10	0	5	$7.14	$14.83	$7.14	2.5	19.0	0%	100%
Showerhead 1.50gpm Any Commercial Except Fitness Center Gas Water Heating partial territory	10	0	8	$7.14	$21.53	$7.14	3.9	27.8	0%	100%
Showerhead 1.75gpm Fitness Center Gas Water Heating partial territory	10	0	46	$7.14	$138.72	$7.14	23.8	177.5	0%	100%
Showerhead 1.50gpm Fitness Center Gas Water Heating partial territory	10	0	71	$7.14	$201.40	$7.14	36.7	259.9	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
Showerhead 1.75gpm Any Commercial Except Fitness Center Gas Water Heating	10	0	5	$7.14	$13.99	$7.14	2.94	17.6
Showerhead 1.50gpm Any Commercial Except Fitness Center Gas Water Heating	10	0	8	$7.14	$20.30	$7.14	4.53	25.8
Showerhead 1.75gpm Fitness Center Gas Water Heating	10	0	46	$7.14	$130.78	$7.14	27.48	164.6
Showerhead 1.50gpm Fitness Center Gas Water Heating	10	0	71	$7.14	$189.87	$7.14	42.40	241.5

Requirements
- Installation of showerheads and shower wands with a flow rate of 1.75 or 1.5 gpm.
- PMC determined minimum number of showerheads and/or shower wands that must be purchased (currently 10 but subject to change). Product must be purchased 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 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%.

Gas water heater efficiency is updated from 75% to 80% per the DOE baseline, intermediate, and max-tech thermal efficiency levels for representative commercial water heating equipment[1]. The updated cost effectiveness calculations now use 80% for commercial applications. Steady state efficiency for gas water heaters changed from 75% to 80%.

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 reflected 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 shower wand 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 10th 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

[1] https://www.energy.gov/sites/prod/files/2016/04/f30/Commercial%20Water%20Heating%20Equipment%20ECS%20NOPR.pdf; pg 109

- 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 gas-only 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 in Table 1 and Table 2 are for reference only and are not suggested incentives. Incentives will be structured per unit with a minimum purchase quantity per site.

Follow-Up

This measure is set to expire after one year on December 31st, 2020. 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

77 Commercial Showerheads 2020.x

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
8/20/2019	77.3	Extend expiration date

Table 4 Related Measures

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

Approved & Reviewed by

Kenji Spielman
Planning Engineer

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Measure Approval Document for Condensing Furnaces in Multifamily

Valid Dates

1/1/2020 through 12/31/2022

Description

Condensing natural gas furnaces of less than 225,000 Btu/h input capacity installed in new and existing multifamily.

Program Applicability

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

- New Buildings - Multifamily
- Existing Multifamily
    - Stacked structures greater than four units
- Existing Buildings Washington, where they serve commercial-rate multifamily buildings

Expected building types are include

- Assisted living or retirement communities
- Dormitories
- Affordable or market rate apartments

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

- New
- Replacement

Purpose of Re-Evaluating Measure

This update tested using the most up to date cost effective calculator. There are no changes to savings or costs.

Cost Effectiveness

Table 1 and Table 2 demonstrate cost effectiveness of three tiers of condensing furnaces in multifamily buildings in Oregon and Washington respectively. In these and the following tables, all values are based on the kBtu/h input capacity of the furnace.

Table 1 Cost Effectiveness Table – Furnace tiers in Multifamily in Oregon

Measure	Measure Life (years)	Savings (therms/ kBtu/h)	Incremental Costs ($/kBtu/h)	Maximum Incentive ($/kBtu/h)	UCT BCR at Max Incentive	TRC BCR
Furnace, 91%, Multifamily	18	1.41	$8.66	$8.66	1.60	1.60
Furnace, 95%, Multifamily	18	1.92	$12.30	$12.30	1.54	1.54
Furnace, 98%, Multifamily	18	2.31	$14.92	$14.92	1.52	1.52

Table 2 Cost Effectiveness Table – Furnace tiers in Multifamily in Washington

Measure	Measure Life (years)	Savings (therms/ kBtu/h)	Incremental Costs ($/kBtu/h)	Maximum Incentive ($/kBtu/h)	UCT BCR at Max Incentive	TRC BCR
Furnace, 91%, Multifamily	18	1.34	$8.66	$8.66	1.93	1.93
Furnace, 95%, Multifamily	18	1.83	$12.30	$12.30	1.86	1.86
Furnace, 98%, Multifamily	18	2.20	$14.92	$14.92	1.84	1.84

Table 3 and Table 4 demonstrate that the increments between the tiers of furnaces are cost effective in Oregon and Washington respectively. This indicates that higher incentives for higher tiers of equipment may be appropriate, with maximum increments between tier incentives listed in the tables.

Table 3 Cost Effectiveness Table - increments between furnace tiers, Multifamily in Oregon

Measure	Measure Life (years)	Incremental Savings (therms/ kBtu/h)	Incremental Costs ($/kBtu/h)	Maximum Incremental Incentive ($/kBtu/h)	UCT BCR at Max Incentive	TRC BCR
Incremental 91% to 95%	18	0.51	$3.64	$3.64	1.38	1.38
Incremental 91% to 98%	18	0.90	$6.26	$6.26	1.41	1.41
Incremental 95% to 98%	18	0.39	$2.62	$2.62	1.70	1.70

Table 4 Cost Effectiveness Table - increments between furnace tiers, Multifamily in Washington

Measure	Measure Life (years)	Incremental Savings (therms/ kBtu/h)	Incremental Costs ($/kBtu/h)	Maximum Incremental Incentive ($/kBtu/h)	UCT BCR at Max Incentive	TRC BCR
Incremental 91% to 95%	18	0.49	$3.64	$3.64	1.68	1.68
Incremental 91% to 98%	18	0.86	$6.26	$6.26	1.72	1.72
Incremental 95% to 98%	18	0.37	$2.62	$2.62	2.05	2.05

Requirements

- Furnace must be part of a centralized heating system serving at least two dwelling units or regularly occupied multifamily common space.
- Furnace must serve multifamily space with continuous occupancy (e.g. living units, common spaces). Furnaces in multifamily projects serving spaces without continuous occupancy (e.g. office spaces) do not qualify for this measure.
- Natural gas condensing furnace with input capacity less than 225,000 Btu/h
- For furnaces rated in both Et (thermal efficiency) and AFUE (annual fuel utilization efficiency), Et shall be used to determine qualification.

Details

Condensing gas furnaces recover heat from the combustion exhaust air stream to preheat incoming water, increasing overall operating efficiency. This measure applies to furnaces with input capacities less than 225,000 Btu/h. Units larger than this size are better classified as condensing RTUs, which differ in a number of significant ways (e.g. costs, availability, efficiency standards) from furnaces included in this measure. Units may be rated as commercial or residential equipment. Furnaces are not particularly common heating method in stacked multifamily buildings, but they are used occasionally. Participation is expected to be highest in assisted living and other similar situations.

Measure Analysis

Baseline

The baseline for this measure is a gas furnace with a thermal efficiency of 80%. This is the minimum required efficiency for gas fired warm air furnaces with input capacity less than 225,000 Btu/h, in the 2014 Oregon Energy Efficiency Specialty Code, OEESC. Builders and multifamily property owners and managers are assumed to put in code minimum equipment typically. New Buildings outreach managers have contributed to this assumption and this baseline matches the decision making assumptions used for furnaces in smaller multifamily projects (MAD 22).

Building Modeling

Baseline and high efficiency condensing gas furnaces were modeled by CLEAResult's new construction engineering team using the New Buildings program's prototype models for the Small Office, Strip Mall Retail, Primary School, and Low-Rise Multifamily (40 units) building types in eQuest 3.65. These models are meant to represent typical code-minimum new construction. The measure was modeled by modifying the gas furnace heat input ratio (HIR) value in the models, calculating the HIR as the inverse of thermal efficiency (Et). HIRs were modeled representing thermal efficiencies of 80% (code minimum baseline), 91%, 92%, 93%, 94%, 95%, 96%, 97%, and 98%.

The modeling methodology varies the furnace thermal efficiency, the standard for the modeling software. However, furnaces of this size are often rated in AFUE instead of thermal efficiency. A furnace's AFUE is expected to be lower than its thermal efficiency, as the AFUE value takes seasonal performance and standby losses into account. Therefore, a condensing furnace with an AFUE of 91%, for example, would have higher performance than a condensing furnace with a thermal efficiency of 91%. As such, furnaces may qualify for this measure based on either AFUE or thermal efficiency. If a furnace is rated in both AFUE and thermal efficiency, the thermal efficiency rating shall be used to determine qualification.

The model assumes furnaces are perfectly sized to meet the heating loads, and are smaller than typical residential furnaces when serving a single dwelling unit or are shared between dwelling units, particularly in assisted living or similar situations. Expected sizes are 50-80 kBtuh. In 2018 and 2019 participating projects included furnaces serving multiple dwelling units. These furnaces ranged for 60 to 120 kBtuh and on average and served both dwelling units and common areas and do not appear to be oversized.

The measures were modeled for the three Oregon climate zones (Coast/Astoria, Valley/Portland, Central/Redmond). The savings for each climate zone were combined into a weighted average using the following program-assumed weightings:

- Coast: 3%
- Valley: 87%

- Central: 10%

For Washington, the savings were weighted 100% for the Valley climate zone, resulting in lower savings for Washington than Oregon.

Results and Savings

Savings are normalized on a per-kBtuh input basis, based on the furnace capacities calculated by the models. Since the model assumed a newly constructed building meeting code minimums, the savings are conservative for existing buildings, which often have aged shell conditions and may have been built to less stringent codes.

Savings for three specific efficiency tiers – 91%-94%, 95%-97%, and 98% – were selected for consideration, based on the distribution of efficiencies for units available in the market.

Results of modeling and other analysis demonstrated that savings from condensing furnaces in multifamily situations were higher than in other building types. Commercial furnace measures were not cost effective in offices, schools or retail. Savings for condensing furnaces in multifamily in the various tiers can be found in Table 1 and Table 2. Savings and other information regarding the performance of furnaces in these building types can be found in supporting documents.

Measure Life

The measure life is 18 years.

Cost

Cost estimates were gathered from various sources, and outdated information and outliers were excluded. The final cost estimate sources used are the US DOE (2013), the US EIA (2014), FurnacePriceGuides.com, GasFurnaceGuide.com, and a contractor bid analysis performed by the Existing Homes program (2014). These sources were used to determine estimates of the incremental cost of a condensing furnace compared to a code baseline furnace The cost estimate for the 91% efficiency level was determined by averaging the cost estimates for 90% and 92% efficient furnaces, as none of the sources include costs specifically for 91% efficient furnaces. The sources include costs specifically for 95% and 98% efficient furnaces, which were used in the cost effectiveness analysis. Most costs are based on 80 kBtu/h input models, which are the most common size with the most readily available cost information. This size range does not exactly correspond to the modeled sizes.

Costs for different efficiency levels were normalized on a per-kBtu/h input capacity basis. There have not been enough projects in 2018 and 2019 to verify cost assumptions.

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 kBtu/h of furnace input capacity. If a tiered approach is taken, incentives must be selected such that the incremental incentive between tiers is cost effective.

Follow-Up

Oregon 2019 Energy Code is expected to adopt ASHRAE 90.1 2016. This measure and baseline are not affected by the 2019 code update. It is expected that Oregon will adopt ASHRAE 90.1 2019 as the 2020 Energy Code. Late in 2019, ASHRAE 90.1 2019 will be published at which time this measure will need to be re-evaluated for baseline implications.

Costs should be reviewed at next update based on the actual sizes of furnaces installed.

Supporting Documents

The cost effective screening for these measures is attached and can be found along with additional supporting documents at: I:\Groups\Planning\Measure Development\Commercial and Industrial\ Commercial HVAC\Furnaces\multifamily

OR-WA-CE Calculator-2020-v1.1

Condensing Furnace Savings Ana

Version History and Related Measures

Table 5 Version History

Date	Version	Reason for revision
2004	86.1	Approve various gas measures for commercial programs, including furnaces.
9/12/17	203.1	New approval for commercial condensing furnaces multifamily buildings. MAD 86 will be retired.
6/21/2019	203.2	Update to screen at 2020 avoided costs

Table 6 Related Measures

Measures	MAD ID
Residential Gas Furnace in small multifamily, single family rentals, manufactured home rentals, and Savings within Reach	22
Residential Gas Furnace in Washington	23

Approved & Reviewed by

Jackie Goss, PE
Sr. Planning Engineer

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Measure Approval Document for Condensing Pool Heaters

Valid Dates
August 1, 2019 to December 31, 2022

End Use or Description
Replacement of existing standard efficiency pool heaters with 96% efficient condensing pool heaters.

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
- Existing Multifamily

Within these programs, applicability to the following building types are expected:

- Hospitality
- Fitness Centers
- Recreational Facilities
- Apartment buildings and complexes

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

- Replacement

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
Outdoor Pools - condensing pool heater - per SF	10	1.10	$3.52	$3.52	$3.52	1.1
Indoor Pools - condensing pool heater - per SF	10	0.68	$2.35	$2.35	$2.35	1.1

Table 2 Cost Effectiveness Calculator Washington

Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR
Outdoor Pools - condensing pool heater - per SF	10	1.10	$3.52	$3.52	1.2	1.2
Indoor Pools - condensing pool heater - per SF	10	0.68	$2.35	$2.35	1.1	1.1

Requirements
- Replacement of a gas fired pool heater with minimum capacity of 350 kBtu

- Condensing pool heaters must have minimum efficiency of 96%
- Site must be in eligible gas utility territory.
- Indoor pool surface area must be a minimum of 1,350 square feet.
- Outdoor pool surface area must be a minimum of 900 square feet.
- Covered pools and spas are not eligible
    - New Construction pools are not eligible because covers are required by codes.
    - This measure cannot be combined with MAD 99 – Efficient Spa Covers or any other pool cover measure.

Details

Pool covers reduce heating load by as much as 50% and are common on smaller pools and new pools. Due to the lower potential savings in covered pool applications, they are not included in this analysis. Messaging around this measure will need to be clear that Energy Trust supports the use of pool covers and does not recommend this measure instead of a cover.

Indoor and outdoor pool minimum allowable surface areas represent the smallest cost-effective pools that size and specify qualifying equipment for this measure.

Baseline

This measure uses a: Code Baseline.

ASHRAE 90.1 – 2016 aligns with Code of Federal Regulations 10 CFR Part 430 which specifies gas-fired pool heaters shall have a thermal efficiency no less than 82%.

Savings and Measure Analysis

Savings estimates used in cost-effectiveness calculations assume a baseline 82% efficient pool heater is replaced with a 96% condensing pool heater.

This analysis estimates the heating energy required to replace the energy lost from small indoor and outdoor pools. Pool heat loss is primarily the result of evaporation from the water surface. Additional heat is lost via radiation and convection modes [2].

Evaporation losses are estimated using MM Shah Methods Calculation for Evaporation from pools for Indoor and Outdoor swimming pools. [3] This method relies on empirical coefficients for swimming pools and spas, per reference Table 14: Summary of Recommended Calculation Methods for guidance in calculating evaporation rates in unoccupied swimming pools.

Estimates using [3] and [10] were benchmarked against the more simplistic approach outlined by the Department of Energy [4] for calculating outdoor pool heat losses.

The following numbered equations from the Shah method are used to calculate evaporation rate in $lb/ft^2 \cdot h$.

For **outdoor unoccupied** pools, the larger of the equations 1 through 3 was used:

1. $E_0 = C\rho_w(\rho_r - \rho_w)^{\frac{1}{3}}(W_w - W_r)$

Where:

E_0 = rate of evaporation from unoccupied pools (lb/ft^2.h)
C = 290
ρ_w = density of air at saturated water surface (lb/ft^3)
ρ_r = density of air at room temperature and humidity (lb/ft^3)
W_w = specific humidity of air saturated at water surface temperature
W_r = specific humidity of air at room temperature and humidity

2. $E_0 = b(p_w - p_r)$

Where:

b = 0.0346
p_w = partial pressure of water vapor in air at water surface (in.Hg)
p_r = partial pressure of water vapor in air at room temperature and humidity (in.Hg)

3. $E_0 = a(\frac{u}{b})^{0.7}(p_w - p_a)$

Where:

a = 0.0346
b = 30 fpm
u = air velocity (fpm)
p_a = partial pressure of water vapor in air away from the surface of water (in.Hg)

The final evaporation rate for outdoor pools is a sum of the result of Eq. 4 and the greater of Eq. 1, 2, 3.

For **outdoor occupied** pools:

4. $E_{occ} = (\,1.9 - 21(\rho_r - \rho_w) + 5.3N) * E_O$

Where:

N = pool occupants per unit area

Evaporation calculations for **indoor unoccupied** pools are based on assumptions described below and from [3]; Table 5: 'Calculated Evaporation rate from Unoccupied Pools at Typical Design Conditions'. Evaporation rate for indoor occupied pools is calculated using Eq. 4.

Total evaporation heat loss is determined by converting the total evaporation rate in lbs/hr (sum of Eq. 4 and the greater of Eq. 1, 2, 3) into total required heating energy using the following formula:

5. $Heat\ loss_{evap} = ((E_0 * \ hours_o) + (E_{0cc} * \ hours_{occ})) \cdot 1048\frac{btu}{lb}$

Additional heat losses from convection and radiation are added to the heat loss from evaporation. The assumptions for this analysis are that for outdoor pools, 44% of the evaporative heat loss is attributed to radiation and convection modes. For indoor pools, 30% additional heat loss is assumed.

Savings are the result of the difference in efficiency between baseline and condensing heaters.

6. $$Savings\ (therms) = \frac{\left(Heat\ loss_{evap} * (1+C)\right) * (eff_{base} - eff_{cond})}{100000 \frac{Btu}{therm}}$$

Where:

C = additional heat loss from convection and radiation
eff_{base} = baseline efficiency
eff_{cond} = condensing heater efficiency

Assumptions:

- Pool Temperature: Per DOE guidelines [5] accounting for adults and children, 80ºF assumed for indoor and outdoor pools.
- Pool Surface Area:
    - Online sources [7], [8], [9] stated that a 400 kBtu outdoor pool heater requiring a temperature rise of 20ºF (Pool temp – Avg ambient temp of coldest month) would ideally serve a ~1,000 sq.ft pool. This was confirmed with online vendors at Inyo Pools – screenshots included in supporting spreadsheet tab 'Pool Size'.
    - If the ambient temperature and humidity conditions are maintained as described below, the area of the indoor swimming pool that a 400 kBtu heater would serve is ~ 1,500 sqft [12]. This was confirmed with vendors from Inyo Pools
- Pool Months:
    - Outdoor pools assumed to be operating June through September (4 months)
    - Indoor pools assumed to run year-long (12 months)
- Pool Hours:
    - Outdoor pools assumed to run 10 hours a day (~10 AM to 8PM)
    - Indoor pools assumed to run 14 hours a day – most community pools in Portland had similar/longer schedules.
- Outdoor Weather data:
    - Calculations use dry-bulb temp and wind speed data from TMY3 records. Daily averages are used with the ability to switch between Portland, Grants Pass and Astoria. Savings estimates from Portland are used in cost-effectiveness calculations. Savings from the other two cities are also cost-effective.
    - Air Density Difference: Portland's June-Sept average relative humidity was found to be 60.4% (see tab 'OR Weather' in CEC). While Astoria and Grants Pass had higher and lower relative humidity respectively, a correlation between relative humidity and air density could not be easily established. The Shah paper provided density difference values for 50% and 60% relative humidity. For this analysis, 60% was assumed.
- Ambient conditions for indoor pools:
    - 82ºF ambient air temperature [10]
    - 50% relative humidity for indoor pools [11]
- Number of people in occupied pool assumed to be four – required in Eq. 4 above. Changing this number does not significantly change the overall energy use.

Measure Life

DOE [4] states that a typical pool heater lasts 5 years or more but does not specify the efficiency of the pool heater for this estimate. Conversation with Anderson Poolworks (email included in CEC tab 'Measure Life') suggests efficient pool heaters are expected to last more than 11 years based on in-service heater records. Manufacturers of heaters with stainless steel and titanium heat exchanges claim 15 year operation at listed efficiencies. Assuming proper maintenance of pool heaters occurs half of the time, the average of 5, 11, and 15 years (10.33 years) is recommended. Cost-effectiveness calculations round down and use 10 years.

This measure assumes that the pH of the water is maintained at 7.2 – 7.8 per Model Aquatic Health Code guidelines [1] for the pool heater's service life to be applicable.

Cost

Costs are sourced from quotes provided by Anderson Poolworks, online shopping queries, and online vendors for a 96% efficient pool heater. The same sources were used to find an average of all available baseline quotes for standard 82% efficient heaters. The incremental cost is the difference between these averaged costs.

Incentive Structure

The maximum incentives listed in Table 1 and Table 2 are for reference only and are not suggested incentives. The incentive is structured per square foot of pool area.

SRAF

Typical program SRAFs apply to these measures.

Follow-Up

Measures should remain aligned with changes in OEESC requirements or federal standards for pool heater type or efficiency.

Program should consider prevalence of pool covers and potential for future measures for customers who use covers.

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\pools and spas\pool heaters

OR-WA-CEC_2020-v
1.1-Small Pool Heate

References

[1] https://www.cdc.gov/mahc/pdf/2018-MAHC-Code-Clean-508.pdf; section 5.7.3.4.1
[2] http://www.rlmartin.com/rspec/whatis/studies_outdoor_inactive.htm; section 3.7

[3] https://mmshah.org/publications/ASHRAE%202014%20Evaporation%20paper.pdf
[4] https://www.energy.gov/energysaver/gas-swimming-pool-heaters#299555-tab-1
[5] https://www.energy.gov/energysaver/managing-swimming-pool-temperature-energy-efficiency
[6] https://www.cpsc.gov/content/cpsc-warns-of-hot-tub-temperatures
[7] https://www.poolsupplyworld.com/blog/wp-content/uploads/2014/09/heater_pump_sizing.pdf
[8] https://www.poolcenter.com/heatersWhatSize
[9] https://www.bryanboilers.com/pdfs/EP/WPIndirectPoolHeaters/1078.pdf
[10] https://www.ashrae.org/search?q=indoor%20pool
[11] https://serescodehumidifiers.com/engineers/indoor-pool-design/Seresco-Natatorium-Design-Guide-2013.pdf
[12] https://www.bryanboilers.com/pdfs/EP/WPIndirectPoolHeaters/1078.pdf
[13] ASHRAE Handbook of Heating, Ventilating and Air Conditioner Applications; Table A5.6

Version History and Related Measures

Table 3 Version History

Date	Version	Reason for revision
8/1/2019	238.1	New Measure for commercial pool heaters with 96% efficiency.

Table 4 Related Measures

Measures	MAD ID
Efficient Commercial Pool Pumps	237
Efficient Spa Covers	99

Approved & Reviewed by

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Measure Approval Document for Condensing Unit Heaters in Greenhouses

Valid Dates

1/1/2020 to 12/31/2022

End Use or Description

Unit heaters are used to heat greenhouses, typically to maintain overnight or winter temperatures. Typical applications include one or more unit heaters per greenhouse in the range of 180-310 kBtu input capacity. Projects are likely to replace more than one heater at a time.

Program Applicability

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

- Production Efficiency
- Existing Buildings WA

Within these programs, applicability to the following building types are expected:

- Greenhouses

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

- Retrofit
- Replacement
- New

Purpose of Re-Evaluating Measure

Updated cost effective analysis to 2020 avoided cost. No changes to savings or costs.

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
Condensing Unit Heaters in Greenhouses	12	6.29	$11.18	$11.18	3.4	3.4

Table 2 Cost Effectiveness Calculator Washington

Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR
Condensing Unit Heaters in Greenhouses	12	6.29	$11.18	$11.18	5.21	5.21

Requirements

- Heater must be installed in a greenhouse with transparent or translucent sides and roof – this measure is not appropriate for warehouses heating or indoor grow applications.
- Must heat to 55 degrees or greater for a least two months per year

- Minimum greenhouse size 1,000 sq. ft

Baseline

This measure uses a Full Market Baseline.

Federal guidelines for unit heaters do not have a specific efficiency requirement, requiring only that the design uses a power vent or automatic flue damper[1]. The baseline for this measure is a standard 80% efficient power vent or gravity fed unit heater. We assume the efficient equipment has little to no market share.

Measure Analysis

Savings for greenhouse heating depend on crop type, which influences set points, and climate so deemed savings from other regions are not suitable comparisons. Additionally, greenhouse construction also has a large impact on savings. Savings were calculated based on 32 completed greenhouse projects that went through the PE program between 2011 and 2015. Using actual participant project information allows for a project mix representative of growers in Energy Trust territory. Savings for each of these projects was calculated using the Department of Agriculture's Virtual Grower Tool, a greenhouse energy modeling application which uses a variety of inputs including greenhouse materials, heating set points and local weather data.

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

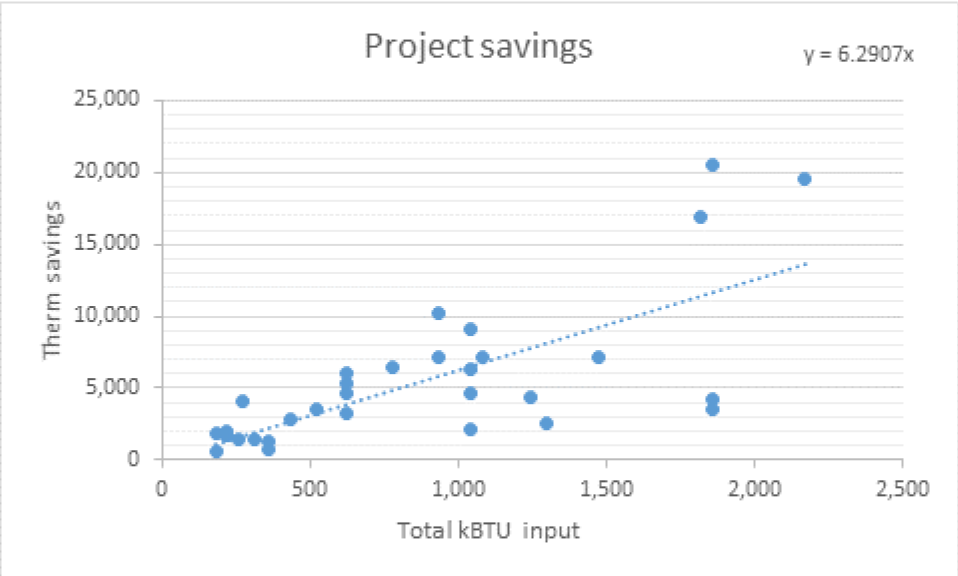

Figure 1: Savings versus kBtu Input

[1] Federal Register Vol. 70 No. 200, 10/18/2005 (https://www.govinfo.gov/content/pkg/FR-2005-10-18/pdf/FR-2005-10-18.pdf)

Measure Life

A measure life of 12 years is assumed for unit heaters, in line with unit heater measures in other applications.

Cost

Costs for both condensing and non-condensing unit heaters were collected from the two primary manufacturers of unit heaters installed in greenhouse applications in 2015. Incremental prices range from $7 to $18 per kBtu. An average incremental cost of $11.18 was used in the cost effectives testing, representing the average incremental cost/kBtu for all sizes of the more expensive manufacturer.

Incentive Structure

Since this is most often a retrofit measure, the maximum incentive listed in Table 1 and Table 2 is the incremental cost. *This is listed for reference only and is not a suggested incentive*. Incentives will structured be per kBtu input capacity.

While this measure is primarily used by the Production Efficiency program in Oregon, it may also be implemented by the Existing Buildings program in Washington, where EB has responsibility for industrial and agricultural gas projects including greenhouses. Alignment of incentives between the programs is recommended.

SRAF

Standard program SRAFs apply to this measure.

Follow-Up

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

Supporting Documents

The cost effective screening for this measure is attached and can be found along with supporting documentation at: I:\Groups\Planning\Measure Development\Commercial and Industrial\Agriculture\greenhouse\Greenhouse unit heaters

MAD 134.2-Condensing U

Greenhouse Heater savings analysis.xlsx

Version History and Related Measures

Table 3 Version History

Date	Version	Reason for revision
6/18/2015	134.1	Introduce Condensing Unit Heaters in Greenhouses measure
6/3/2019	134.2	Update avoided costs

Table 4 Related Measures

Measures	MAD ID
Greenhouse Controller	103
Greenhouse Measures	104

Approved & Reviewed by

Jackie Goss, PE
Sr. Planning Engineer

Disclaimer

EnergyTrust of Oregon

Measure Approval Document for Retrofit Cooler Doors

Valid Dates
1/1/2020 – 12/31/2022

End Use or Description
Cooler doors installed on existing open coolers

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

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

- Grocery

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

- Retrofit

Purpose of Re-Evaluating Measure
Updates include

- Savings and costs have been updated, based on improvements to assumptions regarding refrigeration EER and updated weather data. Maximum incentives changed as a result
- Use of measures in single fuel territories is clarified
- A new measure for use in electrically heated stores is now included
- Only the retrofit measures in MAD 47 have been used since 2017 when MAD 201 for new cases was released. This update removes references to new and replacement cases.

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	% Elec Allo	% Gas Allo
Cooler Door Retrofit – Gas Heat	15	1,033	39	$316	$0.00	$316	3.5	3.5	72%	28%
Cooler Door Retrofit Gas only territory, Gas Heat	15	0	39	$316	$77.25	$304	1.0	3.6	0%	100%
Cooler Door Retrofit – Electric only territory, Gas heat	15	1,033	0	$316	$29.25	$316	2.5	3.5	100%	0%
Cooler Door Retrofit – Electric heat	15	1,317	0	$316	$0.00	$316	3.2	3.2	100%	0%

Table 2 Cost Effectiveness Calculator Washington

Measure	Measure Life (years)	Unclaimed Savings (kWh)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Elec Allo	% Gas Allo
Cooler Door Retrofit – Gas Heat	15	1,033	39	316.32	$79.56	$316	1.4	3.9	100%	0%

Requirements
- Doors must be retrofit onto cooler cases where the existing condition is open coolers
- Stores heated with other fuels, such as propane, can use the Electric only territory measure if they have a participating electric utility.

Baseline
This measure uses an existing condition baseline. The required existing condition for this measure is open coolers.

Measure Analysis and Savings
Savings and analysis for this measure are taken directly from “Add Doors to WIRI_V2” tab from the RTF’s cooler door retrofit measure analysis[1]. The earlier version of this analysis used older values for Portland design heating and cooling data. This updated measure uses ASHRAE Fundamentals 2009 and 90.1 2004 for these same values, with the exception of HVAC cooling EER which has been selected to align with more recent RTF assumptions. These values and calculations, which provide the best available savings estimate, can be found within the “Add Doors to WIRI_V2” tab of the RTF workbook for cooler door retrofit. Energy Trust is using the RTF’s V2 method as it is the most rigorous in terms of analysis, interactive effects and climate dependence.

Savings are 952 kWh and 39 therms per linear foot of doors installed on refrigerated cases. The savings are achieved as the refrigerated space is separated from the conditioned space of the store. In addition to refrigeration savings, there are interactive effects with the store’s heating and cooling systems leading to heating savings and an increase in cooling load. Assumptions used in analysis are given in Table 3.

[1] https://rtf.nwcouncil.org/measure/walk-inreach-door-retrofit

Table 3 RTF Grocery Refrigeration Assumptions

Parameter	Values	Sources
EER	10.6 Btu-h/kWh (3.1 kWh heat removal / kWh electricity)	Value from SIW (based on PECI/GrocerSmart modeling of typical systems)
Annual compressor system full-load hours (FLH)	5,781	Navigant Consulting "Energy Savings Potential and R&D Opportunities for Commercial Refrigeration," 2009 page 70, table 4-17
Auxiliary Wattage (baseline)	Discharge fan = 366 W Return fan = 300 W Lighting = 170 W	1 fan at 60 hz, 230 V, standard efficiency 1 fan at 60 hz, 230 V, standard efficiency 2 rows of canopy lights, standard T8 fluorescents
Case Load (baseline)	21,180 Btu/h	Hussman product specification (DX5RRIS)
Auxiliary Wattage (measure)	Doors antisweat heat = 0 W Frame antisweat heat = 119 W Fluorescent lighting = 360 W	Hussman 5-door walk-in cooler door model #IWM2475A
Case Load (measure)	2,680 Btu/h	Hussman 5-door walk-in cooler door model #WM2475A
Cooling Degree Days	423 °F day	2009 ASHRAE Fundamentals Handbook, base 65F
Heating Degree Days	4222 °F day	2009 ASHRAE Fundamentals Handbook, base 65F
Gas HVAC Efficiency	80%	Typical
Electric HVAC Efficiency	3.2 COP	2014 OEESC
Design Temp, Heating	23.9°F	2009 ASHRAE design values for Portland, OR
Design Temp, Cooling	91.2 °F	2009 ASHRAE design values for Portland, OR
Temperature Inside	71°F	Typical Inside Temperature for Grocery Store

General equations used are as follows:

Annual energy savings, including the added load on the air conditioning system due to the loss of the refrigeration systems heat sink:

$$\Delta kWh = (kWh_{base} - kWh_{ee}) + AdditionalHVAC_{COOLING}$$

Where,

$$Additional\ \ HVAC_{cooling} = \frac{Annual\ \ Load_{COOLING}}{EER_{HVAC\ COOLING} * 1000}$$

Annual gas savings:

$$Saved\ HVAC_{HEATING} = \frac{Annual\ \ Load_{HEATING}}{100{,}000 * Gas\ Efficiency}$$

Annual cooling and heating loads:

$$AnnualLoad_{HEATING} = \frac{\Delta ZoneLoad * HeatingDegreeDays * 24}{DesignTemp_{HEATING} - Temp_{INSIDET}}$$

$$AnnualLoad_{COOLING} = \frac{\Delta ZoneLoad * CoolingDegreeDays * 24}{DesignTemp_{COOLING} - Temp_{INSIDE}}$$

Comparison to RTF and other programs

This measure directly follows the RTF approach, which has since deactivated the measure due to difficulty verifying assumptions. Modifications to the RTF's analysis include updated weather are refrigeration efficiency assumptions in line with active RTF refrigeration measures.

This measure differs from cooler doors on new equipment, MAD 201, due to the expected differences in refrigeration efficiencies of new and older equipment.

Measure Life

Measure life for cooler doors is 15 years, consistent with other grocery refrigeration measures.

Cost

Historical project costs from 2014-2019 were reviewed. The variation in costs was somewhat high over time, ranging from $105 to $2293 per linear foot. This variation is likely due to non-itemized invoices which make project costs unreliable. Rather than using the average, the median of $316.32 is used in to represent the costs a typical project would experience.

Incentive Structure

The maximum incentives listed in Table 1 and Table 2 *are for reference only and are not suggested incentives.* Incentives, like savings, will be structured per linear foot of case length.

SRAF

Existing Buildings SRAFs apply to this measure.

Follow-Up

At next update regional potential or new retrofit door technology, i.e. Vacuum Insulated Glass (VIG) should be assessed.

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\Grocery\cooler doors\retrofit coolers

OR-WA-CEC-2020-v
1.1 - 47 - Cooler Doc

Version History and Related Measures

Table 4 Version History

Date	Version	Reason for revision
01/06/2013	47.1	Introduce cooler door measures for new and existing cases
08/11/2017	201.1	Approve cooler doors for new cases separately in MAD 201, effectively deactivating the replacement and new measures within MAD 47.1
06/04/2019	47.2	Update savings. Include single fuel territory and electrically heated buildings. Clarifies that New Buildings and new cases use 201 instead of 47.

Table 5 Related Measures

Measures	MAD ID
Floating Head and Suction Pressure Controls	105
Antisweat Heater Controls	114
LED Refrigerated Case Lighting	78
Evaporator Fan Motors for Reach-in and Walk-in Coolers and Freezers	149
Strip Curtains	120
New Refrigerated Cases with Doors	201
Direct Install Refrigeration	TBD

Approved & Reviewed by

Jackie Goss, PE
Sr. Planning Engineer

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Measure Approval Document for Prescriptive Demand Controlled Kitchen Ventilation

Valid Dates

1/1/2020 – 12/31/2022

End Use or Description

This measure describes demand controlled kitchen ventilation in commercial kitchens accomplished with speed controlled motors in both the vent hood and make-up air units which automatically vary the fan speed based on cooling load and/or time of day.

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
- Multifamily
- Production Efficiency

Within these programs, applicability to the following building types are expected:

- Buildings with onsite commercial kitchens, including, but not limited to:
  - Restaurant
  - Cafeteria
  - Grocery

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

- Retrofit

Purpose of Re-Evaluating Measure

The update aligns the assumptions and calculation method with the New Buildings program. Savings, costs, size requirements and maximum incentives have been updated.

Cost Effectiveness

Vent hood measures will be offered per controlled HP, but savings and in particular costs do not scale linearly with HP. To determine the range of cost effective sizes, cost effectiveness was tested for vent hoods ranging from 1 to 10 HP for all heating configurations. These results are included in the attached workbook. Table 1 and Table 2 demonstrate savings and cost effectiveness per HP at the approved sizes only.

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
37	DCKV - gas heat – dual fuel	15	1,088	142	$1,919	$0.00	$1,919	1.0	1.0	44%	56%
38	DCKV - electric heat	15	4,397	0	$2,188	$0.00	$2,188	1.7	1.6	100%	0%
39	DCKV – gas heat -gas only	15	0	142	$1,858	$81.40	$1,115	1.0	1.1	0%	100%
40	DCKV - other heat – or gas in electric only	15	1,088	0	$1,919	$107.26	$894	1.0	1.1	100%	0%

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
8	DCKV - gas heat	15	NA	142	$2,188	$82.26	$1,629	1.0	1.1	0%	100%

Requirements

- Motor speeds must be controlled by a programmable controller, with scheduling, occupancy sensing, and heat sensing capabilities
- Variable speed control must be installed on both the make-up air unit motor and the hood exhaust motor.
- Make up air must be tempered
- Retrofit horsepower must not exceed total existing horsepower of makeup air unit and exhaust fan motor.
- Sites that use propane or other heating fuels may use the measure designed for gas heated buildings in electric-only territory.
- Some vent hood sizes not eligible. Projects with smaller fans may use the vent hood calculator (MAD 184) and test for cost effectiveness on a project by project basis. Size requirements are summarized in Table 3.
  - In electrically heated buildings the total controlled horsepower must be 1 HP or greater
  - In gas or other heated buildings with electric-only participation the total controlled horsepower must be 3 HP or greater.
  - In gas heated buildings with gas-only participation in Oregon the total controlled horsepower must be 4 HP or greater.
  - There are no size restrictions for Washington

Table 3 Utility Participation mapping and size requirements

State	Heating Fuel	Electric Utility	Gas Utility	Minimum Controlled Motor Size	Measure Number
Oregon	Electric	Yes	Yes or No	1 HP	38
	Gas	Yes	Yes	3 HP	37
	Gas	No	Yes	4 HP	39
	Gas	Yes	No	3 HP	40
	Other	Yes	Yes or No	3 HP	40
Washington	Gas	No	Yes	No Limit	8

Baseline

This measure uses an existing condition baseline.

The baseline for this measure is an existing vent hood without demand control. 2019 OEESC includes an exhaust air volume capacity limit of 5000 CFM which requires demand ventilation for a minimum of 75% of the exhaust and makeup air for projects of that size. The 2020 OEESC may lower that CFM requirement, but that change would not impact retrofit conditions.

Measure Analysis and Savings

Measure analysis relied on the Kitchen Hood Calculator designed by Energy Trust's New Buildings Program. This prescriptive measure uses assumptions and analysis methods taken directly from the calculator tool (MAD 184), which is used to provide custom incentives for projects going beyond code requirements in New Buildings. For this prescriptive offering, annual operating hours, percent fan turndown, and site location are based on typical commercial applications, operating conditions, and total project costs.

For each configuration, the savings at approved sizes are included in the per horsepower average.

Heating Savings

Electric and gas energy savings are projected using an hourly bin analysis with TMY3 data from Portland Intl Airport. Key assumptions are based on typical restaurant applications. While this measure is approved for other commercial kitchen spaces and regions, these assumptions are expected to by typical of the majority of projects.

- Annual operating hours assumed to be 14 hours per day, 6 days per week
- Fan system and VFD performance assumptions (See Fan Savings below)
- VFD turndown ratio during off-peak operating hours (See Fan Savings below)
- A dedicated make-up air unit supplies the exhaust hood required air volume

A range of motor sizes were input into the Kitchen Hood Calculator to determine savings for typical system sizes.

Building heating and fan motor loads are impacted by exhaust system characteristics, since makeup air must be tempered before entering the kitchen space. When make-up air and exhaust fan motors operate at full speed, full flow is produced and maximum energy is consumed by the system.

The baseline assumption is that both the make-up air unit and the vent hood are running at 100% flow during both peak and off-peak periods. The heating and cooling loads for the baseline system and updated system are calculated as follows:

$$Q = CFM \times (t_{outside} - t_{inside}) \times 1.08Btuh$$

The model then calculates the proposed energy needed based on peak and off-peak heat loss and heat gain. The proposed energy and baseline energy are both calculated as follows:

$$Proposed\ (Baseline)\ Energy = \sum(Number\ of\ Hours\ \times Q)_{Off\ Peak} + \sum(Number\ of\ Hours\ \times Q)_{Peak}$$

Where the annual operating hours are assumed to match the NEEA 2014 Commercial Building Stock Assessment weekly hours of operation for restaurants.

The baseline and proposed energy are then divided by system efficiencies, which default to code minimum values and are converted to therms and kWh as appropriate for heating and cooling. The differences between these final values provides the heating and cooling savings for the measure.

Fan Savings

Additional savings result from reduced fan motor energy which is calculated using fan affinity laws. The analysis assumes certain parameters which are detailed below:

- Static pressure: 2 inwg assumed, which is the low end of vent hood normal operating pressures with grease extraction
- Fan motor and VFD efficiency: Industry standard assumptions are used.
- VFD turndown ratio: With the typical range being 50% - 75%, the assumption used is 70% to be conservative
- Fan motor load factor: A load factor of 75% is used, with the observation in industry practice that motors are oversized, on average, by 25%.
- Off-peak flow periods use VFD and motor efficiency reduction factors which have been identified to account for the motor and VFD having reduced efficiency under the part load conditions.
- Fan energy savings due to speed reduction are the sum of make-up air fan motor AND exhaust hood fan motor savings.

The heating energy savings are then added to the fan motor energy savings to provide the total measure savings.

Comparison to other programs

Energy Trust's New Buildings program uses a calculator tool rather than a prescriptive measure for kitchen demand control ventilation. That tool is approved in MAD 184 and shares a calculation method with this offering.

The RTF does not have an equivalent measure.

Measure Life

The measure life of 15 years aligns with DEER exhaust demand controlled ventilation systems.

Cost

Costs have been determined via a detailed review of past project invoices. Costs ranged from $1,7500 to $3,100 per horsepower, with smaller systems costing more per horsepower.

For cost effectiveness testing, costs of the approved size range for each configuration were used. For example, in gas heated buildings in dual fuel territory are limited to 3 HP and above, so costs of systems ranging from 3-10 HP were averaged resulting in a cost of $1,919/HP.

Non-energy Benefits

Out of territory energy savings are included as non-energy benefits using Energy Trust's blended commercial rates. Propane savings are assumed to be equivalent to out of territory gas NEBs.

Incentive Structure

The maximum incentives listed in ***Error! Reference source not found.*** *and Table 2 are for reference only and are not suggested incentives.* Incentives will be structured per controlled motor HP. Due to the complexity of configuration requirements, Planning suggests that the same incentive be used for all configurations, which indicates a maximum incentive of $894/HP.

SRAF

Standard program SRAFs apply to these measures.

Follow-Up

2020 OEESC may change requirements for kitchen ventilation systems, reducing the current requirement for exhaust systems with >5000 CFM to something lower, but this would not likely impact retrofits.

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\Food Service\venthoods\venthood calculator]

OR-WA-CEC-2020-v
1.1 - 122 - Venthooc

Version History and Related Measures

Energy Trust has had retrofit offerings for demand controlled kitchen ventilation or efficient vent hoods for many years. These offerings predate our measure approval documentation and record retention policies. Table 4 may be incomplete, particularly for approvals prior to 2013.

Table 4 Version History

Date	Version	Reason for revision
12/12/2005	122.x	Approval to use a PG&E kitchen ventilation calculator tool
3/06/2009	122.x	Change to prescriptive measure, update costs, calculation methods, measure life and tempered air requirements.
10/17/2014	122.1	Change size requirements, change maximum incentives
7/05/2019	122.2	Update savings calculation methods, costs, maximum incentives, change size requirements, clarify partial territory configuration

Table 5 Related Measures

Measures	MAD ID
Demand Controlled Kitchen Ventilation Calculator tool	184

Approved & Reviewed by

Jackie Goss, PE
Sr. Planning Engineer

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EnergyTrust of Oregon

Measure Approval Document for Direct Install Smart Thermostats with Complimentary Funds

Valid Dates
June 12, 2019 – December 31, 2020

End Use or Description
The professional installation of qualified web-enabled thermostats where complimentary funding is provided by a utility, community-based organization or low-income agency as described in this document. This document does not approve a specific prescriptive installation scenario and costs but instead provides the bounds of incentives and participant payments that are cost effective when combined with eligible complimentary funding. Energy Trust expects each scenario to have unique costs, complimentary funding levels and installation parameters.

Web-enabled thermostats with occupancy detection provide energy savings through reduced run time of heating and/or cooling systems. Some models achieve additional savings when paired with heat pumps through changes in strip heat control.

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:

- Retrofit

Purpose of Re-Evaluating Measure
Update to allow for expansion of eligible complimentary funding agreements. Among the updates:

- Expanded eligibility to any complimentary funding applications conforming to cost effectiveness guidelines.
- Corrected and updated load profiles, including use of the new profile Res Space Conditioning where appropriate.
- Added gas only service territory measures.

Cost Effectiveness
Energy Trust has received guidance from the Oregon PUC that complimentary funding may be subtracted from the incremental cost of a measure, and the remaining cost used in the cost effectiveness calculations. For this measure, we anticipate this will be most often understood as the customer payment plus Energy Trust incentive.

Total cost = Customer Payment + Supplemental Funding + Energy Trust Incentive

Remaining cost = Total Cost - Supplemental Funding = Customer Payment + Energy Trust Incentive

For each heating system type, the remaining cost column in the cost effectiveness tables indicates the maximum remaining cost after complementary funding that is cost effective.

Table 1 Cost Effectiveness Calculator Oregon

Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Max Remaining Costs ($)	Total NEB (Annual $)	Max Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Ele Allo	% Gas Allo
SF DI Tstat gFAF w/CAC - Comp Funding	11	46	35	$261	$0.00	$261	1.0	1.0	26%	74%
SF DI Tstat gFAF - Comp Funding	11	17	35	$207	$0.00	$207	1.0	1.0	6%	94%
SF DI Tstat gFAF - Gas Only - Comp Funding	11	0	35	$211	$1.99	$194	1.0	1.0	0%	100%
SF DI Tstat eFAF w/CAC - Comp Funding	11	389	0.0	$339	$0.00	$339	1.0	1.0	100%	0%
SF DI Tstat eFAF - Comp Funding	11	360	0.0	$274	$0.00	$274	1.0	1.0	100%	0%
SF DI Tstat ASHP - Comp Funding	11	594	0.0	$517	$0.00	$517	1.0	1.0	100%	0%
MF DI Tstat gFAF w/CAC - Comp Funding	11	36	27.5	$205	$0.00	$205	1.0	1.0	26%	74%
MF DI Tstat gFAF - Comp Funding	11	13	27.5	$162	$0.00	$162	1.0	1.0	6%	94%
MF DI Tstat gFAF - Gas Only - Comp Funding	11	0	27.5	$166	$1.56	$152	1.0	1.0	0%	100%
MF DI Tstat eFAF w/CAC - Comp Funding	11	306	0.0	$266	$0.00	$266	1.0	1.0	100%	0%
MF DI Tstat eFAF - Comp Funding	11	282	0.0	$215	$0.00	$215	1.0	1.0	100%	0%
MF DI Tstat ASHP - Comp Funding	11	467	0.0	$406	$0.00	$406	1.0	1.0	100%	0%

Table 2 Cost Effectiveness Calculator Washington

Measure	Measure Life (years)	Not-Claimed Savings (kWh)	Savings (therms)	Max Remaining Costs ($)	Total NEB (Annual $)	Max Incentive ($)	UCT BCR at Max Incentive	TRC BCR
SF SWWA DI Tstat gFAF w/CAC - Comp Funding	11	46	35	$301	$3.78	$271	1.00	1.00
SF SWWA DI Tstat gFAF - Comp Funding	11	17	35	$282	$1.37	$271	1.00	1.00
MF SWWA DI Tstat gFAF w/CAC - Comp Funding	11	36	27.5	$237	$2.97	$213	1.00	1.00
MF SWWA DI Tstat gFAF - Comp Funding	11	13	27.5	$222	$1.07	$213	1.00	1.00

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.[1] To allow use of this measure in homes with gas furnaces and central AC at a remaining cost of $250. *This exception is only for installations as a part of PGE's residential thermostat direct install program*, *RTDIP.*

[1] Granted Measure Exceptions Library, August 30, 2018. Fwd Approval of Minor Measure Exception for the Direct Install Programmable Thermostats in Gas-Heated Homes

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.

This exception was granted for two years or until the measure becomes greater than five percent of the Program's savings or the TRC drops, with an expiration date of August 30, 2020. Non-cost effective measures must be discontinued at that time unless further exceptions are approved.

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 was 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 required 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. This workshop was held on 2/15/2019.
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. That report will be presented by 8/30/2019.

The cost effectiveness of the PGE gas furnace with central AC measures are shown in Table 3. The single family gas forced air furnace with Central AC is now cost effective while the multifamily version of the measure is still under the exception August 30, through 2020. Improvements in cost effectiveness are due to changes to avoided costs and an updated load profile that represents both heating and cooling savings.

Table 3 PGE RTDIP Cost Effectiveness for Measures Under OPUC Exception

Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Remaining Cost	Current 2019 BCR	BCR at Time of Exception
PGE SF DI Tstat gFAF w/CAC	11	46	35	$250	1.04	0.65
PGE MF DI Tstat gFAF w/CAC	11	36	27.5	$250	0.82	0.51

Requirements

- Thermostats must be on the Smart Thermostat qualified products list.
- Home must be heated with fuel provided by a participating Energy Trust utility.
- Internal Energy Trust Program staff must review each proposed application of these measures to ensure compliance with OPUC direction on measures utilizing other funding sources.
- The following equation describe the limits cost effectiveness eligibility for any complimentary funding agreement as shown in Table 1and Table 2. Any complimentary funding arrangements which do not conform to this equation are not approved through this MAD. Those agreements would require an OPUC exception specific to that funding model and measure.

$$\text{Max Remaining Cost} \geq \text{Energy Trust Incentive} + \text{Customer Payment}$$

Baseline

This measure uses an Existing Condition Baseline.

The baseline for this measure is an existing programmable or manual thermostat. There is reasonable certainty that homes will not have an existing qualified thermostat under the assumption that a complimentary funding entity would not pay for the installation of a second qualified thermostat.

Savings and Measure Analysis

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

Table 4 Savings Estimates and Non-Energy Benefits by Heating and Cooling System Combinations

Housing Type	Installation Scenario	Heating Savings		Cooling Savings	Total Claimed Electric Savings	Total Gas Savings	NEBs
		kWh	Therms	kWh	kWh	Therms	Annual $
Single Family	Gas Furnace with CAC	17	35	30	46	35	
Single Family	Gas Furnace (no CAC)	17	35	0	17	35	
Single Family	Gas Furnace (no CAC) Gas Only	17	35	0	0	35	$1.99
Single Family	Electric Furnace with AC	360	0	30	389	0	
Single Family	Electric Furnace (no CAC)	360	0	0	360	0	
Single Family	Heat Pump	not disaggregated	0	not disaggregated	594	0	
Multifamily	Gas Furnace with CAC	13	27.5	23	36	27.5	
Multifamily	Gas Furnace (no CAC)	13	27.5	0	13	27.5	
Multifamily	Gas Furnace (no CAC) Gas Only	13	27.5	0	0	27.5	$1.56
Multifamily	Electric Furnace with AC	282	0	23	306	0	
Multifamily	Electric Furnace (no CAC)	282	0	0	282	0	
Multifamily	Heat Pump	not disaggregated	0	not disaggregated	467	0	

Baseline loads for heating and cooling

For single family homes, the average annual heating loads are derived from the 2011 RBSA.[2] 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 2 and are used for electric furnace and gas furnace heated homes in this analysis. The heating load for heat pump homes are sourced from Energy Trust's follow up billing analysis from the 2013-2014 Nest thermostat pilot evaluation.[3]

[2] 2011 RBSA: Single Family Characteristics and Energy Use. Ecotope, 2012. https://neea.org/resources/2011-rbsa-single-family-characteristics-and-energy-use
[3] *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

Cooling loads are less well established, however the same Nest pilot evaluation found 200 kWh of cooling usage while the 2016 summer Seasonal Savings billing analysis found 787 kWh of Portland summer cooling load, which straddles cooling zones 1 and 2.[4] 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 workbook v1.3.[5] 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, a factor of 0.79, was applied to the single family average gas heating load of 583 therms resulting in an estimated multifamily gas heating load of 458 therms.

Heating savings
This measure utilizes a six percent savings rate Energy Trust's gas thermostat pilot[6]. Heat pump savings of 594 kWh are based on findings in Energy Trust's 2014 Nest thermostat pilot billing analysis.

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 six percent, equivalent to gas heating load savings.

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

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 cooling equipment is present savings as a percent of load are assumed to be the same as forced air furnace heating load savings of six percent.

Install rate
All thermostats will be direct-installed by a contractor or other qualified installer and a 100% installation rate will be used.

Comparison to RTF or other programs
Energy Trust uses a longer measure life than the RTF and includes gas heated measures which are not included in the RTF workbooks. RTF analysis identifies specific heating zone measures whereas this Energy Trust blends all zones together for thermostat measures.

This offer differs from the standard Energy Trust retail smart thermoset measure in several ways. First, the retail measure, approved in MAD 153, blends all electric heating systems together due to uncertainties in heating system reporting. This measure specifies direct installation of thermostats providing greater certainty in heating, and cooling, system reporting of the home. Second, the retail measure does not include installation costs or complementary funding.

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

Cost
Costs for each thermostat installation will vary based on the detail of complimentary funding agreements. Similar to other retrofit measures, the actual cost for specific program efforts will be recorded in Project Tracker and used to screen for program level cost effectiveness at year end.

Costs unrelated to energy efficiency intervention
Costs incurred during a thermostat installation unrelated to energy efficiency may be excluded from the total cost for purposes of calculating remaining cost. *These exclusions must be approved by Energy Trust Program staff*. In these instances, the incidental costs must be made up via additional qualifying non-rate payer complimentary funds or through participant payments.

Non Energy Benefits
In both Oregon and Washington, unclaimed electric savings are included as non-energy benefits valued at the retail rate of electricity for those territories ($0.119/kWh OR, $0.082/kWh SW WA).

Incentive Structure
The maximum incentives listed in ***Error! Reference source not found.*** *and* ***Error! Reference source not found.*** *are for reference only and are not suggested incentives*. These values represent the maximum allowable Energy Trust incentive for offers that include complimentary funding.

Incentives will be determined for each specific application of this offering as the level of complimentary funding will vary between offers. Incentives will be paid per thermostat installed.

SRAF
No free-ridership SRAF components 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
- Additional impact evaluation results are expected in Q3-4 of 2019 and can be incorporated in the update of this MAD at its next update. To the extent possible, this MAD should be updated on the same schedule as MAD 153 since the offerings share much of the same assumptions and analysis.

[4] *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
[5] *RTF Connected Thermostats v1.3.* https://rtf.nwcouncil.org/measure/connected-thermostats
[6] *Energy Trust of Oregon Smart Thermostat Pilot Evaluation*. Apex Analytics, 2016 https://www.energytrust.org/wp-content/upload /2016/12/ Smart Thermostat Pilot_ Evaluation-Final_wSR.pdf

- 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 authorization. That report will be presented by 8/30/2019, marking one year from the exception.

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

DI Smart Tstat
Comp Fund - CEC 2(

Version History and Related Measures

Table 5 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.
6/12/2019	222.2	Expanded eligibility of MAD. Corrected load profiles. Added gas only service territory measures.

Table 6 Related Measures

Measures	MAD ID
Retail Web-Enabled Thermostats	153
Automated Thermostat Optimization	173
Residential Thermostat Optimization Pilot	217
Strip heat lock out for heat pumps	19
Contractor installed thermostats on heat pumps	148
Commercial DI thermostat pilot	235

Approved & Reviewed by

Jackie Goss, PE
Sr. Planning Engineer

Disclaimer

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Energy Trust of Oregon

Measure Approval Document for Direct Install and Washington Multifamily Showerheads and Shower Wands

Valid Dates
1/1/2020 – 12/31/2020

End Use or Description
Low flow showerheads and shower wands by direct install in Oregon single and multifamily. Low flow water devices save energy by reducing the volume of water that needs to be heated. Additionally, energy savings are generated from the reduction at water and wastewater (W/WW) treatment plants

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

Within these programs, applicability to the following building types or market segments or other program tracks are expected:
- In Oregon, direct install in Single Family or Multifamily
- In Washington, customer purchased is in qualifying commercial rate multifamily entities
- In Washington, leave-behind offering, the PMC (upon approved contract from Energy Trust) performs a walkthrough survey of eligible facilities to identify potential energy saving opportunities.

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

Purpose of Re-Evaluating Measure
Change expiration date. No changes to costs or savings.

Cost Effectiveness
Cost effusiveness in Oregon is demonstrated in Table 1. Cost effectiveness in Washington is demonstrated in 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	% Elec	% Gas
SF Direct Install 1.75 GPM Showerhead Any Electric	15	287	0.0	$12	$29.27	$12.00	19.9	46.1	100%	0%
SF Direct Install 1.75 GPM Showerhead Full Territory Gas	15	8	12.8	$12	$29.27	$12.00	6.7	32.9	8%	92%
SF Direct Install 1.75 GPM Showerhead Partial Territory Gas	15	0	12.8	$12	$30.02	$12.00	6.1	33.0	0%	100%
SF Direct Install 1.50 GPM Showerhead Any Electric	15	372	0.0	$12	$37.89	$12.00	25.8	59.7	100%	0%
SF Direct Install 1.50 GPM Showerhead Full Territory Gas	15	10	16.6	$12	$37.89	$12.00	8.6	42.5	8%	92%
SF Direct Install 1.50 GPM Showerhead Partial Territory Gas	15	0	16.6	$12	$38.85	$12.00	7.9	42.7	0%	100%
SF Direct Install 1.75 GPM Shower Wand Any Electric	15	285	0.0	$28	$29.01	$28.00	8.5	19.6	100%	0%
SF Direct Install 1.75 GPM Shower Wand Full Territory Gas	15	8	12.7	$28	$29.01	$28.00	2.8	14.0	8%	92%
SF Direct Install 1.75 GPM Shower Wand Partial Territory Gas	15	0	12.7	$28	$29.75	$28.00	2.6	14.0	0%	100%
SF Direct Install 1.50 GPM Shower Wand Any Electric	15	415	0.0	$28	$42.28	$28.00	12.3	28.5	100%	0%
SF Direct Install 1.50 GPM Shower Wand Full Territory Gas	15	12	18.5	$28	$42.28	$28.00	4.1	20.4	9%	91%
SF Direct Install 1.50 GPM Shower Wand Partial Territory Gas	15	0	18.5	$28	$43.36	$28.00	3.8	20.4	0%	100%
MH Direct Install 1.75 GPM Showerhead Any Electric	15	333	0.0	$12	$33.96	$12.00	23.1	53.5	100%	0%
MH Direct Install 1.75 GPM Showerhead Full Territory Gas	15	9	14.9	$12	$33.96	$12.00	7.7	38.1	8%	92%
MH Direct Install 1.75 GPM Showerhead Partial Territory Gas	15	0	14.9	$12	$34.83	$12.00	7.1	38.3	0%	100%
MH Direct Install 1.50 GPM Showerhead Any Electric	15	411	0.0	$12	$41.88	$12.00	28.5	66.0	100%	0%
MH Direct Install 1.50 GPM Showerhead Full Territory Gas	15	12	18.4	$12	$41.88	$12.00	9.6	47.1	9%	91%
MH Direct Install 1.50 GPM Showerhead Partial Territory Gas	15	0	18.4	$12	$42.95	$12.00	8.8	47.2	0%	100%
MH Direct Install 1.75 GPM Shower Wand Any Electric	15	330	0.0	$28	$33.57	$28.00	9.8	22.7	100%	0%
MH Direct Install 1.75 GPM Shower Wand Full Territory Gas	15	9	14.7	$28	$33.57	$28.00	3.3	16.1	8%	92%
MH Direct Install 1.75 GPM Shower Wand Partial Territory Gas	15	0	14.7	$28	$34.43	$28.00	3.0	16.2	0%	100%
MH Direct Install 1.50 GPM Shower Wand Any Electric	15	449	0.0	$28	$45.77	$28.00	13.3	30.9	100%	0%
MH Direct Install 1.50 GPM Shower Wand Full Territory Gas	15	13	20.1	$28	$45.77	$28.00	4.5	22.0	9%	91%
MH Direct Install 1.50 GPM Shower Wand Partial Territory Gas	15	0	20.1	$28	$46.94	$28.00	4.1	22.1	0%	100%
MF Direct Install 1.50 GPM Showerhead Any Electric	15	340	0.0	$12	$34.61	$12.00	23.6	54.5	100%	0%
MF Direct Install 1.50 GPM Showerhead Full Territory Gas	15	10	15.2	$12	$34.61	$12.00	7.9	38.9	9%	91%
MF Direct Install 1.50 GPM Showerhead Partial Territory Gas	15	0	15.2	$12	$35.50	$12.00	7.2	39.0	0%	100%
MF Direct Install 1.50 GPM Shower Wand Any Electric	15	250	0.0	$28	$25.47	$28.00	7.4	17.2	100%	0%
MF Direct Install 1.50 GPM Shower Wand Full Territory Gas	15	7	11.2	$28	$25.47	$28.00	2.5	12.3	8%	92%
MF Direct Install 1.50 GPM Shower Wand Partial Territory Gas	15	0	11.2	$28	$26.12	$28.00	2.3	12.3	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	% Elec	% Gas
WA Customer Purchase MF Gas 1 75 GPM Showerhead	15	0	9.8	$7.14	$13.80	$7.14	8.5	27.8	0%	100%
WA Customer Purchase MF Gas 1 50 GPM Showerhead	15	0	13.5	$7.14	$18.91	$7.14	11.8	38.1	0%	100%
WA Customer Purchase MF Gas 1 75 GPM Shower Wand	15	0	4.3	$7.14	$6.04	$7.14	3.7	12.2	0%	100%
WA Customer Purchase MF Gas 1 50 GPM Shower Wand	15	0	9.9	$7.14	$13.92	$7.14	8.6	28.0	0%	100%
WA Leave Behind MF Gas 1 75 GPM Showerhead	15	0	7.4	$12.00	$13.80	$12.00	3.8	15.3	0%	100%
WA Leave Behind MF Gas 1 50 GPM Showerhead	15	0	10.1	$12.00	$18.91	$12.00	5.2	20.9	0%	100%
WA Leave Behind MF Gas 1 75 GPM Shower Wand	15	0	3.2	$28.00	$6.04	$19.90	1.0	2.9	0%	100%
WA Leave Behind MF Gas 1 50 GPM Shower Wand	15	0	7.4	$28.00	$13.92	$28.00	1.6	6.6	0%	100%

Requirements

- Water heating fuel must be provided by an Energy Trust Utility
- 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

Baseline

This measure uses a:

- Existing Condition Baseline

The Oregon Existing Multifamily program screens 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 through on-site verification. Therefore, the baseline flow rate is higher than in other programs

The residential Programs and Washington Multifamily program do not perform as extensive screening and therefore a baseline that includes more efficient products in their baseline.

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%
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] It should be noted that the RTF has released an updated workbook v4.2 that was not released in time for inclusion in this analysis.

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)]

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	Energy Intensity (kWh/gallon)	Energy Intensity (therms/gallon)
Electric Resistance	1.00	75	52.5	0.128	
Electric HPWH	2.00	75	52.5	0.064	
Gas	0.75	75	52.5		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
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.

[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

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 of SF (events/yr)	Event duration (minutes/event)	End-use energy intensity (kWh or therms/gal)	W/WW energy intensity (kWh/gal)	W/WW cost, net of energy cost ($/gal)
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

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

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 savings calculation for Oregon electric showerhead measures in the direct install track. An installation rate of 90% is applied to savings in all sectors. In Washington, since the measure is customer-installed, a 60% installation rate is used.

Table 10 Example Savings Calculation for Oregon Direct Install 1.75 gpm Showerheads

Territory	Water Heat Type	Energy DHW (therms or kwh/yr)	Water (gal/yr)	W/WW Energy (kWh/yr)	W/WW cost ($/yr)	Energy DHW (therms or kwh/yr)	Water (gal/yr)	W/WW Energy (kWh/yr)	W/WW cost ($/yr)	Total kWh savings (kWh/yr)	Total savings (therms/yr)	Final NEBs
		Baseline				**Measure**						
Full	Any Electric	1,022 kwh	8,053	30	$107.10	711 kwh	5,607	21	$74.58	287	-	$29.27
Full	Gas	47 therm	8,053	30	$107.10	33 therm	5,607	21	$74.58	8	12.8	$29.27
Partial	Gas	47 therm	8,053	30	$107.10	33 therm	5,607	21	$74.58	0	12.8	$30.02

Comparison to RTF or other programs

All comparisons below are relative the v3.1 RTF workbook and not the latest v4.2 workbook.

- 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 agreed to by PMC and Energy Trust Program staff including 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
The RTF v4.2 workbook should be considered for inclusion in the next update.

Inputs most likely to change:
- Potential occupancy per dwelling type updates from American Community Survey (this analysis 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\bencost\Direct Install

157 DI SH and SW 2020.xlsx

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

Version History and Related Measures
Energy Trust has been offering showerhead measures for many years. These offers predate our measure approval documentation practices and our record retention timelines. Table 11 may be incomplete, particularly for offers prior to 2013.

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, 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
7/22/19	157.5	Extend expiration date.

Table 12 Related Measures

Measures	MAD ID
Retail showerheads and wands	26
Commercial showerheads	77
Direct install and Washington Aerators	51
New Buildings and New Multifamily showerheads	144
Energy Saver Kit (includes showerheads and wands)	27
New Homes showerheads and wands (not active)	131
Retail shower wands, additional sizes (not active)	156
Living Wise Kit (includes showerhead) (not active)	30
Carry Home Savings Kit (includes showerhead) (not active)	154
Community Event and Utility Give Away (includes showerhead) (not active)	155
Leave-behind showerhead and wands single family Washington only (not active)	43

Approved & Reviewed by

Kenji Spielman
Planning Engineer

Jackie Goss, PE
Sr. Planning Engineer

Disclaimer

Measure Approval Document for Energy Saver Kits

Valid Dates
January 1, 2020 through December 31, 2020

End Use or Description
Energy Saver Kits – Package LED lighting and water devices that customer can request online to be mailed for self-install.

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

Purpose of Re-Evaluating Measure
- Showerheads and wands
  - Administrative update
- Aerators:
  - Administrative update
- LED measures:
  - savings, incentive levels and non-energy benefits updated based on market analysis of baselines.
  - HVAC interactions and non-energy benefits from future avoided purchase of lamps are now included in the analysis.
  - The baseline is adjusted from market to direct install.

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	% Ele	% Gas
OR By Request Showerhead - Full Territory Any Electric 1.75 GPM	15	177	0.00	$7.00	$17.99	$7.00	21.0	48.6	100%	0%
OR By Request Showerhead - Full Territory Any Electric 1.50 GPM	15	212	0.00	$7.00	$21.60	$7.00	25.2	58.3	100%	0%
OR By Request Showerhead - Full Territory Gas 1.75 GPM	15	5	7.90	$7.00	$18.02	$7.00	7.1	34.7	8%	92%
OR By Request Showerhead - Full Territory Gas 1.50 GPM	15	6	9.48	$7.00	$21.63	$7.00	8.5	41.7	8%	92%
OR By Request Showerhead - Partial Territory Gas 1.75 GPM	15	0	7.90	$7.00	$18.48	$7.00	6.5	34.8	0%	100%
OR By Request Showerhead - Partial Territory Gas 1.50 GPM	15	0	9.48	$7.00	$22.19	$7.00	7.8	41.8	0%	100%
OR By Request Shower Wand - Full Territory Any Electric 1.75 GPM	15	150	0.00	$12.00	$15.25	$12.00	10.4	24.0	100%	0%
OR By Request Shower Wand - Full Territory Any Electric 1.50 GPM	15	240	0.00	$12.00	$24.40	$12.00	16.6	38.4	100%	0%
OR By Request Shower Wand - Full Territory Gas 1.75 GPM	15	5	7.66	$12.00	$17.47	$12.00	4.0	19.6	8%	92%
OR By Request Shower Wand - Full Territory Gas 1.50 GPM	15	7	11.67	$12.00	$26.62	$12.00	6.1	29.9	8%	92%
OR By Request Shower Wand - Partial Territory Gas 1.75 GPM	15	0	7.66	$12.00	$17.92	$12.00	3.7	19.7	0%	100%
OR By Request Shower Wand - Partial Territory Gas 1.50 GPM	15	0	11.67	$12.00	$27.30	$12.00	5.6	30.0	0%	100%
OR By Request Bathroom Aerator 1 GPM ELE	15	26	0.00	$1.35	$4.13	$1.35	16.1	49.0	100%	0%
OR By Request Bathroom Aerator 1 GPM GAS	15	1	1.14	$1.35	$4.13	$1.35	5.5	38.4	13%	87%
OR By Request Bathroom Aerator 1 GPM Partial Territory Gas	15	0	1.14	$1.35	$4.24	$1.35	4.8	38.6	0%	100%
OR By Request Kitchen Aerator 1.5 GPM ELE	15	32	0.00	$1.85	$4.24	$1.85	14.5	39.1	100%	0%
OR By Request Kitchen Aerator 1.5 GPM Gas	15	1	1.42	$1.85	$4.24	$1.85	4.9	29.5	11%	89%
OR By Request Kitchen Aerator 1.5 GPM Partial Territory Gas	15	0	1.42	$1.85	$4.35	$1.85	4.4	29.6	0%	100%
By Request General Purpose and Three-Way 250 to 1049 lumens	12	5.3	(0.05)	$2.91	$0.20	$2.91	1.2	1.8	100%	0%
By Request Reflectors and Outdoor 250 to 1049 lumens	12	7.9	(0.06)	$2.50	$0.49	$2.50	2.0	3.8	100%	0%

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
WA By Request Showerhead - Partial Territory Gas 1.75 GPM	15		8.19	$7.00	$15.32	$7.00	7.3	29.0
WA By Request Showerhead - Partial Territory Gas 1.50 GPM	15		9.93	$7.00	$18.56	$7.00	8.8	35.2
WA By Request Shower Wand - Partial Territory Gas 1.75 GPM	15		7.90	$12.00	$14.77	$12.00	4.1	16.3
WA By Request Shower Wand - Partial Territory Gas 1.50 GPM	15		12.23	$12.00	$22.86	$12.00	6.3	25.3
WA By Request Bathroom Aerator 1 GPM Partial Territory Gas	15		1.14	$1.35	$3.39	$1.35	5.3	30.2
WA By Request Kitchen Aerator 1.5 GPM Partial Territory Gas	15		1.42	$1.85	$3.47	$1.85	4.8	23.4

Requirements
- The maximum number of products distributed in each kit shall be determined by PMC program staff in consultation with Energy Trust.
- In gas-only service territory, showerheads and aerators should only be distributed to customers with gas water heating.
- In electric only service territory, showerheads and aerators should only be distributed to customers with electric water heat.
- Lighting products should not be distributed in gas-only service territory.

- 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.
- General purpose bulbs must be 9 W or less, reflectors must be 8 W or less.
- Bulbs should only be distributed to homes where they are expected to replace incandescent or halogen bulbs.

Baseline

Showerheads and wands

These measures use an Existing Condition Baseline.

Table 3 contains the baseline flow rate distributions by housing type. 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.[1] (72% showerhead, 28% wand). Flow rates are then weighted by housing type based on surveys conducted in 2018 by Energy Trust and shown in Table 4 to determine baseline flow rates.

Table 3 RBSA I and Multifamily Field Test Distribution of Showerhead/Wand Flow Rate Distributions by Housing Type

	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**
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 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%				

Aerators

These measures use and Existing Condition baseline.

For aerators, 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 as shown in Table 5.

Table 5 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%
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	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%
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%

LED measures

These measure use Early Retirement Baseline.

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.[2] The workbook models a shift in the baseline energy usage over time as inefficient

[1] Energy Trust Multifamily Showerhead Study Report
[2] Energy Trust modified RTF Lighting workbook

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. Much more detailed description of the methodology is available on the RTF website.[3]

Showerheads and shower wands

Measure Analysis

Savings analysis is based on a modified version of the RTF's and commercial and residential showerhead workbook v3.1.[4]

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)]

Assumptions

Table 6 through Table 9Table 8 describe the various inputs used to estimate individual UECs for all combinations of baseline and efficient showerheads, with specific outputs presented in Table 10.

UECs are combined with existing distributions of flow rates by housing types from Table 3 to generate a weighted existing baseline energy consumption from which specific UECs for flow rates can be subtracted to generate unit energy savings, UESs, discussed in Table 12. These values are then multiplied by the installation rates found in Table 13 and weighted based on the housing type distribution found in Table 4.

Table 6 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.[5] Heat pump water heater recovery efficiency of 200% is an RTF judgement. Remaining values are RTF input assumptions and calculations.

Table 6 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 7 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).[6] 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 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 7 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 8 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 8 Showerheads per Dwelling, Total Showerheads and Occupancy per Housing Type

	SF	MH	MF	Weighted Avg
Oregon				
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 9 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).

[3] https://rtf.nwcouncil.org/measure/residential-lighting
[4] RTF Commercial and Residential Showerheads v3.1
[5] RTF Standard information workbook v2.6 (current SIW version as of this publication date is v3.2, but values remain the same).
[6] Aquacraft, Inc. Residential End Uses of Water

Table 9 Examples of Combined Inputs used for Oregon Single Family Showerhead Unit Energy Consumption Calculation

Showerhead Water Heater Type and Flow Rate	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.)	Water/ waste water cost, net of energy ($/gal.)
Electric Resistance 1.75 GPM	90%	402	8.9	0.128	0.0037	$0.013
Electric Resistance 1.50 GPM	88%	402	9.2	0.128	0.0037	$0.013
Electric HPWH 1.75 GPM	90%	402	8.9	0.064	0.0037	$0.013
Electric HPWH 1.50 GPM	88%	402	9.2	0.064	0.0037	$0.013
Gas 1.75 GPM	90%	402	8.9	0.0058	0.0037	$0.013
Gas 1.50 GPM	88%	402	9.2	0.0058	0.0037	$0.013

Table 10 Shows the UEC values based on the inputs from Table 9.

Table 10 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)	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 11 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 11 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 12 illustrates the calculation of water energy UESs for Oregon electric showerhead measures. The existing baseline distribution (Table 3) 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 13. These rates are applied to DHW, waste water and non-energy benefit values to determine final estimated savings.

Table 13 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%

Aerators

Measure Analysis

Analysis is based on a modified version the RTF's analysis of Aerators v1.1[7]. 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.

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

Assumptions

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 hot water usage was referenced from SBW studies on Single Family and Multifamily usage[8,9]. 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[10] on mixed water temperatures of kitchen and bathroom faucets, the simple calculation is shown below:

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

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

Regional RBSA II data is 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.

Water Savings and Embedded Energy

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).

Table 17 Oregon Kit Aerator Measures

Row Labels	Sum of Weighted Electric Savings (kWh)	Sum of Weighted Gas Savings (therms)	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 (kWh)	Sum of Weighted Gas Savings (therms)	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

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 13.

LEDs

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[11]. For brevity, only high level overview is provided.

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:
    - Bulb type
    - Lumen bin
    - Delivery channel

[8] 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.
[9] SBW Consulting, 1994. "Energy Efficient Showerhead and Faucet Aerator Metering Study: Multifamily Residences. Final Report." SBW Report Number 9408 for Bonneville Power Administration.
[10] Cadmus and Opinion Dynamics for the Michigan Evaluation Working Group, 2013. "Showerhead and Faucet Aerator Meter Study."
[11] https://www.bpa.gov/EE/Utility/research-archive/Documents/Momentum-Savings-Resources/Chain_Logic_Presentation.pdf

- 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.

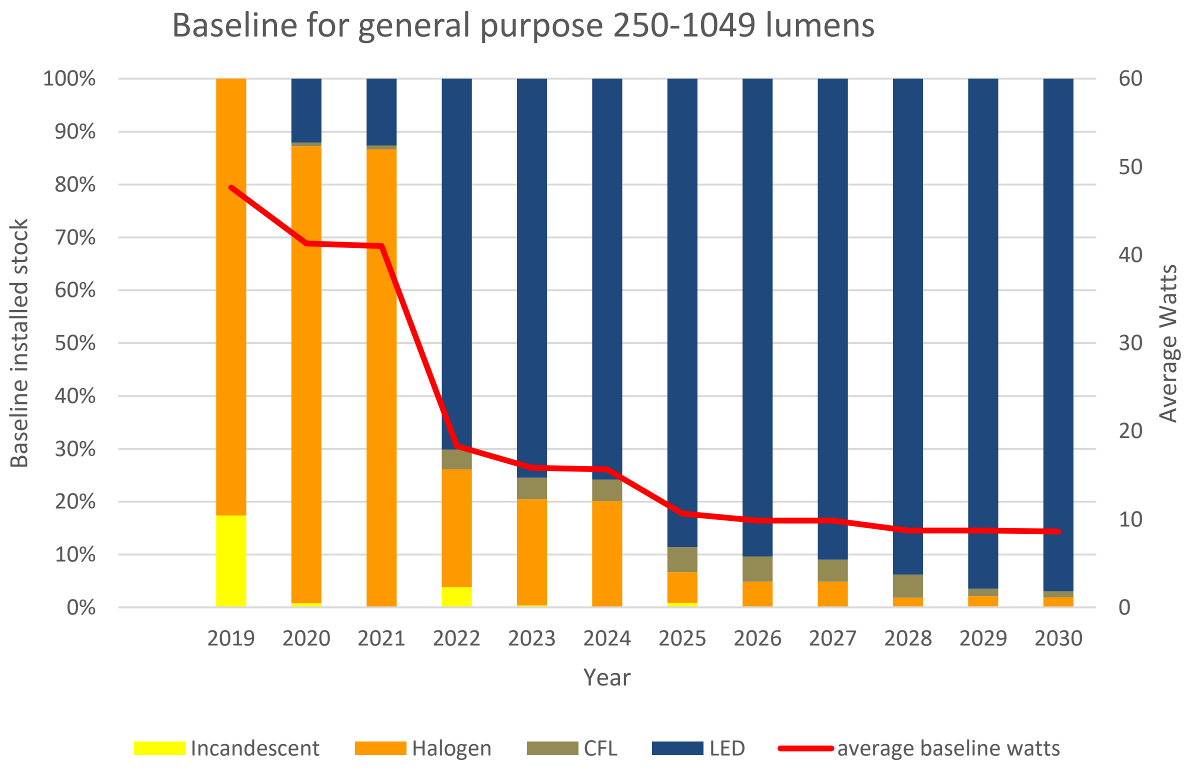
The RTF tool creates two distinct savings periods, pre-EISA and post EISA. For the purposes of cost-effectiveness testing for Energy Trust, final savings are a weighted average of savings estimated in each period based on their relative length of time within the 12-year measure life.

- Table 19 shows the savings values as well as HVAC interaction, full measure life average savings are used in this analysis.
- Installation rates identified in Table 13 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 (Therms)	Annualized lamp replacement savings (2017$)
By request General Purpose and Three-Way 250 to 1049 lumens	71%	6.07	(0.05)	$0.20
By request Reflectors and Outdoor 250 to 1049 lumens	73%	7.03	(0.06)	$0.49

Figure 1 Example baseline wattage



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.
- The baseline for “By Request” measures mimics direct install, as the online logic for choosing kit contents only selects bulbs for customers who have inefficient bulbs installed to replace.
- The final measure analysis tab is adjusted to match the anticipated program bulbs wattage.

Comparison to RTF or other programs

Showerheads and wands and aerators

Similar analysis is used across all Energy Trust residential and multifamily (new/existing) programs. Energy Trust has a few different assumptions than 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.
- RTF assumes a 10-year measure life.

LED Lamps

Similar analysis is used across all Energy Trust residential and multifamily (new/existing) programs. Energy Trust has a few different assumptions than RTF.

- For purposes of measure analysis, EISA 2020 is ignored.
- Based on program design the baseline for “By Request” measures is direct install instead of market baseline.

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 Table 1 and Table 2**.**

Non Energy Benefits

Showerheads and aerators

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

Combined water rates net of embedded electricity is 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.

Incentive Structure

The maximum incentives listed in Table 1 and Table 2 are for reference only and are not suggested incentives, if negotiated prices exceed maximum incentives, the measure must be re-approved. Incentives will be structured per device (e.g., showerhead/wand, aerator or LED lamp). These are provided directly to the kit vendor, and not to customers.

SRAF

Program SRAFs are applied to Energy Saver Kit components.

Follow-Up

Showerheads

At the next update, the measure life should be set to 10 years and the following should be reviewed and updated if newer information is available.

- Occupancy per dwelling type updates from American Community Survey
- 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).

Aerators

At the next update, the measure life should be set to 10 years and the following should be reviewed and updated if newer information is available.

- Occupancy per dwelling type updates from American Community Survey
- Data regarding constant duration vs. constant flow values.

LEDs

Energy Trust researches the lighting market baseline every six months which will likely result in shifts to the baseline product mix and alter savings and NEBs. 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

Energy Saver Kits 2020.xlsm

ResLighting_v7_1 ETO MOD ESK.xlsm

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
8/x/2019	27.6	Updated savings, NEBs and max incentives for bulbs based on new market data and a baseline change. Updated cost.

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

Disclaimer

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:

$$Fan\ kWh\ savings\ = \frac{(therm\ savings\ *\ 100{,}000 Btu/therm)}{input\ Btu/h} *\ fan\ input$$

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

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Measure Approval Document for Greenhouse Controllers

Valid Dates

1/1/2020 to 12/31/2022

End Use

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

Program Applicability

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

- Production Efficiency
- Existing Buildings in WA

Within these programs, applicability to the following building types are expected:

- Greenhouses

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

- Retrofit
- New

Purpose of Re-Evaluating Measure

Updated to test with 2020 avoided costs. No changes to savings or cost assumptions. Maximum incentive has been updated.

Cost Effectiveness

Table 1 Cost Effectiveness Calculator Oregon, per square foot

Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR
Greenhouse Controller Weighted average size/schedule	15	0.28	$0.58	$0.58	3.9	3.9

Table 2 Cost Effectiveness Calculator Washington, per square foot

Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR
Greenhouse Controller Weighted average size/schedule	15	0.28	$0.58	$0.58	5.7	5.7

Requirements

- Must use a single sensor or an average of multiple sensors
- Must have a minimum of two temperature stages in a 24-hour period (i.e. allow for night setback)
- Heating and ventilation appliances must be controlled by the same sensor or same average sensor value if multiple sensors are used

- Must allow for a dead-band zone of 5°F or greater between heating and ventilation events
- Must force a delay between heating and ventilation events
- Must have the ability to temporarily override set program temperatures
- Must control all active heating devices in the given greenhouse including all fans and automated ventilation systems when applicable
- Limited to a maximum size of 15,000 sq ft per controller
- House must be heated to at least 50 degrees for 30 or more days in a year

The requirement for a maximum size of 15,000 sq ft per controller is meant to account for and include several small-medium sized greenhouses are "gutter connected" together. In these cases, a single controller can still adequately handle the simple operation of HVAC systems within each greenhouse. Although it is not expected to occur frequently, this type of setup is lower cost because a single controller is handling a greater amount of square footage.

Details

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

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

Greenhouse controllers operate from a single control temperature (which could come from one temperature sensor or more than one sensor where the multiple temps are averaged). These relatively simple controllers can control heaters, fans, and vents and also allow for an automatic night-setback temperature.

Baseline

This measure uses a Full Market Baseline.

There are no codes that apply to the equipment relevant to this measure. Baseline assumes that 25% of small and medium sized greenhouses have controllers. Large greenhouses typically employ much more complex and robust control systems, and are therefore excluded from this offer.

Measure Analysis

To determine savings, three greenhouse sizes and three heating schedules were defined, based on an analysis from the Program Delivery Contractor's local greenhouse expert. They are shown in Table 3 and Table 4.

Table 3 Green House Sizes

Greenhouse Sizes		**Overall distribution**	**Small/Medium distribution**
Small	20' x 96' (1920 sq ft)	30%	40%
Medium	30' x 96' (2880 sq ft)	45%	60%
Large	60' x 96' (5760 sq ft)	25%	

Table 4 Typical Greenhouse Heating Schedules

Greenhouse heating schedules		Overall distribution	Small/Medium distribution
Minimum	50 degrees, January only	40%	
Medium	65 degrees, February thru May	35%	58%
Maximum	70 degrees, Year Round	25%	42%

Savings for each of the above scenarios was calculated using the Department of Agriculture's Virtual Grower Tool, a greenhouse energy modeling application which uses a variety of inputs including greenhouse materials, heating set points and Willamette valley weather data. A 5 degree night set back was used to represent a reasonable set point that would not be considered detrimental to plant growth. For this analysis, the assumption was that the temperature would start at 8pm and return to normal operating temperature at 8am.

Savings were estimated for each individual greenhouse size and heating schedule then weighted to predict what the program would typically encounter for a single measure offering across all greenhouse sizes and heating schedules. The final weighted savings were reduced by 25% to account for the market acceptance of controllers.

To determine the overall expected savings given the population of greenhouses within Energy Trust's service territory weighted averages are used. We assume 30% of the greenhouses are small, 45% are medium, and 25% are large. However, because small to medium-sized greenhouses are the primary targets of this only the population of small-medium size greenhouses are included. Within those size classes, 40% were assumed to be small and 60% were assumed to be medium, as shown in Table 3.

To weight the heating schedules, we assume the distribution of greenhouse heating schedules would be around 40% heating to the minimum schedule, 35% to the medium schedule, and 25% to the maximum schedule. These are based on PMC experience. However, because it is more common to use smaller greenhouses for high temperature plant propagation, and then move those plants to larger (somewhat cooler) houses later on, the adjusted weighting of 58% medium heat and 42% maximum heat was used in the analysis to represent only the small to medium-sized greenhouses as shown in Table 4.

Measure Life

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

Cost

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

To obtain a single weighted average incremental cost for the measure, the costs for each controller type were then weighted by the make-up of each greenhouses size, as discussed above. Finally, in all cases an additional $500 installation cost was added to the weighted average equipment cost on a square foot basis. An average incremental cost of $0.58 per square foot of greenhouse was used in the cost effectives testing, representing the weighted average of controller costs for the scenarios analyzed for this measure.

Incentive Structure

The maximum incentives listed in Table 1 and Table 2 are for reference only and are not suggested incentives. Incentives will be offered per square foot of conditioned square footage controlled by the controller. Incentives are not to exceed project costs.

While this measure is primarily used by the Production Efficiency program in Oregon, it may also be implemented by the Existing Buildings program in Washington, where EB has responsibility for industrial and agricultural gas projects including greenhouses. Alignment of incentives between the programs is recommended.

SRAF

Standard program SRAFs apply to this measure.

Follow-Up

The cost and sophistication of controllers targeted at small and medium greenhouses could change over time. The costs for this measure should be reevaluated if there are significant changes in the market of commonly available controllers intended for small and medium greenhouses.

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\Agriculture\greenhouse\Greenhouse Controllers]()

MAD
103.2-Greenhouse C

Version History and Related Measures

Energy Trust has been offering greenhouse measures for many years. These predate our measure approval documentation practices and our record retention timelines. Table 5 may be incomplete, particularly for activities prior to 2012.

Table 5 Version History

Date	Version	Reason for revision
7/08/2011	103.x	Introduce Greenhouse Controller measure
6/30/2014	103.1	Updated avoided costs, added EB in WA
6/3/2019	103.2	Updated avoided costs and maximum incentives

Table 6 Related Measures

Measures	MAD ID
Greenhouse Measures	104
Condensing Unit Heaters in Greenhouses	134

Approved & Reviewed by

Jackie Goss, PE
Sr. Planning Engineer

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Measure Approval Document for Greenhouse Measures

Valid Dates
1/1/2020 to 12/31/2022

End Use or Description
Greenhouse weatherization and heating measures

- IR Film Polyethylene Greenhouse Covers on inner walls reduces heating loads in greenhouses by reducing heat loss through the walls and ceiling.
- Greenhouse thermal curtains are typically designed to be deployed horizontally above the growing zone within a greenhouse.
- Under-Bench heating systems are an alternative to unit heaters for keeping plant root zones warm. Typically, these are hydronic systems.

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

- Production Efficiency
- Existing Buildings WA

Within these programs, applicability to the following building types are expected:

- Greenhouses

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

- Retrofit
- New, IR film and thermal curtain only

Purpose of Re-Evaluating Measure
Updated to test with 2020 avoided costs. No changes to savings or cost assumptions. Maximum incentives have been updated.

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
IR Poly Film (per SF of film)	4	0.23	$0.10	$0.10	4.2	4.2
Thermal Curtain (per SF space)	10	0.41	$1.17	$1.17	1.7	1.7
Under Bench Heating (per SF floor space)	12	1.25	$2.19	$2.19	3.4	3.4

Table 2 Cost Effectiveness Calculator Washington

Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR
IR Poly Film (per SF of film)	4	0.23	$0.10	$0.10	7.7	7.7
Thermal Curtain (per SF floor space)	10	0.41	$1.17	$1.17	2.7	2.7
Under Bench Heating (per SF floor space)	12	1.25	$2.19	$2.19	5.3	5.3

Requirements

IR Film Polyethylene Greenhouse Cover

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

Thermal Curtain

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

Under-Bench Heating

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

Baseline

This measure uses a

- Full Market Baseline for IR film and thermal curtains
- Existing Condition Baseline for under-bench heating

The baseline equipment consists of a representative single bay, 8,192 square foot greenhouse with an 80% efficient unit heater, no thermal curtain, and no IR film as outlined in ICF's greenhouse research piece[1]. There are no codes that apply to the equipment considered in these measures.

We assume IR film retrofits in the baseline of 16.8% of heated greenhouses based on experience of Cascade Energy. In the case of new construction thermal curtains, we assume the efficient equipment has minimal market share and new greenhouses are generally built without thermal curtains in the absence of incentives[2].

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[1] ICF International, (August 2007). *Natural Gas Energy Efficiency Measures for Greenhouses*
[2] Southern California Edison. (2009). *Greenhouse Thermal Curtains* (Work Paper PGECOAGR101 Ver00)

Measure Analysis

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

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

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

IR Film

IR film on inner walls reduces heating loads in greenhouses by reducing heat loss through the walls and ceiling. The greenhouse modeled had a double layer inflated polyethylene roof and walls. Both the inner and outer layers were assumed be 6 mill clear polyethylene for the baseline case. For modeling scenarios with IR film, the inner film was assumed to be IR enhanced (outer layer remained clear polyethylene). A floor area to film area ratio of 60% was applied to correlate the savings to the film surface area. That rate of efficient base case has is assumed to be to 16.8% based on analysis completed by Cascade Energy in 2009.

Thermal Curtain

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

Modeling showed the impact of adding thermal curtains and IR film as separate measures to the baseline greenhouse, as well as adding both measures. Alone, the addition of a thermal curtain reduced energy consumption in the models approximately 24%, 0.41 therms/sf.

Under-Bench Heating

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

For the eQUEST modeling it was assumed that the setpoint temperature can be reduced 7° F for an under-bench system, while still maintaining the same root zone temperature. This setpoint reduction contributes to 74% gas use reduction, 1.25 therms/sf.

Measure Life

IR Film

IR film is generally sold with a 1-year or 4-year lifetime expectation, the program requires products to have a 4-year expected life.

Thermal Curtains

Thermal curtain systems have can be considered in two parts, the mechanical support and control system and the curtain itself. Curtains are typically rated at 5 years, which is the typical manufacturer claim and the measure life in use in other areas. Distributers in our area indicate that 5-8 years is normal. However, the costs and baseline assumptions used in this analysis assume a new curtain system not a replacement and include the costs of the mechanicals. Mechanical portions of the system are expected to have a life exceeding 10 years. A measure life of 10 years is used, with the assumption that an additional curtain will be purchased within that time.

Under-Bench Heating

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

Cost

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

IR Film

IR film costs ranged from $0.06 to $0.22 with an average cost of $0.10 per sf. Only 2 projects were over $0.20. Even the most expensive installation is cost effective.

Thermal Curtains

Thermal curtains ranged from $0.26 to $2.63 per sf with an average cost of $0.90. Two projects over this period have been more expensive than the limits of the cost effectiveness test. These appear to be anomalous cases of particularly small greenhouses, which did not achieve an economy of scale for labor or shipping costs. On the low end of the cost range is a project whose invoice only includes the cost of the curtain and does not include the mechanical portion of the project cost. Conversation with the suppliers indicated that curtains account for approximately 40% of project cost. The cost of a replacement curtain was assumed for year six, and the present value of that cost ($0.27) added to the initial cost of the curtain and mechanicals, for a total of $1.17. $0.36/sf higher curtain-only invoice we have available to reference.

Under-bench Heating

Under-bench heating systems ranged from $0.89 to $5.00 per sf with the average cost of $2.16. All projects are within the cost effective range. This is a particularly large range because while savings are best measured on a per SF basis, the cost of the heating system is also defendant other variables such as spacing of growing benches and existing equipment on site.

Incentive Structure

The maximum incentives listed in Table 1 and Table 2 are for reference only and are not suggested incentives. IR film incentives are based on square footage of film, while thermal curtains and under-bench heating are based on conditioned floor area. Incentives are not to exceed project costs.

While this measure is primarily used by the Production Efficiency program in Oregon, it may also be implemented by the Existing Buildings program in Washington, where EB has responsibility for industrial and agricultural gas projects including greenhouses. Alignment of incentives between the programs is recommended.

Non-Energy Benefits

IR film and thermal curtains save electricity in addition to gas. The amount of electricity is too small per square foot to be processed or quantified reliably, about 0.1 kWh/sf. Customers in large sites may benefit from reduced electricity bills.

SRAF

Standard program SRAFs apply to this measure.

Follow-Up

New materials may become available that could extend the service life of the IR Poly measure. If these materials become common, the measure life for this measure should be reevaluated.

The prevalence of under-bench heating in the market baseline should be considered in the next update which could make that measure available to new construction

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\Agriculture\greenhouse\Greenhouse film curtains under bench

MAD
104.2-Greenhouse M

Version History and Related Measures

Energy Trust has been offering greenhouse measures for many years. These predate our measure approval documentation practices and our record retention timelines. Table 3 may be incomplete, particularly for activities prior to 2012.

Table 3 Version History

Date	Version	Reason for revision
11/2/2007	104.x	Introduce Greenhouse Measures
9/18/2014	104.x	Updated all measures, add existing buildings in Washington, removed unit heater
6/15/2015	104.1	Incremental cost update, update measure life
6/04/2019	104.2	Extend expiration date, update max incentives

Table 4 Related Measures

Measures	MAD ID
Greenhouse Controller	103
Condensing Unit Heaters in Greenhouses	134

Approved & Reviewed by

Jackie Goss, PE
Sr. Planning Engineer

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Measure Approval Document for Modulating Burners

Valid Dates
From 1/1/2020 to 12/31/2022.

End Use or Description
Modulating burner on HVAC boilers. Modulating burners reduce cycling losses and improve boiler efficiency.

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

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

- Retrofit

Purpose of Re-Evaluating Measure
Energy Trust ran a modulating boiler burner field test from 2016 through 2019 with the aim of understanding baseline conditions, costs and typical applications such as buildings types, hours of operation and setpoints. Within these years, participation in the field test was lower than expected and the program's incentive processing process did not include for pre-installation inspections or data collection. The measure is reevaluated to reflect data collected from five completed applications and includes updates to savings and cost.

- The hours for the educational buildings were reduced by nearly half.
- Baseline assumes half are dual stage and half are on/off control types. Previously, the on/off control type was not used in the analysis, but it was found that most of the projects have been replacing on/off burners.

Cost Effectiveness
The savings and costs in the following tables are per kBtu/h of burner rated capacity. Typical burners in commercial applications range from 1,000 kBtu/h to 25,000 kBtu/h.

Table 1 Cost Effectiveness Calculator Oregon

Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR
Modulating Burner	20	1.4	$9.50	$9.50	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
Modulating Burner	20	1.4	$9.50	$9.50	2.1	2.1

Requirements
- Burner must be installed on a natural gas-fired boiler on an eligible rate schedule
- Burner installation must be for space heating boilers
    - Boilers used for process heating, DHW or pool heat are not eligible.
- Modulating burner must have 5-to-1 turndown ratio or higher

- Modulating burner installation must meet either one of the specifications below:
  - Replacement of a dual stage burner
  - Replacement of an on-off burner
- May not be combined with condensing boiler measure. That measure assumes (but does not require) modulating burners.

Description

Modulating burner reduces cycling losses and improves boiler efficiency. Frequent cycling occurs for the boiler burners that operate in an on-off mode, or with a lower turndown burner. Frequent cycling reduces the overall thermal efficiency of the boiler.

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

Baseline

This measure uses an existing condition baseline.

The baseline equipment for this measure is a 50/50 blend of on/off and dual stage burners. A sample of 5 applications of the measure, 3 utilized on/off control and the other two did not report the control type.

Measure Analysis

An hourly bin analysis for Oregon climate in various cities was used. The heat load was determined for each temperature bin then used to calculate the gas required for a 5:1 burner as well as the two baseline types. The dynamic efficiencies of the boilers are calculated at each load rate and vary depending on control type and boiler type.

The following assumptions are used in the analysis:

- Correctly sized boilers for modulating burner applications
  - Min temp to determine max load, -10°F. This is a conservative assumption that accounts for oversizing.
- Baseline: 50/50 blend of on/off and dual-stage burner types
- Balance points: 55ºF/50ºF (occupied/unoccupied)
- Condensing boiler efficiencies: 88.2% at full fire, 88.8 % at low fire based on hot water return temperature at 140ºF.
- Non-condensing boiler efficiencies: 84% at full fire.
- Steam boiler efficiencies: 80% at full fire.
- 3% loss in efficiency between high and low fire is based on percent excess air increase at low fire, and efficiency is determined by using stoichiometric combustion analysis
- ΔT between hot water supply and hot water return: 40ºF in peak heating, 5ºF in mild heating

- Load factor at high fire: 90%
- A minimum dynamic thermal efficiency of 20% was applied in all boiler types. This prevents potentially exaggerated savings at very low rates of fire.
- Building occupancy hours are based on the data from CBECS (Commercial Buildings Energy Consumption Survey). Table 3**Error! Reference source not found.** shows the building types analyzed and the average occupancy hours.
- Setback during unoccupied period: 10ºF lower than the occupied temperature
- Heating start/stop: one hour before/after occupancy hours. In lodging applications, using 22 occupied hours results in 24 hour operation.
- Cities for hourly bin analysis: Portland, Newport, Bend, Pendleton, Klamath Falls

Table 3 Building Occupancy Hours

Building Types	Occupied Hours			Holidays/Closing
	Mon-Fri	Sat	Sun	
Office buildings	12	0	0	All public holidays
Lodging	22	22	22	
Public Assembly buildings	11	8	6	All public holidays
Education buildings	8	0	0	All public holidays, and when classes not in session

Dynamic Efficiency

The term Dynamic Efficiency is used to determine the net efficiency after considering the cycling losses. The dynamic efficiency decreases when short cycling occurs.

Efficiency of the non-condensing hot water boiler at high fire is assumed to be 84%, by using the specification of Parker boiler Model #T300LR to T3900LR. The efficiency of steam boiler at high fire is 80%, by using Parker boiler Models 102 and 103. The efficiency at low fire is assumed to be 3% drop from the high fire due to higher %O_2 and less heat transfer efficiency at low fire.

Lochinvar boiler Models Crest, Sync, Knight and XFTL were used to determine the efficiency of condensing hot water boiler. As opposed to the non-condensing hot water boiler, the dynamic efficiency of the condensing hot water boiler decreases with the increase in firing rate. This relates to the condensing point of the flue gases and the residual oxygen level to allow for the condensation to occur. The higher the hot water return temperature, the lower the efficiency. The average efficiencies with two different hot water return (HWR) temperatures are shown below in Table 4, based on the Lochinvar Boiler models.

Table 4 Condensing hot water boiler efficiencies

% fire	HWR temperature	
	120F % eff	140F % eff
5%	91.3%	88.8%
25%	90.8%	88.7%
50%	90.3%	88.4%
75%	90.2%	88.2%
100%	90.1%	88.2%

For the purpose of the analysis, 88.2% efficiency at full fire and 88.8 % at low fire are used, at 140ºF hot water return temperature are used. Using 140ºF hot water return temperature is considered to be conservative.

Radiation and Cycling Losses

Four-pass gas-fired Cleaverbrooks boiler specification is used to determine the losses.

Radiation and convection losses for 4-pass boiler are 1.6% of the input at low fire and 0.4% at high fire.

The cycling losses are estimated from the amount of hot gases being purged out during pre-purge and post-purge periods in each cycle. The volume of purged gas is estimated from the Cleaverbrooks 4-pass boiler design requirements. The pre and post-purge duration are approximately 60 sec and 15 sec respectively.

Figure 1 shows how the calculated dynamic efficiencies compare over the load spectrum. The floor of 20% is a conservative measure to prevent runaway values with very low efficiencies in the denominator during shoulder seasons.

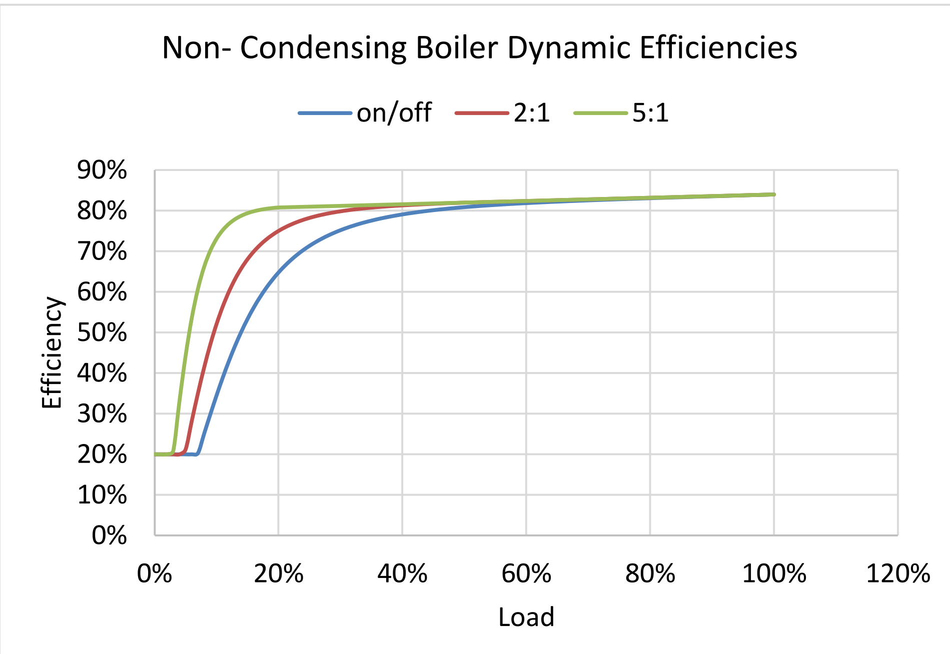

Figure 1 Dynamic efficiency inputs for non-condensing boilers

The savings are based on the weighted average results from the analysis for each city and building type and the average of the two baseline types. The resulting savings for a modulating burner is 1.4 therms per year per kBTU/h of burner rated capacity.

Measure Life

A standard equipment measure life of 20 years is used in the analysis to align with SEED program guidelines.[1]

[1] http://www.oregon.gov/energy/CONS/SEED/docs/AppendixJ.pdf

Cost

The cost for implementing this measure is valued at $9.5 per kBTU rated capacity. This value is the average of 14 observations between 2016 and 2019. Five of these are from the data collected on actual applications of the measure and the other 9 are from vendor estimations. The cost data covers a range from 1,000 kBTU to 25,000 kBTU applications and averages 10,000 kBTU.

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 kBtu/h of burner rated capacity.

Follow-Up

This measure should be reviewed at the end of the term for a cost update.

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\boilers\Modulating boiler burners

OR-WA-CEC-2020-v1.1 - MAD 142.xlsx

Mod burner_summary & (

Version History and Related Measures

Table 5 Version History

Date	Version	Reason for revision
9/8/2015	142.1	Introduce Modulating Boiler Burners as a field test
9/3/2019	142.2	Update savings and cost, transition to regular measure

Table 6 Related Measures

Measures	MAD ID
Commercial and Multifamily Boilers	88
Commercial Steam Traps	42

Approved & Reviewed by

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Measure Approval Document for Multifamily Condensing Tankless Water Heaters <200 kBtu/h

Valid Dates

January 1, 2020 – December 31, 2022

End Use or Description

Prescriptive measure for replacement of central domestic hot water (DHW) systems in Multifamily buildings.

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 Multifamily, Oregon
- Existing Buildings in Multifamily situations in Washington only
- New Buildings, Multifamily

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

- Stacked Multifamily structures

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

- Replacement
- New

Purpose of Re-Evaluating Measure

Savings have been updated based on past installation practices and updated occupancy information.

Measure requirements and analysis have been updated to use UEF instead of EF.

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
MF < 200 kBtuh Tankless Water Heater	15	132	$320	$320	2.4	2.4

Table 2 Cost Effectiveness Calculator Washington

Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR
MF < 200 kBtuh Tankless Water Heater	15	132	$320	$320	2.6	2.6

Requirements

- Stacked structures with central water heating
- Installation of condensing tankless water heaters with uniform energy factor (UEF) greater than or equal to 0.93

- Additional storage tanks are not added
- Input of 200 kBtu/h or less
    - Commercially sized equipment (>200 kBtu/h) is approved through MAD ID 72 with different savings and requirements.

Details

The practice of installing multiple residentially sized (typically 199.999 kBtu/h) tankless water heaters in parallel as a central domestic water heating system in multifamily buildings is relatively new and is displacing the use of more expensive domestic water boilers. This measure is designed to encourage the use of condensing tankless water heaters in such situations and discourage the addition of storage tanks which increase losses.

Baseline

This measure uses a code baseline

The baseline technology is a non-condensing tankless water heater (TWH) with UEF of 0.81. The savings from a condensing tankless water heater (CTWH) are generated by capturing latent heat from the combustion exhaust through condensation. All tankless water heaters are rated according to their energy factor which takes into account recovery efficiency, standby losses, and cycling losses.

Savings

System Sizing

For multi-unit tankless systems, sizing refers to the quantity of tankless water heaters in parallel rather than the capacity of the water heaters themselves or the volume of available storage. Since these systems have no storage to handle intermittent spikes in DHW demand, tankless systems are sized based on the expected peak demand per minute whereas storage systems are sized with respect to peak hourly demand. The number of dwelling units served by the system has a significant effect on system sizing. When the number of dwelling units is large, there is greater diversity in the time of water use which means that actual peak demand is much lower than total possible peak demand. In other words, as there are more water fixtures, the probability that they will be in use concurrently decreases due to the broader range of occupancy and usage patters of the tenants. This allows for a higher ratio of dwelling units served per water heater as building size increases.

The analysis used the modified Hunter's method[1] to determine appropriate sizing based on the number of water supply fixture units (WSFU) in typical multifamily installations. The modified Hunter's method provides WSFU values for typical equipment such as a shower, kitchen faucet, bathroom sink, etc. To determine the number of bathrooms in a typical apartment, it is assumed there will be a one-to-one ratio between bathrooms and bedrooms. The Multifamily RBSA II[2] lists 1.5 bedrooms on average for multifamily buildings in Oregon. These values were used to determine a peak demand which was used to determine the number of necessary water heaters in various sizes of multifamily buildings, as shown in Table 3 Summary of Sizing and Savings.

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[1] American Society of Heating, Refrigeration, and Air-conditioning Engineers, (2015) HVAC Applications.
[2] Regional Building Stock Assessment II Multifamily Homes Report 2016 – 2017. Northwest Energy Efficiency Alliance. Revised April 2019.

The previous analysis (MAD 196.3) assumed 40 dwelling units per building based on the DOE's Commercial Reference Buildings for midrise apartments. Based on program data captured through the past two years, the average unit number was 180 for users of this measure. Due to uncertainty in this value, the analysis uses 100 units as a basis for the calculations. To prevent the use of this measure in small multifamily buildings where savings (and cost effectiveness) are much lower, this offer is limited to stacked structures.

The analysis assumes a 70 degree F rise in water temperature based on an inlet temperature of 50 F and an outlet temperature of 120 F. The density of water is taken at 8.33 lb / gal and the specific heat is 1.00 Btu/lb * F. The baseline UEF is 0.81 and the efficient case is 0.93. The predominant tankless unit size will be 199.99 kBtu/h. Using the factors above results in a maximum gallons per minute (GPM) of 4.61 GPM for the base case and 5.29 GPM for the efficient case. These values are used in the system sizing analysis below.

Annual Domestic Hot Water Usage

The total domestic hot water consumption of a multifamily complex is calculated by using the DOE's Commercial Reference Building Models of the National Stock[3] calculated value for daily DHW demand of 44.0 gal/day/dwelling unit.

Table 3 Summary of Sizing and Savings

Dwelling Units	Min number of CTWH	Dwelling Units / CTWH	Savings / System (therms)	Max Savings / CTWH (therms)
2	1.89	1.06	30	16
4	2.65	1.51	60	23
5	2.84	1.76	75	26
10	3.97	2.52	149	38
15	4.92	3.05	224	46
20	5.48	3.65	299	54
25	6.05	4.13	373	62
30	6.43	4.67	448	70
35	6.81	5.14	522	77
40	7.18	5.57	597	83
45	7.56	5.95	672	89
50	7.94	6.30	746	94
100	11.34	8.82	1493	132
150	14.18	10.58	2239	158
300	22.69	13.22	4478	197

Measure Life

The measure life is 15 years which agrees with commercial tankless water heater measures offered by Energy Trust. For residential applications, the measure life is 20 years but the expected use in Multifamily is expected to bear more resemblance to commercial applications. The expected full load hours are considerably higher in commercial applications.

[3] U.S. Department of Energy Commercial Reference Building Models of the National Building Stock. February 2011. http://www.nrel.gov/docs/fy11osti/46861.pdf

Cost

The difference in material cost was determined by performing an online survey of prices from major manufacturers. Most manufacturer's offer both a TWH and CTWH option which allowed for a more representative cost across all manufacturers.

TWH's typically use stainless steel venting because of the higher exhaust gas temperatures. CTWH's have lower exhaust gas temperatures and use PVC venting which is less expensive. CTWH's require the installation of a condensate line. These costs were taken from a study by the California Statewide Utility Codes and Standards Program. This study is for residential applications but the costs are expected to be independent of market sector.

With all costs considered, the incremental cost is $320.

Non Energy Benefits

There are no Non Energy Benefits associated with this measure.

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 condensing tankless water heater.

Follow-Up

The previous MAD version noted that the prevalence of storage tanks should be monitored and the results included in this analysis. At present, there is still insufficient data to draw strong conclusions. It is suspected that savings are being under estimated for situations where a tank is installed, due to the higher expected full load hours for the units. The program will collect information regarding the prevalence of storage tanks and incorporate into the next update if feasible.

The program should continue to track participating building unit counts and unit/CTWH ratio.

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 Water Heating\gas tankless water heat\Multifamily Tankless less than 199

MF CTWH Less 200 kBtu CEC.xlsx

Version History and Related Measures

Table 4 Version History

Date	Version	Reason for revision
3/30/17	196.1	New measure
4/10/17	196.2	Include New Multifamily
1/25/18	196.3	Correct requirement to < 200 kBtu, to allow for 199.999 kBtu units
7/26/19	196.4	Adjusted assumed units per building and updated with RBSA II.

Table 5 Related Measures

Measures	MAD ID
Commercial and Multifamily Condensing Tankless >199 kBtu/h	72
Commercial and Multifamily Condensing Tank Water Heaters	21
Multifamily DHW Recirculation Demand Control	66
New Homes Tankless	178

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Measure Approval Document for Multifamily Pipe Insulation

Valid Dates

1/1/2020 – 12/31/2022

End Use or Description

Pipe insulation serves to reduce heat loss from uninsulated low pressure steam (LPS) or domestic hot water (DHW) piping.

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 Multifamily
- Existing Buildings in Washington, limited to multifamily sites served by that program

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

- Retrofit

Purpose of Re-Evaluating Measure

This analysis revises hours or operation for steam systems, corrects an error in the past analysis resulting in changes to saving. This update changes structure of measure to identify measures based on pipe diameter up to 4 inches, rather than an average across sizes.

Cost Effectiveness

Cost effectiveness for pipe insulation in Oregon and Washington is demonstrated in Table 1 and Table 2 respectively.

Table 1 Cost Effectiveness Calculator Oregon

Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR
3/4" DHW pipe insulated to 1.5"	15	2.3	$12.99	$12.99	1.0	1.0
1" DHW pipe insulated to 1.5"	15	2.8	$13.61	$13.61	1.2	1.2
2" DHW pipe insulated to 2"	15	4.9	$16.86	$16.86	1.7	1.7
3" DHW pipe insulated to 2"	15	6.9	$20.02	$20.02	2.0	2.0
4" DHW pipe insulated to 2"	15	8.7	$23.13	$23.13	2.2	2.2
3/4" LPS (<15 psig) pipe insulated to 1.5"	15	1.7	$12.99	$12.99	1.1	1.1
1" LPS (<15 psig) pipe insulated to 1.5"	15	2.1	$13.61	$13.61	1.3	1.3
2" LPS (<15 psig) pipe insulated to 2"	15	3.7	$16.86	$16.86	1.8	1.8
3" LPS (<15 psig) pipe insulated to 2"	15	5.2	$20.02	$20.02	2.1	2.1
4" LPS (<15 psig) pipe insulated to 2"	15	6.5	$23.13	$23.13	2.3	2.3

Table 2 Cost Effectiveness Calculator Washington

Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR
3/4" DHW pipe insulated to 1.5"	15	2.3	$12.99	$12.99	1.1	1.1
1" DHW pipe insulated to 1.5"	15	2.8	$13.61	$13.61	1.3	1.3
2" DHW pipe insulated to 2"	15	4.9	$16.86	$16.86	1.8	1.8
3" DHW pipe insulated to 2"	15	6.9	$20.02	$20.02	2.2	2.2
4" DHW pipe insulated to 2"	15	8.7	$23.13	$23.13	2.3	2.3
3/4" LPS (<15 psig) pipe insulated to 1.5"	15	1.7	$12.99	$12.99	1.4	1.4
1" LPS (<15 psig) pipe insulated to 1.5"	15	2.1	$13.61	$13.61	1.7	1.7
2" LPS (<15 psig) pipe insulated to 2"	15	3.7	$16.86	$16.86	2.3	2.3
3" LPS (<15 psig) pipe insulated to 2"	15	5.2	$20.02	$20.02	2.8	2.8
4" LPS (<15 psig) pipe insulated to 2"	15	6.5	$23.13	$23.13	3.0	3.0

Requirements

- Incentives and savings will be based on straight linear feet of pipe, not equivalent length. Therefore, fittings and pipe bends should not be accounted for in savings and incentive calculation.
- All Service Jacketing (ASJ) will be required for indoor pipe insulation projects, and aluminum jacketing for outdoor piping insulation projects to maintain the life of the insulation.
- Steam systems must be low pressure (<15 psig)
- Domestic Hot water must be central gas-fired systems with recirculation
- The following insulation thicknesses are required based on pipe size:
    - 1.5” pipe diameter or less – 1.5” minimum insulation thickness
    - Above 1.5” pipe diameter - 2” minimum insulation thickness

Details

The 2014 Energy Efficiency Specialty Code was referenced to determine insulation levels required for participation. The minimum insulation thickness for DHW pipes was set above code. The LPS insulation minimum thickness is below code due to feedback from the field indicating that code level insulation thicknesses were physically difficult to apply to existing pipe configurations in many cases. Since existing properties are not subject to code level requirements for insulation, this is not expected to be a barrier to installation and will ideally result in more applications becoming eligible for insulation measures.

Baseline

This measure uses an Existing Condition Baseline. The baseline is existing, uninsulated schedule 40 steel pipe.

Measure Analysis

Heat Transfer

Savings were based on a 2010 ICF study[1] on behalf of Energy Trust of Oregon that analyzed the impact of pipe insulation in commercial and industrial applications. The analysis looked at several different applications and their associated operating hours and fluid temperatures that would commonly be found at each facility. Table 3 is a summary of some of the analysis assumptions.

Table 3 Input Parameter Summary

Input Parameter	Value	Units
Boiler Efficiency	78%	N/A
Thermal conductivity, steel pipe (k)	314.4	Btu-in/hr-ft^2-F
Thermal conductivity, insulation (k)	0.29	Btu-in/hr-ft^2-F
Ambient Temperature	70	F
DHW Fluid Temperature Supply/Return	130/124	F
Steam Fluid Temperature Supply/Return	250/212	F
Steam pressure	15	Psig
Surface emittance, pipe (ε)	0.8	N/A
Surface emittance, insulation (ε)	0.8	N/A

The analysis assumes that 90% of pipes will be located indoors and 10% will be located outdoors. All indoor pipes were modeled with All Service Jacketing (ASJ) while all outdoor piping insulation was modeled with aluminum jacketing.

The study determined savings by using heat transfer engineering equations to model a horizontal pipe with internal fluid flow along with empirical relations for the necessary heat transfer coefficients. The following equation was used to determine heat loss from the pipe:

$$q = \frac{Q}{L} = \frac{\pi \Delta T}{R_1 + R_{pipe} + R_{ins} + R_2}$$

Where R_1 is the thermal resistance due to convection between the fluid and inside pipe surface:

$$R_1 = \frac{1}{h_1 D_1}$$

R_2 is the thermal resistance due to convection and radiation at the exterior insulation surface:

$$R_2 = \frac{1}{h_{3,c} D_3} + \frac{1}{h_{3,r} D_3}$$

Where $h_{3,c}$ and $h_{3,r}$ are the convection and radiation heat transfer coefficients respectively.

[1] Impact of Pipe Insulation on Natural Gas Consumption Commercial and Industrial Applications. April 2010. Prepared for Energy Trust of Oregon. ICF International Company. ICF Report No. 20902D.

R_{pipe} and R_{ins} are represented by:

$$R_{pipe} = \frac{\ln(\frac{D_2}{D_1})}{2k_{pipe}}$$

$$R_{ins} = \frac{\ln\left(\frac{D_3}{D_2}\right)}{2k_{ins}}$$

Where applicable, the following subscripts refer to:

1 – fluid to pipe inner diameter surface
2 – pipe outer diameter to insulation inner diameter surface
3 - insulation outer diameter to air surface

The equations above are solved using the following empirical relations:

$$h_1 = \left(\frac{k_{fluid}}{D_1}\right) Nu = \left(\frac{k_{fluid}}{D_1}\right) 23Re^{0.8}Pr^{\frac{1}{3}}$$

$$h_{3,c} = 0.503\left(\frac{\Delta T}{D}\right)^{\frac{1}{4}}$$

$$h_{3,r} = \frac{\varepsilon\sigma\left(T_{3,R}^4 - T_{air,R}^4\right)}{\Delta T}$$

Hours of Operation

The hours of use for low pressure steam systems was take as the average of the following three values:

- Case Study – Apartments A – estimated 2,014 effective full load hours (EFLH) based on billing data and estimated existing boiler efficiency for LPS
- Case Study – Apartments B – estimated 1,064 EFLH based on billing data and estimated existing boiler efficiency for LPS
- Contractor feedback and TMY3 data – estimated 954 EFLH based on contractor estimate of 5,000 hours of operation per year for LPS

The hours of use for domestic hot water systems was calculated based on expected usage hours from 6 AM to 10 PM.

Table 4 Hours of Use Summary

Application	Hours of Use
Low Pressure Steam	1,344
Domestic Hot Water	5,840

Comparison to RTF or other programs

Multifamily pipe insulation is not offered by the RTF. A similar measure exists for Energy Trust of Oregon's Industrial and Commercial sectors. In these sectors, savings are higher due to longer hours of use except for small commercial DHW. In these sectors, there is an offering for medium pressure steam which also has higher savings due to higher fluid temperature.

Measure Life

The 2007 ASHRAE Handbook assigns a 20 year measure life to molded insulation, and a 2005 DEER Database report referencing CALMAC data lists 15 years for pipe wrap. Although pipe insulation in high traffic areas would likely deteriorate faster than these estimates, the program assumes that OSHA requirements would already require pipe insulation (especially on steam systems) to be installed in these high exposure areas. Because insulation is rarely maintained and could potentially become damaged the program will require installing ASJ on indoor piping and aluminum jacketing on outdoor piping to ensure savings realization for the life of the measure.

A measure life of 15 years for multifamily pipe insulation was used in the cost effectiveness screening.

Cost

The installed cost of pipe insulation was determined by quotes received in 2012 from pipe insulation contractors in the Portland, Oregon area. Cost were based on providing preformed fiberglass pipe insulation which is assumed to be the most common type used. For insulation wrap, All Service Jacketing (ASJ) was quoted for piping located indoors, and aluminum jacketing was quoted for piping located outdoors. To determine an average cost for install, the analysis assumed that the physical location of the piping systems is a mixture of 90% ASJ (indoors) and 10% aluminum (outdoors). Cost excluded painting, pipe identification, overtime, and/or shift work.

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 linear foot of insulation.

SRAF

Typical SRAF rates apply.

Follow-Up

Cost should be reviewed during the next measure update. Any additional studies or evaluation results on multifamily pipe insulation should be evaluated for inclusion in the analysis.

For simplicity, this analysis does not include interactions with DHW circulation controls. If controls measures become increasingly common or are frequently installed at the same properties as pipe insulation, we should consider including interactive effects to either this measure or the controls measure and updating assumptions such as hours and other system characteristics to align.

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\Process Equipment\pipe insulation\multifamily pipe insulation

CEC MF Pipe Insulation.xlsx

Version History and Related Measures

Table 5 Version History

Date	Version	Reason for revision
02/08/2012	111.x	Introduce pipe insulation on LPS pipes in multifamily
11/28/2012	111.1	Add pipe insulation to DHW distribution systems. Updated hours of operation Changed average measure to only include pipes less than 2"
04/25/2019	111.2	Updated hours of operation, corrected error in analysis Removed average measure, now use distinct savings for each size

Table 6 Related Measures

Measures	MAD ID
Commercial and Industrial Pipe Insulation	91
Multifamily DHW re-circulation controls	66
Multifamily steam traps	40
Condensing tank water heaters (central DHW)	21
Multifamily condensing tankless <199 kBtu (central DHW)	196
Commercial condensing tankless >199 kBtu (central DHW)_	72

Approved & Reviewed by

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Measure Approval Document for Existing Multifamily Windows

Valid Dates
1/1/2020 – 12/31/2022

End Use or Description
Low U value windows reduce heat loss during the heating season and reduce heating from the environment during the cooling season.

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 Multifamily – stacked structures with more than 5 units

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

- Retrofit

Purpose of Re-Evaluating Measure
Measure analysis is updated to include cooling savings. Measure is no longer under exception.

Cost Effectiveness
Cost effectiveness for retrofit of single pane windows in multifamily buildings with electric heat is demonstrated in Table 1. Replacement of windows in gas heated buildings and replacement of double pane windows continue to be not cost effective and are not approved.

Table 1 Cost Effectiveness Calculator Oregon per square foot of window

Measure	Measure Life (years)	Savings (kWh)	Incremental Costs ($)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR
Single Pane Aluminum Frame to U < 0.30	45	8.8	$17.30	$17.30	1.2	1.2
Single Pane Wood Frame to U < 0.30	45	8.1	$17.30	$17.30	1.1	1.1
Single Pane Aluminum Frame with Storm Window to U < 0.30	45	8.4	$17.30	$17.30	1.1	1.1

Requirements
- Window retrofit with U-value of 0.30 or less
- Existing condition windows must be single pane aluminum or wood or single pane aluminum with removable storm windows
- Stacked structures with 5 or more units (windows in smaller multifamily applications are included in MAD 23)
- Buildings must use electric heat

Baseline
This measure uses an Existing Condition Baseline.

Windows in the multifamily market are a retrofit measure with an existing condition baseline. Multifamily market research conducted in 2013 found that few windows projects would take place without the Energy Trust incentive.

Measure Analysis

This analysis combines savings estimates from a partially calibrated Regional Technical Forum (RTF) model with previous savings estimates developed by using the equations created by Stellar Processes in 2010 which Energy Trust used between 2011 and 2016. The RTF model is accompanied by a limited set of heat load data, show in the section below, that gives us the minimum confidence needed to average the RTF's modelled savings with the Energy Trust's savings derived from billing analysis. Averaging the results of the two methods denotes our belief that, while Energy Trust's estimate is based on a larger set of building load data, the RTF estimate provides a useful second point of reference.

Stellar Processes Method

In 2010, Stellar Processes, under contract to the Energy Trust, built a spreadsheet calculator for multifamily weatherization measures based on their evaluation findings from a 2009 analysis of electric use data from energy bills. It calculates energy savings according to the following equations:

$$Savings\left(\frac{kwh}{sf}\right) = 5.85\ kWh * (U_{baseline} - U_{retrofit})$$

The equation is empirically derived from the savings achieved by buildings in the program that installed weatherization measures.

The assumed U-values for various window types are shown in Table 2.

Table 2 U-values for various window frames

Window Frame	U Value
Aluminum Frame – SG	1.17
Wood Frame	0.96
Aluminum Frame – DG	0.78
Vinyl	0.34

Regional Technical Forum (RTF) Method

On March 15, 2016, the RTF approved a research strategy for updating savings estimates for multifamily windows. A part of the strategy is a provisional estimate of savings and some initial investigation of how to calibrate their SEEM models with Variable Based Degree Day (VBDD) data. The RTF also compared their models to the available energy consumption data from the RBSA. Although more billing analysis will be needed to get a proven Unit Energy Savings (UES), the provisional estimate can be modified by the Calibration Test Results, done by the RTF and show in Figure 1.

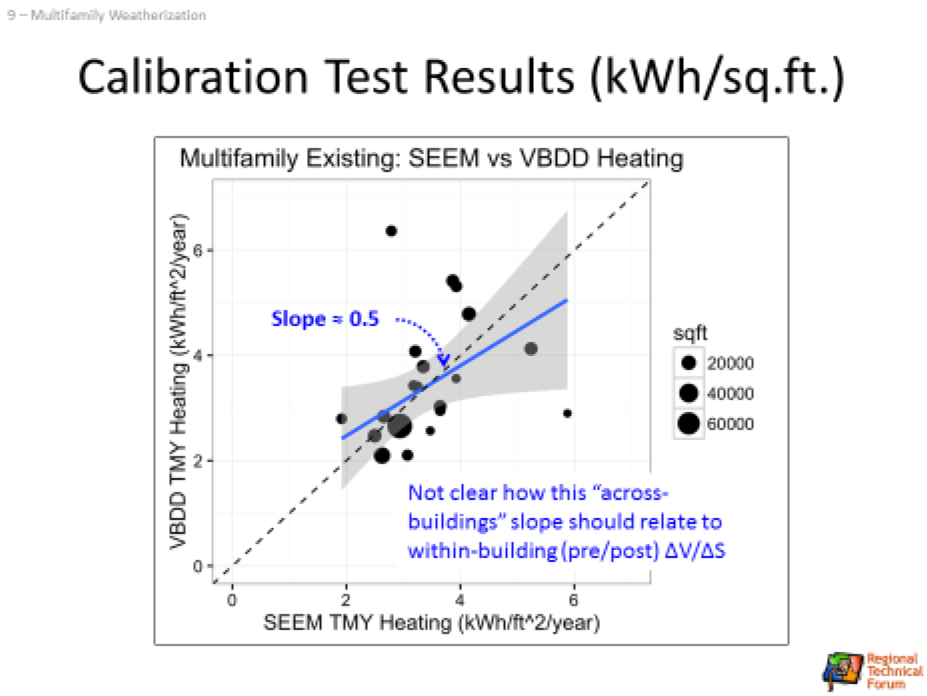

Figure 1 RTF Multifamily Window SEEM Calibration test results

The calibration results indicate that RTF's provisional savings estimates should be multiplied by 0.5. The comments within the figure indicate the RTF's reason for not considering the calibration to be complete without further billing data.

Average Results from the Two Methods

The provisional estimates and the initial calibration results are combined with Energy Trust's previous savings estimates as shown in Table 3.

Neither the Energy Trust nor the RTF separately calculate savings when storm windows are present. Energy Trust previously estimated that the savings were half way between the savings for replacing single pane windows and double pane windows. However, field data suggest that storm window panes are often removed for ventilation. The analysis assumes that the storm window panes are removed 90% of the time and replacing them gets no less savings than replacing a single pane window. The remaining 10% of the time, the baseline for storm windows is modelled as a double pane window.

Table 3 Summary of multifamily window heating savings for window with U-factor ≤ 0.30

	RTF provisional savings (kWh/sf)	Calibrated RTF savings (kWh/sf)	Stellar Processes' method savings (kWh/sf)	Average of methods savings (kWh/sf)
Single pane aluminum frame	23.7	11.9	5.1	**8.5**
Single pane wood frame	23.7	11.9	3.9	**7.9**
Single pane aluminum frame and storm window	22.6	11.3	4.0	**8.1**
Double pane	12.8	6.4	2.8	**4.6**

Cooling Savings

Neither of the above calculations include cooling savings. The cooling savings were calculated using the following equation:

$$\Delta E_{cooling} = \phi_{cool/heat} * \theta_{MF\ Cooling} * \Delta E_{heating}$$

Where $\phi_{cool/heat}$ is the ratio of cooling degree days to heating degree days. The RTF's Climate Zone Calculation workbook[1] was used to determine these values. Portland International Airport was chosen for the location which has 4187 HDD and 367 CDD resulting in a ratio of 9%.

$\theta_{MF\ Cooling}$ is the prevalence of cooling in Multifamily residences. The Regional Building Stock Assessment (RBSA) II[2] was referenced for this value. The prevalence of any cooling system in Multifamily residencies in Oregon Cooling Zone 1 is 36%. This results in minor cooling savings summarized in Table 4.

Table 4 Savings Summary for window with U-factor ≤ 0.30

	Heating Savings (kWh/sq ft)	Cooling Savings (kWh/sq ft)	Total Savings (kWh/sq ft)	Cooling Savings / Total Savings
Single Pane Aluminum Frame	8.5	0.3	8.8	3%
Single Pane Wood Frame	7.9	0.2	8.1	3%
Single Pane Aluminum Frame and Storm Window	8.1	0.3	8.4	3%

Comparison to RTF or other programs

The RTF's current active measure is the calibrated output of their SEEM workbooks. This is higher than Energy Trust assumes based on past project performance.

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[1] RTF_ClimateZoneCalculation_v1_2. Regional Technical Forum. Uploaded 09/27/2017. QC Review Complete. https://rtf.nwcouncil.org/work-products/supporting-documents/climate-zones

[2] Residential Building Stock Assessment II. Multifamily Buildings Report 2016 - 2017. Revised 04/2019. Northwest Energy Efficiency Alliance. https://neea.org/img/documents/Residential-Building-Stock-Assessment-II-Multifamily-Homes-Report-2016-2017.pdf

This measure applies to sites in both heating zone 1 and zone 2. The Stellar Processes method does not have a separate savings for heating zone 2, though the RTF does. When the RTF calibration process is complete, Energy Trust will consider creating a separate set of measures for multifamily windows in heating zone 2 using the RTF analysis.

Measure Life

Measure life is 45 years, consistent with other Energy Trust windows measures and other weatherization measures and RTF.

Load Profile

Savings now include both heating and cooling savings. About 3% of savings occur in summer months, therefor the air source heat pump load profile is used. This is a change from prior version of this measure.

Cost

Cost is $17.30 per square foot, estimated by the Regional Technical Forum from the first quartile (lower cost) multifamily windows installation.

Non Energy Benefits

There are significant non-quantified non-energy benefits for windows in multifamily buildings. Non-energy benefits to the building owner include decreased vacancy rates and decreased turnover and possible reduced repair costs or higher rents received. These reflect direct benefits to tenants, including improved aesthetics, comfort, and in some cases improved air quality. These non-quantifiable benefits were the basis of the past cost effectiveness exception.

Incentive Structure

The maximum incentives listed in Table 1 are for reference only and are not suggested incentives. Incentives will be structured per square foot of windows.

Follow-Up

Costs should be updated at the next measure update.

The RTF calibration process may be complete by the end of 2019. If it is completed, Energy Trust will consider updating these measures and creating a separate set of measures for multifamily windows in heating zone 2 using the RTF 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\Residential\Multifamily\Weatherization\Multifamily windows

CEC 2020
Multifamily Window

Version History and Related Measures

Energy Trust has been offering measures for residential and multifamily windows for many years. These measures predate our current measure approval process and our record retention guidelines. Table 5 may be incomplete, particularly for events prior to 2013.

Table 5 Version History

Date	Version	Reason for revision
2004	X	Approve windows in multifamily buildings with aluminum window frames in existing condition.
7/11/08	X	Add replacement of vinyl windows in poor condition
Unknown	171.x	Measure redesign based on Stellar Processes report and tools. Aluminum frame single and double pane, and wood frame single pane existing conditions. Large multifamily, gas or electric heat. Retrofit U ≤ 0.30
2012	171.x	Adds storm windows in existing condition
3/20/12	171.x	Clarifications for storm windows in existing condition
5/08/13	171.x	Merged small and large multifamily
5/09/16	171.1	Updated savings based on RTF calibrated models. Removed gas heated buildings. Separated stacked structures from 2-4 units and side by side units, 2-4 and side by side now included in MAD 28. Requirements based on exception details
11/8/2017	171.2	Remove double pane. Updated for 2018 avoided costs and requirements based on exception details.
5/13/19	171.3	Measure analysis is updated to include cooling savings.

Table 6 Related Measures

Measures	MAD ID
Residential High Performance Windows, including small multifamily	28

Approved & Reviewed by

Jackie Goss, PE
Sr. Planning Engineer

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Measure Approval Document for New Construction Commercial Showerheads and Shower Wands

Valid Dates
January 1, 2020 through December 31, 2020

End Use or Description
This measure category is for high efficiency showerheads and shower wands and is intended to reduce water heating energy related to showering in new commercial and multifamily buildings by reducing the amount of water used during each shower event.

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:

- New Buildings
- New Multifamily

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

- Hospitality (hotels and motels)
- Healthcare
- Schools
- Offices
- Commercial Gym (Fitness Center) (dedicated fitness business not incorporated into other listed building type)
- Multifamily
- Assisted Living

Within these program tracks, the measure is applicable to the following cases:

- New Construction

Purpose of Re-Evaluating Measure:
Version 144.4 is an administrative update, with no changes to savings or costs. Measures were re-tested with the latest avoided costs and the expiration date was extended through 2020.

While the Regional Technical Forum (RTF) measure this analysis is based upon was updated in 2019, there was insufficient time to adequately update the analysis to represent Energy Trust territory.

Version 144.5 corrects an error in the Washington CEC.

Cost Effectiveness
Cost effectiveness and savings are demonstrated in Tables 1- 5. Table 1 includes showerhead and shower wand measures in new multifamily, including both electric and gas water heat and in dual and single-fuel territory in Oregon. Table 2 includes showerhead and shower wand measures in new commercial buildings with electric water heat in Oregon. Table 3 includes showerhead and shower wand measures in new commercial buildings with gas water heat in dual-fuel territory in Oregon. Table 4 includes showerhead and shower wand measures in new commercial buildings with gas water heat in gas-only territory in Oregon. Table 5 includes showerhead and shower wand measures in new commercial and multifamily buildings with gas water heat in Washington, which is gas-only territory.

Table 1 Cost Effectiveness Calculator Oregon – Multifamily Measures

Measure	Measure Life (years)	Savings (kWh)	Savings (Therms)	Incremental Costs ($)	Non-Energy Benefits (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Ele	% Gas
Multifamily Any Electric 2.00 GPM Showerhead Full Territory	10	173	0	$8.50	$17.60	$8.50	11.7	28.1	100%	0%
Multifamily Any Electric 1.80 GPM Showerhead Full Territory	10	222	0	$8.50	$22.57	$8.50	15.1	36.1	100%	0%
Multifamily Any Electric 1.75 GPM Showerhead Full Territory	10	231	0	$8.50	$23.49	$8.50	15.7	37.6	100%	0%
Multifamily Any Electric 1.60 GPM Showerhead Full Territory	10	279	0	$8.50	$28.40	$8.50	18.9	45.4	100%	0%
Multifamily Any Electric 1.50 GPM Showerhead Full Territory	10	322	0	$8.50	$32.84	$8.50	21.9	52.4	100%	0%
Multifamily Gas 2.00 GPM Showerhead Full Territory	10	5	8	$8.50	$17.60	$8.50	3.8	20.2	9%	91%
Multifamily Gas 1.80 GPM Showerhead Full Territory	10	6	10	$8.50	$22.57	$8.50	4.8	25.8	9%	91%
Multifamily Gas 1.75 GPM Showerhead Full Territory	10	6	10	$8.50	$23.49	$8.50	4.8	26.6	9%	91%
Multifamily Gas 1.60 GPM Showerhead Full Territory	10	8	12	$8.50	$28.40	$8.50	5.8	32.2	9%	91%
Multifamily Gas 1.50 GPM Showerhead Full Territory	10	9	14	$8.50	$32.84	$8.50	6.7	37.3	9%	91%
Multifamily Gas 2.00 GPM Showerhead Partial Territory	10	0	8	$8.50	$18.05	$8.50	3.5	20.3	0%	100%
Multifamily Gas 1.80 GPM Showerhead Partial Territory	10	0	10	$8.50	$23.14	$8.50	4.4	25.9	0%	100%
Multifamily Gas 1.75 GPM Showerhead Partial Territory	10	0	10	$8.50	$24.09	$8.50	4.4	26.8	0%	100%
Multifamily Gas 1.60 GPM Showerhead Partial Territory	10	0	12	$8.50	$29.13	$8.50	5.2	32.3	0%	100%
Multifamily Gas 1.50 GPM Showerhead Partial Territory	10	0	14	$8.50	$33.68	$8.50	6.1	37.5	0%	100%
Multifamily Any Electric 2.00 GPM Shower Wand Full Territory	10	173	0	$22.95	$17.60	$22.95	4.4	10.4	100%	0%
Multifamily Any Electric 1.80 GPM Shower Wand Full Territory	10	222	0	$22.95	$22.57	$22.95	5.6	13.4	100%	0%
Multifamily Any Electric 1.75 GPM Shower Wand Full Territory	10	231	0	$22.95	$23.49	$22.95	5.8	13.9	100%	0%
Multifamily Any Electric 1.60 GPM Shower Wand Full Territory	10	279	0	$22.95	$28.40	$22.95	7	16.8	100%	0%
Multifamily Any Electric 1.50 GPM Shower Wand Full Territory	10	372	0	$22.95	$32.84	$22.95	9.4	20.7	100%	0%
Multifamily Gas 2.00 GPM Shower Wand Full Territory	10	5	8	$22.95	$17.60	$22.95	1.4	7.5	9%	91%
Multifamily Gas 1.80 GPM Shower Wand Full Territory	10	6	10	$22.95	$22.57	$22.95	1.8	9.5	9%	91%
Multifamily Gas 1.75 GPM Shower Wand Full Territory	10	6	10	$22.95	$23.49	$22.95	1.8	9.9	9%	91%
Multifamily Gas 1.60 GPM Shower Wand Full Territory	10	8	12	$22.95	$28.40	$22.95	2.1	11.9	9%	91%
Multifamily Gas 1.50 GPM Shower Wand Full Territory	10	10	17	$22.95	$32.84	$22.95	3	14.3	8%	92%
Multifamily Gas 2.00 GPM Shower Wand Partial Territory	10	0	8	$22.95	$18.05	$22.95	1.3	7.5	0%	100%
Multifamily Gas 1.80 GPM Shower Wand Partial Territory	10	0	10	$22.95	$23.14	$22.95	1.6	9.6	0%	100%
Multifamily Gas 1.75 GPM Shower Wand Partial Territory	10	0	10	$22.95	$24.09	$22.95	1.6	9.9	0%	100%
Multifamily Gas 1.60 GPM Shower Wand Partial Territory	10	0	12	$22.95	$29.13	$22.95	1.9	12	0%	100%
Multifamily Gas 1.50 GPM Shower Wand Partial Territory	10	0	17	$22.95	$33.68	$22.95	2.7	14.4	0%	100%

Table 2 Cost Effectiveness Calculator Oregon - Commercial Measures - Electric

Measure	Measure Life (years)	Savings (kWh)	Savings (Therms)	Incremental Costs ($)	Non-Energy Benefits (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Ele	% Gas
Hospitality Any Electric 2.00 GPM Showerhead/ Shower wand Full Territory	10	145	0	$8.50	$17.90	$8.50	9.3	26	100%	0%
Hospitality Any Electric 1.8 or 1.75 GPM Showerhead/ Shower wand Full Territory	10	155	0	$8.50	$20.14	$8.50	9.9	28.7	100%	0%
Hospitality Any Electric 1.6 GPM Showerhead/ Shower wand Full Territory	10	216	0	$8.50	$26.85	$8.50	13.9	38.8	100%	0%
Hospitality Any Electric 1.5 GPM Showerhead/ Shower wand Full Territory	10	256	0	$8.50	$31.32	$8.50	16.4	45.6	100%	0%
Health Care Any Electric 2.00 GPM Showerhead/ Shower wand Full Territory	10	104	0	$8.50	$12.90	$8.50	6.7	18.7	100%	0%
Health Care Any Electric 1.8 or 1.75 GPM Showerhead/ Shower wand Full Territory	10	112	0	$8.50	$14.51	$8.50	7.2	20.7	100%	0%
Health Care Any Electric 1.6 GPM Showerhead/ Shower wand Full Territory	10	156	0	$8.50	$19.34	$8.50	10	28	100%	0%
Health Care Any Electric 1.5 GPM Showerhead/ Shower wand Full Territory	10	184	0	$8.50	$22.57	$8.50	11.8	32.8	100%	0%
Commercial (Employee Shower) Any Electric 2.00 GPM Showerhead/ Shower wand Full Territory	10	78	0	$8.50	$9.66	$8.50	5	14	100%	0%
Commercial (Employee Shower) Any Electric 1.8 or 1.75 GPM Showerhead/ Shower wand Full Territory	10	84	0	$8.50	$10.87	$8.50	5.4	15.5	100%	0%
Commercial (Employee Shower) Any Electric 1.6 GPM Showerhead/ Shower wand Full Territory	10	117	0	$8.50	$14.49	$8.50	7.5	21	100%	0%
Commercial (Employee Shower) Any Electric 1.5 GPM Showerhead/ Shower wand Full Territory	10	138	0	$8.50	$16.91	$8.50	8.9	24.6	100%	0%
School Any Electric 2.00 GPM Showerhead/ Shower wand Full Territory	10	85	0	$8.50	$10.50	$8.50	5.5	15.3	100%	0%
School Any Electric 1.8 or 1.75 GPM Showerhead/ Shower wand Full Territory	10	91	0	$8.50	$11.81	$8.50	5.9	16.9	100%	0%
School Any Electric 1.6 GPM Showerhead/ Shower wand Full Territory	10	127	0	$8.50	$15.74	$8.50	8.3	22.9	100%	0%
School Any Electric 1.5 GPM Showerhead/ Shower wand Full Territory	10	150	0	$8.50	$18.37	$8.50	9.8	26.9	100%	0%
Commercial Gym Any Electric 2.00 GPM Showerhead/ Shower wand Full Territory	10	1,170	0	$8.50	$144.49	$8.50	78.1	212	100%	0%
Commercial Gym Any Electric 1.8 or 1.75 GPM Showerhead/ Shower wand Full Territory	10	1,250	0	$8.50	$162.56	$8.50	83.5	234	100%	0%
Commercial Gym Any Electric 1.6 GPM Showerhead/ Shower wand Full Territory	10	1,744	0	$8.50	$216.74	$8.50	116.4	318	100%	0%
Commercial Gym Any Electric 1.5 GPM Showerhead/ Shower wand Full Territory	10	2,063	0	$8.50	$252.86	$8.50	137.7	373	100%	0%

Table 3 Cost Effectiveness Calculator Oregon - Commercial Measures - Gas - Full Territory

Measure	Measure Life (years)	Savings (kWh)	Savings (Therms)	Incremental Costs ($)	Non-Energy Benefits (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Ele	% Gas
Hospitality Gas 2.00 GPM Showerhead/ Shower wand Full Territory	10	5	6	$8.50	$17.90	$8.50	2.9	19.6	11%	89%
Hospitality Gas 1.8 or 1.75 GPM Showerhead/ Shower wand Full Territory	10	5	7	$8.50	$20.14	$8.50	3.4	22.1	10%	90%
Hospitality Gas 1.6 GPM Showerhead/ Shower wand Full Territory	10	7	10	$8.50	$26.85	$8.50	4.8	29.8	9%	91%
Hospitality Gas 1.5 GPM Showerhead/ Shower wand Full Territory	10	8	11	$8.50	$31.32	$8.50	5.3	34.5	10%	90%
Health Care Gas 2.00 GPM Showerhead/ Shower wand Full Territory	10	3	5	$8.50	$12.90	$8.50	2.4	14.4	8%	92%
Health Care Gas 1.8 or 1.75 GPM Showerhead/ Shower wand Full Territory	10	4	5	$8.50	$14.51	$8.50	2.4	15.9	11%	89%
Health Care Gas 1.6 GPM Showerhead/ Shower wand Full Territory	10	5	7	$8.50	$19.34	$8.50	3.4	21.4	10%	90%
Health Care Gas 1.5 GPM Showerhead/ Shower wand Full Territory	10	6	8	$8.50	$22.57	$8.50	3.9	24.9	10%	90%
Commercial (Employee Shower) Gas 2.00 GPM Showerhead/ Shower wand Full Territory	10	3	3	$8.50	$9.66	$8.50	1.5	10.5	13%	87%
Commercial (Employee Shower) Gas 1.8 or 1.75 GPM Showerhead/ Shower wand Full Territory	10	5	4	$8.50	$10.87	$8.50	2.1	12.2	16%	84%
Commercial (Employee Shower) Gas 1.6 GPM Showerhead/ Shower wand Full Territory	10	8	7	$8.50	$14.49	$8.50	3.6	17.1	14%	86%
Commercial (Employee Shower) Gas 1.5 GPM Showerhead/ Shower wand Full Territory	10	7	6	$8.50	$16.91	$8.50	3.1	18.8	15%	85%
School Gas 2.00 GPM Showerhead/ Shower wand Full Territory	10	4	4	$8.50	$10.50	$8.50	2	11.8	13%	87%
School Gas 1.8 or 1.75 GPM Showerhead/ Shower wand Full Territory	10	5	4	$8.50	$11.81	$8.50	2.1	13.1	16%	84%
School Gas 1.6 GPM Showerhead/ Shower wand Full Territory	10	8	7	$8.50	$15.74	$8.50	3.6	18.2	15%	85%
School Gas 1.5 GPM Showerhead/ Shower wand Full Territory	10	8	7	$8.50	$18.37	$8.50	3.6	20.7	15%	85%
Commercial Gym Gas 2.00 GPM Showerhead/ Shower wand Full Territory	10	38	52	$8.50	$144.49	$8.50	25.2	160	10%	90%
Commercial Gym Gas 1.8 or 1.75 GPM Showerhead/ Shower wand Full Territory	10	42	55	$8.50	$162.56	$8.50	26.8	178	10%	90%
Commercial Gym Gas 1.6 GPM Showerhead/ Shower wand Full Territory	10	56	77	$8.50	$216.74	$8.50	37.3	239	10%	90%
Commercial Gym Gas 1.5 GPM Showerhead/ Shower wand Full Territory	10	66	91	$8.50	$252.86	$8.50	44.1	280	10%	90%

Table 4 Cost Effectiveness Calculator Oregon - Commercial Measures - Gas - Partial Territory

Measure	Measure Life (years)	Savings (kWh)	Savings (Therms)	Incremental Costs ($)	Non-Energy Benefits (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Ele	% Gas
Hospitality Gas 2.00 GPM Showerhead Partial Territory	10	0	6	$8.50	$18.33	$8.50	2.6	19.7	0%	100%
Hospitality Gas 1.8 or 1.75 GPM Showerhead Partial Territory	10	0	7	$8.50	$20.62	$8.50	3.1	22.2	0%	100%
Hospitality Gas 1.6 GPM Showerhead Partial Territory	10	0	10	$8.50	$27.49	$8.50	4.4	29.9	0%	100%
Hospitality Gas 1.5 GPM Showerhead Partial Territory	10	0	11	$8.50	$32.08	$8.50	4.8	34.7	0%	100%
Health Care Gas 2.00 GPM Showerhead Partial Territory	10	0	5	$8.50	$13.21	$8.50	2.2	14.5	0%	100%
Health Care Gas 1.8 or 1.75 GPM Showerhead Partial Territory	10	0	5	$8.50	$14.86	$8.50	2.2	16	0%	100%
Health Care Gas 1.6 GPM Showerhead Partial Territory	10	0	7	$8.50	$19.81	$8.50	3.1	21.5	0%	100%
Health Care Gas 1.5 GPM Showerhead Partial Territory	10	0	8	$8.50	$23.11	$8.50	3.5	25	0%	100%
Commercial (Employee Shower) Gas 2.00 GPM Showerhead Partial Territory	10	0	3	$8.50	$9.89	$8.50	1.3	10.5	0%	100%
Commercial (Employee Shower) Gas 1.8 or 1.75 GPM Showerhead Partial Territory	10	0	4	$8.50	$11.13	$8.50	1.7	12.1	0%	100%
Commercial (Employee Shower) Gas 1.6 GPM Showerhead Partial Territory	10	0	7	$8.50	$14.84	$8.50	3.1	16.9	0%	100%
Commercial (Employee Shower) Gas 1.5 GPM Showerhead Partial Territory	10	0	6	$8.50	$17.31	$8.50	2.6	18.7	0%	100%
School Gas 2.00 GPM Showerhead Partial Territory	10	0	4	$8.50	$10.75	$8.50	1.7	11.8	0%	100%
School Gas 1.8 or 1.75 GPM Showerhead Partial Territory	10	0	4	$8.50	$12.09	$8.50	1.7	13	0%	100%
School Gas 1.6 GPM Showerhead Partial Territory	10	0	7	$8.50	$16.12	$8.50	3.1	18.1	0%	100%
School Gas 1.5 GPM Showerhead Partial Territory	10	0	7	$8.50	$20.41	$8.50	3.1	22.1	0%	100%
Commercial Gym Gas 2.00 GPM Showerhead Partial Territory	10	0	52	$8.50	$147.96	$8.50	22.7	161	0%	100%
Commercial Gym Gas 1.8 or 1.75 GPM Showerhead Partial Territory	10	0	55	$8.50	$166.46	$8.50	24	179	0%	100%
Commercial Gym Gas 1.6 GPM Showerhead Partial Territory	10	0	77	$8.50	$221.94	$8.50	33.6	240	0%	100%
Commercial Gym Gas 1.5 GPM Showerhead Partial Territory	10	0	91	$8.50	$258.93	$8.50	39.7	281	0%	100%

Table 5 Cost Effectiveness Calculator Washington – Multifamily and Commercial Gas Only

Measure	Measure Life (years)	Savings (kWh)	Savings (Therms)	Incremental Costs ($)	Non-Energy Benefits (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR
Multifamily_Gas_2_00 GPM Showerhead Partial Territory	10	0	7.7	$8.50	$15.99	$8.50	3.9	18.0
Multifamily_Gas_1_80 GPM Showerhead Partial Territory	10	0	9.9	$8.50	$20.51	$8.50	5.0	23.1
Multifamily_Gas_1_75 GPM Showerhead Partial Territory	10	0	10.3	$8.50	$21.35	$8.50	5.2	24.0
Multifamily_Gas_1_60 GPM Showerhead Partial Territory	10	0	12.5	$8.50	$25.81	$8.50	6.3	29.0
Multifamily_Gas_1_50 GPM Showerhead Partial Territory	10	0	14.4	$8.50	$29.85	$8.50	7.3	33.5
Multifamily_Gas_2_00 GPM Shower Wand Partial Territory	10	0	7.7	$22.95	$15.99	$22.95	1.4	6.7
Multifamily_Gas_1_80 GPM Shower Wand Partial Territory	10	0	9.9	$22.95	$20.51	$22.95	1.8	8.5
Multifamily_Gas_1_75 GPM Shower Wand Partial Territory	10	0	10.3	$22.95	$21.35	$22.95	1.9	8.9
Multifamily_Gas_1_60 GPM Shower Wand Partial Territory	10	0	12.5	$22.95	$25.81	$22.95	2.3	10.7
Multifamily_Gas_1_50 GPM Shower WandPartial Territory	10	0	14.4	$22.95	$34.44	$22.95	2.7	13.9
Hospitality_Gas_2_00 GPM_ Showerhead/ Shower wand Partial Territory	10	0	6.4	$8.50	$17.28	$8.50	3.2	18.4
Hospitality_Gas_1_8 or 1_75 GPM_ Showerhead/ Shower wand Partial Territory	10	0	6.8	$8.50	$19.44	$8.50	3.4	20.6
Hospitality_Gas_1_6 GPM_ Showerhead/ Shower wand Partial Territory	10	0	9.5	$8.50	$25.92	$8.50	4.8	27.6
Hospitality_Gas_1_5 GPM_ Showerhead/ Shower wand Partial Territory	10	0	11.3	$8.50	$30.24	$8.50	5.7	32.3
Health Care_Gas_2_00 GPM_ Showerhead/ Shower wand Partial Territory	10	0	4.6	$8.50	$12.45	$8.50	2.3	13.3
Health Care_Gas_1_8 or 1_75 GPM_ Showerhead/ Shower wand Partial Territory	10	0	4.9	$8.50	$14.01	$8.50	2.5	14.8
Health Care_Gas_1_6 GPM_ Showerhead/ Shower wand Partial Territory	10	0	6.9	$8.50	$18.68	$8.50	3.5	19.9
Health Care_Gas_1_5 GPM_ Showerhead/ Shower wand Partial Territory	10	0	8.1	$8.50	$21.79	$8.50	4.1	23.3
Commercial (Employee Shower)_Gas_2_00 GPM_ Showerhead/ Shower wand Partial Territory	10	0	3.4	$8.50	$9.33	$8.50	1.7	10.0
Commercial (Employee Shower)_Gas_1_8 or 1_75 GPM_ Showerhead/ Shower wand Partial Territory	10	0	3.7	$8.50	$10.49	$8.50	1.9	11.1
Commercial (Employee Shower)_Gas_1_6 GPM_ Showerhead/ Shower wand Partial Territory	10	0	6.8	$8.50	$13.99	$8.50	3.4	15.8
Commercial (Employee Shower)_Gas_1_5 GPM_ Showerhead/ Shower wand Partial Territory	10	0	6.1	$8.50	$16.32	$8.50	3.1	17.4
School_Gas_2_00 GPM_ Showerhead/ Shower wand Partial Territory	10	0	3.7	$8.50	$10.13	$8.50	1.9	10.8
School_Gas_1_8 or 1_75 GPM_ Showerhead/ Shower wand Partial Territory	10	0	4.0	$8.50	$11.40	$8.50	2.0	12.1
School_Gas_1_6 GPM_ Showerhead/ Shower wand and Partial Territory	10	0	7.4	$8.50	$15.20	$8.50	3.7	17.1
School_Gas_1_5 GPM_ Showerhead/ Shower wand Partial Territory	10	0	6.6	$8.50	$20.41	$8.50	3.3	21.3
Commercial Gym_Gas_2_00 GPM_ Showerhead/ Shower wand Partial Territory	10	0	51.5	$8.50	$139.50	$8.50	26.0	148.8
Commercial Gym_Gas_1_8 or 1_75 GPM_ Showerhead/ Shower wand Partial Territory	10	0	55.0	$8.50	$156.93	$8.50	27.7	165.9
Commercial Gym_Gas_1_6 GPM_ Showerhead/ Shower wand Partial Territory	10	0	76.8	$8.50	$209.25	$8.50	38.7	223.0
Commercial Gym_Gas_1_5 GPM_ Showerhead/ Shower wand Partial Territory	10	0	90.9	$8.50	$244.12	$8.50	45.8	260.8

Requirements

- Rated flows between 1.5 and 2.0 gallons per minute (gpm)
- Showerheads and shower wands must be WaterSense® certified
- The measure may not be used in conjunction with low-rise multifamily code compliance Option 5a in Washington. This measure is not intended to be used by low-rise multifamily buildings (three stories and less) that are subject to the Washington State Energy Code, Residential Provisions 2015 due to the code compliance Option 5a.

Baseline

This measure uses a Code Baseline

The baseline for this measure was determined by the Energy Policy Act of 1992 federal standard that went into effect in 1994 and is utilized by both Oregon and Washington in their respective plumbing codes. The current baseline is 2.5 gpm for each installed showerhead or shower wand.

Measure Analysis

The savings analysis supporting this measure approval document uses the RTF commercial and residential showerhead workbook v3.1, with modifications specific to the Energy Trust of Oregon. The modifications include the use of different embedded water savings and non-electric benefits.

The RTF uses the following equations to develop unit energy consumption (UEC) values for each water heater technology, flow rate of showerhead/wand, and housing/building type or commercial application:

1. [Water consumption]
   a. Multifamily
      i. <u>All Multifamily</u> = {in-situ flow rate *[rated flow rate (gallons/minute)] x [in use flow adjustment)]*} x [# of events/yr] x [event duration (minutes/event)]

   b. Commercial
      i. <u>Hospitality</u> = [in-situ flow rate] x [minutes per day per showerhead] [1]x [average occupancy rate[2]] x [days per year]

      ii. <u>Health Care</u> = [in-situ flow rate] x [minutes per day client] [3]x [clients per shower at full capacity] [4]x [average occupancy rate] [5]x [days per year]

      iii. <u>Commercial Office</u> = [in-situ flow rate] x [residential use minutes per day per showerhead] x [6][assumed fraction of residential usage at employee shower]

      iv. <u>Schools</u> = [in-situ flow rate] x [total annual metered shower water consumption from two schools (gallons)] [7]/ [total number of showers at the two schools] / estimated flow rate of showerheads]

      v. <u>Commercial Gym (Fitness Center)</u> = [in-situ flow rate] x annual shower utilization (minutes per year)[8]

2. [End-use Energy consumption] = [water consumption] x [mixed hot water energy intensity (kWh/gallon)]

3. [Embedded water/wastewater energy consumption] = [water consumption] x [water/waste water energy intensity (kWh/gallon)]

The following tables describe the inputs used to estimate individual UEC values for all combinations of measure types.

Table 6 presents the inputs to estimate the energy intensity of water heating in multifamily buildings across different technologies associated with the shower minutes. Recovery energy (RE) for electric resistance and gas storage water heaters are sourced from the RTF standard information workbook, SIW.[9] Heat pump water heater RE of 200% is an RTF judgement. Remaining values are RTF input assumptions and calculations.

Table 6 Water Heater Recovery Energy, Temperature Rise and Energy Intensities by Water Heater Type and Fuel - Multifamily

Water Heating Type	RE	Water Heater ΔT	Effective delta T of mixed hot water for shower	Specific Heat of Water (kWh/gallon/°F)	Specific Heat of Water (Therms/gallon/°F)	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 7 depicts the commercial water energy intensity used to determine the mixed water heating energy associated with each showerhead. Each rated gpm is assigned a percentage of hot water to reach the shower temperature.

Table 7 Water Energy Intensity by Showerhead Flow Rate for Commercial Applications

Rated gpm	ΔT (°F)	Hot Water Percentage	Temperature (°F)	Electric DHW - kWh/ gallon	Gas DHW - Therms/ gallon
2.5	53	73.1%	108	0.133	0.00593
2	55	75.5%	110	0.137	0.00612
1.8	56	76.1%	111	0.138	0.00617
1.75	56	76.7%	111	0.139	0.00622
1.6	56	77.3%	111	0.141	0.00627
1.5	57	77.9%	112	0.142	0.00632

Table 8 shows the Regional Building Stock Assessment I (RBSA I)and 2015 American Community Survey (ACS) inputs that are used to generate the total shower gallons per year for multifamily applications.

[1] Gleick, P., Haasz, D., Henges-Jeck, C., Srinivasan, V., Wolff, G., Cushing, K. K., et al. (2003).
[2] American Hotel and Lodging Association Website (www.ahla.com), annual Lodging Industry Profile
[3] Gleick, P., Haasz, D., Henges-Jeck, C., Srinivasan, V., Wolff, G., Cushing, K. K., et al. (2003)
[4] Professional judgement of RTF staff, assumes that each shower serves two clients at full capacity
[5] StateHealthFacts.org
[6] RTF approved minutes per year for residential showerhead: ResShowerheads_v2.1.xlsm
[7] Planning and Management Consultants, Ltd., Aquacraft, Inc., and John Olaf Nelson Water Resources Management. "Commercial and Institutional End Uses of Water". For the American Water Works Association. 2000.
[8] Informal telephone survey of Fitness Centers in the Northwest conducted by RTF staff in June, 2013
[9] RTF Standard information workbook v2.6 (current SIW version as of this publication date is v3.2, but values remain the same).

Table 8 Showerheads per Multifamily Dwelling Unit and Shower Events Per Year

	MF
Oregon total # of showerheads (RBSA I)	269,610
Oregon average # of showerheads per residence (RBSA I)	1.21
Occupants per dwelling (2015 OR ACS)	2.11
Occupants per shower Oregon	1.75
Total Oregon shower events (at 250 events per person/yr)	**436**
Occupants per gas dwelling (2015 SW WA ACS)	2.34
Occupants per shower SW Washington	1.94
Total Washington shower events (at 250 events per person/yr)	**484**

Table 9 shows how the commercial shower usage is applied to each showerhead regardless of flow rate installed instead of the baseline. Static values for shower minutes are applied uniformly across all showerhead flow rates. This deviates from the multifamily calculations where the shower length increases as showerhead flow rates decrease. For more information about multifamily shower length, refer to the Retail Showerhead MAD 26.3.

Table 9 Commercial Use Shower Minutes Per Year

Commercial Use Type	Annual Minutes Per Showerhead
Hospitality	3,509
Health Care	2,528
Commercial - Employee Shower	1,894
School	2,057
Any Commercial Except Fitness Center	3,029
Commercial Gym (Fitness Center)	28,326

The electric energy consumption in kWh from water treatment for residential, commercial, and institutional end-uses are added to the baseline consumption, as well as to the efficient case consumption to generate the total kWh consumption associated with water use. Both electric and gas end-uses have an associated kWh consumption for water treatment, consistent with the 7th Power Plan, and this is how a kWh value is associated with full territory gas water heater measures.

Savings

Savings for showerheads and shower wands are calculated by subtracting the unit energy consumption of the high efficiency showerhead or wand from the baseline UEC and then multiplying that by the installation rate.

The unit energy consumption for each showerhead flow rate is outlined above in the measure analysis section.

All showerheads in all applications are assumed to have an installation rate and uninstall rate of 90% and 10% respectively. This is the rate applied to the final unit energy savings for each iteration of the measure.

Comparison to RTF or other programs

While much of this MAD's analysis replicates the RTF's v3.1 approach, there are some specific differences with regards to Multifamily:

- RTF uses full regional RBSA I data. 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 the 2015 1-year American Community Survey (ACS) rather than the RBSA I. Sample sizes in the ACS are larger and the data are more recent than the 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 in 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. The commercial in-situ flow rates for all but the 1.5 gpm showerhead are assumed to be 90% of the rated flow; the 1.5 gpm showerhead is assumed to be 100% of the rated flow.
- Savings for 1.6 and 1.8 gpm devices used by Energy Trust programs are calculated, in addition to the 1.5, 1.75 and 2.0 gpm savings calculated by the RTF. Savings for the 1.8 and 1.75 gpm showerheads in commercial buildings were consolidated to the 1.75 gpm savings.

Measure Life

Measure life is 10 years, consistent with prior MAD and RTF Showerhead workbook.

Cost

The provided costs are the same as Retail Showerhead MAD 26.3. These costs are based on the 25th percentile of manufacturer suggested retail price for showerheads and wands offered by retailers participating in 2017. Using the 25th percentile accounts 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. Cost by product type used in this cost effectiveness screening:

- Showerhead $8.50
- Shower wand $22.95

Non-Energy Benefits

The analysis uses reduced water consumption from low flow devices as a Non-Energy Benefit (NEB).

Combined water rates with embedded electricity are used in Oregon for gas and electric territories, and total water rates without removing embedded energy is used for Oregon gas only territory. Washington uses the combined water rate including embedded energy use for wastewater treatment. See Table 10 for each rate applied to the UEC.

Table 10 Incremental Water/wastewater rates

Rate	Units	Residential (OR)	Residential (OR) Partial Territory	Residential (WA)	Non-Manufacturing/ Commercial (OR)	Non-Manufacturing/ Commercial (OR) Partial Territory	Non-Manufacturing/ Commercial (WA)
Combined Water Rate	$/gallon	$0.0133	$0.01364	$0.0109	$0.01417	$0.01451	$0.0133

Incentive Structure

The maximum incentives listed in Table 1 through Table 5 are for reference only and are not suggested incentives. Incentives will be structured per showerhead or shower wand installed in New Buildings commercial or multifamily applications.

SRAF

Standard program SRAF applies.

Follow-Up

RTF's current showerhead workbook, v4.2, sunsets in February 2020 and revisions are likely to include RBSA II data such as:

- 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 costs of shower wands, as using the 25th percentile may not be appropriate

Measures should be reviewed in 2020 with the newer versions of the RTF Savings Calculator. Appropriate incremental cost for shower wands should be examined. Any code updates should be reflected.

The 2014 New Buildings impact evaluation found that low flow faucet aerators, shower wands and showerheads had lower than expected realization rates, due in part to customers removing them for satisfaction reasons. The evaluation recommended engaging customers during the late stage of project completion to ensure building occupants understand the benefits of these devices. Further study of this will be included in the next New Buildings evaluation.

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 showerheads and aerators\showerhead_Commercial

144 New Buildings Showerheads and S

NB Showerhead Analysis_07-30-2018

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

Version History and Related Measures

Table 11 Version History

Date	Version	Reason for revision
10/12/2016	144.x	Added publication date of 4/15/2016, expiration date of 12/31/2018
4/18/2016	144.x	New measure published
3/14/2016	144.x	MAD ID added
9/15/2016	144.1	Measure details added, with expiration date of 6/30/2018
8/28/2018	144.2	Align with RTF v3.1 showerhead workbook, added measures for additional flow rates and separate building types. Added separate WA measure table. Updated product costs.
9/20/2018	144.3	Adjust measure names to explicitly include shower wands.
8/7/2019	144.4	Extend expiration date, update avoided costs.
9/20/2019	144.5	Corrected error in Washington CEC

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

Disclaimer

Measure Approval Document for Residential Gas Tankless Water Heaters in SW Washington

Valid Dates
July 1, 2019 – December 21, 2021

End Use or Description
0.82+ EF or 0.81+ UEF gas tankless water heaters in existing residential construction.

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

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

- Existing Homes
- Existing Manufactured Homes
- Existing Multifamily: 2-4 units and side by side structures, administered by the residential programs

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

- Replacement,

Purpose of Re-Evaluating Measure
Updated assumed efficiency level of new equipment, from 0.91 to 0.92 EF based on recent program activity, resulting in increased costs and savings. In combination with 2019 avoided costs this yielded an increase in maximum incentive. Update requirements to align with UEF specifications which are becoming increasingly common. This version is for inclusion Energy Trust's 2019 mid-year filing with the WUCT.

Cost Effectiveness
Table 1 Cost Effectiveness Calculator Washington

Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR
EF 0.82+/UEF 0.81+ Tankless Gas Water Heater	20	76.0	$1,838	$601	1.0	0.3

Exceptions
Measure level total resource cost effectiveness is not required in NW Natural Washington's portfolio. The WUTC was anticipated to revisit this requirement in 2018 to determine if relying on the UCT as the primary cost effectiveness screening method for NW Natural Washington programs should continue, as of this publication no change has been announced. If the WUTC changes policy within the valid dates of this analysis, the MAD will need to be revisited.

Requirements

- Installed in SW Washington.
- Gas tankless water heaters with an energy factor (EF) greater than or equal to 0.82 or a uniform energy factor (UEF) greater than or equal to 0.81.
- Input less than 200 kBtu/hr.
- Manufacturers have created a category of “hybrid” gas water heaters between tankless and storage that have a tank with a capacity over two gallons burner with a rating greater than 75 kBtu/hr. These are *excluded* from eligibility under this MAD.

Details

In 2015, new federal energy efficiency standards for water heaters went into effect. These standards, based on capacity of storage tank, effectively increase the minimum EF rating to 0.60 for a 50-gallon water heater. Tankless water heater designs can improve the efficiency factors to over 0.90 by eliminating standby losses incurred from storage tanks and electronic ignitions.

Savings and Baseline

This measure uses a:

- Inefficient Market Baseline

Baseline equipment is a new gas storage water heater with and EF of 0.60.

While the required minimum efficiency for tankless in the program is 0.82 EF, the expected average EF is 0.92 based on past installations.

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 an impact evaluation conducted by Michael Blasnik for Energy Trust of Oregon on tankless water heaters. Average tankless EF of 0.91 for savings calculations is sourced from past SW Washington program data on incented tankless units.

The savings for equipment with higher energy factors are calculated using the following equation:

$$\text{Savings} = 218 \text{ therms} * (1-(\text{baseline EF}/\text{efficient EF}))$$

Based on average EF in 2018 program data, the estimated savings of a tankless water heater in SW WA are 76 therms as shown in Table 2Table 1.

Table 2 Tankless Therm Savings Estimate

Baseline Use Estimate (therms)	Baseline EF	Efficient EF in 2018	Savings (therms)
218	0.60	0.92	76.0

Measure Life

Measure life of 20 years, based on federal water heater standard Technical Support Document.

Cost

Past project cost information from the Existing Homes program in Washington from 2018 for tankless water heaters and 2011-2015 for gas storage units. Installed cost information was not available for 0.60 EF units from program historical data. To estimate incremental costs, program data from a retired 0.62-0.66 EF measure was used as a proxy for a 0.60 EF baseline including installation given that these units all use a standing pilot light and are expected to have similar costs.

Baseline costs were normalized to 2017 dollars, the most recent value available in the RTF's GDP deflator, to ensure relative cost parity with the 2018 program data. Sales tax is removed from Washington project costs upon entry in Project Tracker.

Table 3 Installed and Incremental Costs

Efficiency Tier	Median Cost
0.62-0.66 EF Storage Baseline Proxy	$1,183
0.82+ EF Tankless	$3,333
Incremental Cost	$2,150

The expected useful life of tankless water heaters is 20 years compared to 13 years for a gas storage unit. This longer measure life will result in a partially avoided replacement cost for a storage water heater after year 13, or 54% of a future storage water heater. The future value of the avoided replacement is $637, with a present value of $312, which is deducted from the initial incremental cost of $2,150 for a final value of $1,838. This process is described in Table 4.

Table 4 Avoided future cost calculations

	Calculation	Result
Useful life of tankless beyond baseline	7 years – 54% of 13-year lifetime	54%
Estimated storage installation cost	From Table 3	$1,183
Avoided future replacement cost	$1,167 * 54%	$637
Present values of avoided future replacement at 5.53% discount rate	PV ($628, 5.64%,7)	$312
Incremental cost	From Table 3	$2,150
Final incremental cost	**$2,146 - $312**	**$1,838**

Incentive Structure

The maximum incentive listed in Table 1 is for reference only and is not a suggested incentive. Incentives are likely to vary by program and sales channel and may be paid to end customers, home builders or passed through or kept by retail channels or distributers. Incentives are per water heater.

SRAF

Free ridership is not currently applied in NW Natural SW WA Territory per WUTC policy.

Follow-Up

If the WUTC reinstates TRC screening requirements this measure will need to be revisited.

Supporting Documents

The cost effective screening for these measures is attached and can be found along with supporting documentation at:
\\etoo.org\home\Groups\Planning\Measure Development\Residential\Res Water Heating\tankless\Existing homes\Wa only\bencost

SW WA Res
Tankless - CEC 2019-

References

US DOE Technical Support Document for residential water heaters:
https://www.regulations.gov/contentStreamer?documentId=EERE-2006-STD-0129-0170&attachmentNumber=26&disposition=attachment&contentType=pdf.

Version History and Related Measures

Table 5 Version History

Date	Version	Reason for revision
2007	x	Tankless in existing homes approved
12/31/2011	x	Tankless measure canceled for existing homes
04/24/2017	197.1	Re-introduce tankless water heaters to existing homes in SW Washington
12/4/2018	197.2	Update expected efficiency rating to 0.92 EF. Include UEF specification.

Table 6 Related Measures

Measures	MAD ID
Residential gas storage water heaters	102
New homes and new small multifamily tankless water heaters	178
Multifamily central system tankless water heaters ≤199 kBtu/h	196
Commercial tankless water heaters	72

Approved & Reviewed by

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Measure Approval Document for Resideo Winter Thermostat Optimization

Valid Dates
October 23, 2019 through December 31, 2022

End Use or Description
Thermostat optimization is a service where a company applies optimization algorithms to internet-connected thermostats on central heating systems to reduce energy consumption. This approval is for the Resideo optimization service (formerly known as Whisker Labs) in winter.

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

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

Purpose of Re-Evaluating Measure
Transitioning from a the residential thermostat optimization pilot to a standard measure for Resideo's winter optimization services.

Cost Effectiveness
Table 1 Cost Effectiveness Calculator Oregon

Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Max Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Ele Allo	% Gas Allo
Resideo Tstat Optimization - Winter gFAF	1	43	15.5	$8.00	$0.56	$8.00	1.1	1.2	34%	66%
Resideo Tstat Optimization - Winter eFAF	1	448	0	$8.00	$0.00	$8.00	3.9	3.9	100%	0%
Resideo Tstat Optimization - Winter Heat Pump	1	171	0	$8.00	$0.00	$8.00	1.5	1.5	100%	0%

Table 2 Cost Effectiveness Calculator Washington

Measure	Measure Life (years)	Unclaimed Savings (kWh)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Max Incentive ($)	UCT BCR at Max Incentive	TRC BCR
Resideo Tstat Optimization - Winter gFAF	1	47	15.5	$8.00	$3.87	$8.00	1.6	2.0

Details
Program implementers pay Resideo for each device that is enrolled in the optimization program. The program will receive data about the number of devices enrolled by zipcode and heating system type (gas FAF, electric FAF, heat pump) from Resideo. A utility split based will be applied at the zipcode level to determine the savings that will be recorded in PT for each utility, using virtual sites.

Customers are enrolled either through the Honeywell app or through an online form accessed by the customer through a recruitment email. Only customers who are currently using the Honeywell Total Comfort Control or Lyric app to remotely control their device are sent requests to enroll.

Resideo's optimization algorithm can be applied for either the winter, summer or both – only winter savings have been validated and are approved. A summer evaluation is expected in late 2019 and this document may be updated if summer savings are found and are cost effective. Enrollment will take place during in the late-fall/early-winter time-period to ensure that heating season savings are captured.

Participants are notified of their enrollment and can opt-out of the service once enrolled. Resideo reported a 3.2% overall attrition rate for pilot participants, which has been applied to the savings values presented here. Participant attrition was due customer opt-out, disconnected service, move-outs, and disqualification.

Baseline
This measure uses an Existing Condition Baseline.

The baseline condition is the existing settings of internet-connected Honeywell thermostats.

Measure Analysis
Pilot Summary and Results
Energy Trust ran a pilot on this technology in 2018 and 2019 in PGE territory. The pilot included Ecobee devices but these will not be part of the ongoing Resideo offering.

Apex analytics conducted a runtime analysis of test and control participants to determine savings during the winter of 2018-19[1] and normalized to a typical mean year (TMY). The key finding from the savings analysis was that "Combined runtime and billing analyses found reductions of 3.2% primary heating fuel savings and 5.1% fan electric savings for thermostats connected to furnaces. For heat pumps, we found reductions of 4.0% of heating electric use." Primary savings are shown in Table 3, which is directly from the draft report.

Table 3 Energy Savings for the Resideo Connected Savings Pilot, by System and Fuel Type

System	Fuel	TMY Heating Savings	90% CI	TMY Heating Savings (%)
Gas Furnace	Therms	16	±7	3.2%
Electric Furnace**	kWh	414	±170	3.2%
Furnace Fan	kWh	49	±22	5.1%
Heat Pump	kWh	177	±146	4.0%

** Electric Furnace values calculated using Gas Furnace values converted to therms.

Furnace fan savings shown in Table 3 are added to both gas furnace and electric furnace heating savings.

Opt-outs and leakage

An estimated 10% of devices installed on gas forced air furnaces are expected to fall outside Energy Trust electric territory in Oregon, referred to as leakage. This estimate is based on analysis of Project Tracker data used in the Nest Seasonal Savings optimization analysis and assumes that the geographic distribution of Resideo eligible devices mirrors that of Nest devices in Oregon. Fan savings for gFAF systems are de-rated by 10% to account for those sites outside Energy Trust electric territory.

All savings were reduced by 3.2% to account for opt-outs.

Comparison to RTF or other programs

The RTF does not currently have a measure for internet-connected thermostat optimization.

Measure Life

A one year measure life is used in this analysis, as the $8 fee paid to Resideo for each device covers deployment of the savings algorithm for 1 heating season.

Participating devices can be enrolled again for the following heating season(s). Persistence of savings has not been studied.

Cost

The cost of deploying the optimization algorithm is $8 per device per winter or summer season and $12 for both seasons. Only the winter season is approved at this time. This fee is charged to Energy Trust. The service is free to the end use customer.

Non Energy Benefits

Fan savings for the 10% of Oregon gas furnace sites expected to be out of electric territory are instead converted to a customer bill savings NEB at the Energy Trust blended electric rate of $0.119/kWh for a total NEB value of $0.56/year.

In SW Washington the full fan savings are converted to a NEB at a rate of $0.082/kWh based on Clark PUD's residential retail rate for a total value of $3.87 per year.

Incentive Structure

Incentives will be structured per device where the optimization algorithm is applied. Incentives are paid to Resideo, not participants, after confirmed enrollment of a device. If participants opt-out of the service or disconnect their device, incentives cannot be recouped.

SRAF

Residential program SRAFs apply to this measure

Follow-Up

The pilot's summer savings results are expected in late 2019. If summer savings prove to be statistically significant and cost effective, this MAD may be updated to include summer offerings.

Future evaluations may identify persistence of savings beyond one year which can be incorporated into the analysis. Savings for heat pumps have high uncertainty. If future evaluations find more certain results, those should be incorporated.

The program will monitor opt-out rates and adjust at next update. Opt-out rates may differ between winter and summer.

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\optimization\Resideo

Resideo Tstat
Optimization - CEC 2

Version History and Related Measures

Table 4 Version History

Date	Version	Reason for revision
6/12/2018	217.1	Approval for Whisker Labs pilot
10/23/2019	217.2	Transition to standard measure. Winter only.

Table 5 Related Measures

Measures	MAD ID
Retail web-enabled thermostats	153
Nest Seasonal Savings Winter	173

[1] Apex Analytics "ETO Whisker Intrm Winter Memo DRAFT 081619" 2019

Approved & Reviewed by

Jackie Goss, PE
Sr. Planning Engineer

Disclaimer

EnergyTrust of Oregon

Measure Approval Document for Retail Showerheads and Shower Wands

Valid Dates
January 1, 2020 through December 31, 2020

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 for use in the following programs:

- Residential

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

- Midstream Retail

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

- Replacement - Assumes full market baseline

Purpose of Re-Evaluating Measure
Administrative update for one year, full update to be conducted in 2020.

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	% Ele Allo	% Gas Allo
Retail Showerhead - Full Territory Any Electric 2.00 GPM	15	29	0.0	$8.50	$2.94	$8.50	2.8	6.5	100%	0%
Retail Showerhead - Full Territory Any Electric 1.80 GPM	15	69	0.0	$8.50	$7.00	$8.50	6.7	15.6	100%	0%
Retail Showerhead - Full Territory Any Electric 1.75 GPM	15	76	0.0	$8.50	$7.76	$8.50	7.5	17.3	100%	0%
Retail Showerhead - Full Territory Any Electric 1.60 GPM	15	116	0.0	$8.50	$11.78	$8.50	11.3	26.2	100%	0%
Retail Showerhead - Full Territory Any Electric 1.50 GPM	15	151	0.0	$8.50	$15.42	$8.50	14.8	34.3	100%	0%
Retail Showerhead - Full Territory Gas 2.00 GPM	15	1	1.3	$8.50	$2.94	$8.04	1.0	4.7	8%	92%
Retail Showerhead - Full Territory Gas 1.80 GPM	15	2	3.1	$8.50	$7.00	$8.50	2.3	11.1	8%	92%
Retail Showerhead - Full Territory Gas 1.75 GPM	15	2	3.4	$8.50	$7.76	$8.50	2.5	12.3	8%	92%
Retail Showerhead - Full Territory Gas 1.60 GPM	15	3	5.2	$8.50	$11.78	$8.50	3.8	18.7	8%	92%
Retail Showerhead - Full Territory Gas 1.50 GPM	15	4	6.8	$8.50	$15.42	$8.50	5.0	24.4	8%	92%
Retail Showerhead - Partial Territory Gas 2.00 GPM	15	0	1.3	$8.50	$3.01	$7.37	1.0	4.7	0%	100%
Retail Showerhead - Partial Territory Gas 1.80 GPM	15	0	3.1	$8.50	$7.18	$8.50	2.1	11.1	0%	100%
Retail Showerhead - Partial Territory Gas 1.75 GPM	15	0	3.4	$8.50	$7.96	$8.50	2.3	12.3	0%	100%
Retail Showerhead - Partial Territory Gas 1.60 GPM	15	0	5.2	$8.50	$12.08	$8.50	3.5	18.7	0%	100%
Retail Showerhead - Partial Territory Gas 1.50 GPM	15	0	6.8	$8.50	$15.81	$8.50	4.5	24.5	0%	100%
Retail Shower Wands - Full Territory Any Electric 2.00 GPM	15	28	0.0	$22.95	$2.82	$22.95	1.0	2.3	100%	0%
Retail Shower Wands - Full Territory Any Electric 1.80 GPM	15	68	0.0	$22.95	$6.89	$22.95	2.4	5.7	100%	0%
Retail Shower Wands - Full Territory Any Electric 1.75 GPM	15	75	0.0	$22.95	$7.64	$22.95	2.7	6.3	100%	0%
Retail Shower Wands - Full Territory Any Electric 1.60 GPM	15	115	0.0	$22.95	$11.66	$22.95	4.1	9.6	100%	0%
Retail Shower Wands - Full Territory Any Electric 1.50 GPM	15	191	0.0	$22.95	$19.44	$22.95	6.9	16.0	100%	0%
Retail Shower Wands - Full Territory Gas 2.00 GPM	15	1	1.2	$22.95	$2.82	$7.72	1.0	1.7	8%	92%
Retail Shower Wands - Full Territory Gas 1.80 GPM	15	2	3.0	$22.95	$6.89	$18.86	1.0	4.0	8%	92%
Retail Shower Wands - Full Territory Gas 1.75 GPM	15	2	3.3	$22.95	$7.64	$20.92	1.0	4.5	8%	92%
Retail Shower Wands - Full Territory Gas 1.60 GPM	15	3	5.1	$22.95	$11.66	$22.95	1.4	6.8	8%	92%
Retail Shower Wands - Full Territory Gas 1.50 GPM	15	5	8.5	$22.95	$19.44	$22.95	2.3	11.4	8%	92%
Retail Shower Wands - Partial Territory Gas 2.00 GPM	15	0	1.2	$22.95	$2.89	$7.07	1.0	1.7	0%	100%
Retail Shower Wands - Partial Territory Gas 1.80 GPM	15	0	3.0	$22.95	$7.06	$17.27	1.0	4.1	0%	100%
Retail Shower Wands - Partial Territory Gas 1.75 GPM	15	0	3.3	$22.95	$7.84	$19.16	1.0	4.5	0%	100%
Retail Shower Wands - Partial Territory Gas 1.60 GPM	15	0	5.1	$22.95	$11.96	$22.95	1.3	6.9	0%	100%
Retail Shower Wands - Partial Territory Gas 1.50 GPM	15	0	8.5	$22.95	$19.93	$22.95	2.1	11.5	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
Retail Showerhead - Partial Territory Gas 2.00 GPM	15	0	1	9	$2.57	$8.50	1.0	4.0
Retail Showerhead - Partial Territory Gas 1.80 GPM	15	0	3	9	$6.13	$8.50	2.4	9.6
Retail Showerhead - Partial Territory Gas 1.75 GPM	15	0	4	9	$6.79	$8.50	2.7	10.6
Retail Showerhead - Partial Territory Gas 1.60 GPM	15	0	6	9	$10.32	$8.50	4.0	16.1
Retail Showerhead - Partial Territory Gas 1.50 GPM	15	0	7	9	$13.50	$8.50	5.3	21.1
Retail Shower Wands - Partial Territory Gas 2.00 GPM	15	0	1	23	$2.47	$8.21	1.0	1.4
Retail Shower Wands - Partial Territory Gas 1.80 GPM	15	0	3	23	$6.03	$20.06	1.0	3.5
Retail Shower Wands - Partial Territory Gas 1.75 GPM	15	0	4	23	$6.69	$22.25	1.0	3.9
Retail Shower Wands - Partial Territory Gas 1.60 GPM	15	0	5	23	$10.21	$22.95	1.5	5.9
Retail Shower Wands - Partial Territory Gas 1.50 GPM	15	0	9	23	$17.02	$22.95	2.5	9.9

Requirements

- Rated flows between 1.5 and 2.0 gallons per minute
- Showerheads and shower wands must be WaterSense® certified.

Baseline

This measure uses a:

- Full 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	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 and shonwn in Table 9.

Table 4 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 presents the in-situ multipliers for the various flow rate categories in addition to the estimated 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.

[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

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 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				
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 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

Water Heater Type	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.)	Oregon water/waste water cost, net of energy cost ($/gal.)
Electric Resistance	1.75	90%	402	8.9	0.128	0.0037	$0.013
	1.50	88%	402	9.2	0.128	0.0037	$0.013
Electric HPWH	1.75	90%	402	8.9	0.064	0.0037	$0.013
	1.50	88%	402	9.2	0.064	0.0037	$0.013
Gas	1.75	90%	402	8.9	0.0058	0.0037	$0.013
	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

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	$65.01	1.32

The split used between standard electric resistance storage and heat pump water heaters is assumed to be 98% resistance and 2% heat pump. 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.

Savings

Table 9 illustrates the calculation of water energy UESs for Oregon electric showerhead measures at retail. The retail baseline distribution in 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 9 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 10 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 10 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 is 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

Follow-Up

For 2020, this measure was not updated. It must be updated for use in 2021 to either align with most recent RTF updates, or break from RTF entirely: 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)

Other inputs that may need updates:

- Potential occupancy per dwelling type updates from American Community Survey (this MAD uses 2015 data)
- Retail product mix by flow rate
- Measure life should be changed to 10 years in line with RTF analysis.

- Review of 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

Retail Showerheads and Wands 2020.xlsm

Version History and Related Measures

Energy Trust has been offering showerheads at retail for many years. These measures pre-date our measure approval documentation and record retention policies. Table 11 may be incomplete, particularly for approvals prior to 2013.

Table 11 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.
10/11/2019	26.4	Admin update for one year.

Table 12 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

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Measure Approval Document for Web Enabled Smart Thermostats

Valid Dates
August 1, 2019 – December 31, 2022

End Use or Description
Web-enabled smart thermostats with occupancy detection provide energy savings through reduced run time of heating and/or cooling systems. Some models achieve additional savings when paired with heat pumps through changes in strip heat control.

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, applicability to the following program tracks are expected:
- Retail downstream via consumer applications,
- Midstream/Downstream through instant coupon platforms or allocated via the most current version of the Regional Sales Allocation Tool ("RSAT") or Distributor Sales Allocation Tool ("DSAT").

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

Purpose of Re-Evaluating Measure
- Updating electric savings analysis to most recent RTF savings estimates for electric forced air furnaces and air source heat pumps in all housing types.
- Blending of housing types (Single family, multifamily and manufactured homes) into combined measures.
- Moving from incremental to existing condition retrofit baseline.
- Updated costs.
- Addition of cooling savings.

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
Smart Tstat Any Home - Electric	11	486	-	$170	$0.00	$170	2.2	2.2	100%	0%
Smart Tstat Any Home - Gas	11	42	31.8	$170	$0.00	$170	1.4	1.4	25%	75%
Smart Tstat Any Home - Gas Only	11	0	31.8	$170	$4.95	$170	1.0	1.3	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
WA Smart Tstat Any Home - Gas	11		31.8	$170	$3.41	$170	1.45	1.61

Requirements
- Thermostat must be on Smart Thermostat Qualified Products List.[1]
- Home must be heated with fuel provided by a participating Energy Trust utility, or allocated appropriately through one of the allocation platforms.

The qualified product list is maintained by the residential sector with input by the Planning and Evaluation teams. It is based on proven savings in conjunction with required features.
- Thermostat detects occupancy and can automatically change the temperature during unoccupied periods.
- Demonstrate savings and customer satisfaction from at least one published study or pilot program with 3rd party evaluation.
- Include simple, step-by-step instructions for customer installation of the thermostat. If instructions are not included in the box, they must be easily accessible online.

Baseline
This measure uses a:
- Existing Condition Baseline

The baseline assumes a standard programmable or manual thermostat in a home with average HVAC loads.

Measure Analysis
Electric Heating System Savings
Electric forced air furnace and air source heat pump baseline loads and savings percentages are from the RTF's connected thermostat workbook.[2] The analysis applies the Energy Trust evaluated gas furnace heating savings estimate of 6% to electric forced air furnace heating and cooling loads. Heat pumps save an estimated 14% of heating loads, also sourced from Energy Trust research.[3] RTF cooling saving estimates for heat pumps and forced air furnaces is 6%, based on the assumption that the driver of savings is reduced run times similar to heating savings for forced air furnaces. RTF savings estimates are shown in Table 3.

[1] Energy Trust Thermostat QPL
[2] RTF Connected Tstats v1.3
[3] Energy Trust Follow-up Billing Analysis for the Nest Thermostat Heat Pump Control Pilot, 2015

Table 3 RTF Electric Furnace and Air Source Heat Pump Home Savings

Home Size	Heating System Type	Heating Zone	% Heating Savings – Smart Tstat	% Cooling Savings - Smart Tstat	Heating Savings (kWh)	Cooling Savings (kWh)
SF and MH =< 1600 sq ft and all MF	Electric FAF	HZ1	6%	6%	377	0
SF and MH > 1600 sq ft	Electric FAF	HZ1	6%	6%	539	0
SF and MH =< 1600 sq ft and all MF	Electric FAF	HZ2	6%	6%	496	0
SF and MH > 1600 sq ft	Electric FAF	HZ2	6%	6%	672	0
SF and MH =< 1600 sq ft and all MF	Heat Pump	HZ1	14%	6%	458	8
SF and MH > 1600 sq ft	Heat Pump	HZ1	14%	6%	558	7
SF and MH =< 1600 sq ft and all MF	Heat Pump	HZ2	14%	6%	723	20
SF and MH > 1600 sq ft	Heat Pump	HZ2	14%	6%	807	22

Given the nature of retail midstream and downstream delivery, accurate data collection on these attributes can be difficult to obtain from participants leading to a weighted approach to savings estimates. The RTF modeled heating and cooling loads by housing type, size, heating zone and heating type, which were weighted based on RTF and RBSA II data were used to collapse savings estimates into blended values. Weighting factors are shown in Table 4. Final savings levels for electric heating systems by housing type and blended are presented in Table 5.

Table 4 Heating Zone, Housing Size and Heating System Weights

Home Size	Heating System Type	Heating Zone	SF/MH/MF Heating Zone Weight	SF/MH Heating System and Size Weight	MF Heating System Weight
SF and MH =< 1600 sq ft and all MF	Electric FAF	HZ1	95%	33%	65%
SF and MH > 1600 sq ft	Electric FAF	HZ1	95%	18%	0%
SF and MH =< 1600 sq ft and all MF	Electric FAF	HZ2	5%	33%	65%
SF and MH > 1600 sq ft	Electric FAF	HZ2	5%	18%	0%
SF and MH =< 1600 sq ft and all MF	Heat Pump	HZ1	95%	17%	35%
SF and MH > 1600 sq ft	Heat Pump	HZ1	95%	32%	0%
SF and MH =< 1600 sq ft and all MF	Heat Pump	HZ2	5%	17%	35%
SF and MH > 1600 sq ft	Heat Pump	HZ2	5%	32%	0%

Table 5 Final Electric Heating System Savings Estimates

Measure	Savings (kWh)	Housing Weight
Smart Tstat Single/Manufactured Home - Electric	491	94%
Smart Tstat Multifamily - Electric	416	6%
Smart Tstat Any Home - Electric	486	100%

Gas Furnace Savings

Energy Trust's pilot evaluation of homes heated by a gas furnace resulted in heating savings of 6%.[4] For single family homes, the average annual heating loads are derived from the RBSA I.[5] The average heating loads for Oregon gas heated homes was 583 therms. These values include both heating zone 1 and heating zone 2.

For multifamily dwelling units, the average annual heating load for electrically heated units is derived from the RTF's Connected thermostat measure analysis. 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.

Gas Furnace Fan 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. Furnace fan savings are based on the RTF's estimate of fan input energy of 0.53 kW and Energy Trust residential project data on average furnace input energy of 63,000 Btu/hr. Estimated Fan runtime savings are based on the following equation:

$$Fan\ kWh\ savings = \frac{(therm\ savings * 100{,}000 Btu/therm)}{input\ Btu/h} * fan\ input$$

Inputs result in fan savings of 27 kWh for single family/manufactured homes and 21 kWh for multifamily.

Cooling Savings for homes with Gas Furnaces

Cooling loads for gas furnace homes are based on an average estimated cooling load from Energy Trust's heat pump pilot and runtime analysis in Energy Trust's Nest seasonal savings pilot. Annual cooling load estimates were 200 and 787 kWh for single family dwellings, given the large range this analysis uses the mid-point of 494 kWh/year for single and manufactured housing. Applying the ratio used to estimate multifamily gas loads above, multifamily cooling loads are 388 kWh annually.

RBSA II data for single family, manufactured homes and multifamily was used to estimate prevalence of central AC equipped gas furnace homes. Single family and manufactured home combined central AC saturation is 57% and multifamily is 30%.

Final smart thermostat savings estimates for gas furnace are shown in Table 6.

[4] Energy Trust of Oregon Smart Thermostat Pilot Evaluation (Gas Furnaces). Apex analytics, 2016.
[5] NEEA 2011-12 RBSA I

Table 6 Final Gas Furnace Heating, Fan and Cooling Savings

Housing Type	Fuel	Heating Savings Therms	Fan Savings kWh	Cooling Savings kWh	Total kWh Savings	NEB	Cooling Savings %
Single/Manufactured Home	Gas	32.2	27	16	43	$0.00	37%
Single/Manufactured Home	Gas Only Territory	32.2	-		-	$5.07	
Multifamily	Gas	25.3	21	6	28	$0.00	23%
Multifamily	Gas Only Territory	25.3	0		-	$3.29	

Install rate

The 2014 gas thermostat pilot, which depended on self-install, yielded 415 total purchased thermostats, of which 32 were returned. This is a 92% install rate. This factor is applied to heating, cooling and fan energy savings to account for products that are purchased and either not installed or later uninstalled and is embedded in the previous analysis tables.

Housing Type Blending

Data for from Energy Trust Project Tracker from January 2018 to March 2019 on incented midstream smart thermostats was used to determine blended savings for dwelling types, shown in Table 7**Error! Reference source not found.**.

Table 7 Distribution of Energy Trust Mid/Downstream Incented Smart Thermostats Between Housing Types

Housing Type	Distribution
Multifamily	6%
Single Family/Manufactured Homes	94%

Final savings, costs, NEBs and fan/cooling related savings for thermostats by fuel, housing types, and blended together are shown below in Table 8

Table 8 Final Smart Thermostat Savings, Costs and NEBs

Measure	Total Savings (kWh)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Housing Weight	Fan Savings (kWh)	Cooling Savings (kWh)	Percent Cooling
Single/Manufactured Home - Electric	491	-	$170	$0.00	94%			
Single/Manufactured Home - Gas	43	32.2	$170	$0.00	94%	27	16	37%
Single/Manufactured Home - Gas Only	-	32.2	$170	$5.07	94%			
Multifamily - Electric	416	-	$170	$0.00	6%			
Multifamily - Gas	28	25.3	$170	$0.00	6%	21	6	23%
Multifamily - Gas Only	-	25.3	$170	$3.29	6%			
Any Home - Electric	**486**	**-**	**$170**	**$0.00**	**100%**			
Any Home - Gas	**42**	**31.8**	**$170**	**$0.00**	**100%**	**27**	**15**	**36%**
Any Home - Gas Only	**-**	**31.8**	**$170**	**$4.95**	**100%**			
SW WA Any Home - Gas Only	**-**	**31.8**	**$170**	**$3.41**	**100%**			

Comparison to RTF or other programs

Energy Trust uses a longer measure life than the RTF and includes gas heated measures which are not included in the RTF workbooks. RTF analysis identifies specific heating zone measures whereas this MAD blends RTF savings estimates by zone together for these measures.

Energy Trust also offers smart thermostats through PGE's demand response direct install pilot and may in the future participate in further direct install efforts with other partners. Those offerings have higher costs and more site-specific savings and are approved through MAD 222. Contractor installed smart thermostats in homes with heat pumps are approved through MADs 148 and 19.

Measure Life

The California Database for Energy Efficiency Resources (DEER) lists the expected lifespan of a programmable thermostat as 11 years.

Cost

The Nest E represents the base cost of a thermostat with the features associated with proven energy savings. These products have averaged $170 from online retail sites (accessed March & June 2019).

Non Energy Benefits

In both Oregon and Washington, unclaimed electric savings are included as non-energy benefits valued at the retail rate of electricity for those territories ($0.119/kWh OR, $0.082/kWh SW WA).

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 purchased thermostat.

SRAF

The shift to gross savings reporting in 2020 will remove free rider calculations from thermostat measures. These measures use standard program SRAFs.

Follow-Up

Additional impact evaluation results are expected in Q3-4 of 2019 and can be incorporated into this MAD at the next update. To the extent possible, this MAD should be updated on the same schedule as MAD 22 since these measures share much of the same assumptions and analysis.

Differentiated product level savings may be necessary in future updates as manufacturers alter device algorithms or incorporate enhanced savings

Distribution of incented thermostats between single family, multifamily and manufactured home should be refreshed in subsequent updates to maintain blended savings accuracy.

Costs for thermostats may come down as more manufacturers enter the market and technology matures.

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\Self installed

Res Web Enabled
Smart Tstats - CEC 2(

Version History and Related Measures

Table 9 Version History

Date	Version	Reason for revision
9/12/13	x	Nest heat pump pilot
10/9/14	132	Web-enabled thermostat gas heated homes pilot
8/17/15	138	Retail and contractor installed web-enabled thermostats, electric and gas
10/22/15	148	Contractor installed web-enabled thermostats for heat pumps only
4/1/16	153.1	Retail-only web-enabled thermostat measure, electric and gas. Update avoided costs. Supersedes MAD 138.
5/15/17	153.2	Specifies savings for multifamily. Fan savings added. Contractor install included, may be offered concurrently with MAD 148.
7/11/2019	153.3	Update to electric savings based on RTF analysis. Move from incremental to retrofit baseline and costs. Blending Res/MF. Addition of cooling savings to gFAF measures.

Table 10 Related Measures

Measures	MAD ID
DI Smart Thermostats with Funding Partners	222
DI Commercial Smart Thermostats Pilot	235
Automated Thermostat Optimization	173
Residential Thermostat Optimization Pilot	217
Contractor Installer Thermostats for New Heat Pumps	19
Contractor Installer Thermostats for Existing Heat Pumps	148

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Measure Approval Document for Existing Single Family and Small Multifamily Insulation Retrofit

Valid Dates
January 1, 2020 – December 31, 2022

End Use or Description
Insulation for ceilings or attics, walls (includes knee wall and rim joist applications) and floors to reduce overall space conditioning energy consumption.

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

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

- Residential – Existing Single Family
- Small Multifamily – 2-4 and side-by-side units

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

- Retrofit

Purpose of Re-Evaluating Measure
This analysis updates gas and electric heating savings. Cooling savings and fan savings are now included in the analysis.

Costs are updated to reflect more recent program data.

Knee wall insulation, which had a separate MAD, is now included under wall insulation savings.

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	% Ele Allo	% Gas Allo
1	Attic insulation Gas Heat (R0-R11 starting condition) HZ1	45	0.195	0.074	$1.50	$0.010	$1.50	1.4	1.5	34%	66%
2	Attic insulation Gas Heat (R0-R11 starting condition) HZ2	45	0.179	0.074	$1.50	$0.008	$1.50	1.3	1.4	32%	68%
17	Attic insulation Gas Heat (R0-R11 starting condition) HZ1 - Gas Only	45	-	0.074	$1.50	$0.088	$1.37	1.0	2.0	0%	100%
18	Attic insulation Gas Heat (R0-R11 starting condition) HZ2 - Gas Only	45	-	0.074	$1.50	$0.084	$1.37	1.0	2.0	0%	100%
9	Attic insulation Ele Heat (R0-R11 starting condition) Any Zone	45	0.726	-	$1.38	$0.014	$1.38	1.2	1.4	100%	0%
5	Wall insulation Gas Heat HZ1	45	0.080	0.052	$3.07	$0.021	$1.26	1.0	0.5	23%	77%
6	Wall insulation Gas Heat HZ2	45	0.101	0.057	$3.07	$0.022	$1.43	1.0	0.6	26%	74%
21	Wall insulation Gas Heat HZ1 - Gas Only	45	-	0.052	$3.07	$0.069	$0.96	1.0	0.7	0%	100%
22	Wall insulation Gas Heat HZ2 - Gas Only	45	-	0.057	$3.07	$0.076	$1.06	1.0	0.8	0%	100%
11	Wall insulation Ele Heat Any Zone	45	1.339	-	$1.89	$0.029	$1.89	1.6	1.9	100%	0%
7	Floor insulation Gas Heat HZ1	45	(0.021)	0.042	$2.18	$0.005	$0.74	1.0	0.4	0%	100%
8	Floor insulation Gas Heat HZ2	45	(0.031)	0.046	$2.18	$0.005	$0.79	1.0	0.4	0%	100%
23	Floor insulation Gas Heat HZ1 - Gas Only	45	-	0.042	$2.18	$0.034	$0.78	1.0	0.7	0%	100%
24	Floor insulation Gas Heat HZ2 - Gas Only	45	-	0.046	$2.18	$0.035	$0.85	1.0	0.7	0%	100%
12	Floor insulation Ele Heat Any Zone	45	0.610	-	$1.98	$0.014	$1.25	1.0	0.8	100%	0%

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
1	Attic insulation Gas Heat WA (R0-R11 starting condition)	45		0.074	$1.46	$0.025	$1.46	1.1	1.3
2	Wall insulation Gas Heat WA	45		0.052	$2.52	$0.027	$1.09	1.0	0.6
3	Floor insulation Gas Heat WA	45		0.042	$2.07	$0.004	$0.88	1.0	0.5

Exceptions
A minor cost effectiveness exception was granted by the Oregon Public Utility Commission on September 26, 2019 for specific single and small multifamily gas and electric measures:

- Wall insulation gas heat HZ1 (single family/small multifamily)
- Wall insulation gas heat HZ2 (single family/small multifamily)
- Floor insulation gas heat HZ1 (single family/small multifamily)
- Floor insulation gas heat HZ2 (single family/small multifamily)
- Floor insulation electric heat any zone (single family/small multifamily)

The exception was granted based on Exception Criteria A: This measure produces significant non-quantifiable non-energy benefits and Exception Criteria G: The measure is required by law or is consistent with Commission policy and/or direction. Furthermore, the exception is consistent with past Orders addressing insulation.

Energy Trust must study potential demand response benefits of insulation with other technologies. Energy Trust must report this information within a year of the exception.

The exception is granted through December 31, 2022 or unit the measure savings exceed 5% of the program's savings.

OPUC order 15-140 entered April 30, 2015 put limits on incentives for non-cost effective insulation measures. Several of these are no longer in place since the measures are now cost effective. The incentive for standard track wall and floor insulation for gas heated homes in Oregon is capped at $150 and must be done at the same time as attic insulation for standard market rate offers. This cap does not apply to multifamily, rentals or savings within reach projects.

Measure-level cost effectiveness is not a requirement in Washington.

Requirements

Ceiling and Attic Insulation Requirements:

- Existing insulation must be R-11 or less. Must insulate to R-38 or greater or fill cavity.

Wall Insulation Requirements:

- Standard track homes heated by gas can receive wall insulation incentives that are capped at $150,and must be installed with qualifying ceiling insulation.
  - Multifamily, moderate income and renter tracks have no incentive cap.
- If home is primarily heated by gas, must be installed with qualifying attic insulation.
- Existing wall, rim joist, and knee wall insulation must be R-4 or less.
- Exterior Walls must be insulated to R-11 or fill cavity. All heated exterior wall surfaces must be insulated.
- Rim joists, if existing condition is R-4 or less, must be insulated to R-15 or fill cavity
- Knee walls must be insulated to R-15 for 2x4 cavities or R-21 for 2x6 cavities. Attic insulation must be R-19 or higher in order for knee wall insulation to be eligible for an incentive.

Floor Insulation Requirements

- Existing insulation must be R-0. Must insulate to R-30 or greater or fill cavity. Standard track homes heated by gas can receive up to $150 total and must be installed with qualifying attic insulation.
  - Multifamily, moderate income and renter tracks have no incentive cap.

Baseline

This measure uses an Existing Condition Baseline.

The baseline is a dwelling with little to no insulation.

Measure Analysis

Ceiling and attic insulation serve the same purposes and are used interchangeably in this document. Small multifamily buildings are expected to have similar heating and cooling characteristics to single family.

For Wall and Floor insulation, the analysis uses RBSA II data on the distribution of electric heating systems in order to create weights for the RTF's zonal, eFAF and heat pump measures. Table 3 shows the weight values used in the savings analysis.

Table 3 RBSA II Electric Heating System Distribution for RTF Savings Weighting

RBSA II Oregon Electric Heating and Cooling Systems	Electric Heating System Prevalence	Electric Heating System Category	Electric Heating System Category Prevalence
Electric Furnace - Central AC	4.80%	Electric FAF	9.6%
Electric Furnace - None	3.70%		
Electric Furnace - Permanent Room AC	0.30%		
Electric Furnace - Portable Room AC	0.80%		
Electric Heat Pump - Central AC	35.60%	Heat Pump	47.9%
Electric Heat Pump - None	0.30%		
Electric Heat Pump - Permanent Room AC	12.00%		
Electric Zonal - None	37.10%	Zonal or DHP	42.5%
Electric Zonal - Permanent Room AC	0.60%		
Electric Zonal - Portable Room AC	4.80%		

While the RTF does calculate heating zone 3 savings, heating zone 3 customers may use measures designed for heating zone 2, as the fraction of Energy Trust's rate payer base in heating zone 3 is quite small. For electric measures a blending of zones 1 and 2 are used to create any zone measures, this was done based on recent Energy Trust Project Tracker information about the distribution of insulation projects, by type, to create single territory wide measures. For gas measures, this same approach was applied, however, due to the OPUC exception specifying separate gas heating zone measures, the weighted measures are not approved.

Ceiling and Attic Insulation Heating

Energy Trust's billing analysis of ceiling insulation for 2009-2014 was used for ceiling insulation heating (and for the electric measure, embedded cooling) savings per site.[1] Only 2014 savings estimates were used as 2013 was a transition year where the market rate maximum starting condition of R18 was lowered to R12 – potentially biasing the sample for projects occurring in the first few months of the year. These site savings were divided by average treatment square footage from the project database with the top and bottom two percentiles removed, leading to estimated average savings per square foot of 0.074 therms and 0.73 kWh. The analysis did not differentiate savings by heating zones.

Table 4 2014 Energy Trust Ceiling Insulation Impact Evaluation Results

Fuel	Average Project Savings	2014 Average Project Square Footage	Savings per Square Foot
Gas (therms)	86	1,162	0.074
Electricity (kwh)	865	1,192	0.73

[1] Energy Trust: Ceiling Insulation 2009-2014 draft final 4 (internal document)

Wall Insulation Heating

Gas heating savings are from an Energy Trust billing analysis[2], where wall insulation projects from 2007 to 2009 show varying amounts of energy savings, from 0.038 to 0.062 annual therms per square foot. As there is a fairly wide range between the results, this analysis uses 0.052 annual therms from the 2007 impact evaluation, which is the median amount. The analysis did not distinguish between heating zones, but heating zone 1 made up nearly 100% of the sample. A ratio of heating degree days was used to estimate a heating zone 2 savings of 0.046 therms/sqft.

Electric heating savings are based on RTF modeling from the single family weatherization workbook v3.7 and weighted according to Table 3.

Floor Insulation Heating

Energy Trust billing analysis of floor insulation projects from 2007 to 2009 show varying amounts from 0.035 to 0.051 therms per square foot. As there is a fairly wide range between the results, this analysis uses 0.036 therms from the 2009 impact evaluation, which is the median amount.[3] The analysis did not distinguish between heating zones, but zone 1 made up nearly 100% of the sample. A ratio of heating degree days was used to estimate a heating zone 2 savings of 0.057 therms/sqft.

Electric heating savings are based on RTF modeling from the single family weatherization workbook v3.7 and weighted according to Table 3.

Gas Furnace Fan

Fan savings use inputs and an engineering equation from prior Energy Trust gas furnace analysis and are added to the evaluated savings for gas insulation measures:[4]

$$Fan\ kWh\ savings = \frac{(therm\ savings * 100{,}000 Btu/therm)}{input\ Btu/h} * fan\ input$$

Average furnace kBtu/hr input from project data used in the prior analysis was 63, with an estimated fan input of 0.53 kW sourced from the RTF's SEEM modeled electric forced air furnace fan input. These values lead to the estimates fan savings per square foot of gas insulation in Table 5. Fan savings for electrically heated homes are embedded in the RTF's modeled analysis.

Table 5 Gas Furnace Fan Savings Calculation by Insulation Type

Measure	Gas Savings (therms/sqft)	Fan Savings (kWh/sqft)
Attic insulation Gas Heat (R0-R11 starting condition) HZ1	0.074	0.06
Attic insulation Gas Heat (R0-R11 starting condition) HZ2	0.074	0.06
Wall insulation Gas Heat HZ1	0.052	0.04
Wall insulation Gas Heat HZ2	0.057	0.05
Floor insulation Gas Heat HZ1	0.042	0.04
Floor insulation Gas Heat HZ2	0.046	0.04

Cooling

The RTF estimates cooling savings or penalties based on starting and ending conditions of insulation for various heating systems. Cooling zones are weighted into heating zones to facilitate the deployment of fewer measures. RBSA II data on saturation of cooling system prevalence was used in conjunction with the RTF analysis to create final estimates of cooling season reductions or increases in air conditioning usage. All cooling savings (or penalties) for electric measures stem from RTF analysis in their weatherization workbook v3.7.[5] For gas heated wall and floor insulation measures, cooling savings are based on RTF SEEM modeling runs used in the weatherization workbook.[6]

Total savings

Table 6 shows the savings components and total savings for gas and electric insulation measures.

Table 6 Savings Components

Measure	Fan Savings (kWh/sqft)	Electric Heating Savings (kWh/sqft)	Cooling Savings (kWh/sqft)	Total Electric Savings (kWh/sqft)	Total Gas Savings (therms/sqft)
Attic insulation Gas Heat (R0-R11 starting condition) HZ1	0.06	0	0.133	0.195	0.074
Attic insulation Gas Heat (R0-R11 starting condition) HZ2	0.06	0	0.116	0.179	0.074
Attic insulation Ele Heat (R0-R11 starting condition) Any Zone	Not disaggregated	Not disaggregated	Not disaggregated	0.726	0
Wall insulation Gas Heat HZ1	0.04	0	0.037	0.080	0.052
Wall insulation Gas Heat HZ2	0.05	0	0.053	0.101	0.057
Wall insulation Ele Heat Any Zone	Not disaggregated	1.31	0.0283	1.339	0
Floor insulation Gas Heat HZ1	0.04	0	(0.056)	(0.021)	0.042
Floor insulation Gas Heat HZ2	0.04	0	(0.070)	(0.031)	0.046
Floor insulation Ele Hea– Any Zone	Not disaggregated	0.648	(0.0388)	0.610	0

Comparison to RTF or other programs

The RTF's analysis estimates savings by heating/cooling zones, electric HVAC system and beginning/ending R values for attic, floor, wall insulation as separate measure identifiers. This analysis blends these measures based on RBSA and Energy Trust project information on the distribution of these inputs specific to Energy Trust or Oregon.

Measure Life

Insulation measures carry a 45-year measure life, in line with previous Energy Trust analysis and RTF regional estimates.

[2] DRAFT Energy Trust of Oregon 2008 Existing Homes Gas Impact Analysis – See Appendix C: Energy Trust 2006-2007 Existing Homes Impact Analysis – Table 16.
[3] DRAFT Energy Trust of Oregon 2009 Existing Homes Gas Impact Analysis – Table 6
[4] Energy Trust: Gas Furnace in small multifamily and savings within reach, measure approval document 22
[5] RTF Residential single family workbook v3.7
[6] RTF Single family SEEM runs Feb 2016

Cost

Energy Trust project tracker data for small multifamily and single family insulation costs in 2018 were used in this analysis. Median cost per square foot of insulation by heating fuel was used to reduce the influence of outliers, poorly itemized invoices and potential data entry errors. These costs are shown in Table 7.

Table 7 Median Costs by Insulation Type and Fuel in Small Multifamily and Single Family Applications in 2018

Insulation and Fuel Type	Cost per Sqft.
Electric Ceiling Insulation	$1.38
Electric Floor Insulation	$1.98
Electric Wall Insulation	$1.89
Gas Ceiling Insulation	$1.50
Gas Floor Insulation	$2.18
Gas Wall Insulation	$3.07

Non Energy Benefits

Non-electric fuel displacement

The RTF models estimates kWh-equivalent displacement of non-electric supplemental fuels (e.g., wood, oil propane), which is then converted to dollars based on electric rates. Table 8 shows the estimated non-utility fuel savings.[7] For electric measures, NEBs are taken from the RTF Single Family Weatherization workbook v3.7.

Table 8 Non-electric Fuel displacement NEB, per sqft

Measure	Non-Electric Savings (kWh equivalent)	Total NEB (Annual $)
Attic insulation Gas Heat (R0-R11 starting condition) HZ1	0.08	$0.01
Attic insulation Gas Heat (R0-R11 starting condition) HZ2	0.07	$0.01
Wall insulation Gas Heat HZ1	0.18	$0.02
Wall insulation Gas Heat HZ2	0.18	$0.02
Floor insulation Gas Heat HZ1	0.04	$0.01
Floor insulation Gas Heat HZ2	0.04	$0.00
Attic insulation Ele Heat (R0-R11 starting condition) Any Zone		$0.014
Wall insulation Ele Heat Any Zone		$0.029
Floor insulation Ele Heat Any Zone		$0.014

Partial Service Territory

For gas measures installed outside Energy Trust's electric service territory, fan and cooling savings are converted to a NEB at a rate of $0.119/kWh. These are identified as 'gas only' in Table 1 Cost Effectiveness Calculator Oregon.

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 square foot of insulation installed. The incentive for standard track wall and floor insulation for gas heated homes in Oregon is capped at $150 and must be done at the same time as attic insulation for standard market rate offers.

SRAF

Standard program SRAFs are applied to these measures. Negative savings are recorded as SRAF components and do not count against the programs' accomplishments.

Follow-Up

Further billing analysis is expected to be complete in 2020, and updated RTF analysis should be reviewed with the next update for updates to heating, cooling and non-energy impacts to measures.

Cost trends, should be monitored to ascertain patterns and if possible, identify causes of increases.

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 Weatherization\insulation\existing homes and small mf

Single Family Insulation Retrofit -

Version History and Related Measures

Energy Trust has been incenting residential and small multifamily insulation since at least 2004. The measures have been updated numerous times and predate our current measure approval documentation and record retention processes. Table 9 may be incomplete, particularly for activities prior to 2013.

[7] SEEMruns_SingleFamilyExistingHVACandWeatherization_Feb2016

Table 9 Version History

Date	Version	Reason for revision
3/7/2007	x	Approval for insulation measures on a per square foot basis
3/9/2007	106.1	Knee wall insulation approved as a type of wall insulation
11/29/2012	58.x	Update costs and savings for all measures. Change starting condition requirement to less than R12.
12/20/2012	58.x	Update savings for wall and floor insulation.
8/6/2013	58.x	Adds heating zone 2 analysis for gas measures. Update format to show maximum incentives.
9/9/2014	58.x	Includes Washington-specific measure with starting condition R19. OPUC Reauthorization of 12-394 exceptions and requirements to develop approaches to improve cost effectiveness and shift resources to highest savings/TRC measures.
6/11/2015	58.1	Updated to include requirements dictated by OPUC order 15-140 including incentive caps on some measures.
10/24/2019	58.2	Updated savings, costs and addition of cooling savings. Knee wall included in wall insulation. MAD 106 to be retired.

Table 10 Related Measures

Measures	MAD ID
Multifamily Insulation	110
Residential Knee Wall Insulation (inactive for 2020)	106

Approved & Reviewed by

Jackie Goss, PE
Sr. Planning Engineer

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.

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[2] *See*

https://www.commerce.wa.gov/growing-the-economy/energy/clean-energy-fund/energy-revolving-loan-fund/

- 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 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.