NW Natural 2021
Energy Efficiency Plan

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1 SUMMARY

The following plan outlines how NW Natural plans to save 390,090 therms across its energy efficiency programs. These savings are expected to cost $3,665,417 to acquire.

2021 EE Plan Summary		Annual Therms Goal	Annual Cost
Incentive Program	Commercial Program	238,107	$1,670,382
	Residential Programs	148,573	$1,672,067
Low Income	WA-LIEE	3,410	$74,340
Market Transformation	NEEA	9,867	$88,148
Regional Collaboration	RTF	N/A	$10,400
Pilots & Trial Programs	Pilots & Trial Programs	TBD	$150,080
Evaluation	Evaluation	N/A	N/A
	EE Plan Total	**399,957**	**$3,665,417**

2 PART I – Background

2.1 History

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

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

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

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

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.

The Company anticipates it will be participating in the rulemaking process for HB 1257 and will make appropriate programmatic adjustments in subsequently filed Energy Efficiency Plans.

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 and Community Action Council of Lewis, Mason and Thurston Counties 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 & 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, single-family homes through incentives, education, trade and program ally support and quality assurance.

For existing 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

[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.

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

There are four tracks within the Residential Incentive program, Standard Home Retrofit (including Multifamily), Mid-stream (distributor) 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. Multifamily properties that are served with commercial rate schedule gas service are served through the Commercial Program.

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 Retail Products strategy focuses on retail engagement to promote efficient natural gas appliances and fixtures. However, due to the sunset of the Bonneville Power Administration's ("BPA") Simple Steps retail showerhead program, there are no retail measures planned for 2021.

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.

In the fourth quarter, the new homes program will be introducing a new market engagement strategy, whereby incremental performance through single, standard measures will be awarded. The 2018 Washington State Energy Code points structure will

be used to determine incentives; awarding incentives for every half point a home achieves greater than code.

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)

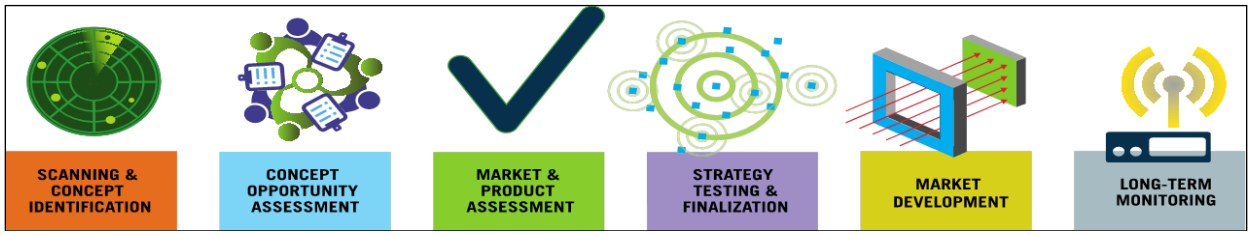
In 2021 the Commercial Program will provide standard, prescriptive measure offerings for new commercial buildings and will also provide a custom, modeled approach for some appropriate projects. New construction has continued to be an important market segment for savings acquisition. Through this work 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 the Northwest Energy Efficiency Alliance ("NEEA") as a necessary investment in the future of gas demand side management ("DSM") and as an enduring component of regional power planning. NEEA's primary work, 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 in an 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 Utility Cost Test ("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 the National Standard Practice Manual ("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.

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

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

2.5.5 Avoided Cost

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 2021. These values were used in the 2018 IRP and are described in chapter four. https://www.nwnatural.com/about-us/rates-and-regulations/resource-planning

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 on 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 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 and Engagement Schedule

2.8.1.1 Program Year Schedule

January 1st	Start of program year
March 216th	1st Quarter check in with EEAG
May 18th	2nd Quarter check in with EEAG
June 1st	Annual report for previous program year is filed
August 17th	3rd Quarter check in with EEAG & EE Plan
October 1st	EE Plan Filed
November 1st	Requested effective date of program cost filing
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, virtually or by teleconference to review the annual report and will be 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 in the temporary rate adjustments. 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 – 2021 Plan

3.1 Current-Year Program Drivers

With the success of the Company's incentive program efforts in 2020 despite Covid-19 related setbacks, the 2021 strategy will continue with a few additional offerings and enhancements.

2019 Washington Energy Legislation

The Company will continue to track and assess outcomes of relevant laws passed during Washington's 2019 Legislative Session, including the Department of Commerce's Appliance Standards Rulemaking and HB 1257. 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

Overview

Energy Trust helps single-family and small multifamily homeowners served by NW Natural in Washington achieve gas energy savings by offering cash incentives for efficient space heating and controls, water heating, insulation, windows, water conservation, behavioral actions, education, trade ally support, financing with repayment through utility bills and market interventions. The program also influences new residential construction by engaging with builders to increase gas energy efficiency of newly constructed homes through incentives, education, trade and program ally support and quality assurance. 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 program response to the COVID-19 pandemic is expected to continue shaping implementation and delivery tactics in 2021. As in 2020, Washington homeowners will continue to navigate changing economic and social conditions in 2021. Increased bonus incentives for HVAC systems, Domestic Hot Water (DHW) and insulation will be necessary to lower barriers for capital measures for impacted customers. The small multifamily market in Southwest Washington is full of potential. The single-family rental housing stock continues to hold opportunities for growth. New coordination opportunities with the Program's Commercial team will be leveraged to acquire more multifamily savings. The program will sunset retail showerheads, but low-cost smart thermostats will replace these offers as low-cost options for customers. Energy Saver Kits were planned to be removed as a program offering, however the latest engineering study data implies there are still savings opportunities in the market. Energy Trust will explore the development of a cost-effective kit strategy that will be launched sometime in late 2021.

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

2021 Residential Key Activities

a. Respond to any reductions in portfolio savings and capital measure participation driven by the economic downturn due to COVID-19 through cost reduction strategies (such as Campaign ally and Fixed Price promotion offers) for measures and marketing activities to increase awareness of promotional offers.

b. Promote bonus incentives for efficient gas HVAC equipment. Communicate bonus promotions to drive low-cost installations across customer types. Measures that will be supported through bonuses will include; Attic, floor, and wall insulation, gas furnaces, windows, thermostats, and tankless water heaters. Incentive levels will be evaluated in March to determine if it's necessary to continue increased levels. The residential budget reflects reducing the increased levels after March. This reduction was budgeted to ensure responsible use of rate payer funds and to also ensure levelized cost of portfolio was managed to be below the level stated within this EE Plan.

c. Expand the installed base of smart thermostats through instant coupon promotions, downstream incentives and direct ship.

d. Work with residential weatherization market actors to promote bonus incentives for insulation.

e. Identify and engage with single-family housing rental property owners to installations of weatherization, DHW, and HVAC efficiency upgrades.

f. Develop new strategies to support do it yourself (DIY) participation, including technical support, promotions and marketing.

g. Continue to develop targeted marketing and communications strategies to drive leads to contractors, highlight ongoing bonus incentives and special promotions.

h. Promote low-cost smart thermostat or community partner funded offerings through existing relationships with local community-based organizations (CBO) serving low-to-moderate-income residents, in light of the discontinuation of Energy Saver Kits.

i. Introduce incentives for New Manufactured Homes through the onboarding of new manufactured home retailer participants.

j. Expand community-based organization collaboration to bring capital measures to new customer segments through the newly created Community Partner Funding ("CPF") pathway which is a set of increased incentive offers exclusively for CBOs to support

programs for underserved populations living in detached single-family homes. Provide support to New Home Construction (EPS) participants to help the market prepare for program changes scheduled for Q4. Impacts of program changes will largely be realized in 2022. Builder participation in EPS will remain strong in 2021 and the program expects to maintain its current market share of 45%. In the fourth quarter, the new homes program will be introducing a new market engagement strategy, whereby incremental performance through single, standard measures will be awarded. The 2018 Washington State Energy Code points structure will be used to determine incentives; awarding incentives for every half point a home achieves greater than code.

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
- 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 and on-line/virtual 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

Energy Trust provides standard and custom capital, operations and maintenance and retrocommissioning incentives for Washington State business customers on qualifying NW Natural commercial firm or interruptible rate schedules. These include upgrades and retrofits for existing buildings; energy-efficient equipment for new construction; energy-efficient equipment and retrofits at existing and new multifamily properties with two or more units; and measures for natural gas-heated production greenhouses.

The robust building market coupled with ongoing construction labor shortages continue to divert commercial customers' attention away from energy efficiency projects. Tariffs are increasing costs and have led to projects being rebid leading to delays. Many projects have also been delayed because of halts to construction due to COVID-19. At the same time, the passage of Washington school bond measures has led to significant retrofit and new construction activity 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. Washington HB 1444 and HB 1257 will begin to impact Energy Trust's ability to offer certain measures including commercial fryers, dishwashers, steam cookers, and showerheads beginning in 2022. COVID-19 will dominate changes in market trends in 2021, shifting customer priorities due to economic impacts and required operational changes. Updated evaluations have resulted in greater savings per measure which has resulted in a slight increase of savings from last time we projected 2021.

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/custom), 0.89/0.88; Existing Buildings Multifamily, 1.0; New Buildings (standard and custom), 0.90; and New Buildings (whole buildings), 0.84. 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 therms and saved at 161,632. In 2019, the working savings goal was 170,016 therm, 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 therms. With the application of the 2020 SRAFs, these savings are then reduced to 111,413 therms.
For 2021 Commercial working savings are forecasted at 269,440 therms. With the application of the SRAFs, the Reportable savings is 238,107 therms.

Mega Project – Vancouver Innovation Center

Commercial savings goals have increased by over 138,000 therms from 2020 because of a large mega project being introduced into the project pipeline. The Program has been working with a developer on a project that is expected to bring in large amounts of savings over the next two years. Savings are expected to be realized in three phases; phase one, 38,000 therms; phase two, 135,050 therms; and phase three 180,000 therms. Some of these savings might be realized starting in 2020.

Forecasted Commercial Project Pipeline

The Program has developed a pipeline of projects that is used for tracking and forecasting. Tracking information of the pipeline is updated monthly as details change; completion dates are shifted, projects complete, and new projects are identified. The pipeline consists of multiple school projects in the various SW WA school districts, Clark College, WSU campus buildings, libraries, county buildings, malls, and other commercial projects. Smaller capital measures such as restaurant equipment and steam traps are not typically included in the forecasted pipeline as they are typically identified just before completion. However, through outreach, many projects are identified as "prospects". Custom Studies are also indicators of future prospects and projects. Studies typically need to be completed and the building manager is asked to provide some level of commitment before a studied project is included in the forecasted pipeline. Some studies never materialize into projects.

The Forecasted Commercial Pipeline includes, projects totaling anywhere between 10,000 to 100,000+ therms, on average, depending on the time of year and market conditions. As of Q4 2020, the project pipeline contains projects totaling ~56,817 therms. Studies have also been completed for projects totaling ~422,000 potential therms; which includes the previously mentioned, Vancouver Innovation Center mega-project.

Commercial Strategic Focus

Increase the flexibility and adaptability of Efficiency Programs

- 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 and beyond.

Advance the viability, relevance and performance of programs

- Organize trade ally outreach 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
- Explore new approach to direct install that can support Existing Buildings in Washington
- Explore and utilize other market channels such as buy-down programs to more effectively deliver program elements such as restaurant equipment

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

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

2021 Commercial Key Activities

a. Coordinate and manage the transition to a new Existing Buildings PMC. Based on this rebid, in 2021 Existing Buildings and Multifamily will be combined under a single contract, Existing Buildings.
b. Explore efficiencies gained from the combination of Existing Buildings and Multifamily programs.
c. Offer a range of standard measures, including restaurant equipment, insulation, water heaters and boilers.
d. Continue to provide 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.
e. Increase outreach, technical services and other support to small- to medium-sized and rural commercial customers and trade allies.
f. Launch new marketing campaigns targeted to smaller, rural and minority-owned businesses.
g. Continue to focus outreach activities on low-income housing by working with the Vancouver Housing Authority and other local agencies.
h. Increase outreach and promotion of Building Operator Certification training to capital improvement project teams; specifically, schools project teams.

i. Participate in local, community-focused events, including chambers and business associations.
j. 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.
k. Coordinate with NW Natural on new marketing guidelines for NW Natural Washington delivery territory.
l. Collaborate with Clark Public Utility District to explore co-funding of technical studies that provide electric and gas savings.
m. Work with Energy Trust Planning, NW Natural and the Washington Utilities and Transportation Commission to draft a Washington Conservation Potential Assessment. Work to implement a two-year plan for 2022 and 2023; this includes adjusting the filing schedule in 2021.
n. 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.
o. 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.

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. 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 2021 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 Integrated Resource Plan ("IRP").

The program's primary goal is to meet system demand with the least cost conservation as required per WAC 480-90-238(1). The therm savings target is aligned with the demand-side management targets for the programs offered as identified in the Company's 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 and geographic size of the Company's Washington service territory can make it difficult to manage the averaged levelized cost per therm compared to a larger and more diverse service territory.

To reflect updated avoided costs the Program Implementor's engineering staff have started to explore the potential impacts to the levelized cost threshold. Initial results indicate that with increased avoided costs the Levelized Cost threshold could be $0.89 and still be cost effective (calculated at a TRC of 1.0). The company will continue to evaluate the Levelized cost performance metric and share this work with the EEAG.

- 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	48,782
	Existing Buildings - Custom	164,843
	New Buildings - Standard	19,778
	New Buildings - Custom	4,703
	Commercial Total	**238,107**
Residential Programs	Existing Homes Retrofit	88,623
	Mid-stream - Distributor	9,957
	EPS New Construction	49,993
	Residential total	**148,573**
	Total savings	**386,680**

3.2.2 Expenses by Incentive Program

Incentive Program		Budgeted Expenditures	
Commercial	Programs	$	1,566,735
	Commercial administration	$	103,647
	Commercial Total	**$**	**1,670,382**
Residential	Programs	$	1,608,542
	Residential Administration	$	63,525
	Residential total	**$**	**1,672,067**
	Total Expenditures	**$**	**3,342,449**

Expenditures include Incentives and Delivery

3.2.3 Incentives by Incentive Program

Incentive Program		Incentives Budget	Percent incentives/expenditures
Commercial Programs	Existing Buildings - Standard	$158,599	--
	Existing Buildings - Custom*	$688,816	--
	New Buildings - Standard	$53,621	--
	New Buildings – Custom*	$35,675	--
	Commercial Total	**$944,711**	**57%**
Residential Programs	Existing Homes Retrofit	$ 544,950	--
	Mid-stream: Distributor	$34,985	--
	EPS New Construction	$421,711	--
	Residential total	**$ 1,001,645**	**60%**
	Total Incentives	**$ 1,946,356**	**58%**

* Commercial Custom Studies included in Custom Track

- Percent Incentives is calculated by dividing budgeted incentives by total budgeted expenditures
- Program expenditures not available or calculated by track

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.

2021 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	3.15	2.35
Residential Programs	2.09	1.27
Total NW Natural Washington Efficiency Program Portfolio	**2.58**	**1.71**

- Values based on forecasted measure quantities and savings

3.3 Low Income Metrics and Budget

The WA-LIEE program will strive to weatherize **10** 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 @ 10 homes	3,410
	Total Low Income savings	**3,410**

3.3.2 Low Income Budget

WA-LIEE			Budget
WA-LIEE	WA-LIEE Measures	$	60,800
	WA-LIEE Agency Administration (15%)	$	9,120
	Health / Safety	$	10,000
	WA-LIEE application processing admin (5% cap)	$	3,040
	WA-LIEE Total	**$**	**82,960**

The WA-LIEE 2021 goal for Clark County program has been adjusted based on the impacts of COVID-19. Efforts initiated in 2019 in coordination with the Energy Project will encourage the weatherization of gas homes in the Company's outlying service areas made some progress but were put on hold due to the pandemic. Program outreach and coordination will continue in 2021 once it is safe for customers, contractors and staff.

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 2021 and have a set an ongoing 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. The 2021 program year will see a credit based on the previous 5-year budget cycle.

3.4.1 Market Transformation Budget

Market Transformation			Budget
NEEA	2020-2024 NW Natural Washington Allocation	$	588,239
	2021 NEEA Total	**$**	**88,148**

3.4.2 Market Transformation Energy Savings

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

There are some near term savings that NEEA forecasts and those Program Measure efforts have been included in the 2021 target.

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.

Residential New Construction Advanced Wall Study

The 2018 Washington State Energy Code will be introduced in 2021 and will become mandatory for any building permits submitted on or after February 1, 2021. The new homes program always expects a delay of about 6-8 months before homes under the new code are built under the program. However, in late Q3 the program will be moving to a new code baseline that programs homes will need to adhere to. After this time, it will be very difficult for homes to qualify with the program unless wall construction upgrades are implemented. The Program plans to work with two leading SW WA builder to help them implement new wall construction techniques. Increased incentives for these are needed to help facilitate the learning curve and off-set construction materials. Increased outreach will also be needed to help facilitate this pilot. The program envisions needing less than $75,000 pilot budget to facilitate, however is requesting this as an approved budget cap. This study could be crucial to ensure continued builder participation with future new construction programs.

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. The company will continue to operate a temporary program until there is an appropriate tariff revision. 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 2021 goal matching the home total for Clark, Klickitat and Skamania Counties.

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. While this effort was put on hold due to COVID-19, the Company is looking to continue this partnership and leverage the ongoing efforts to enable qualified gas customers to also participate. When safe to resume, the Company plans to test additional outreach and marketing to increase uptake and refer customers to the Weatherization program. The

all-in costs are estimated to be approximately $305 per home for installation with an estimate of 30 installs and some funding for communication efforts.

3.5.1 Pilot & Trial Program Budget

Pilots & Trial Programs		Budget	
	New Residential Construction Advanced Wall Study	$	75,000
	Low Income Furnace Tune Ups	$	15,000
	Low Income Program Adjustment	$	55,080
	Low Income Thermostat Direct Install	$	5,000
	Pilot Total	**$**	**150,080**

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)

The Company previously 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 2021 Work Plan – NWN WA	$	10,400
	RTF Total	**$**	**10,400**

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 5.

3.8 Evaluation Activities and Budget

In 2010 the Company hired Navigant for a two-part study on the Company’s Washington Energy Efficiency program. The first part was a benchmark study to evaluate how the pilot program compared to other programs in Washington and the second part was an evaluation of how the Company should proceed with turning the pilot into a full-fledged program. The Company has no plans for Program level outside evaluation work in 2021.

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

2021 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 #
Savings change	EPS New Construction	EPS	SWWAEPS1	SW WA EPS Path 1 - 2018	1GHNACG	Res Heating	34	$467.60	$ 949.00		79.9	$1,505.25	$949.00		$13.18	1.59	3.22	1.79	$0.39	145
Savings change	EPS New Construction	EPS	SWWAEPS2	SW WA EPS Path 2 - 2018	1GHNACG	Res Heating	39	$952.55	$ 2,463.00		142.1	$2,831.00	$2,463.00		$14.88	1.15	2.97	1.24	$0.43	145
Savings change	EPS New Construction	EPS	SWWAEPS3	SW WA EPS Path 3 - 2018	1GHNACG	Res Heating	42	$1,143.67	$ 6,437.00		258.2	$5,278.50	$5,278.50		$52.36	1.00	4.62	0.95	$0.28	145
Savings change	EPS New Construction	EPS	SWWAEPS4	SW WA EPS Path 4 - 2018	1GHNACG	Res Heating	43	$1,440.00	$ 8,519.00		293	$6,035.48	$6,035.48		$53.90	1.00	4.19	0.81	$0.31	145
No change	Multifamily	GASFURNACE	GASFURNRENTALWA	Gas Furnance - Rentals 90%+ AFUE	GEXSPHT	Res Heating	25	$550.00	$1,607.32		91.81	$1,464.91	$1,464.91	updated in August	$2.16	1.00	2.66	0.93	$0.45	23
Incentive Change	Multifamily	GASFURNACE	HEGASFURN95	Gas Furnace SW WA 95%+ AFUE	GEXSPHT	Res Heating	25	$550.00	$1,607.32		91.81	$1,464.91	$1,464.91		$2.16	1.00	2.66	0.93	$0.45	23
Incentive Change	Home Retrofit	GASFURNACE	HEGASFURN95	Gas Furnace SW WA 95%+ AFUE	GEXSPHT	Res Heating	25	$550.00	$1,607.32		91.81	$1,464.91	$1,464.91		$2.16	1.00	2.66	0.93	$0.45	23
No change	Home Retrofit	GASFURNACE	GASFURNRENTALWA	Gas Furance - Rentals 90%+ AFUE	GEXSPHT	Res Heating	25	$550.00	$1,607.32		91.81	$1,464.91	$1,464.91	updated in August	$2.16	1.00	2.66	0.93	$0.45	23
New Measure	Home Retrofit	TSTATOPT	RESIDEOGFACGO	Resideo Annual Thermostat Optimization gFAF + AC Gas Only	GEXSPHT	Res Heating	1	$12.00	$12.00		15.23	$12.52	$12.00		$6.25	1.04	1.04	1.54	$0.83	217
New Measure	Home Retrofit	TSTATOPT	RESIDEOGFGO	Resideo Annual Thermostat Optimization gFAF Gas Only	GEXSPHT	Res Heating	1	$12.00	$12.00		15.23	$12.52	$12.00		$3.81	1.04	1.04	1.34	$0.83	217
Savings, incentives change	Midstream	TANKDHW	MIDGASWH	ENERGY STAR Storage Water Heater	RESDHWG	DHW	13	$150.00	$277.00		25.5	$139.38	$139.38		$5.72	1.00	0.93	0.69	$0.65	102
Incentive change	Home Retrofit	TANKLESS	GASTANKLESS	SW WA Gas Tankless Water Heater	RESDHWG	DHW	20	$400.00	$1,838.00		76	$600.59	$600.59		$0.00	1.00	1.50	0.33	$0.45	197
Incentive change	Multifamily	TANKLESS	GASTANKLESS	SW WA Gas Tankless Water Heater	RESDHWG	DHW	20	$400.00	$1,838.00		76	$600.59	$600.59		$0.00	1.00	1.50	0.33	$0.45	197
New Measure	Multifamily	THERMOSTAT	DSSMARTSTATGO	Direct Ship Smart Thermostat Gas Only	GEXSPHT	Res Heating	11	$224.00	$249.00		31.8	$246.39	$246.39		$0.00	1.00	1.10	0.99	$0.88	250
New measure	Home Retrofit	THERMOSTAT	DSSMARTSTATGO	Direct Ship Smart Thermostat Gas Only	GEXSPHT	Res Heating	11	$224.00	$249.00		31.8	$246.39	$246.39		$0.00	1.00	1.10	0.99	$0.88	250
New Measure	Home Retrofit	WINDOWS	WINDOWS24GO	Windows - GAS - U <=.24 Gas only	GEXSPHT	Res Heating	45	$10.00	$2.57		0.46	$9.61	$2.57		$0.03	3.74	0.96	3.93	$1.34	28
New Measure	Home Retrofit	WINDOWS	WINDOWS27GO	Windows - GAS- U .25-.27 Gas only	GEXSPHT	Res Heating	45	$4.00	$1.50		0.27	$5.64	$1.50		$0.02	3.76	1.41	3.98	$0.91	28
Savings change	Home Retrofit	WINDOWS	WINDOWS2830GO	Windows - GAS - U .28-.30	GEXSPHT	Res Heating	45	$1.75	$0.71		0.13	$2.72	$0.71		$0.01	3.82	1.55	4.05	$0.83	28
New Measure	Multifamily	WINDOWS	WINDOWS24GO	Windows - GAS - U <=.24 Gas only	GEXSPHT	Res Heating	45	$6.00	$2.57		0.46	$9.61	$2.57		$0.03	3.74	1.60	3.93	$0.80	28
New Measure	Multifamily	WINDOWS	WINDOWS27GO	Windows - GAS- U .25-.27 Gas only	GEXSPHT	Res Heating	45	$4.00	$1.50		0.27	$5.64	$1.50		$0.02	3.76	1.41	3.98	$0.91	28
Savings change	Multifamily	WINDOWS	WINDOWS2830GO	Windows - GAS - U .28-.30	GEXSPHT	Res Heating	45	$1.75	$0.71		0.13	$2.72	$0.71		$0.01	3.82	1.55	4.05	$0.83	28
Incentive Change	Home Retrofit	CEILINGINSULATE	INSCEILGH	SF Attic Insulation/SQFT, Gas Heat	GEXSPHT	Res Heating	45	$1.25	$1.46		0.07	$1.55	$1.46		$0.01	1.06	1.24	1.17	$1.04	58
Incentive Change	Home Retrofit	FLOORINSULATE	INSFLRGHZ	SF Floor Insulation/SQFT, Gas Heat	GEXSPHT	Res Heating	45	$0.75	$2.07		0.042	$0.88	$0.88		$0.01	1.00	1.17	0.50	$1.10	58
Savings change	Multifamily	GASFIRE	GASHRTH7074	Gas Hearth 70-74 FE	GEXSPHT	Res Heating	20	$150.00	$0.01		48.54	$661.13	$0.01		$0.00	66113.47	4.41	66113.47	$0.26	29
Savings change	Multifamily	GASFIRE	GASHRTH75	Gas Hearth 75+ FE w/ ele ignition	GEXSPHT	Res Heating	20	$250.00	$0.01		60.51	$824.17	$0.01		$0.00	82417.10	3.30	82417.10	$0.35	29
Savings change	Home Retrofit	GASFIRE	GASHRTH7074	Gas Hearth 70-74 FE	GEXSPHT	Res Heating	20	$150.00	$0.01		48.54	$661.13	$0.01		$0.00	66113.47	4.41	66113.47	$0.26	29
Savings change	Home Retrofit	GASFIRE	GASHRTH75	Gas Hearth 75+ FE	GEXSPHT	Res Heating	20	$250.00	$0.01		60.51	$824.17	$0.01		$0.00	82417.10	3.30	82417.10	$0.35	29
Savings change	Midstream	GASFIRE	GASHRTHPLELE25	Gas hearth-Electronic Ignition $25, retailer/distributor incent	GEXSPHT	Res Heating	20	$25.00	$105.00		7.41	$100.93	$100.93		$0.00	1.00	4.04	0.96	$0.29	29
Savings change	Midstream	GASFIRE	GASHRTHPLELE30	Gas hearth-Electronic Ignition $30, retailer/distributor incent	GEXSPHT	Res Heating	20	$30.00	$105.00		7.41	$100.93	$100.93		$0.00	1.00	3.36	0.96	$0.34	29
Savings change	Multifamily	THERMOSTAT	SMARTSTATGOT	Smart Thermostat - Gas Only Territory	GEXSPHT	Res Heating	11	$100.00	$170.00		39.7	$307.60	$170.00			1.81	3.08	1.81	$0.31	153
Savings change	Multifamily	THERMOSTAT	SMARTSTATGOTIC	Smart Thermostat Instant Coupon - Gas Only Territory	GEXSPHT	Res Heating	11	$100.00	$170.00		39.7	$307.60	$170.00			1.81	3.08	1.81	$0.31	153
Savings change	Multifamily	THERMOSTAT	SMARTSTATGOT	Smart Thermostat - Gas Only Territory	GEXSPHT	Res Heating	11	$100.00	$170.00		39.7	$307.60	$170.00		$1.83	1.81	3.08	1.90	$0.31	153
Savings change	Home Retrofit	THERMOSTAT	SMARTSTATGOT	Smart Thermostat - Gas Only Territory	GEXSPHT	Res Heating	11	$100.00	$170.00		39.7	$307.60	$170.00		$0.01	1.81	3.08	1.81	$0.31	153
Savings change	Home Retrofit	THERMOSTAT	SMARTSTATGOTIC	Smart Thermostat Instant Coupon - Gas Only Territory	GEXSPHT	Res Heating	11	$100.00	$170.00		39.7	$307.60	$170.00			1.81	3.08	1.81	$0.31	153
Incentive Change	Home Retrofit	WALLINSULATE	INSWALLGHZ	SF Wall Insulation/SQFT, Gas Heat	GEXSPHT	Res Heating	45	$0.75	$2.52		0.052	$1.09	$1.09		$0.02	1.00	1.45	0.56	$0.89	58
Incentive Change	Multifamily	CEILINGINSULATE	INSCEILGZ	SF Attic Insulation/SQFT, Gas Heat	GEXSPHT	Res Heating	45	$0.75	$1.46		0.07	$1.55	$1.46		$0.01	1.06	2.06	1.17	$0.62	58
Incentive Change	Multifamily	FLOORINSULATE	INSFLRGHZ	SF Floor Insulation/SQFT, Gas Heat	GEXSPHT	Res Heating	45	$0.75	$2.07		0.042	$0.88	$0.88		$0.01	1.00	1.17	0.50	$1.10	58
Incentive Change	Multifamily	WALLINSULATE	INSWALLGHZ	SF Wall Insulation/SQFT, Gas Heat	GEXSPHT	Res Heating	45	$0.75	$2.52		0.052	$1.09	$1.09		$0.02	1.00	1.45	0.56	$0.89	58
No Change	Home Retrofit	AERATOR	DIAERGOB10	1.0 gpm Bath Aerator Gas Only, Direct Install	RESDHWG	DHW	15	$3.43	$5.00		1.70	$10.57	$5.00		$6.12	2.11	3.08	14.29	$0.20	51
No Change	Home Retrofit	AERATOR	DIAERGOK15	1.5 gpm Kitchen Aerator Gas Only, Direct Install	RESDHWG	DHW	15	$4.83	$5.00		2.80	$17.41	$5.00		$8.49	3.48	3.60	20.37	$0.17	51
Savings change	Multifamily	THERMOSTAT	CPFDISMARTSTATGOT	Community Partner DI SmartStat - Gas Only Territory	GEXSPHT	Res Heating	11	$100.00	$150.00		34	$263.44	$150.00		$0.00	1.76	2.63	1.76	$0.37	222
No Change	Multifamily	GASFURNACE	CPFGASFURNGO	Community Partner Funded Gas Furnace 90%+, Gas-only	GEXSPHT	Res Heating	25	$550.00	$1,607.32		91.81	$1,464.91	$1,464.91		$2.16	1.00	2.66	0.93	$0.45	23
No Change	Multifamily	CEILINGINSULATE	CPFINSCEILGZ1GO	Community Partner Funded Attic Insulation, Gas Heat, Zone 1 GO	GEXSPHT	Res Heating	45	$1.25	$1.46		0.07	$1.46	$1.46		$0.03	1.00	1.17	1.33	$1.10	58
Savings change	Home Retrofit	THERMOSTAT	CPFDISMARTSTATGOT	Community Partner DI SmartStat - Gas Only Territory	GEXSPHT	Res Heating	11	$100.00	$150.00		41.37	$320.54	$150.00		$0.00	2.14	3.21	2.14	$0.30	222
No Change	Home Retrofit	GASFURNACE	CPFGASFURNGO	Community Partner Funded Gas Furnace 90%+, Gas-only	GEXSPHT	Res Heating	25	550	1607.32		91.81	$1,464.91	$1,464.91		$2.16	1.00	2.66	0.93	$0.45	23
No Change	Home Retrofit	CEILINGINSULATE	CPFINSCEILGZ1GO	Community Partner Funded Attic Insulation, Gas Heat, Zone 1 GO	GEXSPHT	Res Heating	45	1.25	1.46		0.07	$1.46	$1.46		$0.03	1.00	1.17	1.33	$1.10	58
No Change	Home Retrofit	FLOORINSULATE	CPFINSFLRGHZ1GO	Community Partner Funded Floor Insulation, Gas Heat, Zone 1 GO	GEXSPHT	Res Heating	45	0.6	2.07		0.04	$0.84	$0.84		$0.00	1.00	1.39	0.40	$0.92	58
No Change	Home Retrofit	WALLINSULATE	CPFINSWALLGHZ1GO	Community Partner Funded Wall Insulation, Gas Heat, Zone 1 GO	GEXSPHT	Res Heating	45	0.75	2.52		0.05	$1.04	$1.04		$0.03	1.00	1.39	0.61	$0.92	58
New Measure	Home Retrofit	WINDOWS	CPFWINDOWS24GO	Community Partner Funded Windows - GAS - U <=.24 Gas only	GEXSPHT	Res Heating	45	$10.00	$2.57		0.46	$9.61	$2.57		$0.03	3.74	0.96	3.93	$1.34	28
New Measure	Home Retrofit	WINDOWS	CPFWINDOWS27GO	Community Partner Funded Windows - GAS- U .25-.27 Gas only	GEXSPHT	Res Heating	45	$4.00	$1.50		0.27	$5.64	$1.50		$0.02	3.76	1.41	3.98	$0.91	28
Savings change	Home Retrofit	WINDOWS	CPFWINDOWS2830GO	Community Partner Funded Windows - GAS - U .28-.30	GEXSPHT	Res Heating	45	$1.75	$0.71		0.13	$2.72	$0.71		$0.01	3.82	1.55	4.05	$0.83	28
New Measure	Multifamily	WINDOWS	CPFWINDOWS24GO	Community Partner Funded Windows - GAS - U <=.24 Gas only	GEXSPHT	Res Heating	45	$10.00	$2.57		0.46	$9.61	$2.57		$0.03	3.74	0.96	3.93	$1.34	28
New Measure	Multifamily	WINDOWS	CPFWINDOWS27GO	Community Partner Funded Windows - GAS- U .25-.27 Gas only	GEXSPHT	Res Heating	45	$4.00	$1.50		0.27	$5.64	$1.50		$0.02	3.76	1.41	3.98	$0.91	28
Savings change	Multifamily	WINDOWS	CPFWINDOWS2830GO	Community Partner Funded Windows - GAS - U .28-.30	GEXSPHT	Res Heating	45	$1.75	$0.71		0.13	$2.72	$0.71		$0.01	3.82	1.55	4.05	$0.83	28
New Measure	Home Retrofit	CEILINGINSULATE	DIINSCEILGOR11	Direct Install Ceiling Insulation R0-R11 - Gas Only	GEXSPHT	Res Heating	45	$3.44	$3.65		0.09	$1.88	$1.88	placeholder measu	$0.01	1.00	0.55	0.56	$2.36	252
New Measure	Home Retrofit	CEILINGINSULATE	DIINSCEILGOR18	Direct Install Ceiling Insulation R2-R18 - Gas Only	GEXSPHT	Res Heating	45	$2.38	$2.55		0.06	$1.25	$1.25	placeholder measu	$0.01	1.00	0.53	0.56	$2.44	252
New Measure	Home Retrofit	HER	CPFHOMEAUDIT	Community Partner Funded Home Audit	None	None	0	$0.00	$0.00		0	NA	NA		$0.00	NA	NA	NA	NA	
New Measure	Multifamily	HER	CPFHOMEAUDIT	Community Partner Funded Home Audit	None	None	0	$0.00	$0.00		0	NA	NA		$0.00	NA	NA	NA	NA	
New Measure	New Manufactured Homes	MANUFACTUREDHOME	ESSPIFGHZ1	Energy Star Mfg Home SPIF, Gas Heat Z1	GEXSPHT	Res Heating	45	$300.00	$3,097.00		106	$2,213.84	$2,213.84		$0.00	1.00	7.38	0.71	$0.17	109
New Measure	New Manufactured Homes	MANUFACTUREDHOME	NMHNPSPIFGHZ1	NEEM+ Mfg Home SPIF, Gas Heat Z1	GEXSPHT	Res Heating	45	$300.00	$5,063.00		124	$2,589.78	$2,589.78		$0.00	1.00	8.63	0.51	$0.15	109
New Measure	New Manufactured Homes	PROMOTION	MHCIENERGYSTAR	Energy Star Mfg Home Customer Incentive	None	None	None	$500.00	$0.00		0	NA	NA		$0.00	NA	NA	NA	NA	109
New Measure	New Manufactured Homes	PROMOTION	MHCINEEMPLUS	NEEM+ Mfg Home Customer Incentive	None	None	None	$1,100.00	$0.00		0	NA	NA		$0.00	NA	NA	NA	NA	109

			total Incentive w/ bonus	Forecasted additio	Savings (Therms) per Quantity	Forecasted additional savings resulting from bonus
Bonus	WAEPS	LowIncome_VERF	Varies - bonus amount = $250	20	Varies	Varies
Bonus	FURNACEBONUS	FURNACEBONUS	450	50	92	4600
Bonus	WAEPS	SWEDASSIST	Varies	12	Varies	Varies

Change	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)	Engineer's Notes	NPV of NEBs per Quantity	Annual NEBs	UCT BCR (2019 WA-Only AC)	TRC BCR (2019 WA-only AC)	2019 Levelized Cost (5.64% Discount Rate)	MAD #
New MAD	AERATORGONLY0P5	Aerator - Gas Hot Water - Bathroom 0.5 GPM or less	RESDHWG	DHW	10	$ 3.00	$ 8.66	19.1	$81.80	$8.66		$509.13	$68.00	27.27	68.24	$0.021	1
New MAD	AERATORGONLYK1P5	Aerator - Gas Hot Water - Kitchen 1.5 GPM or less	RESDHWG	DHW	10	$ 5.00	$ 8.66	7.9	$33.83	$8.66		$209.64	$28.00	6.77	28.12	$0.085	1
New MAD		Aerator - Gas Water Heat - Bathroom 0.5 GPM or less - Leave Behind	RESDHWG	DHW	10	$ 2.00	$ 2.00	14.9	$63.81	$2.00		$396.83	$53.00	31.91	230.32	$0.018	1
New MAD		Aerator - Gas Hot Water - Kitchen 1.5 GPM or less - Leave Behind	RESDHWG	DHW	10	$ 2.00	$ 2.00	6.1	$26.13	$2.00		$164.72	$22.00	13.06	95.42	$0.044	1
		Steam Trap Low Pressure, High Use	GEXPRO	Com Heating	6	$ 0.90	$ 0.90	1	$4.86	$0.90	incentive based on per lb/hr ca	$0.00		5.40	5.40	$0.181	42
		Steam Trap Medium Presure High Use	GEXPRO	Com Heating	6	$ 0.50	$ 0.50	1.9	$9.24	$0.50	incentive based on per lb/hr ca	$0.00		18.48	18.48	$0.053	42
		Steam Trap Low Pressure, Low Use	GEXPRO	Com Heating	6	$ 0.90	$ 0.90	0.6	$2.92	$0.90	incentive based on per lb/hr ca	$0.00		3.24	3.24	$0.302	42
		Steam Trap Medium Presure Low Use	GEXPRO	Com Heating	6	$ 0.50	$ 0.50	1.1	$5.35	$0.50	incentive based on per lb/hr ca	$0.00		10.70	10.70	$0.091	42
		Steam Trap Dry Cleaner	GEXPRO	Flat	6	$ 0.40	$ 0.40	0.3	$0.70	$0.40	incentive based on per lb/hr ca	$0.00		1.75	1.75	$0.268	42
	BEWASHGASPART	Commercial Clothes Washer-Gas Water Heat - commercial laundry	GEXPRO	Clotheswasher	7	$ 65.00	$ 425.00	32	$83.81	$83.81		$955.61	$169.00	1.29	2.45	$0.359	89
	COMBOOVGASWA	Gas Combination Ovens	GNEWPRO	Com Cooking	12	$ 750.00	$ 1.00	277	$1,875.64	$1,878.00	The Energy Star data indicates	$0.00		2.50	1875.64	$0.317	101
	GASSTEAMCOOK	Steam Cooker - Gas	GNEWPRO	Com Cooking	12	$ 1,850.00	$ 2,270.00	865	$5,857.15	$2,270.00	The Energy Star data indicates	$16,257.00	$ 1,901.00	3.17	9.74	$0.250	101
	GFBOIL2500	Boiler > 2,500 kBtuh input	GEXSPHT	Com Heating	35	$ 8.00	$ 10.00	2.85	$57.69	$10.00		$0.00		7.21	5.77	$0.186	88
	GFBOIL300	Boiler < 300 kBtuh input	GEXSPHT	Com Heating	35	$ 10.00	$ 16.00	2.85	$57.69	$16.00		$0.00		5.77	3.61	$0.232	88
	GFBOIL3002500	Boiler ≥ 300, ≤ 2,500 kBtuh input	GEXSPHT	Com Heating	35	$ 9.00	$ 13.00	2.85	$57.69	$13.00		$0.00		6.41	4.44	$0.209	88
	GREENIRPOLY	Infrared (IR) polyethylene greenhouse cover	GEXSPHT	Com Heating	4	$ 0.32	$ 0.10	0.23	$0.77	$0.32	For greenhouse measures, we	$0.00		2.40	7.69	$0.398	104
	GREENTHCUR	Thermal Curtains Installed on Greenhouses	GEXPRO	Com Heating	10	$ 0.30	$ 1.17	0.41	$3.20	$1.19	For greenhouse measures, we	$0.00		10.66	2.73	$0.098	104
	GREENUNDERBENCH	Under-bench heating Green house	GEXSPHT	Com Heating	12	$ 1.05	$ 2.19	1.25	$11.58	$2.19	For greenhouse measures, we	$0.00		11.03	5.29	$0.098	104
	GRNCNTRL	Greenhouse controllers	GEXSPHT	Com Heating	15	$ 0.10	$ 0.58	0.28	$3.21	$0.58	For greenhouse measures, we	$0.00		32.11	5.54	$0.036	103
	INSATTICGWA	Attic Insulation - Gas heating	GEXSPHT	Com Heating	30	$ 0.60	$ 0.90	0.25	$4.71	$0.90		$0.00		7.85	5.23	$0.168	68
	INSROOFGR5R20	Roof Insulation R-5 to R-20 gas heat	GEXSPHT	Com Heating	30	$ 0.30	$ 0.64	0.09	$1.70	$0.64		$0.00		5.65	2.65	$0.233	68
	INSROOFGWA	Roof Insulation - Gas heating	GEXSPHT	Com Heating	30	$ 0.60	$ 0.64	0.25	$4.71	$0.64		$0.00		7.85	7.36	$0.168	68
	INSWALLGWA	Wall Insulation - Gas heating	GEXSPHT	Com Heating	40	$ 0.60	$ 1.41	0.16	$3.41	$1.41		$0.00		5.68	2.42	$0.238	68
	MFSTEAMTRAPWA	Multifamily Steam Traps	GEXPRO	Res Heating	6	$ 100.00	$ 100.00	99	$440.52	$100.00		$0.00		4.41	4.41	$0.203	40
	NCBVD	Boiler Vent Damper	GEXSPHT	Com Heating	12	$ 1,000.00	$ 1,500.00	270	$2,501.02	$1,000.00	The MAD for this measure prec	$0.00		2.50	1.67	$0.433	86
	NCCONVOVENWA	Convection Oven - Gas - Full Size	GEXPRO	Com Cooking	12	$ 315.00	$ 388.00	107	$724.53	$388.00	The Energy Star data indicates	$0.00		2.30	1.87	$0.344	101
	NCDHWCONDMF	MF Domestic Tank Water Heaters	GEXPRO	DHW	18	$ 3.25	$ 3.25	3.2	$23.23	$3.25	Water heaters save varing amo	$0.00		7.15	7.15	$0.091	21
	NCDHWCONDWA	Domestic Tank Water Heaters	GEXPRO	DHW	18	$ 3.00	$ 3.92	2.2	$15.97	$3.92	Water heaters save varing amo	$0.00		5.32	4.07	$0.123	21
	NCIRGASFRY2014	Gas Fryer	GEXPRO	Com Cooking	12	$ 1,000.00	$ 1,290.00	431	$2,918.42	$1,290.00	For fryers, we found the cost ir	$0.00		2.92	2.26	$0.271	101
		Gas Single Rack Oven	GEXPRO	Com Cooking	12	$ 2,500.00	$ 1.00	995	$6,737.41	$3,000.00	The Energy Star data indicates	$0.00		2.69	6737.41	$0.294	101
		Gas Double Rack Oven	GEXPRO	Com Cooking	12	$ 5,000.00	$ 1.00	1689	$11,436.68	$6,000.00	The Energy Star data indicates	$0.00		2.29	11436.68	$0.346	101
		Commercial Tankless Water Heaters ≥200 kBtu/h	GEXPRO	DHW	15	$ 1.00	$ 1.46	0.9	$5.60	$1.46		$0.00	$0.00	5.60	3.83	$0.112	72
		Multifamily Tankless Water Heaters ≥200kBtu/h	GEXPRO	DHW	15	$ 2.25	$ 1.24	0.7	$4.35	$2.45		$0.00	$0.00	1.93	3.51	$0.323	72
	NEW	Greenhouse condensing unit heaters	GEXSPHT	Com Heating	12	$ 5.00	$ 11.18	6.29	$58.26	$11.18		$0.00		11.65	5.21	$0.093	134
	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	DI removed for WA	$151.99	$20.30	4.89	26.09	$0.117	77
	NEW	Commercial Showerhead Replacement 1.50gpm Fitness Center Gas Water Heating	GEXPRO	DHW	10	$ 7.00	$ 7.14	71	$304.08	$7.14	DI removed for WA	$1,421.61	$189.87	43.44	241.69	$0.013	77
		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	DI removed for WA	$104.75	$13.99	3.06	17.67	$0.187	77
		Commercial Showerhead Replacement 1.75gpm Fitness Center Gas Water Heating	GEXPRO	DHW	10	$ 7.00	$ 7.14	46	$197.01	$7.14	DI removed for WA	$979.18	$130.78	28.14	164.73	$0.020	77
New MAD	PIPEINSLN	Pipe Insulation - Hot water - Pipe Diameter > 1.5"	GEXPRO	DHW	15	$ 2.00	$ 18.40	4	$24.87	$18.40	The MAD for this measure prec	$0.00		12.44	1.35	$0.050	91
New MAD	PIPEINSLN	Pipe Insulation - Hot water - Pipe Diameter ≤ 1.5"	GEXPRO	DHW	15	$ 2.00	$ 18.40	4	$24.87	$18.40	The MAD for this measure prec	$0.00		12.44	1.35	$0.050	91
New MAD	PIPEINSLN	Pipe Insulation - Low-Pressure Steam (< 15 psig) - Pipe Diameter > 1.5"	GEXPRO	Flat	15	$ 4.00	$ 18.40	9.3	$51.24	$18.40	The MAD for this measure prec	$0.00		12.81	2.78	$0.043	91
New MAD	PIPEINSLN	Pipe Insulation - Low-Pressure Steam (< 15 psig) - Pipe Diameter ≤ 1.5"	GEXPRO	Flat	15	$ 4.00	$ 18.40	9.3	$51.24	$18.40	The MAD for this measure prec	$0.00		12.81	2.78	$0.043	91
New MAD	PIPEINSLN	Pipe Insulation - Med-Pressure Steam (15–200 psig) - Pipe Diameter > 1.5"	GEXPRO	Flat	15	$ 6.00	$ 14.57	5	$27.55	$14.57	The MAD for this measure prec	$0.00		4.59	1.89	$0.121	91
New MAD	PIPEINSLN	Pipe Insulation - Med-Pressure Steam (15–200 psig) - Pipe Diameter ≤ 1.5"	GEXPRO	Flat	15	$ 6.00	$ 14.57	5	$27.55	$14.57	The MAD for this measure prec	$0.00		4.59	1.89	$0.121	91
	RADHEATMODWA	Radiant Heater, Modulating	GEXSPHT	Com Heating	20	$ 7.00	$ 8.46	3.8	$55.38	$8.46	Incentive per quantity updated	$2.24	$0.19	7.91	6.81	$0.156	117
	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	Incentive per quantity updated	$2.24	$0.19	7.76	6.37	$0.159	117
	STCONHITEMPGASWA	Dishwasher - Single Tank Conveyor - gas high temp	RESDHWG	Flat	20	$ 900.00	$ 2,050.00	280	$1,969.45	$1,969.45		$6,426.75	$544.05	2.19	4.10	$0.272	35
	STCONLOTEMPGAS	Dishwasher - Single Tank Conveyor - gas low temp	RESDHWG	Flat	20	$ 900.00	$ 1.00	545	$3,833.38	$3,835.00		$13,726.47	$1,162.00	4.26	17559.85	$0.140	35
	STDRUPLOTEMPGAS	Dishwasher - Single Tank Door/Upright - gas low temp	RESDHWG	Flat	15	$ 550.00	$ 662.00	675	$3,719.11	$662.00		$13,212.32	$1,328.56	6.76	25.58	$0.082	35
	STDUPHITEMPGASWA	Dishwasher - Single Tank Door/Upright - gas high temp	RESDHWG	Flat	15	$ 825.00	$ 995.00	461	$2,540.01	$995.00		$6,377.73	$641.31	3.08	8.96	$0.180	35
		Dishwasher - Multi Tank Conveyor - High Temp - Gas Water Heat	RESDHWG	Flat	20	$ 800.00	$ 970.00	1063	$7,476.86	$970.00		$17,524.75	$1,483.54	9.35	25.77	$0.064	35
		Dishwasher - Multi Tank Conveyor Low Temp Gas Water Heat	RESDHWG	Flat	20	$ 800.00	$ 970.00	786	$5,528.51	$970.00		$18,277.23	$1,547.24	6.91	24.54	$0.086	35
		Dishwasher - Pot Pan Utensil - High Temp Gas Water Heat	RESDHWG	Flat	10	$ 350.00	$ 1,710.00	138	$521.58	$521.58		$1,297.47	$173.29	1.49	1.06	$0.339	35
		Dishwasher - Undercounter - Low Temp gas water heat	RESDHWG	Flat	10	$ 195.00	$ 234.00	106	$400.63	$234.00		$1,563.94	$208.88	2.05	8.40	$0.246	35
	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		$0.00		5.85	2.72	$0.183	45
	NEW	Multifamily Commercial Clothes Washer Common Areas	RESDHWG	Clotheswasher	11	$ 65.00	$ 425.00	24	$95.31	$95.31		$867.69	$108.00	1.47	2.27	$0.337	89
	BOCINCENTIVE1	BOC - Building Operations Manager Certificate, Level 1	GEXPRO	Flat	3	$ 600.00	$ 600.00	759	$908.15	$600.00		$0.00	$0.00	1.51	1.51	$0.294	137
	BOCINCENTIVE2	BOC - Building Operations Manager Certificate, Level 2	GEXPRO	Flat	3	$ 600.00	$ 600.00	759	$908.15	$600.00		$0.00	$0.00	1.51	1.51	$0.294	137
	New (No code yet)	Cooler Doors	GEXSPHT	Com Heating	15	$ 100.00	$ 375.00	45	$516.09	$375.00		$0.00		5.16	1.38	$0.223	47
New MAD	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		$12.23	$1.23	8.30	6.66	$0.139	195
	New (No code yet)	Multifamily HVAC Hot Water Condensing Gas Boilers <300 kbtu/h	GEXSPHT	Res Heating	35	$ 10.00	$ 16.00	4.1	$78.23	$16.00		$0.00		7.82	4.89	$0.161	147
	New (No code yet)	Multifamily HVAC Hot Water Condensing Gas Boilers ≥300 kbtu/h, ≤2,500 kbtu/h	GEXSPHT	Res Heating	35	$ 9.00	$ 13.00	4.1	$78.23	$13.00		$0.00		8.69	6.02	$0.145	147
	New (No code yet)	Multifamily HVAC Hot Water Condensing Gas Boilers >2,500 kbtu/h	GEXSPHT	Res Heating	35	$ 8.00	$ 10.00	4.1	$78.23	$10.00		$0.00		9.78	7.82	$0.129	147
		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		$52.71	$5.30	2.74	13.28	$0.229	51
		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		$112.68	$11.33	5.72	28.26	$0.109	51
		WA Existing or New MF Customer Purchased Bathroom Aerator 1.0 gpm	RESDHWG	DHW	15	$ 5.00	$ 5.00	2.2	$13.68	$5.00		$65.14	$6.55	2.74	15.76	$0.229	51
		WA Existing or New MF Customer Purchased Bathroom Aerator 0.5 gpm	RESDHWG	DHW	15	$ 5.00	$ 5.00	3.5	$21.76	$5.00		$102.73	$10.33	4.35	24.90	$0.144	51
		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		$52.51	$5.28	2.74	13.24	$0.229	51
		WA Existing or New MF Leave Behind Kitchen Aerator 1.0 gpm	RESDHWG	DHW	15	$ 5.00	$ 5.00	4	$24.87	$5.00		$97.56	$9.81	4.97	24.49	$0.126	51
		WA Existing or New MF Leave Behind Bathroom Aerator 1.0 gpm	RESDHWG	DHW	15	$ 5.00	$ 5.00	1.8	$11.19	$5.00		$51.71	$5.20	2.24	12.58	$0.279	51

Change	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)	Engineer's Notes	NPV of NEBs per Quantity	Annual NEBs	UCT BCR (2019 WA-Only AC)	TRC BCR (2019 WA-only AC)	2019 Levelized Cost (5.64% Discount Rate)	MAD #
		WA Existing or New MF Leave Behind Bathroom Aerator 0.5 gpm	RESDHWG	DHW	15	$ 5.00	$ 5.00	2.7	$16.79	$5.00		$79.96	$8.04	3.36	19.35	$0.186	51
		WA Customer Purchase MF Gas 1.50 gpm Showerhead	RESDHWG	DHW	15	$ 7.00	$ 7.14	13.5	$83.94	$7.14		$188.06	$18.91	11.99	38.10	$0.052	157
		WA Customer Purchase MF Gas 1.50 gpm Showerwand	RESDHWG	DHW	15	$ 7.00	$ 7.14	9.9	$61.56	$7.14		$138.43	$13.92	8.79	28.01	$0.071	157
		WA Leave Behind MF Gas 1.50 gpm Showerhead	RESDHWG	DHW	15	$ 7.00	$ 12.00	10.1	$62.80	$12.00		$188.06	$18.91	8.97	20.90	$0.070	157
		WA Leave Behind MF Gas 1.50 gpm Showerwand	RESDHWG	DHW	15	$ 7.00	$ 28.00	7.4	$46.01	$28.00		$138.43	$13.92	6.57	6.59	$0.095	157
		WA Customer Purchase MF Gas 1.75 gpm Showerhead	RESDHWG	DHW	15	$ 7.00	$ 7.14	9.8	$60.94	$7.14		$137.24	$13.80	8.71	27.76	$0.072	157
		WA Customer Purchase MF Gas 1.75 gpm Showerwand	RESDHWG	DHW	15	$ 7.00	$ 7.14	4.3	$26.74	$7.14		$60.07	$6.04	3.82	12.16	$0.164	157
		WA Leave Behind MF Gas 1.75 gpm Showerhead	RESDHWG	DHW	15	$ 7.00	$ 12.00	7.4	$46.01	$12.00		$137.24	$13.80	6.57	15.27	$0.095	157
		WA Leave Behind MF Gas 1.75 gpm Showerwand	RESDHWG	DHW	15	$ 7.00	$ 28.00	3.2	$19.90	$19.90		$60.07	$6.04	2.84	2.86	$0.220	157
	New (No code yet)	Multifamily Condensing Tankless Water Heater ≤199 kbtu/h	RESDHWG	DHW	15	$ 300.00	$ 320.00	82	$509.87	$320.00		$0.00	$0.00	1.70	1.59	$0.368	196
New MAD	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	Convenience stores/small groc	$212.52	$21.37	6.19	2.08	$0.186	201
New MAD	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	Convenience stores/small groc	$150.27	$15.11	12.06	2.77	$0.096	201
NewMAD	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	Convenience stores/small groc	$378.10	$38.02	11.04	3.71	$0.104	201
	New (No code yet)	Conveyor Broilers <22" wide conveyor - gas only	GNEWPRO	Com Cooking	12	$ 2,015.00		1145		$ 2,523.00			$550.08	3.07	4.94		233
	New (No code yet)	Conveyor Broilers 22-28" wide conveyor - gas only	GNEWPRO	Com Cooking	12	$ 2,515.00		1933		$ 3,146.00			$493.06	4.16	5.50		233
	New (No code yet)	Conveyor Broilers >28" wide conveyor - gas only	GNEWPRO	Com Cooking	12	$ 2,925.00		3161		$ 3,659.00			$1,836.38	5.85	10.14		233
New Measure		Pre Rinse Spray Vaves, 0.81 to 1.0 EB		4		$ 30.00	$ 30	25		$ 30.00			$64.00	2.70	10.20		253
New Measure		Pre Rinse Spray Vaves, 0.61 to 0.80 EB		4		$ 30.00	$ 30	39		$ 30.00			$100.00	4.30	16.10		253
New Measure		Pre Rinse Spray Vaves, 0.81 to 1.0 MF		4		$ 30.00	$ 30	30		$ 30.00			$79.00	3.30	12.50		253
New Measure		Pre Rinse Spray Vaves, 0.61 to 0.80 MF		4		$ 30.00	$ 30	47		$ 30.00			$124.00	5.20	19.80		253
New Measure		Advanced Rooftop-unit controls Retrofit		15		$ 275.00	$ 418	15		$ 289.65			$47.36	1.00	2.28		256
	Gas OD 1/12 HP	Domestic hot water recirculation controls - On demand		New (No code yet)	12	$ 300.00	$ 388	139.5		$ 388.00			$80.00	1.80	3.60		66
	Gas OD 1/6 - 1/4 HP	Domestic hot water recirculation controls - On demand		New (No code yet)	12	$ 1,200.00	$ 2,198	279 - 353.4		$ 1,415.00			$114.00	1.00	1.10		66
	Gas OD 1/2 - 5 HP	Domestic hot water recirculation controls - On demand		New (No code yet)	12	$ 1,900.00	$ 2,198	424		$ 2,150.00	Increm $ range 2198 - 5000		$221.00	1.00	1.80		66
	Gas AQ 1/12 HP	Domestic hot water recirculation controls - Aquastat		New (No code yet)	12	$ 100.00	$ 108	22		$ 108.00			$66.00	1.00	6.30		66
	Gas AQ 1/6 - 1/4 HP	Domestic hot water recirculation controls - Aquastat		New (No code yet)	12	$ 200.00	$ 1,000	44 - 55.8		$ 223.00			$91.00	1.00	1.00		66
	Gas AQ 1/2 - 5 HP	Domestic hot water recirculation controls - Aquastat		New (No code yet)	12	$ 300.00	$ 1,000	67		$ 340.00	Increm $ range 1000 - 3000		$179.00	1.00	1.90		66
	Gas LRN 1/12 HP	Domestic hot water recirculation controls - Learning		New (No code yet)	12	$ 100.00	$ 206	22		$ 112.00			$66.00	1.00	3.30		66
	Gas LRN 1/6 - 1/4 HP	Domestic hot water recirculation controls - Learning		New (No code yet)	12	$ 200.00	$ 1,000	44 - 55.8		$ 223.00			$91.00	1.00	1.00		66
	Gas LRN 1/2 - 5 HP	Domestic hot water recirculation controls - Learning		New (No code yet)	12	$ 300.00	$ 1,000	67		$ 340.00	Increm $ range 1000 - 3000		$179.00	1.00	1.90		66

Bonus Measures

General Measure Description: Use actual description in Brochure	Efficiency Type for Qualification		Current incentive	Bonus percentage	Incentive w/ Bonus				
GFBOIL300	Boiler < 300 kBtuh input		$10/kBtu/h input	60%	$16/kBtu/h input				
GFBOIL3002500	Boiler ≥ 300, ≤ 2,500 kBtuh input		$9/kBtu/h input	30%	$13/kBtu/h input				
GFBOIL2500	Boiler > 2,500 kBtuh input		$8/kBtu/h input	25%	$10/kBtu/h input				

4.2 Appendix 2: Measure Approval Documents

Measure Approval Document for Commercial Aerators

Valid Dates
1/1/2020 – 12/31/2020

End Use or Description
This document describes the installation of low flow aerators for Oregon and Washington qualifying commercial rate customers through retail and leave behind delivery mechanisms. The measures are applicable in public and private lavatories and commercial kitchen faucets.

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

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

- Office, retail, lodging, hospital

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

- Retrofit
- New

Purpose of Re-Evaluating Measure
This measure is re-evaluated to identify changes in equipment costs for both customer purchase and leave-behind delivery channels. Splits bathroom and kitchen.

Version 1.3 corrects an error with some measures being left out of Table 3.

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
1.5 gpm aerator - electric water heat - bathroom	10	141	0	$2.71	$24.40	$2.71	28.4	99.7	100%	0%
1.5 gpm aerator - gas water heat - bathroom	10	6	6	$2.71	$24.40	$2.71	9.1	80.4	14%	86%
1.0 gpm aerator - electric water heat - bathroom	10	241	0	$2.71	$41.83	$2.71	48.6	170.8	100%	0%
1.0 gpm aerator - gas water heat - bathroom	10	11	10	$2.71	$41.83	$2.71	15.6	137.8	14%	86%
0.5 gpm aerator - electric water heat - bathroom	10	342	0	$2.71	$59.26	$2.71	68.9	242.0	100%	0%
0.5 gpm aerator - gas water heat - bathroom	10	15	14	$2.71	$59.26	$2.71	22.1	195.2	14%	86%
Leave behind - 1.5 gpm aerator - electric water heat - bathroom	10	106	0	$2.00	$18.30	$2.00	28.8	101.2	100%	0%
Leave behind - 1.5 gpm aerator - gas water heat - bathroom	10	5	4	$2.00	$18.30	$2.00	9.3	81.7	14%	86%
Leave behind - 1.0 gpm aerator - electric water heat - bathroom	10	181	0	$2.00	$31.37	$2.00	49.4	173.5	100%	0%
Leave behind - 1.0 gpm aerator - gas water heat - bathroom	10	8	7	$2.00	$31.37	$2.00	15.9	140.0	14%	86%
Leave behind - 0.5 gpm aerator - electric water heat - bathroom	10	256	0	$2.00	$44.45	$2.00	70.0	245.9	100%	0%
Leave behind - 0.5 gpm aerator - gas water heat - bathroom	10	12	10	$2.00	$44.45	$2.00	22.5	198.3	14%	86%
1.5 gpm aerator - electric water heat - kitchen	10	168	0	$7.00	$24.40	$7.00	13.1	40.7	100%	0%
1.5 gpm aerator - gas water heat - kitchen	10	6	7	$7.00	$24.40	$7.00	4.1	31.7	12%	88%
1.0 gpm aerator - electric water heat - kitchen	10	288	0	$7.00	$41.83	$7.00	22.5	69.8	100%	0%
1.0 gpm aerator - gas water heat - kitchen	10	11	12	$7.00	$41.83	$7.00	7.1	54.4	12%	88%
0.5 gpm aerator - electric water heat - kitchen	10	409	0	$7.00	$59.26	$7.00	31.9	98.9	100%	0%
0.5 gpm aerator - gas water heat - kitchen	10	15	17	$7.00	$59.26	$7.00	10.1	77.1	12%	88%
Leave behind - 1.5 gpm aerator - electric water heat - kitchen	10	126	0	$2.00	$18.30	$2.00	34.5	106.9	100%	0%
Leave behind - 1.5 gpm aerator - gas water heat - kitchen	10	5	5	$2.00	$18.30	$2.00	10.9	83.3	12%	88%
Leave behind - 1.0 gpm aerator - electric water heat - kitchen	10	216	0	$2.00	$31.37	$2.00	59.1	183.2	100%	0%
Leave behind - 1.0 gpm aerator - gas water heat - kitchen	10	8	9	$2.00	$31.37	$2.00	18.7	142.8	12%	88%
Leave behind - 0.5 gpm aerator - electric water heat - kitchen	10	306	0	$2.00	$44.45	$2.00	83.7	259.5	100%	0%
Leave behind - 0.5 gpm aerator - gas water heat - kitchen	10	12	13	$2.00	$44.45	$2.00	26.4	202.3	12%	88%

Table 2 Cost Effectiveness Calculator Oregon – GAS ONLY

Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR
0.5 gpm aerator - gas water heat - bathroom	10	0	14	$2.71	$60.68	$2.71	19.0	196.3
Leave behind - 0.5 gpm aerator - gas water heat - bathroom	10	0	10	$2.00	$45.51	$2.00	19.3	199.4
1.5 gpm aerator - gas water heat - kitchen	10	0	7	$7.00	$24.99	$7.00	3.7	31.9
1.0 gpm aerator - gas water heat - kitchen	10	0	12	$7.00	$42.84	$7.00	6.3	54.7
0.5 gpm aerator - gas water heat - kitchen	10	0	17	$7.00	$60.68	$7.00	8.9	77.5
Leave behind - 1.5 gpm aerator - gas water heat - kitchen	10	0	5	$2.00	$18.30	$2.00	9.6	82.0
Leave behind - 1.0 gpm aerator - gas water heat - kitchen	10	0	9	$2.00	$32.13	$2.00	16.4	143.6
Leave behind - 0.5 gpm aerator - gas water heat - kitchen	10	0	13	$2.00	$45.51	$2.00	23.3	203.4

Table 3 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
1.5 gpm aerator - gas water heat - bathroom	10	0	6	$2.71	$23.54	$2.71	9.1	74.1
1.0 gpm aerator - gas water heat - bathroom	10	0	10	$2.71	$40.35	$2.71	15.5	127.1
0.5 gpm aerator - gas water heat - bathroom	10	0	14	$2.71	$57.17	$2.71	22.0	180.0
Leave behind - 1.5 gpm aerator - gas water heat - bathroom	10	0	4	$2.00	$17.65	$2.00	9.2	75.3
Leave behind - 1.0 gpm aerator - gas water heat - bathroom	10	0	7	$2.00	$30.26	$2.00	15.8	129.1
Leave behind - 0.5 gpm aerator - gas water heat - bathroom	10	0	10	$2.00	$42.88	$2.00	22.4	182.9
1.5 gpm aerator - gas water heat - kitchen	10	0	7	$7.00	$23.54	$7.00	4.2	29.4
1.0 gpm aerator - gas water heat - kitchen	10	0	12	$7.00	$40.35	$7.00	7.2	50.4
0.5 gpm aerator - gas water heat - kitchen	10	0	17	$7.00	$57.17	$7.00	10.3	71.4
Leave behind - 1.5 gpm aerator - gas water heat - kitchen	10	0	5	$2.00	$17.65	$2.00	11.1	77.2
Leave behind - 1.0 gpm aerator - gas water heat - kitchen	10	0	9	$2.00	$30.26	$2.00	19.0	132.3
Leave behind - 0.5 gpm aerator - gas water heat - kitchen	10	0	13	$2.00	$42.88	$2.00	26.9	187.4

Requirements

- Kitchen faucet aerators with a maximum rated flow of 1.5 gpm or 1.0 gpm.
- Bathroom faucet aerators with a maximum rated flow of 0.5 gpm
- Site water heating fuel must be served by participating utility.
- New Buildings bathroom aerator is limited to private bathroom faucet applications only.
- Commercial private bathrooms are limited to those in lodging, hospitals, and spaces with bathrooms limited to one occupant.

Baseline

This measure uses an existing condition.

The baseline is 2.2 gpm for kitchen and bathroom faucets, per US Code of Federal Regulations – 10 CFR Part 430.32. As current code for new construction is 0.5 gpm for any public bathroom, only private bathrooms are allowed for New Buildings.

Savings & Measure Analysis

Savings estimates use the following assumptions:

Gas water heating efficiency: 80% consistent with water heating efficiency used in MAD 77 – Commercial Showerheads

Mixed water temperature: 86°F for bathroom faucets; 93°F for kitchen faucets from MAD 51 – Cadmus and Opinion Dynamics for the Michigan Evaluation Working Group, 2013. "Showerhead and Faucet Aerator Meter Study."

Ground water temperature: 55.3°F based on RTF SIW v4.1

Minutes per day per faucet: This update holds that assumption based on findings from [1] which finds an average duration of 12.4 minutes per day in hotel faucets.

Water heater outlet temperature: 128°F from RTF Aerators_v1.0, consistent with RTF HPWH and Showerheads measures, and with 7th Plan aerator assumptions.

Hot water mix percentage: 44% per MAD 51.

Installation rates:

- Customer purchase aerators have an assumed installation rate of 80%.
- Leave behind measures have an assumed installation rate of 60%. The installation rates follow MAD 51 assumptions, which reference RTF Showerheads v3.1 workbook.

Comparison to RTF or other programs

Regional assumptions, where applicable, are taken from RTF SIW v4.1:

- Gas water heating efficiency
- Ground water temperature

Other assumptions taken from RTF Aerators_v1.0

- Mixed water temperature
- Water heater outlet temperature

Measure Life

The measure life is 10 years consistent with previous versions and with RTF Aerators_v1.0.

Cost

Cost estimates are based on actual installation costs collected by the Existing Buildings program. Bathroom aerator average cost is $2.71. Kitchen aerator cost is $7.00. Leave behind measure cost is unchanged at $2.00.

Non-Energy Benefits

Non-energy benefits are the result of reduced water consumption from aerator devices is calculated using water rates net of embedded electricity in Oregon for gas and electric territories, and total water rates without removing embedded energy for Oregon gas only territory. Washington uses the combined rate of water without removing embedded energy use for wastewater treatment

- Oregon full territory $14.17/1,000 gallons
- Oregon gas only territory $14.51/1,000 gallons
- Washington $13.68/1,000 gallons

Incentive Structure

The maximum incentives listed in Table 1, Table 3 and Table 3 are for reference only and are not suggested incentives. Incentives will be structured per aerator.

SRAF

Typical program SRAFs apply to these measures.

Follow-Up

This approval is for 1 year only, to allow time for RTF's measure to be finalized. Future versions should look to RTF as guidance and updated with commercial usage and flow data should it be collected. All updates to the RTF analysis should be reviewed at the next 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 showerheads and aerators\aerator_Commercial

Commercial Aerators 2020 v2.xlsx

References

1. Southern California Gas Company Work Paper WPSCGNRWH161222A Revision 0 – Aerators for Faucets in Commercial Buildings.
2. RTF Standard Information Workbook v4.1
3. RTF Aerators_v1.0

Version History and Related Measures

Table 4 Version History

Date	Version	Reason for revision
2/28/2013	1.x	First release
10/28/2014	1.x	Updated analysis, increased incentives
4/6/2015	1.x	Adds leave behind measure
10/14/2019	1.2	Splits bathroom and kitchen aerators, adds partial territory aerators.
10/23/2019	1.3	Adds measures left off the MAD

Table 5 Related Measures

Measures	MAD ID
Residential Aerators	51
Commercial Showerheads	77
Direct Install Showerheads and Showerwands	157
New Buildings Showerheads	144
Retail Showerheads and Showerwands	26

Approved & Reviewed by

Kenji Spielman
Planning Engineer

Disclaimer

Measure Approval Document for Manufacturer-Installed Rooftop Unit Controls

Valid Dates
1/1/2021 – 12/31/2023

Description
This measure is applicable to economizers, demand controlled ventilation (DCV), and variable speed supply fans on rooftop units (RTUs) which are not required by code to include these features. These controls must be included as factory options in new units, not as third-party add-ons.

Variable speed fans are often controlled by variable frequency drives (VFD), though other speed control devices are also included.

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
- Existing Multifamily

Only the DCV measure is applicable to projects in Washington or in Oregon gas-only territory, as this is the only measure that results in gas savings.

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

- Replacement
- New

Purpose of Re-Evaluating Measure
Variable speed supply fan requirements have changed based on code (2019 OZERCC) requirements which require VFDs in more situations than previously.

Despite recent code changes, this update does not include changes to savings or costs. A comparison of prototype buildings designed to meet the prior code (2014 OEESC) and the newer 2019 code indicates a reduction to internal loads of about five percent - within the error of modeled savings analysis. Also, applications in existing buildings not impacted by code changes. Cost estimates were reviewed and found to still be appropriate.

A DCV measure was added for Oregon gas-only customers.

Cost Effectiveness
Cost Effectiveness is demonstrated for Oregon in Table 1 and in Washington in Table 2. Cost Effectiveness was tested using OR-WA CE Calculator 2021 v1.1. In Oregon, the gas and electric avoided cost year is 2021. In Washington, the gas avoided cost year is 2020. The values in these tables are per ton of cooling capacity.

Table 1 Cost Effectiveness Calculator Oregon, per ton

#	Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Ele	% Gas
19	Economizer, New gas heat RTU	15	174	(0.03)	$45.22	$0.00	$45.22	4.9	4.9	100%	0%
25	DCV, New gas heat RTU	15	16	21.46	$38.28	$0.00	$38.28	6.4	6.4	8%	92%
26	Variable Supply fan, new gas heat RTU	15	587	(11.07)	$418.99	$0.00	$418.99	1.0	1.0	100%	0%
29	DCV, New gas heat RTU, gas only territory	15	0	21.46	$38.28	$1.24	$38.28	5.8	6.2	0%	100%
22	Economizer, New heat pump RTU	15	174	0	$45.22	$0.00	$45.22	4.9	4.9	100%	0%
27	DCV, New heat pump RTU	15	196	0	$38.28	$0.00	$38.28	5.6	5.6	100%	0%
28	Variable Supply fan, New heat pump RTU	15	489	0	$418.99	$0.00	$418.99	1.1	1.1	100%	0%

Table 2 Cost Effectiveness Calculator Washington, per ton

#	Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Ele	% Gas
25	DCV, New gas heat RTU	15	21.46	$38.28	$1.23	$38.28	10.7	11.0	0%	100%

Requirements
- These measures are only applicable to installations of new rooftop units with DX cooling and either gas furnace or heat pump heating. Retrofits or add-on equipment to existing rooftop units are approved in MAD 256.

Economizers:
- Economizer savings may only be claimed when installed on rooftop units with cooling capacities less than 54,000 Btu/h.
- This measure is not applicable to projects in Washington or Oregon's gas-only territory.

DCV:
- DCV savings may only be claimed when installed in units which also have economizers.
- DCV savings may only be claimed for units which serve spaces that are not required by code to have DCV.
- A list of spaces by building type which are not required to have DCV accompanies this document – all spaces not listed are required by code to have DCV, or are expected to have negligible DCV savings and so are excluded from this measure. The most common expected spaces in which DCV is not code-required are office spaces (excluding conference rooms and reception areas) and retail sales floors (excluding mall common areas).
- Due to COVID-19 and the latest building ventilation guidelines, many buildings are disabling DCV. Sites that install but do not fully commission DCV may participate. It is assumed DCV will eventually be enabled within the measure life.

Variable Speed Supply Fan:

- May be controlled by VFD, EC motor or other speed control mechanism.
- Supply fan savings may only be claimed when installed in units which also have both DCV and economizers.
- Supply fan savings may only be claimed when installed in units with cooling capacity less than 65,000 Btu/h.
- This measure is not applicable to projects in Washington or Oregon's gas only territory

Baseline

This measure uses a code baseline.

Each of these measures may be code required in particular locations and sizes of equipment and is considered baseline in those situations. These measures were designed using a rolling baseline approach. Using this approach allows savings to be calculated for controls which are not required by code, even if they are combined with other controls that are required by code.

The baseline equipment for the economizer measure is an RTU with no economizer, of a size where an economizer is not required.

- 2019 Oregon Zero Energy Ready Commercial Code (OZERCC) adopts ASHRAE Standard 90.1-2016, which requires economizers on units greater than 54,000 Btu/h per Section 6.5.1.

The baseline equipment for the DCV measure is an RTU with an economizer, in a location where DCV is not required.

- In Oregon, code requirements for DCV are set forth in ASHRAE Standard 90.1-2016 Section 6.4.3.8.
- In Washington, code requirements for DCV are set forth in 2015 Washington State Energy Code (WSEC) Section C403.2.6.2 which references Table 403.3.1.1 of the 2015 International Mechanical Code (IMC).

The baseline equipment for the variable speed supply fan measure is an RTU with an economizer and DCV of a size where a VFD or similar is not required.

- 2019 OZERCC requires VFDs on supply fans for units with cooling capacities 65,000 Btu/h or greater per ASHRAE Standard 90.1-2016 Section 6.5.3.2.1.

Measure Analysis and Modeling

Savings for the advanced rooftop unit controls measure were modeled by CLEAResult's new construction engineering team in 2017 using the New Buildings program's prototype models for the Small Office, Strip Mall Retail, and Primary School building types in eQuest 3.65. These models are meant to represent typical code-minimum new construction. Controls are likely to be installed in one of three potential combinations and were modeled accordingly. These combinations are:

- Economizer
- Economizer + DCV
- Economizer + DCV + Variable Speed Supply Fan

Economizers were modeled by allowing HVAC units to vary the amount of outside air in response to outside air temperature. Economizers were modeled with integrated operation (compressors are not locked out and economization is used in conjunction with mechanical cooling when needed) and with a high-limit cutoff of 70 degrees F.

DCV was modeled by changing the minimum air flow in spaces in which DCV is not code required to the code-prescribed per-square-foot value. Outside air flow in these spaces is then allowed to modulate in response to hourly occupancy, increasing the outside air flow based on the code-prescribed per-person value.

Variable speed supply fans were modeled by assigning variable speed performance curves to HVAC supply fans, and allowing supply fans to ramp down to a minimum of 30% of design speed (in line with typical recommended VFD minimums).

The measures were modeled for three Oregon climate zones (Coast/Astoria HZ1CZ1, Valley/Portland HZ1CZ2, Central/Redmond HZ2CZ1). The savings for each climate zone were combined into a weighted average using the following program-assumed weightings:

- Coast: 3%
- Valley: 87%
- Central: 10%

The weighted average savings for each building type were combined into a weighted average using the following weightings, based on New Buildings Program enrollments from 2015 and 2016:

- Office: 44%
- Retail: 25%
- School: 30%

Savings

Savings for these measures were determined using a rolling baseline approach, allowing a discrete savings value to be assigned to each control addition.

$$Savings_{DCV} = Savings_{Economizer+DCV} - Savings_{Economizer}$$

$$Savings_{VFD} = Savings_{Economizer+DCV+VFD} - Savings_{Economizer+DCV}$$

Comparison to RTF and Others

The Regional Technical Forum (RTF) does not have a standard measure equivalent to these measures. They do have a standard protocol for supply fan VFD, which is study method and does not indicated a deemed savings. Bonneville Power Administration (BPA) has preliminary deemed savings for advanced rooftop controllers (ARCs) which include many of the features of these measures, though it's assumed that most ARC savings are from the VFDs. BPA's savings are in the same range as the total savings for all the measures included in this analysis.

The RTF also has a UES measure for Advance Rooftop Controls (ARC) that is related but differs in that it applies to retrofits of existing packaged units and it has different measure options, which Energy Trusts ARC retrofit measure (MAD 256) is based on. Savings for the retrofit ARC measures are categorized in bins of RTU operating hours and products are designated as Full ARC and ARC-lite. The modeled savings values for new RTU controls are comparable to that RTF measure for the appropriate operating hours ranges and measure categories. The Variable Supply Fan savings are comparable to the ARC-light savings, and the combined Economizer + DCV + Variable Supply Fan savings are comparable to the Full ARC savings.

The modeled savings are compared to available estimates from PNNL's ARC retrofit field-test results[1], PNNL's Rooftop Unit Comparison Calculator[2], and PG&E's work papers for retrofit add-on of economizers, DCV, and supply fan VFDs. The comparison showed that the modeled savings were reasonably in the same range as these other sources, with expected differences arising from different assumptions regarding baselines, climates, applications, etc.

Measure Life

The measure life is assumed to be 15 years, consistent with standard program assumptions regarding HVAC controls measures on new equipment.

Cost

Two leading HVAC manufacturers active in Oregon were surveyed to determine the estimated cost of adding these control features to a 3 ton, 4-5 ton, and 7.5 ton rooftop unit. The manufacturers gave similar costs for the combination of all three measures, however the breakdown of the cost among the individual control features differed. Based on program staff experience, the breakdown from one of the respondents was deemed more representative of typical pricing, where the primary cost driver is VFD and associate sensors. The total per unit cost provided by the second respondent was re-distributed based on the allocations from the other. The manufacturer costs were averaged, then normalized by cooling capacity to determine a $/ton value for each measure. The cost information is summarized in Table 3 and Table 4.

Table 3 Manufacturer-Provided Cost Estimates

	Feature	Factory Installed Price			
		MFGR1	MFGR2	MFGR2 - Adjusted per MFGR 1 breakdown	Average
3 Ton	Advanced Digital Economizer	$200.00	$1,080.00	$129.58	$164.79
	CO2 sensor	$200.00	$475.00	$129.58	$164.79
	Variable speed supply fan motor (and additional sensors for variable flow)	$2,000.00	$0.00	$1,295.83	$1,647.92
	Digital Economizer, CO2, and SF VFD	$2,400.00	$1,555.00	$1,555.00	$1,977.50
4-5 Ton	Advanced Digital Economizer	$200.00	$1,080.00	$119.62	$159.81
	CO2 sensor	$200.00	$475.00	$119.62	$159.81
	Variable speed supply fan motor (and additional sensors for variable flow)	$2,200.00	$0.00	$1,315.77	$1,757.88
	Digital Economizer, CO2, and SF VFD	$2,600.00	$1,555.00	$1,555.00	$2,077.50
7.5 Ton	Advanced Digital Economizer	$200.00	$1,477.00	$165.80	$182.90
	CO2 sensor	$200.00	$1,010.00	$165.80	$182.90
	Variable speed supply fan motor (and additional sensors for variable flow)	$2,600.00	$0.00	$2,155.40	$2,377.70
	Digital Economizer, CO2, and SF VFD	$3,000.00	$2,487.00	$2,487.00	$2,743.50

Table 4 Average Costs Normalized by Cooling Capacity

Measure	Tons	Average Price	$/ton	Avg $/ton
Economizer	3	$164.79	$54.93	$45.22
	4.5	$159.81	$35.51	
DCV	3	$164.79	$54.93	$38.28
	4.5	$159.81	$35.51	
	7.5	$182.90	$24.39	
VFD	3	$1,647.92	$549.31	$418.99
	4.5	$1,757.88	$390.64	
	7.5	$2,377.70	$317.03	

Incentive Structure

Incentives will be structured per ton of cooling capacity. Like the savings values, incentive values will be calculated using an additive approach in which incentives are only added for the installed features which are not code-required.

The maximum incentives listed in Table 1 and Table 2 are for reference only and are not suggested incentives. Bonuses or promotions must not raise incentives above those in Table 1 and Table 2.

SRAF

Negative gas savings are included in Energy Trust's reporting as SRAF components. These are included in cost effectiveness testing but do not subtract from programs' accomplishments.

Follow-Up

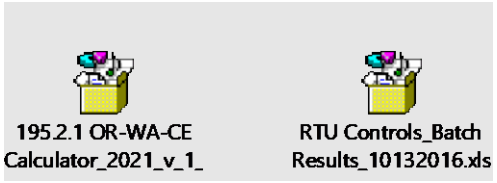
This measure has multiple applicability requirements based on sections of the OZERCC and the OMSC. When the OZERCC or OMSC is updated, this measure should be reviewed and be updated accordingly as needed, even if the MAD has not yet expired.

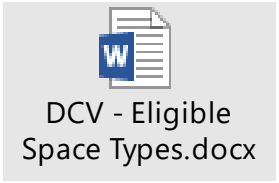
Climate zone and building type weighting should be reviewed and updated if necessary, at next revision.

[1] PNNL Advanced Rooftop Control (ARC) Retrofit: Field-Test Results http://www.pnl.gov/main/publications/external/technical_reports/PNNL-22656.pdf
[2] PNNL Rooftop Unit Comparison Calculator http://www.pnnl.gov/uac/costestimator/main.stm

Supporting Documents and References

The cost effectiveness screening is number 195.2.1. It is attached and can be found along with supporting documentation at: I:\Groups\Planning\Measure Development\Commercial and Industrial\Commercial HVAC\Economizers and controls\new RTU with controls





Version History and Related Measures

Energy Trust has been incentivizing economizers and DCV measures for many years and the offerings have evolved over time and have often been bundled with other measures. The approval of these measures predates our current measure approval documentation systems and record retention timelines. Table 5 includes many revisions of these measures' approvals but may not be fully complete, particularly for approvals issued before 2013.

Table 5 Version History

Date	Version	Reason for revision
12/22/05	185.x	Approves air, water and ground source heat pumps, chillers, heat exchangers and DCV for use in New Buildings
6/05/08	185.x	Add Existing buildings to above.
6/19/08	185.x	Add PE to above.
7/24/09	194.x	Rooftop tune-up pilot approval. Rooftop tune-up included contractor-installed economizers and DCV on existing RTUs.
4/05/10	194.x	Transition rooftop tune-up from pilot to standard offer. Updates to savings and structure based on pilot evaluation.
8/11/10	194.x	Add split-systems and other updates to tune-up offer.
10/6/10	96.x	New Buildings DCV prescriptive measure, aligned with 194.x. Superseded DCV in 185.x above.
2/11/11	185.x	Approval for New Buildings HVAC calculator for unitary equipment including air, ground and water-source heat pumps and air conditioners.
2/14/11	185.x	Adds Existing Buildings and PE as applicable programs to 185.
2/14/11	96.x	Approval for DCV calculator module of New Buildings HVAC calculator, replaces prescriptive DCV for New Buildings.
5/25/11	194.x	Add Production Efficiency as applicable program to tune-up offer.
7/14/11	x	Approval of Economizer module of New Buildings HVAC Calculator.
12/21/11	185.x	Replaces New Buildings HVAC calculator with prescriptive measures for unitary HVAC and economizers for use in New and Existing Buildings.
3/14/12	185.x	Add PE to above.
12/31/13	194.x	Tune up offering canceled, economizers and DCV no longer approved for Existing Buildings. MAD 194 moved to inactive.
3/1/17	195.1	New approval for Economizers, DCV and VFD on supply fans for New and Existing Buildings and PE. With this update, the New Buildings HVAC calculator is no longer in use for any measure. This economizer measure here supersedes the economizers in 185.x This DCV measure supersedes 96.x, which will be moved to inactive.
9/16/20	195.2	Updated requirements based on updated code

Table 6 Related Measures

Measures	MAD ID
Advanced Rooftop controls retrofit	256
Ground and water-source heat pumps (Inactive)	185
Duplicate of 185, (inactive)	121
Market Solutions Restaurant	158
Market Solutions Retail	160
Market Solutions Grocery	161
Market Solutions Office	164
Market Solutions Schools	165

Approved & Reviewed by

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Sr. Planning Engineer

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Measure Approval Document for New Cooler Cases with Doors

Valid Dates
1/1/2021 – 12/31/2023

End Use or Description
Installation of new, vertical, medium-temperature grocery display cases with doors, instead of open cases

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

- Existing Buildings
- New Buildings

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

- Convenience stores and small grocery stores
- Grocery stores
- Big box retail with grocery sections, described here as “large grocery”

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

- New
- Replacement

Purpose of Re-Evaluating Measure
Costs and maximum incentives have been updated.

Cost Effectiveness
Cost effectiveness is demonstrated for Oregon in Table 1 and Washington in Table 2. Cost effectiveness was calculated using the tool OR-WA-CE Calculator 2021-v1.1. In Oregon, the Electric Avoided cost year is 2021 and the Gas Avoided cost year is 2021. In Washington, the Gas Avoided Cost year is 2020.

Table 1 Cost Effectiveness Calculator Oregon, per linear foot

#	Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Elec	% Gas
1	Cooler with doors in Convenience & Small, Electric Heating	15	412	0	$275.29	$0.00	$275.29	1.2	1.2	100%	0%
2	Cooler with doors in Medium Grocery, Electric Heating	15	458	0	$275.29	$0.00	$275.29	1.3	1.3	100%	0%
3	Cooler with doors in Large Grocery, Electric Heating	15	733	0	$275.29	$0.00	$275.29	2.1	2.1	100%	0%
4	Cooler with doors in Convenience & Small, Gas Heating	15	277	18.9	$275.29	$0.00	$275.29	1.5	1.5	53%	47%
5	Cooler with doors in Medium Grocery, Gas Heating	15	196	36.8	$275.29	$0.00	$275.29	2.0	2.0	29%	71%
6	Cooler with doors in Large Grocery, Gas Heating	15	494	33.7	$275.29	$0.00	$275.29	2.7	2.7	53%	47%
7	Cooler Doors in Convenience, Gas Heating, Gas only	15	0	18.9	$275.29	$21.55	$197.00	1.0	1.6	0%	100%
8	Cooler with doors in Medium Grocery, Gas Heating, Gas only	15	0	36.8	$275.29	$15.24	$275.29	1.4	2.0	0%	100%
9	Cooler with doors in Large Grocery, Gas Heating, Gas only	15	0	33.7	$275.29	$38.35	$275.29	1.3	2.8	0%	100%

Table 2 Cost Effectiveness Calculator Washington, per linear foot

#	Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Elec	% Gas
1	Cooler with doors in Convenience & Small, Gas Heating	15	18.9	$275.29	$21.37	$275.29	1.3	2.1	0%	100%
2	Cooler with doors in Medium Grocery, Gas Heating	15	36.8	$275.29	$15.11	$275.29	2.6	3.1	0%	100%
3	Cooler with doors in Large Grocery, Gas Heating	15	33.7	$275.29	$38.02	$275.29	2.3	3.8	0%	100%

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

Store types are defined by area is shown in Table 3.

Table 3 Grocery Store Size Definitions

Store Type	Size
Convenience stores and small grocery	<14,000 SF
Medium grocery store	14,000-74,999 SF
Large grocery or big box with grocery section	≥75,000 SF

Details
Warm air and moisture from the sales floor (infiltration) are responsible for 70-80% of the refrigeration load on open vertical refrigerated display cases. Adding doors greatly reduces this infiltration, thereby reducing the load on the refrigeration system resulting in energy

savings. In addition to refrigeration savings, there are interactive effects with the store's heating and cooling systems leading to heating savings, and a cooling penalty.

Baseline

This measure uses a code baseline.

The baseline is a new vertical medium temperature remote commercial refrigerated display case without doors with code minimum EER (12.85). The related code (10 CFR 431.66[1]) references the AHRI Standard 1200 (I-P) for the EER of remote commercial display cases. The most recent AHRI Standard (AHRI Standard 1200 (I-P/2013))[2] maintains an EER of 12.85 for a medium temperature remote commercial refrigeration display case at an Adjusted Dew Point of 21ºF.

A review of the current baseline was done in 2020 to determine if code accurately reflects the reality of the market. ICF's measure development team spoke with refrigeration vendors, consultants and Ecology Action, a non-profit involved in grocery refrigeration projects, to get their insight on quantity of sales for cases with doors vs. without doors. Interviewees indicated that although the gap is narrowing, open cases still outsell doored cases. According to Ecology Action, small, independent grocers do not have the buying power to install doored cases. At large commercial grocers, there continues to be fear that closed cases will impede the 'impulse buy mentality', which has been a barrier to installation of closed, medium temperature cases.

Measure Analysis

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

The infiltration savings is calculated as the difference between the case load without doors and with doors multiplied by the estimated full load refrigeration hours based on building type and region divided by the code minimum EER (12.85) for a medium temperature remote commercial refrigeration display case[3]. The EFLH hours estimates were derived using hourly reports produced using the GrocerSmart eQUEST models. Hourly reports were generated for the building refrigeration load, heating load, and cooling load. The sum of all hourly loads was divided by the peak annual load to determine the annual equivalent full load hours. Separate models were used representing Convenience Stores, Small Grocery, Medium Grocery, and Large Grocery. Cases with doors are assumed to have 75% lower infiltration loads and 55% lower conduction loads than cases without doors, resulting in overall loads for cases with doors, 27% of those for cases without doors[4].

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

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

Savings were calculated separately based on the following categories:

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

Savings are averaged across different weather locations, as the savings between different locations showed relatively low variation Measures are defined separately for different store sizes and heating system configuration, as the savings between different store types showed relatively high variation. Final savings are shown in Table 1 and Table 2.

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

Comparison to RTF or other programs

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

Energy Trust's Existing Buildings program also has a cooler door retrofit measure (MAD ID 47) based on the RTF's now-inactive measure (workbook v1.0)[5]. That measure is for use when cases are added to existing coolers. Both costs and savings are expected to be lower for new cases than for retrofits. The lower savings are partially due to differences in calculation methods, and partially due to the assumption that new cases have higher efficiency features. Energy Trust's retrofit measure does not differentiate by store type.

Measure Life

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

Cost

It was estimated that the average incremental cost of purchasing a remote commercial medium temperature vertical case with doors compared to one without doors is $275.29/linear foot of case. This incremental cost was derived from outreach data as well as from past projects.

The cost data came from refrigeration vendors, consultants and the Ecology Action. Two of the stakeholders indicated that cases with doors cost 15-25% more than cases without doors. Two other stakeholders provided actual costs; one provided specific costs from three different manufacturers and the other provided average costs based on their experience. The average incremental cost differences provided by the latter two stakeholders were $352/linear foot, which was significantly greater than a 15-25% incremental difference in cost. Applying the 15–25% incremental difference to cost data from five projects completed since January 2019 indicates incremental costs to be roughly $198.57 on average. Taking an average between these two data sets yielded an incremental cost of roughly $275.29/linear foot of case.

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[1] Electronic Code of Federal Regulations, Title 10 Chapter II Subchapter D Part 431, 2020,: https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=5f2659d259957d70f7b89f5643e8518f&mc=true&n=pt10.3.431&r=PART&ty=HTML#se10.3.431_166

[2] AHRI, Commercial Refrigerated Display Merchandise and Storage Cabinets, 2020: http://www.ahrinet.org/Certification/AHRI-Certification-Programs/Commercial-Refrigerated-Display-Merchandise. Select the link in page under 'Related Standard(s) and Documents' for 'ANSI/AHRI 1200 (I-P/2013): Performance Rating of Commercial Refrigerated Display Merchandisers and Storage Cabinets' and refer to Table 1 on pg. 6.

[33] DOE federal standard electronic code of federal regulations Subpart C 2017 references AHRI standard 1200 (I-P)-2010 for the EER of remote commercial display cases.

[4] Faramarzi, Ramin T., B.A. Coburn and R. Sarhadian, 2002. *Performance and Energy Impact of Installing Glass Doors on an Open Vertical Deli/Dairy Display Case*. ASHRAE Transactions, AC-02-7-2, pp 673-679.

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

Non Energy Benefits

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

Incentive Structure

The maximum incentives listed in Table 1 and Table 2 are for reference only and are not suggested incentives. Note that in gas-only territory, maximum incentives are lower than in full-service or electric-only territory and differ by grocery size and between Oregon and Washington.

Incentives will be structured per linear foot of case.

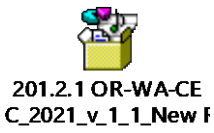
Follow-Up

Minimum efficiency for commercial refrigeration equipment is defined by federal standards. This measure should be revised when commercial refrigeration equipment standards are revised.

If the market share of cases with doors increases, this measure should move to a market baseline.

Supporting Documents

The cost effective screening for these measures is number 201.2.1. It is attached and can be found along with supporting documentation at: I:\Groups\Planning\Measure Development\Commercial and Industrial\Grocery\cooler doors\New coolers



Version History and Related Measures

Table 4 Version History

Date	Version	Reason for revision
8/11/2017	201.1	Introduce case door measure for new cases.
9/9/2020	201.2	Update costs

Table 5 Related Measures

Measures	MAD ID
Cooler Door Retrofits	47
Grocery Market Solutions	161

Approved & Reviewed by

Jackie Goss, PE
Sr. Planning Engineer

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Measure Approval Document for Pre-Rinse Spray Valves (PRSV)

Valid Dates
8/1/2020 – 12/31/2023

End Use or Description
Low-flow pre-rinse spray valves (PRSV) are used in commercial kitchens to rinse food debris from dishes before putting them in dishwashers. These measures are designed to be offered as either direct install or as a standard measure.

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

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

- For Existing Buildings: commercial kitchens in lodging, school, restaurant, and hospital buildings
- For Multifamily: commercial kitchens within campus housing and assisted living

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

- Retrofit
- Replacement

Cost Effectiveness
Cost effectiveness is demonstrated for Oregon in Table 1, and for Washington in Table 2. Cost effectiveness was calculated using the tool OR-WA-CE Calculator 2021_v_1_1. In Oregon, the Electric Avoided cost year is 2021 and the Gas Avoided cost year is 2021. In Washington, the Gas Avoided Cost year is 2020.

Table 1 Cost Effectiveness Calculator Oregon, per unit

#	Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Elec	% Gas
1	PRSV – 0.81_to_1.00_gpm – electric water heat (standard measure) – EB	4	570	0	$30	$97	$30	4.6	16.0	100%	0%
2	PRSV – 0.61_to_0.80_gpm – electric water heat (standard measure) – EB	4	899	0	$30	$153	$30	7.2	25.3	100%	0%
3	PRSV – 0.81_to_1.00_gpm – gas water heat (standard measure, dual fuel territory) – EB	4	21	25	$30	$97	$30	1.8	13.2	9%	91%
4	PRSV – 0.61_to_0.80_gpm – gas water heat (standard measure, dual fuel territory) – EB	4	33	39	$30	$153	$30	2.8	20.9	9%	91%
5	PRSV – 0.81_to_1.00_gpm – electric water heat (direct install) – EB	4	570	0	$173	$97	$140	1.0	2.8	100%	0%
6	PRSV – 0.61_to_0.80_gpm – electric water heat (direct install) – EB	4	899	0	$199	$153	$199	1.1	3.9	100%	0%
7	PRSV – 0.81_to_1.00_gpm – gas water heat (direct install, dual fuel territory) – EB	4	21	25	$173	$97	$54	1.0	2.3	9%	91%
8	PRSV – 0.61_to_0.80_gpm – gas water heat (direct install, dual fuel territory) – EB	4	33	39	$199	$153	$86	1.0	3.2	9%	91%
9	PRSV – 0.81_to_1.00_gpm – gas water heat (standard measure, gas only territory) – EB	4	0	25	$30	$99	$30	1.6	13.3	0%	100%
10	PRSV – 0.61_to_0.80_gpm – gas water heat (standard measure, gas only territory) – EB	4	0	39	$30	$156	$30	2.6	21.0	0%	100%
11	PRSV – 0.81_to_1.00_gpm – gas water heat (direct Install, gas only territory) – EB	4	0	25	$173	$99	$49	1.0	2.3	0%	100%
12	PRSV – 0.61_to_0.80_gpm – gas water heat (direct Install, gas only territory) – EB	4	0	39	$199	$156	$78	1.0	3.2	0%	100%
13	PRSV – 0.81_to_1.00_gpm – electric water heat (standard measure) – MF	4	685	0	$30	$120	$30	5.5	19.6	100%	0%
14	PRSV – 0.61_to_0.80_gpm – electric water heat (standard measure) – MF	4	1082	0	$30	$189	$30	8.7	31.0	100%	0%
15	PRSV – 0.81_to_1.00_gpm – gas water heat (standard measure, dual fuel territory) – MF	4	26	30	$30	$120	$30	2.2	16.3	10%	90%
16	PRSV – 0.61_to_0.80_gpm – gas water heat (standard measure, dual fuel territory) – MF	4	41	47	$30	$189	$30	3.4	25.7	10%	90%
17	PRSV – 0.81_to_1.00_gpm – electric water heat (direct install) – MF	4	685	0	$173	$120	$168	1.0	3.5	100%	0%
18	PRSV – 0.61_to_0.80_gpm – electric water heat (direct install) – MF	4	1082	0	$199	$189	$199	1.3	4.7	100%	0%
19	PRSV – 0.81_to_1.00_gpm – gas water heat (direct install, dual fuel territory) – MF	4	26	30	$173	$120	$65	1.0	2.9	10%	90%
20	PRSV – 0.61_to_0.80_gpm – gas water heat (direct install, dual fuel territory) – MF	4	41	47	$199	$189	$103	1.0	3.9	10%	90%
21	PRSV - 0.81_to_1.00_gpm - gas water heat (standard measure, gas only territory) - MF	4	0	30	$30	$123	$30	1.9	16.4	0%	100%
22	PRSV - 0.61_to_0.80_gpm - gas water heat (standard measure, gas only territory) - MF	4	0	47	$30	$194	$30	3.1	25.9	0%	100%
23	PRSV - 0.81_to_1.00_gpm - gas water heat (direct Install, gas only territory) - MF	4	0	30	$173	$123	$59	1.0	2.9	0%	100%
24	PRSV - 0.61_to_0.80_gpm - gas water heat (direct Install, gas only territory) - MF	4	0	47	$199	$194	$93	1.0	4.0	0%	100%

Table 2 Cost Effectiveness Calculator Washington, per unit

#	Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Elec	% Gas
1	PRSV - 0.81 to 1.00 gpm, gas water heat – Standard measure - EB	4	25	$30	$64	$30	2.7	10.2	0%	100%
2	PRSV - 0.61 to 0.80 gpm, gas water heat – Standard measure - EB	4	39	$30	$100	$30	4.3	16.1	0%	100%
3	PRSV - 0.81 to 1.00 gpm, gas water heat – Direct Install - EB	4	25	$164	$64	$84	1.0	1.9	0%	100%
4	PRSV - 0.61 to 0.80 gpm, gas water heat – Direct Install - EB	4	39	$190	$100	$132	1.0	2.6	0%	100%
5	PRSV - 0.81_to_1.00_gpm - gas water heat – Standard measure - MF	4	30	$30	$79	$30	3.3	12.5	0%	100%
6	PRSV - 0.61_to_0.80_gpm - gas water heat – Standard measure - MF	4	47	$30	$124	$30	5.2	19.8	0%	100%
7	PRSV - 0.81_to_1.00_gpm - gas water heat - Direct Install - MF	4	30	$164	$79	$100	1.0	2.3	0%	100%
8	PRSV - 0.61_to_0.80_gpm - gas water heat - Direct Install - MF	4	47	$190	$124	$159	1.0	3.2	0%	100%

Requirements

- Water heating fuel is supplied by a participating utility.
- For direct installations in Oregon, a licensed plumber is required. In Washington, this is not a requirement.
- Spec. sheet must indicate that the rated GPM falls within the flow rate range of the measure it was applied to.
- Minimum spray force of 4.0 ounces-force.

Baseline

This measure uses

- Existing Condition Baseline Flowrate for Direct Install measures
- Full Market Baseline for Standard measures.

The baseline is a PRSV with a flowrate of 1.33 GPM in both the existing condition and Full Market baseline conditions. Existing Buildings and Multifamily employ the same baseline equipment. This aligns with the baseline in RTF's active small saver measure[1]. The 1.33 GPM is consistent with the DOE's research[2] for development of their new 2019 standard, which found the existing commercial PRSV market to consist of flowrates between 0.59-1.6 GPM. Data also shows that showerhead-type PRSVs with flow rates in the upper flowrate range, comprise most of the market. Currently, there are numerous available products with 1.6 GPM flowrates and very high customer satisfaction is correlated with the upper range of the market flow rate distribution, indicating little update of low flow products at this time.

Savings and Measure Analysis

Savings were modelled for electric and gas water heating. Qualifying PRSV efficiency measures were analyzed for two flow rate categories:

- PRSV with rated flow 0.81-1.00 GPM
- PRSV with rated flow rate of 0.61-0.80 GPM

The energy savings analysis for this measure follows the RTF workbook ComCookingPreRinseSprayValve_v2_5 without modifications for Existing Buildings. For Multifamily, the assumptions from the 'institutional' category in the RTF analysis were used to calculate the savings. The reasoning behind aligning with the 'institutional' building type is based on the examples provided in the definition of 'institutional'.

Water heating energy use for PRSVs hinges on the following parameters:

Table 3 Key Parameters in Measure Analysis

Parameter	Units	Description	Source
Water Energy Intensity	$\left(\frac{kWh}{Gallon\ ^oF}\right)$ $\left(\frac{therms}{Gallon\ ^oF}\right)$	This constant is based on the specific heat capacity of water. • Electric water energy intensity is 0.002443895 $\frac{kWh}{Gallon\ ^oF}$ • Gas water energy intensity is 8.33892E-05 $\frac{therms}{Gallon\ ^oF}$	
Flow Rate	GPM	Baseline flowrate is 1.33 GPM which is based on average measured flow rate of 1.6 GPM nominal valves. Replacement flowrate used in the analysis for the 0.81-1.00 GPM and 0.61-0.80 GPM categories are 0.92 and 0.68 GPM, respectively.	Baseline nominal valve measurements are sourced from Puget Sound Energy (PSE). These values are based on average measured flow rates of PRSVs within the defined ranges. Average measured flow rate of PRSVs were tested by the Food Service Technology Center (FSTC), within the defined ranges.
Usage Time	$\frac{hr}{yr}$	This variable is the weighted average of PRSV use time across different facility types. It is based on the NW program distribution of facility types. Facility types looked at include cafés, a variety of fast food and dine-in restaurants, bakeries, grocery establishments, and institutional facilities. The weighted average value used in the analysis is • 0.63 hrs/day and 232 hrs/yr for Existing Buildings • 0.78 hrs/day and 286 hrs/yr for Multifamily.	Data on PRSV use time is based on the following studies and metered data: Region of Waterloo Pre-Rinse Spray Valve Pilot Study; Final Report (Veritec Consulting Inc.) City of Calgary Pre-Rinse Spray Valve Pilot Study; Final Report (Veritec Consulting Inc.) (Data Only) "Avista Meter Data" (SBW Consulting, Inc.)
Temperature Difference (ΔT)	$(\ ^oF)$	Temperature difference between incoming water from the utility and the average temperature of the water during PRSV use, weighted by heating zone. Incoming water temperature (Cold Temp) in the analysis is assumed to be 54.5°F. Temperature of water used (Mixed Temp) in the analysis is assumed to be 93.7°F for Existing Buildings and 92.6°F for Multifamily.	Cold Temp is based on measurements of incoming water temp from RTF SIW v2.6, Weighted by heating zone. Original source of incoming water temp data is the 2015 NEEA HPWH Model Validation Study. Mixed Temp is based on the average of measured mixed water temperatures in PSE (N = 6,646) and Seattle City Light (SCL) (N = 447) studies, weighted by sample size.
Efficiency of Water Heating Equipment (η)	$(\%)$	For electric equipment, assumed efficiency value is 100% For gas equipment, assumed efficiency value is 75%	

[1] RTF Commercial Cooking Pre-Rinse Spray Valve Workbook, version 2.5, Dec. 20, 2019, https://nwcouncil.app.box.com/v/ComPreRinseSprayValves-v2-5
[2] US DOE, Federal Register / Vol. 81, No. 17 https://www.govinfo.gov/content/pkg/FR-2016-01-27/pdf/2016-00068.pdf

Usage hours are the same pre and post install. Based on use time and the flow rate (GPM) values above, the assumed yearly, water use is calculated using the following formula:

$$\frac{Gallons}{yr} = GPM * 60 * hrs/yr$$

The assumed baseline water use for PRSVs is 18,515 $\frac{Gallons}{yr}$ for Existing Buildings and 22,897 $\frac{Gallons}{yr}$ for Multifamily.

Post installation, the assumed yearly water uses are 12,794 and 9,483 $\frac{Gallons}{yr}$ for the 0.81-1.00 GPM and 0.61-0.80 GPM categories, respectively, for Existing Buildings. For Multifamily, the assumed post installation yearly water uses are 15,822 and 11,727 $\frac{Gallons}{yr}$ for the 0.81-1.00 GPM and 0.61-0.80 GPM categories, respectively.

$$PRSV\ Water\ Heating\ Energy\ Use = \frac{\frac{Gallons}{yr} * \Delta T * Water\ Energy\ Intensity}{\eta}$$

$$PRSV\ Retrofit\ Energy\ Savings = PRSV\ Water\ Heating\ Energy\ Use_{Baseline} - PRSV\ Water\ Heating\ Energy\ Use_{Efficient}$$

Comparison to RTF or other programs

These measures follow RTF guidance and methods. For Existing Buildings, the measures follow the RTF analysis without modifications. For Multifamily, the measures only reflect savings associated with the 'institutional' category in the RTF analysis.

Measure Life

Measure life for PRSV is 4 years as referenced by RTF. This measure life is based on professional judgment of RTF staff, manufacturer claims, a rough estimate based on market size and shipment data and observed 1 year retention rates (94% and 90%).

Cost

The Direct Install measure costs are derived from pricing provided by SmartWatt. Labor costs for Oregon are based on a licensed plumber, Washington labor costs are based on an unlicensed plumber.

For the Standard measures, incremental equipment costs were used. The costs were determined through surveying current costs of CEE certified PRSVs in the 0.61-1.00 GPM range as well as 1.6 GPM rated PRSVs. Efficient PRSVs cost between about $70 to $150 with average cost of $96. Baseline PRSVs cost between $35 to $90 with average cost of $66.

Non-Energy Benefits

Non-energy benefits are based on regionally representative water and wastewater costs. They represent the value of the energy savings reported from water and wastewater treatment and distribution.

Water savings are recognized in one of two ways, based on whether the customer resides in a territory where ETO can claim kWh savings:

- For customers residing in territories where we can claim electric, kWh savings, the NEBs are included added as electricity savings (3.68 kWh/1000 gallons of water treated), plus the Combined Water Rate, net of Embedded Electricity ($16.94/1000 gal). This only applies to Oregon customers in dual-fuel territories.
- For customers residing in gas-only territories the NEBs are: in Oregon gas-only territories, water rate of $17.32/1000 gal, In Washington, the water rate of $11.12/1000 gal

Incentive Structure

The maximum incentives listed in Table 1 and Table 2 are for reference only and are not suggested incentives. For Direct Install measures, incentives are paid directly to the direct install subcontractor and any balance of the project cost is paid by the customer. For Standard measures, incentives are paid directly to the customer. Incentives are per installed PRSV.

Follow-Up

Measures should be reviewed, and costs updated when the measure expires. Other variables that should be updated as needed when the measure reaches its expiration date include:

- Baseline flow rate
- Flow rate in future low flow products

The DOE has issued a Request for Information pertaining to energy conservation standards for commercial PRSVs. In this RFI, the DOE seeks to determine whether they should propose a "no new standard" determination because a more stringent standard: would not result in a significant savings of energy; is not technologically feasible; is not economically justified; or any combination of foregoing. If it is decided that a more stringent standard should be implemented, specifications of PRSVs on the market would change in response.

Supporting Documents

The cost-effective screening for these measures is number CEC number 253.1.1. It is attached and can be found along with supporting documentation at: I:\Groups\Planning\Measure Development\Commercial and Industrial\Food Service\pre rinse spray valves

253_1_1
OR-WA-CEC2021_v_1

Version History and Related Measures

PRSV have been offered at various times since at least 2005. These measures pre-date our measure approval documentation process and our record retention policies. Table 4 is likely incomplete, especially for activities prior to 2013.

Table 4 Version History

Date	Version	Reason for revision
3/18/2005	X	Approve a PRSV pilot
5/6/2005	X	Re-approve PRSV pilot with savings assumption changes. 1.15 gpm
2007	X	Deactivate all PRSV measures
7/14/2020	253.1	Approve PRSV in Existing Buildings and Multifamily in two tiers

Table 5 Related Measures

Measures	MAD ID
Demand Control Kitchen Ventilation	122
Kitchen Vent Hood Calculator	184
Food Service cooking measures	101
Commercial Dishwashers	35
Commercial Aerators	1

Approved & Reviewed by

Jackie Goss, PE
Sr. Planning Engineer

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Measure Approval Document for Advanced Rooftop-unit Controls Retrofit

Valid Dates
August 1, 2020 through December 31, 2023

End Use or Description
Installation of advanced rooftop-unit controls (ARC) on existing unitary systems with electric or gas heat, constant speed supply fan, modulating outdoor air damper, and cooling capacity equal to or greater than five tons.

There are two types of qualifying retrofits, ARC-lite and ARC-full. With both ARC-lite and ARC-full systems, energy savings result from the installation of a supply fan VFD and controller, or a multispeed motor and controller on the existing RTU supply fan motor. With ARC-full systems, additional energy savings are achieved by the addition of a full range economizer control and DCV capabilities.

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

- Existing Buildings
- Multifamily
- Production Efficiency

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

- Retail
- Office
- Restaurant
- Assisted living
- Campus living
- Lodging

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

- Retrofit

Cost Effectiveness
Cost effectiveness of ARC-lite is demonstrated for Oregon in Table 1, ARC-full in Oregon in Table 2 and ARC-lite in Washington in Table 3. Cost effectiveness was calculated using the tool OR-WA-CE Calculator 2021-v1.1. In Oregon the Electric Avoided cost year is 2021 and the Gas Avoided cost year is 2021. In Washington, the Gas Avoided cost year is 2020.

Table 1 Cost Effectiveness Calculator Oregon – ARC-lite, per ton

#	Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Elec	% Gas
4	ARC-lite gas heat - Dual fuel eligible - 3500 to 4500 hrs	15	426	(7)	$275	$0.00	$275.00	1.1	1.1	100%	0%
5	ARC-lite gas heat - Dual fuel eligible - 4500 to 5500 hrs	15	532	(8)	$275	$0.00	$275.00	1.2	1.2	100%	0%
6	ARC-lite gas heat - Dual fuel eligible - 5500 to 6500 hrs	15	639	(10)	$275	$0.00	$275.00	1.5	1.5	100%	0%
7	ARC-lite gas heat - Dual fuel eligible - 6500 to 7500 hrs	15	745	(12)	$275	$0.00	$275.00	1.7	1.7	100%	0%
8	ARC-lite gas heat - Dual fuel eligible - 7500 to 8760 hrs	15	866	(14)	$275	$0.00	$275.00	2.0	2.0	100%	0%
20	ARC-lite heat pump - 3500 to 4500 hrs	15	358	0	$275	$0.00	$275.00	1.1	1.1	100%	0%
21	ARC-lite heat pump - 4500 to 5500 hrs	15	448	0	$275	$0.00	$275.00	1.3	1.3	100%	0%
22	ARC-lite heat pump - 5500 to 6500 hrs	15	538	0	$275	$0.00	$275.00	1.6	1.6	100%	0%
23	ARC-lite heat pump - 6500 to 7500 hrs	15	627	0	$275	$0.00	$275.00	1.8	1.8	100%	0%
24	ARC-lite heat pump - 7500 to 8760 hrs	15	729	0	$275	$0.00	$275.00	2.1	2.1	100%	0%

Table 2 Cost Effectiveness Calculator Oregon – ARC-full, per ton

#	Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Elec	% Gas
9	ARC-full gas heat - Dual fuel eligible - 500 to 1500 hrs	15	418	15	$418	$0.00	$418.00	1.3	1.3	71%	29%
10	ARC-full gas heat - Dual fuel eligible - 1500 to 2500 hrs	15	516	15	$418	$0.00	$418.00	1.5	1.5	75%	25%
11	ARC-full gas heat - Dual fuel eligible - 2500 to 3500 hrs	15	615	15	$418	$0.00	$418.00	1.6	1.6	77%	23%
12	ARC-full gas heat - Dual fuel eligible - 3500 to 4500 hrs	15	714	15	$418	$0.00	$418.00	1.9	1.9	80%	20%
13	ARC-full gas heat - Dual fuel eligible - 4500 to 5500 hrs	15	812	15	$418	$0.00	$418.00	2.0	2.0	81%	19%
14	ARC-full gas heat - Dual fuel eligible - 5500 to 6500 hrs	15	911	15	$418	$0.00	$418.00	2.1	2.1	82%	18%
15	ARC-full gas heat - Dual fuel eligible - 6500 to 7500 hrs	15	1,010	15	$418	$0.00	$418.00	2.3	2.3	84%	16%
16	ARC-full gas heat - Dual fuel eligible - 7500 to 8760 hrs	15	1,121	15	$418	$0.00	$418.00	2.5	2.5	85%	15%
25	ARC-full heat pump - 500 to 1500 hrs	15	570	0	$418	$0.00	$418.00	1.3	1.3	100%	0%
26	ARC-full heat pump - 1500 to 2500 hrs	15	669	0	$418	$0.00	$418.00	1.5	1.5	100%	0%
27	ARC-full heat pump - 2500 to 3500 hrs	15	767	0	$418	$0.00	$418.00	1.6	1.6	100%	0%
28	ARC-full heat pump - 3500 to 4500 hrs	15	866	0	$418	$0.00	$418.00	1.8	1.8	100%	0%
29	ARC-full heat pump - 4500 to 5500 hrs	15	965	0	$418	$0.00	$418.00	1.9	1.9	100%	0%
30	ARC-full heat pump - 5500 to 6500 hrs	15	1,063	0	$418	$0.00	$418.00	2.1	2.1	100%	0%
31	ARC-full heat pump - 6500 to 7500 hrs	15	1,162	0	$418	$0.00	$418.00	2.2	2.2	100%	0%
32	ARC-full heat pump - 7500 to 8760 hrs	15	1,273	0	$418	$0.00	$418.00	2.4	2.4	100%	0%
33	ARC-full gas heat - Gas only eligible - 500 to 1500 hrs	15	0	15	$418	$32.45	$158.40	1.0	1.2	0%	100%
34	ARC-full gas heat - Gas only eligible - 1500 to 2500 hrs	15	0	15	$418	$40.11	$158.40	1.0	1.4	0%	100%
35	ARC-full gas heat - Gas only eligible - 2500 to 3500 hrs	15	0	15	$418	$47.77	$158.40	1.0	1.6	0%	100%
36	ARC-full gas heat - Gas only eligible - 3500 to 4500 hrs	15	0	15	$418	$55.43	$158.40	1.0	1.8	0%	100%
37	ARC-full gas heat - Gas only eligible - 4500 to 5500 hrs	15	0	15	$418	$63.09	$158.40	1.0	2.0	0%	100%
38	ARC-full gas heat - Gas only eligible - 5500 to 6500 hrs	15	0	15	$418	$70.75	$158.40	1.0	2.2	0%	100%
39	ARC-full gas heat - Gas only eligible - 6500 to 7500 hrs	15	0	15	$418	$78.40	$158.40	1.0	2.4	0%	100%
40	ARC-full gas heat - Gas only eligible - 7500 to 8760 hrs	15	0	15	$418	$87.06	$158.40	1.0	2.6	0%	100%
49	ARC-full gas heat - Electric only eligible - 500 to 1500 hrs	15	418	0	$418	$11.40	$391.22	1.0	1.2	100%	0%
50	ARC-full gas heat - Electric only eligible - 1500 to 2500 hrs	15	516	0	$418	$11.40	$418.00	1.2	1.4	100%	0%
51	ARC-full gas heat - Electric only eligible - 2500 to 3500 hrs	15	615	0	$418	$11.40	$418.00	1.3	1.6	100%	0%
52	ARC-full gas heat - Electric only eligible - 3500 to 4500 hrs	15	714	0	$418	$11.40	$418.00	1.5	1.8	100%	0%
53	ARC-full gas heat - Electric only eligible - 4500 to 5500 hrs	15	812	0	$418	$11.40	$418.00	1.6	1.9	100%	0%
54	ARC-full gas heat - Electric only eligible - 5500 to 6500 hrs	15	911	0	$418	$11.40	$418.00	1.8	2.1	100%	0%
55	ARC-full gas heat - Electric only eligible - 6500 to 7500 hrs	15	1,010	0	$418	$11.40	$418.00	1.9	2.2	100%	0%
56	ARC-full gas heat - Electric only eligible - 7500 to 8760 hrs	15	1,121	0	$418	$11.40	$418.00	2.1	2.4	100%	0%

Table 3 Cost Effectiveness Calculator Washington – ARC-full, per ton

#	Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Elec	% Gas
1	ARC-full gas heat - 500 to 1500 hrs	15	15	$418	$32.18	$289.65	1.00	1.51	0%	100%
2	ARC-full gas heat - 1500 to 2500 hrs	15	15	$418	$39.77	$289.65	1.00	1.70	0%	100%
3	ARC-full gas heat - 2500 to 3500 hrs	15	15	$418	$47.36	$289.65	1.00	1.89	0%	100%
4	ARC-full gas heat - 3500 to 4500 hrs	15	15	$418	$54.95	$289.65	1.00	2.08	0%	100%
5	ARC-full gas heat - 4500 to 5500 hrs	15	15	$418	$62.55	$289.65	1.00	2.28	0%	100%
6	ARC-full gas heat - 5500 to 6500 hrs	15	15	$418	$70.14	$289.65	1.00	2.47	0%	100%
7	ARC-full gas heat - 6500 to 7500 hrs	15	15	$418	$77.73	$289.65	1.00	2.66	0%	100%
8	ARC-full gas heat - 7500 to 8760 hrs	15	15	$418	$86.31	$289.65	1.00	2.88	0%	100%

Requirements

- ARC-lite is offered to existing buildings commercial customers with greater than 3,500 annual operating hours only.
- ARC-full is available to all commercial customers with annual operating hours greater than 500.
- The installed equipment controls must be listed on BPA's qualifying product list for ARC-full and ARC-lite systems.
- For ARC-lite installations, the pre-existing system must:
  - Have a nominal cooling capacity of 5 tons or greater
  - Have a single speed supply fan or motor
  - Not be equipped with a VFD
- For ARC-full installations, the pre-existing system must:
  - Have a nominal cooling capacity of 5 tons or greater

    - Have a single speed supply fan or motor
    - Not be previously equipped with a VFD or demand-controlled ventilation
- ARC-lite is not approved in gas-only territory.
- Measures labeled as gas heat electric only eligible are suitable for customers with gas heat but not on eligible gas rates, such as transport customers.

Installation Description

ARC-lite

A variable frequency drive shall be installed and controlled to, at a minimum, reduce the supply fan motor to 40% of full speed during ventilation-only operation. The outdoor air damper shall be controlled to maintain proper ventilation rates according to ASHRAE Standard 62.2 under different fan speeds.

Exceptions to this are as follows:

- Where the volume of outdoor air required to comply with the ventilation requirements of the International Mechanical Code exceeds the volume of outdoor air that would be delivered with the supply fan motor at 40% of full speed and with the outdoor air damper in the maximum open position, the minimum speed shall be selected to provide the required ventilation air.
- Higher supply fan motor speeds are allowed during periods of cold outdoor air temperatures (e.g. below 30°F) in order to maintain comfortable supply air temperatures (e.g. above 60°F).

ARC-full

In addition to the ARC-lite installations noted above, economizer controls and a demand-controlled ventilation (DCV) system shall be installed.

Economizer controls

Controls must automatically allow the cooling system to supply outside air to reduce or eliminate the need for mechanical cooling during mild or cold weather. Controls with the following characteristics shall be installed:

- The economizer operation shall be integrated with the mechanical cooling system and be configured to provide partial cooling even when additional mechanical cooling is required to meet the remainder for the cooling load.
- The economizer controls and dampers shall be configured to sequence the dampers with mechanical cooling equipment and shall not be controlled by only mixed air temperature.
- The economizer controls shall have the mechanical cooling capacity control interlaced with the air economizer controls such that the outdoor air damper is at the 100% open position when mechanical cooling is on and the outdoor air damper does not begin to close to prevent coil freezing due to minimum compressor run time until the leaving air temperature is less than 45°F (7°C)
- Control shall not have fewer than two stages of cooling
- The economizer shall be configured to automatically reduce outdoor air intake to the design minimum outdoor air quantity when outdoor air intake will no longer reduce cooling energy usage.
- High-limit shutoff can be accomplished using:
    - A differential dry-bulb setting, where the economizer shuts off when the outside air dry-bulb temperature is greater than return air dry-bulb temperature, or
    - A differential enthalpy with fixed dry-bulb temperature, where the economizer shuts off when the outside air enthalpy is greater than the return air enthalpy or when the outside air dry-bulb temperature is greater than 75°F.

DCV System

A ventilation control system shall be installed that is capable of providing automatic reduction of outdoor air intake below design rates when the actual occupancy of space served by the system is less than design occupancy

- A DCV system using a CO2 sensor should be controlled based on the indoor space CO2 levels, as follows:
    - (a) When the CO2 level is 400ppm or less, the minimum ventilation rate for the space's floor area, calculated assuming zero occupants, is provided
    - (b) When the CO2 level is 1000 ppm or higher, ventilation is supplied at the design rate, calculated assuming full occupancy
    - (c) When the CO2 level is between 400 and 1000 ppm, ventilation is supplied at a rate equal to:

$$\left(CO2level_{ppm} - 400\right) \times \frac{\left(VentilationRate_b - VentilationRate_a\right)}{1000}$$

Baseline

This measure uses an existing condition baseline.

The baseline equipment is an existing RTU with a nominal cooling capacity of 5 tons or greater with a single speed supply fan motor and without a VFD or demand-controlled ventilation capability. This baseline was chosen to represent commercial systems which do not already have the upgrades which are part of this measure.

Savings and Measure Analysis

The savings are a summation of the fan savings and compressor savings, as well as space heating and cooling savings that result. The full measure analysis was produced by the RTF[1] and was based on the PNNL field study "Advanced Rooftop Control (ARC) Retrofit: Field-Test Results" from July 2013.

Supply Fan Savings

Fan savings averages are estimated from the five sites included in the PNNL Advanced Rooftop Control (ARC) Retrofit: Field-Test Results. The RTF used savings determined for each of the five PNW sites and annualized and normalized to TMY3 weather data, per ton of nominal cooling capacity, and per hour of RTU-served space annual occupancy hours. Through their analysis, RTF determined that fan savings were an average of 99 kWh/ton/1000 hours of operation which is shown in Table 4.

[1] https://rtf.nwcouncil.org/measure/advanced-rooftop-controls

Table 4 RTF's Average Fan Savings Per Ton Per 1000 Hours of Operation

kWh/ton/1000hrs basis		Fan Savings	Compressor Savings	Full ARC Savings
AC	Average	130 kWh	73 kWh	202 kWh
	SD	15 kWh	2 kWh	13 kWh
	CV	0.11	0.03	0.06
	Precision	13%	3%	7%
HP	Average	78 kWh	130 kWh	208 kWh
	SD	15 kWh	11 kWh	26 kWh
	CV	0.19	0.08	0.12
	Precision	18%	8%	12%
All	Average	99 kWh	107 kWh	206 kWh
	SD	31 kWh	33 kWh	20 kWh
	CV	0.32	0.30	0.10
	Precision	23%	22%	7%

Heating and Cooling Savings

In a gas RTU compressors are used for cooling and in a heat pump RTU they are used for both heating and cooling. The PNNL field study did not analyze gas usage so average compressor savings are estimated from the PNNL field study as the difference between the calculated RTU savings in the report and the supply fan savings. The average compressor savings for heat pump RTU and gas heated RTU with A/C is highlighted in Table 5 RTF's Average Compressor Savings Per TonTable 5.

Table 5 RTF's Average Compressor Savings Per Ton

kWh/ton basis		Fan Savings	Compressor Savings	Full ARC Savings
AC	Average	554 kWh	319 kWh	873 kWh
	SD	43 kWh	7 kWh	36 kWh
	CV	0.08	0.02	0.04
	Precision	9%	3%	5%
HP	Average	278 kWh	472 kWh	750 kWh
	SD	68 kWh	123 kWh	187 kWh
	CV	0.24	0.26	0.25
	Precision	23%	25%	24%
All	Average	389 kWh	411 kWh	799 kWh
	SD	160 kWh	121 kWh	150 kWh
	CV	0.41	0.29	0.19
	Precision	30%	22%	14%

The total heating and cooling savings were then determined applying the fan HVAC interaction factors to fan reduction as indicated in Table 6.

Table 6 RTF's Standard Information Workbook Conversion Factors

RTU Type	HVAC Interaction Factor	
	Heating	Cooling
Heat Pump	-0.17 kWh/kWh	0.08 kWh/kWh
Gas/AC	-1.70 kBtu/kWh	0.08 kWh/kWh

Operating hour bins are then used to scale the average savings from PNNL to this measure offering, as indicated in Table 7 for heat pump RTUs and Table 8 for gas RTUs.

Table 7 Heat Pump RTU Savings Components by Occupied Hour Bin, kwh/ton

RTU Occupied Hours	ARC-lite			ARC-full		
	Fan Savings kWh/ton	Heating Savings kWh/ton	Cooling Savings kWh/ton	Fan Savings kWh/ton	Heating Savings kWh/ton	Cooling Savings kWh/ton
500 to 1500 hrs	99	-17	8	99	152	319
1500 to 2500 hrs	197	-34	16	197	152	319
2500 to 3500 hrs	296	-51	24	296	152	319
3500 to 4500 hrs	394	-67	31	394	152	319
4500 to 5500 hrs	493	-84	39	493	152	319
5500 to 6500 hrs	592	-101	47	592	152	319
6500 to 7500 hrs	690	-118	55	690	152	319
7500 to 8760 hrs	802	-137	64	802	152	319

Table 8 Gas RTU Savings Components by Occupied Hour Bin

RTU Occupied Hours	ARC-lite			ARC-full		
	Fan Savings kWh/ton	Heating Savings therms/ton	Cooling Savings kWh/ton	Fan Savings kWh/ton	Heating Savings therms/ton	Cooling Savings kWh/ton
500 to 1500 hrs	99	-2	8	99	15.2	319
1500 to 2500 hrs	197	-3	16	197	15.2	319
2500 to 3500 hrs	296	-5	24	296	15.2	319
3500 to 4500 hrs	394	-7	31	394	15.2	319
4500 to 5500 hrs	493	-8	39	493	15.2	319
5500 to 6500 hrs	592	-10	47	592	15.2	319
6500 to 7500 hrs	690	-12	55	690	15.2	319
7500 to 8760 hrs	802	-14	64	802	15.2	319

Comparison to RTF or other programs

These measures, use the RTF analysis to determine savings and cost. When screened for cost-effectiveness, measures are cost-effective only for heat pump and gas RTUs that operate for greater than 3500 hours annually, when equipped with ARC-lite systems. Gas and heat pump RTUs are cost-effective for all annual operating hour bins when equipped with ARC-full systems. This is slightly different than BPA territory utilities such as EWEB and Clark PUD which both have incentives of $100/ton for ARC-lite retrofit and $200/ton for ARC-full retrofit with no limitations on operational hours.

Measure Life

The measure life is 15 years, which is consistent with assumed measure lifetimes for VFD and HVAC controls systems. This differs from the 20-year measure life used in MAD 195 for new RTUs with advanced controls. The shorter measure life is justified in this case as it this MAD is applied to existing RTUs and will likely have a shorter life expectancy then when applied to new RTUs.

Load Profile

Electric load profiles were determined based on the load profile of the most likely building in each operation bin set. Small office ventilation was used for below 2,500 hours/year, retail ventilation was used between 2,500 and 4,500 hours/year, grocery ventilation was used between 4,500 and 6,500 hours/year, and lodging ventilation was used above 6,500 hours/year.

The gas load profile is commercial heating was used for all gas RTU measures.

Cost

The cost is influenced largely by the total system tonnage, and whether or not ARC-lite or ARC-full is chosen. Costs were set to follow RTF estimates of $275/ton for ARC-lite and $418/ton for ARC-full, which were then validated using Existing Buildings project history was used to validate the per ton savings and cost assumptions.

Non Energy Benefits

This measure considers NEBs from electric or gas savings from non-eligible utilities.

Incentive Structure

The maximum incentives listed in Tables 1-3 are for reference only and are not suggested incentives. Incentives will be structured per ton. Planning suggests but does not require that incentives do not vary by operating hours to avoid inaccurate hour reporting.

SRAF

Negative gas savings are included in SRAFs and do not count against program goals.

Follow-Up

If any of the measures included within ARC-lite or ARC-full become required to meet code, the measure will need to be reevaluated. This measure is based on RTF work and should be kept in alignment with RTF updates and the latest research at each revision.

Supporting Documents

The cost-effective screening for these measures is number CEC 256.1.1. It is attached and can be found along with supporting documentation at: I:\Groups\Planning\Measure Development\Commercial and Industrial\Commercial HVAC\Economizers and controls

256.1.1 OR-WA-CEC_2021_v_

ComRTUControllers_ v1_1.xlsm

Version History and Related Measures

Table 9 Version History

Date	Version	Reason for revision
7/20/20	256.1	Introduce ARC-lite and ARC full measures as retrofits

Table 10 Related Measures

Measures	MAD ID
Unitary RTUs and economizers (inactive)	185
Commercial and Industrial RTU Controls on new equipment	195

Approved & Reviewed by

Jackie Goss
Sr. Planning Engineer

Disclaimer

Measure Approval Document for Condensing Gas Furnaces in SW Washington

Valid Dates
August 1, 2020 – December 31, 2023

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:

- Existing Small Multifamily
  - 2-4 units and side by side structures
- Home Retrofit

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

- Replacement

Purpose of Re-Evaluating Measure
Savings costs and non-energy benefits are updated.

Cost Effectiveness
Cost effectiveness is demonstrated in Table 1 using Energy Trust's Cost Effectiveness Calculator version 2021 version 1.1 The Washington gas avoided cost year is 2020.

Table 1 Cost Effectiveness Calculator Washington

#	Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Ele	% Gas
3	90-95% AFUE Gas Furnace	25	88	$1,006	$2.15	$1,006	2.38	2.41	0%	100%
2	96%+ AFUE Gas Furnace	25	94	$1,909	$2.16	$1,909	1.34	1.36	0%	100%
1	90% + AFUE Gas Furnace	25	92	$1,607	$2.16	$1,607	1.56	1.58	0%	100%

Requirements

- Installed in Washington only
- 90% or greater AFUE
- Measure #1 is a blended measure assuming a weighted average participation, it is to be used for program designs that provide one option to any furnace above 90%. While, measures #2 and #3 are to be used for program designs that distinguish tiers of efficiency level. Within the same customer group, measure #1 should not be paired with the others since that would skew the weighing used to create measure #1.
  1. At the time of writing, the program anticipates using Measure #1 for savings withing reach customers and measure #2 for market rate customers. As these are distinct customer groups, this is an approved use.

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.

Measure Analysis
Savings calculations are based on characteristics (efficiency and input capacity) of participating projects in the existing homes program for the years 2017 through 2019.

Table 2 Characteristics of furnaces participating in Washington programs in 2017, 2018 and 2019.

AFUE Tiers	Quantity	Average of AFUE	Average Capacity (kBtu/h)t
AFUE 90-95	214	95.0	61.8
AFUE 96+	427	96.2	65.7
Weighted average		95.8	64.4

Gas Savings
Savings are calculated by a difference in differences method, based on the change in gas consumption pre/post install relative to a comparison group for common instances/bundles of measures.

Gas savings can be estimated using the following equation:

$$therm\ savings\ =\ Baseline\ therms - \left(\frac{Baseline\ therms\ *\ 80\ AFUE}{efficient\ AFUE}\right)$$

Representative efficiencies for each tier are 95AFUE and 96.2AFUE, as demonstrated in Table 2. Baseline heating load is 557 therms, which is a weighted average heating consumption across five 20-year vintages of single-family homes based on a 2021 market profile in Southwest Washington.

Table 3 NW Natural WA 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
1992-2012	36,834	206	560	754
Total	49,965	**Weighted Heating Load**	**557**	

This yields savings 88 therms, and 94 therms in savings for 90-95AFUE and 96+AFUE tiers respectively and 92 therms for the weighted average used for the blended measure #1.

Non-Energy Benefits

Electric savings are included as non-energy benefits in because Energy Trust does not provide electric efficiency services in that region.

Fan energy savings are due to reduced fan runtimes, or lower fan speeds, needed to maintain set point temperatures with a more efficient furnace. Estimated Fan runtime savings:

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

Efficient furnace capacities of 61,800 and 65,700 Btu/h, are based on completed projects as shown in Table 2. The updated fan input energy, 0.185 kW, is from RTF SEEM modeling for electric forced air furnaces. Both systems yield ~26kWh in electric savings.

Electric savings are converted to NEBs at the Washington blended residential billing rate of $0.082/kWh.

Comparison to RTF or other programs

This analysis shares several 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 (557therms for WA based on NW Natural's 2012 market profile of consumption vs. 540therms for OR based on Energy Trust's 2009 billing analysis), average AFUEs and furnace capacities as inputs.
- This measure uses the same costs from the same contractor that supplied bids in 2020.

Another comparable measure, condensing furnaces in multi-family, focuses on serving multiple units or common areas and is approved in MAD 203. For systems serving more than one unit, the measures described in MAD 203 are more appropriate than these.

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 by TRC in April 2020 collected bids for 14 gas furnaces from 4 contractors. The bids included furnaces that complied with the federal standard as well as high efficiency furnaces. Baseline furnace costs ranged from $3,671 to $4,942 with an average cost of $4,330 and efficient furnace costs ranged from $4,549 to $7,278. The incremental cost data was weighted using the project tracker installation volume to better reflect the market level incremental cost.

Table 4 Cost Summary

Efficiency tier	2020 Contractor bids	Incremental Cost
80 AFUE	$4,330	-
90 - <= 95 AFUE	$5,336	$1,006
96+ AFUE	$6,238	$1,908
Weighted Average		$1,607

Both baseline and efficient costs have increased significantly since the previous analysis of this measure.

Incentive Structure

The maximum incentives listed in Table 1 are for reference only and are not suggested incentives. Incentives will be per furnace and may be paid to homeowners, property owners, or through contractor instant discounts.

Follow-Up

Electric savings in this measure do not account for fan motor efficiency savings over the baseline. Lack of market data on baseline furnace fans efficiency and lack of energy modeling software that use the FER metric as defined in the federal standard are the key reasons for this omission. Future updates should review baseline furnace fan to determine savings potential, if any.

Cost data for the measure has varied significantly over short periods, frequent cost updates are recommended.

Supporting Documents

The cost-effective screening for these measures is number 23.3.1. It is attached and can be found along with supporting documentation at: I:\Groups\Planning\Measure Development\Residential\Res HVAC\furnace\nwn WA furnaces

23.3.1 CEC 2021 v1.1
Res Furnaces WA.xlsx

References

Regional Technical Forum - Residential Single Family Existing HVAC and Weatherization SEEM data – February 2016:
RTF Supporting documents site, SEEM workbook

Version History and Related Measures

Energy Trust has been offering furnaces in Washington for many years. These predate our measure approval documentation process and record retention requirements. Table 5 may be incomplete, particularly for measures approved prior to 2013.

Table 5 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	Update savings analysis and add fan savings value, update cost.
6/22/2020	23.3	Update savings and cost.

Table 6 Related Measures

Measures	MAD ID
Furnaces in rentals, savings within reach and small multifamily in Oregon	22
Furnaces in large multifamily	203

Approved & Reviewed by

Jackie Goss, PE
Sr. Planning Engineer

Disclaimer

Measure Approval Document for Residential Windows

Valid Dates
July 1, 2020 to December 31st, 2022

End Use or Description
Three tiers of windows measures installed in existing single family, existing manufactured, and small multifamily structures.

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 Homes
- Existing Manufactured Homes
- Existing Multifamily

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

- Contractor installed

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

- Replacement

Purpose of Re-Evaluating Measure
Version 3 of this document: This measure is being re-evaluated in order to restructure the measure offering into 3 tiers of efficiency and incentives, defined according to U-value as follows;

- Tier 1: U-value 0.28 to 0.30
- Tier 2: U-value 0.25 to 0.27
- Tier 3: U value ≤ 0.24

Incremental cost assumptions have been updated to reflect the findings of a 2018 Market Research Report by Apex Analytics[1].

Savings for gas heated homes have been updated to include electric fan savings, which were not previously included in the measure analysis.

Version 4 of this document: correct error in CEC regarding max incentives in Washington.

Cost Effectiveness
Cost effectiveness is demonstrated for Oregon in Table 1 and Washington in Table 2. Cost effectiveness was calculated using the tool: OR-WA-CE Calculator 2021-v1.1. In Oregon the electric avoided cost year is 2021 and the gas avoided cost year is 2021. In Washington the gas avoided cost year is 2020.

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
1	U-value 0.30 to 0.28, Electric Heat	45	1.84	0	$0.71	$0	$4.00	1.0	5.8	100%	0%
2	U-value 0.30 to 0.28, Gas Heat	45	0.11	0.13	$0.71	$0	$2.00	1.6	4.4	6%	94%
3	U-value 0.30 to 0.28, Gas Heat, G.O.T.	45	0	0.13	$0.71	$0.01	$2.00	1.5	4.4	0%	100%
4	U-value 0.25 to 0.27, Electric Heat	45	3.87	0	$1.50	$0	$8.00	1.1	5.8	100%	0%
5	U-value 0.25 to 0.27, Gas Heat	45	0.22	0.27	$1.50	$0	$4.00	1.6	4.4	6%	94%
6	U-value 0.25 to 0.27, Gas Heat, G.O.T.	45	0	0.27	$1.50	$0.03	$4.00	1.5	4.4	0%	100%
7	U-value ≤ 0.24, Electric Heat	45	6.66	0	$2.57	$0	$15.00	1.0	5.8	100%	0%
8	U-value ≤ 0.24, Gas Heat	45	0.38	0.46	$2.57	$0	$8.00	1.4	4.4	6%	94%
9	U-value ≤ 0.24, Gas Heat, G.O.T.	45	0	0.46	$2.57	$0.05	8.00	1.3	4.4	0%	100%

Table 2 Cost Effectiveness Calculator Washington

#	Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Ele	% Gas
1	U-value 0.30 to 0.28, Gas Heat, G.O.T.	45	0.13	$0.71	$0.01	$4.81	1.00	6.98	0%	100%
2	U-value 0.25 to 0.27, Gas Heat, G.O.T.	45	0.27	$1.50	$0.02	$10.12	1.00	6.98	0%	100%
3	U-value ≤ 0.24, Gas Heat, G.O.T.	45	0.46	$2.57	$0.03	$17.39	1.00	6.98	0%	100%

Requirements

- Windows, glass doors or skylights with;
  - Tier 1: NFRC U-factor rating of 0.28 to 0.30
  - Tier 2: NFRC U-factor rating of 0.25 to 0.27
  - Tier 3: NFRC U-factor of 0.24 or less
- Window/ door/ skylight is installed between a conditioned space and an unconditioned space

Baseline
This measure uses a full market baseline.

The sales-weighted average market baseline efficiency level, which is defined in terms of U-factor or U-value. The 2018 Apex Market Research presents total windows market share estimates by U-value bin for the years 2017 and 2022, which are shown in Table 3.

[1] https://www.energytrust.org/wp-content/uploads/2019/02/Energy-Trust-of-Oregon-Windows-2018-Market-Research-final.pdf

Table 3 Market Share Estimates from 2018 Market Research

U-value Range	2017 Market Share	2022 Market Share
> 0.35	4%	4%
0.31 - 0.35	30%	24%
0.28 - 0.30	51%	40%
0.25 - 0.27	11%	24%
0.20 -0.24	3%	6%
< 0.20	1%	2%

The market share values shown in Table 3 represent the total windows market in Oregon, including new construction & retrofit/ remodel market segments, including sales to both program participants and non-participants. The portions of the market belonging to new construction and/or Energy Trust programs were removed from the overall market shares in order to calculate the applicable baseline efficiency for the Existing Homes windows measures.

The new construction market share is estimated to be between 40% and 60% according to market actor interviews from the 2018 Apex Windows Market Research, with the majority of respondents estimating a 50% market share. This analysis assumes that all new construction windows have a U-value of 0.30 or better due to code requirements and market share for new construction is distributed across the U ≤ 0.30 bins in the same proportions as the overall market.

Existing Homes program windows are assumed to represent 6% of total windows market sales in Oregon, based on 2014 market analysis. The 2018 Windows Market Research by Apex provides an estimate of the total number of windows sold annually but does not present the total square footage of windows. Since PT projects are recorded in terms of square footage, it is not possible to compare program volume to the total market size presented in the 2018 Apex market research. For this reason, the 6% Existing Homes program market share assumption has been carried over from the prior analysis. The distribution of Existing Homes program windows across u-value bins is taken from 2017 Energy Trust projects, since this is the most recent year where u-value was recorded by the program.

The remaining baseline market shares and U-values, after new construction and existing homes program windows have been removed, are as follows shown in Table 4. Since this offering will be in place from 2020 to 2022, an average of the 2017 and 2022 baselines are used. The final weighted baseline is U-value 0.317.

Table 4 Replacement Baseline Market Share Estimates and Average U-values

U-Value Range	Average U-value	2017	2022	2017/2022 Average
> 0.35	0.35	4.0%	4.0%	4.0%
0.31 - 0.35	0.33	30.0%	24.0%	27.0%
0.28 - 0.30	0.29	51.0%	40.0%	45.5%
0.25 - 0.27	0.26	11.0%	24.0%	17.5%
0.20 -0.24	0.22	3.0%	6.0%	4.5%
< 0.20	0.20	1.0%	2.0%	1.5%
Weighted Average U-value		**0.322**	**0.311**	**0.317**

For reference, the ENERGYSTAR version 6.0 specification for windows requires U-factor of 0.27 or less for the Northern climate zone, as shown in Figure 1.

Figure 1 ENERGY STAR Program Requirements for Residential Windows, Doors, and Skylights: Version 6.0

Table 1: Energy Efficiency Requirements for Windows

Climate Zone	U-Factor[1]	SHGC[2]
Northern*	≤ 0.27	Any
North-Central	≤ 0.30	≤ 0.40
South-Central	≤ 0.30	≤ 0.25
Southern	≤ 0.40	≤ 0.25

* The effective date for the Northern Zone prescriptive criteria for windows is January 1, 2016.

Measure Analysis

Calculation of savings

Savings for windows in electrically heated homes are based on an electric impact analysis conducted by EcoNorthwest using Energy Trust program data from 2005 and 2006[2]. That analysis found 564 kWh per year savings. Savings for windows in gas heated homes are based on a gas impact analysis completed in 2007 and 2008 by Opinion Dynamics Corporation[3] which found savings of 39 annual therms. This finding was corroborated by billing analysis done by Energy Trust evaluation staff for gas heated homes that installed windows in 2009.

The average area of windows replaced for both evaluations was 151 square feet, which corresponds to savings of 3.76 kWh per square foot, and 0.26 therms per square foot for windows with a U-factor equal to or less than 0.30. In order to translate those energy savings into values that would apply to the current tiering structure and baseline, a linear fit is assumed in relation to the change in U-factor, as described in the following formulas:

*Electric Savings =3.76 * (Baseline U value - Average Tier U Value) / (0.35-0.3)*
*Gas Savings = 0.26 * (Baseline U value - Average Tier U Value) / (0.35-0.3)*

The resulting energy savings after applying the above savings formulas to the weighted average 2017 and 2022 baseline are shown in Table 5 for electrically heated homes and Table 6 for gas heated homes.

Table 5 Energy Savings (kwh) for Electrically Heated Homes

Tier	Average U-value	Savings (kwh)
U-value 0.30 to 0.28	0.292	1.84
U-value 0.27 to 0.25	0.265	3.87
U-value ≤ 0.24	0.228	6.66

[2] https://www.energytrust.org/wp-content/uploads/2016/11/080715_HES_Process_Impact_Report.pdf
[3] https://www.energytrust.org/wp-content/uploads/2016/11/ETO_HES_Process_and_Impact_Report_Volume_1.pdf

Table 6 Energy Savings for Gas Heated Homes

Tier	Average U-value	Savings (therms)	Savings (kwh)
U-value 0.30 to 0.28	0.292	0.127	0.11
U-value 0.27 to 0.25	0.265	0.266	0.22
U-value ≤ 0.24	0.228	0.457	0.38

Additionally, there are electric fan savings associated with window installations in homes heated by gas furnaces which are not captured in the gas impact evaluation results. Fan savings in gas heated homes are calculated according to the following formula;

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

Applying the fan savings formula to the gas savings shown in Table 6 results in the electric fan savings.

Electric fan savings are valued according to their avoided cost value for installations within Energy Trust electric service territory, and as a non-energy benefit according to the value of utility bill savings for installations outside of Energy Trust electric service territory.

Comparison to RTF or other programs

The RTF has a UES measure for windows. The RTF uses a calibrated SEEM modelling approach to estimate energy savings and assumes a retrofit project type with a current conditions baseline. Due to the RTF's work not including an analysis of gas savings, or a baseline that reflects our understanding of customer window purchases, this analysis instead employs Impact Evaluation results from Energy Trust's program to estimate savings.

Energy Trust's multifamily program has windows offerings from stacked structures. These have different savings and baselines due to different construction assumptions and other building and purchasing characteristics.

Measure Life

Measure life is 45 years, consistent with other residential Energy Trust windows measures.

Cost

The 2018 Windows Market Research by Apex Analytics provided incremental cost values by U-value bin and as a linear regression. The hedonic model approach is used in order to control for impacts on price related to attributes other than energy efficiency. Incremental costs in that research which were determined using a hedonic modelling approach based on window prices obtained through web-scraping from three large home improvement retailers. The linear hedonic model results were selected for use in cost effectiveness testing rather than the binned U-value results due to unrealistically high incremental costs found for windows with U-value ≤ 0.24 in the binned model results. The linear hedonic model found that a 0.05 reduction in U-value is associated with an increase in window cost of $1.45 per square foot. Applying this finding to the 2017 & 2022 market baseline u-values results in the incremental cost values shown in Table 7. The simple average of 2017 and 2022 incremental costs has been used for cost-effectiveness testing in this measure analysis.

Table 7 Incremental Measure Costs by Tier ($/sqft)

Tier	Average U-value	2017	2022	Average of 2017/2022
U-value 0.30 to 0.28	0.292	$0.87	$0.55	$0.71
U-value 0.27 to 0.25	0.265	$1.66	$1.34	$1.50
U-value ≤ 0.24	0.228	$2.73	$2.41	$2.57

Apex also created a cost regression using U-value bins. The model that isolates by efficiency bins shows a dramatic increase in cost at the highest efficiency bin and a non-linear cost model. We interpret this difference to mean that other high-cost factors are more prevalent in the most efficient cost bin. We expect that as high efficiency windows become more prevalent, their other characteristics and options will become more equivalent to other efficiencies and they will be available in the same range of frame material, types and at equivalent retailers. As the market adjusts, this model will become less relevant. The results are markedly different for the most efficient tier of products.

Since our market research produced such dramatically different results, we attempted to compare them to other sources as summarized in the attached cost analysis. 2017 is the last year that we have u-value data and costs in for our own projects. After removing extreme outliers, we found no correlation between u-value and project costs. The RTF's Standard Information workbook provides limited installed cost data for windows sourced from BPA projects. That data does show some correlation between costs and U-value. We assumed and created a linear extrapolation of that information based on their mean and 25th percentile costs. The mean costs have a flatter slope, indicating that on average, U-value was not a primary driver of costs, similar to the Energy Trust results. The steeper slope for the 25th percentile indicates that at the low end, efficiency does have an impact on cost.

The range of incremental costs calculated by the Apex Report, Energy Trust project data and BPA project data, when applied to the tiering structure presented in this MAD, are as shown in Table 8. When a model provided a negative incremental cost, we assumed $0 as the minimum.

Table 8 Range of Incremental Costs by Tier ($/sqft)

Tier	Low End of Cost Range	High End of Cost Range
U-value 0.30 to 0.28	$0.00	$15.87
U-value 0.27 to 0.25	$1.16	$25.15
U-value ≤ 0.24	$0.00	$43.22

Non Energy Benefits

Fan savings for gas heated homes outside of Energy Trust territory are valued as a non-energy benefit, according to the most recent statewide average residential electric retail rate of $0.12/ kWh in Oregon and local residential rate of $0.082 in Washington.

Incentive Structure

The maximum incentives listed in Table 1 and Table 2 are for reference only and are not suggested incentives. Incentives will be per square foot of window area.

As Energy Trust sets incentives, we attempt to influence customer purchasing decisions and dealer stocking practices without overspending by paying more than incremental cost. In situations where incremental costs are hard to define, such as windows, this is a challenge. As customers are choosing between products with a wide range of costs, we need an incentive high enough to get customers' attention and to influence decision making and stocking practices.

All incentives are within the range of incremental costs that we are aware of. The cost effectiveness calculator shows very high incentives intended electrically heated homes in special circumstances, such as TLM initiatives or projects with complementary funders who may be influencing customers who would not otherwise replace windows at all. The incentives shown in Table 9 have been discussed with the OPUC because they exceed the incremental costs used in testing the TRC. If programs exceed these incentives for standard projects, the new incentive must be discussed with the OPCU.

Table 9 Expected 2020 incentives and maximums

Tier	Standard Incentive	Max Incentive for special circumstances (Electric only)
U-value 0.30 to 0.28	$2.00	$4.00
U-value 0.27 to 0.25	$4.00	$8.00
U-value ≤ 0.24	$6.00	$15.00

Supporting Documents

The cost effectiveness calculator number 28.4.3. It is attached and can be found along with other supporting documents at I:\Groups\Planning\Measure Development\Residential\Res Weatherization\windows

28.4.3 CEC_2021_v_1_1 res

windows incremental cost analysis.docx

Follow-Up

Baseline should be updated at next revision, either by updated market study or using 2022 baseline assumptions rather than blends.

Costs for the most efficient tier of windows are estimated and expected the shift at these become more available.

This analysis does not include cooling savings in gas heated homes. Customers with cooling will achieve higher savings than estimated. The electric savings do include some cooling savings, though prevalence of cooling has changed since the billing analysis was completed 15 years ago. If possible, cooling savings should be quantified.

Measure History and Related Measures

Energy Trust has been offering incentives for residential windows for many years. These offerings predate our record retention and approval processes. Table 10 may be incomplete, particularly for approvals prior to 2013.

Table 10 Version History

Date	Version	Reason for revision
7/29/10	x	Residential windows approval tiers at 0.22 and 0.30
10/31/11	28.x	Update tiers to 0.25 and 0.30
6/20/14	28.x	Updated baseline. New tiers at 0.27 and 0.30
8/15/14	28.x	Adds small multifamily windows.
5/9/16	28.1	Update definition of small multifamily.
10/18/17	28.2	Update avoided costs resulting in updated max incentives. Minor clarifications throughout
5/29/20	28.3	Update baseline. New tiers at 0.30, 0.27 and 0.24
6/22/20	28.4	Correct error in cost effectiveness calculator Washington tab

Table 11 Related Measures

Measures	MAD ID
Multifamily windows	171

Approved & Reviewed by

Jackie Goss, PE
Sr. Planning Engineer

Disclaimer

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Measure Approval Document for Efficient Gas Fireplaces and Electronic Fireplace Ignitions

Valid Dates
January 1, 2021 to December 31, 2023

End Use or Description
Installation of thermally efficient gas fireplaces in existing single and multifamily construction and sales of electronic ignition equipped units in new and existing 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:

- Electronic Ignitions
  - New Homes
  - Existing Homes
- Fireplace Efficiency Upgrades
  - Existing Homes
  - Existing Multifamily (2-4 living units and side-by-side units)

Purpose of Re-Evaluating Measure
Inputs updated in this MAD:

- Updated fireplace efficiency baseline based on manufacturer and distributor forecasts for 2020, sourced from Energy Trust's 2015 Market Transformation Report[1]
- Updated electronic ignition savings calculation process
- Net to Gross calculations incorporated into working savings

Cost Effectiveness
Cost effectiveness is demonstrated for Oregon in Table 1 and Washington in Table 2. Cost effectiveness was calculated using the tool: OR-WA-CE Calculator 2021-v1.1. In Oregon the gas avoided cost year is 2021. In Washington the gas avoided cost year is 2020.

Table 1 Cost Effectiveness Calculator Oregon

#	Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% ele	% gas
1	Electronic Ignition	20	7.41	$105	$105.00	1.0	1.0	0%	100%
2	Thermal Efficiency 70 to 74.9 FE	20	48.54	$0	$150.00	4.6	68,558	0%	100%
3	Thermal Efficiency 75+ FE	20	60.51	$0	$250.00	3.4	85,476	0%	100%

Table 2 Cost Effectiveness Calculator Washington

#	Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% ele	% gas
1	Electronic Ignition	20	7.41	$105	$105.00	1.6	1.6	0%	100%
2	Thermal Efficiency 70 to 74.9 FE	20	48.54	$0	$150.00	7.3	109,794	0%	100%
3	Thermal Efficiency 75+ FE	20	60.51	$0	$250.00	5.5	136,888	0%	100%

Requirements
Downstream Fireplace Efficiency Upgrade Measures

- Model listed on the Canadian EnerGuide list with natural gas specific FE rating[2]
- 70 or greater fireplace efficiency rating with ignition system identified as "Intermittent" or "Pilot on Demand"

Midstream Electronic Ignitions

- Model listed on the Canadian EnerGuide list with natural gas specific FE rating
- Model ignition system identified as "Intermittent" or "Pilot on Demand"

Baseline
This measure uses a market baseline.

Thermal Efficiency Improvement Baseline
The common market fireplace efficiency baseline for existing homes is determined by removing the portion of the total fireplaces installed in new residential construction and the associated efficiency distribution of these fireplaces.

Table 3 describes the estimate of total fireplace units sold in Oregon and the splits between new and existing homes. In 2016, an estimated 7,515 gas heated homes were completed in Oregon. Energy Trust surveys of builders and new home owners, with findings in both studies being given equal, indicate an average of 0.92 fireplaces are installed per home in new gas heated construction, resulting in an estimated market size of 6,913. Results from the Energy Trust 2015 Gas Fireplace Market Transformation Study indicated the total market at that time was 10,500 units. Analysis from 2018 estimated the existing homes market to be 4,047 units in Energy Trust territory, or approximately 37% of the total market.

Table 3 New and Existing Home Market Share Estimates

Annual market Share Estimate Inputs		Estimated Market Shares
2016 Energy Trust Single and 2-4 dwelling homes completed	9,243	
Gas share of new homes	7,515	
Average of builder/new home owner survey reported fireplaces per new home	0.92	
Estimated unit installations in new homes	6,913	63%
Estimated unit installations in existing homes	4,047	27%
Total estimated Oregon gas fireplace market	10,960	100%

[1] https://www.energytrust.org/wp-content/uploads/2016/12/Energy_Trust_GF_MT_Report_2010142015.pdf
[2] Natural Resources Canada gas fireplace energy efficiency ratings search

Since 2015, the volume of program delivered fireplace & electronic ignition incentives has increased significantly due primarily to a shift from a downstream program design to a midstream focused program design. However, there has not been a updated market study conducted for fireplaces since the 2015 study, and so it is unknown whether the size of the overall fireplace market in Energy Trust Territory has changed, and if so, whether the change was driven by the existing homes or the new homes segment of the market. Due to that uncertainty, this analysis will continue to assume a total market size of 10,960 fireplaces, with existing homes and new homes claiming a 27% and 63% market shares, respectively.

Midstream fireplace data collected from January 2018 to July 2020 include a variable for whether the equipment was installed in an existing home or a new home. New Homes midstream units are used as a proxy in this analysis for the overall fireplace efficiency (FE) distribution in the new homes market. Table 4 presents the midstream distribution of fireplace efficiency applied to the estimated total units installed in new homes.

Table 4 New Home Fireplace Efficiency Distribution

Efficiency Tier	Count of Midstream Units	FE Distribution	Annual New Homes Market
75+ FE	20	.3%	19
70-74.9 FE	119	1.6%	113
65-69.9 FE	208	2.8%	197
50-64.9 FE	6,773	92.7%	6,410
0-49.9 FE	184	2.5%	174
Total	7,304	100.0%	6,913

In 2015 gas fireplace manufacturers and regional distributors were asked to forecast the distribution of fireplace efficiency both in Energy Trust territory and in a comparison territory in eastern Washington and northern Idaho where incentives were not offered. This comparison territory forecast is the basis for the baseline fireplace calculation.

Table 5 and Table 6 detail the manufacturer and distributor forecasts of fireplace efficiency for 2020, applied to the total estimated fireplace market less the new home market share (based on new home unit distribution in Table 4). The Average FE values shown in the tables are based on midstream data collected from January 2018 to July 2020. The result is an estimated weighted baseline fireplace efficiency (FE) for the existing homes market of 59.8 FE.

Table 5 Manufacturer Forecasted Existing Homes Baseline Fireplace Efficiency

Efficiency Tier	Average FE	Estimated 2020 Distribution	Estimated Market Size	Less New Homes	Existing Homes Distribution	Weighted FE
75+ FE	75.9	1.9%	208	189	5%	
70-74 FE	71.9	10.1%	1,112	999	25%	
65-69 FE	67.1	24.2%	2,651	2,454	61%	
50-64 FE	53.8	59.9%	6,562	152	4%	
0-49 FE	43.6	3.9%	428	254	6%	
Totals	**60.4**	**100%**	**10,960**	**4,047**	**100%**	**66.72**

Table 6 Distributor Forecasted Existing Homes Baseline Fireplace Efficiency

Efficiency Tier	Average FE	Estimated 2020 Distribution	Estimated Market Size	Less New Homes	Existing Homes Distribution	Weighted FE
75+ FE	75.9	2.1%	232	213	5%	
70-74 FE	71.9	0.0%	0	0	0%	
65-69 FE	67.1	4.4%	484	287	7%	
50-64 FE	53.8	81.1%	8,891	2,480	60%	
0-49 FE	43.6	12.4%	1,354	1,180	28%	
Totals	**60.4**	**100.0%**	**10,960**	**4,160**	**100%**	**52.98**

Electronic Ignition Baseline

Distributors interviewed for the market transformation study forecasted 82% of fireplaces sold in 2020 to have electronic ignition.

Savings Analysis

Energy Savings from Thermal Efficiency Improvements

The efficiency rating is the Fireplace Efficiency score from the Canadian P4 test.[3] Savings are calculated according to the following formula:

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

A total of 525 annual hours of use were extrapolated from the Energy Trust gas fireplace metering study for Existing Homes based on 15 hours of use per week for 35 weeks.[4] These figures match well with an estimated based on the study's finding of 0.18 hours of use per base 60 heating degree day multiplied by 2,955 (TMY3 base 60) long run heating degree days for Portland, where the majority of fireplaces are installed in Energy Trust service territory.

Table 7 shows the final savings for gas fireplace efficiency upgrades in existing homes. Average existing homes fireplace capacity and efficiency within incented tiers are derived from midstream program data.

Table 7 Existing Homes Fireplace Efficiency Savings

Efficiency Tier	Total Annual Hours of Use	Average Unit Capacity kbtu/hr	Baseline FE	Efficient FE	Savings (therms)
70 - 74.9 FE	525	33.07	59.89	71.90	**48.41**
75+ FE	525	32.61	59.89	75.60	**59.38**

[3] CAN/CSA-P.4.1-15 - Testing method for measuring annual fireplace efficiency
[4] Gas Fireplace Market Research & Metering Study

Energy Savings from Electronic Ignitions

Unlike the thermal efficiency improvement measure, electronic ignition savings are applied in both new and existing applications.

The savings equation for electronic pilot light ignitions is:

$$\Delta therm = (8760 - Annual\ fireplace\ HOU)\ x\ (1 - disabled\ ignitions\ fraction)\ x\ (1 - standing\ units\ disabled\ fraction)\ x\ \frac{1\ kbtu}{hr}$$

Table 8 details the inputs used to calculate both gross and net savings for electronic ignitions on gas fireplaces.

Table 8 Full Electronic Ignition Savings Inputs

Electronic Ignition Variables (IPI and On-demand)	**Input**
Weeks in heating season	35
Weighted Hours of use (15 HOU/27% Existing Homes, 6.1 HOU/63% New Homes)	7.9
Total annual fireplace hours of Use	276
Annual fireplace off hours	8,484
Ignition therm savings (pilot light usage 1 kbtu/h)	84.8
NEEA Study reported fraction of customers disabling EI	11.8%
Electronic Ignition Savings (IPI and On-demand)	74.8
Fraction of Standing Pilot Units left on in the off-season	56.4%
Program incentivized pilot use (therms)	8.51
Baseline ignition assumptions	
Percent Standing pilot light always on	12.4%
Percent Standing pilot light, turned off for non-heating season	9.6%
Comparison territory percent electronic ignition capable	82%
After program influence	
Percent Electronic ignition capable	98%
Percent Electronic ignition enabled	78%

Energy Trust's metering study in existing homes determined incented, efficient fireplaces are used for an average of 15 hours per week during the heating season, while new home occupants reported 6.1 weekly hours of use. A heating season duration of 35 weeks is assumed, in line with the thermal efficiency savings calculations. Based on the new and existing home market share reported in Table 3, average heating season hours of use per week is 7.9, or 276.4 hours of use per year.

US DOE technical support documentation identified the average pilot light in standing mode is one kbtu/hr resulting in 84.8 therms saved over the 8,484 annual hours of off time for electronic ignitions compared to standing pilot lights.

Research by the Northwest Energy Efficiency Alliance (NEEA) in 2017 found that 12% of owners with electronic ignition equipped fireplaces disable the units resulting in standing pilot light operation. Additional NEEA research found just under 50% of owners with standing pilot light units left the pilots running during the non-heating season in Energy Trust service territory while, regionally this figure was 63%. Due to uncertainty in the Energy Trust territory estimate and the wide interval the average, the average of these figures 56.4% of the estimates is used in this analysis. Additional calculations show that 12.4% of the market uses pilot lights all year with 84.8 therms/year of pilot light use. 9.6% of units have a standing pilot light but is turned off outside of the heating season with 56.3 therms per year of pilot light use. 78% of units are found with enabled electronic ignition after the influence of the program. The weighted average system uses 15.92 therms/year of pilot light consumption. Savings are reduced after considering the program's influence on qualifying thermally efficient models, with pilot lights. Distributors interviewed for the market transformation study forecasted a difference in prevalence of electronic ignitions between Energy Trust and its comparison territory of 16% for the 2020 program year. These market actors also estimated that the existence of Energy Trust's program and incentives are responsible for 60% of the difference. These factors combine to yield a savings estimate of 7.41 therms per electronic ignition.

Measure Life

US DOE technical support documentation estimates an effective useful life of 20 years for gas fireplaces.

Cost

Thermal Efficiency Improvement Costs

The market baseline cost for fireplace efficiency upgrades is based on average midstream unit costs, from January 2018 to July 2020, by efficiency tier. Those midstream costs were used to calculate a weighted average Existing Homes baseline cost by removing the estimated new homes market share, using manufacturer and distributor forecasts of 2020 FE distributions, weighted equally. Table 9 shows the resulting average midstream unit costs, by efficiency tier. Weighting the manufacturer and distributor cost baselines equally yields a common market baseline cost of $2,987**.**

Table 9 Midstream Unit Costs January 2018 to July 2020

Efficiency Tier	**Quantity Sold**	**% Distribution**	**Average Unit Cost**
75+ FE	326	9%	$2,763
70-74.9 FE	2,833	77%	$2,868
65-69.9 FE	205	6%	$3,204
50-64.9 FE	320	9%	$2,796
0-49.9 FE	13	0%	$3,059
Grand Total	3,697	100%	**$2,872**

Market studies spanning 2009 to 2017 have consistency found fireplace unit aesthetics, including the flame, are the most important factor when purchasing a gas fireplace, with efficiency and price being other important factors. These studies have also found a persistent and negative or negligible incremental cost for qualifying fireplaces, which is corroborated by recent midstream program data from 2018 to 2020. Despite this, the existing homes market is still dominated by lower efficiency units, suggesting that incentives can play a role in further increasing the prominence of price and efficiency in the purchasing decision for a long-lived piece of heating equipment. Table 10 shows the median incremental cost for both fireplace efficiency upgrade tiers.

Table 10 Fireplace Efficiency Upgrade Incremental Costs by Tier

Efficiency Tier	Median Tier Cost	Market baseline cost	Median Incremental Cost
70 to 74.9 FE	$2,031	$2,987	-$751
75+ FE	$2,236	$2,987	$-956

As there are no indications that this negative/zero incremental cost scenario will change, the program is using hard caps on incentives in order to maintain a substantive presence and endorsement in the retail fireplace marketplace to continue influencing efficiency decisions but constraining incentive outlays.

In cost effectiveness testing, a placeholder incremental cost of $0.01 is used.

Electronic Ignition Costs

US DOE Technical Support Documentation for the rulemaking process gives the incremental manufacturing cost of electronic ignitions at $28 for vented fireplaces and $70 for vented log sets. This analysis takes the higher number and applies a 50% contractor mark-up for a 2015 incremental cost of $105.

Incentive Structure

Fireplace Efficiency Upgrades

The maximum incentives for upgrades are capped at $150 for the 70-74.9 FE tier and $250 for the 75+ FE units. Fireplace efficiency upgrade incentives are currently paid to consumers through downstream application submission. Future program design may shift fireplace efficiency upgrade incentives to midstream and utilize a payment method similar to electronic ignitions.

Electronic Ignitions

The maximum incentives listed in Table 1 and Table 2 are for reference only and are not suggested incentives. Incentives for electronic ignitions will be paid on a per fireplace unit basis via midstream channels to distributors and retailers.

Follow-Up

Updated information about the fireplace market in Energy Trust Territory will be needed at the next measure update.

A Fireplace Market Study should provide updated values for the following input variables, which are the ones most likely to change,

- Common market fireplace efficiency baseline
- Total fireplace units sold in Oregon
- Estimated market share of electronic ignitions in new and existing homes
- Estimated market share of new and existing homes
- Common market baseline costs as non-electronic ignition equipped unit data becomes available
- Energy Trust percent influence on the difference between Energy Trust territory baselines and comparison region baselines

Supporting Documents

The cost effective screening for these measures is number 29.3.2. It is attached and can be found along with supporting documentation at: I:\Groups\Planning\Measure Development\Residential\Res HVAC\fireplace

29_3_2_Or-Wa-CEC_
2011_v_1_1_Gas_Fire

Version History and Related Measures

Table 11 Version History

Date	Version	Reason for revision
2/28/2013	29.x	Approve fireplace efficiency tiers of 65-<70 and 70+ FE
8/11/2014	29.x	Approve electronic ignition savings and updated baseline for fireplace efficiency tiers of 70-<75 and 75+ FE
5/4/2015	29.x	Approve small multifamily applications
8/17/2015	29.1	Approve new fireplace efficiency and electronic ignition savings based on 2015 market transformation study baseline findings
10/27/2017	29.2	Approve new fireplace efficiency baseline, savings and cost calculations. Update savings for electronic ignitions based on Energy Trust and regional research findings
9/29/2020	29.3	Updated FE baseline and savings for both FE improvement and ignition. Net to gross adjustment incorporated directly into working savings.

Table 12 Related Measures

Measures	MAD ID
New Homes EPS	181

Approved & Reviewed by

Kenji Spielman
Planning Engineer

Disclaimer

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.

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[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

Measure Approval Document for Residential Gas Storage Water Heaters

Valid Dates
January 1st, 2021 to December 31st, 2021

End Use or Description
Efficient gas water storage heaters sold to retailers, water heater contractors, builders, and homeowners.

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

- Residential
- Existing Multifamily, 2-4 units and side by side

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

- New
- Replacement

Purpose of Re-Evaluating Measure
This measure update reflects a transition from EF (Efficiency Factor) to UEF (Uniform Energy Factor) as the measure of equipment efficiency and the basis for calculating savings as well as differing requirements based on tank size due to changes in federal requirements.

Cost Effectiveness
Cost effectiveness is demonstrated for Oregon in Table 1 and Washington in Table 2. Cost effectiveness was calculated using the tool: OR-WA-CE Calculator 2021-v1.1. In Oregon the electric avoided cost year is 2021 and the gas avoided cost year is 2021. In Washington the gas avoided cost year is 2020.

Table 1 Cost Effectiveness Calculator Oregon

#	Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	NEBs (Annual $)	Max Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Ele	% Gas
1	0.66+ UEF ≤40 Gal Storage DHW	13	0	24.5	$277	$4.77	$153.34	1.0	0.7	0%	100%
2	0.69+ UEF 41-74 Gal Storage DHW	13	0	25.9	$277	$4.77	$162.30	1.0	0.8	0%	100%
3	0.86+ UEF ≥75 Gal Storage DHW	13	0	19.4	$277	$4.77	$121.38	1.0	0.6	0%	100%
4	Efficient Gas Storage Water Heater- All Tank Sizes	13	0	25.5	$277	$4.77	$159.75	1.0	0.7	0%	100%

Table 2 Cost Effectiveness Calculator Washington

#	Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	NEBs (Annual $)	Max Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Ele	% Gas
1	0.66+ UEF ≤40 Gal Storage DHW	13	24.5	$277	$4.73	$244.99	1.0	1.0	0%	100%
2	0.69+ UEF 41-74 Gal Storage DHW	13	25.9	$277	$4.73	$259.30	1.0	1.1	0%	100%
3	0.86+ UEF ≥75 Gal Storage DHW	13	19.4	$277	$4.73	$193.92	1.0	0.9	0%	100%
4	Efficient Gas Storage Water Heater- All Tank Sizes	13	25.5	$277	$4.73	$255.23	1.0	1.1	0%	100%

Exceptions
Energy Trust was granted an extension of the previous minor cost effectiveness exception for Gas Storage Water Heaters on July 16th, 2020 by OPUC staff. The purpose of this extension is to continue to make the measure available until new analysis is available through the RTF. The exception was granted based on UM 551 Criteria C: “The measure is included for consistency with other demand side management (DSM) programs in the region”. The exception expires December 31, 2021 or if the measure becomes >5% of the Program’s savings or a new MAD is produced and the TRC drops.

Measure level cost effectiveness is not required in Washington.

Exception history:

- Energy Trust originally received an exception for Gas Storage Water Heaters on October 1st, 2014 as part of the UM 1622 major cost-effectiveness docket for gas measures. This exception was based on UM551 Criteria B: Inclusion of the measure will increase market acceptance and is expected to lead to reduced cost of the measure.
- An extension to the 2014 exception was approved by the OPUC in August 2015, again based on UM 551 Criteria B.
- On 12/29/2016 Energy Trust requested a two-year exception extension for Gas Storage Water Heaters. The exception request was approved by OPUC staff with a stipulation that the exception decision needs to be revisited in October 2017. UM 551 Criteria B was also the basis of this exception request.
- On 11/8/2017 Energy Trust received an extension through the minor exception process. When the exception was approved, OPUC Staff stated that “This exception is good for three years or until either of these measures become > 5% of the Program’s savings or a new MAD is produced and the TRC drops.”. It appears that UM 551 Criteria B continued to be used as the basis of the exception request, however the documentation contained in Energy Trust Granted Measure Exceptions repository does not reveal that information.

Requirements
- Minimum Uniform Efficiency Factor (UEF) ratings required for qualifying equipment vary by tank size and are described in Table 3 below.
- Power vent models qualify for this measure, but power venting is not a requirement.
- Condensing storage and tankless units are excluded from these measures.
- Manufacturers have created a category of “hybrid” gas water heaters between tankless and storage that have a greater than 2 gallon tank and a greater than 75 kBtu/hr burner. Further testing of the hybrids is needed to determine their energy savings potential. These are excluded from this measure.

Table 3 Minimum UEF Ratings for Qualifying Equipment

Tank Size Category (gallons)	Minimum UEF Rating
≤40	0.66
41-74	0.69
≥75	0.86

Details

In 2017, the Department of Energy (DOE) updated their specifications for gas water heaters to establish minimum UEF qualification criteria. DOE did not require recertification of existing units at that time; only newly produced models were required to meet new UEF specifications. Existing models continued to be allowed under their previously established EF rating, and there was a mix of EF and UEF rated products available on the market for several years after that change was implemented. Energy Star has yet to finalize a rating criterium based on UEF, although a draft specification is under review. In order to avoid confusion between EF and UEF rated products, the previous version of this offering established ENERGY STAR certification as the minimum qualifying criteria.

It has now been several years since the DOE implemented their shift from EF to UEF, and nearly all gas storage water heaters available in the market today have a certified UEF rating. Beginning in 2021, Energy Trust will shift away from ENERGY STAR certification, towards a Qualified Products List approach.

Baseline

This measure uses a code baseline.

Code is an appropriate baseline due to a very low market-share for above-code equipment in Oregon and Washington[1].

Federal baseline efficiency standards for gas storage water heaters are defined in terms of UEF. Minimum UEF ratings under the current federal standard depend on tank size and domestic hot water (DHW) draw profile, as shown in Table 4.

Table 4 Federal Minimum UEF Requirements

Tank Size (gallons)	Draw Pattern	Federal Minimum UEF
40	Very Small	0.27
	Low	0.52
	Medium	0.58
	High	0.64
50	Very Small	0.25
	Low	0.50
	Medium	0.56
	High	0.63
70	Very Small	0.60
	Low	0.73
	Medium	0.76
	High	0.78

Baseline UEF values were then selected to represent the average expected draw profile for each tank size category for the purposes of this analysis. Those assumed baseline UEF values are shown in Table 7Table 5.

Table 5 Baseline Weighted UEF Values

Tank Size Category (gallons)	Baseline UEF	Draw Pattern Weighting
≤40	0.60	70% Medium/ 30% High
41-74	0.62	10% Medium/ 90% High
≥75	0.78	100% High

Annual baseline DHW energy consumption is based on modeled results from a 2019 study by NEEA and the Gas Technology Institute (GTI).[2] Modeled gas DHW energy consumption are presented in that report for several scenarios which represent the expected range of site conditions that affect DHW energy use. Usage estimates are presented there for each permutation of the following variables:

- Inlet Water Temperature- modeled for 4 cities in the Northwest: Portland, Seattle, Spokane, Helena
- Hot Water Draw profile- modeled for 3 prototype home configurations: 2-bed/1-bath, 3-bed/2-bath, 4-bed/3-bath
- Water Heater location: Garage (un-conditioned), living space (conditioned)

This analysis assumes that RTF Heating Zones are roughly aligned with the different NW inlet water temperature conditions presented in the NEEA/GTI report. DHW energy use estimates for Spokane have been assigned to represent expected baseline gas DHW use in heating zone 2 and estimates for Portland have been assigned to represent baseline heating zone 1 gas DHW energy use.

Annual baseline energy use estimates by heating zone and water heater location are then weighted according to RBSA II in order to calculate statewide average gas DHW use for a 50 gallon 0.62 UEF gas storage water heater. The baseline consumption estimate for a 50 gallon water heater is then converted to annual usage for 40 and 75 gallon water heaters by adjusting for differences in capacity and UEF rating, while holding standby losses constant. The resulting baseline energy use is shown in Table 6

Table 6 Baseline Annual DHW Energy Consumption (therms) by Tank Size Category

Tank Size Category (gallons)	Baseline UEF	Annual Energy Consumption in HZ1 (therms)	Annual Energy Consumption in HZ2 (therms)	Annual Energy Consumption all zones (therms)
≤40	0.58	171.0	191.1	**173.6**
41-74	0.62	187.9	210.3	**190.9**
≥75	0.78	205.0	229.7	**208.3**

[1] https://energytrust.org/wp-content/uploads/2016/12/Gas_Water_Heater_Market_Research_Report_Public_FINAL_wSR.pdf
[2] https://neea.org/img/documents/Lab-Testing-of-Tankless-Water-Heater-Systems.pdf

Measure Analysis

The average UEF rating of recently incented qualified products over 0.69 UEF through the midstream program channel, from January 2020 to August 2020, is assumed as the average efficient case UEF rating for 41 to 74 gallon units. Due to a scarcity of recent midstream program data for ≤ 40 gallons and for ≥75 gallon units, a simple average UEF rating was calculated for these tank size categories using data from the AHRI's Certification Directory, averaging units over the new program minimums of 0.66 and 0.86 UEF, respectively. The assumed efficient case values employed in this analysis for each tank size category are shown in Table 7.

Table 7 Efficient Case UEF Values

Tank Size Category (gallons)	Efficient Case UEF	Source
≤40	0.70	AHRI Directory
41-74	0.72	Midstream Program Data
≥75	0.86	AHRI Directory

Energy savings for gas storage water heaters are calculated according to the following equation:

$$Savings\ (therms) = Baseline\ DWH\ Energy\ Consumption\ (therms) * \left(1 - \frac{baseline\ UEF}{efficient\ UEF}\right)$$

The resulting annual energy savings by tank size category are shown in Table 8.

Table 8 Annual Energy Savings by Tank Size Category

Tank Size Category (gallons)	UEF Rating	Annual Energy Savings in HZ1 (therms)	Annual Energy Savings in HZ2 (therms)	Annual Energy Savings all zones (therms)
≤40	0.66+	24.1	26.9	**24.5**
41-74	0.69+	25.5	28.5	**25.9**
≥75	0.86+	19.1	21.4	**19.4**
		25.1	**28.1**	**25.5**

Measure Life

The lifetime of this measure is 13 years, from the DOE Technical Support Document for the 2015 federal standards change.

Cost

Online retail cost collected through Energy Trust's 2016 Existing Homes Gas Water Heater Market Research Report[3] are used in this analysis to calculate the average incremental measure cost. However, the baseline and efficient case costs presented in that report are defined in terms of EF rather than UEF, consistent with the minimum efficiency levels outlined in prior versions of this MAD. Those costs will be used in this UEF based analysis nonetheless, since very limited cost data is available for gas water heaters.

Average online retail costs and the corresponding incremental cost from Energy Trust's 2016 Market Research report are shown in Table 9

Table 9 Online Retail Cost Assumptions

	Online Retail Costs
Average Baseline Unit	$540
Average Efficient Unit	$817
Incremental	$277

Non Energy Benefits

Non-energy benefits for increased warranty length are included in this analysis. Qualifying atmospherically drafted equipment, which makes up the majority of products, have significantly longer warranty lives than baseline units, typically 12 years instead of 6 or 9 years. Extended coverage offers a financial benefit to consumers who purchase qualifying equipment.

The assumed average warranty lengths for the baseline and efficient case scenarios have been carried over from the previous EF based warranty benefit analysis. Those values are used here as a proxy for the baseline UEF and efficiency case UEF warranty lengths.

Research conducted by Lawrence Berkeley National Laboratory on water heater stock over time was used[4] in this NEB quantification. Their analysis used a Weibull distribution to model the turnover for water heaters over time. Modeled parameters determine the shape of the distribution as well as the speed at which equipment is estimated to fail. The warranty benefit is estimated as the percent of units surviving relative to the baseline equipment's warranty. Each qualifying equipment type's retail cost is multiplied by the relative fraction surviving relative to the baseline to calculate the lifetime warranty benefit. At the end of the average qualifying atmospheric unit's warranty 43% are estimated to be surviving relative to 25% at the end of the baseline warranty length. Multiplying the difference in survival rate by the qualifying units' retail cost yields a $118.34 benefit. This approach also yields a $73.82 penalty when comparing qualifying power vented units to baseline equipment due to shorter warranty lengths for power vented equipment.

Table 10 Warranty Lengths and Unit Cost by Venting Configuration and Efficiency Tier at Retail

Venting Configuration and EF	Average Warranty in Years	Failure percent relative to the baseline	Retail Unit Cost	Warranty Benefit by venting configuration
Baseline < .67 EF, Atmospheric Draft	7.7	-	$540	-
0.67+ EF, Atmospheric Draft	10.7	18%	$652	$118.34
0.67+ EF - Power Vent	6.5	-7%	$989	-$73.82

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.

Follow-Up

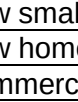
- The RTF is expected to review this measure in 2021, future updates should consider the RTF measure analysis.
- Cost analysis is out of date and needs to be updated.

[3] https://energytrust.org/wp-content/uploads/2016/12/Gas_Water_Heater_Market_Research_Report_Public_FINAL_wSR.pdf
[4] https://ies.lbl.gov/publications/using-national-survey-data-estimate?page=1

- The NEB analysis needs to be re-examined, especially the mix of atmospheric and power vented units.
- Savings analysis based on modeling of draw patterns could be more accurate than savings based on UEF change alone.

Supporting Documents

The cost effective screening for these measures is number 102.3.2. It is attached and can be found along with supporting documentation at: I:\Groups\Planning\Measure Development\Residential\Res Water Heating\gas storage water heat



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Version History and Related Measures

Energy Trust has been offering efficient Gas Storage Water Heater incentives for many years. These predate our measure approval documentation process and record retention requirements. Table 11 may be incomplete, particularly for measures approved prior to 2013.

Table 11 Version History

Date	Version	Reason for revision
5/26/10	102.x	Introduce 0.67 EF water heaters for existing and manufactured homes
5/27/10	102.x	Include small multifamily homes in prior approval.
6/2/10	102.x	Include condensing tank units.
8/10/10	102.x	Included distributor incentive.
1/6/12	102.x	Update cost and incentives.
6/19/12	102.x	Update approval to include maximum incentive.
9/2/15	102.x	Update savings due to federal standard influence of baseline. Removes condensing units.
9/15/15	102.x	Includes small multifamily.
2/16/16	102.x	Includes the products program.
12/30/16	102.1	Update costs and non-energy benefits.
11/8/17	102.2	Updated costs, NEBs. Change qualifying criteria to ENERGY STAR. Clarifies mid-stream program design.
9/16/20	102.3	Updated requirements and analysis for new UEF test method, differentiated volumes

Table 12 Related Measures

Measures	MAD ID
Residential and existing small multifamily heat pump water heaters	52
New small multifamily heat pump water heaters	176
New homes and small multifamily tankless water heaters	178
Commercial condensing tank water heaters	21
Commercial tankless water heaters	72

Approved & Reviewed by

Kenji Spielman
Planning Engineer

Disclaimer

Measure Approval Document for New ENERGY STAR and NEEM+ Manufactured Homes

Valid Dates
January 1, 2020 – December 31, 2023

End Use or Description
New Manufactured Homes

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

- Residential

Purpose of Re-Evaluating Measure
The Northwest Energy Efficiency Manufactured Housing Program (NEEM) is discontinuing the Eco-Rated label, so it is removed from this offering. Also the efficiency label NEEM 2.0 has been rebranded as NEEM+. This document is updated accordingly.

Savings and costs have been updated.

At the request of the Public Utility commission, this update blends all gas heated homes into one measure regardless of efficiency rating or heating zone.

Washington participation is now included.

Cost Effectiveness
Cost effectiveness values are demonstrated in Table 1 for Oregon and Table 2 for Washington. Cost effectiveness was tested using the OR-WA CE Calculator 2021 v1.1. In Oregon the Electric and Gas avoided cost year is 2021. In Washington the gas avoided cost year is 2020.

Table 1 Cost Effectiveness Calculator Oregon, per home

#	Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Ele	% Gas
1	ENERGY STAR Electric Zone 1	45	2,067	0	$3,097	$0.00	$3,096.67	1.3	1.3	100%	0%
2	ENERGY STAR Electric Zone 2	45	3,021	0	$3,097	$0.00	$3,096.67	1.8	1.8	100%	0%
7	NEEM+ Electric Zone 1	45	2,608	0	$5,063	$0.00	$4,905.33	1.0	1.0	100%	0%
8	NEEM+ Electric Zone 2	45	3,734	0	$5,063	$0.00	$5,063.39	1.4	1.4	100%	0%
14	ENERGY STAR or NEEM+ Gas Any Zone	45	24	126	3,097	$0.00	$2,930.81	1.0	0.9	1%	99%
15	ENERGY STAR or NEEM+ Gas Any Zone Gas only	45	0	126	$3,097	$2.91	$2,889.34	1.0	1.0	0%	100%

Table 2 Cost Effectiveness Calculator Washington, per home

#	Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Ele	% Gas
1	ENERGY STAR Gas Zone 1	45	106	3,097	$1.99	$3,096.67	1.3	1.3	0%	100%
2	NEEM+ Gas Zone 1	45	124	5,063	$17.98	$4,706.71	1.0	1.0	0%	100%
3	ENERGY STAR or NEEM+ Gas Zone 1	45	106	3,097	$1.99	$3,096.67	1.3	1.3	0%	100%

Exceptions
Energy Trust was granted an exception from the Oregon Public Utilities Commission (PUC) on 7/16/20 to continue to offer incentives gas heated manufactured homes meeting the ENERGY STAR and NEEM+ Specifications. The exceptions used the minor exception process. The PUC staff suggested that all gas heated qualifying homes be blended into a single measure because the cost effectiveness of rarely built gas heated NEEM+ homes was below the minor exception threshold. Cost effectiveness analysis for each of efficiency type is available in the attached cost effectiveness calculator. The exception was granted under UM551 exception criteria:

> **C. Measure is included for consistency with other programs in the region.** Including Energy Trust, there are twenty-eight utility programs in Oregon that offer incentives for homes certified as ENEGY STAR or NEEM+, many of these are in territory that Energy Trusts serves as gas-only. The NEEM program is a regional effort, supported by NEEA and NW Energy Works, to increase efficiency of manufactured homes throughout the northwest.
>
> **D. Measure helps to increase participation in a cost effective program.** Energy Trust pays retailers a SPIFF to encourage an upsell to energy-efficient models. Restricting the incentive to electrically heated homes would complicate the retailer's sales process and they would be less likely to take the time to upsell energy-efficient models, including the cost effective electrically-heated homes which make up more than 90 percent of the program volume.

PUC staff also acknowledged that manufactured homes are more prevalent in rural areas, and that many manufactured homes are owned by lower income customers. By supporting the availability of new, efficient manufactured homes, it is expected to improve the overall housing stock for lower income and rural customers.

The exception expires on 12/31/2023 or in or when the measure become >5% of the Products Program's savings or a new MAD is produced with a TRC drop. Energy Trust shall notify PUC Staff if gas heated homes increase to 25% of incented new manufactured

homes. The OPUC encourages Energy Trust to monitor uptake of these measures as a method to monitor fuel mix in new manufactured homes.

Similar exceptions for gas heated ENERGY STAR, Eco-Rated and NEEM 2.0 homes were granted on 11/8/17 and 11/21/18. Those expired at the end of 2020.

Requirements

- Homes must be sold and sited within Energy Trust service territory.
- Electrically heated homes must be served by Portland General Electric or Pacific Power.
- Gas-heated homes must be served by NW Natural, Cascade Natural Gas or Avista.
- Homes heated with another fuel do not qualify.
- All homes must be certified by Northwest Energy Efficiency Manufactured Housing Program as ENEGY STAR, or NEEM+.
- In Oregon, where gas heated homes are blended by efficiency tier and heating zone, tier and zone information must continue to be collected.
- If offered in Washington, the program may decide to either offer different measures for each efficiency tier, or use the blended measure.

Details

New ENERGY STAR and NEEM+ manufactured homes save electricity and natural gas through built-in efficiency upgrades across various home components. The current ENERGY STAR certification is based on the NEEM 1.1 specification. Home certification is verified by the NEEM certificate issued by NW Energy Works. The assumed building components to achieve each specification are listed in Table 3.

Table 3 Measure Specifications and SEEM inputs

Component	Baseline (average non-NEEM house)	ENERGY STAR	NEEM 2.0
Heating System	Electric Resistance Furnace, 7.7 HSPF Heat Pump or 84.4% AFUE Gas FAF	Electric Resistance Furnace, 7.7 HSPF Heat Pump or 84.4% AFUE Gas FAF	Electric Resistance Furnace, 7.7 HSPF Heat Pump or 90% AFUE Gas FAF
Floors	R-25 Nominal	R-33 (longitudinal framing)	R-33 (transverse framing)
Walls	R-13 Nominal	R-21	R-21 + R-1 foam sheathing and 2.5-stud corners and R-5 insulated headers
Ceilings	Avg. R-33 Nominal	Flat: R-49 Nominal Vaulted: R-40 Nominal	R-49 Nominal
Glazing	Avg. U = 0.40	U = 0.35 (SHGC assumed at 0.32)	U = 0.28 (SHGC assumed at 0.30)
Envelope Tightness	4.8 ACH_{50}	3.9 ACH_{50} (2009 field study) Spec calls for 5.0 ACH_{50}	3.9 ACH_{50} (2009 field study) Spec calls for 5.0 ACH_{50}
Duct Leakage	13%	5% supply leakage fraction	5% supply leakage fraction
Lighting	50% LED	50% LED	100% LEDs
Appliances	Standard Dishwasher and Refrigerator	ENERGY STAR Dishwasher and Refrigerator	ENERGY STAR Dishwasher and Refrigerator

Baseline

This measure uses a Market Baseline.

The baseline case is the average components of non-NEEM homes, referred to as “HUD Code” in the SEEM modeling tool, though with a few improvements from the actual code, including 40% prevalence of heat pumps in electrically heated homes and 50% LED lighting.

Savings

The RTF’s SEEM modeling tool was used to estimate savings

Heating and Cooling

The majority of the savings comes from heating end uses, which are heavily influenced by building shell measures. The baseline for ceilings, walls, floors and glazing is based on the weighted average efficiency of all non-NEEM homes built by manufacturers, per the “High Performance Manufactured Home Project: State of the Industry Report” prepared for Bonneville Power Administration. The baseline for envelope tightness and duct leakage is based on the average of NEEM homes in the 2000-01, 1997-98, and 1992-93 studies shown in the “Summary of 2006 NEEM Manufactured Homes: Field Data and Billing Analysis” prepared for NEEA. This is based on the fact that the NEEM program did not prioritize air sealing or duct sealing in those years, so they should reflect the baseline non-NEEM homes of today.

Multiple runs of the SEEM modeling tool were conducted. Iterations included each heating and cooling climate zone, the baseline and each efficient specification, each primary heating system (electric forced air furnace, heat pump, and gas forced air furnace). Runs were then weighed based on the average conditioned floor area of 1,572 sq.ft. To calculate one savings value for electrically heated homes, electric forced air furnaces and heat pumps were combined to assume 40% of electrically heated homes have a heat pump installed, in the baseline and in the efficient cases. Although the RTF has differentiated savings between the three dominant cooling zones, Energy Trust determined that the majority of installs would be occurring in areas designated as cooling zone 1. Therefore, the heat pump measure savings are assumed to be occurring in cooling zone 1, which is also the most conservative case

Lighting

The baseline is based on the RTF baseline, weighted to the RBSA mix of lamp types installed in manufactured homes. Savings are calculated as the difference in baseline and efficient case Lighting Power Consumption per lamp multiplied by 36 lamps per house and 1.9 hours of use per day in alignment with other residential lighting measures. This lighting method is not in alignment with other Energy Trust residential lighting measures as it only estimates first year savings and does not account for changes in baseline over time. However, lighting savings are a small component of total home savings so this method is sufficient. Only NEEM+ homes have lighting savings.

Appliances
Savings are calculated as the difference between annual consumption of the baseline case and the energy efficiency case. End-use savings are de-rated by the HVAC interaction factor assigned to the appliance type.

Gas Homes Weighting
For Oregon, measures for gas heated homes have been blended based on past program participation in dual fuel territory. In 2019, there were no participating Gas Heated NEEM+ homes, so they are weighted at 0%. In 2019 10 gas heated ENERGY STAR homes participated in heating zone 1 and 8 participated in heating zone 2.

In Washington, where Energy Trust's territory is only in heating zone 1, the blended measure is identical to the ENERGY STAR measure.

Comparison to RTF or other programs
This analysis is drawn directly from RTF savings and baseline calculations. RTF has more measure identifiers for Manufactured Homes than Energy Trust. For programmatic efficiency, we combine similar measures and weight them based on prevalence.

Measure Life
RTF and current Energy Trust new manufactured homes use a 45-year measure life, reflecting majority of savings are associated with shell improvements.

Cost
Incremental costs were estimated based on the RTF's conversation with NW Energy Works staff on February 16, 2017 and additional conversations with NEEA staff. RTF assumes costs increased 10% between 2017 and 2020 based on manufacturer reporting.

Non Energy Benefits
In gas only territory the electric bill savings are claimed as a non-energy benefit because the electric energy savings are not claimed.

Additional non-energy benefits may be experienced if manufacturers include low flow water devices. These are not included in this analysis because they are not included in the RTF analysis and are not requirements.

Incentive Structure
The maximum incentives listed in Table 1 and Table 2 are for reference only and are not suggested incentives. Incentives will be paid to retailers per qualifying home. Incentives may be split between customers and retailers with a total not to exceed the maximum.

Follow-Up
Baseline home components should be considered at next update, in particular baseline lighting and appliances are expected to change, or if HUD revises its standards. The RTF is expected to update their UES, which this measure is based on in 2023, aligning with Energy Trust's next planned update. RTF's changes should be considered at that time. Recommendation to engage RTF in Q4 2022 or Q1 2023 in effort to update analysis in early 2023.

Weighting of gas homes by efficiency rating and heating zone should be reexamined at next update.

Supporting Documents
The cost effective screening for these measures is number 109.4.2. It is attached and can be found along with supporting documentation at: I:\Groups\Planning\Measure Development\Residential\Manufactured homes\new manufactured homes


109.4.2 CEC 2021v1.1 New Manf I

References
RTF Res New MH UES Workbook v4.0: https://rtf.nwcouncil.org/measure/new-manufactured-homes

Version History and Related Measures
Energy Trust has been offering measures for new manufactured homes for many years. These offerings pre-date our measure approval documentation process and our record retention policy. Table 4 may be incomplete, especially for activities prior to 2013.

Table 4 Version History

Date	Version	Reason for revision
7/21/2005	x	Approved specific stand-alone shell and appliance measures for new manufactured homes.
Unknown	x	Approve ENERGY STAR new manufactured homes
12/19/2008	109.x	Incentive changes
6/15/2009	109.x	Adds Eco Rated homes and homes with heat pumps. Updated savings to 2009 RTF savings.
12/8/2009	109.1	Incentive changes
11/13/2017	109.2	Update to align with latest ENERGY STAR and Eco Rated specs and with 2017 RTF savings.
12/10/2018	109.3	Update to add NEEM 2.0 specs
8/27/2020	109.4	Update to align with 2020 RTF assumptions. Remove Eco-rated spec. Add Washington

Table 5 Related Measures

Measures	MAD ID
Manufactured homes early retirement pilot in electrically heated homes	199
Manufactured homes early retirement pilot in gas heated homes	225

Approved & Reviewed by

Jackie Goss, PE
Sr. Planning Engineer

Disclaimer

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Measure Approval Document for EPS New Homes in Washington

Valid Dates
1/1/2021 – 12/31/2021 or until the program transitions to the 2018 WSEC, whichever is earlier.

End Use or Description
Residential New Construction

Program Applicability
Based on the referenced analysis and associated cost effectives screening, the measures below are approved for use in the follow program:

- EPS-New Construction Washington

Purpose of Re-Evaluating Measure
The Washington residential code update for 2020 (2018 WSEC) has been delayed to at least February 2021. Energy Trust's roll out of the updated program design based on the 2018 WSEC code is subsequently delayed. This update extends the measure to accommodate both the current delay and any possible future for delays in the 2018 WSEC enforcement through 2021.

Cost Effectiveness
Cost effectiveness is demonstrated for Washington in *Table 1*. Cost effectiveness was calculated using the tool: OR-WA-CE Calculator 2021-v1.1. The Washington gas avoided cost year is 2020.

EPS is a custom program, where savings are calculated on a site by site basis. The values in *Table 1* represent example homes and are not used for claiming savings.

Table 1 Cost Effectiveness Calculator Washington

#	Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Elec	% Gas
1	2018 SWWA Path 1	34	79.9	$949	$13.18	$949.36	2.8	3.0	0%	100%
2	2018 SWWA Path 2	39	142.1	$2,463	$14.88	$2,463.20	2.1	2.2	0%	100%
3	2018 SWWA Path 3	42	258.2	$6,437	$52.36	$6,436.90	1.5	1.6	0%	100%
4	2018 SWWA Path 4	43	293.0	$8,519	$53.90	$8,518.64	1.3	1.4	0%	100%
5	Weighted SWWA Paths 1-4	36	110.4	$1,751	$15.67	$1,751.30	2.3	2.3	0%	100%

Requirements
- Homes must be built in Washington and have primary heat provided by Northwest Natural Gas service.
- All projects entering the new homes program will be simulated using program approved modeling software, following program modeling protocol.
- Energy models and supporting documentation will be submitted to the program via the Axis database, with modeling results used for determination of incentives, savings, and overall EPS score. Homes must be field verified by a program verifier.
- Homes must achieve a minimum of ten percent gas improvement over code
- Builders must meet current code requirement and follow the programs requirements as described in the most current EPS Field Guide for quality installation, performance testing, health/safety and qualifying products.
- Verifiers performing field testing and home modeling must be current Trade Ally New Homes Verifiers and meet current program requirements

Details
The New Homes EPS program in SW Washington utilizes a framework of example pathways of likely common configurations of measures expected in participating homes, modeled in an approved modeling software. These pathways are screened for cost-effectiveness and used to set the incentives of the program. This framework provides flexibility when designing new homes allowing builders and raters to compare multiple packages to find feasible and cost-effective options.

Each pathway is modeled in compliance with the latest Northwest Modeling Requirements that were reviewed and discussed as part of a collaborative, Standard Modeling Protocol working group including Northwest Energy Efficiency Alliance, the Bonneville Power Administration, ODOE and Energy Trust. The weighting used within the analysis use distribution based on 2017 participating home counts in Washington from January 1 through September 21, 2017.

Baseline
This measure uses a Code Baseline.

The 2015 Washington Energy Code requires builders to select from a menu of shell and mechanical upgrades to achieve a total of 3.5 points. Based on past NW ENERGY STAR participation, builders were tending to comply following ducts inside and high efficiency equipment options on top of basic ENERGY STAR shell improvements. These two ENERGY STAR and shell improvements are roughly equivalent to 3.5 points on the Washington code table. These familiar combinations were selected to use for the WA Code reference home; additionally, these options leave room for additional improvements to the program. The code baseline used for REM/Rate models and savings include the following options from the 2015 Washington State Energy Code Section R406.2 Table 406.2 Energy Credits:[i]

- 1a-Efficient Building Envelope-5% Ua reductions-0.5 points
- 3a-High Efficiency HVAC Equipment-1 point
- 4-High Efficiency HVAC Distribution (Ducts Inside)-1 point
- 5b-Efficient Water Heating-1 point

Example Paths
Modeled pathways use 2015 Washington State Energy Code as the baseline and likely component combinations that have been seen in Energy Trust's New Homes Program in both Oregon and Washington**.** Pathways were built based on incremental improvements over the code baseline, using combinations of measures that have been seen in the Oregon and Washington programs. These combinations are meant to be incremental in cost, difficulty and create incremental improvements of 10% from one pathway to the next. These pasts are used to illustrate methods of achieving savings, budgeting and planning purposes and testing cost effectiveness. Builders are not required to follow pathways.

Table 2 Pathways compared to 2015 Washington State Energy Code

	Base Code Insulation	Code w/ Option 1a-3a-4-5b	Path 1 - 10%	Path 2 - 20%	Path 3 - 30%	Path 4 - 40%
Slab	R-10 2' Perimeter	R-10 full (1a)	R-10 full (1a)	R-10 full (1a)	R-10 full (1a)	R-10 full (1a)
Framed Floor	R-30 (U-0.034)	R-38 (1a)	R-38 (1a)	R-38 (1a)	R-38 (1a)	R-38 (1a)
Basement Wall	R-21 Int. (U-0.054) 10 ext/15 int. continuous/21 int framed	R-21 Int. (U-0.054) 10 ext/15 int. continuous/21 int framed	R-21 Int. (U-0.054) 10 ext/15 int. continuous/21 int framed	R-20 Cont	R-20 Cont	R-20 Cont
Wall	R-21 int. (U-0.054) 16" OC & headers R-10	R-21 int. (U-0.054) 16" OC & headers R-10	(U-0.051) R-23 BIB or R-21 Adv	(U-0.051) R-23 BIB or R-21 Adv	(U-0.035) 2x 8 Adv. BIB or R-23+7 cont	(U-0.025) R-23+20 cont
Window	U-0.30 (SHGC 0.30 no req.) Skylight U-0.50	**U-0.28 (1a) Skylight U-0.50**	U-0.28 (1a) Skylight U-0.50	U-0.25 SHGC-no requirement- 0.30	U-0.22 SHGC-no requirement-0.25	U-0.20 SHGC-no requirment-0.25
Ceiling	R-49	R-49	R-49 + R-21 Heel	R-60 Adv.	R-60 Adv.	R-60 Adv.
Water Heater	0.82 EF Tankless	**0.74 EF Storage (5b)**	**0.82 EF Tankless**	0.90 EF Tankless	0.95 EF Tankless	0.95 EF Tankless
Furnace	78 AFUE	**94 AFUE (3a)**	94 AFUE	96 AFUE	96 AFUE	96 AFUE
Duct Location	Attic	**Ducts and HVAC Inside (4)**	Ducts and HVAC Inside (4)	Ducts and HVAC Inside (4)	Ducts and HVAC Inside (4)	Ducts and HVAC Inside (4)
Duct Insulation	R8	n/a (R-8 10' return 5' supply unconditioned)	n/a (R-8 10' return 5' supply unconditioned)	n/a (R-8 10' return 5' supply unconditioned)	n/a (R-8 10' return 5' supply unconditioned)	n/a (R-8 10' return 5' supply unconditioned)
Duct Leakage	4% CFM_{25}/CFA	40 CFM_{50}	40 CFM50	40 CFM_{50}	40 CFM_{50}	40 CFM_{50}
Infiltration	5 ACH50	5 ACH50	4.5 ACH50	3.0 ACH 50	2.5 ACH50	2.0 ACH 50
Mechanical Ventilation	Exhaust, standard efficiency 24 hours 40 watts	Exhaust, standard efficiency 24 hours 40 watts	High Efficiency Exhaust (2.857 CFM/watt)	High Efficiency Exhaust (2.857 CFM/watt)	HRV (75% SRE 1.25 CFM/w)	HRV (75% SRE 1.25 CFM/w)
Lights and Appliances	75%	75%	75%	75%	100% and ESTAR Appliances	100% and ESTAR Appliances
Other	x	x	Low flow fixtures	Low flow fixtures	Low flow fixtures	Low flow fixtures
		Therm Savings	80	142	258	293
		kWh Savings	21	42	501	520
		% Better-Gas Only	**15%**	**26.7%**	**44.9%**	**51.0%**

Savings

Savings for actual projects are calculated on a case by case basis. To obtain an estimate of the energy savings and the resulting EPS score, the program has approved energy modeling software such as REM/Rate to model both the expected baseline as well as each home entering the program. Internal Energy Trust review has found the EPS program and modeling protocol to have relatively good accuracy modeling home consumption in the 2009-2011 New Homes Billing Analysis from 06/15/2015.

To calculate savings over a defined baseline, each home is modeled in REM/Rate using installed components and performance testing results. REM/Rate calculates the energy consumptions of the modeled home and simultaneously calculates the consumption of a User Defined Reference Home (UDRH) which uses the specifications of the baseline code home as a comparison baseline to the modeled home. Consumption outputs from the code and improved homes are uploaded from REM/Rate into the EPS calculator tool, Axis. The difference between code and improved consumption determines the savings to be claimed by the program, these savings are compared to the code home consumption to determine the modeled homes percent improvement over code. The EPS score is calculated by converting the annual consumption of the home in kWh and therms to MBtu.

Savings for low flow fixtures are prescriptive rather than modeled, they are determined by the water heating fuel and match the savings for one 1.75 gpm showerhead as approved in the MAD for Low Flow Showerheads in New Homes, MAD ID 131 published April 15, 2016 and expired on December 31, 2018.

Measure Life

Weighted average measure lives are presented in ***Error! Reference source not found.***. Each improvement pathway has its own estimated measure life. REM/Rate does not provide outputs by all specific end-use heating related components. To estimate a weighted average measure life for pathways, incremental modeling of gas efficiency improvements was used to assign savings to specific end uses. Once all gas end uses savings were assigned to an end use load profile, a weighted average measure life was generated for each improvement pathway based on gas avoided costs allowing for cost effectiveness testing and potential incentive levels.

Load Profile

Although the energy savings are based on annual whole home consumption, the Res Heating load profile is selected to represent the largest gas load in a representative gas heated home.

Cost

Costs in **Error! Reference source not found.** are based on a variety of sources for individual improvements in the modeled pathways for a typical 2,200 square foot home. Specific end-use cost sources came from the following sources with a brief discussion of assumptions employed in the analysis.

All Northwest Power and Conservation Council 6th Power plan costs referenced below can be found on the Northwest Power and Conservation Council's website. All costs have been updated to 2017 $ and are in alignment with costs used in the OR EPS MAD 181.2.

Weatherization and Windows

- **Ceiling Insulation R49 + R21 heel -** $0.17/ sqft RTF New Construction Built Green Washington workbook, cost adjusted to $0.17 over R-49 baseline[ii]
- **Ceiling Insulation R-60 Adv. -** $0.17/sqft Sixth power plan Appendix G: table G-2[iii]. Incremental cost of $0.17/sqft.
- **Wall R-23 BIB (U-0.057) -** $0.18/sqft Incremental cost between R-19 Standard to R-21 Advanced is used as a proxy for the incremental cost between R-21 Intermediate and R-23 Intermediate BIB insulation. Sixth power plan Appendix G: table G-2
- **Wall R-30 2x8 BIB (U-0.033) -** $1.02/sqft from baseline. NEEA next step home Phase I data collected from NEEA.
- **Wall R-23+20 cont (U-0.025) -** $1.52/sqft from US DOE, NREL, Measure Guideline: Incorporating Thick Layers of Exterior Rigid Insulation on Walls, Building Science Corp[iv].
- **Window U-0.25 -** Energy Trust PT data shows a negative incremental cost based on $52.58/sqft. $0 is used in the analysis for incremental cost.

- **Window U-0.22 -** Energy Trust PT data shows a negative incremental cost based on $60.74/sqft. $0 is used in the analysis for incremental cost. Same cost use for U-0.22 and U-0.20.
- **Window U-0.20 -** Energy Trust PT data shows a negative incremental cost based on $60.74/sqft. $0 is used in the analysis for incremental cost.
- **Infiltration 1 ACH50 reduction -** $0.11/sqft based on RTF analysis of New Construction Built Green Washington[v]

Space and Water Heating Systems

- **Gas Furnace 96 AFUE -** $457.81 incremental cost from 94 AFUE. $500 cost for 90-94 AFUE and $950 for 95+ AFUE in Gas Furnace in Washington MAD 23 9/4/2014. $457.81 is based on removal of Washington sales tax followed by adjustment to 2017 $s
- **0.82 EF Tankless Water Heater -** $0 incremental cost, California, High-efficiency Water Heater Ready[vi] new construction analysis, cost assumes partial avoidance of a future storage replacement, 13-year measure life, compared to a tankless expected life of 20 years. Cost over 0.74 EF storage unit.
- **0.90 EF Tankless Water Heater -** $704.50 incremental cost, California, High-efficiency Water Heater Ready new construction analysis, cost assumes partial avoidance of a future storage replacement, 13-year measure life, compared to a tankless expected life of 20 years. Cost over 0.74 EF storage unit.
- **0.95 EF Tankless Water Heater -** $939.36 incremental cost, California, High-efficiency Water Heater Ready new construction analysis, cost assumes partial avoidance of a future storage replacement, 13-year measure life, compared to a tankless expected life of 20 years. Cost over 0.74 EF storage unit.

Mechanical Ventilation

- **ASHRAE up to 10.0 cfm/watt -** $59.18 RTF, Oregon Energy Star New SF Homes 2012 RTF workbook v3.3[vii]
- **Heat Recovery Ventilator -** $1,302 from RTF meeting on Energy Star New Homes 8/25/10[viii]

Low Flow Fixtures

- **Low-flow Showerheads - $8.42 showerhead cost based on** the MAD for Low Flow Showerheads in New Homes, MAD ID 131 published April 15, 2016**.**

Lighting upgrades

- **100% High Efficacy Lighting –** $0 no incremental cost to upgrade from 75% to 100% high efficacy Oregon Energy Star New SF Homes 2012 RTF workbook v3.3

Thermostats

- **Web enabled Smart Thermostat -** $100 incremental cost in MAD 153.2; incremental cost for smart thermostats is supported by information from several high-volume program builders purchasing smart thermostat over a standard 7-day programmable thermostat.

Non-Energy Benefits

Non energy benefits are from reduced water use. These are based on customer's reduced water and sewer bills as well as reduce water pumping. Avoided water system pumping from these low flow devices creates additional energy savings in accordance with the 7th Power Plan. For installations outside Energy Trust electric service territory the savings are considered non-energy benefits and are multiplied by the average industrial retail rate of electricity for non-investor owned utilities in Washington. The combined NEB for residential water savings in Washington is $10.87/1,000 gallons.

Incentive Structure

Error! Reference source not found. lists the maximum cost-effective incentive level for each pathway and associated percent savings above code. The maximum is not a suggested incentive and is to be used by the program as a reference only. Incentives will be developed based on percent savings above code. For modeled homes that have savings which fall between the defined pathways a "sliding scale" approach will be used to estimate the savings to be claimed by the program and the incentive level to be paid.

Follow-Up

This offering is approved for homes built to the 2015 Washington State Energy Code. This measure must be sunset once the program transitions to the 2018 WSEC in 2021.

Recent evaluations have shown less savings from showerheads than anticipated. These finding should be incorporated into future versions of new homes packages.

Supporting Documents

The cost-effective screening for these measures is number 145.3.1. It is attached and can be found along with supporting documentation at: I:\Groups\Planning\Measure Development\Residential\New Homes\EPS\WA EPS


145.3.1
CEC_2021_v_1_1 EPS


2021
2018-SWWA_EPS-Pa

Version History and Related Measures

Energy Trust has been offering EPS New Homes in Washington measure for many years. These predate our measure approval documentation process and record retention requirements. *Table 3* may be incomplete, particularly for measures approved prior to 2013.

Table 3 Version History

Date	Version	Reason for revision
6/30/2012	124.x	Introduce NW Energy Star BOPs in Washington
3/4/2014	124.x	Allowed Earth Advantage as "equivalent path"
9/22/2014	124.x	Transition from BOPs to Performance Paths, update for 2012 building code
10/1/2015	145.x	Introduce EPS in Washington, replace MAD ID 124
9/7/2016	145.1	Updates for 2015 building codes, redesigned pathways
10/7/2017	145.2	Update savings and requirements for newer REM/Rate version and modeling protocol
9/23/2020	145.3	Extend valid date due to delay in code adoption

Table 4 Related Measures

Measures	MAD ID
EPS in Oregon	181

Approved & Reviewed by

Jackie Goss, PE
Sr. Planning Engineer

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[i] 2015 Washington State Energy Code: https://fortress.wa.gov/ga/apps/sbcc/Page.aspx?nid=14
[ii] RTF, Residential Single Family Energy Star Built Green Homes, WA 2014: https://nwcouncil.app.box.com/s/xixol3altfb4tvdsttcukkzz3qnj2wnm
[iii] Sixth Northwest Conservation and Electric Power Plan Appendix G: https://www.nwcouncil.org/media/6311/SixthPowerPlan_Appendix_G.pdf
[iv] Measure Guideline: Incorporating Thick Layers of Exterior Rigid Insulation on Walls, Building Science Corp, April 2015: https://www.nrel.gov/docs/fy15osti/63337.pdf
[v] RTF, New Construction Built Green Washington v2.4:http://rtf.nwcouncil.org/measures/measure.asp?id=143
[vi] California, High-efficiency Water Heater Ready, Codes and Standards Enhancements Initiative, October 2011:http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/current/Reports/Residential/Water_Heating/2013_CASE_WH2.WH5_WaterHeaterReady-10.28.2011.pdf
[vii] RTF, Oregon Energy Star New Single Family Homes 2012 v3.3: http://rtf.nwcouncil.org/measures/measure.asp?id=182
[viii] RTF, Energy Star New Homes, Cost Meeting 8/25/2010: http://rtf.nwcouncil.org/meetings/2010/0825/EStar_WA-ID-MT_BG_WA-NewConstruction_ProCostRunsv2.xls

Measure Approval Document for Retail Web Enabled Smart Thermostats

Valid Dates

January 1st, 2021 to December 31st, 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 building types or market segments or program tracks are expected:

- Retail Downstream via consumer applications or instant coupon platforms

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

- Replacement

Purpose of Re-Evaluating Measure

Savings from thermostat optimization services for Nest and ecobee devices have been added to the savings analysis, resulting in updated savings and NEBs.

Cost Effectiveness

Cost effectiveness is demonstrated for Oregon in Table 1 and Washington in Table 2. Cost effectiveness was calculated using the tool: OR-WA-CE Calculator 2021-v1.1. In Oregon the electric avoided cost year is 2021 and the gas avoided cost year is 2021. In Washington the gas avoided cost year is 2020.

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
7	Smart Tstat Any Home - Electric	11	525	0.0	$170	$0	$170.00	2.1	2.1	100%	0%
8	Smart Tstat Any Home - Gas	11	51	39.7	$170	$0	$170.00	2.3	2.3	19%	81%
9	Smart Tstat Any Home - Gas Only	11	0	39.7	$170	$6.11	$170.00	1.8	2.2	0%	100%

Table 2 Cost Effectiveness Calculator Washington

#	Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Ele	% Gas
1	Smart Tstat Any Home - Gas	11	39.7	$170	$4.17	$170	3.2	3.4	0%	100%

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.

Baseline

This measure uses an Existing Condition Baseline.

The baseline assumes a standard programmable or manual thermostat, that is not enrolled in a thermostat optimization service, in a home with average HVAC loads.

Measure Analysis

Energy savings in this analysis have been divided into two categories, thermostat “device” savings and “optimization” savings.

Device savings here refers to the energy savings that are driven by features of the thermostat device, such as occupancy detection, scheduling, maintenance alerts, and an engaging user interface.

Optimization savings, on the other hand, are defined here as incremental savings driven by proprietary manufacturer set-point optimization algorithms. These savings occur as a result of small changes to scheduled heating and/or cooling setpoints, which are designed to be sufficiently small as to not impact customer comfort.

Device Savings- Electric Heating Systems

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 based on RTF assumptions. 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

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. Thermostat Device 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 Thermostat Device Electric Heating System Savings

Measure	Savings (kWh)	Housing Weight
Smart Tstat Single/Manufactured Home - Electric	487	94%
Smart Tstat Multifamily - Electric	413	6%
Smart Tstat Any Home - Electric	482	100%

Device Savings- Gas Furnace Heating Systems

Energy Trust's pilot evaluation of homes heated by a gas furnace resulted in heating savings of 6%.[3] For single family homes, the average annual heating loads are derived from the RBSA I.[4] 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.

Device Savings- 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:

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

Inputs result in fan savings of 29 kWh for single family/manufactured homes and 23 kWh for multifamily.

Device Savings- 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%.

Thermostat Device savings estimates for gas furnace are shown in Table 6.

Table 6 Thermostat Device Base 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	-	-	-	$3.29	-

**Includes a 92% install rate adjustment, discussed on page 3*

[3] Energy Trust of Oregon Smart Thermostat Pilot Evaluation (Gas Furnaces). Apex analytics, 2016.
[4] NEEA 2011-12 RBSA I

Thermostat Optimization Savings.

Beginning in summer 2020, Nest's Seasonal Savings optimization service transitioned to a free service available to all qualified Nest customers. Energy Trust partnered with Google Nest from 2017 to 2019 to deliver a proprietary thermostat optimization service to Nest devices located in Energy Trust territory on a "fee per participating device" basis. Energy Trust previously claimed energy savings for the devices that opted-in to participating in the service using stand-alone Thermostat Optimization measures that were separate and distinct from any thermostat device savings. Customers must have a heating and/or cooling schedule established in order to participate in the service. Similarly, ecobee has also recently announced that launch of similar thermostat optimization service that will also be delivered free-of-charge to all ecobee thermostats. Since these services are now essentially embedded in the thermostat device itself, this update incorporates optimization savings into thermostat measures directly, rather than as a standalone thermostat optimization measure, as had been past practice. This analysis assumes the newer Google Nest product has the same optimization capabilities as other Nest devices.

Heating season optimization savings for Nest devices are based on the per opt-in unit savings results from Energy Trust's 2016/2017 Nest Seasonal Savings pilot evaluation[5]. Average energy savings by heating system type, are shown in Table 7.

Table 7 Pilot Results for Nest Winter Seasonal Savings

Heating System Type	Savings Source	Savings per Opt-in
Gas Furnace	Heating Energy	17.80 therms
	Fan Energy	15.34 kWh
Electric Furnace	Heating Energy	195.89 kWh
	Fan Energy	15.34 kWh
Heat Pump	Heating & Fan Energy	120.90 kWh

Energy Trust's 2016/2017 Nest Seasonal Savings pilot also evaluated summer cooling season savings and found an average of 4.1 kWh annual savings per opt-in participant. Previously, Energy Trust did not participate in summer season optimization because the offering was not cost-effective.

Ecobee conducted a pilot study of their *eco+* optimization service in summer 2019 and found an average of 40 kWh summer cooling savings per device[6]. That savings assumption is used to calculate ecobee optimization savings in this analysis. Ecobee has not yet published an equivalent winter heating season savings value because not all winter season efficiency features were deployed to devices during the pilot period. Ecobee is expected to publish a follow-up pilot report in the near future that details the magnitude of winter season optimization savings.

Average thermostat optimization savings for both heating and cooling across ecobee and Nest devices are weighted using the 2018-2019 prevalence of those thermostat brands in retail program offerings. Nest devices represented 82% of total retail thermostat volume, and ecobee device represented 18% of total retail thermostat volume over the program years 2018-2019.

RBSA II heating/cooling system distributions for Oregon are also factored into calculations of average optimization cooling savings. 65% of gas furnace homes and 44% of electric furnace homes are assumed to have cooling equipment, according to RBSA II values. Homes without cooling equipment are assigned zero cooling savings in this analysis.

Thermostat Optimization Opt-in Rates

A 59.5% opt-in rate assumption is applied to Nest heating season optimization savings, which is the average opt-in rate observed for the service during the program years 2018-2019. A slightly lower opt-in rate is applied to Nest cooling optimization savings, 46.9%, which comes from the 2016/2017 Nest Seasonal Savings pilot. Opt-in rates for Nest devices are effectively a combined participation rate that reflect both the portion of qualified/ eligible devices for the service, as well as the percentage that choose to participate in the service. Ecobee cooling savings are treated with the same opt-in rate as Nest cooling savings, 46.9%, since that information was not reported in ecobee's pilot study report.

Table 8 shows weighted average thermostat optimization savings by heating system type including opt-in rate adjustments.

Table 8 Weighted Average Thermostat Optimization Savings

Heating System Type	Weighted Average Heating & Fan Savings	Weighted Average Cooling Savings
Electric Furnace	102.5 kWh	1.6 kWh
Heat Pump	58.7 kWh	5 kWh
Gas Furnace*	8.64 therms	10.3 kWh

**Gas Furnace Fan savings are shown in cooling column.*

Install rate

The 2014 gas thermostat pilot, which depended on self-install, yielded 415 total purchased thermostats, of which 32 were returned. This represents a 92% install rate. This factor is applied to device heating, device cooling, device fan, and optimization 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 the relative weighting between Single Family/ Manufactured homes and Multifamily dwellings.

Table 9 Distribution of Energy Trust Mid/Downstream Incented Smart Thermostats Between Housing Types

Housing Type	Distribution
Multifamily	6%
Single Family/Manufactured Homes	94%

Final thermostat savings and NEBs by housing type and HVAC type are shown in Table 10.

[5] *https://www.energytrust.org/wp-content/uploads/2017/12/Energy-Trust-of-Oregon-Nest-Seasonal-Savers-Pilot-Evaluation-FINAL-wSR.pdf*
[6] *https://www.ecobee.com/en-us/ecoplusemv/*

Table 10 Final Smart Thermostat Savings

	Device Savings		Optimization Savings		Final Savings	
Housing Type- HVAC Configuration	**kWh**	**Therms**	**kWh**	**Therms**	**kWh**	**Therms**
Single Family/Manufactured Home - Electric	452	0.0	77	0.0	529	0.0
Single Family /Manufactured Home - Gas	43	32.2	9	7.9	52	40.1
Single Family/Manufactured Home - Gas Only	0	32.2	0	7.9	0	40.1
Multifamily - Electric	383	0.0	83	0.0	466	0.0
Multifamily - Gas	28	25.3	8	7.9	35	33.2
Multifamily - Gas Only	0	25.3	0	7.9	0	33.2
Any Home - Electric	447	0.0	78	0.0	**525**	**0.0**
Any Home - Gas	42	31.8	9	7.9	**51**	**39.7**
Any Home - Gas Only	0	31.8	0	7.9	**0**	**39.7**

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. RTF's measure has not been updated for the change in optimization delivery.

Energy Trust also offers smart thermostats in direct install and direct ship scenarios co-funding partners. Those offerings have higher costs and more site-specific savings, including different heat pump savings based on Energy Trust's 2015 pilot[7] and are approved through MADs 222 and 250. Contractor installed smart thermostats in homes with heat pumps are approved through MADs 148.

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 ($0.120/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.

Follow-Up

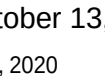
Updated impact evaluation results should be incorporated in the next measure update, including the evaluation that completed in Q4 2019.

Prevalence of ecobee and Nest devices should be revisited at the next measure update. Distribution of incented thermostats between single family, multifamily and manufactured home should be refreshed in subsequent updates to maintain blended savings accuracy.

This MAD should be updated on a similar schedule to MADs 222 and 250 and the analysis methods and assumptions between the three should be aligned.

Supporting Documents

The cost effective screening for these measures is number 153.4.2. It 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



153.4.2 OR-WA CEC 2021 v1.1 Retail Tsta

Version History and Related Measures

Table 11 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.
10/13/2020	153.4	Updated to include thermostat optimization savings for Nest and ecobee devices. Thermostat device savings were updated to include install rate adjustment.

[7] Energy Trust Follow-up Billing Analysis for the Nest Thermostat Heat Pump Control Pilot, 2015

Table 12 Related Measures

Measures	MAD ID
DI Smart Thermostats with Funding Partners	222
DI Commercial Smart Thermostats Pilot	235
Automated Thermostat Optimization (inactive)	173
Residential Thermostat Optimization Pilot (inactive)	217
Direct Ship Smart Thermostats	250
Contractor Installed Thermostats for New Heat Pumps (inactive)	19
Contractor Installed Thermostats on Heat Pumps	148

Approved & Reviewed by

Jackie Goss, PE
Sr. Planning Engineer

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Measure Approval Document for Resideo Thermostat

Valid Dates
5/1/2020 through 12/31/2022

End Use or Description
Thermostat optimization is a service where a company applies optimization algorithms to internet-connected thermostats on central heating and air conditioning systems to reduce energy consumption. This approval is for the Resideo optimization service, currently exclusive to Honeywell products, to be applied continuously for one year.

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

- Home Retrofit

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

- Retrofit

Purpose of Re-Evaluating Measure
This measure was previously approved for use during the winter heating season only. This update adds year-round use including cooling season savings.

Cost Effectiveness
Cost effectiveness is demonstrated for Oregon in Table 1 and Table 2 and in Washington in Table 4 and Table 4. Cost effectiveness was calculated using the tool: OR-WA-CE Calculator 2021-v1.1. In Oregon the electric avoided cost year is 2021 and the gas avoided cost year is 2020.

Table 1 and Table 3 show the approved measures with the cost per installation. One in ten enrolled participants will be in a control group. Table 2 and Table 4 demonstrate the offering is cost effective when the cost of control groups are included allowing for control group participants.

Summer only participation was analyzed and is included in workbooks and documentation but is not cost-effective and not approved.

Table 1 Cost Effectiveness Calculator Oregon – Resideo Measures

#	Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Elec	% Gas
1	Resideo Tstat Optimization - annual - gFAF	1	42	15	$12.00	$0.56	$12.00	1.1	1.2	19%	81%
2	Resideo Tstat Optimization - annual - gFAF + AC	1	69	15	$12.00	$0.92	$12.00	1.4	1.4	33%	67%
3	Resideo Tstat Optimization - annual - eFAF	1	441	0	$12.00	$0.00	$12.00	2.2	2.2	100%	0%
4	Resideo Tstat Optimization - annual - eFAF + AC	1	471	0	$12.00	$0.00	$12.00	3.1	3.1	100%	0%
5	Resideo Tstat Optimization - annual - Heat Pump	1	198	0	$12.00	$0.00	$12.00	1.3	1.3	100%	0%
6	Resideo Tstat Optimization - Winter - gFAF	1	42	15	$8.00	$0.56	$8.00	1.7	1.8	19%	81%
7	Resideo Tstat Optimization - Winter - eFAF	1	441	0	$8.00	$0.00	$8.00	3.3	3.3	100%	0%
8	Resideo Tstat Optimization - Winter - Heat Pump	1	169	0	$8.00	$0.00	$8.00	1.3	1.3	100%	0%

Table 2 Cost Effectiveness Calculator Oregon - Resideo program design

#	Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Elec	% Gas
11	Resideo Tstat Optimization - annual - gFAF - Including control group costs	1	42	15	$13.33	$0.56	$13.33	1.0	1.1	19%	81%
12	Resideo Tstat Optimization - annual - gFAF + AC -Including control group costs	1	69	15	$13.33	$0.92	$13.33	1.2	1.3	33%	67%
13	Resideo Tstat Optimization - annual - eFAF - Including control group costs	1	441	0	$13.33	$0.00	$13.33	2.0	2.0	100%	0%
14	Resideo Tstat Optimization - annual - eFAF + AC - Including control group costs	1	471	0	$13.33	$0.00	$13.33	2.8	2.8	100%	0%
15	Resideo Tstat Optimization - annual - Heat Pump- Including control group costs	1	198	0	$13.33	$0.00	$13.33	1.2	1.2	100%	0%
16	Resideo Tstat Optimization - Winter - gFAF - Including control group costs	1	42	15	$8.89	$0.56	$8.89	1.5	1.6	19%	81%
17	Resideo Tstat Optimization - Winter - eFAF- Including control group costs	1	441	0	$8.89	$0.00	$8.89	3.0	3.0	100%	0%
18	Resideo Tstat Optimization - Winter - Heat Pump - Including control group costs	1	169	0	$8.89	$0.00	$8.89	1.1	1.1	100%	0%

Table 3 Cost Effectiveness Calculator Washington - Resideo Measures

#	Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Elec	% Gas
1	Resideo Tstat Optimization – annual - gFAF	1	15.2	$12.00	$3.81	$12.00	1.8	2.1	0%	100%
2	Resideo Tstat Optimization – annual - gFAF + AC	1	15.2	$12.00	$6.25	$12.00	1.8	2.3	0%	100%
3	Resideo Tstat Optimization – Winter gFAF	1	15.2	$8.00	$3.81	$8.00	2.7	3.1	0%	100%

Table 4 Cost Effectiveness Calculator Washington – Resideo Program Design

#	Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Elec	% Gas
5	Resideo Tstat Optimization – annual - gFAF - Including control group costs	1	15.2	$13.33	$3.81	$13.33	1.6	1.9	0%	100%
6	Resideo Tstat Optimization – annual - gFAF + AC- Including control group costs	1	15.2	$13.33	$6.25	$13.33	1.6	2.0	0%	100%
7	Resideo Tstat Optimization – Winter gFAF - Including control group costs	1	15.2	$8.89	$3.81	$8.89	2.4	2.8	0%	100%

Requirements

- Household must have an internet-connected Honeywell Thermostat or other thermostat compatible with Honeywell's Resideo platform.
- Primary heating system must be a gas forced-air furnace, electric forced-air furnace, or heat pump.
- Primary heating fuel must be provided by Energy Trust participating utility, as determined by size address or assumed at zip code level.
- Annual and winter-only participation are approved. Summer-only participation is not approved.

Details

Program implementers pay Resideo for each device that is enrolled in the optimization program. The program will receive data about the each enrolled device including street address, zip code, heating system type (gas FAF, electric FAF, heat pump), and cooling system type (AC, heat pump, none) from Resideo. Initially, a utility split will be applied at the zip code level to determine the savings that will be recorded in PT for each utility, using virtual sites. The program may transition to a site-based method since this would increase the accuracy of reported savings by utility and overall.

Resideo's optimization algorithm will be applied throughout the year. We expect that all homes will have savings during the winter heating season and that homes with cooling systems will also have savings during the summer. Despite few summer savings, annual participation is preferred because of reduced recruitment efforts.

Participants are notified of their enrollment and can opt-out of the service once enrolled. Resideo reported a 4.8% winter attrition rate and a 3.4% summer attrition rate for pilot participants. These rates have been applied to the savings values presented here. Participant attrition was due to customer opt-outs, 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

Energy Trust implemented this measure through the Connected Savings pilot program in 2018 and 2019. Energy Trust hired Apex Analytics (Apex) to estimate the winter and summer electric and natural gas savings associated with the pilot. The evaluation was based on findings from the 2018/2019 winter and 2019 summer. This analysis relies on the Apex evaluation report[1] for energy savings and participant attrition values.

The key evaluation finding are:

- For thermostats connected to furnaces 3.2% primary heating fuel savings and 5.1% fan electric savings.
- For heat pumps, reductions of 4.0% of heating electric use.
- For central air conditioning systems and heat pumps, reductions of 3.9% of cooling electric use.

These reductions are shown in absolute and percentage energy savings in Table 5.

Table 5 Combined Per-Thermostat Energy Savings for the Connected Savings Pilot, by System and Fuel Type

System	Season	Fuel	TMY* Savings	90% CI*	Relative Precision	Savings as % of TMY Heating or Cooling Load
Gas Furnace	Winter	Therms	16	±7	±44%	3.2%
Electric Furnace**		kWh	414	±170	±41%	3.2%
Furnace Fan***		kWh	49	±22	±45%	5.1%
Heat Pump		kWh	177	±146	±82%	4.0%
Air Conditioner	Summer	kWh	31	±26	±84%	3.9%

* TMY–Typical meteorological year; CI–Confidence interval.
** Electric Furnace values calculated using Gas Furnace values converted to kWh.
*** Furnace fan savings are calculated from the weather-dependent electricity consumption of homes with gas furnaces

The per-thermostat savings apply to homes that were participating for the entire heating or cooling season. Since some participants stop participating during each season, attrition rates were applied. These attrition values are shown in Table 6, and savings were adjusted accordingly.

[1] Energy Trust of Oregon Resideo Thermostat Optimization Pilot Report. Apex Analytics, 2/25/2020 https://www.energytrust.org/wp-content/uploads/2020/04/Energy-Trust-of-Oregon-Resideo-Pilot-Final-Report-wSR-Final.pdf

Table 6 Summary of Connected Savings Pilot Attrition

Season	Winter		Summer	
Setting	Control	Treatment	Control	Treatment
Initial Total	965	1,427	1,009	1,468
Opted-out	0	32	3	16
Disconnected	15	24	9	7
Other	2	13	20	27
Total Attrition	17	69	32	50
Active users	948	1,358	977	1,438
Attrition percent	1.8%	4.8%	3.2%	3.4%

Measure Life

A one year measure life is used in this analysis, as fee paid to Resideo for each device covers deployment for one year.

Participating devices must be re-enrolled each year. Persistence of savings has not been studied.

Load Profile

The load profile is Res Ele Resistance Heat for the and eFAF only and the electric portion of gFAF only scenarios since there are no cooling savings in these cases. We used the Res Air Source HP load profile for the other three cases since there include both heating and cooling savings in proportion to the HP load profile.

Cost and Incentive

The cost of deploying the optimization algorithm is $12 for one full year and $8 for the eight month winter heating season. This fee is charged to Energy Trust and payment of this fee is our incentive. The service is free to the end use customer. There are no incentives paid to the customer.

Ten percent of enrollees are designated to be “Control” sites and do not receive treatment. Cost effectiveness including control sites is demonstrated in Table 2 and Table 4.

Non Energy Benefits

Electric bill savings for gas only customers is a non-energy benefit.

- In Oregon, electric savings for the 10% of gas sites expected to be out of Energy Trust electric territory are converted to a customer bill savings NEB at the Energy Trust blended electric rate of $0.120/kWh.
- In Washington, electric savings for all sites are converted to a customer bill savings NEB at the Clark County PUD electric rate of $0.082/kWh.

Follow-Up

Future evaluations may identify persistence of savings beyond one year which can be incorporated into the analysis.

Winter savings for heat pumps and summer savings for air conditioners (or heat pumps) have high uncertainty. If future evaluations find more certain results, those should be incorporated.

The program will monitor winter and summer opt-out rates and adjust at next update.

If the offering moves to site-based measures with known utilities, rather than zip-code based utility assumptions, gas measures must be re-calculated to account for gas only customers.

Supporting Documents

The cost effective screening for these measures is CEC 217.3.3 and is attached. It can be found along with supporting documents at: I:\Groups\Planning\Measure Development\Residential\Res HVAC\thermostat\web enabled thermostat\optimization\Resideo

217.3.3 CEC 2020_v_1_1 Resideo.x

Version History and Related Measures

Table 7 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.
5/1/2020	217.3	Expansion to include annual savings.

Table 8 Related Measures

Measures	MAD ID
Retail web-enabled thermostats	153
Direct Ship web-enabled thermostats	250
Co-funded direct install and direct ship web-enabled thermostats	222
Nest Seasonal Savings Winter	173

Approved & Reviewed by

Jackie Goss, PE
Sr. Planning Engineer

Disclaimer

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Measure Approval Document for Direct Install Web Enabled Smart Thermostats with Co-Funding

Valid Dates
10/13/20 – 12/31/2022

End Use or Description
This document approves web-enabled thermostats where complimentary funding is provided by a utility, community-based organization or low-income agency. 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.

This document does not demonstrate cost effectiveness for general use, 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.

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

- Residential
- Existing Multifamily

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

- Retrofit

Purpose of Re-Evaluating Measure

- Added incremental savings from thermostat optimization services for Nest and ecobee devices to the savings.
- Added measure configurations for unspecified or unknown cooling
- PGE's installs in MF with gas heat and cooling at a remaining cost of $250 are now cost effective.

Cost Effectiveness
Cost effectiveness was demonstrated using the tool: OR-WA CE Calculator 2021 v1.1. The Oregon avoided costs year is 2021 for electric and gas. The Washington gas avoided cost year is 2020.

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. For each HVAC 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 Cost ($)	Total NEBs (Annual $)	Max Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Ele	% Gas
1	SF DI Tstat gFAF w/CAC - Comp Funding	11	60	41.4	$414	$0	$414.07	1.0	1.0	21%	79%
2	SF DI Tstat gFAF no CAC- Comp Funding	11	22	41.4	$342	$0	$342.33	1.0	1.0	4%	96%
3	SF DI Tstat gFAF - Gas Only - Comp Funding	11	0	41.4	$372	$5.27	$327.12	1.0	1.0	0%	100%
4	SF DI Tstat eFAF w/CAC - Comp Funding	11	474	0.0	$403	$0	$402.51	1.0	1.0	100%	0%
5	SF DI Tstat eFAF no CAC- Comp Funding	11	435	0.0	$298	$0	$297.69	1.0	1.0	100%	0%
6	SF DI Tstat ASHP - Comp Funding	11	646	0.0	$442	$0	$441.76	1.0	1.0	100%	0%
7	MF DI Tstat gFAF w/CAC - Comp Funding	11	51	33.9	$341	$0	$340.51	1.0	1.0	21%	79%
8	MF DI Tstat gFAF no CAC- Comp Funding	11	19	33.9	$281	$0	$280.61	1.0	1.0	5%	95%
9	MF DI Tstat gFAF - Gas Only - Comp Funding	11	0	33.9	$297	$3.73	$267.85	1.0	1.0	0%	100%
10	MF DI Tstat eFAF w/CAC - Comp Funding	11	390	0.0	$332	$0	$331.63	1.0	1.0	100%	0%
11	MF DI Tstat eFAF no CAC- Comp Funding	11	358	0.0	$245	$0	$245.01	1.0	1.0	100%	0%
12	MF DI Tstat ASHP - Comp Funding	11	519	0.0	$441	$0	$440.90	1.0	1.0	100%	0%
13	SF DI Tstat gFAF unspecified CAC - Comp Funding	11	44	41.4	$391	$0	$390.55	1.0	1.0	16%	84%
14	MF DI Tstat gFAF unspecified CAC - Comp Funding	11	28	33.9	$292	$0	$291.84	1.0	1.0	8%	92%
15	SF DI Tstat eFAF unspecified CAC - Comp Funding	11	447	0.0	$380	$0	$380.25	1.0	1.0	100%	0%
16	MF DI Tstat eFAF unspecified CAC - Comp Funding	11	368	0.0	$313	$0	$312.67	1.0	1.0	100%	0%
17	SF DI Tstat unspecified electric heat unspecified CAC - Comp Funding	11	594	0.0	$505	$0	$505.24	1.0	1.0	100%	0%
18	MF DI Tstat unspecified electric heat unspecified CAC - Comp Funding	11	398	0.0	$338	$0	$338.31	1.0	1.0	100%	0%

Table 2 Cost Effectiveness Calculator Washington

	Measure	Measure Life (years)	Savings (therms)	Max Remaining Cost ($)	Total NEB (Annual $)	Max Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Ele	% Gas
1	SF SWWA DI Tstat gFAF w/CAC - Comp Funding	11	41	$606	$4.93	$564.71	1.0	1.0	0%	100%
2	SF SWWA DI Tstat gFAF no CAC - Comp Funding	11	41	$580	$1.82	$564.71	1.0	1.0	0%	100%
3	MF SWWA DI Tstat gFAF w/CAC - Comp Funding	11	34	$497	$4.12	$462.39	1.0	1.0	0%	100%
4	MF SWWA DI Tstat gFAF no CAC- Comp Funding	11	34	$475	$1.52	$462.39	1.0	1.0	0%	100%
5	SF DI Tstat gFAF unspecified CAC - Comp Funding	11	41	$595	$3.60	$564.71	1.0	1.0	0%	100%
6	MF DI Tstat gFAF unspecified CAC - Comp Funding	11	34	$552	$2.30	$462.39	1.0	1.0	0%	100%

Requirements

- Thermostats must be on the Smart Thermostat qualified products list.
- Home must be heated with fuel provided by a participating Energy Trust utility.
- Where home HVAC configuration is not fully known, program may use the applicable unspecified measures.
- The following equations describe the limits cost effectiveness eligibility for any complimentary funding agreement as shown in Table 1 and **Error! Reference source not found.Error! Reference source not found.**. 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. 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.

Max Remaining Cost ≥ Energy Trust Incentive + Customer Payment
Max Remaining Cost ≥ Total Cost – Co-funding

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.

Baseline loads for heating and cooling

For single family homes, the average annual heating loads are derived from the 2011 RBSA.[1] The average heating loads for Oregon homes are 5,992 kWh and 583 therms for electric and gas heated homes, respectively. These values include both heating zone 1 and 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.[2]

Cooling loads are less well established, however the same Nest pilot evaluation found 200 kWh of cooling usage while the 2016 summer Seasonal Savings billing analysis found 787 kWh of Portland summer cooling load, which straddles cooling zones 1 and 2.[3] 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.[4] To determine the annual heating load for multifamily gas heated units the ratio of the multifamily electric heating load to the single family electric heating load, 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.

Savings and Measure Analysis

Where not otherwise specified, sources for this analysis match those used in the Retail Web-Enabled Thermostat MAD 153.

RBSA II data for single family, manufactured homes and multifamily is used to estimate prevalence of central AC equipment for gas and electric furnace homes, as well as the relative prevalence of electric furnaces and heat pumps. The RBSA II values employed in this analysis are shown in the table below.

Table 3 RBSA II Housing Type and HVAC Type Assumptions

Housing Type	% of Homes	gFAF Cooling Prevalence	eFAF Cooling Prevalence	eFAF/Heat Pump Split
Single Family	94%	57%	31%	26%
Multifamily	6%	30%	30%	80%

Energy savings in this analysis have been divided into two categories; thermostat "device" savings and "optimization" savings.

Device savings refer to the energy savings that are driven by features of the thermostat device, such as occupancy detection, scheduling, maintenance alerts, and an engaging user interface.

Optimization savings are defined here as incremental savings driven by proprietary manufacturer set-point optimization algorithms. These savings occur as a result of small changes to scheduled heating and/or cooling setpoints, which are designed to be sufficiently small as to not impact customer comfort.

Device Savings – Electric Heating Systems

Electric forced air furnace and air source heat pump baseline loads and savings percentages are from the RTF's connected thermostat workbook.[5] The analysis applies the Energy Trust evaluated gas furnace heating savings estimate of 6% to electric forced air furnace

[1] 2011 RBSA: Single Family Characteristics and Energy Use. Ecotope, 2012. https://neea.org/resources/2011-rbsa-single-family-characteristics-and-energy-use
[2] Evaluation of Nest Thermostat Heat Pump Control Pilot. Apex Analytics, 2014. https://www.energytrust.org/wp-content/uploads/2016/12/Nest_Pilot_Study_Evaluation_wSR.pdf
[3] Nest Thermostat Seasonal Savings Pilot Evaluation. Apex Analytics, 2017. https://www.energytrust.org/wp-content/uploads/2017/12/Energy-Trust-of-Oregon-Nest-Seasonal-Savers-Pilot-Evaluation-FINAL-wSR.pdf
[4] RTF Connected Thermostats v1.3. https://rtf.nwcouncil.org/measure/connected-thermostats
[5] RTF Connected Tstats v1.3

heating and cooling loads. Heat pumps save an estimated 12% of heating loads, also sourced from Energy Trust research.[6] 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 4.

Table 4 Savings Estimates by ElectricHeating and Cooling System Combinations

Housing Type	HVAC Configuration	Heating Savings	Cooling Savings	Total Annual Savings
		kWh	kWh	kWh
Single Family	Electric Furnace with AC	360	30	389
Single Family	Electric Furnace (no CAC)	360	0	360
Single Family	Heat Pump	n/a	n/a	594
Multifamily	Electric Furnace with AC	282	23	306
Multifamily	Electric Furnace (no CAC)	282	0	282
Multifamily	Heat Pump	n/a	n/a	467
Single Family	Electric Furnace unspecified CAC	360	9	369
Multifamily	Electric Furnace unspecified CAC	282	7	289
Single Family	Unspecified Electric Heat Unspecified CAC	533	2	536
Multifamily	Unspecified Electric Heat Unspecified CAC	319	6	325

Device Savings- Gas Heating Systems

The average heating loads are assumed to be 583 therms for a single-family home and 458 therms for a multifamily home, based on RBSA results for heating zones 1 and 2. Applying a 6% savings assumption results in average annual savings of 35 therms per single-family home and 27.5 therms per multifamily home.

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, 0.79, multifamily cooling loads are estimated to be 388 kWh annually.

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 as a separate component in electric measures as runtime reduction savings are already captured in the overall heating load and usage reductions.

Thermostat Device savings for gas furnace homes are shown in the table below.

Table 5 Thermostat Device Gas Furnace Heating, Fan and Cooling Savings

Housing Type	HVAC Configuration	Heating Savings		Cooling Savings	Total Annual Savings	
		kWh	Therms	kWh	kWh	Therms
Single Family	Gas Furnace with CAC	17	35.0	30	46	35
Single Family	Gas Furnace (no CAC)	17	35.0	0	17	35
Multifamily	Gas Furnace with CAC	13	27.5	23	36	27.5
Multifamily	Gas Furnace (no CAC)	13	27.5	0	13	27.5
Single Family	Gas Furnace Unspecified CAC	17	35.0	17	34	35.0
Multifamily	Gas Furnace Unspecified CAC	13	27.5	7	20	27.5

Thermostat Optimization Savings.

Energy Trust partnered with Google Nest from 2017 to 2019 to deliver a proprietary thermostat optimization service to Nest devices located in Energy Trust territory on a "fee per participating device" basis. Energy Trust claimed energy savings for the devices that opted-in to participating in the service using stand-alone Thermostat Optimization measures that were separate and distinct from any thermostat device savings. Beginning in summer 2020, Nest's Seasonal Savings optimization service transitioned to a free service available to all qualified Nest customers. Customers must have a heating and/or cooling schedule established in order to participate in the service. Similarly, ecobee has also recently announced that launch of similar thermostat optimization service that will also be delivered free-of-charge to all ecobee thermostats. Since these services are now essentially embedded in the thermostat device itself, this update incorporates optimization savings into thermostat measures directly, rather than as a standalone thermostat optimization measure, as had been past practice.

Heating season optimization savings for Nest devices are based on the per opt-in unit savings results from Energy Trust's 2016/2017 Nest Seasonal Savings pilot evaluation[7]. Average energy savings by heating system type, are shown in Table 6.

Table 6 Pilot Results for Nest Winter Seasonal Savings

Heating System Type	Savings Source	Savings per Opt-in
Gas Furnace	Heating Energy	17.80 therms
	Fan Energy	15.34 kWh
Electric Furnace	Heating Energy	195.89 kWh
	Fan Energy	15.34 kWh
Heat Pump	Heating & Fan Energy	120.90 kWh

Energy Trust's 2016/2017 Nest Seasonal Savings pilot also evaluated summer cooling season savings and found an average of 4.1 kWh annual savings per opt-in participant. Between 2018 and 2020, Energy Trust did not participate in summer season optimization as a measure because the offering was not cost-effective.

[6] Energy Trust Follow-up Billing Analysis for the Nest Thermostat Heat Pump Control Pilot, 2015 https://www.energytrust.org/wp-content/uploads/2016/12/nest_heat_pump_control_pilot_follow-up_billing_analysis.pdf

[7] https://www.energytrust.org/wp-content/uploads/2017/12/Energy-Trust-of-Oregon-Nest-Seasonal-Savers-Pilot-Evaluation-FINAL-wSR.pdf

Ecobee conducted a pilot study of their *eco+* optimization service in summer 2019 and found an average of 40 kWh summer cooling savings per device[8]. That savings assumption is used to calculate ecobee market transformation savings in this analysis. Ecobee has not yet published an equivalent winter heating season savings value because not all winter season efficiency features were deployed to devices during the pilot period. Ecobee is expected to publish a follow-up pilot report in the near future that details the magnitude of winter season optimization savings, which could potentially serve as an additional source of Market Transformation savings for 2020-2022, beyond the ecobee cooling savings calculated here.

Average thermostat optimization savings for both heating and cooling across ecobee and Nest devices are weighted using the 2019 prevalence of those thermostats in the DI thermostat offing. Nest devices represented 60% of total direct-install thermostat volume, and ecobee device represented 40% of total direct-install thermostat volume over the 2019 program year.

RBSA II heating/cooling system distributions for Oregon are also factored into calculations of average optimization cooling savings. 65% of gas furnace homes and 44% of electric furnace homes are assumed to have cooling equipment, according to RBSA II values. Homes without cooling equipment are assigned zero cooling savings in this analysis.

Thermostat Optimization Opt-in Rates

A 59.5% opt-in rate assumption is applied to Nest heating season optimization savings, which is the average opt-in rate observed for the service during the program years 2018-2019. A slightly lower opt-in rate is applied to Nest cooling optimization savings, 46.9%, which comes from the 2016/2017 Nest Seasonal Savings pilot. Opt-in rates for Nest devices are effectively a combined participation rate that reflect both the portion of qualified eligible devices for the service, as well as the percentage that choose to participate in the service. Ecobee cooling savings are treated with the same opt-in rate as Nest cooling savings, 46.9%, since that information was not reported in ecobee's pilot study report.

Table 7 Weighted Average Thermostat Optimization SavingsTable 7 below shows the weighted average thermostat savings by heating system type, including opt-in rate adjustments.

Table 7 Weighted Average Thermostat Optimization Savings

Housing Type	HVAC Configuration	Heating & Fan Savings		Cooling Savings	Total Annual Savings	
		kWh	Therms	kWh	kWh	Therms
Single Family	Gas Furnace with CAC	7	8.64	5	12	8.64
Single Family	Gas Furnace (no CAC)	7	8.64	0	7	8.64
Single Family	Electric Furnace with AC	76	0	9	84	0
Single Family	Electric Furnace (no CAC)	76	0	0	76	0
Single Family	Heat Pump	43	0	9	52	0
Multifamily	Gas Furnace with CAC	7	8.6	5	12	8.64
Multifamily	Gas Furnace (no CAC)	7	8.6	0	7	8.64
Multifamily	Electric Furnace with AC	76	0	9	84	0
Multifamily	Electric Furnace (no CAC)	76	0	0	76	0
Multifamily	Heat Pump	43	0	9	52	0
Single Family	Gas Furnace Unspecified CAC	7	8.64	3	10	8.64
Multifamily	Gas Furnace Unspecified CAC	7	8.64	1	9	8.64
Single Family	Electric Furnace Unspecified CAC	76	0	3	79	0
Multifamily	Electric Furnace Unspecified CAC	76	0	3	78	0
Single Family	Unspecified Electric Heat Unspecified CAC	52	0	7	59	0
Multifamily	Unspecified Electric Heat Unspecified CAC	69	0	4	73	0

Install rate

A 100% installation rate is assumed for direct-install thermostats. Thermostats will be installed by a contractor or other authorized installer. At this time, the only known thermostat co-funding entity who will be using the direct-ship option is PGE as part of their DR thermostat program (aka RTDIP). PGE will provide verification of installation and heating fuel and other HVAC specifics such as presence of central air conditioning, when possible. Energy Trust will only pay incentives and claim savings for installed thermostats.

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.

Energy Trust also offers residential smart thermostats without co-funding. Thermostats sold are retail locations are approved in MAD 153, and those direct shipped to customers are approved in MAD 250. The measures for retail are blended by heating systems due to uncertainties in heating system reporting, while this program design anticipates greater certainty in heating, and cooling system reporting of the home. The self-install measures have reduced savings due to a lower installation rate.

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.

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 remaining cost will be most often understood as the customer payment plus Energy Trust incentive. For each HVAC system type, the maximum remaining cost column in the cost effectiveness tables indicates the maximum remaining cost after complementary funding that is cost effective.

[8] https://www.ecobee.com/en-us/ecoplusemv/

This document specifies the maximum allowable “Remaining Cost” which can be calculated as either:

Max Remaining Cost ≥ Energy Trust Incentive + Customer Payment

Max Remaining Cost ≥ Total Cost – Co-funding

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 ($0.120/kWh OR, $0.082/kWh SW WA).

Incentive Structure

The maximum incentives listed in Table 1 and ***Error! Reference source not found.*** *are for reference only and are not suggested incentives*. These values represent the maximum allowable Energy Trust incentives.

Incentives will be determined for each specific co-funding partnership as the level of complimentary funding will vary between offers. Incentives will be paid per thermostat installed.

Follow-Up

Updated evaluation results should be considered for the next measure update.

This MAD should be kept on a similar update schedule to MADs 153 and 250 and analysis should be aligned between the three as much as possible.

Supporting Documents

The cost effective screening for these measures is number 222.3.3. It 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

222.3.3 OR-WA CEC 2021 v 1.1. DI Tstat v

Version History and Related Measures

Table 8 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.
10/13/20	222.3	Updated to include Thermostat Optimization savings for Nest and ecobee devices. Unspecified HVAC and unspecified cooling measure configurations have also been added. No longer need any exceptions

Table 9 Related Measures

Measures	MAD ID
Retail Web-Enabled Thermostats	153
Direct Ship Web-Enabled Thermostats	250
Automated Thermostat Optimization (inactive)	173
Residential Thermostat Optimization Pilot (inactive)	217
Strip heat lock out for heat pumps (inactive)	19
Contractor installed thermostats on heat pumps	148
Commercial DI thermostat pilot	235

Approved & Reviewed by

Jackie Goss, PE
Sr. Planning Engineer

Disclaimer

Measure Approval Document for Direct Ship Web Enabled Smart Thermostats

Valid Dates

January 1, 2021 – December 31, 2022

End Use or Description

Web-enabled smart thermostats sold or provided directly to customers. Qualifying thermostats provide savings via reduced run time of heating/cooling systems due to occupancy sensing, setpoint optimization and heat pump 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:

- Products provided free of charge to customers
- Products sold online directly to customers at discounted rate

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

- Retrofit

Purpose of Re-Evaluating Measure

- Additional, incremental savings from thermostat optimization services for Nest and ecobee devices (have been added to the savings and cost analysis

Cost Effectiveness

Cost effectiveness is demonstrated for the most costly approved thermostat in Table 1 and Table 2. Cost effectiveness was tested using the tool OR-W-CE Calculator 2021 v 1.1. The Oregon electric and gas avoided cost year is 2021. The Washington gas avoided cost year is 2020.

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
1	DS Tstat - gFAF w/CAC	11	54	39.7	$249	$0.00	$249.00	1.6	1.6	20%	80%
2	DS Tstat - gFAF noCAC	11	22	39.7	$249	$0.00	$249.00	1.3	1.3	5%	95%
3	DS Tstat - gFAF - Gas Only	11	0	39.7	$249	$2.86	$249.00	1.3	1.4	0%	100%
4	DS Tstat - gFAF Unspecified Cooling	11	40	39.7	$249	$0.00	$249.00	1.5	1.5	15%	85%
5	DS Tstat - eFAF w/CAC	11	452	0.0	$249	$0.00	$249.00	1.5	1.5	100%	0%
6	DS Tstat - eFAF noCAC	11	421	0.0	$249	$0.00	$249.00	1.2	1.2	100%	0%
7	DS Tstat - eFAF Unspecified Cooling	11	431	0.0	$249	$0.00	$249.00	1.5	1.5	100%	0%
8	DS Tstat - ASHP	11	598	0.0	$249	$0.00	$249.00	2.0	2.0	100%	0%
9	DS Tstat - Unspecified Elec HVAC	11	550	0.0	$249	$0.00	$249.00	1.9	1.9	100%	0%

Table 2 Cost Effectiveness Calculator Washington

#	Measure	Measure Life (years)	Savings (therms)	Incremental Costs ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Ele	% Gas
2	DS Tstat - Any - gFAF - Gas Only	11	39.7	$249	$1.80	$249.00	2.2	2.2	0%	100%

Requirements

- Thermostat must be on Smart Thermostat Qualified Products List.[1]
- Home must be heated with fuel provided by a participating Energy Trust utility.
- Orders will be limited to one thermostat per central HVAC system, up to two per residence.
    1. If possible, property managers should be able to order products for residences they manage.
- Incentive cannot not exceed total product cost.
- Products provided through the direct ship offering with PGE co-funding should use the measures approved in MAD 222, rather than these.

Implementation may choose to offer HVAC specific measures or blended savings for ‘unspecified’ HVAC scenarios, but cannot use both together in the same offering.

- Measures 4 and 7 can be used if/when heating fuel is known and cooling details are unknown
- Measure 3 should be used for all gas heated homes in gas only territory, regardless of cooling presence/configuration
- Measure 9 should be used if/when heating is known to be electric, but the system type is unknown, regardless of heating presence/configuration
- Remaining HVAC specific measure configurations should be used whenever HVAC details are known

Baseline

This measure uses an Existing Condition Baseline.

The baseline assumes a standard programmable or manual thermostat, that is not enrolled in a thermostat optimization service, in a home with average HVAC loads.

[1] Energy Trust Thermostat QPL

Baseline loads for heating and cooling

For single family homes, 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]

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.

Housing Type and HVAC Configuration Blending

Dwelling type data comes from Energy Trust Project Tracker from January 2018 to March 2019 on qualified, incented midstream smart thermostats. Multifamily applications are lower than the general population because they are more likely to have incompatible zonal heating systems. Distribution of HVAC systems is based on RBSA II. Weighting factors are shown in **Error! Reference source not found.**.

Table 3 Distribution of Energy Trust mid/downstream incented smart thermostats housing types and RBSA HVAC system data

Housing Type	Dwelling Type Distribution	Cooling Prevalence in Central Furnace Homes		Central Electric Heating System Distribution	
		Gas Furnace w/ CAC	Electric Furnace w/ CAC	Electric Furnace	ASHP
Single Family/Manufactured Homes	94%	57%	31%	26%	74%
Multifamily	6%	30%	30%	80%	20%

Savings and Measure Analysis

Energy savings in this analysis have been divided into two categories: thermostat "device" savings and "optimization" savings.

Device savings refers to the energy savings that are driven by features of the thermostat device, such as occupancy detection, scheduling, maintenance alerts, and an engaging user interface.

Optimization savings are defined here as incremental savings driven by proprietary manufacturer set-point optimization algorithms. These savings occur as a result of small changes to scheduled heating and/or cooling setpoints, which are designed to be sufficiently small as to not impact customer comfort.

Device Savings – Electric Heating & Cooling

Electric forced air furnace and air source heat pump baseline loads are based on values used in the RTF connected thermostat workbook.[6] This analysis applies the Energy Trust evaluated gas furnace heating savings estimate of 6% to electric forced air furnace heating and cooling loads. Additionally, the RTF smart thermostat analysis attributes 6% cooling load saving for heat pumps and forced air furnaces, based on the assumption that the driver of savings is reduced run times similar to heating savings for forced air furnaces. This analysis uses 12% heating load savings for heat pumps heating savings.[7]

Device Savings - Gas Heating & Cooling

Gas savings. The average heating loads are assumed to be 583 therms for a single-family home and 458 therms for a multifamily home, based on RBSA results for heating zones 1 and 2. Applying a 6% savings assumption results in average annual savings of 35 therms per single-family home and 27.5 therms per multifamily home.

Cooling electric savings. 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. 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. 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 family homes. Applying the ratio used to estimate multifamily gas loads, 0.79, multifamily cooling loads are estimated to be 388 kWh annually.

Fan energy electric 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 as a separate component in electric measures as runtime reduction savings are already captured in the overall heating load and usage reductions.

Where not otherwise specified, sources for device savings are derived from the 2013-2014 Nest thermostat pilot evaluation; and is summarized in Table 4.

[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
[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] RTF Connected Tstats v1.3
[7] Energy Trust Follow-up Billing Analysis for the Nest Thermostat Heat Pump Control Pilot, 2015

Table 4 Thermostat device savings by HVAC configuration, non-optimization, without installation rates

Housing Type	HVAC Configuration	Device Heating & Fan Savings			Device Cooling Savings	Total Annual Device Savings	
		Heating kWh	Heating Fan kWh	Therms	kWh	kWh	Therms
Single Family	Gas Furnace with CAC		16.7	35.0	30	46	35
Single Family	Gas Furnace (no CAC)		16.7	35.0	0	17	35
Single Family	Gas Furnace (no CAC) Gas Only		16.7	35.0	0	0	35
Single Family	Gas Furnace unspecified CAC		16.7	35.0	17	34	35
Single Family	Electric Furnace with CAC	360			30	389	0
Single Family	Electric Furnace (no CAC)	360			0	360	0
Single Family	Electric Furnace Unspecified CAC	360			9	369	0
Single Family	Heat Pump	594		594		0	
Single Family	Unspecified Electric HVAC	536		536		0	
Multifamily	Gas Furnace with CAC		13.2	27.5	23	36	27
Multifamily	Gas Furnace (no CAC)		13.2	27.5	0	13	27
Multifamily	Gas Furnace (no CAC) Gas Only		13.2	27.5	0	0	27
Multifamily	Gas Furnace unspecified CAC		13.2	27.5	7	20	27
Multifamily	Electric Furnace with CAC	282			23	306	0
Multifamily	Electric Furnace (no CAC)	282			0	282	0
Multifamily	Electric Furnace Unspecified CAC	282			7	289	0
Multifamily	Heat Pump	467				467	0
Multifamily	Unspecified Electric HVAC	325				325	0

**Savings do not include installation rate discount or weightings for single housing type. Heat pump savings are not disaggregated which results in a single savings value for Heat Pumps and Unspecified Electric HVAC.*

Thermostat Optimization Savings

Energy Trust partnered with Google Nest from 2017 to 2019 to deliver a proprietary thermostat optimization service to Nest devices in Energy Trust territory on a "fee per participating device" basis. Energy Trust claimed energy savings for the devices that opted-in to participating in the service using stand-alone Thermostat Optimization measures that were separate and distinct from any thermostat device savings. Beginning in summer 2020, Nest's optimization service transitioned to a free service available to all qualified Nest customers. Customers must have a heating and/or cooling schedule established in order to participate in the service. Similarly, ecobee has also recently announced that launch of similar thermostat optimization service that will also be delivered free-of-charge to all ecobee thermostats. Since these services are now essentially embedded in the thermostat device itself, this measure update incorporates optimization savings into thermostat measures directly, rather than as a standalone thermostat optimization measure as had been past practice. This analysis assumes the newer Google Nest product has the same optimization capabilities as other Nest devices.

Heating season optimization savings for Nest devices are based on the per opt-in unit savings described Energy Trust's 2016/2017 Nest Seasonal Savings pilot evaluation[8]. Average optimization savings by heating system type, are shown in Table 5.

Table 5 Pilot results for Nest winter seasonal savings, original data before opt-in and product weightings

Heating System Type	Savings Source	Savings per Opt-in
Gas Furnace	Heating Energy	17.80 therms
	Fan Energy	15.34 kWh
Electric Furnace	Heating Energy	195.89 kWh
	Fan Energy	15.34 kWh
Heat Pump	Heating & Fan Energy	120.90 kWh

Energy Trust's 2016/2017 Nest Seasonal Savings pilot also evaluated summer cooling season savings and found an average of 4.1 kWh annual savings per opt-in participant. Previously, Energy Trust did not participate in summer season optimization because the offering was not cost-effective.

Ecobee conducted a pilot study of their *eco+* optimization service in summer 2019 and found an average of 40 kWh summer cooling savings per device[9]. That savings assumption is used to calculate ecobee market transformation savings in this analysis. Ecobee has not yet published an equivalent winter heating season savings value because not all winter season efficiency features were deployed to devices during the pilot period. Ecobee is expected to publish a follow-up pilot report in the near future that details the magnitude of winter season optimization savings, which could potentially serve as an additional source of Market Transformation savings for 2020-2022, beyond the ecobee cooling savings calculated here.

Average thermostat optimization savings across ecobee and Nest devices are calculated using the 2018-2019 prevalence of those thermostat brands as weights. Nest devices represented 82% of total retail thermostat volume, and ecobee device represented 18% of total retail thermostat volume over the program years 2018-2019.

RBSA II heating/cooling system distributions for Oregon are also factored into calculations of average optimization cooling savings. Fifty-seven percent of gas furnace homes and 31% of electric furnace homes have central air conditioning according to RBSA II values, as shown in . Homes without cooling equipment are assigned zero cooling savings in this analysis.

Optimization Opt-In Rate

A 59.5% opt-in rate assumption is applied to Nest heating optimization savings, which is the average opt-in rate observed for that service during the years 2018-2019. A slightly lower opt-in rate is applied to Nest cooling optimization savings, 46.9%, which comes from the 2016 Nest Seasonal Savings pilot. Opt-in rates for Nest devices are effectively a combined participation rate that reflect both the portion of qualified/ eligible devices for the service, as well as the percentage that choose to participate in the service.

The ecobee cooling savings are treated with the same opt-in rate as Nest cooling savings, as this data was not reported in the ecobee pilot study report. Heating savings are not currently available from ecobee.

[8] https://www.energytrust.org/wp-content/uploads/2017/12/Energy-Trust-of-Oregon-Nest-Seasonal-Savers-Pilot-Evaluation-FINAL-wSR.pdf
[9] https://www.ecobee.com/en-us/ecoplusemv/

Weighted average thermostat optimization savings by heating system type, including opt-in rate deductions and device weightings are shown in Table 6.

Table 6 Weighted average thermostat optimization savings by HVAC configuration, including opt-in deduction and device weightings

Housing Type	HVAC Configuration	Optimization Heating & Fan Savings		Optimization Cooling Savings	Total Annual Optimization Savings	
		kWh	Therms	kWh	kWh	Therms
Single Family	Gas Furnace with CAC	7	8.6	5	12	8.6
Single Family	Gas Furnace (no CAC)	7	8.6	0	7	8.6
Single Family	Gas Furnace (no CAC) Gas Only	0	8.6	0	0	8.6
Single Family	Gas Furnace unspecified CAC	7	8.6	3	10	8.6
Single Family	Electric Furnace with CAC	102	0	5	107	0
Single Family	Electric Furnace (no CAC)	102	0	0	102	0
Single Family	Electric Furnace unspecified CAC	102	0	2	104	0
Single Family	Heat Pump	59	0	5	64	0
Single Family	Unspecified Electric HVAC	70	0	4	74	0
Multifamily	Gas Furnace with CAC	7	8.6	5	12	8.6
Multifamily	Gas Furnace (no CAC)	7	8.6	0	7	8.6
Multifamily	Gas Furnace (no CAC) Gas Only	0	8.6	0	0	8.6
Multifamily	Gas Furnace unspecified CAC	7	8.6	1	9	8.6
Multifamily	Electric Furnace with CAC	102	0	5	107	0
Multifamily	Electric Furnace (no CAC)	102	0	0	102	0
Multifamily	Electric Furnace unspecified CAC	102	0	1	104	0
Multifamily	Heat Pump	59	0	5	64	0
Multifamily	Unspecified Electric HVAC	94	0	2	96	0

Device 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, fan, and optimization energy savings to account for products that are purchased and either not installed or later uninstalled. This analysis uses the same 92% installation rate for direct ship measures.

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 offers self-installed thermostats sold at retail, approved through MAD 153. Those measures a limited to unspecified HVAC configurations since Energy Trust has less interaction with these customers and less opportunity to verify their configuration details. Energy Trust also offers smart thermostats through PGE's demand response direct install pilot and may in the future, participate in further direct install offerings with other partners. Direct install thermostats with co-funding are offered and approved via MAD 222. Contractor installed smart thermostats in homes with heat pumps are approved through MADs 148 and 19.

Measure Life

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

Cost

For this offering, Energy Trust expects to provide the following products, at up to the cost shown in Table 7 based on online manufacturer pricing September 2020. Shipping and other transaction costs are included. Additional smart thermostat products may be added up to cost of $249. Online retail prices as of September 2020.

Table 7 Thermostat selection and cost

Model Name	Cost
Ecobee 5	$ 249
Nest 3rd Gen	$ 249
Google Nest	$ 129

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 ($0.120/kWh OR, $0.082/kWh SW WA). NEB are calculated for electric fan savings 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 thermostat. Incentives will be applied directly to purchases.

Follow-Up

Distribution of incented thermostats between single family, multifamily and manufactured home should be refreshed in subsequent updates to maintain blended savings accuracy, based on RBSA HVAC data. Install rates may change and should be monitored and updated as possible.

To the extent possible, this MAD should be updated on the same schedule as MADs 153 and 222 and assumptions aligned wherever possible. The next update should include any relevant evaluation findings.

Supporting Documents

The cost-effective screening for these measures is CEC number 250.2.2. It 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

Version History and Related Measures

Table 8 Version History

Date	Version	Reason for revision
4/20/2020	250.1	New offer for direct ship
10/13/2020	250.2	Updated to include Thermostat Optimization savings for Nest and ecobee devices. Unspecified HVAC and unspecified cooling measure configurations have also been added.

Table 9 Related Measures

Measures	MAD ID
Retail smart thermostats	153
DI Smart Thermostats with Funding Partners	222
DI Commercial Smart Thermostats Pilot	235
Automated Thermostat Optimization (inactive)	173
Residential Thermostat Optimization Pilot (inactive)	217
Contractor Installer Thermostats for New Heat Pumps (inactive)	19
Contractor Installer Thermostats for Existing Heat Pumps	148

Approved & Reviewed by

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Disclaimer

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Measure Approval Document for Residential Direct Install Ceiling Insulation with Co-Funding

Valid Dates
July 1st, 2020 to December 31st, 2022

End Use or Description
Direct installed or self-installed insulation for ceilings and/or attics to reduce space conditioning energy consumption.

This measure is expected to be delivered primarily through Community Based Organizations (CBOs), though other delivery partnerships are also approved. Complimentary Funding may come from outside of the utility system (e.g., community development block grants, Community Energy Project), or project incentives may be entirely funded by Energy Trust. The measure may also be delivered as part of co-funding collaborations with low-income weatherization agencies.

The measure may be delivered as a free service with no out-of-pocket costs to the customer, or the customer may be required to pay a small portion of project costs.

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

- Home Retrofit
- Existing Manufactured Homes
- Existing Multifamily
    - Small Multifamily (2-4 and side-by-side units)

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

- Retrofit

Cost Effectiveness
Cost effectiveness was calculated using the tool: OR-WA-CE Calculator 2021-v1.1. In Oregon the electric avoided cost year is 2021 and the gas avoided cost year is 2021. In Washington the gas avoided cost year is 2020.

Energy Trust has received guidance from the Oregon Public Utility Commission that Complimentary Funding may be subtracted from the incremental cost of a measure, and the Remaining Cost used in cost effectiveness calculations. The *Max Remaining Cost* column in Table 1 and Table 2 describes the maximum remaining cost that is cost effective for each heating system type.

Total Cost = Customer Payment + Complimentary Funding + Energy Trust Incentive

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

Table 1 Cost Effectiveness Calculator Oregon Insulation, per square foot

#	Measure	Measure Life (years)	Savings (kWh)	Savings (therms)	Max Remaining Cost ($)	Total NEB (Annual $)	Max Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Electric	% Gas
1	R0-R11 Ceiling Insulation- Gas Heat	45	0.15	0.09	$2.41	$0	$2.41	1.0	1.0	14%	86%
2	R0-R11 Ceiling Insulation- Gas Heat GOT	45	0	0.09	$2.41	$0.02	$2.08	1.0	1.0	0%	100%
3	R0-R11 Ceiling Insulation- Electric Heat	45	1.49	0	$3.38	$0	$3.36	1.0	1.0	100%	0%
4	R12-R18 Ceiling Insulation- Gas Heat	45	0.10	0.06	$1.67	$0	$1.67	1.0	1.0	14%	86%
5	R12-R18 Ceiling Insulation- Gas Heat GOT	45	0	0.06	$1.67	$0.01	$1.44	1.0	1.0	0%	100%
6	R12-R18 Ceiling Insulation- Electric Heat	45	1.03	0	$2.33	$0	$2.33	1.0	1.0	100%	0%

Table 2 Cost Effectiveness Calculator Washington Insulation, per square foot

#	Measure	Measure Life (years)	Savings (therms)	Max Remaining Cost ($)	Total NEB (Annual $)	Maximum Incentive ($)	UCT BCR at Max Incentive	TRC BCR	% Electric	% Gas
1	R0-R11 Ceiling Insulation- Gas Heat GOT	45	0.09	$3.65	$0.01	$3.44	1.0	1.0	0%	100%
2	R2-R18 Ceiling Insulation- Gas Heat GOT	45	0.06	$2.55	$0.01	$2.38	1.0	1.0	0%	100%

Requirements
- Existing condition must be R-19 or less
- Must insulate to R-38 or greater, or fill cavity
- Program must verify that each project or agreement with co-funder is within the maximum remaining cost limits.

Baseline
This measure uses an Existing Condition Baseline.

Savings are calculated for two existing condition ranges of existing insulation:

- R-0 to R-11
- R-12 to R-19

Savings
This measure development is based on evaluation results from Recurve's 2019 Residential Ceiling Insulation Impact Analysis[1], which provides average project energy savings for ceiling insulation projects in single family homes with a starting condition of R-11 or less. The energy savings measured in Recurve's evaluation reflect the average savings across both heating zone 1, 2 and 3, weighted naturally by the relative participation in each heating zone. As such, the measures shown in Table 1 and Table 2 are applicable to all heating zones. The evaluation did not distinguish savings by HVAC system type beyond heating fuel. Therefore, savings reflect the

[1] https://www.energytrust.org/wp-content/uploads/2020/02/Recurve-Ceiling-Insulation-Impact-Analysis-Reports-2013-2017.pdf

participation weighted prevalence of various heating and cooling technologies. The final Recurve evaluation results are summarized in Table 3.

Table 3 Recurve Ceiling Insulation Impact Evaluation Results (starting condtion R0 to R11)

Home Heating Fuel	Savings Type	N	Average Savings per Project	Units
Gas	Gas Heating	477	105	Therms
	Furnace Fan & Cooling Energy	238	170	kWh
Electric	Electric Heating & Cooling	107	1,730	kWh

Energy Savings for the R-12 to R-19 existing condition scenario are calculated by translating the R-0 to R-11 Recurve Impact Analysis results into units of 'energy savings per delta R-value', for each savings type. In gas heated homes, this was 0.0028 therms from gas heating and 0.0045 kWh from furnace fans and cooling per delta R. In electrically heating homes this was 0.0459 kWh per delta R. Those values are then used to calculate savings per project for R-12 to R-19 starting conditions where the average increase in R-value is 23. Extrapolated savings are shown in Table 4.

Table 4 Starting Condition R-12 to R-19 Energy Savings- Extrapolated Recurve Results

Home Heating Fuel	Savings Type	Average Savings per Project	Units
Gas	Gas Heating	73	Therms
	Furnace Fan & Cooling Energy	118	kWh
Electric	Electric Heating & Cooling	1,198	kWh

To calculate energy savings per square foot of insulation, project level savings results are divided by the average project insulation area. The average areas of ceiling insulation projects in the evaluation period was 1,161 sf.

Table 5 Final Ceiling Insulation Savings

Starting Condition	Home Heating Fuel	Savings Type	Savings per Square Foot	Units
R-0 to R-11	Gas	Gas Heating	0.09	Therms
		Furnace Fan & Cooling Energy	0.15	kWh
	Electric	Electric Heating & Cooling	1.49	kWh
R-12 to R-19	Gas	Gas Heating	0.06	Therms
		Furnace Fan & Cooling Energy	0.10	kWh
	Electric	Electric Heating & Cooling	1.03	kWh

Comparison to RTF or other programs

Energy Trust maintains a separate Single Family and Small Multifamily Insulation offering approved through MAD 58, which also includes ceiling/attic insulation for R0-R11 starting condition. The key differences this offering and the standard offer are summarized in Table 6.

Table 6 Comparison of direct install and standard insulation measures

	Direct Install Ceiling Insulation	Standard Insulation
MAD ID	252	58
Measures Included	Ceiling/Attic Insulation	Ceiling/Attic, Floor, Wall and Knee Wall Insulation
OPUC Cost-Effectiveness Exception and incentive caps	No	Yes
Addresses Co-funding	Yes	No
Delivery Pathways	Self Install, Professional Install, Direct Install	Self Install, Professional Install
Source of Savings values	2013-2017 Recurve Impact Study	2009-2014 Energy Trust Billing Analysis

The RTF also maintains ceiling insulation measures for both single family and manufactured homes which describe savings by heating/cooling zone, electric HVAC system and beginning/ending R-values[2]. The Recurve-based savings values in in this analysis are similar to the RTF's savings values for ceiling insulation for both the R-0 to R-11 and the R-12 to R-19 starting condition scenarios. The RTF's analysis also assumes a 45 year measure life.

Measure Life

This measure uses a 45 year measure life, consistent with Energy Trust's other residential insulation and weatherization measures.

Load Profile

Gas savings have been assigned to the load profile *Residential Gas Heat.*

Electric savings in gas heated homes derived from furnace fan and cooling savings have been assigned to the electric load profile *Res Air Source HP,* which is used in situations when cooling savings represent between 2-29% of total annual savings. The same load profile has also been assigned to value the energy savings in electrically heated homes.

Cost

Costs for Direct Install Ceiling Insulation projects will vary based on the details of complimentary funding agreements with individual CBOs. Energy Trust will verify that each project or funding agreement is within the maximum remaining costs. Depending on the details of the funding agreements, remaining cost may be calculated as either:

- The total cost of a project minus complementary funding, or
- The customer's portion of the cost plus Energy Trust's incentive

These requirements are for complimentary funds that are not derived from the public purpose charge (PPC), or from utility ratepayers. Ratepayer funding for the purpose of the cost effectiveness testing is not treated as "complimentary funding".

Costs incurred during a direct install ceiling insulation project, but that are 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 complimentary funds or through participant payments.

[2] https://rtf.nwcouncil.org/measure/single-family

Similar to other retrofit measures, the actual total cost for projects will be recorded in Project Tracker (PT) for use in program level cost-effectiveness testing at year end and other uses.

Non Energy Benefits

In both Oregon and Washington, unclaimed electric savings are included as non-energy benefits valued at the retail residential rate of electricity for those territories, $0.120/kWh in Oregon and $0.082/kWh in SW Washington.

Incentive Structure

The maximum incentives listed in Table 1 and Table 2 are for reference only and are not suggested incentives. In projects with complementary funds sourced from the PPC or other ratepayer sources the total of complementary funding and energy trust incentives must not exceed the maximum incentives.

Incentives may be structured on a per square foot basis or a per project basis but must not exceed the per square foot maximums listed in Table 1 and Table 2. Incentives may be paid directly to contractors, co-funding partners, or customers.

Follow-Up

Aligning methods and sources between this MAD and MAD #58 should be considered. The expiration date on this document is set to align with MAD 58 to encourage concurrent updates.

If Energy Trust is successful in quantifying health related NEBs for weatherization projects they should be considered in the next update

The savings used in this analysis reflect the distribution HVAC system types and efficiencies for the standard offing in the period of 2013-2017, however this is likely to change over time as households replace heating equipment, or if the direct install offering reaches customers with different home characteristics. Cooling savings captured in the 2013-2017 Recurve evaluation reflect the prevalence of cooling for that period. As cooling becomes more prevalent, cooling savings can be expected to increase.

Supporting Documents

The cost effective screening for these measures is number CEC 252.1.1. It 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

252_1_1 CEC OR WA 2021v1_1 Res DI Insu

Version History and Related Measures

Table 7 Version History

Date	MAD ID	Revision Summary
7/3/2020	252.1	Introduce Direct Install Insulation

Table 8 Related Measures

Measures	MAD ID
Single Family and Small Multifamily Insulation	58

Approved & Reviewed by

Jackie Goss, PE
Sr. Planning Engineer

Disclaimer

Measure Approval Document for Income Qualified and Rentals Limited-Time Offer

Valid Dates
September 8, 2020 – March 31, 2021

Description
Energy Trust has assessed ways to increase incentives for vulnerable customer groups who may be experiencing increased impacts of energy costs due to COVID-19 impacts on employment and housing. This limited time offer for select Residential and Multifamily measures provides incentive levels beyond current incremental costs, up to UCT = 1.0 or full project cost, for projects targeting income qualified and rental customers and households.

Measures were selected for inclusion in this limited-time offer based upon the following criteria:

- Raising incentives to the amount where UCT = 1.0 increases incentives enough to increase participation.
- Measure is likely to serve to low or moderate-income households.

This document provides temporarily increased maximum incentives for the following measures. Additional measures may be included in the limited time offer, but are not included here because their approved maximum incentives already allow for increases or are already near UCT = 1.0.

- Ductless Heat Pumps (DHP) in single family homes with existing forced air furnaces (FAF).
- DHPs in manufactured homes with existing zonal or FAF.
- Attic Insulation in single family or small multifamily homes with starting condition R11 or less.
- Wall Insulation in single family or small multifamily homes, with electric heat.
- Smart thermostats through retail channels. Does not include direct installs or direct ship offerings.
- Packaged Terminal Heat Pumps (PTHP) in multifamily homes, including dorms and assisted living.
- Heat Pump Water Heaters (HPWH) in Single family or multifamily homes in heating zone 1.
- Commercial Condensing Tank Water Heaters in multifamily buildings with central water heat.
- Ceiling insulation in stacked multifamily properties with starting condition of R18 or less.
- Floor insulation in stacked multifamily properties with starting of R11 or less, with electric heat.

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

- Existing Multifamily
- Home Retrofit
- Products
- Existing Manufactured Homes

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

- Savings within Reach
- Income Qualified Customers
- Energy Burdened Customers
- Renters and Rental Properties in Single-Family and Multifamily
- Affordable Housing Organizations

Purpose of Re-Evaluating Measure
This document provides updated maximum incentives to previously approved measures. There are no changes to any other measure definitions.

Cost Effectiveness
Cost effectiveness is demonstrated for Oregon in Table 1. Cost effectiveness was calculated using the tool: OR-WA-CE Calculator 2021-v1.1. In Oregon the electric avoided cost year is 2021 and the gas avoided cost year is 2021.

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
1	SF DHP for FAF HZ1 (IQR_LTO)	18	3,863	0.0	$4,148	$36.50	$4,986.51	1.0	1.3	100%	0%
2	SF DHP for FAF HZ2 (IQR_LTO)	18	3,619	0.0	$4,148	$36.50	$4,672.34	1.0	1.2	100%	0%
3	Manufactured Home DHP for Zonal HZ1 (IQR_LTO)	18	3,894	0.0	$3,596	$94.56	$5,027.24	1.0	1.7	100%	0%
4	Manufactured Home DHP for Zonal HZ2 (IQR_LTO)	18	3,894	0.0	$3,596	$82.33	$5,027.24	1.0	1.7	100%	0%
5	Manufactured Home DHP for FAF HZ1 (IQR_LTO)	18	3,324	0.0	$3,360	$118.77	$4,290.91	1.0	1.7	100%	0%
6	Manufactured Home DHP for FAF HZ2 (IQR_LTO)	18	3,324	0.0	$3,360	$161.85	$4,290.91	1.0	1.9	100%	0%
7	SF DHP for FAF HZ1 - Sup Fuel (IQR_LTO)	18	3,512	0.0	$4,148	$401.50	$4,533.84	1.0	2.3	100%	0%
8	SF DHP for FAF HZ2 - Sup Fuel (IQR_LTO)	18	3,512	0.0	$4,148	$401.50	$4,533.84	1.0	2.3	100%	0%
9	SF SMF Attic insulation Gas Heat (R0-R11 starting condition) HZ1 (IQR_LTO)	45	0.20	0.07	$1.50	$0.01	$2.40	1.0	1.7	29%	71%
10	SF SMF Attic insulation Gas Heat (R0-R11 starting condition) HZ2 (IQR_LTO)	45	0.18	0.07	$1.50	$0.01	$2.34	1.0	1.7	27%	73%
11	SF SMF Attic insulation Ele Heat (R0-R11 starting condition) Any Zone (IQR_LTO)	45	0.73	0.00	$1.38	$0.01	$1.64	1.0	1.4	100%	0%
12	SF SMF Wall insulation Ele Heat Any Zone (IQR_LTO)	45	1.34	0.00	$1.89	$0.03	$3.02	1.0	1.9	100%	0%
13	Residential Tier 3+ HPWH (IQR_LTO)	13	1,364	(2.04)	$774	-$6.42	$1,071.52	1.0	1.3	100%	0%
14	Retail Smart Tstat Any Home - Electric (IQR_LTO)	11	486	0.00	$170	$0.00	$332.58	1.0	2.0	100%	0%
15	Retail Smart Tstat Any Home - Gas (IQR_LTO)	11	42	31.75	$170	$0.00	$311.09	1.0	1.8	19%	81%
16	Shift Model Top-Load Clothes Washer Pair - Electric DHW (IQR_LTO)	14	150	0.00	$65	$16.48	$119.25	1.0	4.4	100%	0%
17	Shift Model Top-Load Clothes Washer Pair - Gas DHW (IQR_LTO)	18	137	1.10	$65	$16.48	$115.94	1.0	4.4	94%	6%
18	PTHP in MF in heating zone 1 (IQR_LTO)	18	1,630	0.0	$765	$0.00	$1,357.94	1.0	1.8	100%	0%
19	Condensing tank water heater in MF (IQR_LTO)	18	0	3.20	$3	$0.00	$27.00	1.0	8.3	0%	100%
20	Ceiling insulation – stacked MF ELE SPHT (IQR_LTO)	45	0.39	0.00	$0.36	$0.00	$0.88	1.0	2.4	100%	0%
21	Ceiling insulation – stacked MF GAS SPHT (IQR_LTO)	45	0.05	0.02	$0.36	$0.00	$0.74	1.0	2.0	38%	62%
22	Floor insulation – stacked MF ELE SPHT (IQR_LTO)	45	0.39	0.00	$0.82	$0.00	$0.88	1.0	2.1	100%	0%

Requirements

- All measures must meet the requirements, including size and capacity limits, specified in the corresponding MADs listed in Table 2, as well as all program guidelines.
- Incentives will not exceed the maximum incentives in Table 1, except for shift model clothes washers, which is not a prescriptive incentive.
    - The shift-model clothes washer 2021 v 1.1 CEC tool may be temporarily modified to allow incentives to exceed incremental cost. The 2021 tool should be used for this offer's incentives, including offers in the market in late 2020.
- Incentives are not to exceed full project costs
- Programs must ensure that the increased incentives are being offered to limited income customers and rental properties only.
    - Programs must document how customers are being identified for this limited time offer.

Measure Analysis

This MAD consolidates measures from several existing MADs. Refer to the documents identified in Table 2 for measure analysis such as baselines, measure costs, measure lives and non-energy benefits and requirements.

Table 2 Measure Approval Document versions used in maximum incentive analysis

Description	MAD Version	Publication Date	Active Date	Expiration Date
Ductless Heat Pumps in Existing Single Family and Manuf. Home	70.4	4/1/2020	4/1/2020	3/31/2022
Existing Single Family and Small Multifamily Insulation Retrofit	58.2	10/24/2019	1/1/2020	12/31/2022
Existing Stacked Multifamily Insulation Retrofit	110.2	9/30/2019	1/1/2020	12/31/2022
Residential Heat Pump Water Heaters	52.3	7/16/2019	1/1/2020	12/31/2022
Retail Web Enabled Thermostats	153.3	7/11/2019	8/1/2019	12/31/2022
Shift Model Top-Loading Clothes Washers	218.2	10/11/2019	1/1/2020	12/31/2020
Package Terminal Heat Pump in Multifamily and Lodging	34.3	5/7/2020	1/1/2021	12/31/2023
Commercial Condensing Tank Water Heaters	21.2	7/13/2018	1/1/2019	12/31/2021

This offering is based on the latest approved MADs as of 8/26/2020. Several of these MADs are expected to be replaced or to become active on 1/1/2021 or 2/1/2021, in the middle of the limited time offer. This will lead to mis-matches between savings and other measure definitions for projects going through the offering and regular program activity.

- The PTHP increased incentive is based on a MAD that becomes effective in 2021. As this offer becomes active in Q4 2020, reported savings will be different for participants of this offering and the regular program during 2020.
- The Retail Web-Enabled Thermostats MAD is expected to be updated and a new version will become active 1/1/2021. Reported savings will be different for participants of this offering and the regular program during 2021.
- The Shift Model Clothes Washer MAD will be updated, and a new version will become active 1/1/2021. There are no expected changes to methodology that would result in mis-matched savings.

The measures included in this offering do not include all measures in the associated MADs.

Incentive Structure

Energy Trust obtained approval from OPUC Staff on 8/5/2020 to exceed incremental costs, up to UCT = 1.0 or full project cost, for these measures through 3/31/2021.

Maximum incentives for DHPs, thermostats, HPWHs, and PTHPs are per unit. Maximum incentives for insulation are per square foot of insulation. Maximum incentives for condensing tank water heaters are per kBtu/h capacity.

The incentive for shift-model washers is not prescriptive, but is calculated independently for each retailer. For this limited time offer, the shift-model team may use a modified 2021 CE calculator to allow incentives to exceed incremental cost.

Follow-Up

This limited-time incentive increase is approved through March 31, 2021. Program staff will report to the OPUC in Q1 2021 regarding the resulting impacts and success of this approach.

Any future extensions of these increased incentives will need to incorporate the most current versions of MADs.

Supporting Documents

The cost effective screening for these measures is number 260.1.1. It is attached and can be found along with supporting documentation at: I:\Groups\Planning\Measure Development\Residential\Whole Home\multiple measures incentive\2020 Income Qualified and Renters LTO

260.1.1 OR-WA-CE C_2021_v_1_1 incom

Version History and Related Measures

Table 3 Version History

Date	Version	Reason for revision
9/8/2020	260.1	Approval of selected measures with increased incentives to accommodate the 2020-2021 limited time offer for Income Qualified and Rental Customers and Households

Table 4 Related Measures

Measures	MAD ID
Ductless Heat Pumps in Existing Single Family and Manufactured Home	70
Residential Heat Pump Water Heaters	52
Existing Single Family and Small Multifamily Insulation Retrofit	58
Existing Stacked Multifamily Insulation Retrofit	110
Retail Web Enabled Thermostats	153
Shift Model Top-Loading Clothes Washers	218
Package Terminal Heat Pump in Multifamily and Lodging	34
Commercial Condensing Tank Water Heaters	21

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.

[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.

4.4 Appendix 4: History of Project Counts and Savings

Annual therm targets are forecasted with all information available to Programs. Estimates of market potential along with historical averages is used to provide a general appreciation of what is cost-effectively possible. Specific measure savings and estimated quantities are then used to determine the exact goal. Considering ~87 Residential measures and ~98 Commercial measures, Programs calculate annual goals through determining what quantities are likely to be realized. Commercial programs also consider the contribution of custom projects in their goal forecast. The below information is provided to show the relative impact of savings per measure, which is meant to highlight the relative variability of forecasting to actual realized savings.

			2018	2019	2020
Residential	Retrofit*	Goal	138,115*	152,600*	141,428*
		total therms	76,002	76,851	NA
		measures	2,707	3,140	NA
		average therms/measure	28.08	24.47	NA
	New Con	Goal	61,765	69,114	86,490
		total therms	73,222	75,698	NA
		measures	709	756	NA
		average therms/measure	103.27	100.12	NA
Commercial **		Goal	160,000	147,481	111,413
		total therms	161,632	168,751	NA
		measures	86	94	NA
		average therms per measure	1,879.44	1,688.84	NA

* Only Capital measures were included; Energy Saver Kits, retail showerheads, and thermostat optimization were all excluded.

** Commercial Therms per site can range between 150 and 20,000+