June 2, 2016

Measure Approval Document for Automated Thermostat Optimization Pilot

Valid Dates: June 1, 2016 to December 31, 2017

End Use
Residential Space Conditioning

Program
Existing Homes

Description of Measure
Seasonal Savings is an offering of Nest Labs. It is a service that Nest Labs provides to utility programs on a fee for service basis. Existing customers are recruited via messages on the Nest Thermostat and via e-mail requesting they sign for a free energy saving service. There are two enrollment periods each year, summer and winter. These messages can be cobranded. Once enrolled, Nest Labs applies a series of algorithms over a three week period that seeks to deploy consumer acceptable adjustments to the thermoset settings. This occurs during occupied hours as well as unoccupied times. The changes in interior temperature are minor, less than 1.5 degrees Fahrenheit in all cases. The measure reduces heating and cooling run time by lowering the average delta-t between indoors and outdoors.

Measure Requirements

- Participant to have a web connected Nest thermostat within Energy Trust's Oregon service territory.
    - Winter program: Home heated with air source heat pump or gas or electric forced air furnace.
    - Summer program: Home has central air conditioning.

Savings

Heating Savings
Estimated savings for the winter component of the Seasonal Savings pilot are based on evaluated reductions in heating system run time from a study in the Northeastern United States. Findings indicate the average reduction in system run times was 3.5% which is used as the estimated reduction in energy usage.

Estimated Seasonal Savings by Heating Type and Overall Based on Heating Load

Heating System Type	Heating Load	Savings at 3.5%	Final savings after oil furnace de-rating (3%)	Forced air furnace distribution (Nest installs)	Weighted kWh savings	Weighted therm savings
Gas Forced Air Furnace, Therms	583	20.4	19.8	87%		17.3
Electric Forced Air Furnace, kWh	5,992	210	203	13%	26	
Weighted Forced Air Furnace Heating Savings				100%	26	17.3
Heat Pump, kWh	6,508	228	228			

Savings are based on 3.5% of estimated heating loads currently used for smart thermostat installations on heat pumps and electric or gas fueled forced air furnaces. The RBSA distribution of heat pumps and forced air furnaces in Oregon is used to allocate gas and electric savings, with furnace estimates being de-rated by 3% to account for the share of furnaces fueled by oil.

Given that the fuel source of a forced air furnace cannot be determined, a weighted savings estimate is calculated based on the distribution of customer reported furnace fuel for Nest thermostat installations from October 2015-May 2016.

Cooling Savings

Seasonal Savings will only be offered to customers who have detectable central air conditioning, which can be determined remotely by the control configuration of the thermostat. Air conditioning savings are assumed to be the same across heating systems. Nest reports that the average annual run time for Nest equipped homes is 520 hours in Oregon.

RBSA data indicates the average cooling capacity of central air conditioning units and heat pumps in Oregon is 3.4 tons with an average SEER of 11.6. The US Department of Energy estimates SEER 11.6 units use an average of 1 kW/ton/hour.

Estimated Cooling Savings

Average cooling capacity in tons	Annual central AC hours in Oregon (Nest reported)	kWh/ton/hour	Estimated annual total cooling kWh (when central AC is present)	Estimated kWh savings at 3.5%
3.4	520	1.0	1,829	64

Net to Gross:

Evaluation results from a winter Seasonal Savings deployment in the Northeast US indicated 9% of eligible participants who opted into the offering dropped out before the end of the study period. The 3.5% savings estimated in the study excludes all participants who did not complete the full seasonal savings scheduling adjustment window.

BCR: (link: I:\Groups\Planning\Measure Development\Residential\Res HVAC\thermostat\web enabled thermostat\bencost\Seasonal Savings CE_5_20_2016 Pilot.xlsm)

#	Measure	Measure Life (yrs)	Savings		Incremental Costs ($)	Non-Energy Benefits (Annual $)	Maximum Incentive ($)	Utility BCR at Max Incentive	TRC BCR
			kWh	therms					
1	Gas FAF Winter Seasonal Savings	1	-	19.8	$3	$0	$3	2.59	2.59
2	Electric FAF Winter Seasonal Savings	1	203		$3	$0	$3	4.77	4.77
3	Forced Air Furnace Seasonal Savings Weighted	1	26	17.3	$3	$0	$3	2.87	2.87
4	Heat Pump Winter Seasonal Savings	1	228		$3	$0	$3	5.17	5.17
5	Summer Seasonal Savings Weighted	1	64		$3	$0	$3	2.20	2.20

Measure Life

The Seasonal Savings algorithm is activated once each winter and summer for participants. Given that persistence has not yet been investigated the measure life is one year.

Incentives

The cost effectiveness calculator lists the maximum cost effective incentive level.

Costs

Cost per customer signup is $3 for each summer and winter activation period. There is an additional program fee that is not included in the per unit cost analysis here as it is not yet known how many units will participate in this pilot. If pilot is successful, the annual on-going program fee would need to be considered in final measure cost-effectiveness, but is not likely to be significant as full program participation is expected to be larger than for this pilot (so fee would be distributed over more units).

Support Documents:

Single Family Residential Building Stock Assessment

US DOE Energy Star Central Air Conditioning Calculator

Measure Approval Document for web enabled thermostat for forced air furnaces

Energy Trust Heat Pump Pilot Billing Analysis

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Reviewed by Paul Sklar, PE, Energy Trust of Oregon Planning Engineer

Reviewed by Mike Bailey

Measure Approval Document for 2017 EPS™ New Homes in Washington

Valid Dates
January 1, 2017 to December 31, 2020 or until next Washington residential code update

End Use
Residential New Construction

Program
New Homes Washington

Scope
New Homes EPS™ pathways and program structure are approved for new gas-heated single family construction in Washington. Energy Trust's programs serve only gas customers in Washington and while these homes save both gas and electricity, only gas savings are eligible for incentives.

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

Program Requirements
- All projects participating in the SW WA New Homes program will be simulated using REM/Rate v14.6.1 NW modeling software and uploaded to the Axis database and EPS calculation tool for determination of incentives, savings and overall EPS rating
- Homes must be heated with Northwest Natural gas service
- Builders are required to work with a RESNET® accredited HERS provider

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

Table 1 EPS Pathway Cost Effectiveness, 2,200 sf example home

Measure	Measure Life (yrs)	Savings therms	Incremental Costs ($)	Non-Energy Benefits (Annual $)	Maximum Incentive ($)	Utility BCR at Max Incentive	TRC BCR
Path 1 - 10% Improvement	34	53	$869	$33	$629	1.00	1.45
Path 2 - 20% Improvement	39	111	$2,701	$34	$1,396	1.00	0.78
Path 3 - 30% Improvement	41	161	$7,557	$50	$2,080	1.00	0.41
Path 4 - 40% Improvement	42	199	$8,970	$51	$2,596	1.00	0.41

Aside from pathway 1, these measures do not pass the TRC individually or as a weighted average. These measures are only approved for use in Washington. In Washington, the Washington Utilities and Transportation Commission (WUTC) has directed Energy Trust to use the Utility Cost Test as the primary determinant of cost effectiveness, and to monitor the Total Resource Cost. There is a long history of new home programs leading to market transformation, by increasing building acceptance of advanced practices, leading to lower costs and enhanced building codes. As a result the long term cost-effectiveness is likely to be better than that shown here.

In Washington, Energy Trust does not claim electric savings. The benefits of the electric savings are used in the TRC test, but not in the utility test. Energy Trust will track the electric savings as unclaimed savings and coordinate with electric utilities in the area as needed. All electric savings use the weighted average measure life of the modeled pathway improvement multiplied by the current Clark Public Utility residential retail rate of electricity, $0.082/kWh, to calculate the non-energy benefit associated with reductions in electric usage.

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 elected to use REM/Rate to model both the expected baseline as well as each home entering the program. As an energy modeling tool, REM/Rate is a widely accepted energy modeling engine used for estimating the performance of new homes. 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.[i]

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. Non-energy benefits associated with reduced water and sewer charges are also included in the cost effectiveness screening and align with MAD ID 131.

Baseline

The 2016 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 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:[ii]

- 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. Baseline and modeled paths are shown in Table 2. Red font highlights changes in each path compared to immediately prior less efficient path (upgrades).

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	53	111	161	199
		kWh Savings	216	235	426	445
		% Better-Gas Only	12%	24.1%	35.1%	43.4%

Measure life

Weighted average measure lives are presented in Table 1. Each improvement pathway has its own estimated measure life. REM/Rate does not provide outputs by all specific end-use heating related components. In order 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.

Incentive Structure

Table 1 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 not exceed the maximum cost effective incentive level as described in this document. Incentives will be developed based on percent savings above code. For

REM/Rate modeled homes that have savings which fall between the defined pathways a “sliding scale” approach will be used to estimate the savings to be claimed by the program and the incentive level to be paid.

Costs

Costs in Table 1 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.[iii] These costs 2006 costs are adjusted using the GDP deflator to 2015 dollars (2006$*1.146), the last year with full data available with the RTF’s current standard information workbook.[iv]

Weatherization and Windows

- Ceiling Insulation R49 + R21 heel - New Construction Built Green Washington RTF workbook[iv], cost adjusted to $0.18/sqft from R49 baseline.
- Ceiling Insulation R-60 Adv. - New Construction Built Green Washington RTF workbook[iv], cost adjusted to $0.0146/sqft from R-49 baseline.
- Wall Insulation - (U-0.051) R-23 BIB or R-21 Adv. - Sixth power plan Appendix G: table G-2, cost adjusted to $0.17/sqft.
- Wall Insulation (U-0.035) 2x 8 Adv. BIB or R-23+7 cont. - NEEA NSH Phase I cost data $1.00/sqft.
- Windows - U-0.25 SHGC-no requirement- 0.30 - 6th Plan Appendix G, Table G-2, cost adjusted to $0.89/sqft.
- Windows - 0.22 SHGC-no requirement-0.25 - U-0.22 SHGC-no requirement-0.25 – 6th Plan Appendix G: Table G-2, cost adjusted to $1.84.[v]
- Windows - U-0.20 SHGC-no requirment-0.25 - 6th Plan Appendix G: Table G-2, cost adjusted to $1.84.
- Infiltration 1 ACH50 reduction – RTF New Construction - Energy Star Homes Single Family – Washington analysis[iv], cost adjusted to $0.10/sqft/ACH50 reduction.**Error! Bookmark not defined.**

Heating Systems

- Gas Furnaces 95-96 AFUE – Incremental cost between 91.8% AFUE and 95.7% AFUE is $450, which is the closest available cost estimate to the 94% AFUE baseline furnace.[vi]

Mechanical Ventilation

- Efficient whole-home mechanical ventilation - $57 from RTF OR Energy Star New SF Homes 2012.[vii]
- Heat Recovery Ventilator - HRV (75% SRE 1.25 CFM/w) - NEEA next step homes Phase I cost data, $1837.44.

Low Flow Fixtures

- Showerheads - Includes one 1.75 GPM showerhead cost based on the MAD for Low Flow Showerheads in New Homes, MAD ID 131 published April 15, 2016.

Lighting upgrades

- Lamps – REM/Rate models improved lighting percentages rather than bulb counts and efficacy. The program specification is to increase percent of efficient lighting; the current RTF incremental cost, to increase high efficiency lighting to 100% is $0.[viii]

Supporting Documents

The Cost effective screenings for these measures is attached and can be found at: I:\Groups\Planning\Measure%20Development\Residential\New%20Homes\EPS\WA%20EPS\bencost\WA%20EPS%20CE-2017-v1.2-9_2_2016.xlsm

WA EPS
CE-2017-v1.2-9_2_20

Additional Supporting Documentation can be found at: I:\Groups\Planning\Measure Development\Residential\New Homes\EPS\WA EPS

Follow Up Plans

This offering is approved for homes built to the 2015 Washington State Energy Code. Washington code cycles are on a three year review/change cycle. The program will review code during the next code cycle and will make any necessary updates to the program pathways, savings and incentives if/when substantial energy code changes are implemented.

Measure History and Related Measures

Table 3 EPS Oregon measure approval 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
9/7/16	145.x	Updates for 2015 building codes, redesigned pathways

Table 4 Related Measures

Measure	MAD ID
EPS in Oregon	181

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[i] 2009-2011 New Homes Billing Analysis: Comparison of Modeled vs. Actual Energy Usage http://assets.energytrust.org/api/assets/reports/2009-2011_New_Homes_Billing_Analysis.pdf
[ii] 2015 Washington State Energy Code: https://fortress.wa.gov/ga/apps/sbcc/Page.aspx?nid=14
[iii] Sixth Northwest Conservation and Electric Power Plan Appendix G https://www.nwcouncil.org/media/6311/SixthPowerPlan_Appendix_G.pdf
[iv] RTF Standard Information Workbook: http://rtf.nwcouncil.org/measures/support/files/RTFStandardInformationWorkbook_v2_6%20PENDING%20QC.xlsx
[v] PNNL: www.windowsvolumepurchase.org)
[vi] WA Gas Furnace MAD: https://staffnet.energytrust.org/Operations/PandE/Blessing%20Memos/gas%20furnace%20in%20Washington.docx

[vii] RTF Residential: New Construction - Energy Star Homes SF - Oregon 2012 http://rtf.nwcouncil.org/measures/measure.asp?id=182
[viii] RTF New Construction - Energy Star Homes SF – Washington v2.5.
http://rtf.nwcouncil.org/measures/res/ResSFEStarBuiltGreenHomesWA2014_v2_5.xlsm

November 11, 2015

This revision reduces the required qualifying efficiency rating to align with Energy Star and Products. The savings and maximum incentives are reduced accordingly.

MEASURE APPROVAL DOCUMENT FOR MULTIFAMILY CLOTHES WASHERS

Valid dates: January 1, 2016 to December 31, 2017.

End Use
Clothes washers

Scope
Distributor buy-down of multifamily "in-unit" front-loading clothes washers with **efficiency rating of 2.38 or higher Integrated Modified Energy Factor (IMEF)** and at least 2.5 cubic feet tub capacity. **Incentives for top-loading clothes washers are CANCELLED** due to no longer cost-effective (see below analysis).

Measures are approved as cost-effective for "in-unit" installations in multifamily properties in the following market segments:

- Retrofit
- Replacement
- New

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

- New Multi-Family
- Existing Multi-Family

TABLE 1: Cost Effectiveness Calculator

#	Measure	Measure Life (yrs)	Savings		Incremental Costs ($)	Non-Energy Benefits (Annual $)	Max Incentive ($)	Utility BCR at Max Incentive	TRC BCR	Benefit Ratio	
			kWh	therms						Electric	Gas
1	MF clothes washers - Electric DHW	14	255	-	$209	$60	$209	1.15	3.94	100%	0%
2	MF clothes washers - Gas DHW	14	117	6	$209	$60	$126	1.00	3.54	76%	24%

Measure Analysis
This analysis uses savings estimates from the Regional Technical Forum, approved on April 14, 2015, with a translation to gas savings, where appropriate, based on 75% average thermal efficiency of gas water heating. All dryers are assumed to be electric. The analysis splits the measure out by water heating fuel for the purpose of differentiating savings.

The IMEF is a per unit volume measure of the number of cycles required to use a kilowatt hour of energy. It combines mechanical energy used by the washer, water heating, and energy required to remove

moisture content remaining after the spin cycle. Integrated Water Factor (IWF) is the gallons of water per cycle per unit volume of laundry.

Machine Energy Savings are calculated from the Energy per cycle multiplied by the Cycles per year. Energy per cycle is a function of configuration (front vs top load). Cycles per year is the number of cycles required to wash the Clothing Washed Per Year, assuming the DOE test procedure cloth weight per cycle, which is a function of tub volume.

Dryer Energy Savings are calculated from the difference in moisture content multiplied by the Annual Cloth Weight and the Dryer kWh per lb moisture. For gas fuel, a Gas Correction Factor is applied to the consumption.

DHW Energy is the remainder of the energy calculated by the DOE test procedure after subtracting the Machine Energy and the Dryer Energy. For gas fuel, results are divided by the Gas Water Heating Efficiency. The DOE test procedure uses the following equation for Dryer Energy:

DOE Dryer Energy is (Rated RMC - 4%) * Annual Cloth Weight * 0.5 kWh per lb moisture * Percentage of Washed Clothes Dried

The DOE equation above differs from the *Dryer Energy Savings* above by an additional 35% adjustment factor for the Remaining Moisture content and the Dryer kWh per lb of moisture.

Non-energy water savings are calculated from the average tub size, average IWF, cycles per year, and the RTF's standard water rate.

Savings and baseline
The savings and baseline characterization for this measure are based on MF sales data, which is taken to be representative of the multifamily (in-unit) market. There are two distinct categories of washers in this data set:

1. Federal standard top-loaders (85% of sales)
2. High efficiency front-loaders (15% of sales)

Consistent with the baseline method for Energy Trust's Residential Clothes Washer Measure and with the RTF's baseline method, a combined top & front loader baseline representing current practice for the multifamily "in-unit" market is calculated here for the purpose of determining energy savings. Annual energy use for federal standard top-loaders and for ENERGY STAR front-loaders are taken directly from the RTF workbook for residential clothes washers, and then weighted according to the percentage of distributor sales as noted above.

Since the efficient front-loaders in the MF sales data corresponds to an ENERGY STAR efficiency rating (IMEF>2.38), ENERGY STAR rated front-loaders are taken as the efficient case for quantifying energy savings. Annual energy use for ENERGY STAR front-loaders is taken directly from the RTF's analysis. Calculating savings with respect to a combined baseline in this way assumes that customers who would have bought top-loading clothes washers are able and willing to purchase front-loaders instead.

Annual non-energy benefits are calculated based on the reduced water use between the baseline and the efficient case. The average tub size and the average IWF (Integrated Water Factor) values used in calculating these water savings are taken from the multifamily sales data, and the equations for calculating these savings are consistent with the RTF's analysis.

Measure life

A measure life of 14 years is used, consistent with the RTF's residential clothes washer measure.

Incentive

The maximum incentive is indicated in the cost effectiveness calculator and is the lesser of the incremental cost and the present value of the utility benefit. This value is listed for reference only and is not a suggested incentive.

Cost

All baseline and incremental costs are taken from the multifamily sales data. A combined and weighted top and front-loader baseline is used, with incremental cost representing the difference in cost between the baseline and ENERGY STAR efficiency front-loaders.

The cost effective screening for these measures can be found at:
file:///I:\Groups\Planning\Measure%20Development\Residential\multifamily%20clothes%20washers\ETO%20CEC%20-%20Multifamily%20clothes%20washers.xlsm

Supporting documentation, including the relevant MF sales data and the RTF residential clothes washers workbook, is found in the following folder:
I:\Groups\Planning\Measure Development\Residential\multifamily clothes washers

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Reviewed by Paul Sklar & Mike Bailey

April 19, 2016

Measure Approval Document for Residential Aerators

Valid from April 15, 2015 to December 31, 2018

End Use:
Installation of aerators by a contractor, PMC, multifamily builder, or at a Home Energy Review (HER)

Scope:
Bath faucet aerators and kitchen faucet aerators from 2.0 gpm to 0.5 gpm

Program:
Based on the referenced analysis and associated cost-effectiveness screening, the measures described below are approved as cost-effective for inclusion in the Home Energy Savings, Existing Manufactured Homes, New Multifamily Buildings, **New Homes as it pertains to small multifamily homes (2-11 units),** and Existing Buildings Multifamily programs. Aerators in Washington and aerators in commercial programs are memorialized separately.

Within the approved market segments, applicability to the following building types are expected:

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

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

Purpose of Evaluating the Measure:
The savings analysis for aerators is consolidated in this memo in order to standardize baseline flow rate data, % hot water, average water heater efficiencies, and average occupancy.

Program Requirements:

2.0 gpm kitchen aerator, 1.5 gpm, or 1.0 gpm

1.5 gpm bathroom faucet aerator, 1.0 gpm, or 0.5 gpm

Water heating fuel must be provided by an Energy Trust Utility

BCR Calculator Link: I:\Groups\Planning\Measure Development\Residential\Res Water Reduction\aerator\bencost\ETO CEC Residential Aerator 2015.xlsx

Project	Measure Lifetime (Maximum 70 yrs)	Annual Electricity Savings, kWh	Annual Gas Savings, therm	Total Cost	MAX ETO INCENTIVE	Non Energy Benefits (if any)	Combined Utility System BCR	Combined Societal BCR
Bath Aerator-1.0 gpm- Ele DHW	15	182		$5	$ 172	$219	1.0	78.2
Bath Aerator-1.0 gpm- Gas DHW	15	8	8.08	$5	$ 45	$219	1.0	52.7
Bath Aerator-1.5 gpm- Ele DHW	15	120		$5	$ 114	$145	1.0	51.7
Bath Aerator-1.5 gpm- Gas DHW	15	5	5.35	$5	$ 29	$145	1.0	34.9
Kitchen Aerator-2.0 gpm- Ele DHW	15	91		$5	$ 86	$109	1.0	39.0
Kitchen Aerator-2.0 gpm- Gas DHW	15	4	4.03	$5	$ 22	$109	1.0	26.2
Kitchen Aerator-1.5 gpm- Ele DHW	15	152		$5	$ 144	$183	1.0	65.4
Kitchen Aerator-1.5 gpm- Gas DHW	15	6	6.76	$5	$ 37	$183	1.0	44.1
NBM or ENH multifamily - Bath or Kitchen Aerator-1.5 gpm- Ele DHW	15	73		$5	$ 69	$88	1.0	31.4
NBM or ENH multifamily - Bath or Kitchen Aerator-1.5 gpm- Gas DHW	15	3	3.25	$5	$ 18	$88	1.0	21.2
NBM or ENH multifamily - Bath or Kitchen Aerator-1.0 gpm- Ele DHW	15	125		$5	$ 118	$151	1.0	53.9
NBM or ENH multifamily - Bath or Kitchen Aerator-1.0 gpm-	15	5	5.57	$5	$ 31	$151	1.0	36.3

Measure Analysis

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

Daily use for both bathroom and kitchen faucet aerators is 2.5 minutes per day at 50% of the maximum flow and a 75˚F difference between inlet and outlet water temperature is assumed. Water from the faucet is assumed to be delivered at 104°F on average, which implies 68% hot water. Baseline flow rates

were collected by CSG, during Home Energy Reviews. The existing stock of kitchen aerators averaged 2.71 gpm in single family homes and 2.8 gpm in multifamily buildings, and bath aerators were 2.48 gpm. Savings for both aerators and showerheads are affected by the number of occupants in a household. The average number of occupants used by the RTF is 2.51 for single family and 2.0 for multifamily, resulting in a weighted average occupancy of 2.35 persons per home. For all programs except New Multifamily Buildings **and New Homes small multifamily (2-11 units)** these statistics are weighted and averaged. The same savings should be used for the Home Energy Savings, Existing Manufactured Homes, and Existing Buildings Multifamily programs.

The baseline in New Multifamily Buildings and New Homes small multifamily is 2.2 gpm, which is the federal standard for maximum flow, and the occupancy is 2.0 people per living space. The resulting savings are shown in the cost effectiveness table above.

A 10% uninstall rate is assumed.

Average water heater efficiency assumptions are taken from the RTF; 75% and 98% for gas and electric water heaters, respectively.

Measure life is 15 years, consistent with past aerator and showerhead measures.

Savings, Economics, and Incentives

The incentives listed in the calculator are the maximum cost effective incentives based on the utility test, given that the Energy Trust is paying for the full cost of the measure. However, the maximum incentive for aerators is far and away greater than the actual cost of the showerhead, and should never be paid in the real world. They are indicated here to prove that these measures are cost effective and to allow the program to calculate and meet cost effectiveness and levelized cost targets.

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Reviewed by Mike Bailey

April 1, 2016

Measure approval document for retail web-enabled thermostats

Valid Dates: March 24, 2015 to December 31, 2017

End Use
Residential Space Conditioning

Program
Retail web-enabled thermostats in the Home Energy Solutions and Efficient Home Products programs. New homes are not included under this memo.

Description of Measure
Gas and electric forced air furnaces can achieve energy savings when controlled by a web-enabled thermostat with an occupancy sensor. This memo also approves the self-installation of web-enabled thermostats in homes heated with gas or electric forced air furnaces**.** ***Homes with heat pumps achieve less savings from run-time reduction, as they use less energy to begin with. Thermostats with heat pumps are averaged into the savings amount in order to have a comprehensive retail offer. Additional savings for electric resistance lockout with heat pumps are available through the direct install of thermostats with that additional feature through the Advanced Heat Pump Control measure.***

Measure Requirements

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

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

Table 2: Oregon furnace savings by fuel type

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

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

The preliminary billing analysis[2] completed by Energy Trust Evaluation staff in June, 2015, achieved results similar to studies by NIPSCO in Gary, Indiana and Vectren in Evansville, Indiana. The results from the other studies ranged from 5.6% to 8.6% savings above a baseline programmable thermostat, as shown in table 3 below:

Table 3: 2010-2014 Average Heating Degree Days (base 65F)

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

Source: www.degreedays.net

BCR: (link: I:\Groups\Planning\Measure Development\Residential\Res HVAC\thermostat\web enabled thermostat\bencost\ETO CEC self installed web enabled thermostat.xlsm)

#	Measure	Measure Life (yrs)	Savings		Incremental Costs ($)	Maximum Incentive ($)	Utility BCR at Max Incentive	TRC BCR
			kWh	therms				
1	retail web enabled thermostat, weighted average of electric forced air furnace and heat pump	11	331		$100	$100	2.51	2.51
2	retail web enabled thermostat for gas forced air furnace	11		32	$100	$100	1.35	1.35

Measure Life

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

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

Incentives

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

Install Rate

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

Costs

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

Support Documents:

Single Family Residential Building Stock Assessment

Energy Trust Heat Pump Pilot Billing Analysis

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Reviewed by Mike Bailey

January 22, 2016

Revised to include small multifamily new homes

Measure approval document for commercial clothes washers
Effective Dates:
January 1, 2016 to December 31, 2017

End Use: Commercial clothes washers for laundromats, lodging, hospitals, multifamily common area laundries, and other high use, commercial installations.

Scope: Measure is approved for new and replacement markets for commercial and multi-family installations. Clothes washers are soft mount, generally 30 pounds of capacity or less, and do many loads per day, as they are in a commercial setting, or they are in the common areas of multifamily buildings, and used by several families.

Program: Existing and New Buildings commercial and multifamily programs **including townhomes, condos, and garden style apartments in the New Homes Multifamily program**.

Description of the measure: The Modified Energy Factor (MEF) is a per unit volume measure of the number of cycles required to use a kilowatt hour of energy. It combines mechanical energy used by the washer, water heating, and energy required to remove moisture content remaining after the spin cycle. Water Factor (WF) is the gallons of water per cycle per unit volume of laundry.

Purpose of evaluating the measure: ENERGYSTAR changes their specification for commercial clothe washers in February, 2013 to a Modified Energy Factor (MEF) of 2.2 and a Water Factor (WF) of 4.5. Energy Trust updates its qualified products for this measure in alignment with ENERGYSTAR on an ongoing basis. However, adjustments to savings and incentives are generally made during the budget process for the following year. The savings and incentives given in this memo should be adopted by programs on a timeline that allows them to adjust expectations with PMCs, most likely at the beginning of 2016.

BCR (linked and attached): I:\Groups\Planning\Measure Development\Commercial and Industrial\Commercial Appliances\Clothes Washer\bencost\ETO CEC commercial clotheswasher.xlsm)

#	Measure	Measure Life (yrs)	Savings		Incremental Costs ($)	Non-Energy Benefits (Annual $)	Maximum Incentive ($)	Utility BCR at Max Incentive	TRC BCR	Benefit Ratio	
			kWh	therms						Electric	Gas
1	Full service territory commercial laundry MEF 2.2 or greater	7	485	26	$355	$128	$263	1.00	2.86	75%	25%
2	Electric only service territory commercial laundry MEF 2.2 or greater	7	1,052	-	$355	$128	$355	1.20	3.33	100%	0%
3	Gas only service territory commercial laundry MEF 2.2 or greater	7	-	32	$355	$128	$83	1.00	2.36	0%	100%
4	Full service territory multifamily clothes washer in common area MEF 2.2 or greater	11	636	5	$355	$96	$355	1.18	3.48	95%	5%
5	Electric only service territory multifamily clothes washer in common area MEF 2.2 or greater	11	763	-	$355	$96	$355	1.34	3.65	100%	0%
6	Gas only service territory multifamily clothes washer in common area MEF 2.2 or greater	11	-	24	$355	$96	$93	1.00	2.57	0%	100%

Analysis: Measure analysis is borrowed from the Regional Technical Forum, as it was presented to the forum on April 14, 2015 and using workbook version 4.2.
All parameters from the RTF workbook available here: http://rtf.nwcouncil.org/measures/com/ComClothesWasher%20v4_2.xlsm
Laundromat, lodging, and hospital clothes washer savings are averaged using 2012 CBSA fuel splits of 22% electric service water heat from the Regional Building Characteristics Summary (Table A6) and 77% electric dryers from the total number of commercial dryers in the database.

Multifamily savings are averaged with 2011 RBSA fuel splits of 87% electric DHW and 74% electric dryers. Electric savings are converted to therms by factoring in an average of 75% thermal efficiency for gas water heat.

Savings, Incentives, and Economics
Measure life in New and Existing Buildings is 7 years, which aligns with the RTF. Measure life in Multifamily Buildings is 11 years, based on fewer loads per day.

Program Requirements
ENERGYSTAR (v7.1) Commercial clothes washer. In electric only service territory and gas only service territory, the service hot water fuel must be provided by an Energy Trust utility.

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Blessing Memo for Commercial Condensing Tankless Water Heaters

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Cc: Peter West
Subject: Blessing memo for commercial condensing tankless water heaters

Blessing Memo for Commercial Condensing Tankless Water Heaters

End Use: Commercial condensing tankless gas water heaters

Scope: This measure is proposed for the commercial sector for new equipment or replacement purchases in food service, coin-operated laundries, lodging, and multifamily buildings, but not office buildings.

Program: Based on the referenced analysis and associated cost-effectiveness screening, the measures described below are "blessed" on a prospective basis for inclusion in the new and existing buildings programs in both Oregon and Washington, with the exception of office buildings, where it is not cost effective.

Purpose of Evaluating Measure:
This memo provides incentives and savings for commercially rated condensing tankless gas water heaters. A revised state energy efficiency code went into effect in October of last year (2010). It added a minimum 80% thermal efficiency for tankless water heaters with greater than 200 kBtu/h heat input, where the code previously did not have this category of equipment. The code changes require that the Energy Trust increase the baseline efficiency against which we measure the efficient alternative for commercial tankless water heaters.

BCR calculator: E:\Planning\Cross-Program Measures\Commercial\Water Heating\2009 Analysis Update\Bencost\ETO C-E Calculator WH savings.xlsx

Measure #	Energy Efficiency Measure Name	Measure Lifetime (Maximum 70 yrs)	Annual Natural Gas Savings (therms per kBtu/h)	Incremental Cost of Measure per kBtu/h	Potential Incentive per kBtu/h	Combined Utility System BCR	Combined Societal BCR
7	Average of Fast Food and Full Service Restaurant Cond tankless over code	15	0.57	$3.95	$2.75	1.8	1.28
9	Average of Fast Food and Full Service Restaurant Cond tankless over standard tankless	15	0.39	$3.78	$2.75	1.3	0.94

10	Coin Op Laundry Cond tankless over code	15	2.58	$5.00	$2.75	8.4	4.62
12	Coin Op Laundry Cond tankless over standard tankless	15	1.80	$4.75	$2.75	5.9	3.39
13	Office Cond tankless over code	15	0.20	$5.25	None	na	0.34
15	Office Cond tankless over standard tankless	15	0.14	$4.75	None	na	0.27
22	Average of Hotel and Motel Cond tankless over code	15	1.11	$5.00	$2.75	3.6	1.98
24	Average of Hotel and Motel Cond tankless over standard tankless	15	1.47	$4.75	$2.75	4.8	2.76
25	Multifamily Cond tankless over code	15	1.06	$5.73	$2.75	3.4	1.65
27	Multifamily Cond tankless over standard tankless	15	0.74	$5.44	$2.75	2.4	1.22

Measure Analysis:
This analysis estimates hot water consumption for various facilities such as fast-food and full service restaurants, offices, and coin-op laundry facilities, using data from a 2008 EPRI study, “Commercial Building Energy Efficiency and Efficient Technologies.” The lodging sector is analyzed with floor area data from the 2003 CBECS, combined with energy use intensity data from a Lawrence Berkley National Laboratory report, “Technology Data Characterizing Water Heating In Commercial Buildings: Application To End-Use Forecasting.” Multifamily water heating load data is retained from the 2003 Strategic Energy Group study, on which the Energy Trust bases its condensing gas storage water heater measures.

The 2010 Oregon Energy Efficiency Specialty Code establishes a minimum thermal efficiency (E_t) of 80% for tankless water heaters with a heat input equal to or greater than 200 kBtu/h. The code thermal efficiency is compared, here, to a thermal efficiency of 84% for a standard tankless unit and 95% for the condensing tankless water heaters.

For the baseline tankless water heater, the commercial code minimum of 80% thermal efficiency applies to new buildings. While replacement water heaters in existing buildings do not necessarily have to comply with codes, the least efficient commercial gas tankless water heaters have a thermal efficiency of about 80%, so the same baseline may be used.

This analysis assumes that the consumer has chosen a tankless unit for reasons other than energy conservation, such as a smaller footprint, so that efficiencies are compared only to other tankless units, rather than all water

heaters. The cost effectiveness tables above shows that the incremental cost above code is justified for condensing tankless units. The incremental cost of these units above the standard tankless units are also justified by the additional energy savings, except for restaurants, where it is very close to a BCR of 1.

The heat input, and number of tankless water heater units must satisfy peak hot water demands. For the average coin-op laundry, for example, the peak gallons per minute (gpm) was determined to be 7 gpm by the US DOE. In this case, a commercially rated tankless unit with an input rating of 244 kBtu/h or larger would be needed in order to meet peak demand rates at that given flow. In restaurants, the design recommendations of the Food Service Technology (FSTC) were used as a guideline. The FSTC recommends a minimum heat input of 400 kBtu/h in a medium size fast food restaurant and a series of tankless water heaters with a total heat input of 1,000 kBtu/h at a medium size full service restaurant. For multifamily, a 10 gpm flow rate is assumed, which requires a heat input of at least 349 kBtu/h. Only one tankless water heater is needed in an office building, where the peak demand is low. Two tankless water heaters are needed in a coin-operated laundry, a hotel, a motel or a multifamily building. The number of water heaters varies for restaurants. An average of three is used for the cost-effectiveness calculation.

Savings, Economics, and Incentives:
A standard measure life of 15 years is used, which is in line with existing Energy Trust measure lives for commercial water heaters and is in agreement with other regional utility programs.

In addition to the normal installation and equipment costs, condensing water heaters require the installation of a condensate line. The additional cost is approximately $100.

Condensing tankless water heaters are cost-effective at restaurants, groceries, hotels, motels, coin operated laundries, multifamily buildings, dorms, and assisted living facilities. Restaurants and groceries are taken to be representative of the entire food service sector, and all energy savings and incentive information in this memo regarding restaurants and groceries applies to similar businesses in the food service sector. Lodging consists of hotels and motels. For the purposes of incentive and energy savings, hotels and motels are grouped together. Dorms and assisted living facilities will experience hot water demand much more similar to multifamily buildings. Incentives and energy savings for dorms and assisted living facilities should be based on the multifamily analysis. Condensing tankless water heaters are not cost effective in office buildings or in any building where the primary hot water end uses are hand washing in restrooms and light kitchen use.

The 2008 EPRI data for restaurants distinguishes between fast food and full service restaurants. The data was combined, here, in order to apply it across the sector. The distinction would have been difficult from a supply chain and marketing point of view. In fact, there are high-volume full service restaurants and low-volume fast food restaurants, so the distinction was not considered to be appropriate for program design. Hot water use for hotels and motels was taken from the LBNL report. The amount was multiplied by 60%, as occupancy rates for commercial lodging have fallen in recent years, and occupancy rates were determined by the Oregon Lodging Association to have been 60% of capacity in 2009. The energy savings were then averaged, as the distribution of lodging types is unknown, as is the relative degree of interest in tankless water heaters between lodging types

The incentive is $2.75 per kBtu/h maximum heat input.

Energy savings for condensing tankless water heaters are based on the heat input and are different in each sub-sector. Energy savings in the food service sector are 0.57 annual therms per kBtu/h heat input. For coin operated laundries, energy savings are 2.58 annual therms per kBtu/h. In hotels and motels, energy savings are 1.11 annual therms per kBtu/h, and 1.06 annual therms per kBtu/h in multifamily buildings, dorms, and assisted living facilities. The heat input and number of water heaters depend on the requirements of the site and must be selected by the customer and the designer of the water heating system. The energy savings are calculated from the total heat input of all new tankless water heaters installed at the site.

Program Integration:
New and existing buildings programs should consider how to transition from non-condensing tankless to condensing tankless water heater incentives in response to the commercial code changes. For new buildings, the non-condensing or standard efficiency tankless water heaters are minimally better than code, but cost effective analysis shows the advantage of the condensing tankless. In the case of existing buildings, once a business owner has decided to purchase a tankless water heater, the range of efficiency for non-condensing units is small, from 80% to 85%. Again, the cost effectiveness analysis indicates that greater savings are available from condensing tankless.

The residential tankless water heater measures currently used by the new and existing buildings programs do not need to change, but they should not be applied to commercially rated tankless water heaters, or any water heater with a heat input equal to or greater than 200 kBtu/h.

No changes are suggested to the current tank water heater measures. The choice between tank and tankless appears to be motivated by non-energy concerns, on the part of the business owner. The incentive structure is intended to encourage more efficient options in each category, rather than motivate the choice of a tankless unit over a tank unit, or vice versa.

Measure Requirements:

- Gas condensing tankless water heater with a thermal efficiency greater than or equal to 94%.
- Maximum heat input greater than or equal to 200 kBtu/h.
- Electronic ignition required.
- Single family residential buildings and office buildings are not eligible.

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