9.0 Envelope Deemed Tables

Table 9.1.0

	Front Range	Western Slope	Mountain
HDD	6,016	5,580	9,015
CDD	1,116	1,452	434
Heating Hours	1,825	1,971 ~~1,739~~	2,104
Cooling Hours	590	837	210

Table 9.2.0

	Front Range	Western Slope	Mountain
LAF	0.0730	0.0736	0.0696
ATF	0.891	0.906	0.813

Table 9.3.0

	N_{winter}			N_{summer}		
Stories	Front Range	Western Slope	Mountain	Front Range	Western Slope	Mountain
1	14.328	16.021	15.138	19.313	18.405	18.321
2	11.282	12.405	11.520	16.449	15.969	14.762
3	9.713	10.577	9.730	14.932	14.712	12.890

Table 9.4.0

	Gas Heating Eff	Elec Heating Eff
ASHP	N/A	2.26
GSHP	N/A	3.30
Electric Resistance	N/A	1.00
Natural Gas	0.78	N/A

Table 9.5.0

	Cooling Eff
AC/ASHP	3.93
GSHP	4.13
Evap/None	0

References:

1. California Measurement Advisory Committee (CALMAC) Protocols, Appendix F (www.calmac.org/events/APX_F.pdf).
2. 2017 ASHRAE Fundamentals, Chapter 26, Table 1 - Thermal resistance values for building and insulating materials
3. 2017 ASHRAE Fundamentals, Chapter 26, Table 3 - Thermal resistance values of plane air spaces
4. 2017 ASHRAE Fundamentals, Chapter 26, Table 10 - Thermal resistance values for surface films
5. 2017 ASHRAE Fundamentals, Chapter 27, Example 3 - Thermal resistance values for 2x4 framing studs
6. 2017 ASHRAE Fundamentals, Chapter 16, Equation (41) - Defining equivalent air leakage area
7. 2017 ASHRAE Fundamentals, Chapter 16, Equation (48) - Defining airflow rate from infiltration.
8. 2017 ASHRAE Fundamentals; Chapter 16, Table 4 - Defining stack coefficient, C_s
9. 2017 ASHRAE Fundamentals; Chapter 16, Table 6 - Defining basic model wind coefficient, C_w
10. Door leakage estimate taken from Colorado Energy Office website - http://www.coloradoenergy.org/procorner/stuff/window_air_leakage.htm
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12. Metzger CE, J Zhang, VV Mendon, and KA Cort. 2017. Modeling Cellular Shades in Energy Plus. PNNL-27187. For City of Santa Clara and Silicon Valley Power
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17. 2011 Program Evaluation by Cadmus Group. https://www.xcelenergy.com/staticfiles/xe/Regulatory/Regulatory%20PDFs/CO-DSM/2011-CO-Low-Income-Single-Family-Weatherization-Program-Evaluation.pdf

17.7 DI Strip Curtains

Algorithms

$$Customer\ kW = \frac{Customer\ kWh}{Hours}$$

$$Customer\ kWh = kWh\ Per\ SF \times Area\ SF$$

$$Customer\ Coincident\ kW\ =\ Customer\ kW\ \times\ Coincidence\ Factor$$

Variables

Area SF	See Table 17.7.4	Door area in square feet (Reference 1)
kWh Per SF	See Table 17.7.5	kWh saved per square foot of curtain installed (Reference 1)
Hours	8,760	24/7 operating hours
Lifetime	4	Measure Lifetime in years (Reference 1)
Total Cost	$270.83	Incremental cost of efficient measures (Reference 1) *Costs are re-evaluated throughout the year and updated to account for the evolving market.
Coincidence Factor	100%	Coincidence factor for medium and low temperature applications

Customer Inputs

	M&V Verified	
Facility Type	Yes	Facility and its temperature application
Quantity	Yes	
Pre Existing Curtains	No	

Table 17.7.4

Facility Type	Doorway Area Sq Ft
~~Supermarket - Cooler~~	~~35~~
Supermarket - Freezer	35
~~Convenience Store - Cooler~~	~~21~~
Convenience Store - Freezer	21
~~Restaurant - Cooler~~	~~21~~
Restaurant - Freezer	21
Refrigerated Warehouse	80

Table 17.7.5

Facility Type	Pre-Existing Curtains	kWh Savings/Sq Ft
~~Supermarket - Cooler~~	~~Yes~~	~~37~~
	~~No~~	~~108~~
Supermarket - Freezer	Yes	119
	No	349
~~Convenience Store - Cooler~~	~~Yes~~	~~5~~
	~~No~~	~~20~~
Convenience Store - Freezer	Yes	8
	No	27
~~Restaurant - Cooler~~	~~Yes~~	~~8~~
	~~No~~	~~30~~
Restaurant - Freezer	Yes	34
	No	119
Refrigerated Warehouse	Yes	254
	No	729

References:

1. Data from Illinois TRM 2019. Efficient equipment is a strip curtain at least 0.06 inches thick and covers entire doorway. A doorway area of 26.5 sq ft was assumed based on the weighted average of estimated customer participants by customer type.

Changes from Recent Filing:

New Direct Install Product

18.2 Residential Ground Source Heat Pump

Algorithms

$$Customer\ kW\ Savings = Customer\ kW_{EqCooling} + Customer\ kW_{QICooling}$$

$$Customer\ Coincident\ kW\ Savings = Customer\ Coincident\ kW_{Equipment} + Customer\ Coincident\ kW_{QI}$$

AC Cooling with Gas Heat Baseline:

$$Customer\ kWh\ Savings = Customer\ kWh_{EqCooling} + Customer\ kWh_{QICooling} + Customer\ kWh_{EQ}\&_{QIHeating}\ Penalty + Customer\ Furnace\ Fan\ kWh$$

$$Customer\ DTherms\ Savings = Customer\ GSHP\ DTh_{EQ}\&_{QIHeating}$$

AC Cooling with Electric Resistance Heat Baseline:

$$Customer\ kWh\ Savings = Customer\ kWh_{EqCooling} + Customer\ kWh_{QICooling} + Customer\ kWh_{EQHeating} + Customer\ kWh_{QIHeating}$$

$$Customer\ kW_{EqCooling} = Qty_{prop} \times \frac{\frac{Full\_Load\_Cool}{12{,}000}}{(1 - Sizing\ Loss)} \times \left(\left(\frac{12}{EER_{baseline}}\right) - \left(\frac{12}{EER_{proposed}}\right)\right)$$

$$Customer\ kW_{QICooling} = Qty\_Prop * \frac{Full\_Load\_Cool}{12{,}000} * 12/(EER\_proposed) * ((\frac{1}{1 - Loss_{NoQI}}) - \left(\frac{1}{1 - Loss_{Uncorr}}\right))$$

$$Customer\ Coincident\ kW_{Equipment} = Qty_{Prop} * Coincidence\ Factor * \frac{Full\_Load\_Cool}{12{,}000} * \frac{1}{1 - Sizing\ Loss} * (\left(\frac{12}{EER_{baseline}}\right) - \left(\frac{12}{EER_{Cooling}}\right))$$

$$Customer\ Coincident\ kW_{QI} = Qty_{Prop} * Coincidence\ Factor * \frac{12}{EER_{Cooling}} * \frac{Full\_Load\_Cool}{12{,}000} * ((\frac{1}{1 - Loss_{NoQI}}) - \left(\frac{1}{1 - Loss_{Uncorr}}\right))$$

$$Customer\ kWh_{EqCooling} = Qty_{Prop} * \frac{\left(\frac{Full\_Load\_Cool}{12{,}000}\right)}{1 - Sizing\ Loss} * EFLH_{cooling} * ((\frac{12}{SEER_{baseline}}) - \left(\frac{12}{SEER_{proposed}}\right))$$

$$Customer\ kWh_{QICooling} = Qty_{Prop} * \frac{Full\_Load\_Cool}{12{,}000} * EFLH_{cooling} * \frac{12}{SEER_{proposed}} * ((\frac{1}{1 - Loss_{NoQI}}) - \left(\frac{1}{1 - Loss_{Uncorr}}\right))$$

$$Incremental\ Capital\ Cost_{Equipment} = Qty_{Prop} * \frac{Size_{Heat}}{12{,}000} * (GSHP\_Cost\_per\_Heat\_Ton) - Full_{LoadCooling}/12000 * Base\_AC\_Cost\_per\_Ton - Base\_Furnace\_Cost$$

$$Incremental\ Capital\ Cost_{QI}\ New\ Home = Qty_{Prop} * Inc\ Cost_{QI}$$

$$Incremental\ Capital\ Cost_{QI}\ E\ Home = Qty_{Prop} * MAX(75, Inc\ Cost_{QI} - \frac{Size\_Heat}{12{,}000} * (\left(\frac{1}{1 - Sizing\ Loss}\right) - 1) * Cost\ per\ Ton_{baseline}))$$

$$load\ profile\ slope\ (m) = \frac{(-1 * Size_{Heat} - balance\ pt\ load)}{(Min\ OAT - balance\ pt\ temp)}$$

$$load\ profile\ y\ intercept\ (b) = (-1 * Size\_Heat) - (m * Min\ OAT)$$

$$Full\_Load\_Cooling = m * Max\ OAT + b$$

$$Customer\ kWh_{EQ}\&_{QIHeating}\ Penalty = Qty_{Prop} * -1 * Size\_Heat / (1 - Loss\_uncorr) * EFLH\_Heat * ((0 - (1 / (COP\_Eff * 3.412))) / 1000$$

$$Customer\ GSHP\ DTh_{EQ}\&_{QIHeating} = Qty_{Prop} * -1 * Size\_Heat / (1 - Loss\_No\_QI\_Duct\_Leakage) * EFLH\_Heat * (1 / Baseline\ Gas\ Eff) / 100000$$

$$Customer\ Furnace\ Fan\ kWh = Furnace\_Fan\_kW * EFLH\_Heat$$

$$Customer\ kWh_{EQHeating} = Qty_{Prop} * -1 * Size\_Heat / (1 - loss\_no\_QI) * EFLH\_Heat * (1 / (COP\_baseline * 3.412) - (1 / (COP\_Eff * 3.412)))/1000$$

$$Customer\ kWh\_QIHeating = Qty\_Prop * -1 * Size\_Heat * EFLH\_Heat * 1 / (COP\_Eff * 3.412) * (1 / (1 - loss\_No\_QI) - 1/(1 - Loss\_uncorr)) / 1000$$

Variables

m_load_profile	Calculated	load profile slope (m)
b_load_profile	Calculated	load profile y intercept (b)
Full Load Cooling	Calculated	calculated full load cooling BTUH required to serve the home or space at the maximum Outside Air Temperature
COP_Baseline	See Table 18.0.3	Baseline COP for Ground Source Heat Pump system with Electric Resistance
Baseline Gas Eff	See Table 18.5.2	Efficinecy of the baseline gas furnace
EER_Base	See Table 18.0.3	Efficinecy of the baseline Air Condtioner
GSHP_Cost_per_Heat_Ton	See Table 18.2.1	Cost per heating ton of a ground source heat pump system including wells
Base_AC_Cost_per_Ton	See Table 18.2.1	Cost per cooling ton of a baseline AC unit sized to meet cooling load
Base_Furnace_Cost	See Table 18.2.1	Cost of a furnace sized to meet GSHP heating load including oversize and altitude adjustment factors.
EFLH cooling	See Table 18.0.1	Effective Full Load Hours for cooling load energy savings
EFLH_Heat	See Table 18.0.1	Effective Full Load Hours for heating load energy savings
Balance Pt Temp	See Table 18.0.6	Outdoor Ambient Temperature at which residential cooling and heating loads are zero BTUH
Max OAT	See Table 18.0.6	Maximum Outdoor Ambient Temperature used in building ASHP load profile
Min OAT	See Table 18.0.6	Minimum Outdoor Ambient Temperature for caluclating full load heating.
Balance Pt Load	See Table 18.0.6	Heating and cooling loads are zero at the balance point outdoor ambient temperature
Furnace_Fan_kW	0.357	Furnace Fan EC Motor kW demand for baseline energy calculations
Electric Resistance Heat HSPF	3.412	Electric resistance heat assumed heating season performance factor based on a COP of 1. no climate zone correction required.
Minimum Qualifying Efficiency	See Table 18.0.2	
Lifetime	See Table 18.0.3	

Customer Inputs	**M&V Verified**	
Size_Heat	Yes	AHRI rated Heating Capacity
COP_Eff	Yes	AHRI rated Heating COP
Size_Cool	Yes	AHRI rated Cooling Capacity
EER_Eff	Yes	AHRI rated Cooling Efficiency
Home Type	Yes	Existing or New home
Baseline Heat Type	No	For Existing Homes there is a choice of Electric Resistance or Gas Heat. For New Homes the baseline will be Electric Resistance.
County	No	Location of the home for determining weather zones.

Table 18.2.1 Incremental Capital Costs - New Construction (Plan A) - Reference 8

SEER	GSHP Baseline AC Cost per Ton w/ Labor	GSHP Baseline Cost of Gas Furnace w/ Labor	GSHP Cost per Heat Ton Including Wells
GSHP - EXISTING HOME	$ 422.85	$ 3,922.72	$ 3,957.00
GSHP - NEW HOME	$ 422.85	$ 3,922.72	$ 3,957.00

References:

See 18.1 Residential AC for references

Changes from Recent Filing:

Changed methodology for GSHP measures cooling savings.
Added Gas heating savings for GSHP measures along with electric heating penalty.

18.3 Residential Air Source Heat Pumps

Algorithms

$Customer\ kW\ Savings = Customer\ kW_{EqCooling} + Customer\ kW_{QICooling}$

$Customer\ Coincident\ kW\ Savings = Customer\ Coincident\ kW_{Equipment} + Customer\ Coincident\ kW_{QI}$

ASHP Baseline Cooling Only:

$Customer\ kWh\ Savings = Customer\ kWh_{EqCooling} + Customer\ kWh_{QICooling}$

Electric Resistance Heat Baseline:

$Customer\ kWh\ Savings = Customer\ kWh_{EqCooling} + Customer\ kWh_{QICooling} + Customer\ kWh_{EQHeating} + Customer\ kWh_{QIHeating}$

Dual Fuel Gas Heat Baseline

Customer kWh Savings = Customer kWh$_{EqCooling}$ + Customer kWh$_{QICooling}$ + Customer kWh_Heating Penalty

Customer Dtherm Savings = Customer DTherms_EQ Heating + Customer DTherm_QI Heating

$$EER_{baseline} = iCoef0 * (SEER_{baaseline}^2) + iCoef1 * SEER_{baseline}$$

$$Customer\ kW_{EqCooling} = Qty_{prop} \times \frac{\frac{Size\_Cool}{12{,}000}}{(1 - Sizing\ Loss)} \times \left(\left(\frac{12}{EER_{baseline}}\right) - \left(\frac{12}{EER_{proposed}}\right)\right)$$

$$Customer\ kW_{QICooling} = Qty\_Prop * \frac{Size\_Cool}{12{,}000} * 12/(EER\_proposed\ ) * ((\frac{1}{1 - Loss_{NoQI}}) - \left(\frac{1}{1 - Loss_{Uncorr}}\right))$$

$$Customer\ kWh_{EqCooling} = Qty_{Prop} * \frac{\left(\frac{Size\_Cool}{12{,}000}\right)}{1 - Sizing\ Loss} * EFLH_{cooling} * ((\frac{12}{SEER_{baseline}}) - \left(\frac{12}{SEER_{proposed}}\right))$$

$$Customer\ kWh_{QICooling} = Qty_{Prop} * \frac{Size\_Cool}{12{,}000} * EFLH_{cooling} * \frac{12}{SEER_{proposed}} * ((\frac{1}{1 - Loss_{NoQI}}) - \left(\frac{1}{1 - Loss_{Uncorr}}\right))$$

$$Customer\ Coincident\ kW_{equipment} = Qty_{Prop} * Coincidence\ Factor * \frac{Size\_Cool}{12{,}000} * \frac{1}{1 - Sizing\ Loss} * (\left(\frac{12}{EER_{baseline}}\right) - \left(\frac{12}{EER_{Proposed}}\right))$$

$$Customer\ Coincident\ kW_{QI} = Qty_{Prop} * Coincidence\ Factor * \frac{12}{EER_{Cooling}} * \frac{Size\_Cool}{12{,}000} * ((\frac{1}{1 - Loss_{NoQI}}) - \left(\frac{1}{1 - Loss_{Uncorr}}\right))$$

$$Incremental\ Capital\ Cost_{Equipment} = Qty_{Prop} * Inc\ Cost\ per\ Ton_{EQ} * \frac{Size\_Cool}{12{,}000}$$

$$Incremental\ Capital\ Cost_{QI}\ New\ Home = Qty_{Prop} * Inc\ Cost_{QI}$$

$$Incremental\ Capital\ Cost_{QI}\ E\ Home = Qty_{Prop} * MAX(75, Inc\ Cost_{QI} - \frac{Size\_Cool}{12{,}000} * (\left(\frac{1}{1 - Sizing\ Loss}\right) - 1) * Cost\ per\ Ton_{baseline}))$$

ASHP Heating Energy Savings

m_load_profile = (balance pt load - Size_Cool) / (balance pt temp - Max OAT)

*b_load_profile = Size_Cool - (m_load_profile * Max OAT)*

*Full Load Heat = m_load_profile * Min OAT + b_load_profile*

Electric Resistance Heat Baseline:

*Customer kWh$_{EQHeating}$ = -1 * Full_Load_Heat * EFLH_Heating_HP * (1 / (HSPF_Baseline * HSPF_Adj_Factor) - 1 / (HSPF_Proposed * HSPF_Adj_Factor)) / 1000*

*Customer kWh$_{QIHeating}$ = -1 * Full_Load_Heat * EFLH_Heating_HP * 1 / (HSPF_Proposed * HSPF_Adj_Factor) * (1 / (1- loss_No_QI) - 1/Loss_uncorr) / 1000*

Dual Fuel Gas Heat Baseline

*Customer DTherms_EQ Saved = (-1 * Full_Load_Heat * EFLH_Heating_HP)/ Furnace_Eff / 1,000,000*

*Customer kWh_Heating Penalty = Furnace_Fan_kW * EFLH_Heating_HP - ~~1 *~~ Full_Load_Heat * EFLH_Heating_HP * (0 - (1 / (HPSF_Proposed*HSPF_Adj_Factor))) / 1000*

Customer DTherms_QI = -1 Full_Load_Heat * (EFLH_Heat - EFLH_Heating_HP) / Furnace_Eff * (1 / (1 - Loss_DuctLeakage) - 1 / (1 - Uncorr_Loss)) / 1,000,000*

Variables

Inc Cost per Ton_EQ	See Table #.X.5	Deemed Plan A Incremental Capital Cost per Ton, Based On Unit Efficiency (New Construction)
Cost per Ton_baseline	See Table #.X.5	Baseline capital cost per ton for equipment
EER baseline	See Table 18.0.3	Baseline EER as calculated for residential equipment from the code required SEER.
SEER baseline	See Table 18.0.3	IECC 2012 identified code minimum SEER
Sizing Loss	See Table 18.0.4	
Loss_NoQI	See Table 18.0.4	
Loss_Uncorr	See Table 18.0.4	
Inc Cost_QI	See Table 18.0.4	
Coincidence Factor_EQ	See Table 18.0.3	
Coincidence Factor_QI	See Table 18.0.3	
*iCoef*0	-0.02	coefficient used in polynomial conversion for AC or ASHP EER derived from known SEER.
*iCoef*1	1.12	coefficient used in polynomial conversion for AC or ASHP EER derived from known SEER.
Oversize_Factor__c	20%	Deemed Oversize Safety Factor for heating equipment.
EFLH cooling	See Table 18.0.1	Effective Full Load Hours for cooling load energy savings
EFLH_Heat	See Table 18.0.1	Effective Full Load Hours for heating load QI energy savings
EFLH_Heating_HP	See Table 18.0.1	Effective Full Load Hours for Heat Pump impacted energy savings
Balance Pt Temp	See Table 18.0.6	Outdoor Ambient Temperature at which residential cooling and heating loads are zero BTUH
Max OAT	See Table 18.0.6	Maximum Outdoor Ambient Temperature used in building ASHP load profile
Min OAT	See Table 18.0.6	Minimum Outdoor Ambient Temperature for caluclating full load heating.
Electric Resistance Heat HSPF	3.412	Electric resistance heat assumed heating season performance factor based on a COP of 1. no climate zone correction required.
Balance Pt Load	See Table 18.0.6	Heating and cooling loads are zero at the balance point outdoor ambient temperature
Furnace_Fan_kW	0.357	Furnace Fan EC Motor kW demand for baseline energy calculations
ASHP / MSHP operating temperature cutoff	25 ~~35~~	Outdoor Ambient Temperature below which heat pump operation ceases and gas furnace or electric resistance heating begins.
Furnace Eff	95%	This is the assumed furnace efficiency for the backup gas fired heat (Baseline Heat Type equals Gas Furnace) in a dual fuel ASHP system application.
HSPF_Adj_Factor	See Table 18.0.1	Adjustment factor for correcting HSPF from published data in AHRI's Climate Zone IV to AHRI's Climate Zone V. The HSPF_Adjustment_Factor for Electric Resistance Heat will be 1.
HSPF_Basline	See Table 18.0.3	Heating season performance factor of baseline equipment. For electric resistance heat baseline, a COP of 1 is assumed with no climate zone correction required.
NTG	100.0%	Net-to-gross for ASHP units.
Measure Life - Matched Split-System Air -Source Heat Pump	See Table 18.0.3	Reference 16
Measure Life - Quality Installation	18	Reference 16
Conversion Factors	See Table 18.0.5	

Customer Inputs	**M&V Verified**	
Size Cool	Yes	AHRI rated Cooling Capacity
Quantity proposed equipment	Yes	
EER proposed	Yes	AHRI rated full load Cooling Efficiency
SEER proposed	Yes	AHRI rated part load Cooling Efficiency
Home Type	Yes	~~Existing or New home~~ Single Family, Multi-Family
County	Yes	Location of the home for determining weather zones.
Baseline Heat Type	Yes	baseline heating type; gas furnace or electric resistance backup heat
HSPF Proposed	Yes	AHRI rated Heating HSPF

Table 18.3.1. Incremental Capital Costs - New Construction (Plan A) - Reference 6

SEER	ASHP Cost per Ton	ASHP Incremental Cost per Ton
13 SEER	N/A	N/A
14/14.5 SEER	$ 777.64	N/A
15 SEER	$ 960.40	$ 182.76
16 SEER	$ 1,143.16	$ 365.52
17/18+ SEER	$ 1,325.93	$ 548.29

DEEMED SAVINGS TECHNICAL ASSUMPTIONS

References:

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2. ASHRAE, 2019, Applications Handbook, Ch. 38, table 4, Comparison of Service Life Estimates
3. DOE Appliance Standards Website, Residential Central Air Conditioners and Heat Pumps.
https://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/75
4. Neme, Proctor, Nadel, ACEEE, 1999. Energy Savings Potential From Addressing Residential Air Conditioner and Heat Pump Installation Problems, http://aceee.org/research-report/a992
5. State of Minnesota Technical reference Manual For Energy Conservation Improvement Programs, Version 3.1 https://mn.gov/commerce/industries/energy/utilities/cip/technical-
6 ENERGY STAR Quality Installation standards (ESVI). https://www.energystar.gov/index.cfm?c=hvac_install.hvac_install_index
7. NREL 2011 Measure Guideline Sealing and Insulating Ducts in Existing Homes. http://www.nrel.gov/docs/fy12osti/53494.pdf
8. State of Illinois Technical Reference Manual Version 8, dated 2020
9. For explanation of duct sealing requirements for new homes see "Significant Changes to the 2015 Minnesota Residential Codes (MR 1303, 1309 and 1322)".
http://www.ci.minneapolis.mn.us/www/groups/public/@regservices/documents/webcontent/wcms1p-142763.pdf
10. Incremental costs for MSHPs were determined from the NEEP Incremental Cost Study Phase 2 Report
11. MSHP equipment life is from Measure Life Report Residential and Commercial/Industrial Lighting and HVAC Measures; http://library.cee1.org/content/measure-life-report-residential-and-commercialindustrial-lighting-and-hvac-measures
12. For estimated life of GSHP see http://www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12640 (indoor components up to 25 years; ground loop =50 years)
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14.For assumptions on losses related to overcharge or undercharge on refrigerant see "Sensitivity Analysis of Installation Faults on Heat Pump Performance", by P. Domanski, et. al., Sept 2014, http://www.acca.org/HigherLogic/System/DownloadDocumentFile.ashx?DocumentFileKey=f02c1f61-4d1d-4a24-971d-cc9ea3e626b2&forceDialog=0
15. ENERGY STAR Connected Thermostat Key Product Criteria, Version 1.0, Rev. Jan 2017 -
16. Code of Federal Regulations Title 10: Energy PART 430—ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS Subpart C—Energy and Water
17: "Measure Life Report - Residential and Commercial/Industrial Lighting and HVAC Measures", dated June 2007 for The New England State Program Working Group prepared
18. Assumptions on EC fan operating modes. Center for Energy and Environment Comments to Docket Number EERE-2010-BT-STD-0011-0022, July 27, 2010
19. ECM Furnace Impact Assessment Report https://focusonenergy.com/sites/default/files/emcfurnaceimpactassessment_evaluationreport.pdf
20. Xcel Energy, January 2019. Typical MN Residential Smart Switch Load Relief 2011-2015.
21. Xcel Energy, January 2019. Saver's Switch Control History.
22. Xcel Energy. January 2006. Residential Saver's Switch 2005 Impact Evaluation.
23. http://wpb-radon.com/radon_fan_performance.html33:5032:50A33:50
24. Information from manufacturer and contractors (Radonaway)
25. https://www.radonaway.com/products/radon-fans/rp140-pro.php
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27. Bin analysis using RECS data for thermostat operation and typical CO home cooling and heating conditions.

Changes from Recent Filing:

added dual fuel heating baseline
modified heating savings methodology to incorporate cut-off temperature for both dual fuel and electric resistance baselines
incorporated HSPF addjustments based on AHRI climate zones

18.4 Mini-Split Heat Pumps

Algorithms

$Customer\ kW\ Savings = Customer\ kW_{EqCooling}$

$Customer\ Coincident\ kW\ Savings = Customer\ Coincident\ kW_{Equipment}$

Electric Resistance Heat Baseline:

$Customer\ kWh\ Savings = Customer\ kWh_{EqCooling} + Customer\ kWh_{EQHeating}$

Dual Fuel Gas Heat Baseline:

$Customer\ kWh\ Savings = Customer\ kWh_{EqCooling} + Customer\ kWh\_Heating\ Penalty$

Customer Dtherm Savings = Customer DTherms_EQ Heating

$$EER_{baseline} = (\ iCoef0\_c * (SEER\_Base\ /\ \frac{Size_{Cool}}{12{,}000})\ ^\wedge 3 + iCoef1\_c * (SEER\_Base\ /\ \frac{Size_{Cool}}{12{,}000})\ ^\wedge 2 + iCoef2\_c * (SEER\_Base\ /\ \frac{Size_{Cool}}{12{,}000}) + iCoef3\_c\ ) * (\frac{Size_{Cool}}{12{,}000})$$

$$Customer\ kW_{EqCooling} = Qty_{prop} * \frac{Size_{Cool}}{12{,}000} * \left(\left(\frac{12}{EER_{baseline}}\right) - \left(\frac{12}{EER_{proposed}}\right)\right)$$

$$Customer\ kWh_{EqCooling} = Qty_{Prop} * \frac{Size\_Cool}{12{,}000} * EFLH_{cooling} * ((\frac{12}{SEER_{baseline}}) - \left(\frac{12}{SEER_{proposed}}\right))$$

$$Customer\ Coincident\ kW_{equipment} = Qty_{Prop} * Coincidence\ Factor * \frac{Size\_Cool}{12{,}000} * (\left(\frac{12}{EER_{baseline}}\right) - \left(\frac{12}{EER_{Proposed}}\right))$$

$$Incremental\ Capital\ Cost_{Equipment} = Qty_{Prop} * Inc\ Cost\ per\ Ton_{EQ} * \frac{Size\_Cool}{12{,}000}$$

MSHP Heating Energy Savings

m_load_profile = (balance pt load - Size_Cool) / (balance pt temp - Max OAT)

*b_load_profile = Size_Cool - (m_load_profile * Max OAT)*

*Full Load Heat = m_load_profile * Min OAT + b_load_profile*

*HSPF_Baseline_Adj = HSPF_Baseline * HSPF_Adjustment_Factor*

*HSPF_Proposed_Adj = HSPF_Proposed * HSPF_Adjustment_Factor*

$Customer\ kWh_{EQHeating} = Qty_{Prop}$ *(-1 * Full_Load_Heat * EFLH_Heating_HP * (1 / HSPF_Baseline_Adj - 1 / HSPF_Proposed_Adj)) / 1000*

*Customer DTherms_EQ Saved = (-1 * Full_Load_Heat * EFLH_Heating_HP)/ Furnace_Eff / 1,000,000*

*Customer kWh_Heating Penalty = - 1 * Full_Load_Heat * EFLH_Heating_HP * (0 - (1 / (HPSF_Proposed*HSPF_Adj_Factor))) / 1000*

Variables

Inc Cost per Ton_EQ	See Table 18.4.2	Deemed Plan A Incremental Capital Cost per Ton, Based On Unit Efficiency (New Construction)
Cost per Ton_baseline	See Table 18.4.2	Baseline capital cost per ton for equipment
EER baseline	See Table 18.0.3	Baseline EER as calculated for residential equipment from the code required SEER.
SEER baseline	See Table 18.0.3	IECC 2012 identified code minimum SEER
HSPF_Baseline	See Table 18.0.3	Baseline heating season performance factor for code minimum MSHP. For Electric Resistance Heat Baseline the HSPF will be 3.412 based on a COP of 1 and does not require climate zone correction.
Coincidence Factor	See Table 18.0.3	
iCoef0	See Table 18.4.1	MSHP SEER to EER Conversion Coefficient
iCoef1	See Table 18.4.1	MSHP SEER to EER Conversion Coefficient
iCoef2	See Table 18.4.1	MSHP SEER to EER Conversion Coefficient
iCoef3	See Table 18.4.1	MSHP SEER to EER Conversion Coefficient
EFLH_Cooling	See Table 18.0.1	Effective Full Load Hours for cooling load energy savings
EFLH_Heating_HP	See Table 18.0.1	Effective Full Load Hours for Heat Pump impacted energy savings
ASHP / MSHP operating temperature cutoff	25 35	Outdoor Ambient Temperature below which heat pump operation ceases and electric resistance heating begins
Balance Pt Temp	See Table 18.0.6	Outdoor Ambient Temperature at which residential cooling and heating load profiles equal zero BTUH
Max OAT	See Table 18.0.6	Maximum Outdoor Ambient Temperature used in building ASHP load profile; TMY3 basis
Min OAT	See Table 18.0.6	Minimum Outdoor Ambient Temperature for caluclating full load heating; TMY3 Basis.
HSPF_Adj_Factor	See Table 18.0.1	Adjustment factor for correcting HSPF from published data in climate zone IV to Minnesota Climate zone V. The HSPF_Adjustment_Factor for Electric Resistance Heat will be 1.
Balance Point Load	See Table 18.0.6	BTUH - Heating and cooling loads are zero at the balance point outdoor ambient temperature
m_load_profile	Calculated	load profile slope (m)
b_load_profile	Calculated	load profile y intercept (b)
Full Load Heat	Calculated	calculated full load heating BTUH required to serve the home or space at the minimum Outside Air Temperature
Furnace Eff	95% / 80%	Furnace efficiency based on customer provided Furnace Type; Condensing = 95% and Non-Condensing = 80%
Lifetime	See Table 18.0.3	Measure Lifetime for MSHPs.
Minimum Qualifying Efficiency	See Table 18.0.2	

Customer Inputs	M&V Verified	
Size Cool	Yes	AHRI rated Cooling Capacity
Quantity proposed equipment	Yes	
$EER\_Proposed$	Yes	AHRI rated full load Cooling Efficiency
SEER proposed	Yes	AHRI rated part load Cooling Efficiency
Home Type	Yes	~~Existing or New home~~ Single Family, Multi-Family
County	Yes	Location of the home for determining weather zones.
Baseline Heat Type	Yes	Baseline heating type; gas furnace or electric resistance backup heat
HSPF Proposed	Yes	AHRI rated Heating HSPF

Table 18.4.1: SEER Conversion Coefficients

Equipment type	Coef0	Coef1	Coef2	Coef3	Notes
MSHP - SEER to EER	-0.0002600	0.0101270	0.5263880	-0.0233300	Xcel Derivation

Table 18.4.2 Incremental Capital Costs - Mini-Split Heat Pump (Reference 8)

Mini-Split Heat Pump	Baseline Cost per ton Cooling	Incremental cost per ton Cooling
Mini-Split Heat Pump (15-20 SEER, 11+ EER, 9-12 HSPF)	$ 3,221.07	$ 401.99
Mini-Split Heat Pump (21-26 SEER, 11+ EER, 9-12 HSPF)	$ 3,266.64	$ 555.94

References:

See 18.1 Residential AC references

Changes from Recent Filing:

added dual fuel heating baseline
modified heating savings methodology to incorporate cut-off temperature for both dual fuel and electric resistance baselines
incorporated HSPF addjustments based on AHRI climate zones

18.10 Residential Energy Star Radon Fan

Algorithms

$$Customer\ kWh = (1 - \%EE\ Fans\ Installed) \times (kW_{base} - kW_{ES}) \times Hours$$

$$Customer\ kW = \frac{Customer\ kWh}{Hours}$$

$$Customer\ Coincident\ kW = \frac{Customer\ kWh}{Hours} \times Coincidence\ Factor$$

Variables

Measure Life	10	Life of an energy star Radon Fan (Reference 24)
Hours	8,760	Assumed Hours of operation for a radon fan
% EE Fans Installed	15%	Assumed percentage of Energy Star Radon Fans being sized correctly and installed currently based on contractor feedback (Reference 23)
Incremental Cost	-$4.00 ~~$0.00~~	Incremental cost of RP140 as compared to RP145 (Reference 25)
Pipe Diameter (in)	4.00	Assumption based on contractor feedback (Reference 24)
Pipe Length (ft)	25.00	Assumption based on contractor feedback (Reference 24)
Efficient Radon Fan Operating Pressure	0.68	Operating Pressure in "WC (Reference 24)
Baseline Radon Fan Operating Pressure	1.30	Operating Pressure in "WC (Reference 24)
Coincidence Factor	100%	Fans run 24x7x365
kW_{base}	0.054	Reference 23
kW_{ES}	0.017	Reference 23
Efficient Radon Fan Airflow	33.30	Reference 23
Baseline Radon Fan Airflow	63.20	Reference 23

Customer Inputs	M&V Verified	

References:

See 18.1 Residential Air Conditioning section

Changes from Recent Filing:

None

18.11 Residential Evaporative Cooling

Algorithms

*Customer kW = Qty_Prop * (Size_Cooling * 12 / EER_Baseline - Watts_Proposed * 1000)*

Customer kWh = Qty_{Prop} * *(Size_Cooling * 12 / SEER_Baseline - Watts_Proposed / Watts/kW) * EFLH_Cool*

*Customer Coincident kW = Customer kW * Coincidence Factor*

*Customer Incremental O&M Savings Electric = -1 * Size_Cooling * 12000 * EFLH_Cool / Water_h_fg / Water_Lb/gallon * Water_Rate*

Variables

Coincidence_Factor	70%	Coincidence factor for the refrigerated air system, the probability that peak demand of the AC unit will coincide with peak utility system demand. (Reference 11)
NTG	See Table 18.11.4	Net-to-Gross Factor calculated based on Xcel Energy product experience.
Incremental Costs	See Table 18.11.5	Incremental cost of efficient technology over baseline technology
Measure Life	15	Life of evap cooling equipment
MotorHP	See Table 18.11.3	Motor Horsepower represents the motor size for an evaporative cooler which corresponds to the cooling output of a 3 ton AC unit. (Reference 4)
HP to kW	0.746	Standard conversion from HP to kW
Load Factor on High	80.00%	Load factor for motor - We will use 80% for standard systems and 80% on high and 10% on low for premium systems.
Load Factor on Low	10.00%	Load factor for motor - We will use 80% for standard systems and 80% on high and 10% on low for premium systems.
Motor Eff	81.67%	Efficiency of the evaporative cooler motor (Reference 2)
Watts/kW	See Table 18.0.5	Conversion factor from Watts to kiloWatts
Water_Rate	8.797	combined cost of water and sewer rate per 1000 gallons
EFLH_Cool	See Table 18.0.1	Full Load Cooling hours based on climate zone.
Watts_Proposed	See Table 18.11.3	Evaporative Cooler operating watts, derived from motor horsepower, load factors and efficiency.
Size_Cooling	See Table 18.11.1	Deemed size of baseline cooling equipment for an evaporative cooler in each climate zone.
EER_Baseline	See Table 18.11.2	Calculated full load efficiency of baseline air conditioning equipment, based on the code part load requirements.
SEER_Baseline	See Table 18.11.2	code part load efficiency of baseline air conditioning equipment.
Water_h_fg	See Table 18.0.5	Specific Enthalpy heat of vaporization of water at standard conditions (60 F), BTU / lb
Water_Lb/gallon	See Table 18.0.5	Density of Water at standard conditions

Customer Inputs	M&V Verified	
Qty Proposed	Yes	
County	Yes	
Evap Cooler Type	Yes	

Table 18.11.1 Evap Cooling System Baseline Tons

Description	Front Range	Western Slope	Alamosa / Mountain Area
Standard evaporative cooler	1.8	1.6	1.1
Premium evaporative cooler	2.5	2.2	1.5
Multi-ducted premium evaporative cooler	2.5	2.2	1.5

Table 18.11.2 Evap Cooling System Baseline SEER & EER

Description	Standard evaporative cooler		Premium evaporative cooler		Multi-ducted premium evaporative cooler	
	Baseline SEER	Baseline EER	Baseline SEER	Baseline EER	Baseline SEER	Baseline EER
Front Range	14.0	8.21	13.0	11.18	13.0	11.18
Western Slope	14.0	8.29	13.0	11.18	13.0	11.18
Alamosa/Mountain Area	14.0	8.56	13.0	11.18	13.0	11.18

Table 18.11.3: Evap Cooler Motor HP & Watts

System Type	HP	Watts_Proposed
Standard evaporative cooler	0.52	380
Premium evaporative cooler	0.52	380
Multi-ducted premium evaporative cooler	1.02	745

Table 18.11.4: Net to Gross Factor

System Type	Net To Gross
Standard evaporative cooler	70%
Premium evaporative cooler	70%
Multi-ducted premium evaporative cooler	85.1%

Table 18.11.5: Incremental Cost of Evaporative Coolers (Reference 5,6,7)

			Front Range		Western Slope		Alamosa / Mountain Area	
	Evap Cooler Cost	Baseline Labor Cost	Baseline Equipment Cost	Evap Cooler Inc Cost	Baseline Equipment Cost	Evap Cooler Inc Cost	Baseline Equipment Cost	Evap Cooler Inc Cost
Standard evaporative cooler	$ 433.67	$ -	$ 5,797.93	$ (5,364.26)	$ 5,153.71	$ (4,720.04)	$ 3,543.18	$ (3,109.51)
Premium evaporative cooler	$ 2,778.32	$ 2,542	$ 1,057.13	$ (820.85)	$ 930.27	$ (694.00)	$ 634.28	$ (398.00)
Multi-ducted premium evaporative cooler	$ 4,020.66	$ 2,542	$ 1,057.13	$ 421.48	$ 930.27	$ 548.34	$ 634.28	$ 844.33

Note: Standard Evap Cooler baseline is a code minimum MSHP.

DEEMED SAVINGS TECHNICAL ASSUMPTIONS

References:

1. ESPRE 2.1 engineering model: Simplified energy analysis methods for residential buildings
2. Average motor efficiency for 1 hp motor from NEMA, "Premium Efficiency Motor Selection and Application Guide"
3. Kinney, Larry. New Evaporative Cooling Systems: An Emerging Solution for Homes in Hot Dry Climates with Modest Cooling Loads.
4. Web site information - Grainger Evap Cooler - Essick Model N28W; Pheonix Mfg Corp; Model PD4231
5. http://www.google.com/products?q=home+depot+evaporative+cooler+cost&ie=UTF-8&oe=utf-8&rls=org.mozilla:en-
6. Xcel Program Data
7. SWEEP 2007 Report. O&M Savings based on manufacturers water use data and current Denver water rates (Denver Water Board).
8. ASHRAE Applications 2007 p.36.3 Used AC window unit as estimate for evaporative cooler.
9. https://www.denverwater.org/residential/billing-and-rates/2018-rates
10. https://www.denvergov.org/content/denvergov/en/wastewater-management/billing-and-rates/wastewater-rates.html
11. 2010 Cadmus Program Evaluation

Changes from Recent Filing:

Scaled baseline system sizes to climate zone
adjusted incremental costs to match to new baseline sizes
updated water rates

19.5 BOC

Algorithms

$$Customer\ kWh = ft^2 \times \left[\frac{kWh}{ft^2}\right]$$

$$Customer\ kW = CF \times \frac{Customer\ kWh}{hours}$$

$$Customer\ therms = ft^2 \times \left[\frac{therms}{ft^2}\right]$$

Variables

$\left[\frac{kWh}{ft^2}\right]$	0.109982 ~~0.121~~	kWh/sqft of attributable savings (Reference 1)
$\left[\frac{therms}{ft^2}\right]$	0.006918 ~~0.00806~~	Therms/sqft of attributable savings (Reference 1)
CF	33.00%	Average of Implemented Recommissioning program measures
hours	8760	Hours per year
Lifetime	5	years (Reference 2)

Customer Inputs	M&V Verified	
ft^2		Building Area

References:

1. Department of Energy Resource Technical Reference Manual Version 2.1
2. BOC-Expansion Initiative Market Progress Evaluation Report #1; http://theboc.info/pdf/Eval-BOC-expansion-initiative-market-progress-0414.pdf

20.4 Heat Pump Water Heaters

Algorithms

Hot_Water_Energy = Qty x Hot_Water_Consumption x Water_Heater_Delta_T x Days_Per_Year x Water_Density

Water Heater Delta T = Water_Heater_Temperature - City_Mains_Temperature

Heat Pump Water Heater with Gas Water Heater Baseline:

Customer kWh = Zero

Customer PCkW = Zero

Note: Fuel Switching with HPWH will target predominant use of renewable energy. Therefore generator impact will be set to zero.

Customer_Dth = Baseline_Dth + Heating_Penalty_Dth

Baseline_Dth = Hot_Water_Energy / Baseline_Eff_Gas / 1,000,000

Heating_Penalty_Dth = -1 * (Hot Water Energy / Proposed_Eff) / Heating_Eff * Heating Hours / 8760 / 1,000,000

Baseline_Efficiency_Gas= coef1 - coef2 x Baseline_Tank_Size

Heat Pump Water Heater with Electric Resistance Water Heater Baseline:

Customer kWh = Baseline_kWh - Proposed kWh + Cooling_Benefit kWh + Heating_Penalty kWh

Baseline_kWh = Hot_Water_Energy / Baseline_Eff_Electric / 3,412

Proposed_kWh = Hot_Water_Energy / Proposed_Eff ~~Baseline_Eff_Electric~~ / 3,412

Baseline_Eff_Electric = coef1 - (coef2 x Basline_Tank_Size)

Customer kW = Baseline_kW - Proposed_kW

Baseline_kW = Baseline_kWh / 8760 + Cooling_Benefit_kWh / Cooling_Hrs

Proposed_kW = Proposed_kWh / 8760

Customer_PCkW = Customer_kW x Coincidence_Factor

Heating_Penalty_kWh = -1 * (Hot Water Energy / Proposed_Eff) / Heating_Eff * Heating Hours / 8760 / 3,412

Heating_Penalty_Dth = -1 * (Hot Water Energy / Proposed_Eff) / Heating_Eff * Heating Hours / 8760 / 1,000,000

Cooling_Benefit_kWh = (Hot Water Energy /Proposed_Eff) / (Cooling_SEER * 1000 / 3412) * Cooling_Hrs / 8760 / 3412

Heat Penalty Energy O&M = Heating_Penalty_Dth * Heating Energy O&M Rate

Variables

Hot_Water_Consumption	See Table 20.4.4	Gallons of Water per day based on number of Bedrooms and Home Type
Water Heater Temperature	120.0	Water Heater Tank Temperature
City Mains Temperature	51.4	Water Main temperature average over the year
Conversion from Btu to Dth	1,000,000	1 Dth = 1,000,000 Btuh
Conversion from Btu to Therm	100,000	1 Therm = 100,000 Btuh
Conversion from kW to Watts	1,000	1 kW = 1,000 Watts
Conversion from Btu to kWh	3,412	1 kW = 3,412 Btuh
Specific Heat of Water	1	Btu/lb/°F
Water_Density	8.34	lb/gal H20
Days_Per_Year	365	Days per Year
Coef1	See Table 20.4.1 See Table 20.4.2	Code based forumula for calculation of Baseline efficiency based on water heater type and draw pattern
Coef2	See Table 20.4.1 See Table 20.4.2	Code based forumula for calculation of Baseline efficiency based on water heater type and draw pattern
Baseline_Tank_Size	See Table 20.4.2	Baseline Gas Water Heater Tank Size determined by customer provided First Hour Rating. Tank Size used in baseline efficiency equation.
Baseline_Tank_Size	See Table 20.4.3	Baseline Electric Resistance Water Heater Tank Size and Quantity determined by number of bedrooms. Tank Size used in baseline efficiency equation.
Gas Heating System Efficiency	78%	For homes with Gas heating systems the assumed efficiency for calculating HPWH O&M heating penalty
Air Source Heat Pump Heating System Efficiency	~~8.20~~ 2.40	For homes with ASHP heating systems the assumed efficiency for calculating HPWH ~~O&M~~ kWh heating penalty in COP ~~HSPF~~
Electric Resistance Heating Efficiency	100%	The assumed heating efficiency used for Heating Penalty calculations for homes with electric resistance heat.
Cooling System Efficiency	13.4	SEER of the typical home cooling system for calculating HPWH O&M Cooling benefit
Heating Energy O&M Rate	4.67	Cost per Dth for heating penalty due to heat pump water heater opearting during heating season.
Coincidence_Factor	100%	We are using the average water heater savings over the summer hours. Coincidence factor becomes 100%
Hours per Year	8760	total hours in a year
Heating Hours	6154	Hours in the year at or below the heating enable temp of 62 F
Cooling Hours	957	Hours in the year at or above the cooling enable temp of 77 F
Water Heater Self-Installation Rate	52%	Percent of Water Heaters that self-installed after retail purchase (Reference 9)

Customer Inputs	M&V Verified	
Number of Bedrooms	Yes	total number of bedrooms in the home where a new water heater is being installed
Proposed Eff	Yes	Proposed water heater AHRI Certified Uniform Energy Factor (UEF)
First Hour Rating	Yes	AHRI certified First Hour Rating in gallons per hour (GPH)
Quantity Proposed Equipment	Yes	
Proposed Tank Size	Yes	DOE Rated Storage Volume for tank type water heaters
Type of Proposed Water Heater	No	Type of proposed water heater. (i.e. Storage, Tankless, Heat Pump)
Water Heater Draw Pattern	No	Usage Bin identified on AHRI Certificate

Table 20.4.1 Gas Fired Storage Water Heater and Heat Pump Water Heater Baseline Efficiency Calculation Parameters (Reference 8)

	First Hour Rating to Define Draw Pattern		Electric Storage Water Heater >=20 Gallon and <=55 Gallon Baseline Efficiency Coefficients		Gas Storage WH >=20 gallons and <=55 Gallons Baseline Efficiency Coefficients		Gas Storage WH >55 Gallons and <=100 gallons Baseline Efficiency Coefficients	
Draw Pattern	min (>=Gallons)	max (< Gallons)	coef1	coef2	coef1	coef2	coef1	coef2
Very Small	1	18	0.8808	0.0008	0.3456	0.0020	0.6470	0.0006
Low	18	51	0.9254	0.0003	0.5982	0.0019	0.7689	0.0005
Medium	51	75	0.9307	0.0002	0.6483	0.0017	0.7897	0.0004
High	75	No Upper Limit	0.9349	0.0001	0.6920	0.0013	0.8072	0.0003

Table 20.4.2 Estimated Baseline Gas Storage Water Heater Tank Size

First Hour Draw		
Minimum (>=GPH)	Maximum (< GPH)	Baseline Tank Size
20	45	20
45	55	25
55	64	30
64	72	35
72	81	40
81	89	45
89	99	50
99	106	55
106	115	60
115	125	65
125	135	70
135	140	75
140	149	80
149	157	85
157	167	90
167	199	95

Table 20.4.3 2019 ASHRAE HVAC Applications Chapter 51 Service Water Heating: Table 4 HUD-FHA Minimum Water Heater Capacities for One- and Two-Family Living Units (Reference 12)

Water Heater Type \ Number of Bedrooms	1	2	3	4	5	6
Baseline Quantity Electric Storage Tanks	1	1	1	2	2	2
Baseline Tank Volume Electric Storage Tanks	30	40	55	30	30	40
Baseline Wattage per Electric Storage Tank	3.8	4.5	4.5	4.5	4.5	4.5

Table 20.4.4 Water Usage per Day by Number of Bedrooms

Home Type \ Number of Bedrooms	1	2	3	4	5	6
Single Family total HW usage per day	34	48	60	72	84	96
Multi-Family total HW usage per day	41	53	63	73	83	92

References:

1. Energy Conservation Program for Consumer Products: Test Procedure for Water Heaters; United States Department of Energy; http://www.gpo.gov/fdsys/pkg/FR-1998-05-11/pdf/98-12296.pdf
2. Denver Water's 2006 Treated Water Quality Summary Report; http://www.denverwater.org/docs/assets/9A12FBC5-BCDF-1B42-D1BC5F0B1CE3B115/TreatedWQSummaryReport20061.pdf
3. Energy Star Residential Water Heaters -Final Criterial Analysis, April 2008. http://www.energystar.gov/ia/partners/prod_development/new_specs/downloads/water_heaters/WaterHeaterAnalysis_Final.pdf
4. Not Used
5. US Department of Energy; Residential Heat Pump Water Heaters; http://energy.gov/eere/femp/covered-product-category-residential-heat-pump-water-heaters
6. US Department of Energy; Consumer Water Heaters; https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=32
7. Not Used
8.US Department of Energy,Energy and water conservation standards and their compliance dates: 10 CFR 430.32(d): https://www.ecfr.gov/cgi-bin/text-idx?SID=80dfa785ea350ebeee184bb0ae03e7f0&mc=true&node=se10.3.430_132&rgn=div8
9. EnergyStar - http://aceee.org/sites/default/files/files/pdf/conferences/hwf/2016/Ryan_Session1C_HWF16_2.22.16_0.pdf
10. Equipment Manufacturer Retail Price Information Request (Q4 - 2017)
11. NREL - National Residential Efficiency Measure Database, https://remdb.nrel.gov/measures.php?gId=6&ctId=270
12. 2019 ASHRAE HVAC Applications manual Chapter 51 Service Water Heating
13 Florida Solar Energy Center paper "Estimating Daily Domestic Hot Water Use in North American Homes. https://fsec.ucf.edu/en/publications/pdf/FSEC-PF-464-15.pdf Table 5 on Page 11.

Changes from Recent Filing:

Added baseline of gas storage water heater
changed method for determining hot water consumption in the home
changed method for determining electric resistance water heater baseline tank size and quantity to allow larger HPWH tank sizes

20.5 Water Heater Demand Response

Algorithms

$$Customer\ kWh = HPWH\ Load\ Shifting\ \&\ DR\ kWh$$

$$Customer\ kW = HPWH\_Load\_Shift\_DR\_kW$$

$$Customer\_PCkW = Customer\_kW\ x\ Coincidence\_Factor$$

Variables

HPWH Load Shifting & DR kWh Savings	118.400	kWh savings per year for daily load shifting in Residential Heat Pump WH Unit with a smart switch.
HPWH Load Shifting & DR PCkW @ Customer Savings	0.076	Peak Coincident kW savings per year for daily load shifting in Residential HPWH Unit with a smart switch (Reference 3).
HPWH_Load_Shift_DR_kW	0.536	kW savings of average residential HPWH Unit operating in HP only mode.
Coincidence_Factor	0.142	Coincidence Factor for DR or Load Shifting event of Heat Pump Water Heater.

Customer Inputs	**M&V Verified**	
Quantity Proposed Equipment	Yes	quantity of controlled water heaters.

Table 20.0.2 - Water Heater DR Incremental Costs

~~Cost is the sum of the following elements~~	Incremental Cost
There is no Cost to the Customer to Enroll	$ -
~~Cost of the Communication Dongle~~	~~$ 100.00~~
~~Cost of adapters for properietary WH Comms Ports~~	~~$ 75.00~~
~~Cost of Thermostatic Mixing Valve~~	~~$ 150.00~~

References:

1. Energy Conservation Program for Consumer Products: Test Procedure for Water Heaters; United States Department of Energy; http://www.gpo.gov/fdsys/pkg/FR-1998-05-11/pdf/98-12296.pdf
2. Denver Water's 2006 Treated Water Quality Summary Report; http://www.denverwater.org/docs/assets/9A12FBC5-BCDF-1B42-D1BC5F0B1CE3B115/TreatedWQSummaryReport20061.pdf
3. Energy Star Residential Water Heaters -Final Criterial Analysis, April 2008. http://www.energystar.gov/ia/partners/prod_development/new_specs/downloads/water_heaters/WaterHeaterAnalysis_Final.pdf
4. Not Used
5. US Department of Energy; Residential Heat Pump Water Heaters; http://energy.gov/eere/femp/covered-product-category-residential-heat-pump-water-heaters
6. US Department of Energy; Consumer Water Heaters; https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=32
7. Not Used
8.US Department of Energy,Energy and water conservation standards and their compliance dates: 10 CFR 430.32(d): https://www.ecfr.gov/cgi-bin/text-idx?SID=80dfa785ea350ebeee184bb0ae03e7f0&mc=true&node=se10.3.430_132&rgn=div8
9. EnergyStar - http://aceee.org/sites/default/files/files/pdf/conferences/hwf/2016/Ryan_Session1C_HWF16_2.22.16_0.pdf
10. Equipment Manufacturer Retail Price Information Request (Q4 - 2017)
11. NREL - National Residential Efficiency Measure Database, https://remdb.nrel.gov/measures.php?gId=6&ctId=270
12. 2019 ASHRAE HVAC Applications manual Chapter 51 Service Water Heating
13 Florida Solar Energy Center paper "Estimating Daily Domestic Hot Water Use in North American Homes. https://fsec.ucf.edu/en/publications/pdf/FSEC-PF-464-15.pdf Table 5 on Page 11.

Changes from Recent Filing:

HPWH Load Shifting and DR added in 2020 Q2 60 day notice.