Posting Date: July 31, 2023

➢ Summary of 60-Day Notice: Business HVAC+R Systems

The following 60-Day Notice summarizes Public Service Company of Colorado's (the "Company") action to add Beneficial Electrification measures to the Business HVAC+R Systems product.

The Company is including with this Notice:

- Redlined Deemed Savings worksheets; and
- Updated Technical Assumptions worksheets.

A copy of this notice is available on our website at:
https://www.xcelenergy.com/company/rates_and_regulations/filings/colorado_demand-side_management

New Commercial Beneficial Electrification Measures

Currently the Company offers many beneficial electrification measures in its residential DSM portfolio. The Company is creating these same measures in its commercial DSM portfolio which are listed below, based upon feedback from stakeholders and additional Company research.

Air Source Heat Pumps

In the Company's filed technical assumptions, the Company provides residential sized air source heat pump rebates that are available for commercial customers in new construction and retrofit beneficial electrification scenarios. The new rebates will cover air source heat pumps, cold climate air source heat pumps, mini-split heat pumps, cold climate mini-split heat pumps, and packaged terminal heat pumps that meet minimum efficiency requirements.

VRF Systems

The variable refrigerant flow heat pump system will have a rebate offering that meets our minimum efficiency requirements. These are available to customers in new construction and retrofit scenarios.

Water Source Heat Pumps

The water source heat pumps are currently offered as a rebate program for electric savings but will now also be offered as a beneficial electrification measure in both new construction and retrofit offerings. The ground source heat pump technology was previously rebated as a custom measure. This offering is now available as a beneficial electrification measure for new construction and retrofit scenarios. This technology moves heat from closed loop ground systems for interior comfort.

Heat Pump Water Heaters

The Company will add heat pump water heaters to our commercial portfolio in three tiers for new construction and retrofit offerings. Two tiers of light commercial heat pump water heater rebates will be offered based on the Uniform Energy Factor (UEF). We will also offer larger commercial heat pump water heater rebates based on (UEF) or the Coefficient of Performance (COP) if UEF is unavailable. Additional rebates will be available for demand response capable units.

<u>Dual Fuel Rooftop Units</u>

In the Company's filed technical assumptions, the Company will provide rebates for dual fuel rooftop units. These units provide electric cooling and heating, as well as gas heating backup. The rebates will be based the size of the cooling capacity if the efficiency requirements are met. This beneficial electrification measure will only be available in retrofit scenarios.

These changes are not expected to have a material impact on 2023 product forecasts.

Table 1: Summary of Forecasted Impacts: Business HVAC+R Systems

	2023	
	As Filed	*Revised per 60-day*
Electric Savings (kWh)	40,383,030	40,383,030
Electric Demand Reduction (kW)	13,503	13,503
Budget*	$4,128,134	$4,128,134
MTRC Test Ratio	2.93	2.93
Gas Savings (Dth)	35,869	35,869
Budget*	$235,367	$235,367
MTRC Test Ratio	2.57	2.57

*Rebates only. While the anticipated expenditure impacts are forecasted, the Company acknowledges that this Notice does not change the filed budget.

Table 12.0.1 Deemed Baseline Efficiencies (IECC 2018)

EQUIPMENT BASELINE EFFICIENCIES REQUIRED BY CODE, NOTE: For Rooftop Units Larger Than 5.4 Tons, Add 0.2 to Both IEER and EER for Units That Have No Heat or Electric Heat

Equipment	Equipment Classification	EER	SEER/ IEER/ IPLV	Path A FLV (kW/ton)	Path A IPLV (kW/ton)	COP or HSPF
Rooftop Units less than 5.4 tons	Baseline Efficiency	11.90	**14.00**			
Split Systems less than 5.4 tons	Baseline Efficiency	11.05	**13.00**			
Rooftop Units Condensing Units & Split Systems 5.5-11.3 tons	Baseline Efficiency	**11.00**	**12.60**			
Rooftop Units & Split Systems 11.4-19.9 tons & Condensing Units > 11.4 tons	Baseline Efficiency	**10.80**	**12.20**			
Rooftop Units & Split Systems 20-63.3 tons	Baseline Efficiency	**9.80**	**11.40**			
Rooftop Units greater than 63.3 tons	Baseline Efficiency	**9.50**	**11.00**			
Water Source Heat Pumps (Water:Air - Water Loop)	Baseline Efficiency	13.00	**13.00**			4.30
PTAC Replacement <= 7000 BTUH	Baseline Efficiency	9.41	11.07			
PTAC Replacement >7000 BTUH to <15000 BTUH	Baseline Efficiency	8.34	9.82			
PTAC Replacement >=15000 BTUH	Baseline Efficiency	7.71	9.06			
scroll/screw chiller < 75 tons	Baseline Efficiency			**0.750**	**0.600**	
scroll/screw chiller >=75 to < 150 tons	Baseline Efficiency			**0.720**	**0.560**	
scroll/screw chiller >=150 to <300 tons	Baseline Efficiency			**0.660**	**0.540**	
scroll/screw chiller >= 300 to <600 tons	Baseline Efficiency			**0.610**	**0.520**	
scroll/screw chiller >= 600 tons	Baseline Efficiency			**0.560**	**0.500**	
Centrifugal Chillers < 150 tons	AHRI Rated Efficiency			**0.610**	**0.550**	
Centrifugal Chillers >= 150 to < 300 tons	AHRI Rated Efficiency			**0.610**	**0.550**	
Centrifugal Chillers >=300 tons to < 400 tons	AHRI Rated Efficiency			**0.560**	**0.520**	
Centrifugal Chillers >=400 tons to < 600 tons	AHRI Rated Efficiency			**0.560**	**0.500**	
Centrifugal Chillers >= 600 tons	AHRI Rated Efficiency			**0.560**	**0.500**	
Air-Cooled Chillers - < 150 tons	Baseline Efficiency	**10.100**	**13.700**			
Air-Cooled Chillers - >= 150 tons	Baseline Efficiency	**10.100**	**14.000**			
Mini-Split Heat Pump (16-21 SEER, 9-12 HSPF)	Baseline Efficiency	8.75	14.00			8.20
Mini-Split Heat Pump (21-24 SEER, 9-12 HSPF)	Baseline Efficiency	8.75	14.00			8.20
Mini-Split Heat Pump (24-26 SEER, 9-12 HSPF)	Baseline Efficiency	8.75	14.00			8.20

NOTES

* Bold values indicates direct sourcing to IECC 2018, tables 403.2.3(x), otherwise estimated by using the code SEER in the algorithm above to get EER, or using EER in the following algorithm to get SEER = 28 - SQRT(784 - (50 x EER)). For water-sourced heat pumps only, the EER is set equal to the SEER because the condenser water loop temperature is assumed to be maintained by cooling towers.
* High Efficiency IEER, SEER and EER values are supplied by Customer.
* AHRI rated efficiency is converted to Standard efficiency as per Table 403.3.2(7)
* Values for Centrifugal Chillers assumed to be at AHRI rating conditions of 85 degrees condensing temperature, 44 degrees chilled water temperature, 2.4 gpm/ton chill water flow, and 3 gpm/ton condenser water flow. Reference International Energy Conservation Code (IECC), 2015, Sec. 403.2.3.1 . Reference International Energy Conservation Code (IECC), 2018, Sec. 403.3.2.1
* Values for PTAC from IECC 2018 formula, Table 403.3.2(3) for Cooling Mode, Replacements.
* Chiller categories are now aligned with the IECC 2018.

Table 12.0.2 Equivalent Full Load Hours by Building Type

	County/Zone	CO1	CO1	CO1
	System Type	**Front Range EFLH**	**Front Range EFLH w/ Economizer**	**Front Range EFLH Hydronic System**
Building Type / Market Segment				
Data Center	Data CenterCO1	8760	8760	8760
Full Service Restaurant	Full Service RestaurantCO1	1284	1037	1820
High-rise Apartment	High-rise ApartmentCO1	1797	1387	1768
Hospital	HospitalCO1	2579	1446	3178
Large Office	Large OfficeCO1	2124	1387	2341
LargeHotel	LargeHotelCO1	2404	1005	2453
Medium Office	Medium OfficeCO1	1209	688	1068
Mid-rise Apartment	Mid-rise ApartmentCO1	1647	688	1610
Outpatient Healthcare	Outpatient HealthcareCO1	2469	1358	2662
Primary School	Primary SchoolCO1	948	711	1142
Process Load	Process LoadCO1	5840	5840	5840
Quick Service Restaurant	Quick Service RestaurantCO1	1099	920	2036
Secondary School	Secondary SchoolCO1	1685	1390	1423
Small Hotel	Small HotelCO1	2010	586	1882
Small Office	Small OfficeCO1	826	586	755
Stand-alone Retail	Stand-alone RetailCO1	1154	873	1088
Strip Mall	Strip MallCO1	901	763	885
Warehouse (non-refrigerated)	Warehouse (non-refrigerated)CO1	129	112	765

	County/Zone	CO2	CO2	CO2
	System Type	**Western Slope EFLH**	**Western Slope EFLH w/ Economizer**	**Western Slope EFLH Hydronic System**
Building Type / Market Segment				
Full Service Restaurant	Full Service RestaurantCO2	1440	1224	2028
High-rise Apartment	High-rise ApartmentCO2	2010	1224	1986
Hospital	HospitalCO2	2706	1663	3261
Large Office	Large OfficeCO2	2257	1623	2432
LargeHotel	LargeHotelCO2	2468	1132	2539
Medium Office	Medium OfficeCO2	1309	799	1174
Mid-rise Apartment	Mid-rise ApartmentCO2	1803	799	1767
Outpatient Healthcare	Outpatient HealthcareCO2	2536	1507	2711
Primary School	Primary SchoolCO2	1048	837	1226
Quick Service Restaurant	Quick Service RestaurantCO2	1258	1093	2217
Stand-alone Retail	Stand-alone RetailCO2	1249	1000	1173
Strip Mall	Strip MallCO2	988	865	947
Secondary School	Secondary SchoolCO2	1840	1570	1535
Small Hotel	Small HotelCO2	2061	656	1923
Small Office	Small OfficeCO2	872	656	808
Warehouse (non-refrigerated)	Warehouse (non-refrigerated)CO2	170	156	847
Process Load	Process LoadCO2	5840	5840	5840
Data Center	Data CenterCO2	8760	8760	8760

	County/Zone	CO3	CO3	CO3
	System Type	**Mountain EFLH**	**Mountain EFLH w/ Economizer**	**Mountain EFLH Hydronic System**
Building Type / Market Segment				
Full Service Restaurant	Full Service RestaurantCO3	797	502	1395
High-rise Apartment	High-rise ApartmentCO3	1332	614	1496
Hospital	HospitalCO3	2098	813	3009
Large Office	Large OfficeCO3	1631	726	2093
LargeHotel	LargeHotelCO3	2377	614	2510
Medium Office	Medium OfficeCO3	1058	388	980
Mid-rise Apartment	Mid-rise ApartmentCO3	1277	388	1422
Outpatient Healthcare	Outpatient HealthcareCO3	2109	886	2621
Primary School	Primary SchoolCO3	691	395	941
Quick Service Restaurant	Quick Service RestaurantCO3	591	402	1322
Stand-alone Retail	Stand-alone RetailCO3	915	537	960
Strip Mall	Strip MallCO3	694	457	735
Secondary School	Secondary SchoolCO3	1294	856	1166
Small Hotel	Small HotelCO3	1804	364	1785
Small Office	Small OfficeCO3	668	364	622
Warehouse (non-refrigerated)	Warehouse (non-refrigerated)CO3	83	58	577
Process Load	Process LoadCO3	5840	5840	5840
Data Center	Data CenterCO3	8760	8760	8760

Recommended System Type by Equipment Type

Equipment Type	Table 12.0.2. System Type
Rooftop Units (RTUs) <5.4 tons	EFLH
Rooftop Units (RTUs) >5.4 tons	EFLH w/Economizer
Mini Split System	EFLH
PTAC	EFLH
Water Cooled Chiller	Hydronic System
Water Source Heat Pump	Hydronic System
Air Cooled Chiller	Hydronic System

Heating Equivalent Full Load Hours	Zone	$EFLH_{Heat}$	$EFLH_{Heat,HP}$	$EFLH_{Heat,ccHP}$
CO1: Denver / Front Range	CO1	950	881	943
CO2: Alamosa / Mountain is climate zone	CO2	950	881	943
CO3: Grand Junction / Western Slope	CO3	950	881	943

NOTES:

*** EFLH- Zone 1 (Front Range/Denver); Zone 2 (Western State as represented by Grand Junction) and Zone 3 (Mountain Areas as represented by Alamosa)**
*** Market segment hours scaled from Minnesota OES data (Reference 10) with Office value calculated for Denver and Grand Junction Typical Meteorological Year data. Distributions developed from CBECS data (Reference 3)**
*** WSHP's will use Non-Economizer hours for all projects.**
*** RTU's that are less than 5.4 tons will use Non-Economizer hours for all projects.**
*** Air Cooled Chillers and RTU's will use Hydronic System hours for all projects.**
*** PTAC's will use Non-Economizer Small Hotel hours for all projects.**

Table 12.0.3 Incremental Costs For Equipment in the Midstream Product		
Equipment	**Equipment Tier**	**Incremental Cost per Ton, $/ton (Reference 8)**
Rooftop Units less than 5.4 tons	Tier 1	$97.30
Rooftop Units less than 5.4 tons	Tier 2	$146.42
Rooftop Units less than 5.4 tons	Tier 3	$335.07
Rooftop Units less than 5.4 tons	Tier 4	$790.61
Split Systems less than 5.4 tons	Tier 1	$97.30
Split Systems less than 5.4 tons	Tier 2	$146.42
Split Systems less than 5.4 tons	Tier 3	$335.07
Split Systems less than 5.4 tons	Tier 4	$790.61
Rooftop Units & Split Systems 5.5-11.3 tons	Tier 1	$79.97
Rooftop Units & Split Systems 5.5-11.3 tons	Tier 2	$129.41
Rooftop Units & Split Systems 5.5-11.3 tons	Tier 3	$115.75
Rooftop Units & Split Systems 5.5-11.3 tons	Tier 4	$283.27
Rooftop Units & Split Systems 11.4-19.9 tons	Tier 1	$106.76
Rooftop Units & Split Systems 11.4-19.9 tons	Tier 2	$169.99
Rooftop Units & Split Systems 11.4-19.9 tons	Tier 3	$195.07
Rooftop Units & Split Systems 11.4-19.9 tons	Tier 4	$316.18
Rooftop Units & Split Systems 20-63.3 tons	Tier 1	$12.84
Rooftop Units & Split Systems 20-63.3 tons	Tier 2	$67.72
Rooftop Units & Split Systems 20-63.3 tons	Tier 3	$144.31
Rooftop Units & Split Systems 20-63.3 tons	Tier 4	$163.71
Rooftop Units greater than 63.3 tons	Tier 1	$108.99
Rooftop Units greater than 63.3 tons	Tier 2	$139.21
Rooftop Units greater than 63.3 tons	Tier 3	$264.06
Rooftop Units greater than 63.3 tons	Tier 4	$333.66
Air-Cooled Chillers - < 150 tons	Tier 1	$42.75
Air-Cooled Chillers - < 150 tons	Tier 2	$66.22
Air-Cooled Chillers - < 150 tons	Tier 3	$91.92
Air-Cooled Chillers - < 150 tons	Tier 4	$167.90
Air-Cooled Chillers - >= 150 tons	Tier 1	$42.75
Air-Cooled Chillers - >= 150 tons	Tier 2	$66.22
Air-Cooled Chillers - >= 150 tons	Tier 3	$91.92
Air-Cooled Chillers - >= 150 tons	Tier 4	$167.90
PTAC (Replacements) - 11 EER	Tier 1	$106.62
PTAC (Replacements) - 11.5 EER	Tier 2	$178.85
PTAC (Replacements) - 12 EER	Tier 3	$300.03
Water-source Heat Pumps	Tier 1	$80.53
Water-source Heat Pumps	Tier 2	$167.63
Water-source Heat Pumps	Tier 3	$261.83
Water-source Heat Pumps	Tier 4	$363.72
MSAC 16-21 SEER - MS	Tier 1	$90.52
MSAC 21-24 SEER - MS	Tier 2	$189.28
MSAC 24+ SEER - MS	Tier 3	$366.33
Mini-Split Heat Pump (16-21 SEER, 9-12 HSPF)	Tier 1	$90.52
Mini-Split Heat Pump (21-24 SEER, 9-12 HSPF)	Tier 2	$189.28
Mini-Split Heat Pump (24-26 SEER, 9-12 HSPF)	Tier 3	$366.33

Table 12.0.4. Incremental Costs For Equipment in the Downstream Product		
Equipment		Incremental Cost per Ton, $/ton (References 9, 11)
scroll/screw chiller < 75 tons		$178.14
scroll/screw chiller >=75 to < 150 tons		$124.41
scroll/screw chiller >=150 to <300 tons		$54.25
scroll/screw chiller >= 300 to <600 tons		$23.61
scroll/screw chiller >= 600 tons		$23.61
Centrifugal Chillers < 150 tons		$84.11
Centrifugal Chillers >= 150 to < 300 tons		$96.40
Centrifugal Chillers >=300 tons to < 400 tons		$80.23
Centrifugal Chillers >=400 tons to < 600 tons		$49.25
Centrifugal Chillers >= 600 tons		$26.67
VFD's for Chillers		$71.88

Assumptions:

- Customer selection of cooling equipment is in lieu of equipment of the same size and configuration that met minimum 2018 International Energy Conservation Code requirements.
- Prescriptive rebates are not given for backup cooling equipment.
- Small RTU assumed to have gas heat for code baseline selection
- No Heating kW saving are claimed for MSHP during winter, only summer cooling kW savings are claimed.

EC Motors:

- Each motor is replaced with the same size on a 1 for 1 basis.
- Rebates do not apply to rewound or repaired motors.

References:

1. NYSERDA (New York State Energy Research and Development Authority); NY Energy $mart Programs Deemed Savings Database - Source for coincidence factor
2. ASHRAE, 2011, Applications Handbook, Ch. 37, table 4, Comparison of Service Life Estimates
3. CBECS (Commercial Buildings Energy Consumption Survey), 2012 - Total Floor space of Cooled Buildings by Principal Building Activity - source of market segment distributions
4. NTG for cooling is updated through a 2017 program evaluation.
5. Cypress, Ltd. Analysis of office building load profile and RTU efficiency improvement from application of wet bulb depression to reduce air cooled condensing temperatures.
6. International Energy Conservation Code 2018
7. Building America, Research Benchmark Definitions, 2010 (see p. 10). http://www.nrel.gov/docs/fy10osti/47246.pdf
   Approximation: EER = 1.12 x SEER - 0.02 x SEER^2
8. Midstream Product Data Analysis by Product Management Vendor
9. California DEER Database 2008
10. Minnesota Office of Energy Security (MOES) 2008 Cooling Equivalent Full Load Hours
11. Incremental costs for MSHPs were determined from the NEEP Incremental Cost Study Phase 2 Report
12. 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
13. Energy model analysis of EFLH values completed by Energy Solutions in 2019 following the DOE Uniform Methods process using PNNL prototype buildings. EFLH values were peer reviewed by Michael's Energy; "XCEL ENERGY EFLH – EFLH ANALYSIS".

Changes from 2019 / 2020 Plan

Incremental cost are adjusted according to updated information from registered distributors.
Equivalent Full Load Hours updated to correct discrepancies between climate zones.
EFLH System Type options increased from two to three types.
Water Source Heat Pump measures altered to capture heating energy savings compared to baseline equipment.
Minimum qualifying EERs have been evaluated and updated to improve measure level performance.

12.1 DX Units

Algorithms

$$\text{Customer } kWh = Size \times EFLH \times \left(\frac{12}{SEER_{Baseline}} - \frac{12}{SEER_{Eff}}\right) \times Qty$$

$$\text{Customer kW } = Size \times \left(\frac{12}{EER_{Baseline}} - \frac{12}{EER_{Eff}}\right) \times \text{Qty}$$

$$\text{Customer PC kW } = CF \times Size \times \left(\frac{12}{EER_{Baseline}} - \frac{12}{EER_{Eff}}\right) \times Qty$$

$$EER = SEER \times 0.85$$

$$Incremental\ Cost = Size \times Incremental\ Cost\ per\ Ton$$

Variables

EFLH	See Table 12.0.2	Equivalent Full Load Hours. The equivalent number of hours that the equipment would be running at full load over the course of the year.
$SEER_{Baseline}$ / $IEER_{Baseline}$	See Table 12.0.1	Deemed Baseline Efficiencies based on IECC 2018
$EER_{Baseline}$	See Table 12.0.1	Deemed Baseline Efficiencies based on IECC 2018
CF	90%	Coincidence Factor (Reference 1)
Incremental Costs Per Ton	See Table 12.0.3	Incremental Costs Per Ton.
NTG_Midstream	92%	Net-to-gross = We will use 92% for all midstream cooling equipment (Reference 4).
SEER to EER conversion factor	0.85	SEER to EER conversion factor
Lifetime, years	20	Reference 11

Customer Inputs	**M&V Verified**	
$SEER_{Eff}$ / $IEER_{Eff}$	Yes	Seasonal (or Integrated) Energy Efficiency Ratio in Btu/W-hr of high efficiency equipment that the customer will install.
EER_{Eff}	Yes	EER of high efficiency equipment that the customer will install.
Size	Yes	The equipment capacity in tons.
Building Type / Market Segment	Yes	
County/Zone	Yes	
System Type	Yes	
Quantity Proposed Equipment (Qty)	Yes	

References:

1. NYSERDA (New York State Energy Research and Development Authority); NY Energy $mart Programs Deemed Savings Database - Source for coincidence factor
2. ASHRAE, 2011, Applications Handbook, Ch. 37, table 4, Comparison of Service Life Estimates
3. CBECS (Commercial Buildings Energy Consumption Survey), 2012 - Total Floor space of Cooled Buildings by Principal Building Activity - source of market segment distributions
4. NTG for cooling is updated through a 2017 program evaluation.
5. Cypress, Ltd. Analysis of office building load profile and RTU efficiency improvement from application of wet bulb depression to reduce air cooled condensing temperatures.
6. International Energy Conservation Code 2018
7. Building America, Research Benchmark Definitions, 2010 (see p. 10). http://www.nrel.gov/docs/fy10osti/47246.pdf
8. Midstream Product Data Analysis by Product Management Vendor
9. California DEER Database 2008
10. Incremental costs for MSHPs were determined from the NEEP Incremental Cost Study Phase 2 Report
11. Equipment life is from Minnesota Technical Reference Manual (TRM) version 3.1 Jan 20, 2020.
12. 2017-2019 CO Cooling Program Participation Data, used for forecasts,minimum qualifying efficiencies

Changes from Recent Filing:

EFLH and Building Type/Market Segment updated

12.2 WSHP

Algorithms

$$\cancel{WSHP_{Cooling}kWh = Size \times EFLH \times \left(\frac{12}{SEER_{Baseline}} - \frac{12}{SEER_{Eff}}\right)}$$

$$\cancel{WSHP_{Heating}kWh = Size_{Heat} \times EFLH_{Heat} \times \left(\frac{1}{COP_{Baseline} \times 3412} - \frac{1}{COP_{Eff} \times 3412}\right)}$$

$$\cancel{Customer\ kWh = (WSHP_{Cooling}\ kWh + WSHP_{Heating}kWh) \times Qty}$$

$$Customer\ kW\ = Size \times \left(\frac{12}{EER_{Baseline}} - \frac{12}{EER_{Eff}}\right) \times Qty$$

$$Customer\ PC\ kW\ = CF \times Size \times \left(\frac{12}{EER_{Baseline}} - \frac{12}{EER_{Eff}}\right) \times Qty$$

$$EER = SEER$$

$$Incremental\ Cost = Size\ \times Incremental\ Cost\ per\ Ton$$

Electric Baseline

$$WSHP_{Cooling}kWh = Size \times EFLH \times \left(\frac{12}{SEER_{Baseline}} - \frac{12}{SEER_{Eff}}\right)$$

$$WSHP_{Heating}kWh = Size_{Heat} \times EFLH_{Heat} \times \left(\frac{1}{COP_{Baseline} \times 3412} - \frac{1}{COP_{Eff} \times 3412}\right)$$

$$Customer\ kWh = (WSHP_{Cooling}\ kWh + WSHP_{Heating}kWh) \times Qty$$

Gas Baseline

$$Customer\ kWh = (Size\ \times (EFLH_{Cool} \times \left(\frac{12}{SEER_{Baseline}} - \frac{12}{SEER_{Eff}}\right)) + (kWh_{Heat\ Base} - kWh_{Heat\ Eff})) \times Qty$$

Dth savings per year = $Dth_{Baseline} - Dth_{Eff}$

$$Dth_{Baseline} = \left(\frac{Size_{Heat}}{1{,}000{,}000}\right) \times EFLH_{HP} * \left(\frac{1}{\%Eff_{Base}}\right)$$

$$Dth_{Eff} = 0$$

$$kWh_{Baseline} = 0$$

$$kWh_{Eff} = \frac{Size_{Heat}}{1000} \times EFLH_{HP} \times \frac{1}{HSPF_{Eff}}$$

Variables

EFLH	See Table 12.0.2	Equivalent Full Load Hours. The equivalent number of hours that the equipment would be running at full load over the course of the year.
$EFLH_{Heat}$	See Table 12.0.2	The equivalent number of hours that WSHP equipment would be running at Full Load over the course of the year for heating.
$\%Eff_{Base}$	0.78	Deemed Baseline Efficiencies based on IECC 2018
$SEER_{Baseline}$ / $IEER_{Baseline}$	See Table 12.0.1	Deemed Baseline Efficiencies based on IECC 2018
$EER_{Baseline}$	See Table 12.0.1	Deemed Baseline Efficiencies based on IECC 2018
CF	90%	Coincidence Factor (Reference 1)
Lifetime, years	15	Reference 11
3412	3,412	kWh to BTU conversion factor
NTG_Midstream	92%	Net-to-gross = We will use 92% for all midstream cooling equipment (Reference 4).
Incremental Costs Per Ton	See Table 12.0.3	Incremental Costs Per Ton.
$COP_{Baseline}$	4.30	COP of standard Water Source Heat Pump equipment in Heating Mode for Water:Air Water Loop from the International Energy Conservation Code, 2018, Table 403.3.2(2).

Customer Inputs	M&V Verified	
$SEER_{Eff}$	Yes	SEER of high efficiency equipment that the customer will install.
EER_{Eff}	Yes	EER of high efficiency equipment that the customer will install.
COP_{Eff}	Yes	COP of High Efficiency unit that the customer will install.
Size	Yes	The equipment capacity in tons.
$Size_{Heat}$	Yes	Heating Capacity of Water Source Heat Pumps in BTU/h, provided by customer
Building Type / Market Segment	Yes	
County/Zone	Yes	
Baseline System Type	Yes	Electric or gas heat
Quantity Proposed Equipment (Qty)	Yes	

References:

1. NYSERDA (New York State Energy Research and Development Authority); NY Energy $mart Programs Deemed Savings Database - Source for coincidence factor

2. ASHRAE, 2011, Applications Handbook, Ch. 37, table 4, Comparison of Service Life Estimates
3. CBECS (Commercial Buildings Energy Consumption Survey), 2012 - Total Floor space of Cooled Buildings by Principal Building Activity - source of market
4. NTG for cooling is updated through a 2017 program evaluation.
5. Cypress, Ltd. Analysis of office building load profile and RTU efficiency improvement from application of wet bulb depression to reduce air cooled condensing
6. International Energy Conservation Code 2018
7. Building America, Research Benchmark Definitions, 2010 (see p. 10). http://www.nrel.gov/docs/fy10osti/47246.pdf
8. Midstream Product Data Analysis by Product Management Vendor
9. California DEER Database 2008
10. Incremental costs for MSHPs were determined from the NEEP Incremental Cost Study Phase 2 Report
11. Equipment life is from Minnesota Technical Reference Manual (TRM) version 3.1 Jan 20, 2020.

Changes from Recent Filing:

EFLH and Building Type/Market Segment updated

12.3 PTAC

Algorithms

Customer $kWh = Size \times EFLH \times \left(\frac{12}{SEER_{Baseline}} - \frac{12}{SEER_{Eff}}\right) \times Qty$

Customer kW $= Size \times \left(\frac{12}{EER_{Baseline}} - \frac{12}{EER_{Eff}}\right) \times Qty$

Customer PC kW $= CF \times Size \times \left(\frac{12}{EER_{Baseline}} - \frac{12}{EER_{Eff}}\right) \times Qty$

$EER = SEER \times 0.85$

$Incremental\ Cost = Size \times Incremental\ Cost\ per\ Ton$

Variables

EFLH	See Table 12.0.2	Equivalent Full Load Hours. The equivalent number of hours that the equipment would be running at full load over the course of the year.
$SEER_{Baseline}$ / $IEER_{Baseline}$	See Table 12.0.1	Deemed Baseline Efficiencies based on IECC 2018
$EER_{Baseline}$	See Table 12.0.1	Deemed Baseline Efficiencies based on IECC 2018
CF	90%	Coincidence Factor (Reference 1)
Incremental Costs Per Ton	See Table 12.0.3	Incremental Costs Per Ton.
NTG_Midstream	92%	Net-to-gross = We will use 92% for all midstream cooling equipment (Reference 4).
SEER to EER conversion factor	0.85	SEER to EER conversion factor
Lifetime, years	20	Reference 11

Customer Inputs	M&V Verified	
$SEER_{Eff}$ / $IEER_{Eff}$	Yes	Seasonal (or Integrated) Energy Efficiency Ratio in Btu/W-hr of high efficiency equipment that the customer will install.
EER_{Eff}	Yes	EER of high efficiency equipment that the customer will install.
Size	Yes	The equipment capacity in tons.
Building Type / Market Segment	Yes	
County/Zone	Yes	
System Type	Yes	
Quantity Proposed Equipment (Qty)	Yes	

References:

1. NYSERDA (New York State Energy Research and Development Authority); NY Energy $mart Programs Deemed Savings Database - Source for coincidence factor
2. ASHRAE, 2011, Applications Handbook, Ch. 37, table 4, Comparison of Service Life Estimates
3. CBECS (Commercial Buildings Energy Consumption Survey), 2012 - Total Floor space of Cooled Buildings by Principal Building Activity - source of market segment
4. NTG for cooling is updated through a 2017 program evaluation.
5. Cypress, Ltd. Analysis of office building load profile and RTU efficiency improvement from application of wet bulb depression to reduce air cooled condensing
6. International Energy Conservation Code 2018
7. Building America, Research Benchmark Definitions, 2010 (see p. 10). http://www.nrel.gov/docs/fy10osti/47246.pdf
8. Midstream Product Data Analysis by Product Management Vendor
9. California DEER Database 2008
10. Incremental costs for MSHPs were determined from the NEEP Incremental Cost Study Phase 2 Report
11. Equipment life is from Minnesota Technical Reference Manual (TRM) version 3.1 Jan 20, 2020.

Changes from Recent Filing:

EFLH and Building Type/Market Segment updated

12.4 Scroll-Screw Chiller

Algorithms

$$Customer\ kWh = Size \times EFLH \times \left(IPLV_{Baseline} - IPLV_{Eff}\right) \times Qty$$

$$Customer\ kW = Size \times \left(FLV_{Baseline} - FLV_{Eff}\right) \times Qty$$

$$Customer\ PCkW = CF \times Size \times \left(FLV_{Baseline} - FLV_{Eff}\right) \times Qty$$

$$Incremental\ Cost = Size\ \times Incremental\ Cost\ per\ Ton$$

Variables

EFLH	See Table 12.0.2	Equivalent Full Load Hours. The equivalent number of hours that the equipment would be running at full load over the course of the year.
$FLV_{Baseline}$	See Table 12.0.1	Deemed Baseline Efficiencies based on IECC 2018
$IPLV_{Baseline}$	See Table 12.0.1	Deemed Baseline Efficiencies based on IECC 2018
CF	90%	Coincidence Factor (Reference 1)
Incremental Costs Per Ton	See Table 12.0.3	Incremental Costs Per Ton.
NTG_General_Cooling	92%	Net-to-gross = We will use 92% for all cooling equipment except MSHP units (Reference 4).
Lifetime, years	20	Reference 11

Customer Inputs	**M&V Verified**	
FLV_{Eff}	Yes	Full Load Value cooling efficiency in kW/ton, representing the efficiency at design conditions for the customer's operating conditions.
$IPLV_{Eff}$	Yes	Integrated Part Load Value (representing the average efficiency over a range of loaded states) cooling efficiency in kW/ton of high efficiency equipment at the customer's operating conditions.
Size	Yes	The equipment capacity in tons.
Building Type / Market Segment	Yes	
County/Zone	Yes	
System Type	Yes	
Quantity Proposed Equipment (Qty)	Yes	
Air or Waterside Economizer	Yes	Check if the chiller is equpped with or without an Airside/Waterside Economizer

References:

1. NYSERDA (New York State Energy Research and Development Authority); NY Energy $mart Programs Deemed Savings Database - Source for coincidence factor
2. ASHRAE, 2011, Applications Handbook, Ch. 37, table 4, Comparison of Service Life Estimates
3. CBECS (Commercial Buildings Energy Consumption Survey), 2012 - Total Floor space of Cooled Buildings by Principal Building Activity - source of market segment distributions
4. NTG for cooling is updated through a 2017 program evaluation.
5. Cypress, Ltd. Analysis of office building load profile and RTU efficiency improvement from application of wet bulb depression to reduce air cooled condensing temperatures.
6. International Energy Conservation Code 2018
7. Building America, Research Benchmark Definitions, 2010 (see p. 10). http://www.nrel.gov/docs/fy10osti/47246.pdf
8. Midstream Product Data Analysis by Product Management Vendor
9. California DEER Database 2008
10. Incremental costs for MSHPs were determined from the NEEP Incremental Cost Study Phase 2 Report
11. Equipment life is from Minnesota Technical Reference Manual (TRM) version 3.1 Jan 20, 2020.

Changes from Recent Filing:

EFLH and Building Type/Market Segment updated

12.5 Centrifugal Chillers

Algorithms

$$Customer\ kWh = Size \times EFLH \times (IPLV_{AHRI\_Adj} - IPLV_{Eff}) \times Qty$$

$$Customer\ kW = Size \times (FLV_{AHRI\_Adj} - FLV_{Eff}) \times Qty$$

$$Customer\ PCkW = CF \times Size \times (FLV_{AHRI\_Adj} - FLV_{Eff}) \times Qty$$

$$IPLV_{AHRI\_Adj} = IPLV_{AHRI} \div K_{adj}$$

$$FLV_{AHRI\_Adj} = FLV_{AHRI} \div K_{adj}$$

$$K_{adj} = A \times B$$

$$A = 0.00000014592 \times (Lift)^4 - 0.0000346496 \times (Lift)^3 + 0.00314196 \times (Lift)^2 - 0.147199 \times (Lift) + 3.9302$$

$$B = 0.0015 \times Lvg_{Evap} + 0.934$$

$$Lift = Lvg_{Cond} - Lvg_{Evap}$$

$$Minimum\ Qualifying\ FLV = FLV_{AHRI\_Adj} - Qualifying\ FLV_{Offset}$$

$$Minimum\ Qualifying\ IPLV = IPLV_{AHRI\_Adj} - Qualifying\ IPLV_{Offset}$$

$$Incremental\ Cost = Size \times Incremental\ Cost\ per\ Ton$$

Variables

EFLH	See Table 12.0.2	Equivalent Full Load Hours. The equivalent number of hours that the equipment would be running at full load over the course of the year.
FLV_{AHRI}	See Table 12.0.1	Full load cooling efficiency in kW/ton of standard equipment, based upon the minimum acceptable efficiency defined by International Energy Conservation Code, 2018, Table 403.2.3(7) for selected centrifugal chiller type, size, condensing and chilled water temperature (provided by customer).
$IPLV_{AHRI}$	See Table 12.0.1	Integrated Part Load Value (representing the average efficiency over a range of loaded states) cooling efficiency in kW/ton of standard equipment, based upon the minimum acceptable efficiency defined by International Energy Conservation Code, 2018 for chiller type and size (type and size provided by customer).
FLV_{AHRI_Adj}		IECC based FLV for water cooled centrifugal chillers adjusted to actual site rated conditions (provided by customer) per IECC 2018 code adjustment formulas.
$IPLV_{AHRI\_Adj}$		IECC based IPLV or NPLV for water cooled centrifugal chillers adjusted to actual site rated conditions (provided by customer) per IECC 2018 code adjustment formulas.
Lifetime, years	20	Reference 11
0.00000014592, 0.0000346496, 0.00314196, 0.147199, 3.9302, 0.0015, 0.934		Coefficients to calculate K_{adj} (adjustment factor) per IECC 2018 code adjustment formulas
NTG_General_Cooling	92%	Net-to-gross = We will use 92% for all cooling equipment except MSHP units (Reference 4).
Incremental Costs Per Ton	See Table 12.0.3	Incremental Costs Per Ton.
CF	90%	Coincidence Factor (Reference 1)

Customer Inputs	M&V Verified	
FLV_{Eff}	Yes	Full Load Value cooling efficiency in kW/ton, representing the efficiency at design conditions for the customer's operating conditions.
$IPLV_{Eff}$	Yes	Integrated Part Load Value (representing the average efficiency over a range of loaded states) cooling efficiency in kW/ton of high efficiency equipment at the customer's operating conditions.
Lvg_{Evap} (Chilled water supply temperature [°F] at full load)	Yes	The full load water temperature leaving the evaporator, in °F.
Lvg_{Cond} (Condenser water leaving temperature [°F] at full load)	Yes	The full load water temperature leaving the condenser, in °F.
Size	Yes	The equipment capacity in tons.
Building Type / Market Segment	Yes	
County/Zone	Yes	
System Type	Yes	
Quantity Proposed Equipment (Qty)	Yes	
Chill water flow [gpm/ton] at full load	Yes	
Condenser water flow [gpm/ton] at full load	Yes	

References:

1. NYSERDA (New York State Energy Research and Development Authority); NY Energy $mart Programs Deemed Savings Database - Source for coincidence factor
2. ASHRAE, 2011, Applications Handbook, Ch. 37, table 4, Comparison of Service Life Estimates
3. CBECS (Commercial Buildings Energy Consumption Survey), 2012 - Total Floor space of Cooled Buildings by Principal Building Activity - source of market segment distributions
4. NTG for cooling is updated through a 2017 program evaluation.
5. Cypress, Ltd. Analysis of office building load profile and RTU efficiency improvement from application of wet bulb depression to reduce air cooled condensing temperatures.
6. International Energy Conservation Code 2018
7. Building America, Research Benchmark Definitions, 2010 (see p. 10). http://www.nrel.gov/docs/fy10osti/47246.pdf
8. Midstream Product Data Analysis by Product Management Vendor
9. California DEER Database 2008
10. Incremental costs for MSHPs were determined from the NEEP Incremental Cost Study Phase 2 Report
11. Equipment life is from Minnesota Technical Reference Manual (TRM) version 3.1 Jan 20, 2020.

Changes from Recent Filing:

EFLH and Building Type/Market Segment updated

12.6 Air-Cooled Chillers

Algorithms

$$\text{Customer } kWh = Size \times EFLH \times \left(\frac{12}{SEER_{Baseline}} - \frac{12}{SEER_{Eff}}\right) \times Qty$$

$$\text{Customer kW } = Size \times \left(\frac{12}{EER_{Baseline}} - \frac{12}{EER_{Eff}}\right) \times Qty$$

$$\text{Customer PC kW } = CF \times Size \times \left(\frac{12}{EER_{Baseline}} - \frac{12}{EER_{Eff}}\right) \times Qty$$

$$EER = SEER \times 0.85$$

$$Incremental\ Cost = Size\ \times Incremental\ Cost\ per\ Ton$$

Variables

EFLH	See Table 12.0.2	Equivalent Full Load Hours. The equivalent number of hours that the equipment would be running at full load over the course of the year.
$SEER_{Baseline}$ / $IEER_{Baseline}$	See Table 12.0.1	Deemed Baseline Efficiencies based on IECC 2018
$EER_{Baseline}$	See Table 12.0.1	Deemed Baseline Efficiencies based on IECC 2018
CF	90%	Coincidence Factor (Reference 1)
Incremental Costs Per Ton	See Table 12.0.3	Incremental Costs Per Ton.
NTG_General_Cooling	92%	Net-to-gross = We will use 92% for all cooling equipment except MSHP units (Reference 4).
SEER to EER conversion factor	0.85	SEER to EER conversion factor
Lifetime, years	20	Reference 11

Customer Inputs	M&V Verified	
$SEER_{Eff}$ / $IEER_{Eff}$	Yes	Seasonal (or Integrated) Energy Efficiency Ratio in Btu/W-hr of high efficiency equipment that the customer will install.
EER_{Eff}	Yes	EER of high efficiency equipment that the customer will install.
Size	Yes	The equipment capacity in tons.
Building Type / Market Segment	Yes	
County/Zone	Yes	
System Type	Yes	
Quantity Proposed Equipment (Qty)	Yes	

References:

1. NYSERDA (New York State Energy Research and Development Authority); NY Energy $mart Programs Deemed Savings Database - Source for coincidence factor
2. ASHRAE, 2011, Applications Handbook, Ch. 37, table 4, Comparison of Service Life Estimates
3. CBECS (Commercial Buildings Energy Consumption Survey), 2012 - Total Floor space of Cooled Buildings by Principal Building Activity - source of market
4. NTG for cooling is updated through a 2017 program evaluation.
5. Cypress, Ltd. Analysis of office building load profile and RTU efficiency improvement from application of wet bulb depression to reduce air cooled condensing
6. International Energy Conservation Code 2018
7. Building America, Research Benchmark Definitions, 2010 (see p. 10). http://www.nrel.gov/docs/fy10osti/47246.pdf
8. Midstream Product Data Analysis by Product Management Vendor
9. California DEER Database 2008
10. Incremental costs for MSHPs were determined from the NEEP Incremental Cost Study Phase 2 Report
11. Equipment life is from Minnesota Technical Reference Manual (TRM) version 3.1 Jan 20, 2020.

Changes from Recent Filing:

EFLH and Building Type/Market Segment updated

12.7 VFD Chill Retrofit

Algorithms

$$Customer\ kWh = Size \times EFLH \times \left(IPLV_{VFDBaseline} - IPLV_{VFDEff}\right) \times Qty$$

$$Customer\ kW = Size \times \left(FLV_{VFDBaseline} - FLV_{VFDEff}\right) \times Qty$$

$$Customer\ PCkW = CF \times Size \times \left(FLV_{VFDBaseline} - FLV_{VFDEff}\right) \times Qty$$

$$Incremental\ Cost = Size \times Incremental\ Cost\ per\ Ton$$

Variables

EFLH	See Table 12.0.2	Equivalent Full Load Hours. The equivalent number of hours that the equipment would be running at full load over the course of the year.
Incremental Costs Per Ton	See Table 12.0.3	Incremental Costs Per Ton.
NTG_General_Cooling	92%	Net-to-gross = We will use 92% for all cooling equipment except MSHP units (Reference 4).
Lifetime, years	15	Equal to the value used in the Motors and Drives program for VFDs.

Customer Inputs	M&V Verified	
$FLV_{VFDBaseline}$ [Chiller Full Load efficiency without VFD]	Yes	Full Load Value cooling efficiency in kW/ton, representing the efficiency of existing chiller without a VFD at 95% load.
FLV_{VFDEff} [Chiller Chiller Full Load efficiency with VFD]	Yes	Full Load Value cooling efficiency in kW/ton, representing the efficiency of existing chiller with a VFD at 95% load.
$IPLV_{VFDBaseline}$ [Chiller Part Load efficiency without VFD]	Yes	Integrated Part Load Value (representing the average efficiency over a range of loaded states) cooling efficiency in kW/ton of existing chiller without a VFD.
$IPLV_{VFDEff}$ [ChillerPart Load Efficiency with VFD]	Yes	Integrated Part Load Value (representing the average efficiency over a range of loaded states) cooling efficiency in kW/ton of existing chiller with a VFD.
Size	Yes	The equipment capacity in tons.
Building Type / Market Segment	Yes	
County/Zone	Yes	
System Type	Yes	
Quantity of same size Chillers with VFD Retrofit (Qty)	Yes	

References:

1. NYSERDA (New York State Energy Research and Development Authority); NY Energy $mart Programs Deemed Savings Database - Source for coincidence factor
2. ASHRAE, 2011, Applications Handbook, Ch. 37, table 4, Comparison of Service Life Estimates
3. CBECS (Commercial Buildings Energy Consumption Survey), 2012 - Total Floor space of Cooled Buildings by Principal Building Activity - source of market segment distributions
4. NTG for cooling is updated through a 2017 program evaluation.
5. Cypress, Ltd. Analysis of office building load profile and RTU efficiency improvement from application of wet bulb depression to reduce air cooled condensing temperatures.
6. International Energy Conservation Code 2018
7. Building America, Research Benchmark Definitions, 2010 (see p. 10). http://www.nrel.gov/docs/fy10osti/47246.pdf
8. Midstream Product Data Analysis by Product Management Vendor
9. California DEER Database 2008
10. Incremental costs for MSHPs were determined from the NEEP Incremental Cost Study Phase 2 Report
11. Equipment life is from Minnesota Technical Reference Manual (TRM) version 3.1 Jan 20, 2020.

Changes from Recent Filing:

EFLH and Building Type/Market Segment updated

12.8 CRAC Units

Algorithms

$$Customer\ kWh_{No\ Economizer} = Size * EFLH * \left(\frac{12}{3.412 * SCOP_{Baseline}} - \frac{12}{3.412 * SCOP_{Eff}}\right) * Quantity$$

$$Customer\ Coincident\ kW_{No\ Economizer} = CF * Size * \left(\frac{12}{3.412 * SCOP_{Baseline}} - \frac{12}{3.412 * SCOP_{Eff}}\right) * Quantity$$

$$Customer\ kWh_{With\ Economizer} = \left(\begin{array}{c} Size * Hours_{Not\ Economizing} * \left(\frac{12}{3.412 * SCOP_{Baseline}} - \frac{12}{3.412 * SCOP_{Eff}}\right) + \\ Economizer\ Size * Hours_{Economizing} * \left(\frac{12}{3.412 * SCOP_{Adj\ Baseline}} - \frac{12}{3.412 * SCOP_{Economizer\ Eff}}\right) \end{array}\right) * Quantity$$

$$Customer\ Coincident\ kW_{With\ Economizer} = CF * Size * \left(\frac{12}{3.412 * SCOP_{Baseline}} - \frac{12}{3.412 * SCOP_{Eff}}\right) * Quantity$$

Variables

EFLH	8760	Equivalent Full Load Hours. The equivalent number of hours that the equipment would be running at full load over the course of the year.
$Hours_{Not\ Economizing}$	See Table 12.8.0	Number of hours that cooling is provided by compressors
$Hours_{Economizing}$	See Table 12.8.0	Number of hours that cooling is provided by economization
$SCOP_{Baseline}$	See Table 12.8.1	The minimum acceptable SCOP, as defined by the DOE, for a specific size and type of equipment (Reference 2)
$SCOP_{Adj\ Baseline}$	See Table 12.8.1	The minimum acceptable SCOP during economizer operation, which is defined by adjusting the DOE minimum acceptable SCOP to align with Test D of the rating standard (Reference 1).
Coincidence Factor	100%	Probability that the calculated Customer kW will coincide with the period of peak generator operation
Lifetime	20	Life of a new CRAC unit, in years
NTG_General_Cooling	92%	Net-to-gross = We will use 92% for all cooling equipment except MSHP units (Reference 4).
Incremental Cost	See Table 12.8.1	Incremental cost incurred for purchasing a CRAC unit that is more efficient than the DOE minimum requirement (Reference 3)

Customer Inputs	M&V Verified	
Size	Yes	The rated equipment sensible capacity in tons, based on the actual indoor operating conditions of the data center (RAT and RH) and the outdoor conditions specified in the rating standard (Reference 1). The maximum eligible unit size is 759,999 Btu/h (63.3 tons).
$SCOP_{Eff}$	Yes	The rated SCOP of the equipment that the customer will install, based on the actual indoor operating conditions of the data center (RAT and RH) and the outdoor conditions specified in the rating standard (Reference 1).
Economizer Size	Yes	The rated equipment sensible capacity during economization in tons, based on the actual indoor operating conditions of the data center (RAT and RH) and the outdoor conditions specified in Optional Test D of the rating standard (Reference 1). The maximum eligible unit size is 759,999 Btu/h (63.3 tons).
$SCOP_{Economizer\ Eff}$	Yes	The SCOP of the equipment that the customer will install, based on the actual indoor operating conditions of the data center (RAT and RH) and the outdoor conditions specified in Test D of the rating standard (Reference 1).
Quantity	Yes	Number of more efficient CRAC units that the customer installed

Table 12.8.0

Equipment Type	$Hours_{Economizing}$	$Hours_{Not\ Economizing}$
CRAC, Air-Cooled with Economizer	1,989	6,771
CRAC, Water-Cooled with Economizer	1,289	7,471
CRAC, Glycol-Cooled with Economizer	1,257	7,503

Table 12.8.1

Equipment Type	Net Sensible Cooling Capacity (Btu/h)		SCOP_Standard		SCOP_Standard_Adj		Incremental Cost
	Lower Limit ≥	Upper Limit <	Downflow Units	Upflow Units	Downflow Units	Upflow Units	$/SCOP
CRAC, Air-Cooled	1	65,000	2.20	2.09	N/A	N/A	$7,181.33
	65,000	240,000	2.10	1.99	N/A	N/A	$7,715.73
	240,000	760,000	1.90	1.79	N/A	N/A	$11,110.13
CRAC, Air-Cooled with Economizer	1	65,000	2.20	2.09	6.58	6.25	$12,152.77
	65,000	240,000	2.10	1.99	6.28	5.95	$13,057.12
	240,000	760,000	1.90	1.79	5.67	5.36	$18,801.37
CRAC, Water-Cooled	1	65,000	2.60	2.49	N/A	N/A	$18,628.16
	65,000	240,000	2.50	2.39	N/A	N/A	$32,837.67
	240,000	760,000	2.40	2.29	N/A	N/A	$62,303.50
CRAC, Water-Cooled with Economizer	1	65,000	2.55	2.44	4.86	4.65	$19,714.89
	65,000	240,000	2.45	2.34	4.67	4.46	$34,751.50
	240,000	760,000	2.35	2.24	4.48	4.27	$65,931.00
CRAC, Glycol-Cooled	1	65,000	2.50	2.39	N/A	N/A	$18,575.38
	65,000	240,000	2.15	2.04	N/A	N/A	$32,791.17
	240,000	760,000	2.10	1.99	N/A	N/A	$62,303.50
CRAC, Glycol-Cooled with Economizer	1	65,000	2.45	2.34	4.65	4.44	$19,656.86
	65,000	240,000	2.10	1.99	3.99	3.78	$34,700.33
	240,000	760,000	2.05	1.94	3.89	3.68	$65,931.00

References:

1. ASHRAE 127-2007
2. CFR Title 10, Volume 3, Chapter II, Subchapter D, Part 431, Subpart F
3. Chapter 3 of the Technical Support Document for the DOE CRAC efficiency final rule making, https://www.regulations.gov/document?D=EERE-2011-BT-STD-0029-0039

Changes from Recent Filing:

1. New prescriptive measure

Assumptions:

1. The DOE standard does not apply to CRAH units, horizontal flow units, or ceiling-mounted units; therefore, these units are excluded from this prescriptive rebate.
2. The equipment type of CRAC, Air-Cooled with Economizer is not in the DOE standard, but are included in the prescriptive rebate since these are in the market and have a large market share.
3. Minimum SCOP requirements for CRAC, Air-Cooled with Economizer are assumed to be the same as CRAC, Air-Cooled, because market research showed that these types of unit's don't have additional coils for economization. Therefore, no reduction in minimum SCOP is needed to account for the additional flow resistance through the unit.
4. Proposed SCOP ratings must be based on the same outdoor operating conditions used in the rating standard (Reference 1), i.e. air-cooled units are rated at the same OAT, water-cooled units are rated at the same entering and leaving water temperatures, and glycol-cooled units are rated at the same entering and leaving glycol temperatures.
5. Proposed SCOP ratings must be based on actual indoor operating conditions in the data center, i.e. RAT and RH. Credits or penalties for operating the data center above or below the RAT rating condition of 75F and RH rating condition of 45% are part of the savings for this prescriptive rebate. For Glycol Cooled CRAC units, credits or penalties for operating with a propylene glycol solution above or below the rating condition of 40% are also part of the savings for this prescriptive rebate.
6. Credit for being able to run CRAC fans at reduced speeds is not given in the prescriptive savings, because speed controls are standard on all units with EC fans, i.e. new CRAC units. Since units with EC fans have the necessary controls to reduce speed below 100%, the fan speed in the baseline for a new CRAC unit would be the same as the fan speed in the new, proposed CRAC unit.
7. The rated size for units in economization is required since most Water-Cooled and Glycol-Cooled CRAC units have a separate coil for economization, and this coil typically has a different cooling capacity than the evaporator coil. For Air-Cooled units with Economizer, the rated size in economization is likely the same as non-economization, since these units only have one coil for economization and refrigerant evaporation.
8. Economization hours are based on the OA conditions outlined in rating Test D of the rating standard (Reference 1), and an assumed approach temperature of 15 °F for cooling towers and dry coolers.
9. The efficiency curves used for adjusting the minimum SCOP values for economization are from past M&V projects or previous TAs. The efficiency curves are used to find the difference in efficiency at the outdoor operating conditions in Test A and Test D of the rating standard (Reference 1). This difference is then applied to the DOE minimum SCOP values to obtain the minimum SCOP values for economizer operation.
10. CRAC cost from taken from the DOE's data is only for downflow units (Reference 3), but it is assumed that the incremental cost calculated from this data would be the same for upflow units.
11. The DOE's cost data shows negative incremental cost as efficiency improves for smaller Water-Cooled and Glycol-Cooled CRAC units (Reference 3). The DOE mentioned that the negative values were likely due to an insufficient amount of data and the result did not make sense. Therefore, this was corrected here by using ratios of the known, positive incremental cost to correct the DOE's negative incremental cost.
12. The incremental cost for CRAC, Air-Cooled with Economizer is based on a cost multiplier calculated from past Xcel Energy projects. The DOE's cost multiplier was not used, since it did not account for the additional labor and components associated with a CRAC, Air-Cooled with Economizer. The DOE value only accounted for an additional coil, but air-cooled units with economizers don't have additional coils. These units usually have additional mechanical components (e.g. pumps), and these components require more labor beyond connecting a second coil that is housed within the same CRAC enclosure.

12.9 DEPACC

Algorithms

$$Customer\ kWh_{With\ Economizer} = Size \times DEPACC\ EFLH\ Factor \times EFLH_{With\ Economizer} \times KW\ per\ Ton_{Average}$$

$$Customer\ kWh_{No\ Economizer} = Size \times DEPACC\ EFLH\ Factor \times EFLH_{No\ Economizer} \times KW\ per\ Ton_{Average}$$

$$Customer\ KW = Size \times KW\ per\ Ton_{peak}$$

$$Customer\ PC\ KW = Size \times KW\ per\ Ton_{peak} \times Coincidence\ Factor$$

$$Incremental\ Cost\ of\ Equipment = Size \times Incremental\ Cost\ per\ Ton$$

Variables

DEPACC EFLH Factor	1.1631	= DEPACC_Operating_Hours_Office / EFLH for Front Range Office (w/economizer). Equivalent Full Load Hours. The equivalent number of hours that the equipment would be running at full load over the course of the year.
DEPACC_Operating_Hours_Office	1134	DEPACC Operating hrs/yr = Estimated annual hours of operation of the DEPACC system for an office in the Front Range. Used to scale DEPACC operating hours to A/C EFLH by segment
$EFLH_{With\ Economizer}$	See Table 12.0.2	Equivalent Full Load Hours. The equivalent number of hours that cooling equipment with an economizer would be running at full load over the course of the year.
$EFLH_{No\ Economizer}$	See Table 12.0.2	Equivalent Full Load Hours. The equivalent number of hours that cooling equipment without an economizer would be running at full load over the course of the year
KW per $Ton_{Average}$	0.1488	Average kW/ton = kWh/ ton / DEPACC Operating hrs/yr = Efficiency improvement of incumbent air-cooled condensers in kW per ton resulting from installation of condenser evaporative pre-cooler averaged for annual cooling hours.
KW per Ton_{Peak}	0.4544	Peak Coincident kW/ton = Efficiency improvement of incumbent air-cooled condensers in kW per ton resulting from installation of condenser evaporative pre- cooler at summer cooling design conditions: 0.4% design temperatures @ DIA = 93.9°F DB and 64.7°F WB
Coincidence Factor	90%	Probability that the calculated Customer kW will coincide with the period of peak generator operation
Incremental_O&M_Cost_Factor	0.000886667	$ / ton-hour = (Water Cost / Ton) / DEPACC Operating Hours. Factor used to calculate Incremental annual non-energy Operations and Maintenance cost per ton-hr for water usage.
Incremental Cost of Equipment	See Table 12.9.0 DEPACC Incremental Costs	$ / ton-hour = (Water Cost / Ton) / DEPACC Operating Hours. Factor used to calculate Incremental annual non-energy Operations and Maintenance cost per ton-hr for water usage.
Baseline Cost of Equipment	$0.00	= $0 because the baseline option is to do nothing.
NTG_General_Cooling	92%	Net-to-gross = We will use 92% for all cooling equipment.
Lifetime	20	Life of a new Direct Evaporative Cooling unit, in years

Customer Inputs	**M&V Verified**	
Size	Yes	The rated cooling equipment capacity in tons.
Building Type / Market Segment	Yes	
County/Zone	Yes	
System Type	Yes	
Quantity Proposed Equipment (Qty)	Yes	

Economizer	Yes	Indicates if the equipment does or does not have a functional cooling economizer (ie., Air or Waterside Economizer).

Table 12.9.0 DEPACC Incremental Costs

System Tons	Incremental Capital Cost ($/ton)	Incremental Electrical O&M Cost ($/ton-hr)
10 to 59	$ 248.27	$ 0.0008867
60 to 99	$ 219.91	$ 0.0008867
100 to 139	$ 209.23	$ 0.0008867
140 to 239	$ 202.80	$ 0.0008867
240 and above	$ 190.49	$ 0.0008867

References:

1. Cypress, Ltd. Analysis of office building load profile and RTU efficiency improvement from application of wet bulb depression to reduce air cooled condensing temperatures.

Changes from Recent Filing:

EFLH and Building Type/Market Segment updated

Assumptions:

1. Minimum equipment size that DEPACC can be installed on is 10 ton.

2. Qualifying evaporative cooling units must have a minimum Media Saturation Effectiveness of 75% and above. The units must be installed with an evaporative media, a remote thermostat, outside air temp sensor and a periodic purge water control if sump is used.

3. Units should have outdoor air, humidity and controls to determine operation of spray nozzles to wet media. If sump is used, periodic purge control would need to be installed.

4. Condenser fan energy costs due to DEPACC media are not expected to increase measurably. Media decreases condenser fan cfm while increasing fan static.

5. Denver Water 2018 average rate at $3.167/1000 gal (Source https://www.denverwater.org/business/billing-and-rates/2018-rates)

6. DEPACC estimate of water consumed by the evaporative pre-cooling system is 0.28 gallons per ton-hour of cooling based on manufacturer’s data.

12.10 Mini-Split Heat Pump

Algorithms

$$Cooling\ Electrical\ Energy\ Savings\ (kWh) = Size \times EFLH \times \left(\frac{12}{SEER_{Baseline}} - \frac{12}{SEER_{Eff}}\right)$$

$$Heating\ Electrical\ Energy\ Savings\ (kWh) = \frac{MSHP_{Size_{Heating}}}{1000} \times MSHP\_EFLHH \times \left(\frac{1}{HSPF_{Standard}} - \frac{1}{HSPF\_Eff}\right)$$

$$Customer\ kWh = Cooling\ Electrical\ Energy\ Savings + Heating\ Electrical\ Energy\ Savings$$

$$Customer\ kW = Size \times \left(\frac{12}{EER_{Baseline}} - \frac{12}{EER_{Eff}}\right)$$

$$Customer\ PC\ kW = CF \times Size \times \left(\frac{12}{EER_{Baseline}} - \frac{12}{EER_{Eff}}\right)$$

Electric Heating Baseline

$$Heating\ Electrical\ Energy\ Savings\ (kWh) = \frac{MSHP_{Size_{Heating}}}{1000} \times MSHP\_EFLHH \times \left(\frac{1}{HSPF_{Standard}} - \frac{1}{HSPF\_Eff}\right)$$

Gas Heating Baseline

Dth savings per year = $Dth_{Baseline} - Dth_{Eff}$

$$Dth_{Baseline} = \left(\frac{Capacity_{Heat}}{1{,}000{,}000}\right) \times EFLH_{Heat,Base} * \left(\frac{1}{\%Eff_{Base}}\right)$$

$$Dth_{Eff} = 0$$

$$kWh_{Baseline} = 0$$

$$kWh_{Eff} = \frac{Capacity_{Heat}}{1000} \times EFLH_{HP} \times \frac{1}{HSPF_{Eff}}$$

Variables

EFLH	See Table 12.0.2	Equivalent Full Load Hours. The equivalent number of hours that the equipment would be running at full load over the course of the year.
MSHP_EFLHH	950	Mini-Split Heat Pump Equivalent Full Load Hours Heating: The equivalent number of hours that MSHP equipment would be running at full load over the course of the year for heating. From Heating Efficiency Program.
$SEER_{Baseline}$	See Table 12.0.1	Seasonal (or Integrated) Energy Efficiency Ratio in BTU/W-hr of standard equipment, based upon the minimum acceptable efficiency defined by the current building code.
$EER_{Baseline}$	See Table 12.0.1	EER of standard equipment, based upon the minimum acceptable efficiency defined by the current building code. If unavailable, EER_Baseline is calculated from SEER_Eff using a polynomial conversion.
HSPF_Standard	8.20	Heating Seasonal Performance Factor (HSPF) of standard equipment, based upon the minimum Federal standard for efficiency as manufactured.
SEER to EER conversion factor	0.85	SEER to EER conversion factor
CF	90%	Coincidence Factor
NTG_General_Cooling	92%	Net-to-gross = 92% for all cooling equipment.
Measure Life[2]	18	Life of a new unit, in years

Customer Inputs	M&V Verified	
Cooling capacity (BTU/h)	Yes	(Btu/h) Size - Cooling capacity of equipment at standard ARI test conditions
Cooling efficiency (SEER)	Yes	SEER_Eff - Seasonal (or Integrated) Energy Efficiency Ratio in Btu/W-hr of high efficiency equipment that the customer will install.
Cooling efficiency (EER)	No	EER_Eff - Full-load efficiency of efficient equipment. If unavailable, value is calculated from SEER_Eff using a polynomial conversion.
Heating capacity (BTU/h)	Yes	(Btu/h) MSHP_Size_Heating - Heating capacity of Mini Split Heat Pump at 17 F outdoor air temperature, in BTU/h
Heating efficiency (HSPF)	Yes	HSPF_Eff - Heating Seasonal Performance Factor (HSPF) of High Efficiency equipment that the customer will install.
Building Type / Market Segment	Yes	
County/Zone	Yes	
System Type	Yes	
Quantity Proposed Equipment (Qty)	Yes	
Primary use, cooling or heating (MSHP)	No	

References:

DEEMED SAVINGS TECHNICAL ASSUMPTIONS

1. Incremental costs for MSHPs were determined from the NEEP Incremental Cost Study Phase 2 Report

2. 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

3. IECC 2018 for Equipment Baseline Efficiencies

4. No heating demand (kW) saving are claimed for MSHP during winter, only summer cooling demand (kW) savings are claimed.

5. It is assumed that NO supplemental heating source is used.

6. For new Mini-Split Heat Pumps (MSHP) it is assumed that the MSHP is being installed in either new construction or to supplement an existing heating and cooling system. The MSHP rebate is intended to incent customers to install a high efficiency MSHP rather than the code level baseline unit.

Changes from Recent Filing:

EFLH and Building Type/Market Segment updated

12.11 Mini-Split AC

Algorithms

$$Customer\ kWh = Size \times EFLH \times \left(\frac{12}{SEER_{Baseline}} - \frac{12}{SEER_{Eff}}\right)$$

$$Customer\ kW = Size \times \left(\frac{12}{EER_{Baseline}} - \frac{12}{EER_{Eff}}\right)$$

$$Customer\ PC\ kW = CF \times Size \times \left(\frac{12}{EER_{Baseline}} - \frac{12}{EER_{Eff}}\right)$$

Variables

EFLH	See Table 12.0.2	Equivalent Full Load Hours. The equivalent number of hours that the equipment would be running at full load over the course of the year.
$SEER_{Baseline}$	See Table 12.0.1	Seasonal (or Integrated) Energy Efficiency Ratio in BTU/W-hr of standard equipment, based upon the minimum acceptable efficiency defined by the current building code.
$EER_{Baseline}$	See Table 12.0.1	EER of standard equipment, based upon the minimum acceptable efficiency defined by the current building code. If unavailable, EER_Baseline is calculated from SEER_Eff using a polynomial conversion.
SEER to EER conversion factor	0.85	SEER to EER conversion factor
CF	90%	Coincidence Factor
NTG_General_Cooling	92%	Net-to-gross = We will use 92% for all cooling equipment.
Measure Life[2]	18	Life of a new unit, in years

Customer Inputs	M&V Verified	
Cooling capacity (BTU/h)	Yes	(Btu/h) Size - Cooling capacity of equipment at standard ARI test conditions
Cooling efficiency (SEER)	Yes	SEER_Eff - Seasonal (or Integrated) Energy Efficiency Ratio in Btu/W-hr of high efficiency equipment that the customer will install.
Cooling efficiency (EER)	No	EER_Eff - Full-load efficiency of efficient equipment. If unavailable, value is calculated from SEER_Eff using a polynomial conversion.
County/Zone	No	
Building type	Yes	
System Type	Yes	
Equipment quantity	Yes	
Primary use, cooling or heating (MSHP)	No	

References:

1. Incremental costs were determined from the NEEP Incremental Cost Study Phase 2 Report

2. 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

3. IECC 2018 for Equipment Baseline Efficiencies

4. For new Mini-Split Air Conditioners (MSAC) it is assumed that the MSAC is being installed in either new construction or to supplement an existing cooling system. The MSAC rebate is intended to incent customers to install a high efficiency MSAC rather than the code level baseline unit.

Changes from Recent Filing:

EFLH and Building Type/Market Segment updated

12.12 Plate & Frame Heat Exchangers

Algorithms

$$Customer\ kWh = \left(A \times T_{WB\ Onset}{}^{2} + B \times T_{Balance}{}^{2} + C \times T_{WB\ Onset} \times T_{Balance} + D \times T_{WB\ Onset} + E \times T_{Balance} + F\right) \times \left(\frac{Cooling\ Hrs\ No\ Econ}{G\_EFLH}\right) \times \left(\frac{IPLV_{Eff}}{IPLV_{Baseline}}\right) \times \left(\frac{PF\ Tons\ Offset}{100}\right)$$

$$Customer\ kW = \frac{PF\ Tons\ Offset}{IPLV_{Baseline}}$$

Customer PC kW $= CF \times Customer\ kW$

$$PF\ Tons\ Offset = \left(\frac{Load_{onset}}{(T_{DB\ Design} - T_{Balance})}\right) \times T_{WB\ to\ MCDB} + \left(Load_{onset} - \left(\frac{Load_{onset}}{(T_{DB\ Design} - T_{Balance})}\right) \times T_{DB\ Design}\right)$$

Variables

$IPLV_{Baseline}$	0.570	Baseline Chiller IPLV (kW/ton)
$T_{DB\ Design}$	92	Design dry-bulb temperature for cooling (°F)
$T_{WB\ to\ MCDB}$	30.505	Mean Coincident Dry Bulb Temperature (as determined from binned TMY3 data for the location) corresponding to the Onset Wet Bulb Temperature provided by the customer
A	3.254	Coefficient from regression
B	0	Coefficient from regression
C	0	Coefficient from regression
D	5958.821	Coefficient from regression
E	0	Coefficient from regression
F	-47208.137	Coefficient from regression
G_EFLH	8760	Coefficient from regression
Coincidence Factor (CF)	0%	Coincidence Factor, the probability that peak demand of the equipment will coincide
Cooling Hrs No Econ	8760	Equivalent Full Load Hours. The equivalent number of hours that the equipment would be running at full load over the course of the year.
NTG_General_Cooling	92%	Net-to-gross = We will use 92% for all cooling equipment.
Lifetime	20	Measure life is taken at 20 years for all cooling equipment. (Reference 1) (years)

Customer Inputs	M&V Verified	
$IPLV_{Eff}$	Yes	Efficient Chiller IPLV (kW/ton)
$T_{WB\ Onset}$	No	Wet Bulb Temperature at which waterside economizer is activated (°F)
$Capacity_{HX}$	Yes	Cooling capacity of plate and frame heat exchanger (tons)
$T_{balance}$	No	Building Balance Point Temperature, the outside air dry bulb temperature at which there is no cooling load. Customer input for all segments except Industrial and Data Center (20°F default); Not used for Industrial and Data Centers since Load (OADB) = Load (°F)
$Load_{onset}$	No	Cooling load at onset wet-bulb temperature ($T_{WB\ Onset}$) (tons)
County/Zone	No	
Building type	Yes	
System Type	Yes	
Equipment quantity	Yes	

References:

1. ASHRAE, 2007, Applications Handbook, Ch. 36, table 4, Comparison of Service Life Estimates
2. Data from historic Xcel Energy Custom Efficiency cooling tower projects

Assumptions:

No airside economizers are in operation
Heat exchanger is installed in parallel with the chiller and additional cooling towers are not required

Description

Prescriptive rebates will be offered for installation of plate & frame heat exchangers on existing chiller systems to allow cooling towers to provide "free cooling" in lieu of chiller operation. Eligible systems will NOT have air-side economizers install

12.13 ASHP < 5.5 Tons

w/ HP/Electric baseline

$$Customer\ kWh = (Size\ \times (EFLH_{Cool} \times \left(\frac{12}{SEER_{Baseline}} - \frac{12}{SEER_{Eff}}\right)) + (kWh_{Heat\ Base} - kWh_{Heat\ Eff})) \times Qty$$

$$kWh_{Heat\ Base} = \left(\frac{Capacity_{Heat}}{1{,}000}\right) \times EFLH_{Heat} \times \left(\frac{1}{HSPF_{Base}}\right)$$

$$kWh_{Heat\ Eff} = \left(\frac{Capacity_{Heat}}{1{,}000}\right) \times EFLH_{Heat\ HP} \times \left(\frac{1}{HSPF_{Eff}}\right)$$

$$Customer\ kW = Size * \left(\frac{12}{EER_{Baseline}} - \frac{12}{EER_{Eff}}\right) \times Qty$$

$$Customer\ PCkW = Customer\ kW\ \times\ CF$$

w/Gas heating or dual fuel baseline

$$Customer\ kWh = (Size\ \times (EFLH_{Cool} \times \left(\frac{12}{SEER_{Baseline}} - \frac{12}{SEER_{Eff}}\right)) + (kWh_{Heat\ Base} - kWh_{Heat\ Eff})) \times Qty$$

$$Dth\ savings\ per\ year = Dth_{Baseline} - Dth_{Eff}$$

$$Dth_{Baseline} = \left(\frac{Capacity_{Heat}}{1{,}000{,}000}\right) \times EFLH_{Heat,Base} * \left(\frac{1}{\%Eff_{Base}}\right)$$

$$Dth_{Eff} = 0$$

$$kWh_{Baseline} = 0$$

$$kWh_{Eff} = \frac{Capacity_{Heat}}{1000} \times EFLH_{HP} \times \frac{1}{HSPF_{Eff}}$$

Variables

$EFLH_{Cool}$	See Table 12.0.2	Equivelant Full load Cooling Hours, the equivalent number of hours that the equipment would be running at full load over the course of the year
$EFLH_{Heat}$	See Table 12.0.2	Equivelant Full load Heating Hours, the equivalent number of hours that the equipment would be running at full load over the course of the year
$SEER_{Baseline}$	See Table 12.13.1	Deemed Baseline Efficiencies based on IECC 2018
$EER_{Baseline}$	See Table 12.13.1	Deemed Baseline Efficiencies based on IECC 2018
$HSPF_{Baseline}$	See Table 12.13.1	Deemed Baseline Efficiencies based on IECC 2018
$\%Eff_{Base}$	0.78	Deemed Baseline Efficiencies based on IECC 2018
CF	90%	Coincidence Factor (Reference 1)
Incremental Cost Per Ton	See Table 12.13.2	Incremental Costs Per Ton (Reference 3)
Lifetime	15	MN TRM

Customer Inputs	**M&V Verified**	
$SEER_{Eff}$	Yes	Seasonal Energy Efficiency Ratio inf BTU/W-hr of high efficiency equipment to be installed
EER_{Eff}	Yes	EER of high efficiency equipment to be installed
$HSPF_{Eff}$	Yes	Heating Seasonal Performance Factor
Size	Yes	Equipment Cooling Capacity in tons
$Capacity_{Eff}$	Yes	Equipment Heating Capacity in BTU
System Type	Yes	Split or Packaged System
Building Type	Yes	
Zone	Yes	
Baseline System Type	Yes	Electric or gas heat
Proposed Equipment Quantity	Yes	

Table 12.13.1

Equipment	$SEER_{BASE}$	EER_{BASE}	$HSPF_{BASE}$
ASHP Units less than or equal to 5.4 tons (Split System)	14	11.4	8.2
ASHP Units less than or equal to 5.4 tons (Packaged System)	14	11.4	8

Table 12.13.2

Efficiency level	Incremental Cost
SEER 14	$137.00/ton
SEER 15	$274.00/ton
SEER 16	$411.00/ton
SEER 17	$548.00/ton
SEER 18	$685.00/ton

References

1. NYSERDA (New York State Energy Research and Development Authority); NY Energy $mart Programs Deemed Savings Database - Source for coincidence factor
2. IECC 2018 For baseline equipment efficiencies
3. Equations and measure life from MN TRM

12.14 HPWH - Gas Baseline

Algorithms

$$Customer\ kWh = -1 * Energy_{HeatWater} * \left(\frac{1}{UEF_{efficient}}\right) * \frac{ESAF}{CF_1}$$

$$PC\ kW = Customer\ kWh/8760$$

$$Energy\_HeatWater = C_p * density * gallons/Volume\_Daily\_SqFt\_Usage * SqFt\_Served * Days\_Year * (T_{set} - T_{supply})$$

$$Customer\ Dth = \left(Energy_{HeatWater} + SL_{base} * Hours_{Average} * Qty * Gallons_{Storage}\right) * \left(\frac{1}{Eff_{baseline}}\right) * \frac{(1 - GIF)}{CF_2}$$

$$UEF_{efficient} = (0.7 * COP_{HP} + 0.3) * (1 - Fraction_{Loss})$$

Variables

density	8.33	Density of water, lbs/gal
C_p	1.00	Specific heat of water, Btu / lb - F
Volume_Daily_SqFt_Usage	See Table 12.12.1	Average daily hot water consumption [gallons / 1,000 ft2 / day].
Days_Year	See Table 12.12.1	Applicable days per year of building operation
T_setpoint	140	Water heater setpoint, deg F (Ref 27).
T_supply	58	Supply temperature of city water to water heater, deg F (Ref 27).
Eff_baseline	See Table 12.2.0	Uniform Energy Factor of baseline water heater.
Incremental Cost	$3033.01, $5818.02	Light Commercial and Commercial size HPWH respectively
ESAF	0.914, 0	0.914 if space is heated electrically, 0 if gas heat, uses balance temperature based bin analysis
GIF	0.056	Gas Impact Factor
SL_base	13.21	Standby Losses for baseline storage water heater, BTUH per gallon of storage (Ref 26)
Hours Average	3600	Based on WH participation history
Fraction_Loss	0.074	Deemed loss fraction based on GWH past participation and GWH deemed BTUH loss rate
CF_1	3412	Btu/kWh
CF_2	1,000,000	Btu/Dth
Measure Life	10 Years	MN TRM 4.0 pg. 504 (Ref 48)

Customer Inputs	**M&V Verified**	
Qty	Yes	Quantity of New Equipment for losses and rebate determination
SqFt_Served	Yes	Number of Square feet served by water heater in thousands of square feet, site specific.
UEF_efficient	Yes	Uniform Energy Factor of new water heater
COP_HP	Yes	Efficient Unit COP in heat pump mode, if UEF rating is not available
Building type	Yes	Facility type from picklist
Gallons Storage	Yes	Size of storage tank in gallons
BTUH Heat Pump capacity	Yes	Output BTUH of proposed water heater heat pump
BTUH capacity	Yes	Output BTUH of proposed water heater

Table 12.12.1 Annual Hot Water Use Data (Ref 52)

Building Type	Applicable Days/Year	Gallons / 1,000 ft2 / day	Eligible?
Small Office	250	6.2	Yes
Large Office	250	7.3	Yes
Fast Food Restaurant	365	121.8	Yes
Sit-Down Restaurant	365	121.8	Yes
Retail	365	3.7	Yes
Grocery	365	1.9	Yes
Warehouse	250	5.0	Yes
Elementary School	200	36.4	Yes
Jr. High/High School/College	200	36.4	Yes
Health	365	67.2	No
Motel	365	81.0	Yes
Hotel	365	81.0	Yes
Other Commercial	250	15.8	Yes

References:

1. 2020 Minnesota Energy Code - Chapter 7676.1100 Subpart 3D, 4A
2. Centerpoint TRM
3. International Energy Conservation Code (IECC) 2015 Table C403.2.3 (4)
4. ASHRAE HVAC Systems and Equipment 2008 pg 15.1
5. Whole Building Design Guide for US Army. Tech Note 14: Overhead Radiant Heating <https://www.wbdg.org/ccb/ARMYCOE/COETN/technote14.pdf>

6. 2015 Minnesota Energy Code Table C403.2.3(5) pg C-44
7. Cost data from online review on 8/5/15 of products available at Younits.com, ecomfort.com, hvacdistribution.com, grainger.com, simplyplumbing.com, homedepot.com, h-
8. Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011
9. Sachs, Harvey M., Unit Heaters Deserve Attention for Commercial Programs, ACEEE, April 2003
10. TMY3 Weather data from Department of Energy
11. International Energy Conservation Code (IECC) 2012

12. 2% efficiency improvement for boiler tune up based on Michaels Energy literature review. Sources included (but not limited to):
    12A. Illinois Technical Reference Manual (2015-2016)
    12B. Michigan Energy Measures Database (MEMD) accessed at <http://www.michigan.gov/mpsc/0,4639,7-159-52495_55129---,00.html>
    12C. Arkansas Technical Reference Manual <http://www.apscservices.info/EEInfo/TRM4.pdf>
13. 3% efficiency improvement for boiler outdoor air reset based on Michaels Energy literature review. Sources included (but not limited to):
    13A. Arkansas Technical Reference Manual <http://www.apscservices.info/EEInfo/TRM4.pdf>
    13B. NEEP Mid-Atlantic TRM. V5. >http://www.neep.org/sites/default/files/resources/Mid-Atlantic_TRM_V5_FINAL_5-26-2015.pdf>
14. 1% efficiency improvement for stack dampers based on Michaels Energy literature review. Sources included (but not limited to):

    14A. Arkansas Technical Reference Manual <http://www.apscservices.info/EEInfo/TRM4.pdf>
    14B. Illinois Technical Reference Manual (2015-2016)

14C. Minnesota TRM. Version 1.3. <http://mn.gov/commerce-stat/pdfs/trm-version-1.3.pdf>

15. 3% efficiency improvement for modulating boiler controls based on Michaels Energy literature review. Sources included (but not limited to):
15A. Illinois Technical Reference Manual (2015-2016)
15B. Minnesota TRM. Version 1.3. <http://mn.gov/commerce-stat/pdfs/trm-version-1.3.pdf>

16. 2% efficiency improvement for O2 trim control based on Michaels Energy literature review. Sources included (but not limited to):
16A. Illinois Technical Reference Manual (2015-2016)
16B. Minnesota TRM. Version 1.3. <http://mn.gov/commerce-stat/pdfs/trm-version-1.3.pdf>
17. 80% boiler efficiency assumed based on minimum boiler efficiency from IECC 2015.

18. California DEER Database, 2014 (value used is for remaining useful life of commercial high efficiency furnaces)
19. AHRI Directory of Certified Product Performance; average of Standby Loss in BTUH per gallon of storage calculated for units with 80% or less thermal efficiency for
20. Leakage data from Energy Management Handbook, by Wayne Turner
21. Measure life from the Federal Energy Management Program (FEMP).
22. The average baseline and high efficiency costs are based on the California DEER database.
23. Cost information supplied by Engineered Products
24. Material costs taken from zoro.com for fiberglass pipe insulation (February 2016)
25. Commercial Condensing Boiler Optimization. Center for Energy and Environment. Prepared for Minnesota Department of Commerse, Division of Energy Resources. 2015.
26. AHRI Directory of Certified Product Performance; average of Standby Loss in BTUH per gallon of storage calculated for units with 80% or less thermal efficiency for

27. Arkansas Deemed Savings Quick Start Program Draft Report Commercial Measures Final Report, Nexant.
28. MN Bin Temp Bin Hrs are taken from the "Thermal Environmental Engineering, Third Edition, Thomas H. Kuehn, James W. Ramsey and James L. Threlkeld, Pages 717-
29. Arkansas Deemed Savings Quick Start Program Draft Report Commercial Measures Final Report, Nexant.
30. Baseline and Energy Efficient equipment costs provided by vendors
31. Minnesota DER Deemed Values
32. Bradford White RightSpec® commercial water heater sizing software
33. Bosch tankless water heater sizing software
34. Commercial Buildings Energy Consumption Study (CBECS), 2006
35. 2008 DEER Effective Useful Life Summary October 1st 2008
36. 2007 ASHRAE HVAC Applications Handbook Chapter 36, page 36.3, Table 4

37. 2006 IECC
38. "Electricity Savings from Variable-Speed Furnaces in Cold Climates" Pigg, Scott and Talerico, Tom. ACEEE Summer Study Proceedings 2004
39. U.S. Department of Energy, Preliminary Analysis Report, 2012
40. http://www.grainger.com
41. Wisconsin Focus on Energy, ECM Furnace Fan Impact Evaluation Report, https://focusonenergy.com/sites/default/files/emcfurnaceimpactassessment_evaluationreport.pdf)
42. MN custom rebates and conversations with Distributors (Tim Stoklosa, Clean Energy Designs in Lakewood CO)
43. Illinois 2017 TRM ; http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_6/Final/IL-TRM_Effective_010118_v6.0_Vol_2_C_and_I_020817_Final.pdf

44. St Paul 2015 Water Rate Schedule - http://mn-stpaul.civicplus.com/DocumentView.asp?DID=3493 (From 2017-2019 MN Energy Efficient Showerhead Tech Assumptions)
45. Source BTU for electricity based on MN DOC No. G008/CIP-00-864.07 Reply Comments of May 23, 2003 which states a Source BTU comparison must be made using an
46. Wisconsin Focus on Energy 2019 TRM
47. Historical program participation
48. State of Minnesota Technical Reference Manual for Energy Conservation Improvement Programs version 3.0 Jan 10 2019
49. Custom DCV Projects, 2010-2011
50. MN Lighting Efficiency Tech Assumption , Tab "Forcast Market Segment".
51. 2011 Tetratech Program Evaluation
52. 2023 Illinois Statewide Techinical Reference Manual for Energy Efficiency - Version 11.0

Changes from Recent Filing:

12.15 GSHP

w/ HP/Electric baseline

$$Customer\ kWh = Size\ \times (EFLH_{Cool} \times \left(\frac{12}{IEER_{Base}} - \frac{12}{IEER_{Eff}}\right) + (kWh_{Heat\ Base} - kWh_{Heat\ Eff})) \times Qty$$

$$kWh_{Heat\ Base} = \left(\frac{Capacity_{Heat}}{1{,}000}\right) \times EFLH_{Heat\ Base} \times (\frac{1}{3.412 \times COP_{Base}})$$

$$kWh_{Heat\ Eff} = \left(\frac{Capacity_{Heat}}{1{,}000}\right) \times EFLH_{Heat\ HP} \times \left(\frac{1}{3.412 \times COP_{Eff}}\right)$$

$$Customer\ kW = Size * (\frac{12}{EER_{Base}} - \frac{12}{EER_{Eff}}) \times Qty$$

$$Customer\ PCkW = Customer\ kW\ \times\ CF$$

w/Gas heating or dual fuel baseline

$$Customer\ kWh = (Size\ \times (EFLH_{Cool} \times \left(\frac{12}{SEER_{Baseline}} - \frac{12}{SEER_{Eff}}\right)) + (kWh_{Heat\ Base} - kWh_{Heat\ Eff})) \times Qty$$

Dth savings per year = $Dth_{Baseline} - Dth_{Eff}$

$$Dth_{Baseline} = \left(\frac{Capacity_{Heat}}{1{,}000{,}000}\right) \times EFLH_{Heat,Base} * (\frac{1}{\%Eff_{Base}})$$

$$Dth_{Eff} = 0$$

$$kWh_{Baseline} = 0$$

$$kWh_{Eff} = \frac{Capacity_{Heat}}{1000} \times EFLH_{HP} \times \left(\frac{1}{3.412 \times COP_{Eff}}\right)$$

Variables

$EFLH_{Cool}$	See Table 12.0.2	Equivalent Full load Cooling Hours, the equivalent number of hours that the equipment would be running at full load over the course of the year
$EFLH_{Heat}$	See Table 12.0.2	Equivalent Full load Heating Hours, the equivalent number of hours that the equipment would be running at full load over the course of the year
$IEER_{Base}$	14	Deemed Baseline Efficiencies based on IECC 2018
EER_{Base}	11.9	Deemed Baseline Efficiencies based on IECC 2018
COP_{Base}	1	
$\%Eff_{Base}$	0.78	
Fan Energy%	0.0314	
CF	90%	Coincidence Factor (Reference 1)
Incremental Cost Per Ton	See Table 12.15.1	Incremental Costs Per Ton
Lifetime	15	MN TRM

Customer Inputs	M&V Verified	
$SEER_{Eff}$	Yes	Seasonal Energy Efficiency Ratio inf BTU/W-hr of high efficiency equipment to be installed
EER_{Eff}	Yes	EER of high efficienty equipment to be installed
$HSPF_{Eff}$	Yes	Heating Seasonal Performance Factor
Size	Yes	Equipment Cooling Capacity in tons
$Capacity_{Heat}$	Yes	Equipment Heating Capacity in BTU
System Type	Yes	Open or Closed loop
Building Type	Yes	
Zone	Yes	
Baseline System Type	Yes	Electric or gas heat
Proposed Equipment Quantity	Yes	

Table 12.15.1 Incremental Capital Costs Reference 4

	Baseline AC Cost per Ton w/ Labor	Baseline Cost of Heat / kBTUH	Baseline Air Handler	Proposed Cost per Heat Ton Including Wells
GSHP - w/ Gas Furance & AC Basel	$ 2,507.42	$ 48.37		$ 6,960.00
GSHP - w/ ER Heat & Air Handler &	$ 2,507.42	$ 40.00	$ 1,200.00	$ 6,960.00
GSHP - w/ Boiler Heat & Air Handler	$ 2,507.42	$ 74.22	$ 1,200.00	$ 6,960.00

References

1. NYSERDA (New York State Energy Research and Development Authority); NY Energy $mart Programs Deemed Savings Database - Source for coincidence factor
2. IECC 2018 For baseline equipment efficiencies
3. Equations and measure life from MN TRM
4. IL TRM

12.13 ASHP < 5.5 Tons

w/ HP/Electric baseline

$$Customer\ kWh = (Size\ \times (EFLH_{Cool} \times \left(\frac{12}{SEER_{Baseline}} - \frac{12}{SEER_{Eff}}\right)) + (kWh_{Heat\ Base} - kWh_{Heat\ Eff})) \times Qty$$

$$kWh_{Heat\ Base} = \left(\frac{Capacity_{Heat}}{1{,}000}\right) \times EFLH_{Heat} \times \left(\frac{1}{HSPF_{Base}}\right)$$

$$kWh_{Heat\ Eff} = \left(\frac{Capacity_{Heat}}{1{,}000}\right) \times EFLH_{Heat\ HP} \times \left(\frac{1}{HSPF_{Eff}}\right)$$

$$Customer\ kW = Size\ * \left(\frac{12}{EER_{Baseline}} - \frac{12}{EER_{Eff}}\right) \times Qty$$

$$Customer\ PCkW = Customer\ kW\ \times\ CF$$

w/Gas heating or dual fuel baseline

$$Customer\ kWh = (Size\ \times (EFLH_{Cool} \times \left(\frac{12}{SEER_{Baseline}} - \frac{12}{SEER_{Eff}}\right)) + (kWh_{Heat\ Base} - kWh_{Heat\ Eff})) \times Qty$$

$$Dth\ savings\ per\ year = Dth_{Baseline} - Dth_{Eff}$$

$$Dth_{Baseline} = \left(\frac{Capacity_{Heat}}{1{,}000{,}000}\right) \times EFLH_{Heat,Base} * \left(\frac{1}{\%Eff_{Base}}\right)$$

$$Dth_{Eff} = 0$$

$$kWh_{Baseline} = 0$$

$$kWh_{Eff} = \frac{Capacity_{Heat}}{1000} \times EFLH_{HP} \times \frac{1}{HSPF_{Eff}}$$

$EFLH_{Cool}$	See Table 12.0.2	Equivelant Full load Cooling Hours, the equivalent number of hours that the equipment would be running at full load over the course of the year
$EFLH_{Heat}$	See Table 12.0.2	Equivelant Full load Heating Hours, the equivalent number of hours that the equipment would be running at full load over the course of the year
$SEER_{Baseline}$	See Table 12.13.1	Deemed Baseline Efficiencies based on IECC 2018
$EER_{Baseline}$	See Table 12.13.1	Deemed Baseline Efficiencies based on IECC 2018
$HSPF_{Baseline}$	See Table 12.13.1	Deemed Baseline Efficiencies based on IECC 2018
$\%Eff_{Base}$	0.78	Deemed Baseline Efficiencies based on IECC 2018
CF	90%	Coincidence Factor (Reference 1)
Incremental Cost Per Ton	See Table 12.13.2	Incremental Costs Per Ton (Reference 3)
Lifetime	15	MN TRM

Customer Inputs	M&V Verified	
$SEER_{Eff}$	Yes	Seasonal Energy Efficiency Ratio inf BTU/W-hr of high efficiency equipment to be installed
EER_{Eff}	Yes	EER of high efficienty equipment to be installed
$HSPF_{Eff}$	Yes	Heating Seasonal Performance Factor
Size	Yes	Equipment Cooling Capacity in tons
$Capacity_{Eff}$	Yes	Equipment Heating Capacity in BTU
System Type	Yes	Split or Packaged System
Building Type	Yes	
Zone	Yes	
Baseline System Type	Yes	Electric or gas heat
Proposed Equipment Quantity	Yes	

Table 12.13.1

Equipment	$SEER_{BASE}$	EER_{BASE}	$HSPF_{BASE}$
Baseline ASHP	14	11.4	8.2

References

1. NYSERDA (New York State Energy Research and Development Authority); NY Energy $mart Programs Deemed Savings Database - Source for coincidence factor
2. IECC 2018 For baseline equipment efficiencies
3. Equations and measure life from MN TRM

12.13 PTAC Gas Baseline

$$Customer\ kWh = (Size \times (EFLH_{Cool} \times \left(\frac{12}{SEER_{Baseline}} - \frac{12}{SEER_{Eff}}\right)) + (kWh_{Heat\ Base} - kWh_{Heat\ Eff})) \times Qty$$

$$Dth\ savings\ per\ year = Dth_{Baseline} - Dth_{Eff}$$

$$Dth_{Baseline} = \left(\frac{Capacity_{Heat}}{1{,}000{,}000}\right) \times EFLH_{Heat,Base} * \left(\frac{1}{\%Eff_{Base}}\right)$$

$$Dth_{Eff} = 0$$

$$kWh_{Baseline} = 0$$

$$kWh_{Eff} = \frac{Capacity_{Heat}}{1000} \times EFLH_{HP} \times \frac{1}{HSPF_{Eff}}$$

$$Customer\ kW = Size * \left(\frac{12}{EER_{Baseline}} - \frac{12}{EER_{Eff}}\right) \times Qty$$

$$Customer\ PCkW = Customer\ kW \times CF$$

Variables

$EFLH_{Cool}$	See Table 12.0.2	Equivelant Full load Cooling Hours, the equivalent number of hours that the equipment would be running at full load over the course of the year
$EFLH_{Heat}$	See Table 12.0.2	Equivelant Full load Heating Hours, the equivalent number of hours that the equipment would be running at full load over the course of the year
$SEER_{Baseline}$	See Table 12.0.1	'Deemed Baseline Efficiencies based on IECC 2018
$EER_{Baseline}$	See Table 12.0.1	'Deemed Baseline Efficiencies based on IECC 2018
$\%Eff_{Base}$	0.78	
Fan Energy%	0.0314	
CF	90%	Coincidence Factor (Reference 1)
Incremental Cost Per Ton	See Table 12.0.3	Incremental Costs Per Ton
Lifetime	15	MN TRM

Customer Inputs	M&V Verified	
$SEER_{Eff}$	Yes	Seasonal Energy Efficiency Ratio inf BTU/W-hr of high efficiency equipment to be installed
EER_{Eff}	Yes	EER of high efficienty equipment to be installed
$HSPF_{Eff}$	Yes	Heating Seasonal Performance Factor
Size	Yes	Equipment Cooling Capacity in tons
$Capacity_{Eff}$	Yes	Equipment Heating Capacity in BTU
Building Type	Yes	
Zone	Yes	
System Type	Yes	
Proposed Equipment Quantity	Yes	
$Capacity_{Baseline}$	Yes	Maximum output of the system in BTU/hr or Watt if the baseline is electric

References

1. NYSERDA (New York State Energy Research and Development Authority); NY Energy $mart Programs Deemed Savings Database - Source for coincidence factor
2. IECC 2018 For baseline equipment efficiencies
3. Equations and measure life from MN TRM

12.18 Dual Fuel RTU

Algorithms

$$Cooling\ kWh = EFLH_c \times Size \times (\frac{12}{EER_{Baseline}} - \frac{12}{EER_{Eff}})$$

$$Heating\ dTh = Input\ Capacity \times Alt \times (\frac{EFLH_{hb}}{Effb} - \frac{EFLH_{hh}}{Effh} -) \times 1000000$$

$$Cooling\ kW = Size \times (\frac{12}{EER_{Baseline}} - \frac{12}{EER_{Eff}})$$

$$Cooling\ PCkW = CF \times Size \times (\frac{12}{EER_{Baseline}} - \frac{12}{EER_{Eff}})$$

EER = SEER × 0.85

Incremental Cost = Size × Incremental Cost per Ton

Variables

$EFLH_c$	See Table 12.18.0	Equivalent Full Load Hours, Cooling. The equivalent number of hours that the equipment will run in cooling mode over the course of the year.
$EER_{Baseline}$	See Table 12.18.0	EER of standard equpment based upon the minimum acceptable efficiency defined by ASHRAE 90.1-2010.
CF	0.90	Coincidence factor
Incremental Cost per Ton	See Table 12.18.0	Incremental cost per ton
Alt	1.00	Altitude adjustment factor to adjust the sea level manufacturer's rated input for altitude
EFF_b	See Table 12.18.1	Efficiency of baseline equipment
$EFLH_{hb}$	See Table 12.18.1	Equivalent Full Load Hours, Heating, baseline. The equivalent number of hours that the baseline equipment will run in heating mode over the course of the year
$EFLH_{hh}$	See Table 12.18.1	Equivalent Full Load Hours, Heating, efficient. The equivalent number of hours that the high efficient equipment will run in heating mode over the course of the year
Conversion Factor	1000000	Conversion from BTU to dTh
Lifetime	20	Life of a new unit, in years

Customer Inputs	M&V Verified	
Size	Yes	The equipment capacity in tons.
EER_{EFF}	Yes	EER of high efficiency equipment that the customer will install.
Input Capacity	Yes	Rated input BTUH nameplate data for high efficiency equipment that the customer will install
EFF_h	Yes	Efficiency of purchased high efficiency equipment that the customer will install.

Table 12.18.0	EFLHc [1]	$EER_{Baseline}$	Incremental Cost per Ton [3]
DX Units < 5.4 tons	610	11.05	$1,679.12
DX Units 5.4 - 11.3 tons	1,252	11.00	$855.60
DX Units 11.4 - 19.9 tons	1,596	10.80	$1,424.71
DX Units 20 - 63.3 tons	1,208	9.80	$1,272.06
DX Units ≥ 63.3 tons	1,878	9.50	$1,119.41

Table 12.18.1	EFF_b	$EFLH_h$ [2]	$EFLH_{hh}$ [2]
DX Units < 5.4 tons	80%	1,034	534
DX Units 5.4 - 11.3 tons	80%	1,034	534
DX Units 11.4 - 19.9 tons	80%	1,034	534
DX Units 20 - 63.3 tons	80%	1,034	534
DX Units ≥ 63.3 tons	80%	1,034	534

References:

1. From 2017-2019 DX RTU program participation data
2. From 2018 NREL ComStock Data for commercial buildings in Colorado, 2023 dataset release date
3. Average incremental cost per ton, calculated using published MSRP costs for commercially available dual-fuel RTU units

Changes from Recent Filing:

New offering for beneficial electrification

12.14 HPWH - Gas Baseline

Algorithms

$$Customer\ kWh = Energy_{HeatWater} * \left(\frac{1}{UEF_{baseline}} - \frac{1}{UEF_{efficient}}\right) * \frac{ESAF}{CF_1}$$
$$PC\ kW = Customer\ kWh/8760$$
$$Energy\_HeatWater = C_p * density * gallons/Volume\_Daily\_SqFt\_Usage * SqFt\_Served * Days\_Year * (T_{set} - T_{supply})$$
$$Customer\ Dth = -1 * Energy_{HeatWater} * \frac{1}{UEF_{efficient}} * \frac{GIF}{CF_2}$$
$$UEF_{efficient} = (0.7 * COP_{HP} + 0.3) * (1 - Fraction_{Loss})$$

Variables

density	8.33	Density of water, lbs/gal
C_p	1.00	Specific heat of water, Btu / lb - F
Volume_Daily_SqFt_Usage	See Table 12.12.1	Average daily hot water consumption [gallons / 1,000 ft2 / day].
Days_Year	See Table 12.12.1	Applicable days per year of building operation
T_setpoint	140	Water heater setpoint, deg F (Ref 27).
T_supply	58	Supply temperature of city water to water heater, deg F (Ref 27).
Eff_baseline	See Table 12.2.0	Uniform Energy Factor of baseline water heater.
Incremental Cost	$3033.01, $5818.02	Incremental cost of efficient water heater over standard water heater.
ESAF	0.914, 0	0.914 if space is heated electrically, 0 if gas heat, uses balance temperature based bin analysis
GIF	0.056	Gas Impact Factor
SL_base	13.21	Standby Losses for baseline storage water heater, BTUH per gallon of storage (Ref 26)
Hours Average	3600	Based on WH participation history
Fraction_Loss	0.074	Deemed loss fraction based on GWH past participation and GWH deemed BTUH loss rate
CF_1	3412	Btu/kWh
CF_2	1,000,000	Btu/Dth
Measure Life	10 Years	MN TRM 4.0 pg. 504 (Ref 48)

Customer Inputs	**M&V Verified**	
Qty	Yes	Quantity of New Equipment for losses and rebate determination
SqFt_Served	Yes	Number of Square feet served by water heater in thousands of square feet, site specific.
UEF_efficient	Yes	Uniform Energy Factor of new water heater
COP_HP	Yes	Efficient Unit COP in heat pump mode, if UEF rating is not available
Building type	Yes	Facility type from picklist
Gallons Storage	Yes	Size of storage tank in gallons
BTUH Heat Pump capacity	Yes	Output BTUH of proposed water heater heat pump
BTUH capacity	Yes	Output BTUH of proposed water heater

Table 12.12.1 Annual Hot Water Use Data (Ref 52)

Building Type	Applicable Days/Year	Gallons / 1,000 ft2 / day	Eligible?
Small Office	250	6.2	Yes
Large Office	250	7.3	Yes
Fast Food Restaurant	365	121.8	Yes
Sit-Down Restaurant	365	121.8	Yes
Retail	365	3.7	Yes
Grocery	365	1.9	Yes
Warehouse	250	5.0	Yes
Elementary School	200	36.4	Yes
Jr. High/High School/College	200	36.4	Yes
Health	365	67.2	No
Motel	365	81.0	Yes
Hotel	365	81.0	Yes
Other Commercial	250	15.8	Yes

References:

1. 2020 Minnesota Energy Code - Chapter 7676.1100 Subpart 3D, 4A
2. Centerpoint TRM
3. International Energy Conservation Code (IECC) 2015 Table C403.2.3 (4)
4. ASHRAE HVAC Systems and Equipment 2008 pg 15.1
5. Whole Building Design Guide for US Army. Tech Note 14: Overhead Radiant Heating <https://www.wbdg.org/ccb/ARMYCOE/COETN/technote14.pdf>

6. 2015 Minnesota Energy Code Table C403.2.3(5) pg C-44
7. Cost data from online review on 8/5/15 of products available at Younits.com, ecomfort.com, hvacdistribution.com, grainger.com, simplyplumbing.com, homedepot.com, h-
8. Nicor Gas Energy Efficiency Plan 2011-2014. Revised Plan Filed Pursuant to Order Docket 10-0562, May 27, 2011
9. Sachs, Harvey M., Unit Heaters Deserve Attention for Commercial Programs, ACEEE, April 2003
10. TMY3 Weather data from Department of Energy
11. International Energy Conservation Code (IECC) 2012

12. 2% efficiency improvement for boiler tune up based on Michaels Energy literature review. Sources included (but not limited to):
 12A. Illinois Technical Reference Manual (2015-2016)
 12B. Michigan Energy Measures Database (MEMD) accessed at <http://www.michigan.gov/mpsc/0,4639,7-159-52495_55129---,00.html>
 12C. Arkansas Technical Reference Manual <http://www.apscservices.info/EEInfo/TRM4.pdf>
13. 3% efficiency improvement for boiler outdoor air reset based on Michaels Energy literature review. Sources included (but not limited to):
 13A. Arkansas Technical Reference Manual <http://www.apscservices.info/EEInfo/TRM4.pdf>
 13B. NEEP Mid-Atlantic TRM. V5. >http://www.neep.org/sites/default/files/resources/Mid-Atlantic_TRM_V5_FINAL_5-26-2015.pdf>
14. 1% efficiency improvement for stack dampers based on Michaels Energy literature review. Sources included (but not limited to):

 14A. Arkansas Technical Reference Manual <http://www.apscservices.info/EEInfo/TRM4.pdf>
 14B. Illinois Technical Reference Manual (2015-2016)

14C. Minnesota TRM. Version 1.3. <http://mn.gov/commerce-stat/pdfs/trm-version-1.3.pdf>

15. 3% efficiency improvement for modulating boiler controls based on Michaels Energy literature review. Sources included (but not limited to):
15A. Illinois Technical Reference Manual (2015-2016)
15B. Minnesota TRM. Version 1.3. <http://mn.gov/commerce-stat/pdfs/trm-version-1.3.pdf>

16. 2% efficiency improvement for O2 trim control based on Michaels Energy literature review. Sources included (but not limited to):
16A. Illinois Technical Reference Manual (2015-2016)
16B. Minnesota TRM. Version 1.3. <http://mn.gov/commerce-stat/pdfs/trm-version-1.3.pdf>
17. 80% boiler efficiency assumed based on minimum boiler efficiency from IECC 2015.

18. California DEER Database, 2014 (value used is for remaining useful life of commercial high efficiency furnaces)
19. AHRI Directory of Certified Product Performance; average of Standby Loss in BTUH per gallon of storage calculated for units with 80% or less thermal efficiency for
20. Leakage data from Energy Management Handbook, by Wayne Turner
21. Measure life from the Federal Energy Management Program (FEMP).
22. The average baseline and high efficiency costs are based on the California DEER database.
23. Cost information supplied by Engineered Products
24. Material costs taken from zoro.com for fiberglass pipe insulation (February 2016)
25. Commercial Condensing Boiler Optimization. Center for Energy and Environment. Prepared for Minnesota Department of Commerse, Division of Energy Resources. 2015.
26. AHRI Directory of Certified Product Performance; average of Standby Loss in BTUH per gallon of storage calculated for units with 80% or less thermal efficiency for

27. Arkansas Deemed Savings Quick Start Program Draft Report Commercial Measures Final Report, Nexant.
28. MN Bin Temp Bin Hrs are taken from the "Thermal Environmental Engineering, Third Edition, Thomas H. Kuehn, James W. Ramsey and James L. Threlkeld, Pages 717-
29. Arkansas Deemed Savings Quick Start Program Draft Report Commercial Measures Final Report, Nexant.
30. Baseline and Energy Efficient equipment costs provided by vendors
31. Minnesota DER Deemed Values
32. Bradford White RightSpec® commercial water heater sizing software
33. Bosch tankless water heater sizing software
34. Commercial Buildings Energy Consumption Study (CBECS), 2006
35. 2008 DEER Effective Useful Life Summary October 1st 2008
36. 2007 ASHRAE HVAC Applications Handbook Chapter 36, page 36.3, Table 4

37. 2006 IECC
38. "Electricity Savings from Variable-Speed Furnaces in Cold Climates" Pigg, Scott and Talerico, Tom. ACEEE Summer Study Proceedings 2004
39. U.S. Department of Energy, Preliminary Analysis Report, 2012
40. http://www.grainger.com
41. Wisconsin Focus on Energy, ECM Furnace Fan Impact Evaluation Report, https://focusonenergy.com/sites/default/files/emcfurnaceimpactassessment_evaluationreport.pdf)
42. MN custom rebates and conversations with Distributors (Tim Stoklosa, Clean Energy Designs in Lakewood CO)
43. Illinois 2017 TRM ; http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_6/Final/IL-TRM_Effective_010118_v6.0_Vol_2_C_and_I_020817_Final.pdf

44. St Paul 2015 Water Rate Schedule - http://mn-stpaul.civicplus.com/DocumentView.asp?DID=3493 (From 2017-2019 MN Energy Efficient Showerhead Tech Assumptions)
45. Source BTU for electricity based on MN DOC No. G008/CIP-00-864.07 Reply Comments of May 23, 2003 which states a Source BTU comparison must be made using an
46. Wisconsin Focus on Energy 2019 TRM
47. Historical program participation
48. State of Minnesota Technical Reference Manual for Energy Conservation Improvement Programs version 3.0 Jan 10 2019
49. Custom DCV Projects, 2010-2011
50. MN Lighting Efficiency Tech Assumption , Tab "Forcast Market Segment".
51. 2011 Tetratech Program Evaluation
52. 2023 Illinois Statewide Techinical Reference Manual for Energy Efficiency - Version 11.0

Changes from Recent Filing:

Program	Measure Group	Measure Lifetime (years)	Rebate Amount ($)	Incremental Cost ($)	Annual Customer kWh Savings (kWh/yr)	Annual Customer Peak Coincident Demand Savings (PCkW)	Gas Savings (Dth)	Non-Energy O&M Savings ($)	Electric NTG (%)	Gas NTG (%)	Install Rate (%)	2023 Electric Units	2023 Gas Units
HVAC+R Systems - CO	Steam Cooker	12	$433	$2,270	0	0.000	517.9	$729.40	100%	100%	100%	0	23
HVAC+R Systems - CO	Food Service	12	$479	$3,212	0	0.000	157.5	$0.00	100%	100%	100%	0	19
HVAC+R Systems - CO	Ozone Laundry	1	$0	$0	0	0.000	0.0	$0.00	100%	100%	100%	0	0
HVAC+R Systems - CO	Custom Motors Project	16	$37,881	$161,177	487,067	71.041	0.0	$880.50	87%	87%	100%	3	0
HVAC+R Systems - CO	Custom Cooling Project	19	$26,286	$78,509	101,583	54.853	0.0	-$1,560.43	87%	87%	100%	3	0
HVAC+R Systems - CO	Custom Heating Project	17	$3,808	$39,849	0	0.000	952.1	$238.58	87%	87%	100%	0	4
HVAC+R Systems - CO	Centrifugal Chillers	20	$21,674	$25,890	170,503	35.096	0.0	$0.00	71%	71%	100%	18	0
HVAC+R Systems - CO	VFD Chiller Retrofit	1	$0	$0	0	0.000	0.0	$0.00	100%	100%	100%	0	0
HVAC+R Systems - CO	Air-Cooled Chillers	20	$0	$20,033	54,186	16.423	0.0	$0.00	89%	89%	100%	53	0
HVAC+R Systems - CO	Screw/Scroll Chillers	20	$7,523	$11,545	48,545	12.437	0.0	$0.00	71%	71%	100%	9	0
HVAC+R Systems - CO	DX Units > 63.3 Tons	20	$0	$24,840	26,690	12.135	0.0	$0.00	89%	89%	100%	2	0
HVAC+R Systems - CO	DEPACC	20	$14,769	$29,860	28,035	60.398	0.0	-$167.05	71%	71%	100%	67	0
HVAC+R Systems - CO	DX Units 20 - 63.3 Tons	20	$0	$1,352	4,277	3.275	0.0	$0.00	89%	89%	100%	143	0
HVAC+R Systems - CO	Mini-Split Air Conditioning - MS	18	$138	$368	3,808	0.699	0.0	$0.00	89%	89%	100%	759	0
HVAC+R Systems - CO	DX Units 11.4 - 19.9 Tons	20	$0	$2,175	1,952	1.608	0.0	$0.00	89%	89%	100%	291	0
HVAC+R Systems - CO	DX Units 5.5 - 11.3 Tons	20	$0	$785	1,971	0.985	0.0	$0.00	89%	89%	100%	511	0
HVAC+R Systems - CO	Mini-Split Heat Pump - MS	18	$148	$372	1,159	1.401	0.0	$0.00	89%	89%	100%	570	0
HVAC+R Systems - CO	DX Units < 5.4 Tons	20	$0	$369	383	0.276	0.0	$0.00	89%	89%	100%	480	0
HVAC+R Systems - CO	PTAC	20	$0	$239	456	0.455	0.2	$0.00	89%	89%	100%	3,107	50
HVAC+R Systems - CO	Water-source Heat Pumps	15	$0	$390	314	0.303	0.0	$0.00	89%	89%	100%	1,092	0
HVAC+R Systems - CO	Unit Heater Infrared	15	$350	$144	1,541	0.000	65.6	$0.00	100%	100%	100%	0	45
HVAC+R Systems - CO	Boiler Controls	19	$1,214	$11,201	0	0.000	154.7	$0.00	100%	100%	100%	0	44
HVAC+R Systems - CO	Boiler	20	$1,197	$5,084	0	0.000	110.5	$0.00	86%	86%	100%	0	31
HVAC+R Systems - CO	Pipe Insulation	13	$2,751	$2,734	0	0.000	100.4	$0.00	86%	86%	100%	0	22
HVAC+R Systems - CO	Pipe Insulation - Direct Install	13	$803	$803	0	0.000	100.4	$0.00	86%	86%	100%	0	22
HVAC+R Systems - CO	Steam Traps	5	$50	$258	0	0.000	39.9	$0.00	86%	86%	100%	0	2
HVAC+R Systems - CO	Destratification Fans	15	$2,000	$7,320	0	0.000	87.8	$0.00	86%	86%	100%	0	2
HVAC+R Systems - CO	Water Heater	16	$783	$1,144	0	0.000	46.8	$0.00	86%	86%	100%	0	14
HVAC+R Systems - CO	Unit Heater	20	$70	$227	0	0.000	19.4	$0.00	86%	86%	100%	0	22
HVAC+R Systems - CO	Pump Efficiency (PEI)	16	$2,502	$4,226	50,959	9.291	0.0	$0.00	81%	81%	100%	238	0
HVAC+R Systems - CO	Well Pump VFD	15	$1,273	$8,548	51,202	6.808	0.0	$0.00	81%	81%	100%	16	0
HVAC+R Systems - CO	Fan Efficiency (FEI)	16	$1,850	$3,163	19,722	2.877	0.0	$0.00	81%	81%	100%	192	0
HVAC+R Systems - CO	VFDs	15	$2,764	$5,704	27,533	4.116	0.0	$0.00	81%	81%	100%	406	0
HVAC+R Systems - CO	Integrated Drives	15	$1,101	$3,316	5,250	1.088	0.0	$0.00	81%	81%	100%	175	0
HVAC+R Systems - CO	Fractional HP Circ. Pumps	15	$75	$187	3,081	0.550	0.0	$0.00	81%	81%	100%	10	0
HVAC+R Systems - CO	Motors	1	$0	$0	0	0.000	0.0	$0.00	100%	100%	100%	0	0
HVAC+R Systems - CO	Refigeration Fans	15	$55	$193	611	0.070	0.0	$0.00	100%	100%	100%	100	0
HVAC+R Systems - CO	Fractional HP Fan Motors	15	$75	$187	523	0.221	0.0	$0.00	81%	81%	100%	10	0
HVAC+R Systems - CO	Floating Head Pressure Controls	1	$0	$0	0	0.000	0.0	$0.00	100%	100%	100%	0	0
HVAC+R Systems - CO	Walk-in Freezer Defrost Controls	15	$319	$1,351	3,368	0.385	0.0	$0.00	100%	100%	100%	3	0
HVAC+R Systems - CO	No Heat Case Doors	12	$125	$538	1,572	0.180	0.0	$0.00	100%	100%	100%	6	0
HVAC+R Systems - CO	Anti-Sweat Heater Controls	12	$60	$180	1,415	0.146	0.0	$0.00	100%	100%	100%	64	0
HVAC+R Systems - CO	Retrofit of open multi-deck cases with solid glass doors	12	$125	$498	1,047	0.120	7.5	$0.00	100%	100%	100%	6	0
HVAC+R Systems - CO	Medium-temp Enclosed Reach-In Case	15	$70	$338	970	0.111	0.0	$0.00	100%	100%	100%	3	0
HVAC+R Systems - CO	Cooling Engineering Study	1	$0	$0	0	0.000	0.0	$0.00	100%	100%	100%	0	0
HVAC+R Systems - CO	Motors Engineering Study	1	$0	$0	0	0.000	0.0	$0.00	100%	100%	100%	0	0
HVAC+R Systems - CO	Heat Pump Water Heater - Beneficial Electrification	10	$1,080	$7,837	-10,742	-1.226	108.7	$0.00	100%	100%	100%	50	50
HVAC+R Systems - CO	Heat Pump Water Heater - Electric Efficiency	10	$1,080	$7,837	8,885	1.014	0.0	-$8.58	100%	100%	100%	50	0
HVAC+R Systems - CO	Dual Fuel RTU	20	#DIV/0!	#DIV/0!	-2,709	0.405	32.6	$0.00	100%	100%	100%	100	50
HVAC+R Systems - CO	ASHP < 5.4 Tons	20	#DIV/0!	#DIV/0!	705	0.318	19.6	$0.00	100%	100%	100%	180	60
HVAC+R Systems - CO	GSHP	20	#DIV/0!	#DIV/0!	6,318	1.615	31.7	$0.00	100%	100%	100%	3	1
HVAC+R Systems - CO	WSHP	20	$0	#DIV/0!	-495	0.326	36.6	$0.00	100%	100%	100%	150	75
HVAC+R Systems - CO	MSHP	20	$0	#DIV/0!	182	0.508	4.8	$0.00	100%	100%	100%	160	80