12.1 DX Units

Algorithms

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

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

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 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. 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:

12.2 WSHP

Algorithms

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

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

$$EER = SEER$$

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

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 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:
Addition of gas and electric baselines and updates to deemed baseline efficiencies

12.3 PTAC

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_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
   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. 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:

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
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. 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:

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:

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 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:

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
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. 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:

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	$Hours_{Economizing}$	$Hours_{Not}$
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		SCOP_Standard		SCOP_Standard_Adj		Incremental Cost $/SCOP
	Lower Limit ≥	Upper Limit <	Downflow Units	Upflow Units	Downflow Units	Upflow Units	
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

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.

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:

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	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	No baseline equipment
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

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.

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:

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

DEEMED SAVINGS TECHNICAL ASSUMPTIONS

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:

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:
Added electric and gas baselines

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:

12.12 Plate & Frame Heat Exchangers

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

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	

Assumptions:

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

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

Changes from Recent Filing:

12.13 ASHP < 5.5 Tons

Algorithms

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

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

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

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

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

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

Changes from Recent Filing:

New prescriptive offering

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 12.14.1	Average daily hot water consumption [gallons / 1,000 ft2 / day].
Days_Year	See Table 12.14.1	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 12.14.1 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
ingramswaterandair.com, and zoro.com
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):
<http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15 Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf>
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)
<http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15 Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf>
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):
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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):
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18. California DEER Database, 2014 (value used is for remaining useful life of commercial high efficiency furnaces)
thermal efficiency for efficient unit
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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.
thermal efficiency for efficient unit
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 717-718, Table B.5" to determine full load equivalent hours (FLEH) in Minnesota area. See Forecast furnace operating hours for calculation
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 (http://aceee.org/files/proceedings/2004/data/papers/SS04_Panel1_Paper23.pdf)
39. U.S. Department of Energy, Preliminary Analysis Report, 2012 (http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/ff_prelim_ch_00_execsummary_2012_06_26.pdf)
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)
7500 BTU/Generator kWh , based on typical Heat Rate for Combined-Cycle Natural Gas-fired Plant.
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:
New prescriptive offering

12.15 GSHP

w/ HP/Electric baseline

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

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

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

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

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

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 efficiency 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

Changes from Recent Filing:
New prescriptive offering

12.13 VRF

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
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}	$HSPF_{BASE}$
Baseline ASHP	14	11.4	8.2

References

Savings Database - Source for coincidence factor
2. IECC 2018 For baseline equipment efficiencies
3. Equations and measure life from MN TRM

Changes from Recent Filing:
New prescriptive offering

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

Changes from Recent Filing:
New prescriptive offering

12.18 Dual Fuel RTU

Algorithms

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

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

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

$$EER = SEER \times 0.85$$

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

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

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 prescriptive offering

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
ingramswaterandair.com, and zoro.com
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) <http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15 Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf>
    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>
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    13B. NEEP Mid-Atlantic TRM. V5. >http://www.neep.org/sites/default/files/resources/Mid-Atlantic_TRM_V5_FINAL_5-26-2015.pdf>
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    14A. Arkansas Technical Reference Manual <http://www.apscservices.info/EEInfo/TRM4.pdf>
    14B. Illinois Technical Reference Manual (2015-2016) <http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15 Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf>
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    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):
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    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)
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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)
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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 baseline unit and <96% thermal efficiency for efficient unit
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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 717-718, Table B.5" to determine full load equivalent hours (FLEH) in Minnesota area. See Forecast furnace operating hours for calculation
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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
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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 (http://aceee.org/files/proceedings/2004/data/papers/SS04_Panel1_Paper23.pdf)
39. U.S. Department of Energy, Preliminary Analysis Report, 2012 (http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/ff_prelim_ch_00_execsummary_2012_06_26.pdf)
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 assumed heat rate of 7500 BTU/Generator kWh , based on typical Heat Rate for Combined-Cycle Natural Gas-fired Plant.
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:

New prescriptive offering

13.1.Water Heater

Algorithms

$$Customer\ Dth = Quantity \times (BTUH\ Input \times Alt \times (\left(\frac{EFFh}{EFFb}\right) - 1) \times EFLH + (Gallons\ Storage \times \left(\frac{SL_{Base}}{EFFb} - \frac{SL_{New}}{EFFh}\right)) \times SLHrs/1000000$$

Variables

Alt	See Table 13.0.4	Altitude Adjustment factor to adjust the sea level manufacturer's rated input for altitude effects. No adjustment for near sea-level altitude.
Effb	See Table 13.0.2	Efficiency Rating of standard replacement water heater, Thermal Efficiency
SL_base	13.21	Standby Losses for baseline storage water heater, BTUH per gallon of storage (Ref 26)
SL_new	8.9	Standby Losses for efficient water heater, BTUH per gallon of storage (Ref 26)
SLHrs	8,760	Standby loss annual hours for commercial water heaters.
EFLH	See Table 13.0.3	
NTG	86%	Net-to-gross = 86% Per 2011 Cadmus Program Evaluation and Michaels Energy Review.
Incremental Cost	See Table 13.1.1	Incremental cost of efficient water heater over standard water heater.
Measure Life	See Table 13.0.1	

Customer Inputs	**M&V Verified**	
BTUH input	Yes	BTUH of proposed water heater
Quantity	Yes	Quantity of water heaters
Effh	Yes	Efficiency Rating of high efficiency replacement water heater, Thermal Efficiency
Gallons Storage	Yes	Only needed for tank type water heaters

Table 13.1.1 Commercial Water Heater Incremental Cost (Ref 30)

Water Heater Type/Capacity	Incremental Cost
75,000 to 199,99 BTUh	$1,018.46
200,000 to 299,000 BTUh	$1,000.36
>=300,000 BTUh	$1,728.11
Tankless 75,000 to 199,99 BTUh	$1,242.36
Tankless >= 200,000 BTUh	$1,000.36

References:

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 baseline unit and <96% thermal efficiency for efficient unit

30. Baseline and Energy Efficient equipment costs provided by vendors

Changes from Recent Filing:

13.2 Boiler

Algorithms

$$Customer\ Dth = Input\ Capacity \times Alt \times (\frac{Effh - Adj}{Effb} - 1) \times EFLH$$

Variables

Alt	See Table 13.0.4	Altitude Adjustment factor to adjust the sea level manufacturer's rated input for altitude effects. No adjustment for near sea-level altitude.
EFFb	See Table 13.0.2	Efficiency of Baseline equipment
Adj		Adjustment for operation at less than nominal efficiency
	0%	Efficiency adjustment for non-condensing boilers.
EFLH	See Table 13.0.3	Based on Bin Analysis assuming 30% oversizing for boiler plant. See "Forecast Boiler Op Hours " tab.
Conversion Factor	1000000	Conversion from BTU to Dth
Incremental Cost	See Table 13.2.1	Incremental cost of efficient boiler or furnace over standard equipment.
Measure Life	See Table 13.0.1	

Customer Inputs	M&V Verified	
Input Capacity	Yes	Rated input BTUH nameplate data for the new boiler, furnace, unit heater, or water heater.
EFFh	Yes	Efficiency of purchased boiler, provided by customer.
Use	Yes	Use of boiler: space heating, domestic water, or both.
Cost		

Table 13.2.1a Hot water boiler costs (Ref 23)

Input Capacity Range	Baseline	High Efficient - Non Condensing	Baseline to High Efficient - Non Condensing Incremental Cost
0 - 0.499 MMBTUH	$3,000	$3,500	$500
0.5 - 0.999 MMBTUH	$5,000	$9,000	$4,000
1 - 1.999 MMBTUH	$7,300	$11,700	$4,400
2 - 3.999 MMBTUH	$12,000	$17,000	$5,000
4 - 5.999 MMBTUH	$24,000	$34,000	$10,000
6 - 7.999 MMBTUH	$36,000	$51,000	$15,000
8 -9.999 MMBTUH	$48,000	$68,000	$20,000

Table 13.2.1b Steam boiler costs, Vendor supplied, Engineered Products

Boiler Input Capacity Range	Incremental
Low Pressure Steam Boiler; 0 - 0.499 MMBTUH	$1,320
Low Pressure Steam Boiler; 0.5 - 4.999 MMBTUH	$3,168
Low Pressure Steam Boiler; 5 - 9.999 MMBTUH	$16,500
High Pressure Steam Boiler; 0 - 0.499 MMBTUH	$1,320
High Pressure Steam Boiler; 0.5 - 4.99 MMBTUH	$3,168
High Pressure Steam Boiler; 5 - 9.999 MMBTUH	$16,500

References:

23. Cost information supplied by Engineered Products

Changes from Recent Filing:

13.3 Destratification Fans

Algorithms

$$Customer\ (Dth) = \left(U\ roof \times (Area\ Destrat \times deltaT\ C) + U\ wall \times \sqrt{(Area\ Total)} \times 4 \times \frac{Area\ Destrat}{Area\ Total} \times Ceilingheight \times Destrat\ Height \times deltaT\ C\right) \times HeatingHours \times \frac{\frac{\frac{HrsPerDay}{24}}{HeatEff}}{1000000} + Destrat\ Fan\ kWh \times (\frac{3412}{HeatEff} - Source\ BTU\ Factor)/1000000$$

$$Destrat\ Fan\ kWh = Destrat\ Fan\ kW \times QTY \times Heating\ Hours \times HrsPerDay/24$$

Variables

HeatingHours	6499	Heating hours in season with outdoor air temperatures below 65F. (Ref 10)
deltaT_C	10	Difference between ceiling air temperature (deg F) and floor temperature in stratified space. Ref (48)
Destrat_Height	0.25	Assumption that the top 25% of the wall height will experience the same stratified deltaT as the ceiling.
U_roof	0.08	Average heat transfer coefficient for the roof (BTU/h*ft^2*F). (Ref 48)
U_walls	0.115	Average heat transfer coefficient for the walls (BTU/h*ft^2*F) assuming equal distribution between newer and older buildings. (Ref 43)
Heat_Eff	80%	Assumed efficiency of heating equipment.
Conversion Factor	1,000,000	Conversion factor from BTU to Dth.
Destrat_Fan_kW	0.588	kW per fan, based on typical 1 HP motor with 65% load factor.
Source_BTU_Factor	7500	Source BTU per kWh, used to account for cross-fuel penalty of this measure. (Ref 45)
Measure Life	See Table 13.0.1	Refer to table 15 for measure life.

Customer Inputs	M&V Verified	
HrsPerDay	Yes	Hours per day of destratification fan operation.
Qty	Yes	Quantity of destratification fans installed.
Ceiling Height	Yes	Height of ceiling in space being destratified, in feet.
Area_Destrat	Yes	Total area being destratified, in square feet.
Cost	No	Total cost for equipment and installation of destratification fans.
Area_Total	Yes	Total facility floor area, in square feet

References:

10. TMY3 Weather data from Department of Energy

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

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 assumed heat rate of 7500 BTU/Generator kWh , based on typical Heat Rate for Combined-Cycle Natural Gas-fired Plant.

48. State of Minnesota Technical Reference Manual for Energy Conservation Improvement Programs version 3.0 Jan 10 2019

Changes from Recent Filing:

13.4 Unit Heater

Algorithms

$$Unit\ Heater\ Savings\ (Dth) = Input\ Capacity \times Alt \times (\frac{EFFh}{EFFb} - 1) \times EFLH\_UH \times (Oversize\ Factor_{heat}) \div 1000000$$

$$Infrared\ Heater\ Savings\ (Dth) = Dth\ Base\ Infrared - Dth\ Eff\ Radiant$$

$$Dth\ Base\ Infrared = \left(\frac{Infrared\ Input\ Capacity \times Alt}{Infrared\ Size\ Factor}\right) \times Oversize\ Factor_{heat} \times EFLH_{UH} \times \left(\frac{1\ Dth}{1000000\ BTU}\right) - Dth_{fan}$$

$$Dth\ Eff\ Infrared = Infrared\ Input\ Capacity \times Alt \times Oversize\ Factor\_heat \times EFLH\_UH \times (\frac{1Dth}{1000000\ BTU})$$

$$EFLH_{UH} = \frac{HDD_a \times T_{indoor}{}^2 + HDD_b \times T_{indoor} + HDD_c}{T_{indoor} - T_{design}} \times 24 \times \%conditioned$$

$$FLH = \frac{HDD_a \times T_{indoor}{}^2 + HDD_b \times T_{indoor} + HDD_c}{T_{indoor} - T_{offset}} \times 24 \times \%conditioned$$

$$Fan\_kW = Input\ Capacity\ x\ Heat\_eff\_infrared\ x\ (Alt \div Infrared\ Size\ Factor)\ x\ Oversize\ Factor\_heat\ x\ (HP/BTUh)\ x\ 0.746\ x\ LF \div Mtr\_eff$$

$$Fan\_kWh = Fan\ kW\ x\ FLH$$

$$Dth_{fan} = Fan\_kW \times 3412 \times FLH \div 1000000$$

Variables

Alt	See Table 13.0.4	Altitude Adjustment factor to adjust the sea level manufacturer's rated input for altitude effects.
HP/BTUh	2.96834E-06	Average axial/propeller/centrifugal fan power (rated) per BTU/h of heating output. Taken from manufacturer data for 38 unit heaters from Trane and Sterling; Applies to Infrared Heaters only
Oversize Factor_heat	0.9	Factor to account for design oversize commonly found on unit heater installations. Reference 1
T_design	See Table 13.4.1	Winter Design temperature for the given location. Reference 52.
LF	0.8	Design load factor of fan motor, deemed based on typical engineering assumption
EFFb	80%	Thermal efficiency of the baseline, non-power-vented, code-compliant unit heater. Reference 3.
EFFh	See Table 13.0.2	Thermal efficiency of the new, efficient unit heater
EFLH	See Table 13.0.3	The equivalent full load heating hours for unit heaters.
Heat_eff_infrared	80%	Thermal efficiency of the new, radiant heater. = 0.80, same as baseline because the radiant heaters do not have specific combustion efficiency improvements over the baseline unit heater, their savings are all from radiation heat transfer versus convection. Also, Ref 5 uses this value.
Radiation Size Factor	0.85	Factor to account for the fact that radiant heaters should be designed smaller than an equivalent standard unit heater due to radiation heat transfer being more effective at producing thermal comfort. This also accounts for the lower room temperature afforded by radiant heaters. = 0.85 (Ref 4)
HDD_a	See Table 13.4.1	Polynomial Constants used in calculating HDD based on TMY3 weather data and design indoor temperature. HDD is proportional to the indoor temperature based on the formula HDD = a * Tin^2 + b * Tin + c
HDD_b	See Table 13.4.1	Polynomial Constants used in calculating HDD based on TMY3 weather data and design indoor temperature. HDD is proportional to the indoor temperature based on the formula HDD = a * Tin^2 + b * Tin + c
HDD_c	See Table 13.4.1	Polynomial Constants used in calculating HDD based on TMY3 weather data and design indoor temperature. HDD is proportional to the indoor temperature based on the formula HDD = a * Tin^2 + b * Tin + c
T-Offset	See Table 13.4.1	Difference between the maximum heating degree day and the indoor design temperature.
Mtr_eff	29.58%	Average efficiency of 6 unit heater fans, calculated by taking the manufacturer-provided (Reznor, Sterling, and Trane) current draw to calculate power consumption and working backwards with the rated motor power and an assumed load factor of 0.8 to compute the efficiency for each fan and then taking the average of all of the fans. = 0.296 and includes both axial and centrifugal fans.
Conversion Factor	0.746	Conversion factor from HP to kW
Conversion Factor	1000	Conversion factor from kBTU/h to BTU/h
Conversion Factor	3412	Conversion factor from kW to BTU/h
Measure Life	See Table 13.0.1	Refer to table for measure life.
Incremental Cost	Table 10	Incremental cost of efficient unit heater over standard power vented unit heater.

Customer Inputs	M&V Verified	
Input capacity	Yes	Rated Input Capacity of the new non-infrared heater in BTU/h
Infrared Input Capacity	Yes	Rated Input Capacity of the new infrared heater in BTU/h
%conditioned	Yes	Percentage of the time during heating season the space is heated
T_indoor	Yes	Space temperature set point of space being heated

Table 13.4.1 HDD Estimation Constants and Site Weather Data (Ref 10 and 52)

Climate Zone	HDD_a	HDD_b	HDD_c	T_design	T-Offset
CO1: Denver / Front Range	2.87	-111.29	901.25	-4.00	-12.40
CO2: Alamosa / Mountain is climate zone	2.65	-103.77	906.11	3.40	-14.62
CO3 Grand Junction / Western Slope	3.33	-109.56	1,677.73	-16.80	4.96
Minnesota	2.51	(54.61)	679.14	(16.00)	(12.40)

Table 13.4.2 Unit Heater and Radiant Heater Costs (Ref 7)

	$/kBTUh (output)	Incremental Cost
Baseline Unit Heater	$8.42	N/A
Power-vented Unit Heater (83%)	$10.04	$1.62
Radiant Heater (uses input kBTU/h)	$9.45	$1.03

References:

1. 1999 Minnesota Energy Code - Chapter 7676.1100 Subpart 3D, 4A
3. International Energy Conservation Code (IECC) 2015 Table C403.2.3 (4)
4. ASHRAE HVAC Systems and Equipment 2008 pg 15.1
7. Cost data from online review on 8/5/15 of available products from various distributors
10. TMY3 Weather data from Department of Energy
52. 99.6% design temperature for Denver (Stapleton), taken from the 2005 ASHRAE Handbook - Fundamentals. Grand Junction - Station 724760; Alamosa - Station 724620.

Changes from Recent Filing:

13.5 Boiler Controls

Algorithms

$$Customer\ Dth = Input\ Capacity \times Alt \times (1 - \frac{EFFb}{Effh}) \times EFLH$$

Variables

Alt	See Table 13.0.4	Altitude Adjustment factor to adjust the sea level manufacturer's rated input for altitude effects. No adjustment for near sea-level altitude.
Effb	See Table 13.0.2	Efficiency of Baseline equipment.
Effh	See Table 13.0.2	Efficiency of equipment after controls implemented
EFLH	See Table 13.0.3	Based on Bin Analysis assuming 30% oversizing for boiler plant. (Ref 28)
Measure Life	See Table 13.0.1	

Customer Inputs	M&V Verified	
Input Capacity	Yes	Rated input BTUH nameplate data for the boiler
Use	Yes	Use of boiler: space heating, domestic water, or both.
Cost	Yes	Cost of boiler tuneup

References:

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 717-718, Table B.5" to determine full load equivalent hours (FLEH) in Minnesota area. See Forecast furnace operating hours for calculation. Adjusted for CO

Changes from Recent Filing:

13.6 Steam Traps

Algorithms

$$Customer\ (Dth) = LeakRate \times Leak\ Hours \times \frac{BTU\ Per\ Pound}{EFFb} / 1000000$$

Variables

Leak_Rate	5	Leakage rate for low pressure steam traps in pounds of steam per hour.(Reference 20)
	11	Leakage rate for high pressure steam traps in pounds of steam per hour.(Reference 20)
Leak_Hours	See Table 13.6.1	Annual hours boiler lines are pressurized, based on customer-provided system type.
Effb	See Table 13.0.2	Efficiency of steam boiler
BTU_Per_Pound	1064	Loss in btu/lb for Steam traps in Low Pressure Applications: 1164 BTU per pound for lost to atmosphere, 964 BTU per pound lost to condensate. Assume 50/50 mix = 1064 BTU per pound. (Reference 20)
	1081	Loss in btu/lb for Steam traps in High Pressure Applications: 1181 BTU per pound for lost to atmosphere, 981 BTU per pound lost to condensate. Assume 50/50 mix = 1081 BTU per pound. (Reference 20)
Measure Life	See Table 13.0.1	

Customer Inputs	M&V Verified	
Incremental Cost	No	Cost of replacing or repairing steam traps, per trap, provided by the customer.
Steam Pressure	Yes	Steam pressure, low or high.
Use	Yes	Use of steam system: space heating, domestic water, or both.

Table 13.6.1 Annual Leak Hours - Steam Traps (Ref 28)

Use	Hours
Space Heating	6,000
Domestic Water Heating	8,760
Space and Domestic Water Heating	8,760

References:

20. Leakage data from Energy Management Handbook, by Wayne Turner

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 717-718, Table B.5" to determine full load equivalent hours (FLEH) in Minnesota area. See Forecast furnace operating hours for calculation. Adjusted for CO

Changes from Recent Filing:

13.7 Pipe Insulation

Algorithms

$$Customer\ (Dth) = LFT \times Hrs \times (BTU\ Per\ Foot\ U - BTU\ Per\ Foot\ I) \times Existing/EFFb$$

$$BTU\ Per\ Foot = Coef0 + (Coef1 \times DeltaT) + (Coef2 \times DeltaT^2) + (Coef3 \times DeltaT^3)$$

$$DeltaT = Tfluid - Tambient$$

Variables

Hrs	See Table 13.7.1	The operating hours for the boiler system.
	70	Average temperature of the space surrounding the pipe for conditioned spaces.
	51	= Average temperature of the space surrounding the pipe for outside domestic hot water, full year average based on average TMY3 temperatures for Colorado. (Ref 10)
T ambient	44	= Average temperature of the space surrounding the pipe for outside space heating (average excluding June-September) based on average TMY3 temperatures for Colorado. (Ref 10)
		= Pipe insulation savings multiplier to determine credit if existing deteriorated insulation is being replaced.
	1	= Multiplier of 1 if no existing insulation is present.
Existing	0.25	= Pipe insulation savings multiplier of 0.25 if existing insulation is being replaced.
Effb	See Table 13.0.2	= Efficiency of boiler or water heater serving the pipes being insulated.
Coef0, Coef1, Coef2, Coef3	See Table 13.7.2	= Polynomial coefficients
Measure Life	See Table 13.0.1	Refer to table 15 for measure life.

Customer Inputs	**M&V Verified**	
LFT	Yes	Linear feet of insulation installed, provided by the customer.
T fluid	Yes	Average temperature of the fluid in the pipe receiving insulation in degrees F

Table 13.7.1 Hours for Pipe Insulation (Ref 28)

Use of Pipe	Location	Pipe Insulation Hours	Explanation
Domestic Hot Water	Inside	5,558	Hours when outside temp is above building balance point. Heat loss from pipe is wasted.
Domestic Hot Water	Outside	8,760	Domestic hot water available year round, outside temp is always less than 120 F.
Space Heating	Inside	1,648	Hours when boiler is running but outdoor temp is above building balance point
Space Heating	Outside	4,791	Hours that boiler is running

13.8 Demand Control Ventilation

Algorithms

$$Customer\ kW = Total\ Exaust\ Fan\ HP \times ESF$$

$$Customer\ kWh = Customer\ kW \times Hours$$

$$Customer\ Dth = Total\ Exhaust\ Fan\ HP \times GSF$$

Variables

ESF	0.9054	Demand Controlled Ventilation Electric Savings Factor, kW per name plate HP. (Ref 49)
GSF	42.3224	Demand Controlled Ventilation Gas Savings Factor =42.3224 Dth per name plate hp. (Ref 49)

Customer Inputs	M&V Verified	
Model Name	Yes	
Model Number	Yes	
Quantity	Yes	
Size	Yes	
Total Exhaust Fan hp	Yes	Total nameplate HP of exhaust fans with DCV installed.

Table 13.8.1 Ref (49, 50)	Incremental Cost Per Name Plate HP	Measure Life (yrs)	Coincidence Factor (CF)	O&M Savings - energy Per Name Plate HP	Hours
Demand Controlled Ventilation	$ 2,451.55	20	49.46%	$0	3307

References:

49. Custom DCV Projects, 2010-2011
50. MN Lighting Efficiency Tech Assumption , Tab "Forcast Market Segment".

Changes from Recent Filing:

Table 13.7.2 Deemed Insulation Polynomial Equation Coefficients and Incremental Costs

Pipe Nominal Diameter (inches)	Insulation Thickness (Inches)	Heat Loss (BTU/Hr) at Specified					Polynomial Coefficients				Cost Per Foot	Cost Per 3' Materials
		5	70	135	200	265	Coef0	Coef1	Coef2	Coef3	Total	(Ref 28)
0.50	-	1.73000	35.90	81.40	136.0	201.0	-0.51699304	0.43276708	0.001310573	-2.82203E-07	$ -	$ -
0.50	0.5	0.64500	10.10	21.20	34.4	50.0	-0.02055491	0.13279564	0.000150494	2.291E-07	$ 6.18	$ 6.18
0.50	1	0.46300	7.07	14.80	23.9	34.6	-0.00506792	0.09314387	0.000102935	1.44743E-07	$ 7.47	$ 7.47
0.50	1.5	0.37900	5.75	12.00	19.4	28.0	0.003984993	0.07518613	8.91729E-05	9.74056E-08	$ 14.18	$ 14.18
0.50	2	0.33700	5.10	10.60	17.1	24.7	0.000608336	0.06740019	6.8221E-05	1.1015E-07	$ 22.02	$ 22.02
0.50	2.5	0.29500	4.45	9.28	14.9	21.6	-0.00747838	0.05974442	4.96359E-05	1.22895E-07	$ 26.02	$ 26.02
0.50	3	0.27800	4.18	8.72	14.0	20.3	-0.00630559	0.05611641	4.66467E-05	1.15916E-07	$ 31.44	$ 31.44
0.50	3.5	0.26400	3.97	8.28	13.3	19.2	-0.00185037	0.05272378	5.22687E-05	8.37506E-08	$ 36.87	$ 36.87
0.50	4	0.25300	3.80	7.92	12.7	18.4	-0.0060451	0.05110554	4.13115E-05	1.05295E-07	$ 42.29	$ 42.29
0.50	4.5	0.24200	3.64	7.59	12.2	17.6	-0.00056352	0.04820003	4.96014E-05	7.22E-08	$ 47.71	$ 47.71
0.50	5	0.23500	3.53	7.34	11.8	17.1	-0.00336602	0.04731939	3.88419E-05	9.86193E-08	$ 53.14	$ 53.14
0.50	5.5	0.23400	3.51	7.31	11.8	17.0	0.005221094	0.0459022	5.38618E-05	5.64406E-08	$ 58.56	$ 58.56
0.50	6	0.22700	3.41	7.10	11.4	16.5	-0.00354018	0.04566163	3.91228E-05	8.89091E-08	$ 63.98	$ 63.98
0.75	-	2.09000	43.40	98.50	165.0	245.0	-0.64101619	0.52569402	0.001536569	-8.79988E-08	$ -	$ -
0.75	0.5	0.75300	11.80	24.90	40.4	58.7	-0.02396278	0.15426539	0.000194013	2.26673E-07	$ 7.00	$ 7.00
0.75	1	0.55600	8.51	17.80	28.8	41.8	-0.00762203	0.11236975	0.000117924	2.01487E-07	$ 8.17	$ 8.17
0.75	1.5	0.43900	6.66	13.90	22.4	32.5	-0.00849852	0.08880715	8.10579E-05	1.76301E-07	$ 14.24	$ 14.24
0.75	2	0.38300	5.80	12.10	19.5	28.2	-0.00261003	0.07677564	7.83555E-05	1.26536E-07	$ 22.77	$ 22.77
0.75	2.5	0.32900	4.97	10.40	16.7	24.1	-0.0040483	0.0658327	6.97763E-05	9.43711E-08	$ 26.39	$ 26.39
0.75	3	0.30800	4.64	9.66	15.5	22.5	-0.00946158	0.06266411	4.6068E-05	1.43226E-07	$ 31.73	$ 31.73
0.75	3.5	0.29100	4.38	9.12	14.7	21.2	0.002692685	0.05765753	6.2664E-05	8.16265E-08	$ 37.07	$ 37.07
0.75	4	0.27700	4.17	8.69	14.0	20.2	0.001543377	0.05497413	5.90396E-05	7.98058E-08	$ 42.40	$ 42.40
0.75	4.5	0.26600	3.99	8.32	13.4	19.3	0.003691319	0.05237176	5.99558E-05	6.4937E-08	$ 47.74	$ 47.74
0.75	5	0.25600	3.85	8.02	12.9	18.6	0.000585786	0.05088343	5.32258E-05	7.40404E-08	$ 53.08	$ 53.08
0.75	5.5	0.25300	3.80	7.92	12.7	18.4	-0.0060451	0.05110554	4.13115E-05	1.05295E-07	$ 58.42	$ 58.42
0.75	6	0.24500	3.68	7.67	12.3	17.8	-0.0049141	0.04935649	4.19306E-05	9.55849E-08	$ 63.76	$ 63.76
1.00	-	2.52000	52.60	120.00	201.0	297.0	-0.72836621	0.62472376	0.002067703	-7.0399E-07	$ -	$ -
1.00	0.5	0.88700	13.90	29.40	47.8	69.5	-0.02227222	0.18067121	0.000242842	2.467E-07	$ 7.22	$ 7.22
1.00	1	0.57800	8.83	18.50	29.8	43.2	-0.01520707	0.11731005	0.000117809	2.06949E-07	$ 8.77	$ 8.77
1.00	1.5	0.47600	7.22	15.10	24.3	35.2	-0.00941903	0.09605189	9.35275E-05	1.71142E-07	$ 15.25	$ 15.25
1.00	2	0.41300	6.24	13.00	21.0	30.3	0.005230275	0.08179042	9.32915E-05	1.11364E-07	$ 24.21	$ 24.21
1.00	2.5	0.37300	5.63	11.70	18.9	27.3	0.00381926	0.07414985	7.78159E-05	1.17433E-07	$ 28.23	$ 28.23
1.00	3	0.34500	5.21	10.90	17.5	25.2	-0.00201092	0.06871287	7.74465E-05	8.34471E-08	$ 33.97	$ 33.97
1.00	3.5	0.32400	4.88	10.20	16.4	23.6	0.001685103	0.06407339	7.52741E-05	7.16128E-08	$ 39.72	$ 39.72
1.00	4	0.30700	4.63	9.64	15.5	22.4	-0.00291777	0.06161312	5.81228E-05	1.07116E-07	$ 45.46	$ 45.46
1.00	4.5	0.29200	4.40	9.16	14.7	21.3	-0.00719958	0.05916601	4.73061E-05	1.23805E-07	$ 51.21	$ 51.21
1.00	5	0.26800	4.02	8.37	13.5	19.4	0.0071897	0.05238594	6.46778E-05	5.21924E-08	$ 56.95	$ 56.95
1.00	5.5	0.27500	4.13	8.61	13.8	20.0	-0.00733195	0.05562929	4.39788E-05	1.16826E-07	$ 62.70	$ 62.70
1.00	6	0.26600	4.00	8.33	13.4	19.3	0.001648014	0.05273795	5.69907E-05	7.10059E-08	$ 68.44	$ 68.44
1.00	6.5	0.25800	3.88	8.08	13.0	18.8	-0.00152036	0.05160684	4.87015E-05	9.16401E-08	$ 74.19	$ 74.19
1.00	7	0.25100	3.78	7.87	12.7	18.3	0.0040483	0.04953021	5.68509E-05	6.34198E-08	$ 79.93	$ 79.93
1.00	7.5	0.24500	3.69	7.67	12.3	17.8	-0.00565225	0.04963139	3.93036E-05	1.01654E-07	$ 85.68	$ 85.68
1.00	8	0.24000	3.60	7.50	12.1	17.4	0.006196242	0.04692785	5.77671E-05	4.85511E-08	$ 91.42	$ 91.42
1.00	8.5	0.23500	3.53	7.35	11.8	17.1	-0.00467117	0.04741068	3.85038E-05	9.86193E-08	$ 97.17	$ 97.17
1.00	9	0.23000	3.46	7.20	11.6	16.7	0.003090708	0.04543952	5.10371E-05	5.76544E-08	$ 102.91	$ 102.91
1.00	9.5	0.22600	3.40	7.07	11.4	16.4	0.004308785	0.04451934	5.15157E-05	5.27993E-08	$ 108.66	$ 108.66
1.00	10	0.22200	3.34	6.95	11.2	16.1	0.004221705	0.04369047	5.16562E-05	4.79442E-08	$ 114.40	$ 114.40
1.25	-	3.11000	64.80	147.00	248.0	368.0	-0.81894089	0.76796747	0.002475005	-4.58201E-07	$ -	$ -
1.25	0.5	1.01000	15.80	33.40	54.2	78.8	-0.03151388	0.2063746	0.000264133	3.0041E-07	$ 7.71	$ 7.71
1.25	1	0.73700	11.30	23.70	38.4	55.6	-0.0014191	0.14752113	0.000181817	2.01183E-07	$ 9.48	$ 9.48
1.25	1.5	0.53100	8.05	16.80	27.1	39.2	-0.00257736	0.10635244	0.000111172	1.7266E-07	$ 16.60	$ 16.60
1.25	2	0.48900	7.41	15.50	24.9	36.0	-0.00971317	0.09853622	9.81917E-05	1.61129E-07	$ 25.56	$ 25.56
1.25	2.5	0.43300	6.55	13.70	22.0	31.8	-0.00812404	0.08712265	8.65811E-05	1.41708E-07	$ 30.01	$ 30.01
1.25	3	0.39700	5.98	12.50	20.1	29.0	-0.00106199	0.07896063	8.58034E-05	1.1015E-07	$ 36.07	$ 36.07
1.25	3.5	0.36900	5.56	11.60	18.7	26.9	0.006159386	0.07261071	8.88153E-05	7.61645E-08	$ 42.14	$ 42.14
1.25	4	0.34700	5.23	10.90	17.5	25.3	-0.00557854	0.06983173	6.35978E-05	1.25322E-07	$ 48.21	$ 48.21
1.25	4.5	0.32800	4.94	10.30	16.5	23.9	-0.00994743	0.06655574	5.29215E-05	1.37157E-07	$ 54.27	$ 54.27
1.25	5	0.31400	4.72	9.83	15.8	22.8	-0.0008386	0.06261432	6.21848E-05	9.89228E-08	$ 60.34	$ 60.34
1.25	5.5	0.30300	4.55	9.47	15.2	22.0	-0.00503333	0.06099609	5.12276E-05	1.20467E-07	$ 66.41	$ 66.41
1.25	6	0.29200	4.39	9.14	14.7	21.2	0.000448248	0.05809058	5.95175E-05	8.73919E-08	$ 72.47	$ 72.47
1.50	-	3.50000	73.10	167.00	280.0	416.0	-1.08946746	0.8782643	0.002727811	-3.94477E-07	$ -	$ -
1.50	0.5	1.18000	18.70	39.40	64.1	93.2	-0.04143286	0.24393112	0.00030924	3.70202E-07	$ 8.88	$ 8.88
1.50	1	0.74800	11.50	24.00	38.8	56.2	-0.011669	0.15185253	0.000158962	2.58534E-07	$ 10.23	$ 10.23
1.50	1.5	0.59900	9.11	19.00	30.7	44.4	-0.00057161	0.11994951	0.000129735	1.88439E-07	$ 17.36	$ 17.36
1.50	2	0.47800	7.23	15.10	24.3	35.1	-0.00364976	0.09565997	0.000100122	1.4626E-07	$ 26.68	$ 26.68
1.50	2.5	0.43400	6.54	13.60	22.0	31.7	0.011069068	0.08529243	0.000101654	1.04992E-07	$ 30.92	$ 30.92
1.50	3	0.40100	6.04	12.60	20.3	29.3	0.001635399	0.07960692	8.63392E-05	1.15005E-07	$ 36.97	$ 36.97
1.50	3.5	0.37500	5.65	11.80	19.0	27.4	0.001530008	0.07434559	8.34742E-05	9.86193E-08	$ 43.03	$ 43.03
1.50	4	0.35300	5.31	11.10	17.8	25.7	-0.0051704	0.07067377	6.97919E-05	1.11364E-07	$ 49.08	$ 49.08
1.50	4.5	0.33700	5.06	10.50	17.0	24.5	0.010881306	0.06598783	7.70382E-05	8.58747E-08	$ 55.13	$ 55.13
1.50	5	0.32300	4.85	10.10	16.3	23.5	0.005816529	0.06357831	7.23994E-05	8.4054E-08	$ 61.19	$ 61.19
1.50	5.5	0.32100	4.82	10.00	16.1	23.3	-0.00118663	0.06432578	5.53879E-05	1.27143E-07	$ 67.24	$ 67.24
1.50	6	0.30900	4.64	9.68	15.6	22.5	0.003362065	0.0609862	6.84368E-05	8.22333E-08	$ 73.29	$ 73.29
2.00	-	4.30000	90.00	205.00	346.0	514.0	-1.16894206	1.06399527	0.003504974	-6.97921E-07	$ -	$ -
2.00	0.5	1.43000	22.70	48.00	78.1	114.0	-0.07119943	0.29777781	0.0003583	5.37096E-07	$ 9.48	$ 9.48
2.00	1	0.87700	13.40	28.20	45.5	66.0	-0.0188967	0.17681671	0.000198555	2.80079E-07	$ 11.07	$ 11.07
2.00	1.5	0.68300	10.40	21.70	35.0	50.6	-0.0058209	0.13736995	0.000144615	2.17569E-07	$ 19.13	$ 19.13
2.00	2	0.58000	8.79	18.30	29.6	42.7	0.008893686	0.11491811	0.000134157	1.51722E-07	$ 28.12	$ 28.12
2.00	2.5	0.51600	7.80	16.30	26.2	37.8	-0.00420438	0.10315517	0.000110122	1.46867E-07	$ 32.95	$ 32.95
2.00	3	0.47000	7.09	14.80	23.8	34.4	-0.00454724	0.09412276	9.37057E-05	1.54756E-07	$ 39.34	$ 39.34
2.00	3.5	0.43600	6.56	13.70	22.0	31.8	-0.00555011	0.08732423	8.44242E-05	1.46867E-07	$ 45.74	$ 45.74
2.00	4	0.40500	6.10	12.70	20.4	29.5	-0.00569777	0.08147132	7.28949E-05	1.50205E-07	$ 52.14	$ 52.14
2.00	4.5	0.38400	5.78	12.00	19.4	28.0	0.007290669	0.07588864	8.20756E-05	1.14095E-07	$ 58.54	$ 58.54
2.00	5	0.36600	5.51	11.50	18.5	26.7	-0.0004715	0.07283282	7.6901E-05	1.07419E-07	$ 64.94	$ 64.94
2.00	5.5	0.35600	5.35	11.10	17.9	25.9	0.000920268	0.07109988	6.48261E-05	1.34729E-07	$ 71.33	$ 71.33
2.00	6	0.34900	5.25	10.90	17.6	25.4	0.00518377	0.06911454	7.26374E-05	1.06509E-07	$ 77.73	$ 77.73
2.50	-	5.12000	107.00	244.00	412.0	612.0	-1.36423331	1.26111581	0.00422519	-9.46746E-07	$ -	$ -
2.50	0.5	1.65000	26.20	55.40	90.0	131.0	-0.07811301	0.34273284	0.00043244	5.31027E-07	$ 9.94	$ 9.94
2.50	1	1.01000	15.50	32.40	52.4	75.9	-0.0121108	0.20412695	0.000223103	3.30754E-07	$ 12.60	$ 12.60
2.50	1.5	0.70300	10.70	22.30	35.9	51.9	-0.01111669	0.14211452	0.000138841	2.41845E-07	$ 20.55	$ 20.55
2.50	2	0.61000	9.24	19.30	31.0	44.9	-0.01568503	0.12357472	0.000111288	2.33652E-07	$ 30.28	$ 30.28
2.50	2.5	0.54700	8.26	17.20	27.8	40.1	0.008994837	0.10809514	0.000125032	1.43529E-07	$ 35.59	$ 35.59
2.50	3	0.50100	7.56	15.80	25.4	36.6	-0.00083836	0.09963263	0.000111516	1.27143E-07	$ 42.48	$ 42.48
2.50	3.5	0.46200	6.96	14.50	23.3	33.7	-0.00618287	0.09286046	8.46622E-05	1.69322E-07	$ 49.38	$ 49.38
2.50	4	0.43400	6.54	13.60	21.9	31.6	0.001038507	0.08651054	8.76741E-05	1.35336E-07	$ 56.28	$ 56.28
2.50	4.5	0.41200	6.20	12.90	20.8	30.0	0.004368659	0.08162061	8.79719E-05	1.17736E-07	$ 63.17	$ 63.17
2.50	5	0.38900	5.85	12.20	19.6	28.3	-0.00269763	0.07769832	7.67599E-05	1.24716E-07	$ 70.07	$ 70.07
2.50	5.5	0.39000	5.86	12.20	19.6	28.4	-0.00663112	0.07856673	6.53814E-05	1.60825E-07	$ 76.97	$ 76.97
2.50	6	0.36100	5.42	11.30	18.2	26.2	0.005261903	0.07107351	8.23987E-05	8.46609E-08	$ 83.86	$ 83.86
3.00	-	6.12000	128.00	292.00	493.0	734.0	-1.71305963	1.51885905	0.004913792	-6.43301E-07	$ -	$ -
3.00	0.5	1.97000	31.30	66.30	108.0	157.0	-0.06235022	0.40479604	0.000578041	4.94614E-07	$ 11.11	$ 11.11
3.00	1	1.18000	18.20	38.10	61.5	89.2	-0.03545848	0.24133775	0.000245777	4.30891E-07	$ 13.47	$ 13.47
3.00	1.5	0.90300	13.80	28.80	46.4	67.2	-0.02065047	0.18354569	0.000176359	3.32878E-07	$ 21.50	$ 21.50

3.00	2	0.75600	11.50	23.90	38.6	55.8	-0.00124762	0.15194443	0.000153453	2.56107E-07	$	32.08	$	32.08
3.00	2.5	0.66100	10.00	20.90	33.6	48.6	-0.0108026	0.13295408	0.000131023	2.24245E-07	$	37.28	$	37.28
3.00	3	0.59500	8.98	18.70	30.1	43.6	-0.0078217	0.11980756	0.000107338	2.32135E-07	$	44.37	$	44.37
3.00	3.5	0.53900	8.13	16.90	27.3	39.4	0.007359204	0.10683283	0.000115989	1.58094E-07	$	51.46	$	51.46
3.00	4	0.50200	7.56	15.80	25.4	36.6	0.000265661	0.09960819	0.000111673	1.2684E-07	$	58.56	$	58.56
3.00	4.5	0.47300	7.12	14.80	23.9	34.5	0.006580948	0.09365604	0.000100275	1.41708E-07	$	65.65	$	65.65
3.00	5	0.44200	6.65	13.90	22.3	32.2	-0.00588012	0.08844116	8.79914E-05	1.38977E-07	$	72.75	$	72.75
3.00	5.5	0.42300	6.36	13.30	21.3	30.8	-0.01024901	0.08516517	7.73152E-05	1.50812E-07	$	79.84	$	79.84
3.00	6	0.40600	6.10	12.70	20.4	29.5	-0.00459374	0.08144689	7.30516E-05	1.49901E-07	$	86.93	$	86.93
3.50	0	6.92000	145.00	331.00	559.0	832.0	-1.93043137	1.71646834	0.005630873	-8.86057E-07	$	-	$	-
3.50	0.5	2.18000	34.60	73.30	119.0	174.0	-0.14230418	0.45737022	0.000510683	9.16401E-07	$	13.37	$	13.37
3.50	1	1.11000	17.00	35.70	57.6	83.4	-0.02042864	0.22391562	0.000255225	3.30754E-07	$	14.60	$	14.60
3.50	1.5	0.89900	13.70	28.50	46.0	66.6	-0.01005389	0.18179222	0.000174042	3.34092E-07	$	23.58	$	23.58
3.50	2	0.76700	11.60	24.30	39.1	56.5	-0.00713703	0.15322166	0.000167467	2.22425E-07	$	34.83	$	34.83
3.50	2.5	0.67900	10.30	21.40	34.5	49.9	-0.00525488	0.13683459	0.000128317	2.49128E-07	$	39.94	$	39.94
3.50	3	0.60900	9.19	19.20	30.9	44.6	-0.00147856	0.12129396	0.000131484	1.73267E-07	$	47.27	$	47.27
3.50	3.5	0.56200	8.47	17.70	28.4	41.0	-0.00791849	0.11261127	0.000112466	1.75391E-07	$	54.61	$	54.61
3.50	4	0.52400	7.90	16.50	26.5	38.3	-0.00736386	0.10511607	0.000102467	1.74784E-07	$	61.94	$	61.94
3.50	4.5	0.52600	7.92	16.50	26.6	38.4	0.003398452	0.10439888	0.000111507	1.5597E-07	$	69.28	$	69.28
3.50	5	0.48800	7.34	15.30	24.6	35.6	-0.00533933	0.09784689	9.01541E-05	1.79639E-07	$	76.62	$	76.62
3.50	5.5	0.46500	6.99	14.60	23.4	33.9	-0.01240562	0.0939246	7.89421E-05	1.86618E-07	$	83.95	$	83.95
3.50	6	0.44400	6.68	13.90	22.4	32.3	0.004144041	0.08799887	9.44041E-05	1.26233E-07	$	91.29	$	91.29
4.00	0	7.72000	162.00	369.00	624.0	929.0	-2.11759308	1.91712942	0.006241966	-8.25368E-07	$	-	$	-
4.00	0.5	2.32000	36.70	77.80	126.0	184.0	-0.15691423	0.48603008	0.000540165	9.34608E-07	$	14.12	$	14.12
4.00	1	1.42000	21.90	45.80	74.1	107.0	-0.00829469	0.28613195	0.000349321	3.58064E-07	$	17.83	$	17.83
4.00	1.5	1.09000	16.60	34.70	55.9	80.9	-0.01859211	0.22004346	0.000224585	3.67167E-07	$	24.48	$	24.48
4.00	2	0.90100	13.70	28.50	46.0	66.6	-0.00784584	0.18174334	0.000174355	3.33485E-07	$	37.48	$	37.48
4.00	2.5	0.78100	11.80	24.70	39.7	57.5	-0.01566404	0.15719233	0.000151844	2.78865E-07	$	42.66	$	42.66
4.00	3	0.68800	10.40	21.70	34.9	50.4	-0.00603197	0.13784793	0.000140326	2.16052E-07	$	50.33	$	50.33
4.00	3.5	0.62800	9.48	19.80	31.8	46.0	-0.0114396	0.12640601	0.000119272	2.22121E-07	$	58.01	$	58.01
4.00	4	0.58200	8.77	18.30	29.4	42.5	-0.00748309	0.11675566	0.000111764	1.99666E-07	$	65.68	$	65.68
4.00	4.5	0.53700	8.09	16.90	27.1	39.2	-0.01195737	0.10821834	9.82229E-05	1.95115E-07	$	73.35	$	73.35
4.00	5	0.50800	7.64	15.90	25.6	37.0	-0.00060456	0.10137334	9.83601E-05	1.7357E-07	$	81.03	$	81.03
4.00	5.5	0.48400	7.29	15.20	24.4	35.3	-0.00877487	0.0974755	8.69914E-05	1.80853E-07	$	88.70	$	88.70
4.00	6	0.46300	6.96	14.50	23.3	33.7	-0.00507885	0.09283602	8.48189E-05	1.69018E-07	$	96.37	$	96.37
4.50	0	8.52000	178.00	408.00	689.0	1027.0	-2.40444918	2.10560938	0.00699286	-1.06812E-06	$	-	$	-
4.50	0.5	2.55000	40.30	85.30	139.0	202.0	-0.05858508	0.52038548	0.000748911	6.2206E-07	$	15.84	$	15.84
4.50	1	1.33000	20.30	42.50	64.7	99.3	-0.57481345	0.33922828	-0.00059846	2.78258E-06	$	18.42	$	18.42
4.50	1.5	1.06000	16.10	33.60	54.3	78.5	0.002667794	0.21153564	0.00023601	3.15582E-07	$	25.56	$	25.56
4.50	2	0.89700	13.60	28.40	45.8	66.2	-0.00329127	0.17937951	0.000193236	2.7401E-07	$	40.36	$	40.36
4.50	2.5	0.77800	11.80	24.60	39.5	57.1	-0.01738693	0.15755305	0.000144611	2.79775E-07	$	45.22	$	45.22
4.50	3	0.70300	10.60	22.10	35.6	51.5	-0.00342438	0.14057606	0.000138841	2.41845E-07	$	53.29	$	53.29
4.50	3.5	0.64500	9.73	20.30	32.6	47.2	-0.01333572	0.13015457	0.000115563	2.47307E-07	$	61.36	$	61.36
4.50	4	0.59000	8.89	18.50	29.8	43.1	-0.0020883	0.11804825	0.000112836	2.09376E-07	$	69.43	$	69.43
4.50	4.5	0.59100	8.90	18.60	29.9	43.1	-0.00044406	0.11737559	0.000129873	1.54453E-07	$	77.50	$	77.50
4.50	5	0.55500	8.36	17.40	28.0	40.5	-0.0041952	0.11127415	0.000103397	2.0179E-07	$	85.57	$	85.57
4.50	5.5	0.52800	7.95	16.60	26.6	38.5	-0.01395888	0.10670557	9.16497E-05	2.03914E-07	$	93.64	$	93.64
4.50	6	0.50300	7.56	15.80	25.3	36.6	-0.01296024	0.1014198	8.89414E-05	1.87225E-07	$	101.71	$	101.71
5.00	0	9.49000	199.00	454.00	768.0	1145.0	-2.63998882	2.35783048	0.007642948	-7.55576E-07	$	-	$	-
5.00	0.5	2.90000	46.00	97.40	158.0	231.0	-0.19629105	0.60934239	0.000662657	1.24412E-06	$	17.71	$	17.71
5.00	1	1.76000	27.20	57.00	92.2	134.0	-0.05303284	0.36028654	0.000369179	6.79715E-07	$	20.14	$	20.14
5.00	1.5	1.32000	20.10	42.10	68.0	98.5	-0.01160179	0.26478965	0.00029262	4.18753E-07	$	27.40	$	27.40
5.00	2	1.08000	16.40	34.20	55.1	79.7	-0.01265856	0.21749832	0.000216256	3.70202E-07	$	42.88	$	42.88
5.00	2.5	0.90700	13.70	28.70	46.2	66.8	-0.0072637	0.18098636	0.000196493	2.70976E-07	$	47.73	$	47.73
5.00	3	0.80600	12.20	25.40	40.9	59.2	-0.01008045	0.16244023	0.000150235	3.01623E-07	$	56.00	$	56.00
5.00	3.5	0.73100	11.00	23.00	37.1	53.5	0.009459835	0.14392218	0.000172879	1.7266E-07	$	64.28	$	64.28
5.00	4	0.66100	9.97	20.80	33.5	48.3	0.003031589	0.13119868	0.000146122	1.75694E-07	$	72.56	$	72.56
5.00	4.5	0.61700	9.29	19.40	31.2	45.0	-0.00033867	0.12263692	0.000132737	1.70839E-07	$	80.83	$	80.83
5.00	5	0.58100	8.74	18.20	29.3	42.3	0.000947708	0.11564264	0.000117798	1.81763E-07	$	89.11	$	89.11
5.00	5.5	0.55200	8.31	17.30	27.9	40.2	0.007803212	0.10904227	0.00012328	1.42012E-07	$	97.39	$	97.39
5.00	6	0.52700	7.92	16.50	26.6	38.4	0.004502477	0.10437444	0.000111663	1.55667E-07	$	105.66	$	105.66
6.00	0	11.20000	234.00	535.00	905.0	1350.0	-3.08909812	2.76905087	0.009072892	-9.71021E-07	$	-	$	-
6.00	0.5	3.53000	56.30	119.00	194.0	283.0	-0.15708408	0.7346363	0.000932785	1.23502E-06	$	19.84	$	19.84
6.00	1	2.09000	32.20	67.70	109.0	159.0	-0.12171064	0.43338373	0.000363801	1.0044E-06	$	21.37	$	21.37
6.00	1.5	1.54000	23.50	49.20	79.4	115.0	-0.022132	0.31034744	0.000333273	5.03717E-07	$	28.93	$	28.93
6.00	2	1.22000	18.50	38.70	62.3	90.2	-0.0201056	0.24557579	0.000246973	4.18753E-07	$	44.19	$	44.19
6.00	2.5	1.04000	15.80	32.90	53.1	76.7	-0.00047779	0.20829659	0.000221042	3.21651E-07	$	48.74	$	48.74
6.00	3	0.92000	13.90	29.00	46.7	67.5	-0.00527499	0.18405076	0.000187932	2.97375E-07	$	56.80	$	56.80
6.00	3.5	0.81000	12.20	25.50	41.0	59.3	-0.00868535	0.1620373	0.00016146	2.70065E-07	$	64.86	$	64.86
6.00	4	0.74500	11.20	23.40	37.7	54.4	0.0052322	0.14727491	0.000166165	1.98756E-07	$	72.92	$	72.92
6.00	4.5	0.69200	10.40	21.70	35.0	50.5	0.008414695	0.13653207	0.000154933	1.84494E-07	$	80.98	$	80.98
6.00	5	0.64500	9.70	20.20	32.5	47.0	-0.0038009	0.12901711	0.000121754	2.291E-07	$	89.04	$	89.04
6.00	5.5	0.61600	9.27	19.30	31.1	44.9	0.003054607	0.12241674	0.000127236	1.89349E-07	$	97.10	$	97.10
6.00	6	0.58600	8.82	18.40	29.6	42.7	0.000251824	0.11650911	0.000123835	1.68108E-07	$	105.16	$	105.16
7.00	0	12.70000	267.00	611.00	1034.0	1542.0	-3.55732102	3.15132865	0.010491384	-1.42619E-06	$	-	$	-
7.00	0.5	4.01000	64.00	136.00	221.0	322.0	-0.2219658	0.83503966	0.001116074	1.21074E-06	$	39.14	$	39.14
7.00	1	2.43000	37.60	79.00	128.0	185.0	-0.01491879	0.48849633	0.000649086	5.37096E-07	$	43.13	$	43.13
7.00	1.5	1.68000	25.60	53.60	86.5	125.0	-0.00936056	0.33625832	0.000389024	4.61235E-07	$	47.13	$	47.13
7.00	2	1.36000	20.70	43.20	69.6	101.0	-0.03350231	0.27642001	0.000247584	5.58337E-07	$	51.12	$	51.12
7.00	2.5	1.16000	17.60	36.60	59.1	85.4	0.001981143	0.23222208	0.000240172	3.76271E-07	$	55.11	$	55.11
7.00	3	0.98900	15.00	31.20	50.2	72.6	-0.01514837	0.1999411	0.000182163	3.67471E-07	$	59.11	$	59.11
7.00	3.5	0.89400	13.50	28.10	45.3	65.5	-0.00162122	0.17881971	0.000177095	3.05265E-07	$	63.10	$	63.10
7.00	4	0.82000	12.40	25.80	41.5	59.9	-0.00570934	0.16455708	0.000161337	2.67031E-07	$	67.10	$	67.10
7.00	4.5	0.76000	11.40	23.90	38.4	55.5	-0.00521178	0.15091597	0.000161298	2.24549E-07	$	71.09	$	71.09
7.00	5	0.71100	10.70	22.30	35.9	51.9	-0.00228449	0.14191901	0.000140094	2.39417E-07	$	75.08	$	75.08
7.00	5.5	0.67400	10.20	21.20	34.0	49.2	-0.01884445	0.1372366	0.000108482	2.80989E-07	$	79.08	$	79.08
7.00	6	0.63900	9.62	20.00	32.3	46.6	0.010120892	0.12633902	0.000138448	1.8237E-07	$	83.07	$	83.07
8.00	0	14.30000	300.00	687.00	1163.0	1734.0	-3.91514143	3.53116262	0.011925548	-1.9117E-06	$	-	$	-
8.00	0.5	4.56000	72.80	155.00	252.0	367.0	-0.23655842	0.94586427	0.001334781	1.22591E-06	$	44.73	$	44.73
8.00	1	2.60000	40.20	84.50	137.0	198.0	-0.00621367	0.52111451	0.000708629	5.46199E-07	$	49.29	$	49.29
8.00	1.5	1.86000	28.40	59.40	95.9	139.0	-0.02920684	0.3757041	0.000389921	6.4937E-07	$	53.86	$	53.86
8.00	2	1.50000	22.80	47.70	76.9	111.0	-0.00512257	0.29957171	0.000345731	3.94477E-07	$	58.42	$	58.42
8.00	2.5	1.23000	18.60	38.90	62.6	90.5	-0.01245829	0.24625192	0.000257448	3.85374E-07	$	62.99	$	62.99
8.00	3	1.08000	16.40	34.20	55.1	79.6	-0.00835919	0.21688038	0.000225164	3.39857E-07	$	67.55	$	67.55
8.00	3.5	0.97700	14.80	30.80	49.5	71.6	-0.01874325	0.1977576	0.000175211	3.71112E-07	$	72.12	$	72.12
8.00	4	0.89400	13.50	28.10	45.3	65.4	0.002678146	0.17820177	0.000186003	2.7492E-07	$	76.68	$	76.68
8.00	4.5	0.82700	12.50	26.00	41.8	60.4	-0.00997285	0.16654242	0.000153526	2.95251E-07	$	81.24	$	81.24
8.00	5	0.77200	11.60	24.20	39.0	56.3	0.005703466	0.1527867	0.00016656	2.20907E-07	$	85.81	$	85.81
8.00	5.5	0.73100	11.00	22.90	36.9	53.3	0.002450276	0.14544547	0.0001483	2.33349E-07	$	90.37	$	90.37
8.00	6	0.69300	10.40	21.70	35.0	50.5	0.00951872	0.13650763	0.00015509	1.84191E-07	$	94.94	$	94.94
9.00	0	15.90000	333.00	762.00	1291.0	1926.0	-4.2857455	3.9202278	0.01316464	-1.79032E-06	$	-	$	-
9.00	0.5	4.69000	74.60	158.00	257.0	375.0	-0.24490201	0.97718978	0.001212621	1.67198E-06	$	50.32	$	50.32
9.00	1	2.85000	44.00	92.40	150.0	217.0	0.004233045	0.57031027	0.000765362	6.52405E-07	$	55.46	$	55.46
9.00	1.5	2.04000	31.20	65.20	105.0	152.0	-0.04904922	0.41447862	0.000411236	7.16128E-07	$	60.59	$	60.59
9.00	2	1.57000	23.80	49.70	80.2	116.0	-0.0047678	0.31391692	0.000336283	4.94614E-07	$	65.73	$	65.73
9.00	2.5	1.34000	20.30	42.40	68.3	98.7	-0.00904792	0.26826538	0.00028392	4.12684E-07	$	70.86	$	70.86
9.00	3	1.18000	17.80	37.20	59.9	86.6	-0.00596372	0.23543577	0.000246687	3.70202E-07	$	76.00	$	76.00

9.00	3.5	1.06000	16.00	33.40	53.8	77.7	-0.00110228	0.21119752	0.000225866	3.15582E-07	$ 81.13	$ 81.13
9.00	4	0.96800	14.60	30.50	49.0	70.8	-0.01201649	0.1939775	0.000193308	3.13154E-07	$ 86.27	$ 86.27
9.00	4.5	0.89300	13.50	28.10	45.2	65.2	-0.00415707	0.17882638	0.000180774	2.75224E-07	$ 91.40	$ 91.40
9.00	5	0.83300	12.50	26.20	42.1	60.8	-0.00365951	0.16518526	0.000180735	2.32742E-07	$ 96.53	$ 96.53
9.00	5.5	0.78800	11.90	24.70	39.8	57.4	0.003311945	0.15731625	0.000158468	2.46397E-07	$ 101.67	$ 101.67
9.00	6	0.75100	11.30	23.60	37.9	54.7	-0.00586652	0.14988485	0.000153125	2.2728E-07	$ 106.80	$ 106.80
10.00	-	17.70000	370.00	847.00	1435.0	2142.0	-4.77502048	4.36019572	0.014570323	-1.72963E-06	$ -	$ -
10.00	0.5	5.68000	91.00	193.00	315.0	459.0	-0.23064022	1.17751696	0.001668431	1.61432E-06	$ 55.91	$ 55.91
10.00	1	3.35000	51.90	109.00	177.0	257.0	-0.0441186	0.67825054	0.000823688	1.04688E-06	$ 61.62	$ 61.62
10.00	1.5	2.18000	33.30	69.60	112.0	163.0	-0.0936014	0.44840497	0.000355017	1.03778E-06	$ 67.32	$ 67.32
10.00	2	1.76000	26.80	56.00	90.2	131.0	-0.05060875	0.35834406	0.00031755	7.40404E-07	$ 73.03	$ 73.03
10.00	2.5	1.49000	22.60	47.30	76.2	110.0	-0.0065094	0.29733934	0.000339092	3.97512E-07	$ 78.73	$ 78.73
10.00	3	1.31000	19.80	41.30	66.5	96.1	-0.00784914	0.26219379	0.000267384	4.21787E-07	$ 84.44	$ 84.44
10.00	3.5	1.17000	17.70	36.90	59.4	85.8	-0.00772248	0.23442909	0.000238358	3.73236E-07	$ 90.14	$ 90.14
10.00	4	1.06000	16.10	33.50	53.9	77.9	-0.01580415	0.21425927	0.000201287	3.76271E-07	$ 95.85	$ 95.85
10.00	4.5	0.97800	14.70	30.70	49.5	71.5	0.007093205	0.1934533	0.000213927	2.79775E-07	$ 101.56	$ 101.56
10.00	5	0.91000	13.70	28.60	46.0	66.4	-0.00236244	0.18120045	0.000190201	2.70065E-07	$ 107.26	$ 107.26
10.00	5.5	0.85900	12.90	27.00	43.4	62.7	-0.00429227	0.17072149	0.000180973	2.55196E-07	$ 112.97	$ 112.97
10.00	6	0.81000	12.20	25.40	40.9	59.0	0.002934391	0.1611066	0.000168678	2.39721E-07	$ 118.67	$ 118.67
12.00	-	20.80000	435.00	997.00	1691.0	2524.0	-5.46682879	5.10092117	0.017473698	-2.67031E-06	$ -	$ -
12.00	0.5	6.02000	95.60	203.00	330.0	480.0	-0.25335483	1.24131456	0.001737707	1.57184E-06	$ 67.10	$ 67.10
12.00	1	3.51000	54.10	114.00	184.0	267.0	-0.10928747	0.71373529	0.000813128	1.11971E-06	$ 73.94	$ 73.94
12.00	1.5	2.53000	38.60	80.80	130.0	189.0	-0.09863554	0.5179718	0.000442636	1.11364E-06	$ 80.79	$ 80.79
12.00	2	2.04000	30.90	64.70	104.0	151.0	-0.06195253	0.4138481	0.00036715	8.37506E-07	$ 87.63	$ 87.63
12.00	2.5	1.72000	26.10	54.40	87.7	127.0	-0.02054776	0.3466554	0.00033339	6.31164E-07	$ 94.48	$ 94.48
12.00	3	1.50000	22.70	47.30	76.3	110.0	0.01147929	0.29800789	0.000337278	3.94477E-07	$ 101.33	$ 101.33
12.00	3.5	1.34000	20.20	42.10	67.9	98.1	0.005964757	0.26641416	0.000282229	4.12684E-07	$ 108.17	$ 108.17
12.00	4	1.21000	18.30	38.20	61.4	88.7	-0.01560388	0.24301287	0.00024248	3.91443E-07	$ 115.02	$ 115.02
12.00	4.5	1.11000	16.80	34.90	56.2	81.2	-0.00728604	0.2232242	0.000210358	3.91443E-07	$ 121.87	$ 121.87
12.00	5	1.03000	15.50	32.40	52.1	75.3	-0.00722388	0.20543869	0.000211022	3.24685E-07	$ 128.71	$ 128.71
12.00	5.5	0.97200	14.60	30.50	49.1	70.9	0.002430171	0.19266164	0.000207915	2.81596E-07	$ 135.56	$ 135.56
12.00	6	0.91400	13.80	28.70	46.1	66.6	-0.01264821	0.18416445	0.000166249	3.2954E-07	$ 142.41	$ 142.41

References:

10. TMY3 Weather data from Department of Energy

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 717-718, Table B.5" to determine full load equivalent hours (FLEH) in Minnesota area. See Forecast furnace operating hours for calculation. Adjusted for CO

Changes from Recent Filing:

13.9 Boiler Tune Up

Algorithms

$$Customer\ Dth = Input\ Capacity \times Alt \times (\frac{Effh - Adj}{Effb} - 1) \times EFLH$$

Variables

Alt	1	Altitude Adjustment factor to adjust the sea level manufacturer's rated input for altitude
Effb	See Table 13.0.2	Efficiency of Baseline equipment.
Effh	See Table 13.0.2	Efficiency of Boiler after the tune-up
EFLH	See Table 13.0.3	Based on Bin Analysis assuming 30% oversizing for boiler plant. (Ref 28)
Measure Life	See Table 13.0.1	

Customer Inputs	M&V Verified	
Input Capacity	Yes	Rated input BTUH nameplate data for the boiler
Use	Yes	Use of boiler: space heating, domestic water, or both.
Cost	Yes	Cost of boiler tuneup

References:

1. 1999 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-mac.com, ingramswaterandair.com, and zoro.com
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) <http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15 Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf>
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) <http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15 Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf>
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) <http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15 Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf>
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) <http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15 Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf>
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 baseline unit and <96% thermal efficiency for efficient unit
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 baseline unit and <96% thermal efficiency for efficient unit
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 717-718, Table B.5" to determine full load equivalent hours (FLEH) in Minnesota area. See Forecast furnace operating hours for calculation
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 (http://aceee.org/files/proceedings/2004/data/papers/SS04_Panel1_Paper23.pdf)
39. U.S. Department of Energy, Preliminary Analysis Report, 2012 (http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/ff_prelim_ch_00_execsummary_2012_06_26.pdf)
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 assumed heat rate of 7500 BTU/Generator kWh , based on typical Heat Rate for Combined-Cycle Natural Gas-fired Plant.

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

Changes from Recent Filing:

New product measure offering

13.11 Process Boilers

Algorithms

$$Customer\ Dth = \frac{Input\ Capacity}{Conversion\ Factor} \times Alt \times \left(\frac{Effh}{Effb} - 1\right) \times HOU \times Load\ Factor\ \times Utilization\ Factor$$

$$HOU = 8760$$

Variables

Alt	1	Altitude Adjustment factor to adjust the sea level manufacturer's rated input for altitude effects. No adjustment for near sea-level altitude.
EFFb	See Table 13.0.2	Efficiency of Baseline equipment
EFFh	See Table 13.0.2	Rated Efficiency provided by customer.
HOU	8760	Hours of Use following IL TRM. Load factor and oversize factor accomplished by blended utilization factor.
Conversion Factor	1000000	Conversion from BTU to Dth
Default Utilization Factor	41.9%	Utilization Factor from Illinois TRM 8.0 Vol 2, 4.43 Process Boiler Tune-up. (Ref 53)
Incremental Cost	See Table 13.10.1	Incremental cost of efficient boiler or furnace over standard equipment.
Load Factor	77%	
Measure Life	See Table 13.0.1	Consistent for all Process Boiler sizes.

Customer Inputs	M&V Verified	
Input Capacity	Yes	Rated input BTUH nameplate data for the new boiler, furnace, unit heater, or water heater.
Rated Efficiency	Yes	Rated efficiency of purchased boiler, provided by customer.
Utilization Factor	Yes	Use customer input, or default 41.9% if customer input is not available

Table 13.10.1 Incremental process boiler costs (Ref 48)

Boiler Type	Input Capacity Range	Incremental Cost $/kBtuh
Steam	>2.5 MMBTUH	$1.02
Non-Condensing	>2.5 MMBTUH	$2.50
Condensing	>2.5 MMBTUH	$7.25

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-mac.com, ingramswaterandair.com, and zoro.com
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)
<http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15 Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf>
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)
<http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15 Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf>
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)
<http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15 Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf>
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)
<http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15 Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf>
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 baseline unit and <96% thermal efficiency for efficient unit
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 baseline unit and <96% thermal efficiency for efficient unit
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 717-718, Table B.5" to determine full load equivalent hours (FLEH) in Minnesota area. See Forecast furnace operating hours for calculation
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 (http://aceee.org/files/proceedings/2004/data/papers/SS04_Panel1_Paper23.pdf)
39. U.S. Department of Energy, Preliminary Analysis Report, 2012 (http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/ff_prelim_ch_00_execsummary_2012_06_26.pdf)
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 assumed heat rate of 7500 BTU/Generator kWh , based on typical Heat Rate for Combined-Cycle Natural Gas-fired Plant.
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. Minnesota TRM. Version 3.3. <http://mn.gov/commerce-stat/pdfs/trm-version-3.3.pdf
53. Illinois Technical Reference Manual (2019-2020)
<https://www.ilsag.info/technical-reference-manual/il_trm_version_8/>

Changes from Recent Filing:

New product measure offering

13.12 Process Boiler Tune Up

Algorithms

$$Customer\ Dth = \frac{Input\ Capacity}{Conversion\ Factor} \times Alt \times \left(\frac{Effh}{Effb} - 1\right) \times HOU \times Load\ Factor\ \times Utilization\ Factor$$

$$HOU = 8760$$

Variables

Alt	1	Altitude Adjustment factor to adjust the sea level manufacturer's rated input for altitude
Effb	Use Percent Savings	Quantities not deemed individually, use percent savings term
Effh	Use Percent Savings	Quantities not deemed individually, use percent savings term
Percent Savings	2.20%	Per MN TRM 4.0, Table 2. Modification Savings, pg. 360 (Ref 48)
Conversion Factor	1,000,000	Conversion from BTU to Dth
Default Utilization Factor	41.9%	Utilization Factor from Illinois TRM 8.0 Vol 2, 4.43 Process Boiler Tune-up. (Ref 52)
HOU	8760	Hours of Use, scaled by blended utlization factor.
Load Factor	77%	
Measure Life	See Table 13.0.1	2 years for Process Boiler Tune Up

Customer Inputs	M&V Verified	
Input Capacity	Yes	Rated input BTUH nameplate data for the boiler
Use	Yes	Use of boiler: space heating, domestic water, or both.
Utilization Factor	Yes	Use customer input, or default 41.9% if customer input is not available
Cost	Yes	Cost of boiler tuneup

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

ingramswaterandair.com, and zoro.com

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>

<http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15 Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf>

 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):

<http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15 Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf>

 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):

<http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15 Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf>

 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)

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20. Leakage data from Energy Management Handbook, by Wayne Turner

21. Measure life from the Federal Energy Management Program (FEMP).

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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.

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27. Arkansas Deemed Savings Quick Start Program Draft Report Commercial Measures Final Report, Nexant.

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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

(http://aceee.org/files/proceedings/2004/data/papers/SS04_Panel1_Paper23.pdf)

39. U.S. Department of Energy, Preliminary Analysis Report, 2012 (http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/ff_prelim_ch_00_execsummary_2012_06_26.pdf)

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)
7500 BTU/Generator kWh , based on typical Heat Rate for Combined-Cycle Natural Gas-fired Plant.
46. Wisconsin Focus on Energy 2019 TRM
47. Historical program participation
48. State of Minnesota Technical Reference Manual for Energy Conservation Improvement Programs version 4.0, active 1/1/2024
49. Custom DCV Projects, 2010-2011
50. MN Lighting Efficiency Tech Assumption , Tab "Forcast Market Segment".
51. 2011 Tetratech Program Evaluation
52. Illinois Technical Reference Manual (2019-2020)
<https://www.ilsag.info/technical-reference-manual/il_trm_version_8/>

Changes from Recent Filing:
New product measure