

DEEMED SAVINGS TECHNICAL ASSUMPTIONS

1.12 Refrigerator Replacement

Algorithms

$$Customer\ kWh = Existing\ Equipment\ Quantity \times (kWh_{baseline} - kWh_{EnergyStar})$$

$$Customer\ kW = Existing\ Equipment\ Quantity \times \frac{Customer\ kWh}{Hours\ of\ Use}$$

$$Customer\ Coincident\ kW = Existing\ Equipment\ Quantity \times Customer\ kW \times Coincidence\ Factor$$

Variables

|                           |          |   |
|---------------------------|----------|---|
| kWh <sub>Baseline</sub>   | 741      | Deemed energy consumption based on the age of the equipment (Reference 14)  |
| kWh <sub>EnergyStar</sub> | 320      | Deemed annual energy consumption of the ENERGY STAR unit; Top-Mounted freezer or refrigerator only (automatic defrost) (Reference 13) |
| Coincidence Factor        | 64%      | Probability of equipment operating during peak time (Reference 4, Table 4)  |
| Hours of Use              | 8,760    | Annual hours of use in a year (Reference 13)  |
| Lifetime                  | 14       | Measured Lifetime (Reference 13)  |
| Incremental Cost          | \$630.00 | Difference in cost between the standard equipment and the more efficient equipment (Reference 12)                                     |
| Rebate                    | \$630.00 | (Reference 12)  |

Provided by Product Vendor

M&V Verified

|  |     |
|--|-----|
| Existing Equipment Quantity  | Yes |
| Product Type and Class of ENERGY STAR Refrigerators and Freezers Installed | Yes |

References:

1. Baseline kWh and Average to peak kW ratio from 1995 and 2012 versions of Residential Energy Data Sourcebook for the U.S. Residential Sector.
2. Data on expected life for savings on secondary refrigerators, 9th year Persistence Study for Southern California Edison, KEMA-XENERGY, 2004
3. Estimate for annual energy use for freezers as percent of refrigerator use. See Table Final Estimates on page 6-15 of report by KEMA-XENERGY
4. Data to support CF from "Domestic Refrigerators: Field Studies and Energy Efficiency Improvement", M. Siddhartha Bhatt, CPRI, July 2001.
5. Degradation factor cited in "2006 Refrigerator/Freezer Recycling Program Evaluation", Snohomish County PUD, Kevin L. Smit, February 2007.
6. Shipment Weighted Efficiencies from Residential Energy Databook, Years 1950 - 1995, <http://enduse.lbl.gov/Projects/RED.html>
7. Refrigerator-Freezer Sizes and Energy Factors (Shipment-Weighted Averages), Residential Energy Databook, Years 1972 - 2010,
8. Appliance Standards Awareness Project: Ref. Association of Home Appliance Manufacturers (AHAM)
9. Actual recent program data on age of recycled units were used to create weighted average energy consumption & remaining useful life of units recycled.
10. Data on Efficiency Standards, "Technical Support Document Refrigerators and Freezers", DOE, 2014.
11. Energy Star Program Requirements for Refrigerators. [https://www.energystar.gov/ia/partners/product\\_specs/program\\_reqs/refrig\\_prog\\_req.pdf](https://www.energystar.gov/ia/partners/product_specs/program_reqs/refrig_prog_req.pdf)
12. Income Qualified Single Family Weatherization Colorado Program Data
13. State of Minnesota Technical Reference Manual for Energy Conservation Improvement Programs Version 3.1 January 20, 2020
14. Refrigerator Recycling Colorado Program Data

Changes from Recent Filing:

Added measure for the replacement of an existing refrigerator.

DEEMED SAVINGS TECHNICAL ASSUMPTIONS

18.7 Residential Smart Thermostats

Algorithms

$$\text{Customer kWh} = \text{Customer Cooling kWh} + \text{Customer Heating kWh}$$

$$\text{Customer Coincident kW} = \text{Customer kW} * \text{Coincidence Factor}$$

Smart Thermostat Savings:

$$\text{Customer kW} = (\text{Cooling kW} * \text{TStat Qty Factor}) \times \text{ES Reduction}_{\text{cooling}} * \text{Cooling Scaling Factor}$$

$$\text{Customer Cooling kWh} = (\text{Cooling Tons} * \text{TStat Qty Factor}) * \frac{12}{\text{SEER}_{\text{Avg}}} * \text{EFLH}_{\text{Cooling}} * \text{ES Reduction}_{\text{cooling}} * \text{Cooling Scaling Factor}$$

$$\text{Customer Heating kWh} = (\text{Heating kW} * \text{TStat Qty Factor}) * \text{ES Reduction}_{\text{heating}} * \text{EFLH}_{\text{Heat}} * \text{Heating Scaling Factor}$$

$$\text{Customer DTh} = (\text{Baseline DTh} * \text{TStat Qty Factor}) * \text{ES Reduction}_{\text{heating}} * \text{Heating Scaling Factor}$$

Thermostat Optimization Savings:

$$\text{Customer kW} = \text{Cooling kW} * (1 - \text{ES Reduction}_{\text{cooling}}) * \text{Tstat\_Optimization\_Reduction} * \text{Cooling Scaling Factor}$$

$$\text{Customer Cooling kWh} = \text{Cooling Tons} * \frac{12}{\text{SEER}_{\text{Avg}}} * \text{EFLH}_{\text{Cooling}} * (1 - \text{ES Reduction}_{\text{cooling}}) * \text{Tstat\_Optimization\_Reduction} * \text{Cooling Scaling Factor}$$

$$\text{Customer Heating kWh} = \text{Heating kW} * \text{EFLH}_{\text{Heat}} * (1 - \text{ES Reduction}_{\text{heating}}) * \text{Tstat\_Optimization\_Reduction} * \text{Heating Scaling Factor}$$

$$\text{Customer Dth} = \text{Baseline Dth} * (1 - \text{ES Reduction}_{\text{heating}}) * \text{Tstat\_Optimization\_Reduction} * \text{Heating Scaling Factor}$$

Variables

|  |                  |  |
|--|------------------|--|
| ES Reduction Heating                           | 8%               | Energy Star Connected Thermostat criteria for annual heating equipment runtime reduction (Reference 1)   |
| ES Reduction Cooling                           | 10%              | Energy Star Connected Thermostat criteria for annual cooling equipment runtime reduction (Reference 1)   |
| Typical Res Gas Heating System Efficiency      | 80%              | gas heating system efficiency in existing homes  |
| Typical Res Electric Heating System Efficiency | 100%             | electric resistance heating system efficiency in existing homes  |
| Cooling Tons                                   | 2.690            | Average Home model capacity for Res Cooling (Tons)   |
| SEER_Avg                                       | 13.400           | Average Home model SEER rating   |
| EER_Avg  | 11.417           | Average Home model EER rating (converted from SEER)  |
| Cooling kW                                     | 2.827            | Forecasted High Efficiency Thermostat demand   |
| EFLH_Cooling                                   | See Table 18.0.1 | Forecasted High Efficiency Thermostat hours use Cooling EFLH   |
| Baseline Dth                                   | 101.1            | Forecasted Home gas use estimated from average furnace program participation   |
| Heating kW                                     | 12.989           | Full load kW for electric resistance heating based on forecasted gas usage and annual operating hours.   |
| EFLH_Heat                                      | See Table 18.0.1 | Forecasted High Efficiency Thermostat hours use Heating EFLH   |
| TStat Qty Factor                               | See Table 18.7.3 | The Primary Thermostat in a home saves the full EnergyStar heating or cooling criteria. A Secondary Thermostat in a home saves half of the energy and demand of a Primary Thermostat. The baseline cooling and heating demands will be adjusted by the factor based on the type of thermostat (Primary or Secondary) selected. |
| EnergyStar_CF                                  | 76%              | Coincidence Factor for High Efficiency Thermostat  |
| Cooling Scaling Factor                         | See Table 18.7.1 | Cooling energy and demand percent adjustment for home types  |
| Heating Scaling Factor                         | See Table 18.7.1 | Heating energy percent adjustment for home types   |
| Tstat_Optimization_Reduction                   | 3%               | Assumed percent savings by participating in manufacturer's optimization algorithm updates.   |
| Lifetime                                       | 10               | Measure life for ENERGY STAR Smart Thermostat (Reference 4)  |
| Incremental Cost                               | See Table 18.7.2 | Incremental cost for ENERGY STAR Smart Thermostat (Reference 4)  |

Customer Inputs

M&V Verified

|  |     |  |
|--|-----|--|
| Certified Energy Star Connected Thermostat | Yes |  |
| County                                     | No  |  |
| Home Type                                  | No  |  |
|  |     |  |

Table 18.7.1

| Home type              | Single Family | Multifamily | Townhome |
|------------------------|---------------|-------------|----------|
| Cooling Scaling Factor | 100%          | 35%         | 64%      |
| Heating Scaling Factor | 100%          | 15%         | 52%      |

Table 18.7.2

|  | Incremental Cost |
|--|------------------|
| LI SFW EnergyStar Smart Thermostat       | \$100.00         |
| ENERGY STAR smart thermostat (Reference) | \$200.00         |
| Home Energy Squad Smart Thermostat       | \$125.00         |
| Home Energy Squad upgraded Smart         | \$225.00         |

DEEMED SAVINGS TECHNICAL ASSUMPTIONS

| Table 18.7.3                          | TStat Qty Factor |
|---------------------------------------|------------------|
| Primary EnergyStar Smart Thermostat   | 1.0              |
| Secondary EnergyStar Smart Thermostat | 0.5              |

**References:**

1. ENERGY STAR Connected Thermostat Key Product Criteria - [https://www.energystar.gov/products/heating\\_cooling/smart\\_thermostats/key\\_product\\_criteria](https://www.energystar.gov/products/heating_cooling/smart_thermostats/key_product_criteria)
2. 2017 Seasonal Savings Evaluation, Navigant, 3/5/2018
3. Xcel Study of Winter Seasonal Savings, 2017-2018, Initial Estimates
4. Lifetime of 10 years for programmable T-Stats from "Measure Life Report Residential and Commercial/Industrial Lighting and HVAC Measures", June 2007 by GDS Associates.

**Changes from Recent Filing:**

1. included electric heating savings
2. added Thermostat Optimization savings measure
3. clarified secondary thermostat savings for smart thermostat measures.