Product: Commercial Refrigeration

Description:

Prescriptive rebates will be offered for the installation of reach-in cases with doors, evaporator fan motor controls, night curtains on refrigerator and freezer cases, EC Motors for Refrigeration Evaporators, Anti-Sweat Heater Controls and/or replacement of standard refrigeration case doors with No Heat Case Doors, Retrofit of open multi-deck refrigerated cases with no heat doors, and replacement lighting equipment.

Algorithms:

Enclosed Reach-In Cases	
Enclosed Reach-in Case Electrical Demand	= [(Btuh_base x LF x 1/COP)-(Btuh_ee x LF x 1/COP)] / 3412
Enclosed Reach-in Case Electrical Energy	= [(Btuh_base x LF x 1/COP)-(Btuh_ee x LF x 1/COP)] / 3412 x Hrs
Evaporative Fan Motor Controls	
Evaporator Fan Motor Control Electrical	= Baseline Fan Watts x (1-ESF) x LF
Evaporator Fan Motor Control Electrical	= Baseline Fan Watts x (1-ESF) x LF x Efficient Hours
Night Curtains	
Night Curtains Electrical Demand Savings	= (Btuh_base x LF x 1/COP) / 3412 - (Btuh_base x LF x 1/COP) / 3412 = 0
Night Curtains Electrical Energy Savings	= (Btuh_base x LF x 1/COP) / 3412 * Hrs * (Hours_base - Hours_ee)
CHW Pre-Rinse	
CHW Pre-Rinse Electric (Customer kWh)	= EnergyToHeatWater / EF_electric / ConversionFactor
CHW Pre-Rinse Electric (Customer kW)	= Unit kWh Savings per Year / 8,760 hours
EnergyToHeatWater	= SpecificHeat x Density x WaterSaved x (Tset - Tcold)
WaterSaved	= (Flow_base x Hours_base - Flow_eff x Hours_eff) x Days
EnergyToHeatWater	= SpecificHeat x Density x WaterSaved x (Tset - Tcold)
WaterSaved	= (Flow_base x Hours_base - Flow_eff x Hours_eff) x Days
CHW-Aerator-Electric	
CHW Aerator Electric (Customer kWh)	= EnergyToHeatWater / EF_electric / ConversionFactor
CHW Aerator Electric (Customer kW)	= Unit kWh Savings per Year / 8,760 hours
WaterSaved	= (Flow_base - Flow_eff) x TPD / 60 min/hr x Days
EnergyToHeatWater	= SpecificHeat x Density x WaterSaved x (Tfaucet - Tcold)
EPG	= Density x SpecificHeat x (Tfaucet - Tcold) / (ReEff x ConversionFactor)
Unit Dth Savings per Year	= EnergyToHeatWater / EF_gas / ConversionFactor
WaterSaved	= (Flow_base - Flow_eff) x TPD / 60 min/hr x Days
EnergyToHeatWater	= SpecificHeat x Density x WaterSaved x (Tfaucet - Tcold)
Open to Closed Refrigerated Cases	
Customer kWh	= kWh_open x Linear Feet - kWh_closed x Linear Feet = 521.95 kWh/ft x Linear Feet for Coolers and 1572.34 kWh x Linear Feet for Freezers
Customer kW	= Customer kWh / Hours
kWh_open	= (PC x FI_open) x (LF x 1 / 3412 x Hours x 1 / COPrefrig) - HVAC_kWh = (1500 x 0.818) x (0.62 x 1/3412 x 8760 x 1/2.28) - HVAC_kWh = 627.65 kWh for coolers, 1913.63 Wh for freezers
kWh_closed	= (PC x FI_closed) x (LF x 1 / 3412 x Hours x 1 / COPrefrig) - HVAC_kWh = (1500 x 0.138) x (0.62 x 1/3412 x 8760 x 1/2.28 - HVAC_kWh = 105.70 kWh for coolers, 341.29 kWh for freezers
HVAC_kWh ("free" from refrig system)	= HVAC_kW x Clg_Hrs = 0.078635 kW/ft x 2908 hrs = 229 kWh/ft for open cooler cases, 38.5 kWh/ft for closed cooler cases, 285 kWh/ft for open freezer cases, and 73 kW/ft for closed freezer cases.
HVAC_kW ("free" from refrig system)	= Refr_Infil x 1 / COPhvac x 1 / 3412 x Clg Duty Cyc = 1226.52 x 1/3.2 x 1/3412 x .7 = .078635 kW/ft for open cooler cases and 0.0132404 kW/ft for closed cooler cases, 0.098159 kW/ft for open freezers and 0.017504 kW/ft for closed freezers.
Refr_Infil (using FI_open or FI_closed)	= (PC x FI) = 1500 x .818 = 1226.52 btu/h-ft for open cooler cases and = 1500 x 0.138 = 206.52 btu/h-ft for closed cooler cases. It is 1850 x 0.8276 = 1531.06 btu/h-ft for open freezers and 1850 x 0.14758 = 273.02 btu/h-ft for closed freezers
Unit Dth Savings per Year	= Dth_open x Linear Feet - Dth_closed x Linear Feet = 6.74 Dth/ft x Linear FT for coolers and 8.31 Dth/ft x Linear FT for freezers.
Dth consumption per foot (open or closed)	= Refr_Infil x Htg_Hrs x 1 / 1,000,000 x 1 / heatingeff = 1227 x 5155 x 1/1000000 x 1/0.78 = 8.109 Dth/ft for open coolers, 0.00026538 x 5155 = 1.368 Dth/ft for closed coolers, 0.00196282 x 5155 = 10.118 Dth/ft for open freezers, 0.00035 x 5155 = 1.805 Dth/ft for closed freezers
Algorithms:	
Anti-Sweat Heater Controls kW Savings (Customer kW)	= ASHC_kWh/ASHC_Hours
Anti-Sweat Heater Controls kWh Savings	= ASHC_kWh = ASHC_Baseline_kW x Refrigeration_Factor x ASHC_Hours x %_Off
Electronically Commutated Motor Electrical Demand Savings (Customer kW)	= (ECM_Baseline_Fan_ Watts - ECM_Efficient_Fan_ Watts) x Refrigeration_Factor

Electronically Commutated Motor Electrical Demand Savings (Customer kWh)	= (ECM_Baseline_Fan_ Watts - ECM_Efficient_Fan_ Watts) x Refrigeration_Factor x ECM_Hours
No Heat Case Doors (Customer kW, NHD_kW)	= (NHD_Baseline_kW - NHD_Efficient_kW) x Refrigeration_Factor
No Heat Case Doors (Customer kWh)	= NHD_kW x NHD_Hours
Refrigeration_Factor	= Multiplier to include interactive effects of refrigeration energy to remove heat from the motor. Reduction in motor energy results in a reduction in refrigeration energy. = 1 + R_H/COP (See assumptions for values)
Electrical Demand Savings (Customer kW)	= (kW_Base - kW_EE) x HVAC_cooling_kWsavings_factor
Electrical Energy Savings	= (kW_Base - kW_EE) x Hrs x HVAC_cooling_kWhsavings_factor
Electrical Energy Savings	= Customer kWh / (1-TDLF)
Electrical Demand Savings	= Customer kW x CF / (1-TDLF)
Electrical Energy Savings	= Gross Generator kWh x NTG
Electrical Demand Savings	= Gross Generator kW x NTG

Variables:

Common	
3412	= Conversion 1kWh = 3412 BTU
COP	= Coefficient of performance of compressor in the cooler/freezer. COP = 2.28 for cooler, COP = 1.43 for freezer (Reference. 1)
SpecificHeat	= Specific Heat of Water; 1.0 btu / (lb x °F)
TDLF	= Transmission-Distribution Loss Factor = 6.5%, the percentage loss of electricity as it flows from the power plant to the customer, calculated using factors from Enhanced DSM Filing SRD-2.
LF	= Load Factor of refrigeration system. Assumed to be 0.90 (Reference 2)
SpecificHeat	= Specific Heat of Water, 1.0 btu / (lb x °F)
EF_gas	= Efficiency of gas water heater, 0.75 (Reference 3)
ConversionFactor	= 1,000,000 Btu/Dth (gas water heater)
Enclosed Reach-In Cases	
Btuh_base	= Btuh load of the existing Referencerigerated case. 1,500 btuh/ft for open cases (Reference 3)
Btuh_ee	= Btuh load of the high efficiency Referencerigerated case. 267 btuh/ft for medium temp (Reference 5)
Incremental cost	= Incremental cost of efficient measures = $906.27, Reference 21.
Evaporative Fan Motor Controls	
Speed Reduction	= new speed as a percent of full speed; 10% (Reference 15)
Measure Life	= 15 years (Reference 1)
ESF	=Energy Savings Factor = (Speed Reduction)$^{2.5}$ = 0.32%
Baseline Fan Watts	=Average input watts for shaded pole motor; 95.08 (Reference 15)
Control Time	=percent of time motor operates at reduced speed based on control setting; 30%
Efficient Hours	=Annual hours at reduced speed = baseline hours * control time
Incremental cost	= Incremental cost of efficient measures = $119.75, Reference 1.
Night Curtains	
Btuh_base	= Btuh load of the existing Referencerigerated case. 1,500 btuh/ft for open cases (Reference 3)
C_inf	= Percentage of heat gain coming from infiltration. 69%. (Reference 1)
Hours_base	= Annual operating hours before the night curtains= 2920 (8 hr/day)
Hours_ee	= Annual operating hours after the night curtains = 1496
CF	= Coincidence Factor = 0
Measure Life	= 4 years (Reference 16)
Persistence Factor	= Percent of time the covers are used = 60%. (Reference 15)
O&M Savings	= ($3.16) based on 60 seconds per 15 feet to install or remove curtains (.41 hrs/yr) at CO Minimum wage of $7.78/hr
Incremental cost	= Incremental cost of efficient measures = $37.54, Reference 21.
Open to Closed Cases	
Linear Feet	= Length of open case being retrofit with doors, in feet, provided by customer
Hours	= Annual hours of operation of refrigerated case, assumed to be 8,760 hours
PC	= Refrigerated Case Total Load, BTU/h/ft, 1500 for coolers, 1850 for freezers (Ref 33)
FI_Open, FI_Closed	= Fraction of Refrigerated Case Load that is infiltration, 81.77% for open cooler cases, 82.76% for open freezer cases, 13.77% for closed coolers, 14.76% for closed freezers. Adapted from Ref 33 with modifications to allow for calculation of both open and closed energy consumption, since Ref 33 only computes the difference. The reduction in infiltration from open to closed, 68%, is the same as in Ref 33. The motor and lighting loads from Ref 35, 0.009 kW/ft and 0.014 kW/ft, were used in developing the 81.77% and 82.76% values. FI_Open is 1- FCR-(PL + PM) / PC. FI_Closed is FI_Open - 68%.
FCR	= Fraction of Refrigerated Case Load that is conduction and radiation, 13% for all cases (Ref 33)
LF	= Load Factor/Duty Cycle of refrigeration system compressors, 62% for coolers, 80% for freezers. (Ref 33)
Clg_Hrs	= Number of hours per year that facility is in cooling mode, based on using a location-specific bin hours calculation and an assumed facility balance point of 60 F, = 2,908 hours per year for Denver.

Clg Duty Cyc	= Cooling compressor duty cycle, assumed to be 70%
COPhvac	= Coefficient of Performance for facility HVAC system, specifically cooling, assumed to be 3.2 from Ref 33. This assumes a DX rooftop unit or similar
COPrefrig	= Coefficienct of Performance for the refrigeration system = 2.28 for coolers and 1.43 for freezers, Ref 33.
Htg_hrs	= Number of hours per year that facility is in heating mode, based on using a location-specific bin hours calculation and an assumed facility balance point of 60 F, with a 5 degree economizing dead band before heating starts at 55 F, = 5,155 hours per year for Denver.
heatingeff	= Efficiency of heating system, 78% from Ref 33
CF	= Coincidence Factor, 1, based on 8,760 hour run time per year
Measure Life	= 12 years (Ref 11)
Incremental cost	= Incremental cost of efficient measures = $309.64 / linear foot (Ref 34) The incremental cost is split by avoided revenue requirements between gas and electric cost. 47.64% of the incremental cost is electric for coolers and 68.96% is electric cost for freezers.
Anti-Sweat Heater Controls:	
ASHC_Baseline_kW	= Average anti-sweat heater kW per door without controls, Table 4 (Reference 23 and 24)
ASHC_Hours	= Hours per year for anti-sweat heaters, Table 4 (Reference 23)
CF	= Coincidence Factor, Table 4 (Reference 15)
%_Off	= Percent of time the anti-sweat heaters are turned off by the controller, Table 4 (Reference15)
Incremental cost	= Incremental cost of efficient measures; See Tables 4
EC Motors for Refrigeration Evaporators:	
ECM_Baseline_Fan_ Watts	= Average input watts for shaded pole or permanent split capacitor motor, Table 3 (Reference 15)
ECM_Efficient_Fan_Watts	= Average input watts for efficient motor, Table 3 (Reference 15)
ECM_Hours	= Hours per year (freezer subtracts defrost time), Table 3 (Reference 15)
Incremental cost	= Incremental cost of efficient measures; See Table 3
No Heat Case Doors:	
NHD_Baseline_kW	= Average kW for a standard case door, Table 5 (Reference 23 and 24)
NHD_Efficient_kW	= Average kW for a no heat case door, Table 5 (Reference 2)
NHD_Hours	= Hours per year for no heat case doors, Table 5 (Reference 2)
NHD_kW	= No heat case doors kW savings
R_H	must be removed by the refrigeration unit. = 100% for evaporator motors and 35% for anti-sweat heaters and no heat doors

Coincidence Factor	= Refer to Table 7
Measure Life	= Length of time the measure will be operational: 15 years for EC Motors, (Reference 17); 12 years for ASHC (Reference 21); 10 years for No
NTG	Net-To-Gross = 100%
Incremental cost	= Incremental cost of efficient measures; See Table 5
Lighting:	Refer to the Lighting Efficiency Product Deemed savings for calculations and assumptions.

Required inputs from customer/contractor:	**Verified during M&V:**
Evaporative Fan Motor Controls	
Capacity (tons) of Refrigeration Unit	
CHW Pre-Rinse	
Gas or electric water heater, customer ZIP code	
CHW-Aerator	
Gas or electric water heater, customer ZIP code	
For Electronically Commutated	
Size of motor	Yes
Application of motor (Display Case or Walk-in)	Yes
Case or Walk-in temperature (Medium Temp or Low Temp)	Yes
For Walk-in's: Fan diameter (<= 15 inches or >15 inches	Yes
Cost	
For Anti-Sweat Heaters:	
Number of doors controlled	Yes
Number of controllers	Yes
Cost	
For No Heat Doors:	
Number of doors replaced	Yes
Door kW	Yes
Cost	Yes
Lighting	
Number of Fixtures	Yes
Lighting equipment type	Yes
Building type	Yes
Existence of air conditioning	Yes
Open to Closed Case Retrofit	
Length of Case(s)	Yes
Freezer or Cooler?	Yes

Assumptions:

Enclosed Reach-In Cases, Open to Closed Case Retrofit

Existing case must be either a freezer or cooler multi-deck case.
Existing specialty, self-contained, and island cases do not qualify.
This measure is for replacement of open cases with new cases that include a case door.
Replacement cases must have doors, be tied into a central refrigeration system, and be purchased new.
Open to Closed Case retrofits must use "no heat" doors

Night Curtains

Install night curtains on open refrigerated cases to reduce heat transfer and mixing of air inside and outside the case.
Applies to professionally-installed, “permanent”, low emissivity (reflective) night curtain products only. (per linear foot)

EC Motors

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

Lighting

- Each replacement lighting fixture is going in on a one-for-one basis for existing fixtures. New construction fixtures are put in on a one-for-one basis instead of lower efficiency options.
with the HVAC Cooling Demand factor.

Table 1: Average Water Mains Temperatures (Ref. 6).

Location	Temperature (ºF)
Denver, CO	57.6
Golden, CO	55.6
Grand Junction, CO	59.7

Table 2: Deemed Annual Hot Water Use by Building Type (Ref. 6)

Building Type	Days Per Year
Large Office	250
Fast Food Restaurant	365
Sit-Down Restaurant	365
Grocery	365
Elementary School	200
Jr. High/High School/College	200
Health	365
Hotel	365
Other Commercial	250
Average	**304**

The following building types were considered not to apply to this measure: Small Office, Retail, Warehouse and Motel.

Table 3: Baseline Watts, Efficient Watts, Operating Hours and Incremental Cost for EC Motors by Application (Reference 15 and 18)

Motor Application	ECM_Baseline_Fan_ Watts	ECM_Efficient_ Fan_Watts	ECM_Hours	ECM Incremental Cost
EC Motors - Medium Temp Display Case	71	24	8,672	$ 88.00
EC Motors - Low Temp Display Case	81	27	8,672	$ 88.00
EC Motors - Medium Temp Walk-in, Evap fan <= 15" Diameter	136	44	8,585	$ 180.00
EC Motors - Low Temp Walk-in, Evap fan <= 15" Diameter	154	50	8,585	$ 180.00
EC Motors - Medium Temp Walk-in, Evap fan > 15" Diameter	138	69	8,585	$ 180.00
EC Motors - Low Temp Walk-in, Evap fan > 15" Diameter	156	78	8,585	$ 180.00

Table 4: Baseline kW, % Off, Operating Hours and Incremental Cost for Anti-Sweat Heater Controls by Application (Reference 23 and 24)

Anti-Sweat Heater Controls	ASHC_Baseline_kW	%_Off	ASHC_Hours	Incremental Cost	CF
Medium Temp Display Case	0.105	97%	8,760	$ 180.00	97%
Low Temp Display Case	0.191	97%	8,760	$ 180.00	97%

Table 5: Baseline Watts, Efficient Watts, Operating Hours and Incremental Cost for No Heat Case Doors by Application (Reference 2, 23 and 24)

No Heat Case Doors	NHD_Baseline_kW	NHD_Efficient_kW	NHD_Hours	NHD Incremental Cost
Medium Temp Display Case	0.121	0.000	8,760	$ 275.00
Low Temp Display Case	0.238	0.000	8,760	$ 800.00

Table 6: HVAC Interactive Factors (Reference 29)

HVAC system	HVAC_cooling_kWhsavings_factor	HVAC_cooling_kWsavings_factor	Heating Penalty
Heating only	1.00	1.00	-0.00054027
Heating and cooling	1.11	1.33	-0.00054027
Cooler Door Retrofit to LED Secondary Benefits Factor	1.41	1.41	0.000000
Freezer Door Retrofit to LED Secondary Benefits Factor	1.59	1.59	0.000000

Table 7: Coincident Peak Demand Factors and Annual Operating Hours by Building Type (Reference 28 and 30)

Building Type	CF	Annual Operating Hours
24-Hour Facility	94%	8234
College	71%	5010
Cooler Door Retrofit to LED	94%	8760
Elemen./Second. School	73%	2080
Freezer Door Retrofit to LED	94%	8760
Grocery (All) / Big Box Retail (larger than 50,000 SF)	94%	5478
Health	84%	3392
Hospital	84%	4532
Hotel/Motel	51%	2697
Manufacturing	96%	5913
Night Time Exterior (LED Canopy/Soffit Lights Only)	0%	4380
Office	78%	3435
Other/Misc.	96%	2278
Restaurant	94%	4156
Retail	94%	3068
Safety or Code Required (Including Exit Signs)	100%	8760
Traffic Signals	50%	4380
Warehouse	96%	2388

Table 8: Measure Lifetimes in Years (Reference 31 and 15)

Measure	Lifetime in Years
LED Interior Lamps	12
LED Interior Fixtures	20
Low Wattage T8 Lamps	8
Ballasted CFLs	18
Integrated 25W Ceramic Metal Halide	7
T8 Lighting Systems	18
T5 Lighting Systems	18
Lighting Controls	18

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