South Dakota Energy Efficiency
Impact Algorithms

This document provides the algorithms and engineering estimates used to determine actual energy savings for 2009 for MidAmerican's South Dakota Energy Efficiency Plan. Please note in the algorithms that the term "2008 Assessment of Potential" refers to the 2008 Assessment of Energy and Capacity Savings in Iowa prepared for the Iowa Utilities Association by Quantec, LLC (now The Cadmus Group), which is required by Iowa Utilities Board rule before five-year energy efficiency plans can be submitted in Iowa.

In addition, kWh and kW savings outlined in these algorithms are stated at the meter level. Energy savings are adjusted for losses for reporting purposes. Loss factors are 5.82% for energy savings and 7.74% for peak demand savings.

IMPACTS FOR RESIDENTIAL EQUIPMENT

Air Conditioner <65 MBtuh

$$\text{Annual kWh} = \left(\frac{1}{\text{SEER}_{\text{base}}} - \frac{1}{\text{SEER}_{\text{eff}}} \right) \times \text{CAP}_{\text{c}} \times \text{EFLH}_{\text{c}}$$

$$\text{Peak kW} = \text{Annual kWh} \times \text{CF}$$

$SEER_{base}$ = 13 = Seasonal Energy Efficiency Ratio of new baseline efficiency system
Source: Updated 2006 IECC (IA State Code) Table 503.2.3(1)

$SEER_{eff}$ = Seasonal Energy Efficiency Ratio of new high efficiency system
Source: Entered from application form
Range: 14 to 23

CAP_c = Capacity of cooling system in MBtuh
Source: Entered from application form
Range: 8 to 65

$EFLH_c$ = 602 = Equivalent Full Load Hours of cooling
Source: Inferred from 2008 Assessment of Potential

CF = 0.0011434 = Coincidence Factor
Source: 2008 Assessment of Potential (from SFCO loadshape)

Room Air Conditioner

$$\text{Annual kWh} = \left(\frac{1}{EER_{base}} - \frac{1}{EER_{eff}} \right) \times CAP_c \times EFLH_c$$

$$\text{Peak kW} = \text{Annual kWh} \times CF$$

EER_{base} = Energy Efficiency Ratio of new baseline efficiency system from table below
Source: Federal Standard, from Energy Star

Size (MBtuh)	EER_{base}
<6	9.7
≥6 and <8	9.7
≥8 and <14	9.8
≥14 and <20	9.7
≥20	8.5

EER_{eff} = Energy Efficiency Ratio of new high efficiency system
Source: Entered from application form
Range: 9.4 to 15

CAP_c = Capacity of cooling system in MBtuh
Source: Entered from application form
Range: 4 to 30

$EFLH_c$ = 826 = Equivalent Full Load Hours of cooling
Source: Inferred from 2008 Assessment of Potential

CF = 0.0011434 = Coincidence Factor
Source: 2008 Assessment of Potential (from SFCO loadshape)

Air-Source Heat Pump, Add-on Heat Pump

$$\text{Cooling kWh} = \text{Same as Annual kWh for Air Conditioner}$$

$$\text{Heating kWh} = \left(\frac{1}{HSPF_{base}} - \frac{1}{HSPF_{eff}} \right) \times CAP_h \times EFLH_h$$

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

$$\text{Peak kW} = \text{Cooling kWh} \times CF$$

$HSPF_{base}$ = 7.7 = Heating Seasonal Performance Factor of new baseline efficiency system
Source: 2006 Federal Standard (DOE)

$HSPF_{eff}$ = Heating Seasonal Performance Factor of new high efficiency system
Source: Entered from application form
Range: 8.5 to 11.0

CAP_h = Heating capacity of heat pump in MBtuh
Source: Entered from application form
Range: 8 to 65

$EFLH_h$ = 1,031 = Equivalent Full Load Hours of Heating
Source: Inferred from 2008 Assessment of Potential

CF = 0.0011434 = Coincidence Factor
Source: 2008 Assessment of Potential (from SFCO loadshape)

Ground-Source Heat Pump

$$\text{Cooling kWh} = \left[\left(\text{EER}_{\text{eff}} - 13.5\right) \times 71.0 + 150.5\right] \times \frac{\text{CAP}}{12}$$

$$\text{Heating kWh} = \left[\left(\text{COP}_{\text{eff}} - 3.2\right) \times 701.0 + 656.5\right] \times \frac{\text{CAP}}{12}$$

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

$$\text{Peak kW} = \text{Cooling kWh} \times \text{CF}$$

EER_{eff} = Energy Efficiency Ratio of new ground-source heat pump system
Source: Entered from application form
Range: 13.5 to 32

COP_{eff} = Coefficient of Performance of new ground-source heat pump system
Source: Entered from application form
Range: 3.2 to 6.0

CAP = Capacity of ground-source heat pump in MBtuh

71.0 = Per-ton and per-EER cooling impact of ground-source heat pump (kWh/EER/ton)
Source: Inferred from 2008 Assessment of Potential

150.5 = Cooling impact of a ground-source heat pump over an air-source heat pump per ton (kWh/ton)
Source: Inferred from 2008 Assessment of Potential

701.0 = Per-ton and per-EER heating impact of ground-source heat pump (kWh/EER/ton)
Source: Inferred from 2008 Assessment of Potential

656.5 = Heating impact of a ground-source heat pump over an air-source heat pump per ton (kWh/ton)
Source: Inferred from 2008 Assessment of Potential

13.5 = Baseline EER for a ground-source heat pump
Source: 2008 Assessment of Potential

3.2 = Baseline COP for a ground-source heat pump
Source: 2008 Assessment of Potential

CF = 0.0011434 = Coincidence Factor
Source: 2008 Assessment of Potential (from SFCO loadshape)

Furnace Fan (Furnace <225 MBtuh)

$$\text{Annual kWh} = \text{Eae}_{\text{eff}} \times F_{\text{adj, heating hours}} \times F_{\text{savings}}$$

$$\text{Peak kW} = 0$$

Eae_{eff} = Furnace average annual auxiliary electrical energy consumption (kWh/year)
Source: Entered by ATEC from GAMA database, found at
http://www.gamanet.org/gama/inforesources.nsf/vContentEntries/Product+Directories
Range: 100 to 800

$F_{\text{adj, heating hours}}$ = 1.1298 = Factor adjusting Eae from national to local heating conditions
Source: Inferred from DOE Average Heating Load Hours map

F_{savings} = 1.6863 = Savings factor comparing electrical energy consumption of a baseline furnace fan to Eae of an efficient furnace fan
Source: Inferred from 2008 Assessment of Potential and 2005 ETO Furnace Fan Market Assessment Study

Electric Water Heater

$$\text{Annual kWh} = \left(1 - \frac{0.97 - (0.00132 \times \text{GAL})}{\text{EF}_{\text{eff}}}\right) \times \text{UEC}$$

$$\text{Peak kW} = \text{Annual kWh} \times \text{CF}$$

GAL = Water heater capacity in gallons
Source: Entered from application form
Range: 20 to 80

EF_{eff} = Efficiency Factor
Source: Entered from application form
Range: 0.93 to 0.99

UEC = 2,611 = Unit Energy Consumption (kWh)
Source: 2008 Assessment of Potential

0.97 & 0.00132 = Numbers used in building code to calculate EF of a code-compliant unit
Source: 2006 IECC, Table 503.2.3(3)

CF = 0.00011353 = Coincidence Factor
Source: 2008 Assessment of Potential (from SFEWH loadshape)

Gas Water Heater ≤ 75 MBtuh

$$\text{Annual Therms} = \left(1 - \frac{0.67 - (0.0019 \times \text{GAL})}{\text{EF}_{\text{eff}}}\right) \times \text{UEC}$$

$$\text{Peak Day Therms} = \text{Annual Therms} \times \text{CF}$$

GAL = Water heater capacity in gallons
Source: Entered from application form
Range: 20 to 80

EF_{eff} = Efficiency Factor
Source: Entered from application form
Range: 0.59 to 0.90

UEC = 186 = Unit Energy Consumption (therms)
Source: 2008 Assessment of Potential

0.67 & 0.0019 = Numbers used in building code to calculate EF of a code-compliant unit
Source: 2006 IECC, Table 503.2.3(3)

CF = 0.0026770 = Coincidence Factor
Source: 2008 Assessment of Potential (from SFGWH loadshape)

Gas Tankless Water Heater

$$\text{Annual Therms} = \left(1 - \frac{EF_{base}}{EF_{eff}}\right) \times \text{UEC}$$

$$\text{Peak Day Therms} = \text{Annual Therms} \times \text{CF}$$

EF_{base} = 0.594 = Efficiency Factor of new baseline efficiency system (based on 40 gal tank)
Source: 2006 IECC (IA State Code) Table 504.2

EF_{eff} = Efficiency Factor of new high efficiency tankless water heater system
Source: Entered from application form
Range: 0.75 to 0.90

UEC = 186 = Unit Energy Consumption (therms)
Source: 2008 Assessment of Potential

CF = 0.0026770 = Coincidence Factor
Source: 2008 Assessment of Potential (from SFGWH loadshape)

Gas Water Heater > 75 MBtuh

$$\text{Annual Therms} = \left(1 - \frac{Et_{base}}{Et_{eff}}\right) \times \text{UEC}$$

$$\text{Peak Day Therms} = \text{Annual Therms} \times \text{CF}$$

Et_{base} = 0.80 = Thermal Efficiency for new baseline efficiency water heater
Source: 2006 IECC (IA State Code) – Table 504.2

Et_{eff} = Thermal Efficiency for new high efficiency water heater
Source: Entered from application form
Range: 0.85 to 0.98

UEC = 186 = Unit Energy Consumption (therms)
Source: 2008 Assessment of Potential

CF = 0.0026770 = Coincidence Factor
Source: 2008 Assessment of Potential (from SFGWH loadshape)

Gas Furnace <225 MBtuh

$$\text{Annual Therms} = \left(\frac{1}{\text{AFUE}_{\text{base}}} - \frac{1}{\text{AFUE}_{\text{eff}}} \right) \times \frac{\text{CAP} \times \text{HDD} \times 24 \times \text{F}_{\text{adj}}}{100 \times 80}$$

$$\text{Peak Day Therms} = \text{Annual Therms} \times \text{CF}$$

$AFUE_{base}$ = 0.837 = Annual Fuel Utilization Efficiency for new baseline efficiency furnace
Source: 2002 Assessment of Potential, Volume I, Page D-3

$AFUE_{eff}$ = Annual Fuel Utilization Efficiency for new high efficiency furnace
Source: Entered from application form
Range: 0.84 to 0.98

CAP = Capacity of heating system in MBtuh
Source: Entered from application form
Range for Furnace: 36 to 225

HDD = 6,645 = Heating Degree Days
Source: National Climatic Data Center, NOAA, 2001

24 = Hours/Day

F_{adj} = 0.354 = Actual heating load to calculated heating load adjustment factor
Source: Inferred from 2008 Assessment of Potential

100= MBtu/therm

80 = Design temperature difference

CF = 0.014226 = Coincidence Factor
Source: 2008 Assessment of Potential (from SFGSH loadshape)

Gas Boiler <300 MBtuh

$$\text{Annual Therms} = \left(\frac{1}{\text{AFUE}_{\text{base}}} - \frac{1}{\text{AFUE}_{\text{eff}}} \right) \times \frac{\text{CAP} \times \text{HDD} \times 24 \times \text{F}_{\text{adj}}}{100 \times 80}$$

$$\text{Peak Day Therms} = \text{Annual Therms} \times \text{CF}$$

$AFUE_{base}$ for Boiler = 0.809 = Annual Fuel Utilization Efficiency for new baseline efficiency boiler

Source: 2002 Assessment of Potential, Volume I, Page D-3

$AFUE_{eff}$ = Annual Fuel Utilization Efficiency for new high efficiency boiler

Source: Entered from application form
Range: 0.84 to 0.98

CAP = Capacity of heating system in MBtuh

Source: Entered from application form
Range for Boiler: 36 to 300

HDD = 6,645 = Heating Degree Days

Source: National Climatic Data Center, NOAA, 2001

24 = Hours/Day

F_{adj} = 0.387 = Actual heating load to calculated heating load adjustment factor

Source: Inferred from 2008 Assessment of Potential

100 = MBtu/therm

80 = Design temperature difference

CF = 0.014226 = Coincidence Factor

Source: 2008 Assessment of Potential (from SFGSH loadshape)

Programmable Thermostats

Gas Furnace Heat

Annual Therms = 19.7
Source: 2008 Assessment of Potential

$$\text{Peak Day Therms} = \text{Annual Therms} \times CF_{gas}$$

Gas Boiler Heat

Annual Therms = 24.5
Source: 2008 Assessment of Potential

$$\text{Peak Day Therms} = \text{Annual Therms} \times CF_{gas}$$

Electric Cooling

Cooling kWh = 72.8
Source: 2008 Assessment of Potential

$$\text{Peak kW} = \text{Cooling kWh} \times CF_{c}$$

Electric Resistance Heat

Annual kWh = 449.9
Source: 2008 Assessment of Potential

Cooling kWh = 72.8
Source: Same as Gas Heated Building

Heating kWh = 449.9 – 72.8 = 377.1

$$\text{Peak kW} = \text{Cooling kWh} \times CF_{c}$$

Programmable Thermostats

Air-Source Heat Pump

Annual kWh = 397.8
Source: 2008 Assessment of Potential

Cooling kWh = 72.8
Source: Same as Gas Heated Building

Heating kWh = 397.8 – 72.8 = 325.0

$$\text{Peak kW} = \text{Cooling kWh} \times CF_c$$

IMPACTS FOR RESIDENTIAL AUDIT

Water Heater Blanket

With Gas Water Heater

Annual Therms = 11.7
Source: 2008 Assessment of Potential

$$\text{Peak Day Therms} = \text{Annual Therms} \times \text{CF}$$

CF = 0.0026770 = Coincidence Factor
Source: 2008 Assessment of Potential (from SFGWH loadshape)

With Electric Water Heater

Annual kWh = 175.6
Source: 2008 Assessment of Potential

$$\text{Peak kW} = \text{Annual kWh} \times \text{CF}$$

CF = 0.00011353 = Coincidence Factor
Source: 2008 Assessment of Potential (from SFEWH loadshape)

Pipe Insulation

With Gas Water Heater

$\text{Annual therms} = 0.361 \times \text{L}$

Source: Inferred from 2008 Assessment of Potential

L = Linear feet of hot water pipes insulated

Source: Entered from application form

Range: 1 to 6

$\text{Peak Day Therms} = \text{Annual Therms} \times \text{CF}$

CF = 0.0026770 = Coincidence Factor

Source: 2008 Assessment of Potential (from SFGWH loadshape)

With Electric Water Heater

$\text{Annual kWh} = 5.371 \times \text{L}$

Source: Inferred from 2008 Assessment of Potential

L = Linear feet of hot water pipes insulated

Source: Entered from application form

Range: 1 to 6

$\text{Peak kW} = \text{Annual kWh} \times \text{CF}$

CF = 0.00011353 = Coincidence Factor

Source: 2008 Assessment of Potential (from SFEWH loadshape)

Low-flow Showerhead

With Gas Water Heater

Annual Therms (per showerhead – 2.0 gpm) = 19.2
Source: 2008 Assessment of Potential

$$\text{Peak Day Therms} = \text{Annual Therms} \times \text{CF}$$

CF = 0.0026770 = Coincidence Factor
Source: 2008 Assessment of Potential (from SFGWH loadshape)

With Electric Water Heater

Annual kWh (per showerhead – 2.0 gpm) = 285.7
Source: 2008 Assessment of Potential

$$\text{Peak kW} = \text{Annual kWh} \times \text{CF}$$

CF = 0.00011353 = Coincidence Factor
Source: 2008 Assessment of Potential (from SFEWH loadshape)

Faucet and Kitchen Aerator

With Gas Water Heater

Annual Therms (per faucet – 1.5 gpm) = 5.6
Source: 2008 Assessment of Potential

$$\text{Peak Day Therms} = \text{Annual Therms} \times \text{CF}$$

CF = 0.0026770 = Coincidence Factor
Source: 2008 Assessment of Potential (from SFGWH loadshape)

With Electric Water Heater

Annual kWh (per faucet – 1.5 gpm) = 60.7
Source: 2008 Assessment of Potential

$$\text{Peak kW} = \text{Annual kWh} \times \text{CF}$$

CF = 0.00011353 = Coincidence Factor
Source: 2008 Assessment of Potential (from SFEWH loadshape)

Programmable Thermostat

Gas Furnace Heat

Annual Therms = 19.7
Source: 2008 Assessment of Potential

$$\text{Peak Day Therms} = \text{Annual Therms} \times CF_{gas}$$

Gas Boiler Heat

Annual Therms = 24.5
Source: 2008 Assessment of Potential

$$\text{Peak Day Therms} = \text{Annual Therms} \times CF_{gas}$$

Electric Cooling

Cooling kWh = 72.8
Source: 2008 Assessment of Potential

$$\text{Peak kW} = \text{Cooling kWh} \times CF_{c}$$

Electric Resistance Heat

Annual kWh = 449.9
Source: 2008 Assessment of Potential

Cooling kWh = 72.8
Source: Same as Gas Heated Building

Heating kWh = 449.9 – 72.8 = 377.1

$$\text{Peak kW} = \text{Cooling kWh} \times CF_{c}$$

Programmable Thermostat

Air-Source Heat Pump

Annual kWh = 397.8
Source: 2008 Assessment of Potential

Cooling kWh = 72.8
Source: Same as Gas Heated Building

Heating kWh = 397.8 – 72.8 = 325.0

$$\text{Peak kW} = \text{Cooling kWh} \times CF_c$$

Ground-Source Heat Pump

Annual kWh = 306.5
Source: Inferred from 2008 Assessment of Potential

Cooling kWh = 56.1
Source: Inferred from 2008 Assessment of Potential

Heating kWh = 306.5 – 56.1 = 250.4

$$\text{Peak kW} = \text{Cooling kWh} \times CF_c$$

All Heating/Cooling Systems

CF_{gas} = 0.0142262 = Coincidence Factor for gas heat
Source: 2008 Assessment of Potential (from SFGSH loadshape)

CF_c = 0.0011434 = Coincidence Factor for electric cooling
Source: 2008 Assessment of Potential (from SFCO loadshape)

Attic Insulation

Gas Heated Home

$$\text{Annual Therms} = \frac{A \times HDD \times 24 \times F_h}{AFUE \times 100{,}000} \times \left[\frac{1}{R_i} - \frac{1}{R_f}\right]$$

$$\text{Peak Day Therms} = \text{Annual Therms} \times CF_{gas}$$

$$\text{Annual kWh} = \frac{A \times CDD \times 24 \times F_c}{SEER \times 1{,}000} \times \left[\frac{1}{R_i} - \frac{1}{R_f}\right]$$

$$\text{Peak kW} = \text{Annual kWh} \times CF_c$$

Electric Heated Home

Cooling kWh = Same as Annual kWh for Gas Heated Home

$$\text{Heating kWh} = \frac{A \times HDD \times 24 \times F_{eh}}{3{,}412} \times \left[\frac{1}{R_i} - \frac{1}{R_f}\right]$$

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

$$\text{Peak kW} = \text{Cooling kWh} \times CF_c$$

Heat Pump Heated Home

Cooling kWh = Same as Annual kWh for Gas Heated Home

$$\text{Heating kWh} = \frac{A \times HDD \times 24 \times F_{hp}}{HSPF \times 1{,}000} \times \left[\frac{1}{R_i} - \frac{1}{R_f}\right]$$

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

$$\text{Peak kW} = \text{Cooling kWh} \times CF_c$$

All Heating and Cooling Types

A = Area of attic insulated
Source: Entered from application form
Range: 50 to 12,000

HDD = 6,645 = Heating Degree Days
CDD = 961 = Cooling Degree Days
Source: National Climatic Data Center, NOAA, 2001

24 = Hours per day

1,000 = W/kW

100,000 = Btu/therm

3,412 = Btu/kWh

F_h , furnace = 0.58860 = Actual heating load to calculated load adjustment factor
F_h , boiler = 0.73316 = Actual heating load to calculated load adjustment factor
F_c = 0.99311 = Actual cooling load to calculated load adjustment factor
F_{eh} = 0.50216 = Actual heating load to calculated load adjustment factor
F_{hp} = 0.63608 = Actual heating load to calculated load adjustment factor
Source: Inferred from 2008 Assessment of Potential

R_i = Initial R-value
Source: Entered from application form
Range: 3 to 49 (if no pre-existing insulation or insulation less than R-3, use 3.0 as baseline)
Source: 3.0 = R-value of structural components, from 2008 Assessment of Potential

R_f = Final R-value
Source: Entered from application form
Range: 24 to 70

AFUE = Annual Fuel Utilization Efficiency of existing furnace or boiler
Source: Entered from application form
Range: 0.50 to 0.98

SEER = Seasonal Energy Efficiency Ratio of existing air conditioner or heat pump
Source: Entered from application form
Range: 6 to 22.0

HSPF = Heating Seasonal Performance Factor of existing heat pump
Source: Entered from application form
Range: 5 to 11.0

CF_{gas} = 0.014226 = Coincidence Factor for gas heating
Source: 2008 Assessment of Potential (from SFGSH loadshape)

CF_c = 0.0011434 = Coincidence Factor for electric cooling
Source: 2008 Assessment of Potential (from SFCOOL loadshape)

Wall Insulation

Gas Heated Home

$$\text{Annual Therms} = \frac{A \times HDD \times 24 \times F_h}{AFUE \times 100{,}000} \times \left[\frac{1}{R_i + R} - \frac{1}{R_f + R}\right]$$

$$\text{Peak Day Therms} = \text{Annual Therms} \times CF_{gas}$$

$$\text{Annual kWh} = \frac{A \times CDD \times 24 \times F_c}{SEER \times 1{,}000} \times \left[\frac{1}{R_i + R} - \frac{1}{R_f + R}\right]$$

$$\text{Peak kW} = \text{Annual kWh} \times CF_c$$

Electric Heated Home

Cooling kWh = Same as Annual kWh for Gas Heated Home

$$\text{Heating kWh} = \frac{A \times HDD \times 24 \times F_{eh}}{3{,}412} \times \left[\frac{1}{R_i + R} - \frac{1}{R_f + R}\right]$$

Annual kWh = Cooling kWh + Heating kWh

$$\text{Peak kW} = \text{Cooling kWh} \times CF_c$$

Heat Pump Heated Home

Cooling kWh = Same as Annual kWh for Gas Heated Home

$$\text{Heating kWh} = \frac{A \times HDD \times 24 \times F_{hp}}{HSPF \times 1{,}000} \times \left[\frac{1}{R_i + R} - \frac{1}{R_f + R}\right]$$

Annual kWh = Cooling kWh + Heating kWh

$$\text{Peak kW} = \text{Cooling kWh} \times CF_c$$

All Heating and Cooling Types

A = Area of walls insulated

Source: Entered from application form
Range: 80 to 6,000

HDD = 6,645 = Heating Degree Days
CDD = 961 = Cooling Degree Days
Source: National Climatic Data Center, NOAA, 2001

24 = Hours per day

1,000 = W/kW

100,000 = Btu/therm

3,412 = Btu/kWh

F_h , furnace = 0.43638 = Actual heating load to calculated load adjustment factor
F_h , boiler = 0.54355 = Actual heating load to calculated load adjustment factor
F_c = 0.11232 = Actual cooling load to calculated load adjustment factor
F_{eh} = 0.35195 = Actual heating load to calculated load adjustment factor
F_{hp} = 0.60966 = Actual heating load to calculated load adjustment factor
Source: Inferred from 2008 Assessment of Potential

R_i = Initial R-value
Source: Entered from application form
Range: 0 to 19

R = 3.63 = R-value of structural components
Source: 2008 Assessment of Potential

R_f = Final R-value
Source: Entered from application form
Range: 10 to 25

AFUE = Annual Fuel Utilization Efficiency of existing furnace or boiler
Source: Entered from application form
Range: 0.50 to 0.98

SEER = Seasonal Energy Efficiency Ratio of existing air conditioner or heat pump
Source: Entered from application form
Range: 6 to 22

HSPF = Heating Seasonal Performance Factor of existing heat pump
Source: Entered from application form
Range: 5 to 11.0

CF_{gas} = 0.014226 = Coincidence Factor for gas heating
Source: 2008 Assessment of Potential (from SFGSH loadshape)

CF_c = 0.0011434 = Coincidence Factor for electric cooling
Source: 2008 Assessment of Potential (from SFCOOL loadshape)

Crawl Space (Floor) Insulation

Gas Heated Home

$$\text{Annual Therms} = \frac{A \times HDD \times 24 \times F_h}{AFUE \times 100{,}000} \times \left[\frac{1}{R_i + R} - \frac{1}{R_f + R}\right]$$

$$\text{Peak Day Therms} = \text{Annual Therms} \times CF_{gas}$$

$$\text{Annual kWh} = \frac{A \times CDD \times 24 \times F_c}{SEER \times 1{,}000} \times \left[\frac{1}{R_i + R} - \frac{1}{R_f + R}\right]$$

$$\text{Peak kW} = \text{Annual kWh} \times CF_c$$

Electric Heated Home

Cooling kWh = Same as Annual kWh for Gas Heated Home

$$\text{Heating kWh} = \frac{A \times HDD \times 24 \times F_{eh}}{3{,}412} \times \left[\frac{1}{R_i + R} - \frac{1}{R_f + R}\right]$$

Annual kWh = Cooling kWh + Heating kWh

$$\text{Peak kW} = \text{Cooling kWh} \times CF_c$$

Heat Pump Heated Home

Cooling kWh = Same as Annual kWh for Gas Heated Home

$$\text{Heating kWh} = \frac{A \times HDD \times 24 \times F_{hp}}{HSPF \times 1{,}000} \times \left[\frac{1}{R_i + R} - \frac{1}{R_f + R}\right]$$

Annual kWh = Cooling kWh + Heating kWh

$$\text{Peak kW} = \text{Cooling kWh} \times CF_c$$

All Heating and Cooling Types

A = Area of crawl space insulated
Source: Entered from application form

Range: 40 to 6,000

HDD = 6,645 = Heating Degree Days
CDD = 961 = Cooling Degree Days
Source: National Climatic Data Center, NOAA, 2001

24 = Hours per day

1,000 = W/kW

100,000 = Btu/therm

3,412 = Btu/kWh

F_h , furnace = 0.63572 = Actual heating load to calculated load adjustment factor
F_h , boiler = 0.79184 = Actual heating load to calculated load adjustment factor
F_c = 1.01722 = Actual cooling load to calculated load adjustment factor
F_{eh} = 0.51458 = Actual heating load to calculated load adjustment factor
F_{hp} = 0.84757 = Actual heating load to calculated load adjustment factor
Source: Inferred from 2008 Assessment of Potential

R_i = Initial R-value
Source: Entered from application form
Range: 0 to 24

R = 4.29 = R-value of structural components
Source: 2008 Assessment of Potential

R_f = Final R-value
Source: Entered from application form
Range: 10 to 45

AFUE = Annual Fuel Utilization Efficiency of existing furnace or boiler
Source: Entered from application form
Range: 0.50 to 0.98

SEER = Seasonal Energy Efficiency Ratio of existing air conditioner or heat pump
Source: Entered from application form
Range: 6 to 22

HSPF = Heating Seasonal Performance Factor of existing heat pump
Source: Entered from application form
Range: 5 to 11.0

CF_{gas} = 0.014226 = Coincidence Factor for gas heating
Source: 2008 Assessment of Potential (from SFGSH loadshape)

CF_c = 0.0011434 = Coincidence Factor for electric cooling
Source: 2008 Assessment of Potential (from SFCOOL loadshape)

Foundation (Basement Wall) Insulation

Gas Heated Home

$$\text{Annual Therms} = \frac{A \times HDD \times 24 \times F_h}{AFUE \times 100{,}000} \times \left[\frac{1}{R_i + R} - \frac{1}{R_f + R}\right]$$

$$\text{Peak Day Therms} = \text{Annual Therms} \times CF_{gas}$$

$$\text{Annual kWh} = \frac{A \times CDD \times 24 \times F_c}{SEER \times 1{,}000} \times \left[\frac{1}{R_i + R} - \frac{1}{R_f + R}\right]$$

$$\text{Peak kW} = \text{Annual kWh} \times CF_c$$

Electric Heated Home

$$\text{Cooling kWh} = \text{Same as Annual kWh for Gas Heated Home}$$

$$\text{Heating kWh} = \frac{A \times HDD \times 24 \times F_{eh}}{3{,}412} \times \left[\frac{1}{R_i + R} - \frac{1}{R_f + R}\right]$$

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

$$\text{Peak kW} = \text{Cooling kWh} \times CF_c$$

Heat Pump Heated Home

$$\text{Cooling kWh} = \text{Same as Annual kWh for Gas Heated Home}$$

$$\text{Heating kWh} = \frac{A \times HDD \times 24 \times F_{hp}}{HSPF \times 1{,}000} \times \left[\frac{1}{R_i + R} - \frac{1}{R_f + R}\right]$$

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

$$\text{Peak kW} = \text{Cooling kWh} \times CF_c$$

All Heating and Cooling Types

A = Area of foundation insulation
Source: Entered from application form
Range: 80 to 6,000

HDD = 6,645 = Heating Degree Days
CDD = 961 = Cooling Degree Days
Source: National Climatic Data Center, NOAA, 2001

24 = Hours per day

1,000 = W/kW

100,000 = Btu/therm

3,412 = Btu/kWh

F_h, furnace = 0.70398 = Actual heating load to calculated load adjustment factor
F_h, boiler = 0.87687 = Actual heating load to calculated load adjustment factor
F_c = 1.12239 = Actual cooling load to calculated load adjustment factor
F_{eh} = 0.56778 = Actual heating load to calculated load adjustment factor
F_{hp} = 0.84568 = Actual heating load to calculated load adjustment factor
Source: Inferred from 2008 Assessment of Potential

R_i = Initial R-value
Source: Entered from application form
Range: 0 to 30

R = 4.29 = R-value of structural components
Source: 2008 Assessment of Potential

R_f = Final R-value
Source: Entered from application form
Range: 10 to 38

AFUE = Annual Fuel Utilization Efficiency of existing furnace or boiler
Source: Entered from application form
Range: 0.50 to 0.98

SEER = Seasonal Energy Efficiency Ratio of existing air conditioner or heat pump
Source: Entered from application form
Range: 6 to 22

HSPF = Heating Seasonal Performance Factor of existing heat pump
Source: Entered from application form
Range: 5 to 11.0

CF_{gas} = 0.014226 = Coincidence Factor for gas heating
Source: 2008 Assessment of Potential (from SFGSH loadshape)

CF_c = 0.0011434 = Coincidence Factor for electric cooling

Source: 2008 Assessment of Potential (from SFCOOL loadshape)

Rim & Band Joist Insulation

Gas Heated Home

$$\text{Annual Therms} = F_h \times L$$

$$\text{Peak Day Therms} = \text{Annual Therms} \times CF_{gas}$$

$$\text{Annual kWh} = F_c \times L$$

$$\text{Peak kW} = \text{Annual kWh} \times CF_c$$

Electric Resistance Heated Home

Cooling kWh = Same as Annual kWh for Gas Heated Home

$$\text{Heating kWh} = F_{eh} \times L$$

Annual kWh = Cooling kWh + Heating kWh

$$\text{Peak kW} = \text{Cooling kWh} \times CF_c$$

Air Source Heat Pump Heated Home

Cooling kWh = Same as Annual kWh for Gas Heated Home

$$\text{Heating kWh} = F_{hp} \times L$$

Annual kWh = Cooling kWh + Heating kWh

$$\text{Peak kW} = \text{Cooling kWh} \times CF_c$$

All Heating and Cooling Types

F_h , furnace = 0.17545 = Per-foot therm gas furnace therm heating impact
F_h , boiler = 0.21761 = Per-foot therm gas boiler therm heating impact
F_c = 0.71558 = Per-foot kWh electric cooling impact
F_{eh} = 3.3059 = Per-foot kWh resistance heating impact
F_{hp} = 3.4875 = Per-foot kWh heat pump heating impact
Source: Inferred from 2008 Assessment of Potential

L = Linear feet of band joist insulated
Source: Entered from application form
Range: 5 to 500

CF_{gas} = 0.014226 = Coincidence Factor for gas heating
Source: 2008 Assessment of Potential (from SFGSH loadshape)

CF_c = 0.0011434 = Coincidence Factor for electric cooling
Source: 2008 Assessment of Potential (from SFCOOL loadshape)

Duct Insulation

Gas Heated Home

$$\text{Annual Therms} = F_h \times L$$

$$\text{Peak Day Therms} = \text{Annual Therms} \times CF_{gas}$$

$$\text{Annual kWh} = F_c \times L$$

$$\text{Peak kW} = \text{Annual kWh} \times CF_c$$

Electric Resistance Heated Home

Cooling kWh = Same as Annual kWh for Gas Heated Home

$$\text{Heating kWh} = F_{eh} \times L$$

Annual kWh = Cooling kWh + Heating kWh

$$\text{Peak kW} = \text{Cooling kWh} \times CF_c$$

Air Source Heat Pump Heated Home

Cooling kWh = Same as Annual kWh for Gas Heated Home

$$\text{Heating kWh} = F_{hp} \times L$$

Annual kWh = Cooling kWh + Heating kWh

$$\text{Peak kW} = \text{Cooling kWh} \times CF_c$$

All Heating and Cooling Types

F_h = 0.41102 = Per-foot gas furnace therm heating impact
F_c = 3.5469 = Per-foot kWh electric cooling impact
F_{eh} = 7.8697 = Per-foot kWh resistance heating impact
F_{hp} = 6.7817 = Per-foot kWh heat pump heating impact
Source: Inferred from 2008 Assessment of Potential

L = Linear feet of duct insulated
Source: Entered from application form
Range: 5 to 250

CF_{gas} = 0.014226 = Coincidence Factor for gas heating
Source: 2008 Assessment of Potential (from SFGSH loadshape)

CF_c = 0.0011434 = Coincidence Factor for electric cooling
Source: 2008 Assessment of Potential (from SFCOOL loadshape)

IMPACTS FOR MULTI FAMILY RESIDENTIAL AUDIT

Pipe Insulation

With Gas Water Heater

$$\text{Annual therms} = 0.338 \times L$$

Source: Inferred from 2008 Assessment of Potential

L = Linear feet of hot water pipes insulated
Source: Entered from application form
Range: 1 to 6

$$\text{Peak Day Therms} = \text{Annual Therms} \times CF$$

CF = 0.0026509 = Coincidence Factor
Source: 2008 Assessment of Potential (from MFGWH loadshape)

With Electric Water Heater

$$\text{Annual kWh} = 4.972 \times L$$

Source: Inferred from 2008 Assessment of Potential

L = Linear feet of hot water pipes insulated
Source: Entered from application form
Range: 1 to 6

$$\text{Peak kW} = \text{Annual kWh} \times CF$$

CF = 0.00011198 = Coincidence Factor
Source: 2008 Assessment of Potential (from MFEWH loadshape)

Low-flow Showerhead

With Gas Water Heater

Annual Therms (per fixture) = 25.9
Source: 2008 Assessment of Potential

$$\text{Peak Day Therms} = \text{Annual Therms} \times \text{CF}$$

CF = 0.0026509 = Coincidence Factor
Source: 2008 Assessment of Potential (from MFGWH loadshape)

With Electric Water Heater

Annual kWh (per fixture) = 380.1
Source: 2008 Assessment of Potential

$$\text{Peak kW} = \text{Annual kWh} \times \text{CF}$$

CF = 0.00011198 = Coincidence Factor
Source: 2008 Assessment of Potential (from MFEWH loadshape)

Faucet and Kitchen Aerator

With Gas Water Heater

Annual Therms (per faucet) = 4.78
Source: 2008 Assessment of Potential (From 3.0 GPM (stock) to 1.5 GPM)

$$\text{Peak Day Therms} = \text{Annual Therms} \times \text{CF}$$

CF = 0.0026509 = Coincidence Factor
Source: 2008 Assessment of Potential (from MFGWH loadshape)

With Electric Water Heater

Annual kWh (per faucet) = 76.4
Source: 2008 Assessment of Potential (From 3.0 GPM (stock) to 1.5 GPM)

$$\text{Peak kW} = \text{Annual kWh} \times \text{CF}$$

CF = 0.00011198 = Coincidence Factor
Source: 2008 Assessment of Potential (from MFEWH loadshape)

IMPACTS FOR NONRESIDENTIAL EQUIPMENT

Air Conditioner <65 MBtuh (air-cooled, single-phase)

$$\text{Cooling kWh} = \left(\frac{1}{\text{SEER}_{\text{base}} \times F_{ac}} - \frac{1}{\text{SEER}_{\text{eff}} \times F_{ac}} \right) \times \text{CAP}_c \times \text{EFLH}_c$$

$$\text{Peak kW} = \text{Annual kWh} \times \text{CF}$$

$SEER_{base}$ = 13.0 = Seasonal Energy Efficiency Ratio of new baseline efficiency system
Source: 2006 IECC (IA State Code) – Table 503.2.3(1)

$SEER_{eff}$ = Seasonal Energy Efficiency Ratio of new high efficiency system
Source: Entered from application form
Range: 14.0 to 23.0

CAP_c = Capacity of cooling system in MBtuh
Source: Entered from application form
Range: 8 to 64.9

F_{ac} = 0.86690 = EER/SEER adjustment factor
Source: inferred from AHRI Air Conditioner Product Data listing

$EFLH_c$ = 786 = Equivalent Full Load Hours of cooling
Source: Inferred from 2008 Assessment of Potential

CF = 0.00053228 = Coincidence Factor
Source: 2008 Assessment of Potential (from SOCO loadshape)

Air Conditioner <65 MBtuh (air-cooled, three-phase)

$$\text{Annual kWh} = \left(\frac{1}{\text{SEER}_{\text{base}} \times F_{ac}} - \frac{1}{\text{SEER}_{\text{eff}} \times F_{ac}} \right) \times \text{CAP}_c \times \text{EFLH}_c$$

$$\text{Peak kW} = \text{Annual kWh} \times \text{CF}$$

$SEER_{base}$ = 13.0 = Seasonal Energy Efficiency Ratio of new baseline efficiency system
Source: 2006 IECC (IA State Code) – Table 503.2.3(1)

$SEER_{eff}$ = Seasonal Energy Efficiency Ratio of new high efficiency system
Source: Entered from application form
Range: 14.0 to 23.0

CAP_c = Capacity of cooling system in MBtuh
Source: Entered from application form
Range: 8 to 64.9

F_{ac} = 0.86690 = EER/SEER adjustment factor
Source: inferred from AHRI Air Conditioner Product Data listing

$EFLH_c$ = 786 = Equivalent Full Load Hours of cooling
Source: Inferred from 2008 Assessment of Potential

CF = 0.00053228 = Coincidence Factor
Source: 2008 Assessment of Potential (from SOCO loadshape)

Water-source Heat Pump

$$\text{Cooling kWh} = \left[\left(\text{EER}_{\text{eff}} - 11.9\right) \times 21.5 + 99.0\right] \times \frac{\text{CAP}}{12}$$

$$\text{Heating kWh} = \left[\left(\text{COP}_{\text{eff}} - 4.2\right) \times 194.6 + 200.9\right] \times \frac{\text{CAP}}{12}$$

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

$$\text{Peak kW} = \text{Cooling kWh} \times \text{CF}$$

EER_{eff} = Energy Efficiency Ratio of new water-source heat pump system
Source: Entered from application form
Range: 11.8 to 32

COP_{eff} = Coefficient of Performance of new water-source heat pump system
Source: Entered from application form
Range: 4.2 to 6.0

CAP = Cooling capacity of water-source heat pump in MBtuh
Source: Entered from application form
Range: 36 to 6,000

21.5 = Per-ton and per-EER cooling impact of water-source heat pump (kWh/EER/ton)
Source: Inferred from 2008 Assessment of Potential

99.0 = Cooling impact of a water-source over an air-source heat pump per ton (kWh/ton)
Source: Inferred from 2008 Assessment of Potential

194.6 = Per-ton and per-EER heating impact of water-source heat pump (kWh/EER/ton)
Source: Inferred from 2008 Assessment of Potential

200.9 = Heating impact of a water-source over an air-source heat pump per ton (kWh/ton)
Source: Inferred from 2008 Assessment of Potential

11.9 = Baseline EER for a water-source heat pump
Source: 2008 Assessment of Potential

4.2 = Baseline COP for a water-source heat pump
Source: 2008 Assessment of Potential

CF = 0.00045902 = Coincidence Factor
Source: 2008 Assessment of Potential (from LRCO loadshape)

Ground-Source Heat Pump

$$\text{Cooling kWh} = \left[\left(\text{EER}_{\text{eff}} - 13.5\right) \times 21.5 + 36.1\right] \times \frac{\text{CAP}}{12}$$

$$\text{Heating kWh} = \left[\left(\text{COP}_{\text{eff}} - 3.3\right) \times 391.4 + 168.0\right] \times \frac{\text{CAP}}{12}$$

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

$$\text{Peak kW} = \text{Cooling kWh} \times \text{CF}$$

EER_{eff} = Energy Efficiency Ratio of new ground-source heat pump system
Source: Entered from application form
Range: 13.5 to 32

COP_{eff} = Coefficient of Performance of new ground-source heat pump system
Source: Entered from application form
Range: 3.3 to 6.0

CAP = Cooling capacity of ground-source heat pump in MBtuh
Source: Entered from application form
Range: 36 to 6000

21.5 = Per-ton and per-EER cooling impact of ground-source heat pump (kWh/EER/ton)
Source: Inferred from 2008 Assessment of Potential

36.1 = Cooling impact of a ground-source over an air-source heat pump per ton (kWh/ton)
Source: Inferred from 2008 Assessment of Potential

391.4 = Per-ton and per-EER heating impact of ground-source heat pump (kWh/EER/ton)
Source: Inferred from 2008 Assessment of Potential

168.0 = Heating impact of a ground-source over an air-source heat pump per ton (kWh/ton)
Source: Inferred from 2008 Assessment of Potential

13.5 = Baseline EER for a ground-source heat pump
Source: 2008 Assessment of Potential

3.3 = Baseline COP for a ground-source heat pump
Source: 2008 Assessment of Potential

CF = 0.00053228 = Coincidence Factor
Source: 2008 Assessment of Potential (from SOCO loadshape)

Water-cooled Chiller

$$\text{Annual kWh} = \left(\frac{kW}{ton_{base}} - \frac{kW}{ton_{eff}} \right) \times CAP_c \times EFLH_c$$

$$\text{Peak kW} = \text{Annual kWh} \times CF$$

kW/ton_{base} = Efficiency in kW/ton of new baseline efficiency system from table below
Source: 2006 IECC (IA State Code) – Table 503.2.3(7)

Size (tons)	kW/ton_{base}	kW/ton_{eff} (min)
<150	0.790	0.700
≥150 and <300	0.718	0.630
≥300	0.639	0.580

kW/ton_{eff} = Efficiency in kW/ton of new high efficiency system
Source: Entered from application form
Range: 0.400 to 0.700 (see table above)

CAP_c = Capacity of cooling system in tons
Source: Entered from application form
Range: 25 to 2,500

$EFLH_c$ = 1,715 = Equivalent Full Load Hours of cooling
Source: Inferred from 2008 Assessment of Potential

CF = 0.00036107 = Coincidence Factor
Source: 2008 Assessment of Potential (from LOCHI loadshape)

Air-cooled Chiller

$$\text{Annual kWh} = \left({}^{\text{kW}}\!/_{\text{ton}_{\text{base}}} - {}^{\text{kW}}\!/_{\text{ton}_{\text{eff}}} \right) \times \text{CAP}_{\text{c}} \times \text{EFLH}_{\text{c}}$$

$$\text{Peak kW} = \text{Annual kWh} \times \text{CF}$$

kW/ton_{base} = Efficiency in kW/ton of new baseline efficiency system from table below
Source: 2006 IECC (IA State Code) – Table 503.2.3(7)

Size (tons)	kW/ton_{base}	kW/ton_{eff} (min)
<150	1.256	1.25
≥150	1.407	1.25

kW/ton_{eff} = Efficiency in kW/ton of new high efficiency system
Source: Entered from application form
Range: 0.80 to 1.25 (see table above)

CAP_c = Capacity of cooling system in tons
Source: Entered from application form
Range: 10 to 750

$EFLH_c$ = 1,715 = Equivalent Full Load Hours of cooling
Source: Inferred from 2008 Assessment of Potential

CF = 0.00036107 = Coincidence Factor
Source: 2008 Assessment of Potential (from LOCHI loadshape)

Furnace <225 MBtuh

$$\text{Annual Therms} = \left(\frac{1}{\text{AFUE}_{\text{base}}} - \frac{1}{\text{AFUE}_{\text{eff}}} \right) \times \frac{\text{CAP} \times \text{HDD} \times 24 \times \text{F}_{\text{adj}}}{100 \times 80}$$

$$\text{Peak Day Therms} = \text{Annual Therms} \times \text{CF}$$

$\text{AFUE}_{\text{base}}$ = 0.837 = Annual Fuel Utilization Efficiency for new baseline efficiency furnace
Source: 2002 Assessment of Potential, Volume I, Page D-3

AFUE_{eff} = Annual Fuel Utilization Efficiency for new high efficiency system
Source: Entered from application form
Range: 0.92 to 0.98

CAP = Capacity of heating system in MBtuh
Source: Entered from application form
Range: 36 to 225

HDD = 6,645 = Heating Degree Days
Source: National Climatic Data Center, NOAA, 2001

25 = Hours/Day

F_{adj} = 0.240 = Actual heating load to calculated heating load adjustment factor
Source: Inferred from 2008 Assessment of Potential

101= MBtu/therm

80 = Design temperature difference

CF = 0.012504 = Coincidence Factor
Source: 2008 Assessment of Potential (from SOGSH loadshape)

Boiler <300 MBtuh

$$\text{Annual Therms} = \left(\frac{1}{\text{AFUE}_{\text{base}}} - \frac{1}{\text{AFUE}_{\text{eff}}} \right) \times \frac{\text{CAP} \times \text{HDD} \times 24 \times \text{F}_{\text{adj}}}{100 \times 80}$$

$$\text{Peak Day Therms} = \text{Annual Therms} \times \text{CF}$$

$AFUE_{base}$ for Boiler = 0.809 = Annual Fuel Utilization Efficiency for new baseline efficiency boiler
Source: 2002 Assessment of Potential, Volume I, Page D-3

$AFUE_{eff}$ = Annual Fuel Utilization Efficiency for new high efficiency system
Source: Entered from application form
Range: 0.85 to 0.98

CAP = Capacity of heating system in MBtuh
Source: Entered from application form
Range: 36 to 300

HDD = 6,645 = Heating Degree Days
Source: National Climatic Data Center, NOAA, 2001

24 = Hours/Day

F_{adj} = 0.387 = Actual heating load to calculated heating load adjustment factor
Source: Inferred from 2008 Assessment of Potential

100 = MBtu/therm

80 = Design temperature difference

CF = 0.0092310 = Coincidence Factor
Source: 2008 Assessment of Potential (from SRGSH loadshape)

Boiler ≥300 MBtuh

$$\text{Annual Therms} = \left(\frac{1}{Et_{base}} - \frac{1}{Et_{eff}} \right) \times \frac{CAP \times HDD \times 24 \times F_{adj}}{100 \times 80}$$

$$\text{Peak Day Therms} = \text{Annual Therms} \times CF$$

Et_{base} = 0.80 = Thermal Efficiency for new baseline efficiency system
Source: 2006 IECC (IA State Code) – Table 503.2.3(5)

Et_{eff} = Thermal Efficiency for new high efficiency system
Source: Entered from application form
Range: 0.82 to 0.98

CAP = Capacity of heating system in MBtuh
Source: Entered from application form
Range: 300 to 18,000

HDD = 6,645 = Heating Degree Days
Source: National Climatic Data Center, NOAA, 2001

24 = Hours/Day

F_{adj} = 0.512 = Actual heating load to calculated heating load adjustment factor
Source: Inferred from 2008 Assessment of Potential

100 = MBtu/therm

80 = Design temperature difference

CF = 0.0059342 = Coincidence Factor
Source: 2008 Assessment of Potential (from LOGSH loadshape)

Gas Water Heater ≤ 75 MBtuh

$$\text{Annual Therms} = \left(1 - \frac{0.67 - (0.0019 \times \text{GAL})}{\text{EF}_{\text{eff}}}\right) \times \text{UEC}$$

$$\text{Peak Day Therms} = \text{Annual Therms} \times \text{CF}$$

GAL = Water heater capacity in gallons
Source: Entered from application form
Range: 20 to 80

EF_{eff} = Efficiency Factor of new high efficiency water heater
Source: Entered from application form
Range: 0.64 to 0.80

UEC = 64.6 = Unit Energy Consumption
Source: 2008 Assessment of Potential Energy Forecast Output for Small Office

0.67 & 0.0019 = Numbers used in building code to calculate EF of a code-compliant unit
Source: 2006 IECC, Table 503.2.3(3)

CF = 0.0042192 = Coincidence Factor
Source: 2008 Assessment of Potential (from SOGWH loadshape)

Gas Water Heater > 75 MBtuh

$$\text{Annual Therms} = \left(1 - \frac{Et_{base}}{Et_{eff}}\right) \times \text{UEC}$$

$$\text{Peak Day Therms} = \text{Annual Therms} \times \text{CF}$$

Et_{base} = 0.80 = Thermal Efficiency for new baseline efficiency water heater
Source: 2006 IECC (IA State Code) – Table 504.2

Et_{eff} = Thermal Efficiency for new high efficiency water heater
Source: Entered from application form
Range: 0.85 to 0.98

UEC = 279.6 = Unit Energy Consumption
Source: 2008 Assessment of Potential Energy Forecast Output for Restaurant

CF = 0.00293747 = Coincidence Factor
Source: 2008 Assessment of Potential (from FSGWH loadshape)

Screw-in Compact Fluorescent Lamps/Fixtures

$$\text{Annual kWh} = \left(kW_{\text{base}} - \text{kW}_{\text{eff}}\right) \times \text{OPHRS}$$

$$\text{Peak kW} = \text{Annual kWh} \times \text{CF}$$

kW_{eff} = Wattage of efficient screw-in lamp or hard-wired fixture / 1000
Source: Entered from application form
Range: 3 to 200

kW_{base} = Wattage of baseline lamp/fixture, from table below / 1000
Source: Grainger Catalog #393, Pages 720-723

W_{eff}	W_{base} Screw-in
≤6	25
7-11	40
12-17	60
18-21	75
22-25	90
26-31	100
32-41	150
42-71	200
≥72	300

OPHRS = Annual lamp/fixture operating hours
Source: Entered from application form
Range: 100 to 8,760

CF = 0.0001898 = Coincidence Factor
Source: 2008 Assessment of Potential (from SRLIT loadshape)

Hard-wired Compact Fluorescent Lamps/Fixtures

$$\text{Annual kWh} = \left(kW_{\text{base}} - \text{kW}_{\text{eff}}\right) \times \text{OPHRS}$$

$$\text{Peak kW} = \text{Annual kWh} \times \text{CF}$$

kW_{eff} = Wattage of efficient screw-in lamp or hard-wired fixture / 1000
Source: Entered from application form
Range: 3 to 200

kW_{base} = Wattage of baseline lamp/fixture, from table below / 1000
Source: Grainger Catalog #393, Pages 720-723

W_{eff}	W_{base} Hard-wired
≤6	25 – (# of lamps X 3.3)
7-11	40 – (# of lamps X 3.3)
12-17	60 – (# of lamps X 3.3)
18-21	75 – (# of lamps X 3.3)
22-25	90 – (# of lamps X 3.3)
26-31	100 – (# of lamps X 3.3)
32-41	150 – (# of lamps X 3.3)
42-71	200 – (# of lamps X 3.3)
≥72	300 – (# of lamps X 3.3)

3.3 = Factor to account for wattage of lamps/fixtures with lamps separate from ballasts
Source: Precision Research, Inc. 11/2003 analysis

OPHRS = Annual lamp/fixture operating hours
Source: Entered from application form
Range: 100 to 8,760

CF = 0.0001907 = Coincidence Factor
Source: 2008 Assessment of Potential (from SROGLIT and LOOGLIT loadshapes)

T-8/T-5 Fixtures (Existing or New Buildings)

$$\text{Annual kWh} = \left(kW_{\text{base}} - \text{kW}_{\text{eff}}\right) \times \text{OPHRS}$$

$$\text{Peak kW} = \text{Annual kWh} \times \text{CF}$$

kW_{base} = Wattage of baseline T12 fixture, from table on following page / 1000
Source: Averages of various manufacturers' laboratory tests (ANSI)
Range: 28 to 10,000

kW_{eff} = Wattage of efficient T8/T5 fixture, from table on following page / 1000
Source: Averages of various manufacturers' laboratory tests (ANSI)
Range: 20 to 10,000

OPHRS = Annual fixture operating hours
Source: Entered from application form
Range: 100 to 8,760

CF = 0.0001907 = Coincidence Factor
Source: 2008 Assessment of Potential (from SROGLIT and LOOGLIT loadshapes)

T-8/T-5 FIXTURES		
Size (length . # of lamps)	W_{base}	W_{eff}
2.2 U-bend T8	72	59
2.1 T8	28	20
2.2 T8	56	33
4.1 T8	43	31
4.2 T8	72	59
4.3 T8	115	89
4.4 T8	144	112
8.1 T8	75	58
8.2 T8	160	109
8.1 T8 HO	121	80
8.2 T8 HO	207	160
2.1 T5	28	18
2.2 T5	56	33
4.1 T5	43	32
4.2 T5	72	63
4.3 T5	115	96
4.4 T5	144	126
4.6 T5	216	190
Hi-Bay 4.3 T8 VHLO	295	112
Hi-Bay 4.4 T8 VHLO	458	151
Hi-Bay 4.5 T8 VHLO	458	189
Hi-Bay 4.6 T8 VHLO	458	226
Hi-Bay 4.7 T8 VHLO	458	264
Hi-Bay 4.8 T8 VHLO	458	301
Hi-Bay 4.3 T5 HO	295	179
Hi-Bay 4.4 T5 HO	458	234
Hi-Bay 4.5 T5 HO	458	296
Hi-Bay 4.6 T5 HO	458	351
Hi-Bay 4.7 T5 HO	850	410
Hi-Bay 4.8 T5 HO	850	468

Metal Halide Fixtures

$$\text{Annual kWh} = (kW_{base} - kW_{eff}) \times \text{OPHRS}$$

$$\text{Peak kW} = \text{Annual kWh} \times \text{CF}$$

kW_{base} = Wattage of baseline MH fixture, from table below / 1000
Source: Averages of various manufacturers' laboratory tests (ANSI)

kW_{eff} = Wattage of efficient MH fixture / 1000
Source: Averages of various manufacturers' laboratory tests (ANSI)

Metal Halide FIXTURES		
Type	W_{base}	W_{eff}
Reduced wattage (360 watts)	458	418
Pulse-start	458	380

OPHRS = Annual fixture operating hours
Source: Entered from application form
Range: 100 to 8,760

CF = 0.0001917 = Coincidence Factor
Source: 2008 Assessment of Potential (from LOLIT loadshape)

Efficient Motor

$$\text{Annual kWh} = \left(\frac{1}{\text{BASE}} - \frac{1}{\text{EFF}} \right) \times \text{HP} \times 0.746 \times \text{LF} \times \text{OPHRS}$$

$$\text{Peak kW} = \frac{\text{Annual kWh}}{\text{OPHRS}}$$

BASE = Efficiency rating of new baseline motor from table below
Source: Full-load efficiencies for NEMA EPACT Energy-Efficient motors
Note: If motor type and/or speed are not known, the average value may be used as a default.

HP	Open Drip-Proof (ODP)			Totally Enclosed Fan-Cooled (TEFC)			Average of all motor types and speeds
	1200 RPM	1800 RPM	3600 RPM	1200 RPM	1800 RPM	3600 RPM	
1	80.0%	82.5%	75.5%	80.0%	82.5%	75.5%	79.3%
1.5	84.0%	84.0%	82.5%	85.5%	84.0%	82.5%	83.8%
2	85.5%	84.0%	84.0%	86.5%	84.0%	84.0%	84.7%
3	86.5%	86.5%	84.0%	87.5%	87.5%	85.5%	86.3%
5	87.5%	87.5%	85.5%	87.5%	87.5%	87.5%	87.2%
7.5	88.5%	88.5%	87.5%	89.5%	89.5%	88.5%	88.7%
10	90.2%	89.5%	88.5%	89.5%	89.5%	89.5%	89.5%
15	90.2%	91.0%	89.5%	90.2%	91.0%	90.2%	90.4%
20	91.0%	91.0%	90.2%	90.2%	91.0%	90.2%	90.6%
25	91.7%	91.7%	91.0%	91.7%	92.4%	91.0%	91.6%
30	92.4%	92.4%	91.0%	91.7%	92.4%	91.0%	91.8%
40	93.0%	93.0%	91.7%	93.0%	93.0%	91.7%	92.6%
50	93.0%	93.0%	92.4%	93.0%	93.0%	92.4%	92.8%
60	93.6%	93.6%	93.0%	93.6%	93.6%	93.0%	93.4%
75	93.6%	94.1%	93.0%	93.6%	94.1%	93.0%	93.6%
100	94.1%	94.1%	93.0%	94.1%	94.5%	93.6%	93.9%
125	94.1%	94.5%	93.6%	94.1%	94.5%	94.5%	94.2%
150	94.5%	95.0%	93.6%	95.0%	95.0%	94.5%	94.6%
200	94.5%	95.0%	94.5%	95.0%	95.0%	95.0%	94.8%

EFF = Efficiency rating of new high efficiency motor
Source: Entered from application form
Range: 0.770 to 0.980 (77.0% to 98.0%)

HP = Horsepower of new high efficiency motor
Source: Entered from application form
Range: 1 to 200

LF = 0.75 = Loading Factor
Source: 2002 Assessment of Potential (confirmed 2008)

OPHRS = Annual operating hours
Source: Entered from application form
Range: 3,000 to 8,760

Variable Speed Drive

$$\text{Annual kWh} = \left(\frac{\text{HP}}{\text{EFF}_{\text{mot}}}\right) \times \text{EFF}_{\text{vsd}} \times 0.746 \times \text{LF} \times \text{OPHRS} \times \text{SF}$$

$$\text{Peak kW} = \frac{\text{Annual kWh}}{\text{OPHRS}} \times \text{CF}$$

HP = Horsepower of motor being controlled by VSD
Source: Entered from application form
Range: 1 to 200

EFF_{mot} = Efficiency rating of motor being controlled by VSD
Source: Entered from application form (or from table in “Efficient Motor” algorithm)
Range: 0.500 to 0.980 (50.0% to 98.0%)
Note: If motor efficiency is not known, use efficiency from table in “Efficient Motor” algorithm. If motor type and/or speed are not known, the average value may be used as a default.

EFF_{vsd} = Efficiency rating of variable speed drive
Source: Entered from application form
Range: 0.800 to 0.980 (80.0% to 98.0%)

LF = 0.75 = Loading Factor
Source: 2002 Assessment of Potential (confirmed 2008)

OPHRS = Annual operating hours
Source: Entered from application form
Range: 3,000 to 8,760

SF = 0.40 = Savings Factor
Source: Department of Energy Office of Industrial Technologies (confirmed 2008)

CF = Coincidence Factor from table below

Type of Application	CF
Manufacturing/Process Equipment	1
HVAC Equipment	0

Programmable Thermostat

Gas Furnace Heat

Annual Therms = 76.5
Source: 2008 Assessment of Potential

$$\text{Peak Day Therms} = \text{Annual Therms} \times CF_{gas}$$

Gas Boiler Heat

Annual Therms = 70.5
Source: 2008 Assessment of Potential

$$\text{Peak Day Therms} = \text{Annual Therms} \times CF_{gas}$$

Electric Cooling

Cooling kWh = 475.7
Source: 2008 Assessment of Potential

$$\text{Peak kW} = \text{Cooling kWh} \times CF_{elec}$$

Electric Resistance Heat

Annual kWh = 1,738.7
Source: 2008 Assessment of Potential

Cooling kWh = 475.7
Source: Same as Gas Heated Building

Heating kWh = 1,738.7 – 475.7 = 1,263.1

$$\text{Peak kW} = \text{Cooling kWh} \times CF_{elec}$$

Programmable Thermostat

Air-Source Heat Pump

Annual kWh = 1,683.0
Source: 2008 Assessment of Potential

Cooling kWh = 475.7
Source: Same as Gas Heated Building

Heating kWh = 1,683.0 – 475.7 = 1,207.3

$$\text{Peak kW} = \text{Cooling kWh} \times CF_{elec}$$

Ground-Source Heat Pump

Annual kWh = 1,603.0
Source: 2008 Assessment of Potential

Cooling kWh = 453.1
Source: 2008 Assessment of Potential

Heating kWh = 1,603.0 – 453.1 = 1,150.0

$$\text{Peak kW} = \text{Cooling kWh} \times CF_{elec}$$

All Heating/Cooling Systems

CF_{gas} = 0.0125035 = Coincidence Factor
Source: 2008 Assessment of Potential (from SOGSH loadshape)

CF_{elec} = 0.00053228 = Coincidence Factor
Source: 2008 Assessment of Potential (from SOCO loadshape)

Occupancy Sensor (Wall, Ceiling, or Switch Mounted)

Annual kWh = 279

Source: 2008 Assessment of Potential (per sensor)

$$\text{Peak kW} = \text{Annual kWh} \times \text{CF}$$

CF = 0.00020539 = Coincidence Factor

Source: 2008 Assessment of Potential (from SOLT loadshape)

LED Exit Sign

Annual kWh = 183.9

Source: 2008 Assessment of Potential, Baseline CFL 26W and LED Exit Sign 5W

$$\text{Peak kW} = \text{Annual kWh} \times \text{CF}$$

CF = 0.00011416 = Coincidence Factor

Source: 2008 Assessment of Potential (from 8760 loadshape)

LED Traffic Lights

Annual kWh:

12” red ball = 622
10” red ball = 533
8” red ball = 443
12” green ball = 478
10” green ball = 427
8” green ball = 376
Green arrow = 474
12” Pedestrian crossing signal = 1077
8” Pedestrian crossing signal = 805

Source: 2008 Assessment of Potential

$$\text{Peak kW} = \text{Annual kWh} \times \text{CF}$$

CF = 0.00011416 = Coincidence Factor
Source: 2008 Assessment of Potential (from 8760 loadshape)

IMPACTS FOR SMALL COMMERCIAL ENERGY AUDIT

Pipe Insulation

With Gas Water Heater

$\text{Annual therms} = 0.0129 \times \text{L}$

Source: Inferred from 2008 Assessment of Potential

L = Linear feet of hot water pipes insulated

Source: Entered from application form

Range: 1 to 2000

$\text{Peak Day Therms} = \text{Annual Therms} \times \text{CF}$

CF = 0.0042192 = Coincidence Factor

Source: 2008 Assessment of Potential (from SOGWH loadshape)

With Electric Water Heater

$\text{Annual kWh} = 0.393 \times \text{L}$

Source: Inferred from 2008 Assessment of Potential

L = Linear feet of hot water pipes insulated

Source: Entered from application form

Range: 1 to 2000

$\text{Peak kW} = \text{Annual kWh} \times \text{CF}$

CF = 0.00016354 = Coincidence Factor

Source: 2008 Assessment of Potential (from SOEWH loadshape)

Low-flow Showerhead

With Gas Water Heater

Annual Therms (per fixture) = 0.5
Source: 2008 Assessment of Potential

$$\text{Peak Day Therms} = \text{Annual Therms} \times \text{CF}$$

CF = 0.0042192 = Coincidence Factor
Source: 2008 Assessment of Potential (from SOGWH loadshape)

With Electric Water Heater

Annual kWh (per fixture) = 13.0
Source: 2008 Assessment of Potential

$$\text{Peak kW} = \text{Annual kWh} \times \text{CF}$$

CF = 0.00016354 = Coincidence Factor
Source: 2008 Assessment of Potential (from SOEWH loadshape)

Faucet and Kitchen Aerator

With Gas Water Heater

Annual Therms (per faucet) = 0.32

Source: 2008 Assessment of Potential (From 2.5 GPM (code) to 1.5 GPM)

$$\text{Peak Day Therms} = \text{Annual Therms} \times \text{CF}$$

CF = 0.0042192 = Coincidence Factor

Source: 2008 Assessment of Potential (from SOGWH loadshape)

With Electric Water Heater

Annual kWh (per faucet) = 22.1

Source: 2008 Assessment of Potential (From 2.5 GPM (code) to 1.5 GPM)

$$\text{Peak kW} = \text{Annual kWh} \times \text{CF}$$

CF = 0.00016354 = Coincidence Factor

Source: 2008 Assessment of Potential (from SOEWH loadshape)