4.2.3 Commercial Steam Cooker

Description

To qualify for this measure the installed equipment must be an ENERGY STAR® steamer in place of a standard steamer in a commercial kitchen. Savings are presented dependent on the pan capacity and corresponding idle rate at heavy load cooking capacity and if the steamer is gas or electric.

This measure was developed to be applicable to the following program types: TOS. If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be as follows:

Gas	Electric
ENERGY STAR® qualified with 38% minimum cooking energy efficiency at heavy load (potato) cooking capacity for gas steam cookers.	ENERGY STAR® qualified with 50% minimum cooking energy efficiency at heavy load (potato) cooking capacity for electric steam cookers.

DEFINITION OF BASELINE EQUIPMENT

The baseline condition is assumed to be a non-ENERGY STAR® commercial steamer at end of life. It is assumed that the efficient equipment and baseline equipment have the same number of pans.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 12 years[1]

DEEMED MEASURE COST

The incremental capital cost for this measure is $998[2] for a natural gas steam cooker or $2490[3] for an electric steam cooker.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape C01 - Commercial Electric Cooking

1California DEER 2008 which is also used by both the Food Service Technology Center and ENERGY STAR®.
2Source for incremental cost for efficient natural gas steamer is RSG Commercial Gas Steamer Workpaper, January 2012.
3Source for efficient electric steamer incremental cost is $2,490 per 2009 PG&E Workpaper - PGECOFST104.1 - Commercial Steam Cooker - Electric and Gas as reference by KEMA in the ComEd C & I TRM.

COINCIDENCE FACTOR

Summer Peak Coincidence Factor for measure is provided below for different building type[4]:

Location	CF
Fast Food Limited Menu	0.32
Fast Food Expanded Menu	0.41
Pizza	0.46
Full Service Limited Menu	0.51
Full Service Expanded Menu	0.36
Cafeteria	0.36
Unknown	0.40

Algorithm

CALCULATION OF SAVINGS

Formulas below are applicable to both gas and electric steam cookers. Please use appropriate lookup values and identified flags.

ENERGY SAVINGS

ΔSavings = (ΔIdle Energy + ΔPreheat Energy + ΔCooking Energy) * Z

For a gas cooker: ΔSavings = ΔBtu * 1/100,000 *Z

For an electric steam cooker: ΔSavings = ΔkWh *Z

Where Z = days/yr steamer operating (use 365.25 days/yr if heavy use restaurant and exact number unknown)

Where:

ΔIdle Energy = $((((1\text{- } CSM_{\%Baseline}) * IDLE_{BASE} + CSM_{\%Baseline} * PC_{BASE} * E_{FOOD} / EFF_{BASE}) * (HOURS_{day} - (F / PC_{Base}) - (PRE_{number} * 0.25))) - (((1\text{- } CSM_{\%ENERGYSTAR}) * IDLE_{ENERGYSTAR} + CSM_{\%ENERGYSTAR} * PC_{ENERGY} * E_{FOOD} / EFF_{ENERGYSTAR}) * (HOURS_{Day} - (F\ l/ PC_{ENERGY}) - (PRE_{number} * 0.25))))$

[4]Minnesota 2012 Technical Reference Manual, Electric Food Service_v03.2.xls, http://mn.gov/commerce/energy/topics/conservation/Design-Resources/Deemed-Savings.jspech. Unknown is an average of other location types

Where:

$CSM_{\%Baseline}$ = Baseline Steamer Time in Manual Steam Mode (% of time)

= 90%[5]

$IDLE_{Base}$ = Idle Energy Rate of Base Steamer[6]

Number of Pans	$IDLE_{BASE}$ - Gas, Btu/hr	$IDLE_{BASE}$ - Electric, kw
3	11,000	1.0
4	14,667	1.33
5	18,333	1.67
6	22,000	2.0

PC_{Base} = Production Capacity of Base Steamer[7]

Number of Pans	PC_{BASE}, gas (lbs/hr)	PC_{BASE}, electric (lbs/hr)
3	65	70
4	87	93
5	108	117
6	130	140

E_{FOOD}= Amount of Energy Absorbed by the food during cooking known as ASTM Energy to Food (Btu/lb or kW/lb)

=105 Btu/lb[8] (gas steamers) or 0.0308[8] (electric steamers)

---

[5]Food Service Technology Center 2011 Savings Calculator

[6]Food Service Technology Center 2011 Savings Calculator

7Production capacity per Food Service Technology Center 2011 Savings Calculator of 23.3333 lb/hr per pan for electric baseline steam cookers and 21.6667 lb/hr per pan for natural gas baseline steam cookers. ENERGY STAR® savings calculator uses 23.3 lb/hr per pan for both electric and natural gas baseline steamers.

[8]Reference ENERGY STAR® savings calculator at

EFF_{BASE} =Heavy Load Cooking Efficiency for Base Steamer

=15%[9] (gas steamers) or 26%[9] (electric steamers)

$HOURS_{day}$ = Average Daily Operation (hours)

Type of Food Service	Hoursday[10]
Fast Food, limited menu	4
Fast Food, expanded menu	5
Pizza	8
Full Service, limited menu	8
Full Service, expanded menu	7
Cafeteria	6
Unknown	6[11]
Custom	Varies

F = Food cooked per day (lbs/day)

= custom or if unknown, use 100 lbs/day[12]

$CSM_{\%ENERGYSTAR}$ = ENERGY STAR Steamer's Time in Manual Steam Mode (% of time)[13]

= 0%

$IDLE_{ENERGYSTAR}$ = Idle Energy Rate of ENERGY STAR®[14]

---

http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COC.

9Reference Food Service Technology Center 2011 Savings Calculator values as used by Consortium for Energy Efficiency, Inc. for baseline electric and natural gas steamer heavy cooking load energy efficiencies.

10Minnesota 2012 Technical Reference Manual, Electric Food Service_v03.2.xls, http://mn.gov/commerce/energy/topics/conservation/Design-Resources/Deemed-Savings.jspech

11Unknown is average of other locations

12Reference amount used by both Food Service Technology Center and ENERGY STAR® savings calculator

13Reference information from the Food Service Technology Center siting that ENERGY STAR® steamers are not typically operated in constant steam mode, but rather are used in timed mode. Reference ENERGY STAR® savings calculator at http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COC for efficient steamer. Both baseline & efficient steamer mode values should be considered for users in Illinois market.

14Food Service Technology Center 2011 Savings Calculator

Number of Pans	$IDLE_{ENERGY\ STAR}$ – gas, (Btu/hr)	$IDLE_{ENERGY\ STAR}$ – electric, (kW)
3	6250	0.40
4	8333	0.53
5	10417	0.67
6	12500	0.80

PC_{ENERGY} = Production Capacity of ENERGY STAR® Steamer[15]

Number of Pans	PC_{ENERGY} - gas(lbs/hr)	PC_{ENERGY} – electric (lbs/hr)
3	55	50
4	73	67
5	92	83
6	110	100

$EFF_{ENERGYSTAR}$ = Heavy Load Cooking Efficiency for ENERGY STAR® Steamer(%)

=38%[16] (gas steamer) or 50%[15] (electric steamer)

PRE_{number} = Number of preheats per day

=1[17] (if unknown, use 1)

Where:

ΔPreheat Energy = (PRE_{number} * Δ Pre_{heat})

Where:

PRE_{number} = Number of Preheats per Day

=1[18](if unknown, use 1)

[15]Production capacity per Food Service Technology Center 2011 Savings Calculator of 18.3333 lb/hr per pan for gas ENERGY STAR® steam cookers and 16.6667 lb/hr per pan for electric ENERGY STAR® steam cookers. ENERGY STAR® savings calculator uses 16.7 lb/hr per pan for electric and 20 lb/hr for natural gas ENERGY STAR® steamers.

[16]Reference Food Service Technology Center 2011 Savings Calculator values as used by Consortium for Energy Efficiency, Inc. for Tier 1A and Tier 1B qualified electric and natural gas steamer heavy cooking load energy efficiencies and http://www.energystar.gov/ia/partners/product_specs/program_reqs/Commercial_Steam_Cookers_Program_Requirements.pdf?7010-36eb

[17]Reference ENERGY STAR® savings calculator at http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COC and Food

PRE_{heat} = Preheat energy savings per preheat

= 11,000 Btu/preheat[19] (gas steamer) or 0.5 kWh/preheat[20] (electric steamer)

Where:

ΔCooking Energy = ((1/ EFFBASE) - (1/ EFFENERGY STAR®)) * F * E_{FOOD}

Where:

EFF_{BASE} =Heavy Load Cooking Efficiency for Base Steamer

=15%[21] (gas steamer) or 26%[28] (electric steamer)

$EFF_{ENERGYSTAR}$ =Heavy Load Cooking Efficiency for ENERGY STAR® Steamer

=38%[22] (gas steamer) or 50%[23] (electric steamer)

F = Food cooked per day (lbs/day)

= custom or if unknown, use 100 lbs/day[23]

E_{FOOD} = Amount of Energy Absorbed by the food during cooking known as ASTM Energy to Food[24]

E_{FOOD} - gas(Btu/lb)	E_{FOOD} (kWh/lb)
105[25]	0.0308[26]

[18]Reference ENERGY STAR® savings calculator at http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COC and Food
[19]Ohio TRM which references 2002 Food Service Technology Center "Commercial Cooking Appliance Technology Assessment" Chapter 8: Steamers. This is time also used by ENERGY STAR® savings calculator at http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COC. 11,000 Btu/preheat is from 72,000 Btu/hr * 15 min/hr /60 min/hr for gas steamers and 0.5 kWh/preheat is from 6 kW/preheat * 15 min/hr / 60 min/hr
[20] Reference Food Service Technology Center 2011 Savings Calculator values for Baseline Preheat Energy.
[21] Reference Food Service Technology Center 2011 Savings Calculator values as used by Consortium for Energy Efficiency, Inc. for baseline electric and natural gas steamer heavy cooking load energy efficiencies.
[22] Ibid.
[23]Amount used by both Food Service Technology Center and ENERGY STAR® savings calculator
[24]Reference ENERGY STAR® savings calculator at http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COC.
[25]Ibid.
[26]Ibid.

EXAMPLE

For a gas steam cooker: A 3 pan steamer in a restaurant

ΔSavings = ΔIdle Energy + ΔPreheat Energy + ΔCooking Energy *Z * 1/100.000

ΔIdle Energy = ((((1- .9)* 11000 + .9 * 65 * 105 /.15)*(12 - (100 / 65)-(1-.25))) - (((1-0) * 6250 + 0 * 55 * 105 / 0.38) * (12 - (100 / 55) - (1-0.25)))) +

ΔPreheat Energy = (1 *11,000) +

ΔCooking Energy = (((1/ 0.15) - (1/ 0.38)) * (100 lb/day * 105 btu/lb)))

* 365.25 days)) *1/100,000 =

=1536 therms

For an electric steam cooker: A 3 pan steamer in a restaurant

SUMMER COINCIDENT PEAK DEMAND SAVINGS

This is only applicable to the electric steam cooker.

ΔkW = (ΔkWh/(HOURSDay *DaysYear)) * CF

Where:

CF =Summer Peak Coincidence Factor for measure is provided below for different locations[27]:

Location	CF
Fast Food Limited Menu	0.32
Fast Food Expanded Menu	0.41
Pizza	0.46
Full Service Limited Menu	0.51
Full Service Expanded Menu	0.36
Cafeteria	0.36

$Days_{Year}$ =Annual Days of Operation

=custom or 365.25 days a year[28]

[27]Minnesota 2012 Technical Reference Manual, Electric Food Service_v03.2.xls, http://mn.gov/commerce/energy/topics/conservation/Design-Resources/Deemed-Savings.jspech

Other values as defined above

EXAMPLE
For 3 pan electric steam cooker located in a cafeteria:
ΔkW = $(\Delta kWh/(HOURS_{Day} * Days_{Year})) * CF$ =
(30,533/(12*365.25))*.36 =
2.51 kW

WATER IMPACT DESCRIPTIONS AND CALCULATION

This is applicable to both gas and electric steam cookers.

$$\Delta Water = [(W_{BASE} - W_{ENERGYSTAR®})*HOURS_{Day} *Days_{Year}$$

Where

W_{BASE} = Water Consumption Rate of Base Steamer (gal/hr)

= 40[29]

$W_{ENERGYSTAR}$ = Water Consumption Rate of ENERGY STAR® Steamer look up[30]

CEE Tier	gal/hr
Tier 1A	15
Tier 1B	4
Avg Efficient	10
Avg Most Efficient	3

$Days_{Year}$ =Annual Days of Operation

=custom or 365.25 days a year[31]

[29] FSTC (2002). Commercial Cooking Appliance Technology Assessment. Chapter 8: Steamers.

[30] Source Consortium for Energy Efficiency, Inc. September 2010 "Program Design Guidance for Steamers" for Tier 1A and Tier 1B water requirements. Ohio Technical Reference Manual 2010 for 10 gal/hr water consumption which can be used when Tier level is not known.

EXAMPLE

For example, an electric 3 pan steamer with average efficiency in a restaurant

ΔWater =

ΔWater = [(40 -10)*12*365.25

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

REFERENCE TABLES

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-FSE-STMC-V02-120601

[31]Source for 365.25 days/yr is ENERGY STAR® savings calculator which references Food Service Technology research on average use, 2009.

4.3.2 Low Flow Faucet Aerators

Description

This measure relates to the direct installation of a low flow faucet aerator in a kitchen or bath faucet fixture in a commercial building. Expected applications include small business, office, restaurant, or motel. For multifamily or senior housing, the residential low flow faucet aerator should be used.

This measure was developed to be applicable to the following program types, DI.
If applied to other program types, the measure savings should be verified.

Definition of Efficient Equipment

To qualify for this measure the installed equipment must be an energy efficient faucet aerator, for bathrooms rated at 1.5 gallons per minute (GPM) or less, or for kitchens rated at 2.2 GPM or less. Savings are calculated on an average savings per faucet fixture basis.

Definition of Baseline Equipment

The baseline condition is assumed to be a standard bathroom faucet aerator rated at 2.25 GPM or more, or a standard kitchen faucet aerator rated at 2.75 GPM or more.

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 9 years.[32]

Deemed Measure Cost

The incremental cost for this measure is $8[33] or program actual

Deemed O&M Cost Adjustments

N/A

Loadshape

Loadshape C02 - Commercial Electric DHW

Coincidence Factor

The coincidence factor for this measure is assumed to be 2.2%[34]

---

[32] Table C-6, Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.
"http://neep.org/uploads/EMV%20Forum/EMV%20Studies/measure_life_GDS%5B1%5D.pdf"

[33] Direct-install price per faucet assumes cost of aerator and install time. (2011, Market research average of $3 and assess and install time of $5 (20min @ $15/hr)

[34] Calculated as follows: Assume 18% aerator use takes place during peak hours (based on: http://www.aquacraft.com/sites/default/files/pub/DeOreo-%282001%29-Disaggregated-Hot-Water-Use-in-Single-Family-Homes-Using-Flow-Trace-Analysis.pdf) There are 65 days in the summer peak period, so the percentage of

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

NOTE THESE SAVINGS ARE *PER* FAUCET RETROFITTED[35].

ΔkWh = %ElectricDHW * ((GPM_base * L_base - GPM_low * L_low) * NOPF* 365.25 *DF) * EPG_electric * ISR

Where:

%ElectricDHW = proportion of water heating supplied by electric resistance heating

DHW fuel	%Electric_DHW
Electric	100%
Fossil Fuel	0%
Unknown	16%[36]

NOPF = Number of occupants per faucet. For example if there is an office with 20 people and 4 faucets total, the number of people per faucet is 5.This assumes that all faucets in count, have been retrofitted with low flow.

Occupant input	Number
Custom	Estimated number of people using the faucet

365.25 = Days in a year, on average.

---

total annual aerator use in peak period is 0.18*65/365.25 = 3.21%. The number of hours of recovery during peak periods is therefore assumed to be 3.21% * 180= 5.8 hours of recovery during peak period. There are 180 hours in the peak period so the probability you will see savings during the peak period is 5.8/180= 0.022

[35] This algorithm calculates the amount of energy saved per aerator by determining the fraction of water consumption savings for the upgraded fixture. Due to the distribution of water consumption by fixture type, as well as the different number of fixtures in a building, several variables must be incorporated.

[36] Default assumption for unknown fuel is based on EIA Residential Energy Consumption Survey (RECS) 2009 for Midwest Region, data for the state of IL. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area then that should be used

DF = Drain Factor

Faucet Type	Drain Factor[37]
Kitchen	75%
Bath	90%
Unknown	79.5%

GPM_base = Average flow rate, in gallons per minute, of the baseline faucet "as-used"

= 1.2[38] or custom based on metering studies[39]

GPM_low = Average flow rate, in gallons per minute, of the low-flow faucet aerator "as-used"

= 0.94[40] or custom based on metering studies[41]

L_base = Average baseline length faucet use per capita for all faucets in minutes

= 9.85 min/person/day[42] or custom based on metering studies

L_low = Average retrofit length faucet use per capita for all faucets in minutes

= 9.85 min/person/day[43] or custom based on metering studies

---

[37] Because faucet usages are at times dictated by volume, it is assumed only half of the kitchen usage is of the sort that would go straight down the drain. VEIC is unaware of any metering study that has determined this specific factor and so through consensus with the Illinois Technical Advisory Group have deemed these values to be 75% for the kitchen and 90% for the bathroom. If the aerator location is unknown an average of 79.5% should be used which is based on the assumption that 70% of household water runs through the kitchen faucet and 30% through the bathroom (0.7*0.75)+(0.3*0.9)=0.795.

[38] Representative baseline flow rate for kitchen and bathroom faucet aerators from sources 2, 4, 5, and 7. This accounts for all throttling and differences from rated flow rates. The most comprehensive available studies did not disaggregate kitchen use from bathroom use, but instead looked at total flow and length of use for all faucets. This makes it difficult to reliably separate kitchen water use from bathroom water use.

[39] Measurement should be based on actual average flow consumed over a period of time rather than a onetime spot measurement for maximum flow. Studies have shown maximum flow rates do not correspond well to average flow rate due to occupant behavior which does not always use maximum flow.

[40] Average retrofit flow rate for kitchen and bathroom faucet aerators from sources 2, 4, 5, and 7. This accounts for all throttling and differences from rated flow rates. Assumes all kitchen aerators at 2.2 gpm or less and all bathroom aerators at 1.5 gpm or less. The most comprehensive available studies did not disaggregate kitchen use from bathroom use, but instead looked at total flow and length of use for all faucets. This makes it difficult to reliably separate kitchen water use from bathroom water use. It is possible that programs installing low flow aerators lower than the 2.2 gpm for kitchens and 1.5 gpm for bathrooms will see a lower overall average retrofit flow rate.

[41] Measurement should be based on actual average flow consumed over a period of time rather than a onetime spot measurement for maximum flow. Studies have shown maximum flow rates do not correspond well to average flow rate due to occupant behavior which does not always use maximum flow.

[42] This coincides with the middle of the range (6.74 min/per/day to 13.4 min/per/day) from sources 2, 3, 4, and 5 (See Source Table at end of measure section). A recent Midwest evaluation study included a small metering sample with measured faucet use at 4.5 min/per/day for kitchen faucets and 2.6 min/per/day for bathroom faucets. This sample was too small to extrapolate to the population as a whole, but is within the range of total faucet time per the referenced reports and confirms previous findings.

EPG_electric = Energy per gallon of water used by faucet supplied by electric water heater

= (8.33 * 1.0 * (WaterTemp - SupplyTemp)) / (RE_electric * 3412)

= (8.33 * 1.0 * (90 – 54.1)) / (0.98 * 3412)

= 0.0894 kWh/gal

8.33 = Specific weight of water (lbs/gallon)

1.0 = Heat Capacity of water (btu/lb-F)

WaterTemp = Assumed temperature of mixed water

= 90F [44]

SupplyTemp = Assumed temperature of water entering house

= 54.1F [45]

RE_electric = Recovery efficiency of electric water heater

= 98% [46]

3412 = Converts Btu to kWh (Btu/kWh)

[43] Set equal to L_base. Studies show conflicting results with some studies showing increased time for retrofit homes and some showing decreased time. Engineering judgment leads us to conclude that using the baseline time is a reasonable assumption.

[44] Temperature cited from SBW Consulting, Evaluation for the Bonneville Power Authority, 1994, http://www.bpa.gov/energy/n/reports/evaluation/residential/faucet_aerator.cfm. This is a variable that would benefit from further evaluation.

[45] US DOE Building America Program. Building America Analysis Spreadsheet. For Chicago, IL http://www1.eere.energy.gov/buildings/building_america/analysis_spreadsheets.html.

[46] Electric water heater have recovery efficiency of 98%: http://www.ahrinet.org/ARI/util/showdoc.aspx?doc=576

ISR = In service rate of faucet aerators dependant on install method as listed in table below[47]

Selection	ISR
Direct Install - Deemed	0.95

EXAMPLE

For example, a direct installed faucet in an office with electric DHW, 4 faucets and 20 office occupants (savings per faucet):

ΔkWh = 1 *((1.2*9.85-0.94*9.85)*(20/4)*365.25*0.795)*0.0894*0.95

= 315.8 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = (ΔkWh / Hours) * CF

Where:

ΔkWh = calculated value above on a per faucet basis

Hours = Annual electric DHW recovery hours for faucet use

= (GPM_base * L_base) * NOPF * 365.25 * DF * 0.545[48])/GPH

=340.0

Where :

GPH = Gallons per hour recovery of electric water heater calculated for 65.9F temp rise (120-54.1), 98% recovery efficiency, and typical 4.5kW electric resistance storage tank.

= 27.51

CF = Coincidence Factor for electric load reduction

= 0.022[49].

---

[47] ComEd Energy Efficiency/ Demand Response Plan: Plan Year 2 (6/1/2009-5/31/2010) Evaluation Report: All Electric Single Family Home Energy Performance Tune-Up Program Table 3-8

[48] 54.5% is the proportion of hot 120F water mixed with 54.1F supply water to give 90F mixed faucet water.

[49] Calculated as follows: Assume 18% aerator use takes place during peak hours (based on: http://www.aquacraft.com/sites/default/files/pub/DeOreo-%282001%29-Disaggregated-Hot-Water-Use-in-Single-Family-Homes-Using-Flow-Trace-Analysis.pdf) There are 65 days in the summer peak period, so the percentage of total annual aerator use in peak period is 0.18*65/365.25 = 3.21%. The number of hours of recovery during peak periods is therefore assumed to be 3.21% *180 = 5.8 hours of recovery during peak period where 180 equals the

EXAMPLE

For example, a direct installed faucet in an office with electric DHW, 4 faucets and 20 office occupants (savings per faucet):

ΔkW =(315.8/340) * 0.022

= .0.102 kW

FOSSIL FUEL IMPACT DESCRIPTIONS AND CALCULATION

ΔTherms = %FossilDHW * ((GPM_base * L_base - GPM_low * L_low) * NOPF * 365.25 *DF) * EPG_gas * ISR

Where:

%FossilDHW = proportion of water heating supplied by fossil fuel heating

DHW fuel	%Fossil_DHW
Electric	0%
Fossil Fuel	100%
Unknown	84%[50]

EPG_gas = Energy per gallon of Hot water supplied by gas

= (8.33 * 1.0 * (WaterTemp - SupplyTemp)) / (RE_gas * 100,000)

= 0.0045 Therm/gal

average annual electric DHW recovery hours for faucet use including SF and MF homes. There are 260 hours in the peak period so the probability you will see savings during the peak period is 5.8/260 = 0.022

[50] Default assumption for unknown fuel is based on EIA Residential Energy Consumption Survey (RECS) 2009 for Midwest Region, data for the state of IL. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area then that should be used

Where:

RE_gas = Recovery efficiency of gas water heater

` = 67% [51]

100,000 = Converts Btus to Therms (Btu/Therm)

Other variables as defined above.

EXAMPLE
For example, a direct installed bath faucet in an office with gas DHW, 4 faucets and 20 office occupants (savings per faucet):
ΔTherms = 1 * (1.2*9.85 – 0.94*9.85)* 20/4* 365.25 *0.795 * 0.0045 * 0.95
= 15.9 Therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

Δgallons = ((GPM_base * L_base - GPM_low * L_low) * NOPF * 365.25 *DF) * ISR

Variables as defined above

EXAMPLE
For example, a direct installed 1 faucet in an office, 4 faucets and 20 office occupants (savings per faucet
Δgallons = ((1.2*9.85)-(0.94*9.85))*(20/4)*365.25*0.795* 0.95
= 3532.3 gallons

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

SOURCES

Source ID	Reference

[51] Review of AHRI Directory suggests range of recovery efficiency ratings for new Gas DHW units of 70-87%. Average of existing units is estimated at 75%. Commercial properties are more similar to MF homes than SF homes. MF hot water is often provided by a larger commercial boiler. This suggests that the average recovery efficiency is somewhere between a typical central boiler efficiency of .59 and the .75 for single family home. An average is used for this analysis by default.

1	2011, DeOreo, William. California Single Family Water Use Efficiency Study. April 20, 2011.
2	2000, Mayer, Peter, William DeOreo, and David Lewis. Seattle Home Water Conservation Study. December 2000.
3	1999, Mayer, Peter, William DeOreo. Residential End Uses of Water. Published by AWWA Research Foundation and American Water Works Association. 1999.
4	2003, Mayer, Peter, William DeOreo. Residential Indoor Water Conservation Study. Aquacraft, Inc. Water Engineering and Management. Prepared for East Bay Municipal Utility District and the US EPA. July 2003.
5	2011, DeOreo, William. Analysis of Water Use in New Single Family Homes. By Aquacraft. For Salt Lake City Corporation and US EPA. July 20, 2011.
6	2011, Aquacraft. Albuquerque Single Family Water Use Efficiency and Retrofit Study. For Albuquerque Bernalillo County Water Utility Authority. December 1, 2011.
7	2008, Schultdt, Marc, and Debra Tachibana. Energy related Water Fixture Measurements: Securing the Baseline for Northwest Single Family Homes. 2008 ACEEE Summer Study on Energy Efficiency in Buildings.

MEASURE CODE: CI-HW_-LFFA-V02-120601

4.3.3 Low Flow Showerheads

DESCRIPTION

This measure relates to the direct installation of a low flow showerhead in a commercial building. Expected applications include small business, office, restaurant, or small motel. For multifamily or senior housing, the residential low flow showerhead should be used.

This measure was developed to be applicable to the following program types: DI.

If applied to other program types, the measure savings should be verified

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be an energy efficient showerhead rated at 2.0 gallons per minute (GPM) or less. Savings are calculated on a per showerhead fixture basis.

DEFINITION OF BASELINE EQUIPMENT

The baseline condition is assumed to be a standard showerhead rated at 2.5 GPM.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 10 years.[52]

DEEMED MEASURE COST

The incremental cost for this measure is $12[53] or program actual.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape C02 - Commercial Electric DHW

COINCIDENCE FACTOR

The coincidence factor for this measure is assumed to be 2.78%[54].

---

[52] Table C-6, Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007. Evaluations indicate that consumer dissatisfaction may lead to reductions in persistence, particularly in Multi-Family , "http://neep.org/uploads/EMV%20Forum/EMV%20Studies/measure_life_GDS%5B1%5D.pdf"

[53] Direct-install price per showerhead assumes cost of showerhead (Market research average of $7 and assess and install time of $5 (20min @ $15/hr)

[54] Calculated as follows: Assume 11% showers take place during peak hours (based on: http://www.aquacraft.com/sites/default/files/pub/DeOreo-%282001%29-Disaggregated-Hot-Water-Use-in-Single-Family-Homes-Using-Flow-Trace-Analysis.pdf). There are 65 days in the summer peak period, so the percentage of total annual aerator use in peak period is 0.11*65/365 = 1.96%. The number of hours of recovery during peak periods is therefore assumed to be 1.96% * 369 = 7.23 hours of recovery during peak period. There are 260 hours

Algorithm

CALCULATION OF SAVINGS [55]

ELECTRIC ENERGY SAVINGS

Note these savings are per showerhead fixture

ΔkWh =

%ElectricDHW * ((GPM_base * L_base - GPM_low * L_low) * NSPD * 365.25) * EPG_electric * ISR

Where:

%ElectricDHW = proportion of water heating supplied by electric resistance heating

= 1 if electric DHW, 0 if fuel DHW, if unknown assume 16% [56]

GPM_base = Flow rate of the baseline showerhead

= 2.67 for Direct-install programs[57]

GPM_low = As-used flow rate of the low-flow showerhead, which may, as a result of measurements of program evaulations deviate from rated flows, see table below:

Rated Flow
2.0 GPM
1.75 GPM
1.5 GPM
Custom or Actual[58]

L_base = Shower length in minutes with baseline showerhead

= 8.20 min[59]

in the peak period so the probability you will see savings during the peak period is 7,23/260 = 0..0278

[55]Based on excel spreadsheet 120911.xls …on SharePoint

[56] Table HC8.9. Water Heating in U.S. Homes in Midwest Region, Divisions, and States, 2009 (RECS)

[57] Based on measured data from Ameren IL EM&V of Direct-Install program. Program targets showers that are rated 2.5 GPM or above.

[58] Note that actual values may be either a) program-specific minimum flow rate, or b)program-specific evaluation-based value of actual effective flow-rate due to increased duration or temperatures. The latter increases in likelihood as the rated flow drops and may become significant at or below rated flows of 1.5 GPM. The impact can be viewed as the inverse of the throttling described in the footnote for baseline flowrate.

[59] Representative value from sources 1, 2, 3, 4, 5, and 6 (See Source Table at end of measure section)

L_low = Shower length in minutes with low-flow showerhead

= 8.20 min[60]

365.25 = Days per year, on average.

NSPD = Estimated number of showers taken per day for one showerhead

EPG_electric = Energy per gallon of hot water supplied by electric

= (8.33 * 1.0 * (ShowerTemp - SupplyTemp)) / (RE_electric * 3412)

= (8.33 * 1.0 * (105 – 54.1)) / (0.98 * 3412)

= 0.127 kWh/gal

8.33 = Specific weight of water (lbs/gallon)

1.0 = Heat Capacity of water (btu/lb-F)

ShowerTemp = Assumed temperature of water

= 105F [61]

SupplyTemp = Assumed temperature of water entering house

= 54.1F [62]

RE_electric = Recovery efficiency of electric water heater

= 98% [63]

3412 = Converts Btu to kWh (btu/kWh)

[60] Set equal to L_base.
[61] Shower temperature cited from SBW Consulting, Evaluation for the Bonneville Power Authority, 1994, http://www.bpa.gov/energy/n/reports/evaluation/residential/faucet_aerator.cfm
[62] US DOE Building America Program. Building America Analysis Spreadsheet. For Chicago, IL http://www1.eere.energy.gov/buildings/building_america/analysis_spreadsheets.html.
[63] Electric water heater have recovery efficiency of 98%: http://www.ahrinet.org/ARI/util/showdoc.aspx?doc=576

ISR = In service rate of showerhead

= Dependant on program delivery method as listed in table below

Selection	ISR[64]
Direct Install - Deemed	0.98

EXAMPLE

For example, a direct-installed 1.5 GPM showerhead in an office with electric DHW where the number of showers is estimated at 3 per day:

ΔkWh = 1 * ((2.67*8.20)- (1.5*8.20)) * 3*365.25) *0.127 * 0.98

= 1308.4 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh/Hours * CF

Where:

ΔkWh = calculated value above

Hours = Annual electric DHW recovery hours for showerhead use

= ((GPM_base * L_base) *NSPD * 365.25) * 0.773[65] / GPH

Where:

GPH = Gallons per hour recovery of electric water heater calculated for 65.9F temp rise (120-54.1), 98% recovery efficiency, and typical 4.5kW electric resistance storage tank.

= 27.51

CF = Coincidence Factor for electric load reduction

= 0.0278[66]

64 Deemed values are from ComEd Energy Efficiency/ Demand Response Plan: Plan Year 2 (6/1/2009-5/31/2010) Evaluation Report: All Electric Single Family Home Energy Performance Tune-Up Program Table 3-8. Alternative ISRs may be developed for program delivery methods based on evaluation results.

65 77.3% is the proportion of hot 120F water mixed with 54.1F supply water to give 105F shower water.

66 Calculated as follows: Assume 11% showers take place during peak hours (based on: http://www.aquacraft.com/sites/default/files/pub/DeOreo-%282001%29-Disaggregated-Hot-Water-Use-in-Single-

EXAMPLE

For example, a direct-installed 1.5 GPM showerhead in an office with electric DHW where the number of showers is estimated at 3 per day:

ΔkW = (1308.4 / 674.1)*0.0278

FOSSIL FUEL IMPACT DESCRIPTIONS AND CALCULATION

ΔTherms = %FossilDHW * ((GPM_base * L_base - GPM_low * L_low) * NSPD* 365.25) * EPG_gas * ISR

Where:

%FossilDHW = proportion of water heating supplied by fossil fuel heating

DHW fuel	%Fossil_DHW
Electric	0%
Fossil Fuel	100%
Unknown	84%[67]

EPG_gas = Energy per gallon of Hot water supplied by gas

= (8.33 * 1.0 * (ShowerTemp - SupplyTemp)) / (RE_gas * 100,000)

= 0.0063 Therm/gal

Where:

RE_gas = Recovery efficiency of gas water heater

= 67% [68]

Family-Homes-Using-Flow-Trace-Analysis.pdf). There are 65 days in the summer peak period, so the percentage of total annual aerator use in peak period is 0.11*65/365.25 = 1.96%. The number of hours of recovery during peak periods is therefore assumed to be 1.96% * 369 = 7.23 hours of recovery during peak period where 369 equals the average annual electric DHW recovery hours for showerhead use including SF and MF homes with Direct Install and Retrofit/TOS measures. There are 260 hours in the peak period so the probability you will see savings during the peak period is 7.23/260 = 0.0278

[67] Default assumption for unknown fuel is based on EIA Residential Energy Consumption Survey (RECS) 2009 for Midwest Region, data for the state of IL. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area then that should be used

[68] Review of AHRI Directory suggests range of recovery efficiency ratings for new Gas DHW units of 70-87%. Average of existing units is estimated at 75%. Commercial properties are more similar to MF homes than SF homes. MF hot water is often provided by a larger commercial boiler. This suggests that the average recovery efficiency is somewhere between a typical central boiler efficiency of .59 and the .75 for single family home. An

100,000 = Converts Btus to Therms (btu/Therm)

Other variables as defined above.

EXAMPLE

For example, a direct-installed 1.5 GPM showerhead in an office with gas DHW where the number of showers is estimated at 3 per day:

ΔTherms = 1.0 * ((2.67 *8.2) – (1.5 * 8.2)) * 3 * 365.25 * 0.0063 * 0.98

= 64.9 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

Δgallons = ((GPM_base * L_base - GPM_low * L_low) * NSPD * 365.25 * ISR

Variables as defined above

EXAMPLE

For example, a direct-installed 1.5 GPM showerhead in an office with where the number of showers is estimated at 3 per day:

Δgallons = ((2.67 * 8.20)-(1.5 * 8.20)) * 3 * 365.25 * 0.98

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

average is used for this analysis by default.

SOURCES

Source ID	Reference
1	2011, DeOreo, William. California Single Family Water Use Efficiency Study. April 20, 2011.
2	2000, Mayer, Peter, William DeOreo, and David Lewis. Seattle Home Water Conservation Study. December 2000.
3	1999, Mayer, Peter, William DeOreo. Residential End Uses of Water. Published by AWWA Research Foundation and American Water Works Association. 1999.
4	2003, Mayer, Peter, William DeOreo. Residential Indoor Water Conservation Study. Aquacraft, Inc. Water Engineering and Management. Prepared for East Bay Municipal Utility District and the US EPA. July 2003.
5	2011, DeOreo, William. Analysis of Water Use in New Single Family Homes. By Aquacraft. For Salt Lake City Corporation and US EPA. July 20, 2011.
6	2011, Aquacraft. Albuquerque Single Family Water Use Efficiency and Retrofit Study. For Albuquerque Bernalillo County Water Utility Authority. December 1, 2011.
7	2008, Schultdt, Marc, and Debra Tachibana. Energy related Water Fixture Measurements: Securing the Baseline for Northwest Single Family Homes. 2008 ACEEE Summer Study on Energy Efficiency in Buildings.

MEASURE CODE: CI-HW_-LFSH-V02-120601

4.3.4 Tankless Water Heater

Description

This measure covers the installation of on-demand or instantaneous tankless water heaters. Tankless water heaters function similar to standard hot water heaters except they do not have a storage tank. When there is a call for hot water, the water is heated instantaneously as it passes through the heating element and then proceeds to the user or appliance calling for hot water. Tankless water heaters achieve savings by eliminating the standby losses that occur in stand-alone or tank-type water heaters and by being more efficient than the baseline storage hot water heater.

This measure was developed to be applicable to the following program types: TOS, RF, ER.
If applied to other program types, the measure savings should be verified.

Definition of Efficient Equipment

Electric	Gas
To qualify for this measure, the tankless water heater shall be a new electric powered tankless hot water heater with an energy factor greater than or equal to 0.98 with an output greater than or equal to 5 GPM output at 70° F temperature rise	To qualify for this measure, the tankless water heater shall meet or exceed the efficiency requirements for tankless hot water heaters mandated by the International Energy Conservation Code (IECC) 2012, Table C404.2.

Definition of Baseline Equipment

Electric	Gas
The baseline condition is assumed to be an electric commercial-grade tanked water heater 50 or more gallon storage capacity with an energy factor less than or equal to 0.9 or the water heater is five or more years old	The baseline condition is assumed to be a gas-fired tank-type water heater meeting the efficiency requirements mandated by the International Energy conservation Code (IECC) 2012, Table C404.2.

Deemed Lifetime of Efficient Equipment

Electric	Gas
The expected measure life is assumed to be 5 years[69].	The expected measure life is assumed to be 20 years[70]

Deemed Measure Cost

The incremental capital cost for an electric tankless heater this measure is assumed to be[71]

[69] Ohio Technical Reference Manual 8/2/2010 referencing CenterPoint Energy-Triennial CIP/DSM Plan 2010-2012 Report; Additional reference stating >20 years is at Energy Savers.Gov online at http://www.energysavers.gov/your_home/water_heating/index.cfm/mytopic=12820

[70] Ibid.

Output (gpm) at delta T 70	Incremental Cost
5	$1050
10	$1050
15	$1950

The incremental capital cost for a gas fired tankless heater is as follows:

Program	Capital Cost, $ per unit
Retrofit	$3,255[72]
Time of Sale or New Construction	$2,526[73]

DEEMED O&M COST ADJUSTMENTS

$100[74]

LOADSHAPE

Loadshape C02 - Commercial Electric DHW

COINCIDENCE FACTOR

The measure has deemed kW savings therefor a coincidence factor is not applied

[71] Act on Energy Technical Reference Manual, Table 9.6.2-3

[72] Based on AOE historical average installation data of 42 tankless gas hot water heaters

[73] http://www.mncee.org/getattachment/7b8982e9-4d95-4bc9-8e64-f89033617f37/, Low contractor estimate used to reflect less labor required in new construction of venting.

[74] Water heaters (WH) require annual maintenance. There are different levels of effort for annual maintenance depending if the unit is gas or electric, tanked or tankless. Electric and gas tank water heater manufacturers recommend an annual tank drain to clear sediments. Also recommended are "periodic" inspections by qualified service professionals of operating controls, heating element and wiring for electric WHs and thermostat, burner, relief valve internal flue-way and venting systems for gas WHs. Tankless WH require annual maintenance by licensed professionals to clean control compartments, burners, venting system and heat exchangers. This information is from WH manufacturer product brochures including GE, Rennai, Rheem, Takagi and Kenmore. References for incremental O&M costs were not found, therefore the incremental cost of the additional annual maintenance for tankless WH is estimated at $100.

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS [75]

The annual electric savings from an electric tankless heater is a deemed value and assumed to be:

Output (gpm) at delta T 70	Savings (kWh)
5.0	2,991.98
10.0	7,904.82
15.0	12,878.51

SUMMER COINCIDENT PEAK DEMAND SAVINGS [76]

The annual kW savings from an electric tankless heater is a deemed value and assumed to be:

Output (gpm) at delta T 70	Savings (kW)
5.0	0.34
10.0	0.90
15.0	1.47

NATURAL GAS ENERGY SAVINGS

ΔTherms=[[Wgal x 8.33 x 1 x (Tout - Tin) x [(1/Eff base) - (1/Eff ee)]]/100,000] +[[(SL x 8,766)/Eff base]] / 100,000 Btu/Therms]

Where:

Wgal = Annual water use for equipment in gallons

= custom, otherwise assume 21,915 gallons [77]

8.33 lbm/gal = weight in pounds of one gallon of water

1 Btu/lbm°F = Specific heat of water: 1 Btu/lbm/°F

8,766 hr/yr = hours a year

Tout = Unmixed Outlet Water Temperature

= custom, otherwise assume 130 degree F[78]

[75] Act on Energy Technical Reference Manual, Table 9.6.2-3

[76] Ibid.

[77] 21,915 gallons is an estimate of 60 gal/day for 365.25 days/yr. If building type is known, reference 2007 ASHRAE Handbook HVAC Applications p. 49.14 Table 7 Hot Water Demands and Use for Various Types of Buildings to help estimate hot water consumption.

Tin = Inlet Water Temperature

= custom, otherwise assume 54.1 degree F[79]

Eff base = Rated efficiency of baseline water heater expressed as Energy Factor (EF) or Thermal Efficiency (Et); see table below[80]

Input Btuh of existing, tanked water heater	Eff base	Units
Size: ≤ 75,000 Btu/h	0.67 - 0.0019*Tank Volume	Energy Factor
Size: >75,000 Btu/h and ≤ 155,000 Btu/h	80%	Thermal Efficiency
Size: >155,000 Btu/h	80%	Thermal Efficiency

Where Tank Volume = custom input, if unknown assume 60 gallons for Size: ≤ 75,000 Btu/h

Please note: Units in base case must match units in efficient case. If Energy Factor used in base case, Energy Factor to be used in efficient case. If Themal Efficiency is used in base case, Thermal Efficiency must be used in efficient case.

Eff ee = Rated efficiency of efficient water heater expressed as Energy Factor (EF) or Thermal Efficiency (Eff t)

= custom input, if unknown assume 0.84[81]

SL = Stand-by Loss in Base Case Btu/hr

= custom input based on formula in table below, if unknown assume unit size in table below[82]

Input Btu/h of new, tankless water heater	Standby Loss (SL)
Size: ≤ 75,000 Btu/h	0
Size: >75,000 Btu/h	(Input rating/800)+(110*√Tank Volume))

Where:

[78] Based on 2010 Ohio Techical Reference Manual and NAHB Research Center, (2002) Performance Comparison of Residential hot Water Systems. Prepared for National Renewable Energy Laboratory, Golden, Colorado.
[79] August 31, 2011 Memo of Savings for Hot Water Savings Measures to Nicor Gas from Navigant states that 54.1°F was calculated from the weighted average of monthly water mains temperatures reported in the 2010 Building America Benchmark Study for Chicago-Waukegan, Illinois.
[80] IECC 2012, Table C404.2, Minimum Performance of Water-Heating Equipment
[81] Specifications of energy efficient tankless water heater. Reference Consortium for Energy Efficiency (CEE) which maintains a list of high efficiency tankless water heaters which currently have Energy Factors up to .96. Ameren currently requires minimum .82 energy factor.
[82] Stand-by loss is provided 2012 International Energy Conservation Code (IECC2012), Table C404.2, Minimum Performance of Water-Heating Equipment

Tank Volume = custom input, if unknown assume, 60 gallons for <75,000 Btu/hr, 75 gallons for >75,000 Btu/h and ≤ 155,000 Btu/h and 150 for Size >155,000 Btu/h

Input Value = nameplate Btu/hr rating of water heater

EXAMPLE

For example, a 75,000 Btu/h tankless unit using 21,915 gal/yr with outlet temperature at 130.0 and inlet temperature at 54.1, replacing a baseline unit with 0.8 thermal efficiency and standby losses of 1008.3 btu/hr:

ΔTherms =[[(21,915 x 8.33x 1 x (130 – 54.1) x [(1/.8) - (1/.84)]/100,000] +[(1008.3 x 8,766)/.8]] / 100,000

=115 Therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

The deemed O&M cost adjustment for a gas fired tankless heater is $100

REFERENCE TABLES

Minimum Performance Water Heating Equipment[83]

[83] International Energy Conservation Code (IECC)2012

TABLE C404.2
MINIMUM PERFORMANCE OF WATER-HEATING EQUIPMENT

EQUIPMENT TYPE	SIZE CATEGORY (input)	SUBCATEGORY OR RATING CONDITION	PERFORMANCE REQUIRED[a, b]	TEST PROCEDURE
Water heaters, electric	≤ 12 kW	Resistance	0.97 - 0.00132 V, EF	DOE 10 CFR Part 430
	> 12 kW	Resistance	1.73 V+ 155 SL, Btu/h	ANSI Z21.10.3
	≤ 24 amps and ≤ 250 volts	Heat pump	0.93 - 0.00132 V, EF	DOE 10 CFR Part 430
Storage water heaters, gas	≤ 75,000 Btu/h	≥ 20 gal	0.67 - 0.0019 V, EF	DOE 10 CFR Part 430
	> 75,000 Btu/h and ≤ 155,000 Btu/h	< 4,000 Btu/h/gal	80% E_t $(Q/800 + 110\sqrt{V})$ SL, Btu/h	ANSI Z21.10.3
	> 155,000 Btu/h	< 4,000 Btu/h/gal	80% E_t $(Q/800 + 110\sqrt{V})$ SL, Btu/h	
Instantaneous water heaters, gas	> 50,000 Btu/h and < 200,000 Btu/h[c]	≥ 4,000 (Btu/h)/gal and < 2 gal	0.62 - 0.0019 V, EF	DOE 10 CFR Part 430
	≥ 200,000 Btu/h	≥ 4,000 Btu/h/gal and < 10 gal	80% E_t	ANSI Z21.10.3
	≥ 200,000 Btu/h	≥ 4,000 Btu/h/gal and ≥ 10 gal	80% E_t $(Q/800 + 110\sqrt{V})$ SL, Btu/h	
Storage water heaters, oil	≤ 105,000 Btu/h	≥ 20 gal	0.59 - 0.0019 V, EF	DOE 10 CFR Part 430
	≥ 105,000 Btu/h	< 4,000 Btu/h/gal	78% E_t $(Q/800 + 110\sqrt{V})$ SL, Btu/h	ANSI Z21.10.3
Instantaneous water heaters, oil	≤ 210,000 Btu/h	≥ 4,000 Btu/h/gal and < 2 gal	0.59 - 0.0019V, EF	DOE 10 CFR Part 430
	> 210,000 Btu/h	≥ 4,000 Btu/h/gal and < 10 gal	80% E_t	ANSI Z21.10.3
	> 210,000 Btu/h	≥ 4,000 Btu/h/gal and ≥ 10 gal	78% E_t $(Q/800 + 110\sqrt{V})$ SL, Btu/h	
Hot water supply boilers, gas and oil	≥ 300,000 Btu/h and < 12,500,000 Btu/h	≥ 4,000 Btu/h/gal and < 10 gal	80% E_t	ANSI Z21.10.3
Hot water supply boilers, gas	≥ 300,000 Btu/h and < 12,500,000 Btu/h	≥ 4,000 Btu/h/gal and ≥ 10 gal	80% E_t $(Q/800 + 110\sqrt{V})$ SL, Btu/h	
Hot water supply boilers, oil	> 300,000 Btu/h and < 12,500,000 Btu/h	> 4,000 Btu/h/gal and > 10 gal	78% E_t $(Q/800 + 110\sqrt{V})$ SL, Btu/h	
Pool heaters, gas and oil	All	—	78% E_t	ASHRAE 146
Heat pump pool heaters	All	—	4.0 COP	AHRI 1160
Unfired storage tanks	All	—	Minimum insulation requirement R-12.5 $(h \cdot ft^2 \cdot {}^\circ F)/Btu$	(none)

For SI: °C = [(°F) - 32]/1.8, 1 British thermal unit per hour = 0.2931 W, 1 gallon = 3.785 L, 1 British thermal unit per hour per gallon = 0.078 W/L.

a. Energy factor (EF) and thermal efficiency (E_t) are minimum requirements. In the EF equation, V is the rated volume in gallons.

b. Standby loss (SL) is the maximum Btu/h based on a nominal 70°F temperature difference between stored water and ambient requirements. In the SL equation, Q is the nameplate input rate in Btu/h. In the SL equation for electric water heaters, V is the rated volume in gallons. In the SL equation for oil and gas water heaters and boilers, V is the rated volume in gallons.

c. Instantaneous water heaters with input rates below 200,000 Btu/h must comply with these requirements if the water heater is designed to heat water to temperatures 180°F or higher.

MEASURE CODE: CI-HW_-TKWH-V02-120601

4.4.10 High Efficiency Boiler

Description

To qualify for this measure the installed equipment must be replacement of an existing boiler at the end of its service life, in a commercial or multifamily space with a high efficiency, gas-fired steam or hot water boiler. High efficiency boilers achieve gas savings through the utilization of a sealed combustion chamber and multiple heat exchangers that remove a significant portion of the waste heat from flue gasses. Because multiple heat exchangers are used to remove waste heat from the escaping flue gasses, some of the flue gasses condense and must be drained.

This measure was developed to be applicable to the following program types: TOS, RF. If applied to other program types, the measure savings should be verified.

Definition of Efficient Equipment

To qualify for this measure the installed equipment must be a boiler used 80% or more for space heating, not process, and boiler AFUE, TE (thermal efficiency), or Ec (combustion efficiency) rating must be rated greater than or equal to 85% for hot water boilers and 81% for steam boilers.

Definition of Baseline Equipment

Dependent on when the unit is installed and whether the unit is hot water or steam. The baseline efficiency source is the Energy Independence and Security Act of 2007 with technical amendments from Federal Register, volume 73, Number 145, Monday, July 28, 2008 for boilers <300,000 Btu/h and is Final Rule, Federal Register, volume 74, Number 139, Wednesday, July 22, 2009 for boiler ≥300,000 Btu/h.

Hot water boiler baseline:

Year	Efficiency
Hot Water <300,000 Btu/h < June 1, 2013[84]	80% AFUE
Hot Water <300,000 Btu/h ≥ June 1, 2013	82% AFUE
Hot Water ≥300,000 & ≤2,500,000 Btu/h	80% TE
Hot Water >2,500,000 Btu/h	82% Ec

[84] The Federal baseline for boilers <300,000 btu/hr changes from 80% to 82% in September 2012. To prevent a change in baseline mid-program, the increase in efficiency is delayed until June 2013 when a new program year starts.

Steam boiler baseline:

Year	Efficiency
Steam <300,000 Btu/h < June 1, 2013[85]	75% AFUE
Steam <300,000 Btu/h ≥June 1, 2013	80% AFUE
Steam - all except natural draft ≥300,000 & ≤2,500,000 Btu/h	79% TE
Steam - natural draft ≥300,000 & ≤2,500,000 Btu/h	77% TE
Steam - all except natural draft >2,500,000 Btu/h	79% TE
Steam - natural draft >2,500,000 Btu/h	77% TE

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 20 years[86]

Deemed Measure Cost

The incremental capital cost for this measure depends on efficiency as listed below[87]

Measure Tier	Incr. Cost, per unit
ENERGY STAR® Minimum	$1,470
AFUE 90%	$2,400
AFUE 95%	$3,370
AFUE ≥ 96%	$4,340
Boilers > 300,000 Btu/h with TE (thermal efficiency) rating	Custom

Deemed O&M Cost Adjustments

N/A

Loadshape

N/A

Coincidence Factor

N/A

[85] Ibid.

[86] The Technical support documents for federal residential appliance standards: http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/fb_fr_tsd/appendix_e.pdf Note that this value is below the 20 years used by CA's DEER and the range of 20-40 year estimate made by the Consortium for Energy Efficiency in 2010

[87] Average of low and high incremental cost based on Nicor Gas program data for non-condensing and condensing boilers. Nicor Gas Energy Efficiency Plan 2011 - 2014, May 27, 2011 $1,470 for ≤ 300,000 Btu/hr for non-condensing hydronic boilers >85% AFUE & $3,365 for condensing boilers > 90% AFUE. The exception is $4,340 for AFUE ≥ 96% AFUE which was obtained from extrapolation above the size range that Nicor Gas Energy Efficiency Plan provided for incremental cost.

Algorithm

CALCULATION OF ENERGY SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

ΔTherms = EFLH * Capacity * (1/EfficiencyRating(base)) – (1/EfficiencyRating(actual)) / 100,000

Where:

EFH = Equivalent Full Load Hours for heating[88] (hr)

Building Type	EFLH Zone 1 (Rockford)	Zone 2 (Chicago)	Zone 3 (Springfield)	Zone 4 (Belleville/	Zone 5 (Marion)
Office - High Rise	2,746	2,768	2,656	2,155	2,420
Office - Mid Rise	996	879	824	519	544
Office - Low Rise	797	666	647	343	329
Convenience	696	550	585	272	297
Healthcare Clinic	1,118	1,036	1,029	694	737
Manufacturing Facility	1,116	1,123	904	771	857
Lodging Hotel/ Motel/ Multifamily	2,098	2,050	1,780	1,365	1,666
High School	969	807	999	569	674
Hospital	2,031	1,929	1,863	1,497	1,800
Elementary	970	840	927	524	637
Religious Facility	1,830	1,657	1,730	1,276	1,484
Restaurant	1,496	1,379	1,291	872	1,185
Retail - Strip Mall	1,266	1,147	1,151	732	863
Retail - Department Store	1,065	927	900	578	646
College/University	373	404	376	187	187
Warehouse	416	443	427	226	232
Unknown	1,249	1,163	1,130	786	910

Capacity = Nominal Heating Capacity Boiler Size (btuh)

[88] Equivalent full load hours for heating were developed using eQuest models for various building types averaged across each climate zones for Illinois for the following building types: office, healthcare/clinic, manufacturing, lodging, high school, hospital, elementary school, religious/assembly, restaurant, retail, college and warehouse. eQuest models were those developed for IL lighting interactive effects.

= custom Boiler input capacity in Btu/hr

EfficiencyRating(base) = Baseline Boiler Efficiency Rating, dependant on year and boiler type. Baseline efficiency values by boiler type and capacity are found in the Definition of Baseline Equipment Section

EfficiencyRating(actual) = Efficent Boiler Efficiency Rating use actual value

Measure Type	Actual AFUE
ENERGY STAR® Minimum	85%
AFUE 90%	90%
AFUE 95%	95%
AFUE ≥ 96%	≥ 96%
Custom	Value to one significant digit i.e. 95.7%

EXAMPLE

For example, a 150,000 btu/hr water boiler meeting AFUE 90% in Rockford at a high rise office building , in the year 2012

ΔTherms = 2,746* 150,000 * (1/.80 - 1/.90) / 100,000 Btu/Therm
= 572 Therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-BOIL-V02-120601

4.4.13 Package Terminal Air Conditioner (PTAC) and Package Terminal Heat Pump (PTHP)

Description

A PTAC is a packaged terminal air conditioner that cools and sometimes provides heat through an electric resistance heater (heat strip). A PTHP is a packaged terminal heat pump. A PTHP uses its compressor year round to heat or cool. In warm weather, it efficiently captures heat from inside your building and pumps it outside for cooling. In cool weather, it captures heat from outdoor air and pumps it into your home, adding heat from electric heat strips as necessary to provide heat.

This measure was developed to be applicable to the following program types: TOS NC. If applied to other program types, the measure savings should be verified.

Definition of Efficient Equipment

In order for this characterization to apply, the efficient equipment is assumed to be PTACs or PTHPs that exceed baseline efficiencies replacing existing equipment at the end of its useful life.

Definition of Baseline Equipment

In order for this characterization to apply, the baseline conditions must be met as listed in the reference table.

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 15 years. [89]

Deemed Measure Cost

The incremental capital cost for this equipment is estimated to be $84/ton.[90]

Deemed O&M Cost Adjustments

N/A

Loadshape

Loadshape C03 - Commercial Cooling

Coincidence Factor

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid

[89]Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, Inc., June 2007

[90]DEER 2008 This assumes that baseline shift from IECC 2006 to IECC 2012 carries the same incremental costs. Values should be verified during evaluation

into PJM's Forward Capacity Market. Both values provided are based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren.

CF_{SSP} = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

= 91.3% [91]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

= 47.8% [92]

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Electric savings for PTACs and PTHPs should be calculated using the following algorithms

ENERGY SAVINGS

PTAC ΔkWh[93] = Annual kWh $Savings_{cool}$

PTHP ΔkWh = Annual kWh $Savings_{cool}$ + Annual kWh $Savings_{heat}$

Annual kWh $Savings_{cool}$ = $(kBtu/h_{cool}) * [(1/EERbase) – (1/EERee)] * EFLH_{cool}$

Annual kWh $Savings_{heat}$ = $(kBtu/h_{heat})/3.412 * [(1/COPbase) – (1/COPee)] * EFLH_{heat}$

Where:

$kBtu/h_{cool}$ = capacity of the cooling equipment in kBtu per hour (1 ton of cooling capacity equals 12 kBtu/h).

= Actual installed

[91] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

[92] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year

[93] There are no heating efficiency improvements for PTACs since although some do provide heating, it is always through electric resistance and therefore the COPbase and COPee would be 1.0.

TABLE C403.2.3(3)
MINIMUM EFFICIENCY REQUIREMENTS:
ELECTRICALLY OPERATED PACKAGED TERMINAL AIR CONDITIONERS, PACKAGED TERMINAL HEAT PUMPS, SINGLE-PACKAGE VERTICAL AIR CONDITIONERS, SINGLE VERTICAL HEAT PUMPS, ROOM AIR CONDITIONERS AND ROOM AIR-CONDITIONER HEAT PUMPS

EQUIPMENT TYPE	SIZE CATEGORY (INPUT)	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY		TEST PROCEDURE[a]
			Before 10/08/2012	As of 10/08/2012	
PTAC (cooling mode) new construction	All Capacities	95°F db outdoor air	12.5 - (0.213 × Cap/1000) EER	13.8 - (0.300 × Cap/1000) EER	AHRI 310/380
PTAC (cooling mode) replacements[b]	All Capacities	95°F db outdoor air	10.9 - (0.213 × Cap/1000) EER	10.9 - (0.213 × Cap/1000) EER	
PTHP (cooling mode) new construction	All Capacities	95°F db outdoor air	12.3 - (0.213 × Cap/1000) EER	14.0 - (0.300 × Cap/1000) EER	
PTHP (cooling mode) replacements[b]	All Capacities	95°F db outdoor air	10.8 - (0.213 × Cap/1000) EER	10.8 - (0.213 × Cap/1000) EER	
PTHP (heating mode) new construction	All Capacities	—	3.2 - (0.26 × Cap/1000) COP	3.2 - (0.26 × Cap/1000) COP	
PTHP (heating mode) replacements[b]	All Capacities	—	2.9 - (0.26 × Cap/1000) COP	2.9 - (0.26 × Cap/1000) COP	

For SI: 1 British thermal unit per hour = 0.2931 W, °C = [(°F) - 32]/1.8.
"Cap" = The rated cooling capacity of the project in Btu/h. If the unit's capacity is less than 7000 Btu/h, use 7000 Btu/h in the calculation. If the unit's capacity is greater than 15,000 Btu/h, use 15,000 Btu/h in the calculations.
a. Chapter 6 of the referenced standard contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
b. Replacement unit shall be factory labeled as follows: "MANUFACTURED FOR REPLACEMENT APPLICATIONS ONLY: NOT TO BE INSTALLED IN NEW CONSTRUCTION PROJECTS." Replacement efficiencies apply only to units with existing sleeves less than 16 inches (406 mm) in height and less than 42 inches (1067 mm) in width.

$EFLH_{cool}$ = cooling mode equivalent full load hours; see table below for default values:

Zone	Equivalent Full Load Hours Cooling (EFLHI)[94]	Equivalent Full Load heating Cooling (EFLH)
1 (Rockford)	816	1153
2 (Chicago)	819	1069
3 (Springfield)	1001	885
4 (Belleville)	1261	621
5 (Marion)	819	623

$EFLH_{heat}$ = heating mode equivalent full load hours; see table above for default values.

EERbase = Energy Efficiency Ratio of the baseline equipment; see the table above for values. Since IECC 2009 does not provide EER requirements for air-cooled heat pumps < 65 kBtu/h, assume the following conversion from SEER to EER: EER≈SEER/1.1.

EERee = Energy Efficiency Ratio of the energy efficient equipment. For air-cooled air

[94] Heating and cooling EFLH data based on a series of prototypical small commercial building simulation runs for the Ohio TRM. Values shown are weighted averages across fast food restaurant, full service restaurant, assembly, big box retail, small retail, small office, light industrial and school building models. The prototypes are based on the California DEER study prototypes, modified for local construction practices. Simulations were run using TMY3 weather data for each of the cities listed. Building prototypes used in the energy modeling are described in Appendix A - Prototypical Building Energy Simulation Model Development. The Ohio values were adjusted base on CCD and HDD for IL locations. Further study recommended for IL specific building types.

conditioners < 65 kBtu/h, if the actual EERee is unknown, assume the following conversion from SEER to EER: EER≈SEER/1.1.

= Actual installed

$kBtu/h_{heat}$ = capacity of the heating equipment in kBtu per hour.

= Actual installed

3.412 = Btu per Wh.

COPbase = coefficient of performance of the baseline equipment; see table above for values.

COPee = coefficient of performance of the energy efficient equipment.

= Actual installed

For example a 1 ton replacement cooling unit with no heating with an efficient SEER of 12 in Rockford saves

= [(12) * [(1/7.7) – (1/12)] * 816

= 455 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = (kBtu/h_{cool}) * [(1/EERbase) - (1/EERee)] * CF$$

Depending on situation:

CF_{SSP} = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

= 91.3% [95]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

= 47.8% [96]

[95] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

[96] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year

For example a 1 ton replacement cooling unit with no heating with an efficient EER of 12 in Rockford saves

ΔkW = (12) * [(1/7.7) – (1/12)] *0.913

=0.51

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-PTAC-V02-120601

5.3.5 Gas High Efficiency Boiler

Description

This measure describes the purchase and installation of a new high efficiency, gas-fired hot water boiler in a residential location. High efficiency boilers achieve most gas savings through the utilization of a sealed combustion chamber and multiple heat exchangers that remove a significant portion of the waste heat from flue gasses. Because multiple heat exchangers are used to remove waste heat from the escaping flue gasses, some of the flue gasses condense and must be drained.

This measure was developed to be applicable to the following program types: TOS, NC.
If applied to other program types, the measure savings should be verified.

Definition of Efficient Equipment

To qualify for this measure the installed Boiler must be ENERGY STAR qualified (AFUE rated at or greater than 85% and input capacity less than 300,000 BTUh).

Definition of Baseline Equipment

The baseline equipment for this measure is a new, gas-fired, standard-efficiency water boiler. The current Federal Standard minimum AFUE rating is 80%. For boilers manufactured after September 2012 the Federal Standards is raised to 82% AFUE. Baseline assumptions are therefore provided below:

Program Year	AFUE
June 2012 – May 2013[97]	80%
June 2013 on	82%

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 25 years[98].

Deemed Measure Cost

The incremental install cost for this measure is dependent on tier[99]:

Measure Type	Installation Cost	Incremental Install Cost (June 2012 – May 2013)	Incremental Install Cost (June 2013 on)
AFUE 80%	$3334	n/a	
AFUE 82%	$3543		

[97] There will be some delay to the baseline shift while existing stocks of lower efficiency equipment is sold.
[98] Table 8.3.3 The Technical support documents for federal residential appliance standards: http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/fb_fr_tsd/chapter_8.pdf
[99] Based on data provided in Appendix E of the Appliance Standards Technical Support Documents including equipment cost and installation labor (http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/fb_fr_tsd/appendix_e.pdf). Where efficiency ratings are not provided, the values are interpolated from those that are.

AFUE 85% (Energy Star Minimum)	$4268	$934	$725
AFUE 90%	$4815	$1,481	$1,272
AFUE 95%	$5328	$1,994	$1,785

Deemed O&M Cost Adjustments

N/A

Loadshape

N/A

Coincidence Factor

N/A

Algorithm

Calculation of Savings

Electric Energy Savings

N/A

Summer Coincident Peak Demand Savings

N/A

Natural Gas Savings

ΔTherms = Gas_Boiler_Load * (1/AFUE(base) - 1/AFUE(eff))

Where:

Gas_Boiler_Load[100]

= Estimate of annual household Load for gas boiler heated single-family homes. If location is unknown, assume the average below[101].

= or Actual if informed by site-specific load calculations, ACCA Manual J or

[100] Boiler consumption values are informed by an evaluation which did not identify any fraction of heating load due to domestic hot water (DHW) provided by the boiler. Thus these values are an average of both homes with boilers only providing heat, and homes with boilers that also provide DHW. Heating load is used to describe the household heating need, which is equal to (gas heating consumption * AFUE)

[101] Values are based on household heating consumption values and inferred average AFUE results from Table 3-4, Program Sample Analysis, *Nicor R29 Res Rebate Evaluation Report 092611_REV FINAL to Nicor*). Adjusting to a statewide average using relative HDD values to adjust for the evaluation results focus on northern region. Values for individual cities are then calculated by comparing average HDD to the individual city's HDD.

equivalent[102].

Climate Zone (City based upon)	Gas_Boiler Load (therms)
1 (Rockford)	1275
2 (Chicago)	1218
3 (Springfield)	1043
4 (Belleville)	805
5 (Marion)	819
Average	1158

AFUE(base) = Baseline Boiler Annual Fuel Utilization Efficiency Rating

= Dependent on year as listed below:

Program Year	AFUE(base)
June 2012 – May 2013	80%
June 2013 on	82%

AFUE(eff) = Efficent Boiler Annual Fuel Utilization Efficiency Rating

= Actual. If unknown, use defaults dependent[103] on tier as listed below:

Measure Type	AFUE(eff)
ENERGY STAR®	87.5%
AFUE 90%	92.5%
AFUE 95%	95%

For example, a default sized ENERGY STAR boiler purchased and installed near Springfield in the year 2012

ΔTherms = (1043) * (1/0.8) - 1/0.875)

= 112 Therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-GHEB-V02-120601

[102] The Air Conditioning Contractors of America Manual J, Residential Load Calculation 8th Edition produces equipment sizing loads for Single Family, Multi-single, and Condominiums using input characteristics of the home. A best practice for equipment selection and installation of Heating and Air Conditioning, load calculations should be completed by contractors during the selection process and may be readily available for program data purposes.

[103] Default values per tier selected based upon the average AFUE value for the tier range except for the top tier where the minimum is used due to proximity to the maximum possible.

5.3.6 Gas High Efficiency Furnace

Description

This measure covers the purchase of a new ENERGY STAR-qualified high efficiency gas-fired condensing furnace for residential space heating in place of a new Federal Standard furnace. High efficiency features may include improved heat exchangers and modulating multi-stage burners.

This measure was developed to be applicable to the following program types: TOS, NC.
If applied to other program types, the measure savings should be verified.

Definition of Efficient Equipment

To qualify for this measure the installed equipment must be a residential sized (input energy less than 225,000 BTUh) ENERGY STAR rated natural gas fired furnace with an Annual Fuel Utilization Efficiency (AFUE) rating and fan electrical efficiency in accordance with ENERGY STAR criteria[104], as defined below:

ENERGY STAR Furnaces Specification	Min. AFUE	Min. Fan Efficiency[105]	Max. Air Leakage
Version 2.0 – Effective until 2.1.12	90%	N/A	N/A
Version 3.0 – Effective 2.1.12	95%	2.0%	N/A
Version 4.0 – Effective 2.1.13	95%	2.0%	2.0%

Definition of Baseline Equipment

Although the current Federal Standard for gas furnaces is an AFUE rating of 78%, based upon review of available product in the AHRI database, the baseline efficiency for this characterization is assumed to be 80%. The baseline will be adjusted when the Federal Standard is updated.

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 20 years[106].

Deemed Measure Cost

The incremental capital cost for this measure depends on efficiency as listed below[107]:

---

[104] Source: Final Furnace Version3.0/4.0 Specification schedules available here: http://www.energystar.gov/index.cfm?c=revisions.furnace_spec

[105] Fan efficiency, as determined by the "Interim Approach for Determining Furnace Fan Energy Use Rev. June-2011" is a performance-based metric that was designed to function in a manner that resembles past program criteria requiring an ECM or BPM fan motor.

[106] Table 8.3.3 The Technical support documents for federal residential appliance standards: http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/fb_fr_tsd/chapter_8.pdf

[107] Based on data from Appendix E of the Appliance Standards Technical Support Documents including equipment cost and installation labor (http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/fb_fr_tsd/appendix_e.pdf). Where efficiency ratings are not provided, the values are interpolated from those that are.

AFUE	Installation Cost	Incremental Install Cost
80%	$2011	n/a
90%	$2641	$630
91%	$2727	$716
92%	$2813	$802
93%	$3049	$1,038
94%	$3286	$1,275
95%	$3522	$1,511
96%	$3758	$1,747

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Electrical energy savings from the more fan-efficient (typically using brushless permanent magnet (BPM) blower motor) should also be claimed, please refer to "Furnace Blower Motor" characterization for details.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

If the blower motor is also used for cooling, coincident peak demand savings should also be claimed, please refer to "Furnace Blower Motor" characterization for savings details.

NATURAL GAS SAVINGS

ΔTherms = Gas_Furnace_Heating_Load * (1/AFUE(base) - 1/AFUE(eff))

Where:

Gas_Furnace_Heating_Load

= Estimate of annual household heating load [108] for gas furnace heated single-family homes. If location is unknown, assume the average below[109].

[108] Heating load is used to describe the household heating need, which is equal to (gas consumption * AFUE)
[109] Values are based on household heating consumption values and inferred average AFUE results from Table 3-4, Program Sample Analysis, *Nicor R29 Res Rebate Evaluation Report 092611_REV FINAL to Nicor*) Adjusting to a

= Actual if informed by site-specific load calculations, ACCA Manual J or equivalent[110].

Climate Zone (City based upon)	Gas_Furnace_Heating_Load (therms)
1 (Rockford)	843
2 (Chicago)	806
3 (Springfield)	690
4 (Belleville)	532
5 (Marion)	542
Average	766

AFUE(base) = Baseline Furnace Annual Fuel Utilization Efficiency Rating

= 80%[111]:

AFUE(eff) = Efficent Furnace Annual Fuel Utilization Efficiency Rating

= Actual. If unknown, assume 95%[112]

For example, a 95% AFUE furnace near Rockford and purchased in the year 2012

ΔTherms = 843 * (1/0.8 - 1/0.95)

=166 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-GHEF-V02-120601

statewide average using relative HDD values to adjust for the evaluation results focus on northern region. Values for individual cities are then calculated by comparing average HDD to the individual city's HDD.

110 The Air Conditioning Contractors of America Manual J, Residential Load Calculation 8th Edition produces equipment sizing loads for Single Family, Multi-single, and Condominiums using input characteristics of the home. A best practice for equipment slection and installation of Heating and Air Conditioning, load calculations are commonly completed by contractors during the selection process and may be readily available for program data purposes.

111 Though the Federal Minimum AFUE is 78%, there were only 37 active models listed in the AHRI database at that level (as of 1/16/2013). At AFUE 79% there are 39 and 2,780 at AFUE 80%. There are 5,318 active furnace models listed with AFUE ratings between 78 and 89.9%.

112 Minimum ENERGY STAR efficiency after 2.1.2012.

5.5.4 Exterior Hardwired Compact Fluorescent Lamp (CFL) Fixture

Description

An ENERGY STAR lighting fixture wired for exclusive use with pin-based compact fluorescent lamps is installed in an exterior residential setting. This measure could relate to either a fixture replacement or new installation (i.e. time of sale).

Federal legislation stemming from the Energy Independence and Security Act of 2007 will require all general-purpose light bulbs between 40 and 100W to be approximately 30% more energy efficient than current incandescent bulbs. Production of 100W, standard efficacy incandescent lamps ends in 2012, followed by restrictions on 75W in 2013 and 60W and 40W in 2014. The baseline for this measure will therefore become bulbs (improved incandescent or halogen) that meet the new standard.

To account for these new standards, the expected delay in clearing retail inventory and potential for movement of product across state borders, the first year annual savings for this measure is reduced for 100W equivalent bulbs in June 2012, for 75W equivalent bulbs in June 2013 and for 60 and 40W equivalent bulbs in June 2014.

In addition, since during the lifetime of a CFL, the baseline bulb will be replaced multiple times, the annual savings claim must also be reduced within the life of the measure. For example, for 60W equivalent bulbs installed in 2012, the full savings (as calculated below in the Algorithm) should be claimed for the first two years, but a reduced annual savings based on the EISA-compliant baseline should be claimed for the remainder of the measure life. The appropriate adjustment factors are provided in the 'Mid Life Baseline Adjustment' section below.

Finally, a provision in the EISA regulations requires that by January 1, 2020, all lamps meet efficiency criteria of at least 45 lumens per watt, in essence making the baseline equivalent to a current day CFL. Therefore the measure life (number of years that savings should be claimed) should be reduced once the assumed lifetime of the bulb exceeds 2020. Due to expected delay in clearing retail inventory and to account for the operating life of a halogen incandescent potentially spanning over 2020, this shift is assumed not to occur until mid-2020.

This measure was developed to be applicable to the following program types: TOS, NC. If applied to other program types, the measure savings should be verified.

Definition of Efficient Equipment

The efficient condition is an ENERGY STAR lighting exterior fixture for pin-based compact fluorescent lamps.

Definition of Baseline Equipment

The baseline condition is a standard incandescent exterior fixture, up until when EISA regulations dictate higher efficiency baseline bulbs. A 100W baseline bulb becomes a 72W bulb in June 2012, a 75W bulb becomes 53W in June 2012 and 60W and 40W bulbs become 43W and 29W respectively in June 2014. Annual savings are reduced to account for this baseline shift within the life of a measure and the measure life is reduced to account for the baseline replacements becoming equivalent to a current day CFL by June 2020.

Deemed Lifetime of Efficient Equipment

The expected life of an interior fixture is 20 years[113]. However due to the backstop provision in the Energy Independence and Security Act of 2007 that requires by January 1, 2020, all lamps meet efficiency criteria of at least 45 lumens per watt, the baseline replacement would become a CFL in that year. The expected measure life for CFL fixtures installed June 2012 – May 2013 is therefore assumed to be 8 years. For bulbs installed June 2013 – May 2014, this would be reduced to 7 years and should be reduced each year[114].

Deemed Measure Cost

The incremental cost for an interior fixture is assumed to be $17[115].

Deemed O&M Cost Adjustments

The Net Present Value of the baseline replacement costs for each CFL lumen range and installation year (2012 - 2016) are presented below[116]:

Lumen Range	NPV of replacement costs per bulb			
	Baseline			Efficient
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015	All
1490-2600	$18.34	$16.28	$14.12	$1.90
1050-1489	$17.36	$16.28	$14.12	
750-1049	$15.50	$15.30	$14.12	
310-749	$15.50	$15.30	$14.12	

The annual levelized baseline replacement costs using the statewide real discount rate of 5.23% are presented below:

Lumen Range	Levelized annual replacement costs per bulb			
	Baseline			Efficient
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015	All
1490-2600	$2.86	$2.54	$2.20	$0.30
1050-1489	$2.71	$2.54	$2.20	
750-1049	$2.42	$2.39	$2.20	
310-749	$2.42	$2.39	$2.20	

[113] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007 (http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf) gives 20 years for an interior fluorescent fixture.

[114] Due to expected delay in clearing stock from retail outlets and to account for the operating life of a halogen incandescent potentially spanning over 2020, this shift is assumed not to occur until mid-2020.

[115] ENERGY STAR Qualified Lighting Savings Calculator default incremental cost input for exterior fixture (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/LightingCalculator.xlsx?b299-55ae&b299-55ae)

[116] See 'RES CFL Fixture O&M calc.xls' for more details.

LOADSHAPE

Loadshape R07 - Residential Outdoor Lighting

COINCIDENCE FACTOR

The summer peak coincidence factor is assumed to be 0.4%[117].

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = ((WattsBase - WattsEE) / 1000) * ISR * Hours$$

Where:

WattsBase = Based on lumens of CFL bulb and program year purchased:

Minimum Lumens	Maximum Lumens	Incandescent Equivalent Pre-EISA 2007 ($Watts_{Base}$)	Incandescent Equivalent Post-EISA 2007 ($Watts_{Base}$)	Effective date from which Post – EISA 2007 assumption should be used
1490	2600	100	72	June 2012
1050	1489	75	53	June 2013
750	1049	60	43	June 2014
310	749	40	29	June 2014

WattsEE = Actual wattage of CFL purchased

[117] Estimated based on Commercial Outdoor Lighting coincidence factor calculation from analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. Residential Outdoor Lighting is not provided in this data set.

ISR = In Service Rate or the percentage of units rebated that get installed.

Program	Weighted Average 1st year In Service Rate (ISR)	2nd year Installations	3rd year Installations	Final Lifetime In Service Rate
Retail (Time of Sale)	87.5%[118]	5.7%	4.8%	98.0%[119]
Direct Install	96.9[120]			

Hours = Average hours of use per year

=1643 (4.5 hrs per day)[121]

Deferred Installs

As presented above, the characterization assumes that a percentage of bulbs purchased are not installed until Year 2 and Year 3 (see ISR assumption above). The Illinois Technical Advisory Committee has determined the following methodology for calculating the savings of these future installs.

Year 1 (Purchase Year) installs: Characterized using assumptions provided above or evaluated assumptions if available.

Year 2 and 3 installs: Characterized using delta watts assumption and hours of use from the Install Year i.e. the actual deemed (or evaluated if available) assumptions active in Year 2 and 3 should be applied.

The NTG factor for the Purchase Year should be applied.

For example, for a 2 x 14W pin based CFL fixture (60W standard incandescent and 43W EISA qualified incandescent/halogen) purchased in 2013.

$\Delta kWH_{1st\ year\ installs}$ = ((120 - 28) / 1000) * 0.875 * 1643

118 1st year in service rate is based upon review of PY2-3 evaluations from ComEd (see 'IL RES Lighting ISR.xls' for more information. The average first year ISR was calculated weighted by the number of bulbs in the each year's survey.

119 The 98% Lifetime ISR assumption is consistent with the assumption for standard CFLs (in the absence of evidence that it should be different for this bulb type) based upon review of two evaluations:
'Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009' and 'KEMA Inc, Feb 2010, Final Evaluation Report:, Upstream Lighting Program, Volume 1.' This implies that only 2% of bulbs purchased are never installed. The second and third year installations are based upon Ameren analysis of the Californian KEMA study showing that 54% of future installs occur in year 2 and 46% in year 3. The 2nd and 3rd year installations should be counted as part of those future program year savings.

120 In the absence of evaluation results for Direct Install Fixtures specifically, this is made consistent with the Direct Install CFL measure which is based upon review of the PY2 and PY3 ComEd Direct Install program surveys.

121 Updated results from above study, presented in 2005 memo;
http://publicservice.vermont.gov/energy/ee_files/efficiency/eval/marivtfinalresultsmemodelivered.pdf

= 132.3 kWh

$\Delta kWH_{2nd\ year\ installs}$ = ((86 - 28) / 1000) * 0.057 * 1643

= 5.4 kWh

Note: Here we assume no change in hours assumption. NTG value from Purchase year applied.

$\Delta kWH_{3rd\ year\ installs}$ = ((86 - 28) / 1000) * 0.048 * 1643

= 4.6 kWh

MID LIFE BASELINE ADJUSTMENT

During the lifetime of a CFL, a baseline incandescent bulb would need to be replaced multiple times. Since the baseline bulb changes over time the annual savings claim must be reduced within the life of the measure to account for this baseline shift.

For example, for 60W equivalent bulbs installed in 2012, the full savings (as calculated above in the Algorithm) should be claimed for the first two years, but a reduced annual savings claimed for the remainder of the measure life. If the delta watts assumption is already based on the post EISA value, no mid-life adjustment is necessary. For deferred installs (described above) the delta watts and appropriate mid life adjustment (if any) should be applied.

The appropriate adjustment factors are provided below.

Lumen Range	Pre EISA WattsBase	Post EISA WattsBase	CFL Equivalent	Delta Watts Before EISA	Delta Watts After EISA	Mid Life Adjustment	Adjustment made from date
1490-2600	100	72	25	75	47	63%	N/A (2012 is already post EISA)
1050-1489	75	53	20	55	33	60%	June, 2013
750-1049	60	43	14	46	29	63%	June, 2014
310-749	40	29	11	29	18	62%	June, 2014

For example, a 2 x 14W pin based CFL fixture *installed* in 2013 (i.e. for this example we are ignoring the ISR):

First Year savings:

$\Delta kWH_{1st\ year}$ = ((120 - 28) / 1000) * 1643

= 151.2 kWh

This value should be claimed in June 2013 – May 2014. However after June 2014 the baseline replacement bulb shifts to the EISA compliant 43W bulb and so savings for that same bulb purchased and installed in 2013 will claim the following in that second year and for all subsequent years through the measure life:

Annual savings for same installed bulbs after 1^{st} replacement:

$\Delta kWH_{remaining\ years}$ = ((86 - 28) / 1000) * 1643

= 95.3 kWh

Another way to calculate this is to use the mid life adjustment factors provided above;

= 151.2 * 0.63

= 95.3 kWh

Note these adjustments should be applied to kW and fuel impacts.

Example showing both deferred bulb installs and mid life adjustment.

A 2 x 14W pin based CFL fixture is *purchased* in 2012:

First year savings:

$\Delta kWH_{1st\ year\ installs}$ = ((120 - 28) / 1000) * 0.875 * 1643

= 132.3 kWh

Second year savings:

$\Delta kWH_{1st\ year\ installs}$ = 132.3 * 0.63

= 83.3 kWh

Plus second year installs:

$\Delta kWH_{2nd\ year\ installs}$ = ((86 - 28) / 1000) * 0.057 * 1643

= 5.4 kWh

ΔkWH_{Total} = 83.3 + 5.4 = 88.7 kWh

Third year savings:

$\Delta kWH_{1st\ year\ installs}$ = 83.3 kWh

$\Delta kWH_{2nd\ year\ installs}$ = 5.4 kWh

$\Delta kWH_{3rd\ year\ installs}$ = ((86 - 28) / 1000) * 0.048 * 1643

= 4.6 kWh

ΔkWH_{Total} = 83.3 + 5.4 + 4.6 = 93.3 kWh

Note the measure life for each year's install would end at 2020 (due to the EISA backstop provision of 2020).

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ((WattsBase - WattsEE) / 1 000) * ISR * CF

Where:

CF = Summer Peak Coincidence Factor for measure.

= 0.4%[122]

Other factors as defined above

For example, a 2 x 14W pin-based CFL fixture is purchased in 2013:

$\Delta kW_{1st\ year}$ = ((120 - 28) / 1000) * 0.875 * 0.004

= 0.0003 kW

Second and third year install savings should be calculated using the appropriate ISR and the delta watts and hours from the install year. The appropriate baseline shift adjustment should then be applied to all installs.

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

In order to account for the shift in baseline due to the Energy Independence and Security Act of 2007, an equivalent annual levelized baseline replacement cost over the lifetime of the CFL is calculated (see 'RES CFL Fixture O&M calc.xls'). The key assumptions used in this calculation are documented below[123]:

	Standard Incandescent	Efficient Incandescent	CFL
Replacement Cost	$0.50	$1.50	$2.50
Component Rated Life (hrs)	1000	1000[124]	8000

The Net Present Value of the baseline replacement costs for each CFL lumen range and installation year (2012 - 2016) are presented below:

Lumen Range	NPV of replacement costs per bulb			
	Baseline			Efficient
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015	All
1490-2600	$18.34	$16.28	$14.12	$1.90
1050-1489	$17.36	$16.28	$14.12	

122 Estimated based on Commercial Outdoor Lighting coincidence factor calculation from analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. Residential Outdoor Lighting is not provided in this data set.
123 See 'RES CFL Fixture O&M calc.xls' for more details.
124 The manufacturers of the new minimally compliant EISA Halogens are using regular incandescent lamps with halogen fill gas rather than halogen infrared to meet the standard and so the component rated life is equal to the standard incandescent.

750-1049	$15.50	$15.30	$14.12	
310-749	$15.50	$15.30	$14.12	

The annual levelized baseline replacement costs using the statewide real discount rate of 5.23% are presented below:

Lumen Range	Levelized annual replacement costs per bulb			
	Baseline			Efficient
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015	All
1490-2600	$2.86	$2.54	$2.20	$0.30
1050-1489	$2.71	$2.54	$2.20	
750-1049	$2.42	$2.39	$2.20	
310-749	$2.42	$2.39	$2.20	

MEASURE CODE: RS-LTG-EFIX-V02-120601

5.5.5 Interior Hardwired Compact Fluorescent Lamp (CFL) Fixture

Description

An ENERGY STAR lighting fixture wired for exclusive use with pin-based compact fluorescent lamps is installed in an interior residential setting. This measure could relate to either a fixture replacement or new installation (i.e. time of sale).

Federal legislation stemming from the Energy Independence and Security Act of 2007 will require all general-purpose light bulbs between 40 and 100W to be approximately 30% more energy efficient than current incandescent bulbs. Production of 100W, standard efficacy incandescent lamps ends in 2012, followed by restrictions on 75W in 2013 and 60W and 40W in 2014. The baseline for this measure will therefore become bulbs (improved incandescent or halogen) that meet the new standard.

To account for these new standards, the expected delay in clearing retail inventory and potential for movement of product across state borders, the first year annual savings for this measure is reduced for 100W equivalent bulbs in June 2012, for 75W equivalent bulbs in June 2013 and for 60 and 40W equivalent bulbs in June 2014.

In addition, since during the lifetime of a CFL, the baseline bulb will be replaced multiple times, the annual savings claim must also be reduced within the life of the measure. For example, for 60W equivalent bulbs installed in 2012, the full savings (as calculated below in the Algorithm) should be claimed for the first two years, but a reduced annual savings based on the EISA-compliant baseline should be claimed for the remainder of the measure life. The appropriate adjustment factors are provided in the 'Mid Life Baseline Adjustment' section below.

Finally, a provision in the EISA regulations requires that by January 1, 2020, all lamps meet efficiency criteria of at least 45 lumens per watt, in essence making the baseline equivalent to a current day CFL. Therefore the measure life (number of years that savings should be claimed) should be reduced once the assumed lifetime of the bulb exceeds 2020. Due to expected delay in clearing retail inventory and to account for the operating life of a halogen incandescent potentially spanning over 2020, this shift is assumed not to occur until mid-2020.

This measure was developed to be applicable to the following program types: TOS, NC. If applied to other program types, the measure savings should be verified.

Definition of Efficient Equipment

The efficient condition is an ENERGY STAR lighting interior fixture for pin-based compact fluorescent lamps.

Definition of Baseline Equipment

The baseline condition is a standard incandescent interior fixture, up until when EISA regulations dictate higher efficiency baseline bulbs. A 100W baseline bulb becomes a 72W bulb in June 2012, a 75W bulb becomes 53W in June 2012 and 60W and 40W bulbs become 43W and 29W respectively in June 2014. Annual savings are reduced to account for this baseline shift within the life of a measure and the measure life is reduced to account for the baseline replacements becoming equivalent to a current day CFL by June 2020..

Deemed Lifetime of Efficient Equipment

The expected life of an interior fixture is 20 years[125]. However due to the backstop provision in the Energy

[125] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007 (http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf) gives 20 years for an interior fluorescent fixture.

Independence and Security Act of 2007 that requires by January 1, 2020, all lamps meet efficiency criteria of at least 45 lumens per watt, the baseline replacement would become equivalent to a CFL in that year. The expected measure life for CFL fixtures installed June 2012 – May 2013 is therefore assumed to be 8 years. For bulbs installed June 2013 – May 2014, this would be reduced to 7 years and should be reduced each year[126].

DEEMED MEASURE COST

The incremental cost for an interior fixture is assumed to be $32[127].

DEEMED O&M COST ADJUSTMENTS[128]

Residential and in-unit Multi Family:

The Net Present Value of the baseline replacement costs for each CFL lumen range and installation year (2012 - 2016) are presented below:

	NPV of replacement costs per bulb			
	Baseline			Efficient
Lumen Range	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015	All
1490-2600	$8.44	$7.41	$6.32	$0.00 (No replacements within measure life)
1050-1489	$8.44	$7.41	$6.32	
750-1049	$7.50	$7.41	$6.32	
310-749	$7.50	$7.41	$6.32	

The annual levelized baseline replacement costs using the statewide real discount rate of 5.23% are presented below:

	Levelized annual replacement costs per bulb			
	Baseline			Efficient
Lumen Range	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015	All
1490-2600	$1.32	$1.16	$0.99	$0.00 (No replacements within measure life)
1050-1489	$1.32	$1.16	$0.99	
750-1049	$1.17	$1.16	$0.99	
310-749	$1.17	$1.16	$0.99	

Multi Family common areas:

The Net Present Value of the baseline replacement costs for each CFL lumen range and installation year (2012 -

126 Due to expected delay in clearing stock from retail outlets and to account for the operating life of a halogen incandescent potentially spanning over 2020, this shift is assumed not to occur until mid-2020.

127 ENERGY STAR Qualified Lighting Savings Calculator default incremental cost input for interior fixture (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/LightingCalculator.xlsx?b299-55ae&b299-55ae)

128 See ‘RES CFL Fixture O&M calc.xls’ for more details.

2016) are presented below:

Lumen Range	NPV of replacement costs			
	Baseline			Efficient
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015	All
1490-2600	$57.47	$51.35	$44.90	$4.89
1050-1489	$52.62	$51.35	$44.90	
750-1049	$47.08	$46.50	$44.90	
310-749	$47.08	$46.50	$44.90	

The annual levelized baseline replacement costs using the statewide real discount rate of 5.23% are presented below:

Lumen Range	Levelized annual replacement cost savings			
	Baseline			Efficient
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015	All
1490-2600	$8.97	$8.02	$7.01	$0.76
1050-1489	$8.22	$8.02	$7.01	
750-1049	$7.35	$7.26	$7.01	
310-749	$7.35	$7.26	$7.01	

LOADSHAPE

Loadshape R06 - Residential Indoor Lighting
Loadshape C06 - Commercial Indoor Lighting[129]

COINCIDENCE FACTOR

The summer peak coincidence factor is assumed to be 9.5%[130] for Residential and in-unit Multi Family bulbs and 75%[131] for Multi Family common area bulbs.

Algorithm

[129] For Multi Family common area lighting.
[130] Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation. "ComEd Residential Energy Star Lighting Program Metering Study: Overview of Study Protocols" http://www.icc.illinois.gov/downloads/public/edocket/303835.pdf
"Memo RE: Lighting Logger Study Results – Version 2, Date: May 27, 2011, To: David Nichols and ComEd Residential Lighting Interested Parties, From: Amy Buege and Jeremy Eddy; Navigant Evaluation Team" http://www.icc.illinois.gov/downloads/public/edocket/303834.pdf
[131] Coincidence factor is based on healthcare/clinic value (used as proxy for multi family common area lighting with similar hours of use) developed using Equest models for various building types averaged across 5 climate zones for Illinois for the following building types.

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh = ((WattsBase - WattsEE) / 1000) * ISR * Hours * WHFe

Where:

WattsBase = Based on lumens of CFL bulb and program year purchased:

Minimum Lumens	Maximum Lumens	Incandescent Equivalent Pre-EISA 2007 ($Watts_{Base}$)	Incandescent Equivalent Post-EISA 2007 ($Watts_{Base}$)	Effective date from which Post – EISA 2007 assumption should be used
1490	2600	100	72	June 2012
1050	1489	75	53	June 2013
750	1049	60	43	June 2014
310	749	40	29	June 2014

WattsEE = Actual wattage of CFL purchased

ISR = In Service Rate or the percentage of units rebated that get installed.

Program	Weighted Average 1st year In Service Rate (ISR)	2nd year Installations	3rd year Installations	Final Lifetime In Service Rate
Retail (Time of Sale)	87.5%[132]	5.7%	4.8%	98.0%[133]
Direct Install	96.9[134]			

Hours = Average hours of use per year

[132] 1st year in service rate is based upon review of PY2-3 evaluations from ComEd (see 'IL RES Lighting ISR.xls' for more information. The average first year ISR was calculated weighted by the number of bulbs in the each year's survey.

[133] The 98% Lifetime ISR assumption is consistent with the assumption for standard CFLs (in the absence of evidence that it should be different for this bulb type) based upon review of two evaluations:
'Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009' and 'KEMA Inc, Feb 2010, Final Evaluation Report:, Upstream Lighting Program, Volume 1.' This implies that only 2% of bulbs purchased are never installed. The second and third year installations are based upon Ameren analysis of the Californian KEMA study showing that 54% of future installs occur in year 2 and 46% in year 3. The 2nd and 3rd year installations should be counted as part of those future program year savings.

[134] In the absence of evaluation results for Direct Install Fixtures specifically, this is made consistent with the Direct Install CFL measure which is based upon review of the PY2 and PY3 ComEd Direct Install program surveys.

Installation Location	Hours
Residential and in-unit Multi Family	938 [135]
Multi Family Common Areas	5950[136]

WHFe = Waste heat factor for energy to account for cooling energy savings from efficient lighting

Bulb Location	WHFe
Interior single family or unknown location	1.06 [137]
Multi family in unit	1.04 [138]
Multi family common area	1.04 [139]

Deferred Installs

As presented above, the characterization assumes that a percentage of bulbs purchased are not installed until Year 2 and Year 3 (see ISR assumption above). The Illinois Technical Advisory Committee has determined the following methodology for calculating the savings of these future installs.

Year 1 (Purchase Year) installs: Characterized using assumptions provided above or evaluated assumptions if available.

Year 2 and 3 installs: Characterized using delta watts assumption and hours of use from the Install Year i.e. the actual deemed (or evaluated if available) assumptions active in Year 2 and 3 should be applied.

The NTG factor for the Purchase Year should be applied.

For example, for a 2 x 14W pin based CFL fixture (60W standard incandescent and 43W EISA qualified incandescent/halogen) purchased in 2013.

$\Delta kWH_{1st\ year\ installs}$ = ((120 - 28) / 1000) * 0.875 * 938 * 1.06

[135] Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation.

[136] Multi family common area lighting assumption is 16.3 hours per day (5950 hours per year) based on Focus on Energy Evaluation, ACES Deemed Savings Desk Review, November 2010.

[137] The value is estimated at 1.06 (calculated as 1 + (0.66*(0.27 / 2.8)). Based on cooling loads decreasing by 27% of the lighting savings (average result from REMRate modeling of several different configurations and IL locations of homes), assuming typical cooling system operating efficiency of 2.8 COP (starting from standard assumption of SEER 10.5 central AC unit, converted to 9.5 EER using algorithm (-0.02 * SEER2) + (1.12 * SEER) (from Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder), converted to COP = EER/3.412 = 2.8COP) and 66% of homes in Illinois having central cooling ("Table HC7.9 Air Conditioning in Homes in Midwest Region, Divisions, and States, 2009 from Energy Information Administration", 2009 Residential Energy Consumption Survey; http://www.eia.gov/consumption/residential/data/2009/xls/HC7.9%20Air%20Conditioning%20in%20Midwest%20Region.xls)

[138] As above but using estimate of 45% of multi family buildings in Illinois having central cooling (based on data from "Table HC7.1 Air Conditioning in U.S. Homes, By Housing Unit Type, 2009" which is for the whole of the US, scaled to IL air conditioning prevalence compared to US average); http://205.254.135.7/consumption/residential/data/2009/xls/HC7.1%20Air%20Conditioning%20by%20Housing%20Unit%20Type.xls

[139] Ibid.

= 80.0 kWh

$\Delta kWH_{2nd\ year\ installs}$ = ((86 - 28) / 1000) * 0.057 * 938 * 1.06

= 3.3 kWh

Note: Here we assume no change in hours assumption. NTG value from Purchase year applied.

$\Delta kWH_{3rd\ year\ installs}$ = ((86 - 28) / 1000) * 0.048 * 938 * 1.06

= 2.8 kWh

Mid Life Baseline Adjustment

During the lifetime of a CFL, a baseline incandescent bulb would need to be replaced multiple times. Since the baseline bulb changes over time the annual savings claim must be reduced within the life of the measure to account for this baseline shift.

For example, for 60W equivalent bulbs installed in 2012, the full savings (as calculated above in the Algorithm) should be claimed for the first two years, but a reduced annual savings claimed for the remainder of the measure life. If the delta watts assumption is already based on the post EISA value, no mid-life adjustment is necessary. For deferred installs (described above) the delta watts and appropriate mid life adjustment (if any) should be applied.

The appropriate adjustment factors are provided below.

Lumen Range	Pre EISA WattsBase	Post EISA WattsBase	CFL Equivalent	Delta Watts Before EISA	Delta Watts After EISA	Mid Life Adjustment	Adjustment made from date
1490-2600	100	72	25	75	47	63%	N/A (2012 is already post EISA)
1050-1489	75	53	20	55	33	60%	June, 2013
750-1049	60	43	14	46	29	63%	June, 2014
310-749	40	29	11	29	18	62%	June, 2014

For example, a 2 x 14W pin based CFL fixture *installed* in 2013 (i.e. for this example we are ignoring the ISR):

First Year savings:

$\Delta kWH_{1st\ year}$ = ((120 - 28) / 1000) * 938 * 1.06

= 91.5 kWh

This value should be claimed in June 2013 – May 2014. However after June 2014 the baseline replacement bulb shifts to the EISA compliant 43W bulb and so savings for that same bulb purchased and installed in 2013 will claim the following in that second year and for all subsequent years through the measure life:

Annual savings for same installed bulbs after 1^{st} replacement:

$\Delta kWH_{remaining\ years}$ = ((86 - 28) / 1000) * 938 * 1.06

= 57.7 kWh

Another way to calculate this is to use the mid life adjustment factors provided above;

= 91.5 * 0.63

=57.7 kWh

Example showing both deferred bulb installs and mid life adjustment.

A 2 x 14W pin based CFL fixture is *purchased* in 2012:

First year savings:

$\Delta kWH_{1st\ year\ installs}$ = ((120 - 28) / 1000) * 0.875 * 938 * 1.06

= 80.0 kWh

Second year savings:

$\Delta kWH_{1st\ year\ installs}$ = 80.0 * 0.63

= 50.4 kWh

Plus second year installs:

$\Delta kWH_{2nd\ year\ installs}$ = ((86 - 28) / 1000) * 0.057 * 938 * 1.06

= 3.3 kWh

ΔkWH_{Total} = 50.4 + 3.3 = 53.7 kWh

Third year savings:

$\Delta kWH_{1st\ year\ installs}$ = 50.4 kWh

$\Delta kWH_{2nd\ year\ installs}$ = 3.3 kWh

$\Delta kWH_{3rd\ year\ installs}$ = ((86 - 28) / 1000) * 0.048 * 938 * 1.06

= 2.8 kWh

ΔkWH_{Total} = 50.4 + 3.3 + 2.8 = 56.5 kWh

Note the measure life for each year's install would end at 2020 (due to the EISA backstop provision of 2020).

HEATING PENALTY

If electric heated building:

ΔkWh[140] = - (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF) / ηHeat

Where:

HF = Heating Factor or percentage of light savings that must be heated

[140] Negative value because this is an increase in heating consumption due to the efficient lighting.

= 49%[141] for interior or unknown location

= 0% for unheated location

ηHeat = Efficiency in COP of Heating equipment

= actual. If not available use[142]:

System Type	Age of Equipment	HSPF Estimate	ηHeat (COP Estimate)
Heat Pump	Before 2006	6.8	2.00
	After 2006	7.7	2.26
Resistance	N/A	N/A	1.00

For example, a 2 x 14W pin-based CFL fixture is purchased in 2013 and installed in home with 2.0 COP Heat Pump:

$\Delta kWh_{1st\ year}$ = - (((120 – 28) / 1000) * 0.875 * 938 * 0.49) / 2.0

= - 18.5 kWh

Second and third year install savings should be calculated using the appropriate ISR and the delta watts and hours from the install year. The appropriate baseline shift adjustment should then be applied to all installs.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ((WattsBase - WattsEE) / 1 000) * ISR * WHFd * CF

Where:

[141] This means that heating loads increase by 49% of the lighting savings. This is based on the average result from REMRate modeling of several different configurations and IL locations of homes.

[142] These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.

WHFd = Waste heat factor for demand to account for cooling savings from efficient lighting.

Bulb Location	WHFd
Interior single family or unknown location	1.11[143]
Multi family in unit	1.07[144]
Multi family common area	1.07 [145]
Exterior or uncooled location	1.0

CF = Summer Peak Coincidence Factor for measure.

Bulb Location	CF
Interior single family or unknown location	9.5% [146]
Multi family in unit	9.5% [147]
Multi family common area	75% [148]

Other factors as defined above

For example, a 14W pin-based CFL fixture is purchased in 2013:

$\Delta kW_{1st\ year}$ = ((120 - 28) / 1000) * 0.875 * 1.11 * 0.095

= 0.0085 kW

Second and third year install savings should be calculated using the appropriate ISR and the delta watts and hours from the install year. The appropriate baseline shift adjustment should then be applied to all installs.

NATURAL GAS SAVINGS

ΔTherms[149] = - (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF * 0.03412) / ηHeat

---

[143] The value is estimated at 1.11 (calculated as 1 + (0.66 * 0.466 / 2.8)). See footnote relating to WHFe for details. Note the 46.6% factor represents the average Residential cooling coincidence factor calculated by dividing average load during the peak hours divided by the maximum cooling load.

[144] As above but using estimate of 45% of multi family buildings in Illinois having central cooling (based on data from "Table HC7.1 Air Conditioning in U.S. Homes, By Housing Unit Type, 2009" which is for the whole of the US, scaled to IL air conditioning prevalence compared to US average); http://205.254.135.7/consumption/residential/data/2009/xls/HC7.1%20Air%20Conditioning%20by%20Housing%20Unit%20Type.xls .

[145] Ibid

[146] Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation. "ComEd Residential Energy Star Lighting Program Metering Study: Overview of Study Protocols" http://www.icc.illinois.gov/downloads/public/edocket/303835.pdf
"Memo RE: Lighting Logger Study Results – Version 2, Date: May 27, 2011, To: David Nichols and ComEd Residential Lighting Interested Parties, From: Amy Buege and Jeremy Eddy; Navigant Evaluation Team" http://www.icc.illinois.gov/downloads/public/edocket/303834.pdf

[147] Ibid.

[148] Coincidence factor is based on healthcare/clinic value (used as proxy for multi family common area lighting with similar hours of use) developed using Equest models for various building types averaged across 5 climate zones for Illinois for the following building types.

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49%[150] for interior or unknown location

= 0% for unheated location

0.03412 =Converts kWh to Therms

ηHeat = Efficiency of heating system

=70%[151]

For example, a 2 x 14W pin-based CFL fixture is purchased in 2013 and installed in home with gas heat at 70% efficiency:

$\Delta Therms_{1st\ year}$ = -((120 - 28) / 1000) * 0.875 * 938 * 0.49 * 0.03412) / 0.7

= - 1.8 Therms

Second and third year install savings should be calculated using the appropriate ISR and the delta watts and hours from the install year. The appropriate baseline shift adjustment should then be applied to all installs.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

In order to account for the shift in baseline due to the Energy Independence and Security Act of 2007, an equivalent annual levelized baseline replacement cost over the lifetime of the CFL is calculated (see 'RES CFL Fixture O&M calc.xls'). The key assumptions used in this calculation are documented below:

	Standard Incandescent	Efficient Incandescent	CFL
Replacement Cost	$0.50	$1.50	$2.50
Component Rated Life (hrs)	1000	1000[152]	8000 (or 10,000

149 Negative value because this is an increase in heating consumption due to the efficient lighting.

150 This means that heating loads increase by 49% of the lighting savings. This is based on the average result from REMRate modeling of several different configurations and IL locations of homes.

151 This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on Energy Information Administration, 2009 Residential Energy Consumption Survey: http://www.eia.gov/consumption/residential/data/2009/xls/HC6.9%20Space%20Heating%20in%20Midwest%20Region.xls))

In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:

(0.24*0.92) + (0.76*0.8) * (1-0.15) = 0.70

152 The manufacturers of the new minimally compliant EISA Halogens are using regular incandescent lamps with halogen fill gas rather than halogen infrared to

			for multifamily common areas)

Residential and in-unit Multi Family:

The Net Present Value of the baseline replacement costs for each CFL lumen range and installation year (2012 - 2016) are presented below:

Lumen Range	NPV of replacement costs per bulb			
	Baseline			Efficient
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015	All
1490-2600	$8.44	$7.41	$6.32	$0.00 (No replacements within measure life)
1050-1489	$8.44	$7.41	$6.32	
750-1049	$7.50	$7.41	$6.32	
310-749	$7.50	$7.41	$6.32	

The annual levelized baseline replacement costs using the statewide real discount rate of 5.23% are presented below:

Lumen Range	Levelized annual replacement costs per bulb			
	Baseline			Efficient
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015	All
1490-2600	$1.32	$1.16	$0.99	$0.00 (No replacements within measure life)
1050-1489	$1.32	$1.16	$0.99	
750-1049	$1.17	$1.16	$0.99	
310-749	$1.17	$1.16	$0.99	

Multi Family common areas:

The Net Present Value of the baseline replacement costs for each CFL lumen range and installation year (2012 - 2016) are presented below:

Lumen Range	NPV of replacement costs			
	Baseline			Efficient
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015	All
1490-2600	$57.47	$51.35	$44.90	$4.89
1050-1489	$52.62	$51.35	$44.90	
750-1049	$47.08	$46.50	$44.90	

meet the standard and so the component rated life is equal to the standard incandescent.

310-749	$47.08	$46.50	$44.90	

The annual levelized baseline replacement costs using the statewide real discount rate of 5.23% are presented below:

Lumen Range	Levelized annual replacement cost savings			
	Baseline			Efficient
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015	All
1490-2600	$8.97	$8.02	$7.01	$0.76
1050-1489	$8.22	$8.02	$7.01	
750-1049	$7.35	$7.26	$7.01	
310-749	$7.35	$7.26	$7.01	

MEASURE CODE: RS-LTG-IFIX-V02-120601

5.6.1 Air Sealing

Description

Thermal shell air leaks are sealed through strategic use and location of air-tight materials. Leaks are detected and leakage rates measured with the assistance of a blower-door. The algorithm for this measure can be used when the program implementation does not allow for more detailed forecasting through the use of residential modeling software.

This measure was developed to be applicable to the following program types: RF.
If applied to other program types, the measure savings should be verified.

Definition of Efficient Equipment

Air sealing materials and diagnostic testing should meet all eligibility program qualification criteria. The initial and final tested leakage rates should be performed in such a manner that the identified reductions can be properly discerned, particularly in situations wherein multiple building envelope measures may be implemented simultaneously.

Definition of Baseline Equipment

The existing air leakage should be determined through approved and appropriate test methods using a blower door. The baseline condition of a building upon first inspection significantly impacts the opportunity for cost-effective energy savings through air-sealing.

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 15 years.[153]

Deemed Measure Cost

The actual capital cost for this measure should be used in screening.

Deemed O&M Cost Adjustments

N/A

Loadshape

Loadshape R08 - Residential Cooling
Loadshape R09 - Residential Electric Space Heat
Loadshape R10 - Residential Electric Heating and Cooling

Coincidence Factor

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid

[153] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

into PJM's Forward Capacity Market. Both values provided are based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren.

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)
= 91.5%[154]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)
= 46.6%[155]

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh = ΔkWh_cooling + ΔkWh_heating

Where:

ΔkWh_cooling = If central cooling, reduction in annual cooling requirement due to air sealing

= [(((CFM50_existing - CFM50_new)/N_cool) * 60 * 24 * CDD * DUA * 0.018) / (1000 * ηCool)] * LM

CFM50_existing = Infiltration at 50 Pascals as measured by blower door before air sealing.

= Actual

CFM50_new = Infiltration at 50 Pascals as measured by blower door after air sealing.

= Actual

N_cool = Conversion factor from leakage at 50 Pascal to leakage at natural conditions
=Dependent on exposure:[156]

Climate Zone	Exposure	N-Factor
Zone 2	Well Shielded	22.2
	Normal	18.5
	Exposed	16.7
Zone 3	Well Shielded	25.8
	Normal	21.5

[154] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.
[155] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.
[156] N-factor is used to convert 50-pascal blower door air flows to natural air flows and is dependent on geographic location and exposure of the home to wind (impacts of stack effect based on height of building will not be significant because of reduced delta T during the cooling season) , based on methodology developed by Lawrence Berkeley Laboratory (LBL). N-factor values copied from J. Krigger, C. Dorsi; "Residential Energy: Cost Savings and Comfort for Existing Buildings", p284.

	Exposed	19.4

60 * 24 = Converts Cubic Feet per Minute to Cubic Feet per Day

CDD = Cooling Degree Days

= Dependent on location[157]:

Climate Zone (City based upon)	CDD 65
1 (Rockford)	820
2 (Chicago)	842
3 (Springfield)	1,108
4 (Belleville)	1,570
5 (Marion)	1,370

DUA = Discretionary Use Adjustment (reflects the fact that people do not always operate their AC when conditions may call for it).

= 0.75 [158]

0.018 = Specific Heat Capacity of Air (BTU/ft^3*°F)

1000 = Converts Btu to kBtu

ηCool = Efficiency (SEER) of Air Conditioning equipment (kBtu/kWh)

= Actual (where it is possible to measure or reasonably estimate). If unknown assume the following[159]:

Age of Equipment	SEER Estimate
Before 2006	10
After 2006	13

LM = Latent multiplier to account for latent cooling demand

= dependent on location: [160]

[157] National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 65°F.
[158] This factor's source is: Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research", p31.
[159] These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Central AC was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.
[160] The Latent Multiplier is used to convert the sensible cooling savings calculated to a value representing sensible and latent cooling loads. The values are derived from Harriman et al "Dehumidification and Cooling Loads From Ventilation Air", ASHRAE Journal, by adding the latent and sensible loads to determine the total, then dividing the

Climate Zone (City based upon)	LM
1 (Rockford)	8.5
2 (Chicago)	6.2
3 (Springfield)	6.6
4 (St. Louis, MO)	5.8
5 (Evansville, IN)	6.6

ΔkWh_heating = If electric heat (resistance or heat pump), reduction in annual electric heating due to air sealing

= (((CFM50_existing - CFM50_new)/N_heat) * 60 * 24 * HDD * 0.018) / (ηHeat * 3,412)

N_heat = Conversion factor from leakage at 50 Pascal to leakage at natural conditions
= Based on climate zone, building height and exposure level:[161]

	# Stories:	1	1.5	2	3
Zone 2	Well Shielded	22.2	20.0	17.8	15.5
	Normal	18.5	16.7	14.8	13.0
	Exposed	16.7	15.0	13.3	11.7
Zone 3	Well Shielded	25.8	23.2	20.6	18.1
	Normal	21.5	19.4	17.2	15.1
	Exposed	19.4	17.4	15.5	13.5

HDD = Heating Degree Days

= Dependent on location:[162]

Climate Zone (City based upon)	HDD 65
1 (Rockford)	6,569
2 (Chicago)	6,339
3 (Springfield)	5,497
4 (Belleville)	4,379
5 (Marion)	4,476

total by the sensible load. Where this specialized data was not available, a nearby city was chosen.

[161] N-factor is used to convert 50-pascal blower door air flows to natural air flows and is dependent on geographic location, height of building (stack effect) and exposure of the home to wind, based on methodology developed by Lawrence Berkeley Laboratory (LBL). N-factor values copied from J. Krigger, C. Dorsi; "Residential Energy: Cost Savings and Comfort for Existing Buildings", p284.

[162] National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 65°F. The base temperature was selected to account for the fact that homes receiving airsealing efforts are likely to be more leaky homes where the inside and outside air temperature is more consistent and therefore is more likely to require heating as temperatures drop below 65 degrees. Using this base temperature also reconciles the resulting savings estimates with the results of more sophisticated modeling software.

ηHeat = Efficiency of heating system

= Actual. If not available refer to default table below[163]:

System Type	Age of Equipment	HSPF Estimate	ηHeat (Effective COP Estimate)= (HSPF/3.413)*0.85
Heat Pump	Before 2006	6.8	1.7
	After 2006	7.7	1.92
Resistance	N/A	N/A	1

3412 = Converts Btu to kWh

For example, a well shielded, 2 story single family home in Chicago with 10.5 SEER central cooling and a heat pump with COP of 2 (1.92 including distribution losses), has pre and post blower door test results of 3,400 and 2,250:

ΔkWh = ΔkWh_cooling + ΔkWh_heating

= [((((3,400 – 2,250) / 22.2) * 60 * 24 * 842 * 0.75 * 0.018) / (1000 * 10.5)) * 6.2] + [((3,400 – 2,250) / 17.8)) * 60 * 24 * 6339 * 0.018 / (1.92 * 3,412)]

= 501 + 1620

= 2,121 kWh

ΔkWh_heating = If gas *furnace* heat, kWh savings for reduction in fan run time

= ΔTherms * F_e * 29.3

F_e = Furnace Fan energy consumption as a percentage of annual fuel consumption

= 3.14%[164]

29.3 = kWh per therm

[163] These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time means that using the minimum standard is appropriate. An 85% distribution efficiency is then applied to account for duct losses for heat pumps.

[164] F_e is not one of the AHRI certified ratings provided for residential furnaces, but can be reasonably estimated from a calculation based on the certified values for fuel energy (Ef in MMBTU/yr) and Eae (kWh/yr). An average of a 300 record sample (non-random) out of 1495 was 3.14%. This is, appropriately, ~50% greater than the Energy Star version 3 criteria for 2% F_e. See “Programmable Thermostats Furnace Fan Analysis.xlsx” for reference.

For example, a well shielded, 2 story single family home in Chicago with a gas furnace with system efficiency of 70%, has pre and post blower door test results of 3,400 and 2,250 (see therm calculation in Natural Gas Savings section:

ΔkWh = 152 * 0.0314 * 29.3

= 140 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = (ΔkWh_cooling / FLH_cooling) * CF

Where:

FLH_cooling = Full load hours of air conditioning

= Dependent on location[165]:

Climate Zone (City based upon)	Single Family	Multifamily
1 (Rockford)	512	467
2 (Chicago)	570	506
3 (Springfield)	730	663
4 (Belleville)	1,035	940
5 (Marion)	903	820

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

= 91.5%[166]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

= 46.6%[167]

Other factors as defined above

[165] Full load hours for Chicago, Moline and Rockford are provided in “Final Evaluation Report: Central Air Conditioning Efficiency Services (CACES), 2010, Navigant Consulting”, http://ilsag.org/yahoo_site_admin/assets/docs/ComEd_PY2_CACES_Evaluation_Report_2010-10-18.299122020.pdf p.33. An average FLH/Cooling Degree Day (from NCDC) ratio was calculated for these locations and applied to the CDD of the other locations in order to estimate FLH.

[166] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility’s peak hour is divided by the maximum AC load during the year.

[167] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

For example, a well shielded, 2 story single family home in Chicago with 10.5 SEER central cooling and a heat pump with COP of 2.0, has pre and post blower door test results of 3,400 and 2,250:

ΔkW_{SSP} = 501 / 570 * 0.915

= 0.804 kW

ΔkW_{PJM} = 501 / 570 * 0.466

= 0.410 kW

NATURAL GAS SAVINGS

If Natural Gas heating:

ΔTherms = (((CFM50_existing - CFM50_new)/N_heat) * 60 * 24 * HDD * 0.018) / (ηHeat * 100,000)

Where:

N_heat = Conversion factor from leakage at 50 Pascal to leakage at natural conditions

= Based on climate zone, building height and exposure level[168]:

	# Stories:	1	1.5	2	3
Zone 2	Well Shielded	22.2	20.0	17.8	15.5
	Normal	18.5	16.7	14.8	13.0
	Exposed	16.7	15.0	13.3	11.7
Zone 3	Well Shielded	25.8	23.2	20.6	18.1
	Normal	21.5	19.4	17.2	15.1
	Exposed	19.4	17.4	15.5	13.5

HDD = Heating Degree Days
= dependent on location[169]:

Climate Zone (City based upon)	HDD 65
1 (Rockford)	6,569
2 (Chicago)	6,339
3 (Springfield)	5,497
4 (Belleville)	4,379
5 (Marion)	4,476

[168] N-factor is used to convert 50-pascal blower door air flows to natural air flows and is dependent on geographic location, height of building (stack effect) and exposure of the home to wind, based on methodology developed by Lawrence Berkeley Laboratory (LBL). N-factor values copied from J. Krigger, C. Dorsi; “Residential Energy: Cost Savings and Comfort for Existing Buildings”, p284.

[169] National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 60°F, consistent with the findings of Belzer and Cort, Pacific Northwest National Laboratory in “Statistical Analysis of Historical State-Level Residential Energy Consumption Trends,” 2004..

ηHeat = Efficiency of heating system

= Equipment efficiency * distribution efficiency

= Actual[170]. If not available use 70%[171].

Other factors as defined above

For example, a well shielded, 2 story single family home in Chicago with a gas furnace with system efficiency of 70%, has pre and post blower door test results of 3,400 and 2,250:
ΔTherms = ((3,400 – 2,250)/17.8) * 60 * 24 * 6339 * 0.018) / (0.7 * 100,000)
= 152 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-SHL-AIRS-V02-120601

[170] Ideally, the System Efficiency should be obtained either by recording the AFUE of the unit, or performing a steady state efficiency test. The Distribution Efficiency can be estimated via a visual inspection and by referring to a look up table such as that provided by the Building Performance Institute: (http://www.bpi.org/files/pdf/DistributionEfficiencyTable-BlueSheet.pdf or by performing duct blaster testing.

[171] This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on Energy Information Administration, 2009 Residential Energy Consumption Survey: http://www.eia.gov/consumption/residential/data/2009/xls/HC6.9%20Space%20Heating%20in%20Midwest%20Region.xls)

In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:

(0.24*0.92) + (0.76*0.8) * (1-0.15) = 0.70

5.6.2 Basement Sidewall Insulation

DESCRIPTION

Insulation is added to a basement or crawl space. Insulation added above ground in conditioned space is modeled the same as wall insulation. Below ground insulation is adjusted with an approximation of the thermal resistance of the ground. Insulation in unconditioned spaces is modeled by reducing the degree days to reflect the smaller but non-zero contribution to heating and cooling load. Cooling savings only consider above grade insulation, as below grade has little temperature difference during the cooling season.

This measure was developed to be applicable to the following program types: RF.
If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

This measure requires a member of the implementation staff or a participating contractor to evaluate the pre and post R-values and measure surface areas. The requirements for participation in the program will be defined by the utilities.

DEFINITION OF BASELINE EQUIPMENT

The existing condition will be evaluated by implementation staff or a participating contractor and is likely to be no basement wall or ceiling insulation.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 25 years[172].

DEEMED MEASURE COST

The actual installed cost for this measure should be used in screening.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape R08 - Residential Cooling
Loadshape R09 - Residential Electric Space Heat
Loadshape R10 - Residential Electric Heating and Cooling

COINCIDENCE FACTOR

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid into PJM's Forward Capacity Market. Both values provided are based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren.

[172] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)
= 91.5%[173]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)
= 46.6%[174]

Algorithm

Calculation of Savings

Electric Energy Savings

ΔkWh = ΔkWh_cooling + ΔkWh_heating

Where:

ΔkWh_cooling = If central cooling, reduction in annual cooling requirement due to insulation

= (((1/R_old_AG - 1/(R_added+R_old_AG)) * L_basement_wall_total * H_basement_wall_AG * (1-Framing_factor)) * 24 * CDD * DUA) / (1000 * ηCool))

R_added = R-value of additional spray foam, rigid foam, or cavity insulation.

R_old_AG = R-value value of foundation wall above grade.

= 2.25 [175]

L_basement_wall_total = Length of basement wall around the entire insulated perimeter (ft)

H_basement_wall_AG = Height of insulated basement wall above grade (ft)

Framing_factor = Adjustment to account for area of framing when cavity insulation is used

= 0% if Spray Foam or External Rigid Foam

= 15% if studs and cavity insulation[176]

24 = Converts hours to days

CDD = Cooling Degree Days

= Dependent on location and whether basement is conditioned:[177]

---

[173] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.
[174] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.
[175] ORNL Builders Foundation Handbook, crawl space data from Table 5-5: Initial Effective R-values for Uninsulated Foundation System and Adjacent Soil, 1991, http://www.ornl.gov/sci/roofs+walls/foundation/ORNL_CON-295.pdf
[176] Based on Oak Ridge National Lab, Technology Fact Sheet for Wall Insulation.

Climate Zone (City based upon)	Conditioned CDD 65	Unconditioned CDD 65[178]
1 (Rockford)	820	263
2 (Chicago)	842	281
3 (Springfield)	1,108	436
4 (Belleville)	1,570	538
5 (Marion)	1,370	570
Weighted Average[179]	947	325

DUA = Discretionary Use Adjustment (reflects the fact that people do not always operate their AC when conditions may call for it).

= 0.75 [180]

1000 = Converts Btu to kBtu

ηCool = Seasonal Energy Efficiency Ratio of cooling system (kBtu/kWh)

= Actual (where it is possible to measure or reasonably estimate). If unknown assume the following:[181]

Age of Equipment	ηCool Estimate
Before 2006	10
After 2006	13

ΔkWh_heating = If electric heat (resistance or heat pump), reduction in annual electric heating due to insulation

= [((1/R_old_AG - 1/(R_added+R_old_AG)) * L_basement_wall_total * H_basement_wall_AG * (1-Framing_factor)) + ((1/(R_old_BG - 1/(R_added+R_old_BG)) * L_basement_wall_total * (H_basement_wall_total - H_basement_wall_AG) * (1-Framing_factor))] * 24 * HDD) / (3,412 * ηHeat))

R_old_BG = R-value value of foundation wall below grade (including thermal resistance of

[177] National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 65°F. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.
[178] Five year average cooling degree days with 75F base temp from DegreeDays.net were used in this table because the 30 year climate normals from NCDC used elsewhere are not available at base temps above 72F.
[179] Weighted based on number of occupied residential housing units in each zone.
[180] This factor's source is: Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research", p31.
[181] These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Central AC was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.

the earth) [182]

= dependent on depth of foundation (H_basement_wall_total – H_basement_wall_AG):

Below Grade R-value									
Depth below grade (ft)	0	1	2	3	4	5	6	7	8
Earth R-value (°F-ft^2-h/Btu)	2.44	4.50	6.30	8.40	10.44	12.66	14.49	17.00	20.00
Average Earth R-value (°F-ft2-h/Btu)	2.44	3.47	4.41	5.41	6.42	7.46	8.46	9.53	10.69
Total BG R-value (earth + R-2.25 foundation)	4.69	5.72	6.66	7.66	8.67	9.71	10.71	11.78	12.94

H_basement_wall_total = Total height of basement wall (ft)

HDD = Heating Degree Days

= dependent on location and whether basement is conditioned[183]:

Climate Zone (City based upon)	Conditioned HDD 60	Unconditioned HDD 50
1 (Rockford)	5,352	3,322
2 (Chicago)	5,113	3,079
3 (Springfield)	4,379	2,550
4 (Belleville)	3,378	1,789
5 (Marion)	3,438	1,796
Weighted Average[184]	4,860	2,895

ηHeat = Efficiency of heating system

= Actual. If not available refer to default table below[185]:

[182] Adapted from Table 1, page 24.4, of the 1977 ASHRAE Fundamentals Handbook
[183] National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 60°F for a conditioned basement and 50°F for an unconditioned basement), consistent with the findings of Belzer and Cort, Pacific Northwest National Laboratory in "Statistical Analysis of Historical State-Level Residential Energy Consumption Trends," 2004. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.
[184] Weighted based on number of occupied residential housing units in each zone.
[185] These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time means that using the minimum standard is appropriate. An 85% distribution efficiency is then applied to account for duct losses for heat pumps.

System Type	Age of Equipment	HSPF Estimate	ηHeat (Effective COP Estimate) (HSPF/3.413)*0.85
Heat Pump	Before 2006	6.8	1.7
	After 2006	7.7	1.92
Resistance	N/A	N/A	1

For example, a home in Chicago with a 20 by 25 by 7 foot unconditioned basement, with 3 feet above grade, insulated with R-13 of interior spray foam, 10.5 SEER Central AC and 2.26 COP Heat Pump:

ΔkWh = ΔkWh_cooling + ΔkWh_heating

= [(((1/2.25 - 1/(13 + 2.25))*(20+25+20+25) * 3 * (1 - 0)) * 24 * 281 * 0.75)/(1000 * 10.5)] + [((((1/2.25 - 1/(13 + 2.25)) * (20+25+20+25) * 3 * (1-0)) + ((1 / 8.67 – 1 / (13 + 8.67)) * (20+25+20+25) * 4 * (1-0))) * 24 * 3079) / (3412 * 1.92)]

= 49.3 + 1435

= 1480 kWh

ΔkWh_heating = If gas *furnace* heat, kWh savings for reduction in fan run time

= ΔTherms * F_e * 29.3

F_e = Furnace Fan energy consumption as a percentage of annual fuel consumption

= 3.14%[186]

29.3 = kWh per therm

For example, a home in Chicago with a 20 by 25 by 7 foot unconditioned basement, with 3 feet above grade, insulated with R-13 of interior spray foam, and a 70% efficient furnace (for therm calculation see Natural Gas Savings section :

= 134 * 0.0314 * 29.3

= 123 kWh

SUMMER COINCIDENT PEAK DEMAND

ΔkW = (ΔkWh_cooling / FLH_cooling) * CF

Where:

[186] F_e is not one of the AHRI certified ratings provided for residential furnaces, but can be reasonably estimated from a calculation based on the certified values for fuel energy (Ef in MMBTU/yr) and Eae (kWh/yr). An average of a 300 record sample (non-random) out of 1495 was 3.14%. This is, appropriately, ~50% greater than the Energy Star version 3 criteria for 2% F_e. See “Programmable Thermostats Furnace Fan Analysis.xlsx” for reference.

FLH_cooling = Full load hours of air conditioning

= dependent on location[187]:

Climate Zone (City based upon)	Single Family	Multifamily
1 (Rockford)	512	467
2 (Chicago)	570	506
3 (Springfield)	730	663
4 (Belleville)	1,035	940
5 (Marion)	903	820
Weighted Average[188]	629	564

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

= 91.5%[189]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

= 46.6%[190]

For example, a single family home in Chicago with a 20 by 25 by 7 foot unconditioned basement, with 3 feet above grade, insulated with R-13 of interior spray foam, 10.5 SEER Central AC and 2.26 COP Heat Pump:

ΔkW_{SSP} = 49.3 / 570 * 0.915

= 0.0791 kW

ΔkW_{PJM} = 49.3 / 570 * 0.466

= 0.0403 kW

NATURAL GAS SAVINGS

If Natural Gas heating:

187 Full load hours for Chicago, Moline and Rockford are provided in "Final Evaluation Report: Central Air Conditioning Efficiency Services (CACES), 2010, Navigant Consulting", http://ilsag.org/yahoo_site_admin/assets/docs/ComEd_PY2_CACES_Evaluation_Report_2010-10-18.299122020.pdf, p.33. An average FLH/Cooling Degree Day (from NCDC) ratio was calculated for these locations and applied to the CDD of the other locations in order to estimate FLH. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

188 Weighted based on number of occupied residential housing units in each zone.

189 Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

190 Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

ΔTherms = ((1/R_old_AG - 1/(R_added+R_old_AG)) * L_basement_wall_total * H_basement_wall_AG * (1-Framing_factor) + (1/(R_old_BG - 1/(R_added+R_old_BG)) * L_basement_wall_total * (H_basement_wall_total - H_basement_wall_AG) * (1-Framing_factor)] * 24 * HDD) / (ηHeat * 100,067)

ηHeat = Efficiency of heating system

= Equipment efficiency * distribution efficiency

= Actual. If unknown assume 70%[191]

Other factors as defined above

For example, a home in Chicago with a 20 by 25 by 7 foot unconditioned basement, with 3 feet above grade, insulated with R-13 of interior spray foam, and a 70% efficient furnace:

= ((1/2.25 - 1/(13 + 2.25)) * (20+25+20+25) * 3 * (1-0) + (1/8.67 - 1/(13 + 8.67)) * (20+25+20+25) * 4 * (1 - 0)) * 24 * 3079) / (0.7 * 100,067)

= 134 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-SHL-BINS-V02-120601

[191] This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on Energy Information Administration, 2009 Residential Energy Consumption Survey: http://www.eia.gov/consumption/residential/data/2009/xls/HC6.9%20Space%20Heating%20in%20Midwest%20Region.xls))
In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:
(0.24*0.92) + (0.76*0.8) * (1-0.15) = 0.70

5.6.3 Floor insulation above crawlspace

DESCRIPTION

Insulation is added to the floor above a vented crawl space that does not contain pipes or HVAC equipment. If there are pipes, HVAC, or a basement, it is desirable to keep them within the conditioned space by insulating the crawl space walls and ground. Insulating the floor separates the conditioned space above from the space below the floor, and is only acceptable when there is nothing underneath that could freeze or would operate less efficiently in an environment resembling the outdoors. Even in the case of an empty, unvented crawl space, it is still considered best practice to seal and insulate the crawl space perimeter rather than the floor. Not only is there generally less area to insulate this way, but there are also moisture control benefits. There is a “Basement Insulation” measure for perimeter sealing and insulation. This measure assumes the insulation is installed above an unvented crawl space and should not be used in other situations.

This measure was developed to be applicable to the following program types: RF.
If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

This measure requires a member of the implementation staff or a participating contractor to evaluate the pre and post R-values and measure surface areas. The requirements for participation in the program will be defined by the utilities.

DEFINITION OF BASELINE EQUIPMENT

The existing condition will be evaluated by implementation staff or a participating contractor and is likely to be no insulation on any surface surrounding a crawl space.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 25 years[192].

DEEMED MEASURE COST

The actual installed cost for this measure should be used in screening.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape R08 - Residential Cooling
Loadshape R09 - Residential Electric Space Heat
Loadshape R10 - Residential Electric Heating and Cooling

COINCIDENCE FACTOR

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to

[192] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid into PJM's Forward Capacity Market. Both values provided are based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren.

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)

= 91.5%[193]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)

= 46.6%[194]

Algorithm

CALCULATION OF SAVINGS

Electric **ENERGY SAVINGS**

ΔkWh = ΔkWh_cooling + ΔkWh_heating

Where:

ΔkWh_cooling = If central cooling, reduction in annual cooling requirement due to insulation

= (((1/R_old - 1/(R_added+R_old)) * Area * (1-Framing_factor)) * 24 * CDD * DUA) / (1000 * ηCool))

R_old = R-value value of floor before insulation, assuming 3/4" plywood subfloor and carpet with pad

= 4.94 [195]

R_added = R-value of additional spray foam, rigid foam, or cavity insulation.

Area = Total floor area to be insulated

Framing_factor = Adjustment to account for area of framing

= 15% [196]

24 = Converts hours to days

[193] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

[194] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

[195] Based on 2005 ASHREA Handbook – Fundamentals: assuming 2x8 joists, 16" OC, ¾" subfloor, ½" carpet with rubber pad, and accounting for a still air film above and below: 0.85 cavity share of area * (0.68 + 0.94 + 1.23 + 0.68) + 0.15 framing share * (0.68 + 7.5" * 1.25 R/in + 0.94 + 1.23 + 0.68) = 4.94

[196] Based on Oak Ridge National Lab, Technology Fact Sheet for Wall Insulation.

CDD = Cooling Degree Days

Climate Zone (City based upon)	Unconditioned CDD[197]
1 (Rockford)	263
2 (Chicago)	281
3 (Springfield)	436
4 (Belleville)	538
5 (Marion)	570
Weighted Average[198]	325

DUA = Discretionary Use Adjustment (reflects the fact that people do not always operate their AC when conditions may call for it).

= 0.75 [199]

1000 = Converts Btu to kBtu

ηCool = Seasonal Energy Efficiency Ratio of cooling system (kBtu/kWh)

= Actual (where it is possible to measure or reasonably estimate). If unknown assume the following:[200]

Age of Equipment	ηCool Estimate
Before 2006	10
After 2006	13

ΔkWh_heating = If electric heat (resistance or heat pump), reduction in annual electric heating due to insulation

= ((1/R_old - 1/(R_added + R_old)) * Area * (1-Framing_factor) * 24 * HDD)/ (3,412 * ηHeat))

HDD = Heating Degree Days[201]

Climate Zone (City based upon)	Unconditioned HDD

[197] Five year average cooling degree days with 75F base temp from DegreeDays.net were used in this table because the 30 year climate normals from NCDC used elsewhere are not available at base temps above 72F.
[198] Weighted based on number of occupied residential housing units in each zone.
[199] Energy Center of Wisconsin, May 2008 metering study; “Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research”, p31.
[200] These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Central AC was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.
[201] National Climatic Data Center, Heating Degree Days with a base temp of 50°F to account for lower impact of unconditioned space on heating system. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

1 (Rockford)	3,322
2 (Chicago)	3,079
3 (Springfield)	2,550
4 (Belleville)	1,789
5 (Marion)	1,796
Weighted Average[202]	2,895

ηHeat = Efficiency of heating system

= Actual. If not available refer to default table below:[203]

System Type	Age of Equipment	HSPF Estimate	ηHeat (Effective COP Estimate) (HSPF/3.413)*0.85
Heat Pump	Before 2006	6.8	1.7
	After 2006	7.7	1.92
Resistance	N/A	N/A	1

Other factors as defined above

For example, a home in Chicago with a 20 by 25 footprint, insulated with R-30 spray foam above the crawlspace, a 10.5 SEER Central AC and a newer heat pump:

ΔkWh = ΔkWh_cooling + ΔkWh_heating

=(((1/4.94-1/(30+4.94))*(20*25)*(1-0.15)* 24 * 281*0.75)/(1000*10.5) + ((1/4.94-1/(30+4.94))*(20*25)*(1-0.15) * 24 * 3079)/(3412*1.92)

= 35.6 + 833

= 869 kWh

ΔkWh_heating = If gas *furnace* heat, kWh savings for reduction in fan run time

= ΔTherms * F_e * 29.3

F_e = Furnace Fan energy consumption as a percentage of annual fuel consumption

= 3.14%[204]

202 Weighted based on number of occupied residential housing units in each zone.

203 These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time means that using the minimum standard is appropriate. An 85% distribution efficiency is then applied to account for duct losses for heat pumps.

29.3 = kWh per therm

For example, a single family home in Chicago with a 20 by 25 footprint, insulated with R-30 spray foam above the crawlspace, and a 70% efficient furnace (for therm calculation see Natural Gas Savings section):

ΔkWh = 78 * 0.0314 * 29.3

= 32 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = (ΔkWh_cooling / FLH_cooling) * CF

Where:

FLH_cooling = Full load hours of air conditioning

= Dependent on location[205]:

Climate Zone (City based upon)	Single Family	Multifamily
1 (Rockford)	512	467
2 (Chicago)	570	506
3 (Springfield)	730	663
4 (Belleville)	1,035	940
5 (Marion)	903	820
Weighted Average[206]	629	564

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

= 91.5%[207]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

[204] F_e is not one of the AHRI certified ratings provided for residential furnaces, but can be reasonably estimated from a calculation based on the certified values for fuel energy (Ef in MMBTU/yr) and Eae (kWh/yr). An average of a 300 record sample (non-random) out of 1495 was 3.14%. This is, appropriately, ~50% greater than the Energy Star version 3 criteria for 2% F_e. See "Programmable Thermostats Furnace Fan Analysis.xlsx" for reference.

[205] Full load hours for Chicago, Moline and Rockford are provided in "Final Evaluation Report: Central Air Conditioning Efficiency Services (CACES), 2010, Navigant Consulting", http://ilsag.org/yahoo_site_admin/assets/docs/ComEd_PY2_CACES_Evaluation_Report_2010-10-18.299122020.pdf, p.33. An average FLH/Cooling Degree Day (from NCDC) ratio was calculated for these locations and applied to the CDD of the other locations in order to estimate FLH. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

[206] Weighted based on number of occupied residential housing units in each zone.

[207] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

= 46.6%[208]

For example, a single family home in Chicago with a 20 by 25 footprint, insulated with R-30 spray foam above the crawlspace, a 10.5 SEER Central AC and a newer heat pump:

ΔkW_{SSP} = 35.6 / 570 * 0.915

= 0.057 kW

ΔkW_{SSP} = 35.6 / 570 * 0.466

= 0.029 kW

Natural Gas Savings

If Natural Gas heating:

ΔTherms = (1/R_old - 1/(R_added+R_old)) * Area * (1-Framing_factor)) * 24 * HDD) / (100,000 * ηHeat) *

ηHeat = Efficiency of heating system

= Equipment efficiency * distribution efficiency

= Actual. If unknown assume 70%[209]

Other factors as defined above

For example, a single family home in Chicago with a 20 by 25 footprint, insulated with R-30 spray foam above the crawlspace, and a 70% efficient furnace:

ΔTherms = (1 / 4.94 – 1 /(30 + 4.94))*(20 * 25) * (1 - 0.15) * 24 * 3079) / (100,000 * 0.70)

= 78.0 therms

[208] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

[209] This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on Energy Information Administration, 2009 Residential Energy Consumption Survey: http://www.eia.gov/consumption/residential/data/2009/xls/HC6.9%20Space%20Heating%20in%20Midwest%20Region.xls))
In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:
(0.24*0.92) + (0.76*0.8) * (1-0.15) = 0.70

Water Impact Descriptions and Calculation

N/A

Deemed O&M Cost Adjustment Calculation

N/A

Measure Code: RS-SHL-FINS-V02-120601

5.6.4 Wall and Ceiling/Attic Insulation

Description

Insulation is added to wall cavities, and/or attic. This measure requires a member of the implementation staff evaluating the pre and post R-values and measure surface areas. The efficiency of the heating and cooling equipment in the home should also be evaluated if possible.

This measure was developed to be applicable to the following program types: RF.
If applied to other program types, the measure savings should be verified.

Definition of Efficient Equipment

This measure requires a member of the implementation staff or a participating contractor to evaluate the pre and post R-values and measure surface areas. The requirements for participation in the program will be defined by the utilities.

Definition of Baseline Equipment

The existing condition will be evaluated by implementation staff or a participating contractor and is likely to be empty wall cavities and little or no attic insulation.

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 25 years[210].

Deemed Measure Cost

The actual installed cost for this measure should be used in screening.

Deemed O&M Cost Adjustments

N/A

Loadshape

Loadshape R08 - Residential Cooling
Loadshape R09 - Residential Electric Space Heat
Loadshape R10 - Residential Electric Heating and Cooling

Coincidence Factor

The summer peak coincidence factor for cooling is provided in two different ways below. The first is used to estimate peak savings during the utility peak hour and is most indicative of actual peak benefits, and the second represents the *average* savings over the defined summer peak period, and is presented so that savings can be bid into PJM's Forward Capacity Market. Both values provided are based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren.

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)
= 91.5%[211]

[210] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)
= 46.6%[212]

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh = ΔkWh_cooling + ΔkWh_heating

Where:

ΔkWh_cooling = If central cooling, reduction in annual cooling requirement due to insulation

= [((1/R_old - 1/R_wall) * A_wall * (1-Framing_factor) + (1/R_old - 1/R_attic) * A_attic * (1-Framing_factor/2)) * 24 * CDD * DUA] / (1000 * ηCool)

R_wall = R-value of new wall assembly (including all layers between inside air and outside air).

R_attic = R-value of new attic assembly (including all layers between inside air and outside air).

R_old = R-value value of existing assemble and any existing insulation.

(Minimum of R-5 for uninsulated assemblies[213])

A_wall = Total area of insulated wall (ft^2)

A_attic = Total area of insulated ceiling/attic (ft^2)

Framing_factor = Adjustment to account for area of framing

= 15%[214]

24 = Converts hours to days

CDD = Cooling Degree Days

= dependent on location[215]:

---

[211] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.
[212] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.
[213] An estimate based on review of Madison Gas and Electric, Exterior Wall Insulation, R-value for no insulation in walls, and NREL's Building Energy Simulation Test for Existing Homes (BESTEST-EX).
[214] Based on Oak Ridge National Lab, Technology Fact Sheet for Wall Insulation. Factor is used directly for walls, but reduced by 1/2 for attics, assuming that the average joist is 5.5" and R-38 requires 11" of cellulose, therefore at each joist, 1/2 the thickness of insulation has been added as between the joists.

Climate Zone (City based upon)	CDD 65
1 (Rockford)	820
2 (Chicago)	842
3 (Springfield)	1,108
4 (Belleville)	1,570
5 (Marion)	1,370
Weighted Average[216]	947

DUA = Discretionary Use Adjustment (reflects the fact that people do not always operate their AC when conditions may call for it).

= 0.75 [217]

1000 = Converts Btu to kBtu

ηCool = Seasonal Energy Efficiency Ratio of cooling system (kBtu/kWh)

= Actual (where it is possible to measure or reasonably estimate). If unknown assume the following[218]:

Age of Equipment	ηCool Estimate
Before 2006	10
After 2006	13

kWh_heating = If electric heat (resistance or heat pump), reduction in annual electric heating due to insulation

= [(1/R_old - 1/R_wall) * A_wall * (1-Framing_factor) + (1/R_old - 1/R_attic) * A_attic * (1-Framing_factor/2)) * 24 * HDD] / (ηHeat * 3412)

HDD = Heating Degree Days

= Dependent on location[219]:

---

215 National Climatic Data Center, Cooling Degree Days are based on a base temp of 65°F. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

216 Weighted based on number of occupied residential housing units in each zone.

217 This factor's source is: Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research", p31.

218 These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Central AC was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate.

219 National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 60°F, consistent with the findings of Belzer and Cort, Pacific Northwest National Laboratory in "Statistical Analysis of Historical State-Level Residential Energy Consumption Trends," 2004. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

Climate Zone (City based upon)	HDD 60
1 (Rockford)	5,352
2 (Chicago)	5,113
3 (Springfield)	4,379
4 (Belleville)	3,378
5 (Marion)	3,438
Weighted Average[220]	4,860

ηHeat = Efficiency of heating system

= Actual. If not available refer to default table below[221]:

System Type	Age of Equipment	HSPF Estimate	ηHeat (Effective COP Estimate) (HSPF/3.413)*0.85
Heat Pump	Before 2006	6.8	1.7
	After 2006	7.7	1.92
Resistance	N/A	N/A	1

3412 = Converts Btu to kWh

For example, a single family home in Chicago with 990 ft^2 of R-5 walls insulated to R-11 and 700 ft^2 of R-5 attic insulated to R-38, 10.5 SEER Central AC and 2.26 (1.92 including distribution losses) COP Heat Pump:

ΔkWh = ΔkWh_cooling + ΔkWh_heating

= [(((1/5 - 1/11) * 990 * (1-0.15)) + ((1/5 - 1/38) * 700 * (1-0.15/2)) * 842 * 0.75 * 24)/ (1000 * 10.5)] + [(((1/5 - 1/11) * 990 * (1-0.15)) + (1/5 - 1/38) * 700 * (1-0.15/2)) * 5113 * 24) / (1.92 * 3412

= 295 + 3826

= 4120 kWh

ΔkWh_heating = If gas *furnace* heat, kWh savings for reduction in fan run time

= ΔTherms * F_e * 29.3

F_e = Furnace Fan energy consumption as a percentage of annual fuel consumption

[220] Weighted based on number of occupied residential housing units in each zone.

[221] These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time means that using the minimum standard is appropriate. An 85% distribution efficiency is then applied to account for duct losses for heat pumps.

= 3.14%[222]

29.3 = kWh per therm

For example, a single family home in Chicago with 990 ft^2 of R-5 walls insulated to R-11 and 700 ft^2 of R-5 attic insulated to R-38, with a gas furnace with system efficiency of 66% (for therm calculation see Natural Gas Savings section):

ΔkWh = 380 * 0.0314 * 29.3

= 350 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = (ΔkWh_cooling / FLH_cooling) * CF

Where:

FLH_cooling = Full load hours of air conditioning

= Dependent on location as below[223]:

Climate Zone (City based upon)	Single Family	Multifamily
1 (Rockford)	512	467
2 (Chicago)	570	506
3 (Springfield)	730	663
4 (Belleville)	1,035	940
5 (Marion)	903	820
Weighted Average[224]	629	564

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)

= 91.5%[225]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during peak period)

= 46.6%[226]

[222] F_e is not one of the AHRI certified ratings provided for residential furnaces, but can be reasonably estimated from a calculation based on the certified values for fuel energy (Ef in MMBTU/yr) and Eae (kWh/yr). An average of a 300 record sample (non-random) out of 1495 was 3.14%. This is, appropriately, ~50% greater than the Energy Star version 3 criteria for 2% F_e. See “Programmable Thermostats Furnace Fan Analysis.xlsx” for reference.

[223] Based on Full Load Hours from ENERGY Star with adjustments made in a Navigant Evaluation, other cities were scaled using those results and CDD. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

[224] Weighted based on number of occupied residential housing units in each zone.

[225] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility’s peak hour is divided by the maximum AC load during the year.

For example, a single family home in Chicago with 990 ft^2 of R-5 walls insulated to R-11 and 700 ft^2 of R-5 attic insulated to R-38, 10.5SEER Central AC and 2.26 COP Heat Pump:

ΔkW_{SSP} = 295 / 570 * 0.915

= 0.474 kW

ΔkW_{PJM} = 295 / 570 * 0.466

= 0.241 kW

NATURAL GAS SAVINGS

If Natural Gas heating:

ΔTherms = (((1/R_old - 1/R_wall) * A_wall * (1-Framing_factor) + (1/R_old - 1/R_attic) * A_attic * (1-Framing_factor/2)) * 24 * HDD) / (ηHeat * 100,067 Btu/therm)

Where:

HDD = Heating Degree Days

= Dependent on location[227]:

Climate Zone (City based upon)	HDD 60
1 (Rockford)	5,352
2 (Chicago)	5,113
3 (Springfield)	4,379
4 (Belleville)	3,378
5 (Marion)	3,438
Weighted Average[228]	4,860

ηHeat = Efficiency of heating system

= Equipment efficiency * distribution efficiency

[226] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year.

[227] National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 60°F, consistent with the findings of Belzer and Cort, Pacific Northwest National Laboratory in "Statistical Analysis of Historical State-Level Residential Energy Consumption Trends," 2004. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

[228] Weighted based on number of occupied residential housing units in each zone.

= Actual[229]. If unknown assume 70% [230].

Other factors as defined above

For example, a single family home in Chicago with 990 ft^2 of R-5 walls insulated to R-11 and 700 ft^2 of R-5 attic insulated to R-38, with a gas furnace with system efficiency of 66%: ΔTherms = (((1/5 - 1/11) * 990 * (1-0.15) + (1/5 - 1/38) * 700 * (1-0.15/2)) * 24 * 5113) / (0.66 * 100,067) = 380 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-SHL-AINS-V02-120601

229 Ideally, the System Efficiency should be obtained either by recording the AFUE of the unit, or performing a steady state efficiency test. The Distribution Efficiency can be estimated via a visual inspection and by referring to a look up table such as that provided by the Building Performance Institute: (http://www.bpi.org/files/pdf/DistributionEfficiencyTable-BlueSheet.pdf) or by performing duct blaster testing.

230 This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on Energy Information Administration, 2009 Residential Energy Consumption Survey: http://www.eia.gov/consumption/residential/data/2009/xls/HC6.9%20Space%20Heating%20in%20Midwest%20Region.xls)). In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:
(0.24*0.92) + (0.76*0.8) * (1-0.15) = 0.70