5 Residential Measures

5.1 Appliances End Use

5.1.1 ENERGY STAR Air Purifier/Cleaner

DESCRIPTION

An air purifier (cleaner) meeting the efficiency specifications of ENERGY STAR is purchased and installed in place of a model meeting the current federal standard.

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 equipment is defined as an air purifier meeting the efficiency specifications of ENERGY STAR as provided below.

- Must produce a minimum 50 Clean Air Delivery Rate (CADR) for Dust[462] to be considered under this specification.
- Minimum Performance Requirement: = 2.0 CADR/Watt (Dust)
- Standby Power Requirement: = 2.0 Watts Qualifying models that perform secondary consumer functions (e.g. clock, remote control) must meet the standby power requirement.
- UL Safety Requirement: Models that emit ozone as a byproduct of air cleaning must meet UL Standard 867 (ozone production must not exceed 50ppb)

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is assumed to be a conventional unit[463].

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life is assumed to be 9 years[464].

DEEMED MEASURE COST

The incremental cost for this measure is $70.[465]

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[462] Measured according to the latest ANSI/AHAM AC-1 (AC-1) Standard
[463] As defined as the average of non-ENERGY STAR products found in EPA research, 2008, ENERGY STAR Qualified Room Air Cleaner Calculator,
http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorRoomAirCleaner.xls?8ed7-275b.
[464] ENERGY STAR Qualified Room Air Cleaner Calculator,
http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorRoomAirCleaner.xls?8ed7-275b.
[465] Ibid

DEEMED O&M COST ADJUSTMENTS

There are no operation and maintenance cost adjustments for this measure.[466]

LOADSHAPE

Loadshape C53 - Flat

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is assumed to be 100 % (the unit is assumed to be always on).

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$\Delta kWh = kWh_{Base} - kWh_{ESTAR}$

Where:

kWh_{BASE} = Baseline kWh consumption per year[467]

= see table below

kWh_{ESTAR} = ENERGY STAR kWh consumption per year[468]

= see table below

Clean Air Delivery Rate	Baseline Unit Energy Consumption (kWh/year)	ENERGY STAR Unit Energy Consumption (kWh/year)	ΔkWH
CADR 51-100	596	329	268
CADR 101-150	1,072	548	525
CADR 151-200	1,480	767	714
CADR 201-250	1,887	986	902
CADR Over 250	1,641	1205	437

[466] Some types of room air cleaners require filter replacement or periodic cleaning, but this is likely to be true for both efficient and baseline units and so no difference in cost is assumed.

[467] ENERGY STAR Qualified Room Air Cleaner Calculator, http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorRoomAirCleaner.xls?8ed7-275b

[468] Ibid.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = \Delta kWh/Hours * CF$$

Where:

ΔkWh = Gross customer annual kWh savings for the measure

Hours = Average hours of use per year

= 8766 hours[469]

CF = Summer Peak Coincidence Factor for measure

= 1.0

Clean Air Delivery Rate	ΔkW
CADR 51-100	0.031
CADR 101-150	0.060
CADR 151-200	0.081
CADR 201-250	0.103
CADR Over 250	0.050

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-APL-ESAP-V01-120601

[469] Consistent with ENERGY STAR Qualified Room Air Cleaner Calculator.

5.1.2 ENERGY STAR and CEE Tier 2 and 3 Clothes Washers

Description

This measure relates to the installation of a clothes washer meeting the Energy Star, or CEE Tier 2 or Tier 3 minimum qualifications. Note if the DHW and dryer fuels of the installations are unknown (for example through a retail program) savings should be based on a weighted blend using RECS data (the resultant values (kWh, therms and gallons of water) are provided). The algorithms can also be used to calculate site specific savings where DHW and dryer fuels are known.

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

Clothes washer must meet the ENERGY STAR or CEE Tier 2 or 3 minimum qualifications, as required by the program.

Definition of Baseline Equipment

The baseline condition is a clothes washer meeting the minimum federal baseline.

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 14 years[470].

Deemed Measure Cost

The incremental cost for an Energy Star unit is assumed to be $210, for a CEE Tier 2 unit is $360 and for a CEE Tier 3 unit it is $458[471].

Deemed O&M Cost Adjustments

N/A

Loadshape

Loadshape R01 - Residential Clothes Washer

Coincidence Factor

The coincidence factor for this measure is 3.8%[472].

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[470] Based on DOE Life-Cycle Cost and Payback Period Excel-based analytical tool, available online at: http://www1.eere.energy.gov/buildings/appliance_standards/residential/clothes_washers_support_stakeholder_negotiations.html

[471] Cost estimates are based on Navigant analysis for the Department of Energy (see CW Analysis.xls). This analysis looked at incremental cost and shipment data from manufacturers and the Association of Home Appliance Manufacturers and attempts to find the costs associated only with the efficiency improvements.

[472] Calculated from Itron eShapes, 8760 hourly data by end use for Missouri, as provided by Ameren.

Algorithm

Calculation of Savings

Electric Energy Savings

1. Calculate clothes washer savings based on Modified Energy Factor (MEF).

   The Modified Energy Factor (MEF) includes unit operation, water heating and drying energy use: *"MEF is the quotient of the capacity of the clothes container, C, divided by the total clothes washer energy consumption per cycle, with such energy consumption expressed as the sum of the machine electrical energy consumption, M, the hot water energy consumption, E, and the energy required for removal of the remaining moisture in the wash load, D"* [473].

   The hot water and dryer savings calculated here assumes electric DHW and Dryer (this will be separated in Step 2).

   MEFsavings[474] = Capacity * (1/MEFbase - 1/MEFeff) * Ncycles

Where

Capacity = Clothes Washer capacity (cubic feet)

= Actual. If capacity is unknown assume 3.5 cubic feet [475]

MEFbase = Modified Energy Factor of baseline unit

= 1.64[476]

MEFeff = Modified Energy Factor of efficient unit

= Actual. If unknown assume average values provided below.

Ncycles = Number of Cycles per year

= 295[477]

MEFsavings is provided below based on deemed values[478]:

---

473 **Definition provided on the Energy star website.**

474 **Tsavings represents total kWh only when water heating and drying are 100% electric.**

475 Based on the average clothes washer volume of all post-1/1/2007 units from the California Energy Commission (CEC) database of Clothes Washer products. 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.

476 Average MEF of non-ENERGY STAR units **from the California Energy Commission (CEC) database of Clothes Washer products.**

477 Weighted average of 295 clothes washer cycles per year (based on 2009 Residential Energy Consumption Survey (RECS) national sample survey of housing appliances section, state of IL: http://www.eia.gov/consumption/residential/data/2009/
If utilities have specific evaluation results providing a more appropriate assumption for single-family or multi-family homes, in a particular market, or geographical area then that should be used.

Efficiency Level	MEF	MEFSavings (kWh)
Federal Standard	1.64	0.0
Energy Star	2.07	130
CEE Tier 2	2.28	177
CEE Tier 3	2.71	248

2. Break out savings calculated in Step 1 for electric DHW and electric dryer

ΔkWh = [(Capacity * 1/MEFbase * Ncycles) * (%CWbase + (%DHWbase * %Electric_DHW) + (%Dryerbase * %Electric_Dryer)] - [(Capacity * 1/MEFeff * Ncycles) * (%CWeff + (%DHWeff * %Electric_DHW) + (%Dryereff * %Electric_Dryer)]

Where:

%CW = Percentage of total energy consumption for Clothes Washer operation (different for baseline and efficient unit – see table below)

%DHW = Percentage of total energy consumption used for water heating (different for baseline and efficient unit – see table below)

%Dryer = Percentage of total energy consumption for dryer operation (different for baseline and efficient unit – see table below)

	Percentage of Total Energy Consumption[479]		
	%CW	%DHW	%Dryer
Baseline	7%	33%	59%
Non-CEE Energy Star Units	6%	31%	62%
CEE 2	8%	24%	68%
CEE 3	10%	16%	74%

%Electric_DHW = Percentage of DHW savings assumed to be electric

DHW fuel	%Electric_DHW
Electric	100%
Natural Gas	0%
Unknown	16%[480]

[478] MEF values are the average of the **from the California Energy Commission (CEC) database of Clothes Washer products**. See "CW Analysis.xls" for the calculation.

[479] The percentage of total energy consumption that is used for the machine, heating the hot water or by the dryer is different depending on the efficiency of the unit. Values are based on a sales weighted average of top loading and front loading units based on data from Life-Cycle Cost and Payback Period Excel-based analytical tool, available online at: http://www1.eere.energy.gov/buildings/appliance_standards/residential/clothes_washers_support_stakeholder_negotiations.html. See "CW Analysis.xls" for the calculation.

[480] 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

%Electric_Dryer = Percentage of dryer savings assumed to be electric

Dryer fuel	%Electric_DHW
Electric	100%
Natural Gas	0%
Unknown	27%[481]

In summation, the complete algorithm is as follows:

ΔkWH = [(Capacity * 1/MEFbase * Ncycles) * (%CWbase + (%DHWbase * %Electric_DHW) + (%Dryerbase * %Electric_Dryer)] - [(Capacity * 1/MEFeff * Ncycles) * (%CWeff + (%DHWeff * %Electric_DHW) + (%Dryereff * %Electric_Dryer)]

Using the default assumptions provided above, the prescriptive savings for each configuration are presented below:

	ΔkWH			
	Electric DHW Electric Dryer	Gas DHW Electric Dryer	Electric DHW Gas Dryer	Gas DHW Gas Dryer
Non-CEE Energy Star Units	129.6	75.7	69.8	15.9
CEE 2	177.2	76.4	112.8	12.0
CEE 3	248.0	99.0	157.3	8.3

If the DHW and dryer fuel is unknown the prescriptive kWH savings based on defaults provided above should be:

	ΔkWH
Non-CEE Energy Star Units	40.69
CEE 2	45.52
CEE 3	56.63

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh/Hours * CF

Where:

ΔkWh = Energy Savings as calculated above

Hours = Assumed Run hours of Clothes Washer

assumption for homes in a particular market or geographical area then that should be used

[481] Default assumption for unknown is based on percentage of homes with electric dryer from 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.

= 295 hours[482]

CF = Summer Peak Coincidence Factor for measure.

= 0.038[483]

Using the default assumptions provided above, the prescriptive savings for each configuration are presented below:

	ΔkW			
	Electric DHW Electric Dryer	Gas DHW Electric Dryer	Electric DHW Gas Dryer	Gas DHW Gas Dryer
Non-CEE Energy Star Units	0.017	0.010	0.009	0.002
CEE 2	0.023	0.010	0.015	0.002
CEE 3	0.032	0.013	0.020	0.001

If the DHW and dryer fuel is unknown the prescriptive kW savings should be:

	ΔkW
Non-CEE Energy Star Units	0.005
CEE 2	0.006
CEE 3	0.007

NATURAL GAS SAVINGS

Break out savings calculated in Step 1 of electric energy savings (MEF savings) and extract Natural Gas DHW and Natural Gas dryer savings from total savings:

ΔTherm = [(Capacity * 1/MEFbase * Ncycles) * ((%DHWbase * %Natural Gas_DHW * R_eff) + (%Dryerbase * %Gas _Dryer)] - [(Capacity * 1/MEFeff * Ncycles) * ((%DHWeff * %Natural Gas_DHW * R_eff) + (%Dryereff * %Gas_Dryer)] * Therm_convert

Where:

Therm_convert = Convertion factor from kWh to Therm

= 0.03413

R_eff = Recovery efficiency factor

482 Based on a weighted average of 295 clothes washer cycles per year assuming an average load runs for one hour (2009 Residential Energy Consumption Survey (RECS) national sample survey of housing appliances section: http://www.eia.gov/consumption/residential/data/2009/)

483 Calculated from Itron eShapes, 8760 hourly data by end use for Missouri, as provided by Ameren.

= 1.26[484]

%Natural Gas_DHW = Percentage of DHW savings assumed to be Natural Gas

DHW fuel	%Natural Gas_DHW
Electric	0%
Natural Gas	100%
Unknown	84%[485]

%Gas_Dryer = Percentage of dryer savings assumed to be Natural Gas

Dryer fuel	%Gas_Dryer
Electric	100%
Natural Gas	0%
Unknown	44%[486]

Other factors as defined above

Using the default assumptions provided above, the prescriptive savings for each configuration are presented below:

	ΔTherms			
	Electric DHW Electric Dryer	Gas DHW Electric Dryer	Electric DHW Gas Dryer	Gas DHW Gas Dryer
Non-CEE Energy Star Units	0.00	2.32	2.04	4.36
CEE 2	0.00	4.34	2.20	6.53
CEE 3	0.00	6.41	3.10	9.50

If the DHW and dryer fuel is unknown the prescriptive Therm savings should be:

	ΔTherms
Non-CEE Energy Star Units	2.84
CEE 2	4.61
CEE 3	6.74

[484] To account for the different efficiency of electric and Natural Gas hot water heaters (gas water heater: recovery efficiencies ranging from 0.74 to 0.85 (0.78 used), and electric water heater with 0.98 recovery efficiency (http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Waste_Water_Heat_Recovery_Guidelines.pdf). Therefore a factor of 0.98/0.78 (1.26) is applied.

[485] Default assumption for unknown fuel is based on percentage of homes with gas dryer from 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

[486] Ibid.

WATER IMPACT DESCRIPTIONS AND CALCULATION

ΔWater (gallons) = (Capacity * (WFbase - WFeff)) * Ncycles

Where

WFbase = Water Factor of baseline clothes washer

= 7.59[487]

WFeff = Water Factor of efficient clothes washer

= Actual. If unknown assume average values provided below.

Using the default assumptions provided above, the prescriptive water savings for each efficiency level are presented below:

Efficiency Level	WF[488]	ΔWater (gallons per year)
Federal Standard	7.59	0.0
Energy Star	4.75	2,934
CEE Tier 2	4.15	3,557
CEE Tier 3	3.46	4,264

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-APL-ESCL-V01-120601

[487] Average MEF of non-ENERGY STAR units.

[488] Water Factor is the number of gallons required for each cubic foot of laundry. WF values are the average of the CEC data set. See “CW Analysis.xls” for the calculation.

5.1.3 ENERGY STAR Dehumidifier

Description

A dehumidifier meeting the minimum qualifying efficiency standard established by the current ENERGY STAR (Version 2.1 or 3.0)[489] is purchased and installed in a residential setting in place of a unit that meets the minimum federal standard efficiency.

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 new dehumidifier must meet the ENERGY STAR standards as defined below:

Until 9/30/2012:

Capacity (pints/day)	ENERGY STAR Criteria (L/kWh)
≤25	≥1.20
> 25 to ≤35	≥1.40
> 35 to ≤45	≥1.50
> 45 to ≤ 54	≥1.60
> 54 to ≤ 75	≥1.80
> 75 to ≤ 185	≥2.50

After 10/1/2012[490]:

Capacity (pints/day)	ENERGY STAR Criteria (L/kWh)
<75	≥1.85
75 to ≤185	≥2.80

Qualifying units shall be equipped with an adjustable humidistat control or shall require a remote humidistat control to operate.

Definition of Baseline Equipment

The baseline for this measure is defined as a new dehumidifier that meets the Federal Standard efficiency standards. The Federal Standard for Dehumidifiers changed as of October 2012 as defined below:

Until 9/30/2012:

[489] Energy Star Version 3.0 will become effective 10/1/12
[490] http://www.energystar.gov/ia/partners/prod_development/revisions/downloads/dehumid/ES_Dehumidifiers_Final_V3.0_Eligibility_Criteria.pdf?d70c-99b0

Capacity (pints/day)	Federal Standard Criteria (L/kWh)
≤25	≥1.0
> 25 to ≤35	≥1.20
> 35 to ≤45	≥1.30
> 45 to ≤ 54	≥1.30
> 54 to ≤ 75	≥1.50
> 75 to ≤ 185	≥2.25

Post 10/1/2013

Capacity (pints/day)	Federal Standard Criteria (L/kWh) [491]
Up to 35	≥1.35
> 35 to ≤45	≥1.50
> 45 to ≤ 54	≥1.60
> 54 to ≤ 75	≥1.70
> 75 to ≤ 185	≥2.50

Deemed Lifetime of Efficient Equipment

The assumed lifetime of the measure is 12 years[492].

Deemed Measure Cost

The assumed incremental capital cost for this measure is $40 for units purchased prior to 10/1/2012 and $60 for units purchased after 10/1/2012[493].

Deemed O&M Cost Adjustments

N/A

[491] The Federal Standard for Dehumidifiers changed as of October 2012; https://www.federalregister.gov/articles/2010/12/02/2010-29756/energy-conservation-program-for-consumer-products-test-procedures-for-residential-dishwashers#h-11

[492] ENERGY STAR Dehumidifier Calculator http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDehumidifier.xls

[493] Based on extrapolating available data from the Department of Energy's Life Cycle Cost analysis spreadsheet and weighting based on volume of units available: http://www1.eere.energy.gov/buildings/appliance_standards/residential/docs/lcc_dehumidifier.xls
See 'DOE life cycle cost_dehumidifier.xls' for calculation.

LOADSHAPE

Loadshape R12 - Residential - Dehumidifier

COINCIDENCE FACTOR

The coincidence factor is assumed to be 37% [494].

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh = (((Avg Capacity * 0.473) / 24) * Hours) * (1 / (L/kWh_Base) – 1 / (L/kWh_Eff))

Where:

Avg Capacity = Average capacity of the unit (pints/day)

0.473 = Constant to convert Pints to Liters

24 = Constant to convert Liters/day to Liters/hour

Hours = Run hours per year

= 1620 [495]

L/kWh = Liters of water per kWh consumed, as provided in tables above

Annual kWh results for each capacity class are presented below:

Until 9/30/2012 (V 2.1):

Capacity (pints/day) Range	Capacity Used	Federal Standard Criteria (≥ L/kWh)	ENERGY STAR Criteria (≥ L/kWh)	Annual kWh		
				Federal Standard	ENERGY STAR	Savings
≤25	20	1.0	1.2	643	536	107
> 25 to ≤35	30	1.2	1.4	804	689	115
> 35 to ≤45	40	1.3	1.5	990	858	132
> 45 to ≤ 54	50	1.3	1.6	1237	1005	232
> 54 to ≤ 75	65	1.5	1.8	1394	1161	232
> 75 to ≤ 185	130	2.25	2.5	1858	1673	186

[494] Assume usage is evenly distributed day vs. night, weekend vs. weekday and is used between April through the end of September (4392 possible hours). 1620 operating hours from ENERGY STAR Dehumidifier Calculator. Coincidence peak during summer peak is therefore 1620/4392 = 36.9%

[495] ENERGY STAR Dehumidifier Calculator http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDehumidifier.xls

Average	46	1.31	1.55	1129	953	176

After 10/1/2012 (V 3.0):

Capacity (pints/day) Range	Capacity Used	Federal Standard Criteria (≥ L/kWh)	ENERGY STAR Criteria (≥ L/kWh)	Annual kWh Federal Standard	Annual kWh ENERGY STAR	Annual kWh Savings
≤25	20	1.35	1.85	477	348	129
> 25 to ≤35	30	1.35	1.85	715	522	193
> 35 to ≤45	40	1.5	1.85	858	695	162
> 45 to ≤ 54	50	1.6	1.85	1005	869	136
> 54 to ≤ 75	65	1.7	1.85	1230	1130	100
> 75 to ≤ 185	130	2.5	2.8	1673	1493	179
Average	46	1.51	1.85	983	800	183

Summer Coincident Peak Demand Savings

$$\Delta kW = \Delta kWh/Hours * CF$$

Where:

Hours = Annual operating hours

= 1632 hours [496]

CF = Summer Peak Coincidence Factor for measure

= 0.37 [497]

Summer coincident peak demand results for each capacity class are presented below:

Until 9/30/2012 (V 2.1):

---

[496] Based on 68 days of 24 hour operation; ENERGY STAR Dehumidifier Calculator http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/appliance_calculator.xlsx?f3f7-6a8b&f3f7-6a8b

[497] Assume usage is evenly distributed day vs. night, weekend vs. weekday and is used between April through the end of September (4392 possible hours). 1620 operating hours from ENERGY STAR Dehumidifier Calculator. Coincidence peak during summer peak is therefore 1620/4392 = 36.9%

Capacity (pints/day) Range	Annual Summer peak kW Savings
≤25	0.024
> 25 to ≤35	0.026
> 35 to ≤45	0.030
> 45 to ≤ 54	0.053
> 54 to ≤ 75	0.053
> 75 to ≤ 185	0.042
Average	0.040

After 10/1/2012 (V 3.0):

Capacity (pints/day) Range	Annual Summer peak kW Savings
≤25	0.029
> 25 to ≤35	0.044
> 35 to ≤45	0.037
> 45 to ≤ 54	0.031
> 54 to ≤ 75	0.023
> 75 to ≤ 185	0.041
Average	0.042

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-APL-ESDH-V02-130601

5.1.4 ENERGY STAR Dishwasher

Description

A dishwasher meeting the efficiency specifications of ENERGY STAR is installed in place of a model meeting the federal standard.

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 equipment is defined as a dishwasher meeting the efficiency specifications of ENERGY STAR (for standard and compact dishwashers). The Energy Star standard is presented in the table below:

Dishwasher Type	Maximum kWh/year	Maximum gallons/cycle
Standard	295	4.25
Compact	222	3.5

Definition of Baseline Equipment

The Baseline reflects the minimum federal efficiency standards for dishwashers effective January 1, 2010, as presented in the table below.

Dishwasher Type	Maximum kWh/year	Maximum gallons/cycle
Standard	355	6.5
Compact	260	4.5

Deemed Lifetime of Efficient Equipment

The assumed lifetime of the measure is 13 years[498].

Deemed Measure Cost

The incremental cost for this measure is $50[499].

Deemed O&M Cost Adjustments

N/A

Loadshape

Loadshape R02 - Residential Dish Washer

[498] Koomey, Jonathan et al. (Lawrence Berkeley National Lab), Projected Regional Impacts of Appliance Efficiency Standards for the U.S. Residential Sector, February 1998.
[499] Estimate based on review of Energy Star stakeholder documents

Coincidence Factor

The coincidence factor is assumed to be 2.6%[500].

Algorithm

Calculation of Savings

Electric Energy Savings

$$\Delta kWh^{501} = ((kWh_{Base} - kWh_{ESTAR}) * (\%kWh\_op + (\%kWh\_heat * \%Electric\_DHW)))$$

Where:

kWh_{BASE} = Baseline kWh consumption per year

= 355 kWh for standard

= 260 kWh for Compact

kWh_{ESTAR} = ENERGY STAR kWh annual consumption

= 295 kWh for standard

= 222 kWh for compact

%kWh_op = Percentage of dishwasher energy consumption used for unit operation

= 1 - 56%[502]

= 44%

%kWh_heat = Percentage of dishwasher energy consumption used for water heating

= 56%[503]

%Electric_DHW = Percentage of DHW savings assumed to be electric

DHW fuel	%Electric_DHW
Electric	100%
Natural Gas	0%
Unknown	16%[504]

[500] Calculated from Itron eShapes, 8760 hourly data by end use for Missouri, as provided by Ameren.
[501] The Federal Standard and ENERGY STAR annual consumption values include electric consumption for both the operation of the machine and for heating the water that is used by the machine.
[502] ENERGY STAR Dishwasher Calculator (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls)
[503] Ibid.
[504] 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

An Energy Star standard dishwasher installed in place of a baseline unit with unknown DHW fuel:

ΔkWh = ((355 - 295) * (0.44 + (0.56*0.16)))

= 31.8 kWh

An Energy Star compact dishwasher installed in place of a baseline unit with unknown DHW fuel:

ΔkWh = ((260 - 222) * (0.44 + (0.56*0.16)))

= 20.1 kWh

An Energy Star standard dishwasher installed in place of a baseline unit with electric DHW:

ΔkWh = ((355 - 295) * (0.44 + (0.56*1.0)))

= 60.0 kWh

An Energy Star compact dishwasher installed in place of a baseline unit with electric DHW:

ΔkWh = ((260 - 222) * (0.44 + (0.56*1.0)))

= 38.0 kWh

Summer Coincident Peak Demand Savings

ΔkW = ΔkWh/Hours * CF

Where:

Hours = Annual operating hours[505]

= 252 hours

CF = Summer Peak Coincidence Factor

= 2.6% [506]

An Energy Star standard dishwasher installed in place of a baseline unit with unknown DHW fuel:

ΔkWh = 31.8/252 * 0.026

= 0.003 kW

assumption for homes in a particular market or geographical area then that should be used.

[505] Assuming one and a half hours per cycle and 168 cycles per year therefore 252 operating hours per year; 168 cycles per year is based on a weighted average of dishwasher usage in Illinois derived from the 2009 RECs data; http://205.254.135.7/consumption/residential/data/2009/

[506] End use data from Ameren representing the average DW load during peak hours/peak load.

An Energy Star compact dishwasher installed in place of a baseline unit with unknown DHW fuel:

ΔkWh = 20.1/252 * 0.026

= 0.002 kWh

An Energy Star standard dishwasher installed in place of a baseline unit with electric DHW:

ΔkWh = 60.0/252 * 0.026

= 0.006 kWh

An Energy Star compact dishwasher installed in place of a baseline unit with electric DHW:

ΔkWh = 38.0/252 * 0.026

= 0.004 kWh

NATURAL GAS SAVINGS

Δ Therm = (kWh_{Base} - kWh_{ESTAR}) * %kWh_heat * %Natural Gas_DHW * R_eff * 0.03413

Where

%kWh_heat = % of dishwasher energy used for water heating

= 56%

%Natural Gas_DHW = Percentage of DHW savings assumed to be Natural Gas

DHW fuel	%Natural Gas_DHW
Electric	0%
Natural Gas	100%
Unknown	84%[507]

R_eff = Recovery efficiency factor

= 1.26[508]

0.03413 = factor to convert from kWh to Therm

An Energy Star standard dishwasher installed in place of a baseline unit with unknown DHW fuel:

[507] 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.

[508] To account for the different efficiency of electric and Natural Gas hot water heaters (gas water heater: recovery efficiencies ranging from 0.74 to 0.85 (0.78 used), and electric water heater with 0.98 recovery efficiency (http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Waste_Water_Heat_Recovery_Guidelines.pdf). Therefore a factor of 0.98/0.78 (1.26) is applied.

$$\Delta Therm = (355 - 295) * 0.56 * 0.84 * 1.26 * 0.03413$$

$$= 1.26\ Therm$$

An Energy Star compact dishwasher installed in place of a baseline unit with unknown DHW fuel:

$$\Delta Therm = (260 - 222) * 0.56 * 0.84 * 1.26 * 0.03413$$

$$= 0.77\ Therm$$

An Energy Star standard dishwasher installed in place of a baseline unit with gas DHW:

$$\Delta Therm = (355 - 295) * 0.56 * 1.0 * 1.26 * 0.03413$$

$$= 1.44\ Therm$$

An Energy Star compact dishwasher installed in place of a baseline unit with gas DHW:

$$\Delta Therm = (260 - 222) * 0.56 * 1.0 * 1.26 * 0.03413$$

$$= 0.92\ Therm$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

$$\Delta Water = Water_{Base} - Water_{EFF}$$

Where

$Water_{Base}$ = water consumption of conventional unit

= 1008 gallons[509] for standard unit

= 672 gallons[510] for compact

$Water_{EFF}$ = annual water consumption of efficient unit:

= 672 gallons[511] for standard unit

= 504 gallons[512] for compact

[509] Assuming 6 gallons/cycle based on ENERGY STAR Dishwasher Calculator (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls) and 168 cycles per year based on a weighted average of dishwasher usage in Illinois derived from the 2009 RECs data; http://205.254.135.7/consumption/residential/data/2009/

[510] Assuming 4 gallons/cycle for baseline unit

[511] Assuming 4gallons/cycle based on ENERGY STAR Dishwasher Calculator (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls) and 168 cycles per year based on a weighted average of dishwasher usage in Illinois derived from the 2009 RECs data; http://205.254.135.7/consumption/residential/data/2009/

Δ Water (Standard) = 1008 – 672

= 336 gallons

Δ Water (Compact) = 672 – 504

= 168 gallons

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-APL-ESDI-V01-120601

[512] Assuming 3 gallons/cycle for efficient unit

5.1.5 ENERGY STAR Freezer

DESCRIPTION

A freezer meeting the efficiency specifications of ENERGY STAR is installed in place of a model meeting the federal standard (NAECA). Energy usage specifications are defined in the table below (note, AV is the freezer Adjusted Volume and is calculated as 1.73*Total Volume):[513]

Product Category	NAECA Maximum Energy Usage in kWh/year[514]	ENERGY STAR Maximum Energy Usage in kWh/year[515]	Volume (cubic feet)
Upright Freezers with Manual Defrost	7.55*AV+258.3	6.795*AV+232.47	7.75 or greater
Upright Freezers with Automatic Defrost	12.43*AV+326.1	11.187*AV+293.49	7.75 or greater
Chest Freezers and all other Freezers except Compact Freezers	9.88*AV+143.7	8.892*AV+129.33	7.75 or greater
Compact Upright Freezers with Manual Defrost	9.78*AV+250.8	7.824*AV+200.64	< 7.75 and 36 inches or less in height
Compact Upright Freezers with Automatic Defrost	11.40*AV+391	9.12*AV+312.8	< 7.75 and 36 inches or less in height
Compact Chest Freezers	10.45*AV+152	8.36*AV+121.6	<7.75 and 36 inches or less in height

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 equipment is defined as a freezer meeting the efficiency specifications of ENERGY STAR, as defined below and calculated above:

Equipment	Volume	Criteria
Full Size Freezer	7.75 cubic feet or greater	At least 10% more energy efficient than the minimum federal government standard (NAECA).
Compact Freezer	Less than 7.75 cubic feet and 36 inches or less in height	At least 20% more energy efficient than the minimum federal government standard (NAECA).

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is assumed to be a model that meets the federal minimum standard for energy efficiency. The standard varies depending on the size and configuration of the freezer (chest freezer or upright freezer,

[513] http://www.energystar.gov/ia/products/appliances/refrig/NAECA_calculation.xls?c827-f746
[514] as of July 1, 2001
[515] as of April 28, 2008

automatic or manual defrost) and is defined in the table above.

Deemed Lifetime of Efficient Equipment

The measure life is assumed to be 11 years[516].

Deemed Measure Cost

The incremental cost for this measure is $35[517].

Deemed O&M Cost Adjustments

There are no operation and maintenance cost adjustments for this measure.

Loadshape

Loadshape R04 - Residential Freezer

Coincidence Factor

The summer peak coincidence factor for this measure is assumed to be 95%[518].

Algorithm

Calculation of Savings

Electric Energy Savings:

$$\Delta kWh = kWh_{Base} - kWh_{ESTAR}$$

Where:

kWh_{BASE} = Baseline kWh consumption per year as calculated in algorithm provided in table above.

kWh_{ESTAR} = ENERGY STAR kWh consumption per year as calculated in algorithm provided in table above.

516 Energy Star Freezer Calculator; http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Consumer_Residential_Freezer_Sav_Calc.xls?570a-f000

517 Based on review of data from the Northeast Regional ENERGY STAR Consumer Products Initiative; “2009 ENERGY STAR Appliances Practices Report”, submitted by Lockheed Martin, December 2009.

518 Based on eShapes Residential Freezer load data as provided by Ameren.

For example for a 7.75 cubic foot Upright Freezers with Manual Defrost:

ΔkWh =(7.55*(7.75* 1.73)+258.3) – (6.795*(7.75* 1.73)+232.47)

= 359.5 – 323.6

= 35.9 kWh

If volume is unknown, use the following default values:

Product Category	Volume Used[519]	kWh_{BASE}	kWh_{ESTAR}	kWh Savings
Upright Freezers with Manual Defrost	27.9	469.1	422.2	46.9
Upright Freezers with Automatic Defrost	27.9	673.2	605.9	67.3
Chest Freezers and all other Freezers except Compact Freezers	27.9	419.6	377.6	42.0
Compact Upright Freezers with Manual Defrost	10.4	352.3	281.9	70.5
Compact Upright Freezers with Automatic Defrost	10.4	509.3	407.5	101.9
Compact Chest Freezers	10.4	260.5	208.4	52.1

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh/ Hours * CF

Where:

ΔkWh = Gross customer annual kWh savings for the measure

Hours = Full Load hours per year

= 5890[520]

CF = Summer Peak Coincident Factor

= 0.95 [521].

[519] Volume is based on ENERGY STAR Calculator assumption of 16.14 ft^3 average volume, converted to Adjusted volume by multiplying by 1.73.

[520] Calculated from eShapes Residential Freezer load data as provided by Ameren by dividing total annual load by the maximum kW in any one hour.

For example for a 7.75 cubic foot Upright Freezers with Manual Defrost:

$$\Delta kW = 35.9/5890 * 0.95$$

$$= 0.0058 \text{ kW}$$

If volume is unknown, use the following default values:

Product Category	kW Savings
Upright Freezers with Manual Defrost	0.0076
Upright Freezers with Automatic Defrost	0.0109
Chest Freezers and all other Freezers except Compact Freezers	0.0068
Compact Upright Freezers with Manual Defrost	0.0114
Compact Upright Freezers with Automatic Defrost	0.0164
Compact Chest Freezers	0.0084

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-APL-ESFR-V01-120601

[521] Based on eShapes Residential Freezer load data as provided by Ameren.

5.1.6 ENERGY STAR and CEE Tier 2 Refrigerator

DESCRIPTION

This measure relates to the purchase and installation of a new refrigerator meeting either ENERGY STAR or CEE TIER 2 specifications. Energy usage specifications are defined in the table below (note, Adjusted Volume is calculated as the fresh volume + (1.63 * Freezer Volume):[522]

Product Category	NAECA as of July 1, 2001 Maximum Energy Usage in kWh/year	Current ENERGY STAR level Maximum Energy Usage in kWh/year
1. Refrigerators and Refrigerator-freezers with manual defrost	8.82*AV+248.4	7.056*AV+198.72
2. Refrigerator-Freezer--partial automatic defrost	8.82*AV+248.4	7.056*AV+198.72
3. Refrigerator-Freezers--automatic defrost with top-mounted freezer without through-the-door ice service and all-refrigerators--automatic defrost	9.80*AV+276	7.84*AV+220.8
4. Refrigerator-Freezers--automatic defrost with side-mounted freezer without through-the-door ice service	4.91*AV+507.5	3.928*AV+406
5. Refrigerator-Freezers--automatic defrost with bottom-mounted freezer without through-the-door ice service	4.60*AV+459	3.68*AV+367.2
6. Refrigerator-Freezers--automatic defrost with top-mounted freezer with through-the-door ice service	10.20*AV+356	8.16*AV+284.8
7. Refrigerator-Freezers--automatic defrost with side-mounted freezer with through-the-door ice service	10.10*AV+406	8.08*AV+324.8

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 equipment is defined as a refrigerator meeting the efficiency specifications of ENERGY STAR or CEE Tier 2 (defined as requiring >= 20% or >= 25% less energy consumption than an equivalent unit meeting federal standard requirements respectively). The ENERGY STAR standard varies according to the size and configuration of the unit, as shown in table above.

DEFINITION OF BASELINE EQUIPMENT

The baseline condition is a new refrigerator meeting the minimum federal efficiency standard for refrigerator efficiency. The current federal minimum standard varies according to the size and configuration of the unit, as shown in table above. Note also that this federal standard will be increased for units manufactured after January 1, 2014.

522 http://www.energystar.gov/ia/products/appliances/refrig/NAECA_calculation.xls?c827-f746

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life is assumed to be 12 years.[523]

DEEMED MEASURE COST

The incremental cost for this measure is assumed to be $30[524] for an ENERGY STAR unit and $140[525] for a CEE Tier 2 unit.

DEEMED O&M COST ADJUSTMENTS

There are no operation and maintenance cost adjustments for this measure.

LOADSHAPE

Loadshape R05 - Residential Refrigerator

COINCIDENCE FACTOR

A coincidence factor is not used to calculate peak demand savings for this measure, see below.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS:

$$\Delta kWh = UEC_{BASE} - UEC_{EE}$$

Where:

UEC_{BASE} = Annual Unit Energy Consumption of baseline unit as calculated in algorithm provided in table above.

UEC_{EE} = Annual Unit Energy Consumption of ENERGY STAR unit as calculated in algorithm provided in table above.

For CEE Tier 2, unit consumption is calculated as 25% lower than baseline.

523 From ENERGY STAR calculator: http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Consumer_Residential_Refrig_Sav_Calc.xls

524 Ibid.

525 Based on weighted average of units participating in Efficiency Vermont program and retail cost data provided in Department of Energy, "TECHNICAL REPORT: Analysis of Amended Energy Conservation Standards for Residential Refrigerator-Freezers", October 2005; http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/refrigerator_report_1.pdf

If volume is unknown, use the following defaults:

Product Category	Volume Used[526]	UEC_{base}	ENERGY STAR UEC_{EE}	CEE T2 UEC_{EE}	ENERGY STAR kWh Savings	CEE T2 kWh Savings
1. Refrigerators and Refrigerator-freezers with manual defrost	25.8	475.7	380.5	356.8	95.1	118.9
2. Refrigerator-Freezer--partial automatic defrost	25.8	475.7	380.5	356.8	95.1	118.9
3. Refrigerator-Freezers--automatic defrost with top-mounted freezer without through-the-door ice service and all-refrigerators--automatic defrost	25.8	528.5	422.8	396.4	105.7	132.1
4. Refrigerator-Freezers--automatic defrost with side-mounted freezer without through-the-door ice service	25.8	634.0	507.2	475.5	126.8	158.5
5. Refrigerator-Freezers--automatic defrost with bottom-mounted freezer without through-the-door ice service	25.8	577.5	462.0	433.2	115.5	144.4
6. Refrigerator-Freezers--automatic defrost with top-mounted freezer with through-the-door ice service	25.8	618.8	495.1	464.1	123.8	154.7
7. Refrigerator-Freezers--automatic defrost with side-mounted freezer with through-the-door ice service	25.8	666.3	533.0	499.7	133.3	166.6

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = (ΔkWh/8766) * TAF * LSAF

Where:

TAF = Temperature Adjustment Factor

= 1.25[527]

[526] Volume is based on the ENERGY STAR calculator average assumption of 14.75 ft^3 fresh volume and 6.76 ft^3 freezer volume.

[527] Average temperature adjustment factor (to account for temperature conditions during peak period as compared to year as a whole) based on Blasnik, Michael, "Measurement and Verification of Residential Refrigerator Energy Use, Final Report, 2003-2004 Metering Study", July 29, 2004 (p. 47). It assumes 90 °F average outside temperature during peak period, 71°F average temperature in kitchens and 65°F average temperature in basement, and uses assumption that 66% of homes in Illinois having central cooling (CAC saturation: "Table HC7.9

LSAF = Load Shape Adjustment Factor

= 1.057 [528]

If volume is unknown, use the following defaults:

Product Category	ENERGY STAR kW Savings	CEE T2 kW Savings
1. Refrigerators and Refrigerator-freezers with manual defrost	0.0143	0.0179
2. Refrigerator-Freezer--partial automatic defrost	0.0143	0.0179
3. Refrigerator-Freezers--automatic defrost with top-mounted freezer without through-the-door ice service and all-refrigerators--automatic defrost	0.0159	0.0199
4. Refrigerator-Freezers--automatic defrost with side-mounted freezer without through-the-door ice service	0.0191	0.0239
5. Refrigerator-Freezers--automatic defrost with bottom-mounted freezer without through-the-door ice service	0.0174	0.0218
6. Refrigerator-Freezers--automatic defrost with top-mounted freezer with through-the-door ice service	0.0187	0.0233
7. Refrigerator-Freezers--automatic defrost with side-mounted freezer with through-the-door ice service	0.0201	0.0251

Natural Gas Savings

N/A

Water Impact Descriptions and Calculation

N/A

Deemed O&M Cost Adjustment Calculation

N/A

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)

[528] Daily load shape adjustment factor (average load in peak period /average daily load) also based on Blasnik, Michael, "Measurement and Verification of Residential Refrigerator Energy Use, Final Report, 2003-2004 Metering Study", July 29, 2004 (p. 48, using the average Existing Units Summer Profile for hours 13 through 17)

MEASURE CODE: RS-APL-ESRE-V01-120601

5.1.7 ENERGY STAR and CEE Tier 1 Room Air Conditioner

Description

This measure relates to the purchase and installation of a room air conditioning unit that meets CEE TIER 1 (equivalent to ENERGY STAR version 3.0 which is effective October 1st 2013) minimum qualifying efficiency specifications, in place of a baseline unit meeting ENERGY STAR Version 2.0 efficiency ratings presented below[529]. According to ENERGY STAR Shipment Data the estimated market penetration of ENERGY STAR Room AC went from 33%[530] in 2010 to 62%[531] in 2011. Further in a 2012 Illinois program evaluation found a net-to-gross ratio of just 1% for a Version 2.0 ENERGY STAR unit. This has therefore become the baseline.

Product Class (Btu/H)	Baseline EER: ENERGY STAR V2.0, with louvered sides	Baseline EER: ENERGY STAR, without louvered sides	CEE TIER 1 EER
< 8,000	10.7	9.9	11.2
8,000 to 13,999	10.8	9.4	11.3
14,000 to 19,999	10.7	9.4	11.2
>= 20,000	9.4	9.4	9.8

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 new room air conditioning unit must meet the CEE TIER 1 (equivalent to ENERGY STAR version 3.0 which is effective October 1st 2013) efficiency standards presented above.

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529 http://www.energystar.gov/index.cfm?c=roomac.pr_crit_room_ac and http://www.cee1.org/resid/seha/rm-ac/rm-ac_specs.pdf
Side louvers that extend from a room air conditioner model in order to position the unit in a window. A model without louvered sides is placed in a built-in wall sleeve and are commonly referred to as "through-the-wall" or "built-in" models.
Casement-only refers to a room air conditioner designed for mounting in a casement window of a specific size.
Casement-slider refers to a room air conditioner with an encased assembly designed for mounting in a sliding or casement window of a specific size.
Reverse cycle refers to the heating function found in certain room air conditioner models.
http://www.energystar.gov/ia/partners/product_specs/program_reqs/room_air_conditioners_prog_req.pdf

530 http://www.energystar.gov/ia/partners/downloads/unit_shipment_data/2010_USD_Summary_Report.pdf?3193-51e7

531 http://www.energystar.gov/ia/partners/downloads/unit_shipment_data/2011_USD_Summary_Report.pdf?3193-51e7

DEFINITION OF BASELINE EQUIPMENT

The baseline assumption is a new room air conditioning unit that meets the ENERGY STAR Version 2.0 efficiency standards as presented above.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life is assumed to be 12 years[532].

DEEMED MEASURE COST

The incremental cost for this measure is assumed to be $40 for a CEE TIER 1 unit[533].

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape R08 - Residential Cooling

COINCIDENCE FACTOR

The coincidence factor for this measure is assumed to be 0.3[534].

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = (FLH_{RoomAC} * Btu/H * (1/EERbase - 1/EERee))/1000$$

Where:

FLH_{RoomAC} = Full Load Hours of room air conditioning unit

= dependent on location[535]:

[532] 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

[533] Based on field study conducted by Efficiency Vermont

[534] Consistent with coincidence factors found in: RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008 (http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf)

[535] Full load hours for room AC is significantly lower than for central AC. The average ratio of FLH for Room AC (provided in RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008: http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%2

Climate Zone (City based upon)	FLH_{RoomAC}
1 (Rockford)	220
2 (Chicago)	210
3 (Springfield)	319
4 (Belleville)	428
5 (Marion)	374
Weighted Average[536]	248

Btu/H = Size of rebated unit

= Actual. If unknown assume 8500 BTU/hour[537]

EERbase = Efficiency of baseline unit

= As provided in tables above

EERee = Efficiency of CEE Tier 1 (or ENERGY STAR Version 3.0) unit

= Actual. If unknown assume minimum qualifying standard as provided in tables above

For example for an 8,500 BTU/H capacity unit, with louvered sides, in an unknown location: $\Delta kWH_{CEE\ TIER\ 1}$ = (248 * 8500 * (1/10.8 – 1/11.3)) / 1000

= 8.6 kWh

Summer Coincident Peak Demand Savings

$$\Delta kW = Btu/H * ((1/EERbase - 1/EERee))/1000) * CF$$

Where:

CF = Summer Peak Coincidence Factor for measure

= 0.3[538]

0Res%20RAC.pdf) to FLH for Central Cooling for the same location (provided by AHRI: http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls) is 31%. This ratio is applied to those IL cities that have FLH for Central Cooling provided in the Energy Star calculator. For other cities this is extrapolated using the FLH assumptions VEIC have developed for Central AC. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

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

537 Based on maximum capacity average from the RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008

538 Consistent with coincidence factors found in: RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008

Other variable as defined above

For example for an 8,500 BTU/H capacity unit, with louvered sides, for an unknown location:

$$\Delta kW_{CEE\ TIER\ 1} = (8500 * (1/10.8 – 1/11.3)) / 1000 * 0.3$$

$$= 0.010\ kW$$

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-APL-ESRA-V02-130601

(http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf)

5.1.8 Refrigerator and Freezer Recycling

Description

This measure describes savings from the retirement and recycling of inefficient but operational refrigerators and freezers. Savings are provided based on a 2013 workpaper provided by Cadmus that used data from a 2012 ComEd metering study and metering data from a Michigan study, to develop a regression equation that uses key inputs describing the retired unit. The savings are equivalent to the Unit Energy Consumption of the retired unit and should be claimed for the assumed remaining useful life of that unit. A part use factor is applied to account for those secondary units that are not in use throughout the entire year. The reader should note that the regression algorithm is designed to provide an accurate portrayal of savings for the population as a whole and includes those parameters that have a significant effect on the consumption. The precision of savings for individual units will vary.

The Net to Gross factor applied to these units should incorporate adjustments that account for:

- Those participants who would have removed the unit from the grid anyway (e.g. customers replacing their refrigerator via a big box store and using the pick-up option, customers taking their unit to the landfill or recycling station);
- Those participants who decided, based on the incentive provided by the Appliance Recycling program alone, to replace their existing inefficient unit with a new unit. This segment of participants is expected to be very small and documentation of their intentions will be gathered via telephone surveys (i.e., primary data sources). For such customers, the consumption of the new unit should be subtracted from the retired unit consumption and savings claimed for the remaining life of the existing unit. Note that participants who were already planning to replace their unit, and the incentive just ensured that the retired unit was recycled and not placed on the secondary market, should not be included in this adjustment.

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

Definition of Efficient Equipment

n/a

Definition of Baseline Equipment

The existing inefficient unit must be operational and have a capacity of between 10 and 30 cubic feet.

Deemed Lifetime of Efficient Equipment

The estimated remaining useful life of the recycling units is 8 years [539].

Deemed Measure Cost

Measure cost includes the cost of pickup and recycling of the refrigerator and should be based on actual costs of running the program. If unknown assume $120[540] per unit.

[539] KEMA "Residential refrigerator recycling ninth year retention study", 2004
[540] Based on similar Efficiency Vermont program.

DEEMED O&M COST ADJUSTMENTS

n/a

LOADSHAPE

Loadshape R05 - Residential Refrigerator

COINCIDENCE FACTOR

The coincidence factor is assumed to be 0.00012.

Algorithm

CALCULATION OF SAVINGS

ENERGY SAVINGS

Refrigerators:

Energy savings for refrigerators are based upon a linear regression model using the following coefficients[541]:

Independent Variable Description	Estimate Coefficient
Intercept	116.843
Age (years)	10.895
Pre-1990 (=1 if manufactured pre-1990)	431.788
Size (cubic feet)	19.424
Dummy: Single Door (=1 if single door)	-795.368
Dummy: Side-by-Side (= 1 if side-by-side)	426.407
Dummy: Primary Usage Type (in absence of the program) (= 1 if primary unit)	170.984
Interaction: Located in Unconditioned Space x CDD/365.25	17.342
Interaction: Located in Unconditioned Space x HDD/365.25	-11.776

ΔkWh = [116.84 + (Age * 10.90) + (Pre-1990 * 431.79) + (Size * 19.42) + (Single-Door * -795.37) + (Side-by-side * 426.41) + (Proportion of Primary Appliances * 170.98) + (CDD/365.25 * unconditioned * 17.34) + (HDD/365.25 *unconditioned *-11.78)] * Part Use Factor

Where:

[541] Energy savings are based on an average 30-year TMY temperature of 51.1 degrees. Coefficients provided in January 31, 2013 memo from Cadmus: "Appliance Recycling Update".

Age = Age of retired unit

Pre-1990 = Pre-1990 dummy (=1 if manufactured pre-1990, else 0)

Size = Capacity (cubic feet) of retired unit

Side-by-side = Side-by-side dummy (= 1 if side-by-side, else 0)

Single-Door = Single-Door dummy (= 1 if Single-Door, else 0)

Primary Usage = Primary Usage Type (in absence of the program) dummy (= 1 if Primary, else 0)

Interaction: Located in Unconditioned Space x CDD/365.25

(=1 * CDD/365.25 if in unconditioned space)

CDD = Cooling Degree Days

= Dependent on location[542]:

Climate Zone (City based upon)	CDD 65	CDD/365.25
1 (Rockford)	820	2.25
2 (Chicago)	842	2.31
3 (Springfield)	1,108	3.03
4 (Belleville)	1,570	4.30
5 (Marion)	1,370	3.75

Interaction: Located in Unconditioned Space x HDD/365.25

(=1 * HDD/365.25 if in unconditioned space)

HDD = Heating Degree Days

= Dependent on location:[543]

Climate Zone (City based upon)	HDD 65	HDD/365.25
1 (Rockford)	6,569	17.98
2 (Chicago)	6,339	17.36
3 (Springfield)	5,497	15.05
4 (Belleville)	4,379	11.99
5 (Marion)	4,476	12.25

Part Use Factor = To account for those units that are not running throughout the entire year.

= 0.876[544]

[542] National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 65°F.
[543] National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 65°F.
[544] Weighted average of Part Use factors from Ameren PY2-PY4 and ComEd PY2-PY4, weighted by units recycled.

For example, the program averages for AIC's ARP in PY4 produce the following equation:

ΔkWh = [116.84+ (22.81 * 10.90) + (0.45 * 431.79) + (18.82 * 19.42) + (0.1 * -795.37) + (0.17 * 426.41) + (0.34 * 170.98) + (1.29 * 17.34) + (6.49 * -11.78)] * 0.876

= 920 * 0.876

= 806 kWh

Freezers:

Energy savings for freezers are based upon a linear regression model using the following coefficients[545]:

Independent Variable Description	Estimate Coefficient
Intercept	132.122
Age (years)	12.130
Pre-1990 (=1 if manufactured pre-1990)	156.181
Size (cubic feet)	31.839
Chest Freezer Configuration (=1 if chest freezer)	-19.709
Interaction: Located in Unconditioned Space x CDD/365.25	-12.755
Interaction: Located in Unconditioned Space x HDD/365.25	9.778

ΔkWh = [132.12 + (Age * 12.13) + (Pre-1990 * 156.18) + (Size * 31.84) + (Chest Freezer * -19.71) + (CDDs* unconditioned *9.78) + (HDDs*unconditioned *-12.75)] * Part Use Factor

Where:

Age = Age of retired unit

Pre-1990 = Pre-1990 dummy (=1 if manufactured pre-1990, else 0)

Size = Capacity (cubic feet) of retired unit

Chest Freezer = Chest Freezer dummy (= 1 if chest freezer, else 0)

Interaction: Located in Unconditioned Space x CDD/365.25

See 'Appliance Recycling Part Use Calc.xlsx'

[545] Energy savings are based on an average 30-year TMY temperature of 51.1 degrees. Coefficients provided in January 31, 2013 memo from Cadmus: "Appliance Recycling Update".

(=1 * CDD/365.25 if in unconditioned space)

CDD = Cooling Degree Days (see table above)

Interaction: Located in Unconditioned Space x HDD/365.25

(=1 * HDD/365.25 if in unconditioned space)

HDD = Heating Degree Days (see table above)

Part Use Factor = To account for those units that are not running throughout the entire year.

= 0.825[546]

> The program averages for AIC's ARP PY4 program are used as an example.
>
> ΔkWh = [132.12 + (26.92 * 12.13) + (0.6 * 156.18) + (15.9 * 31.84) + (0.48 * -19.71) + (6.61 * 9.78) + (1.3 * -12.75)] * 0.825
>
> = 977 * 0.825
>
> = 905 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = kWh/8760 * CF

Where:

kWh = Savings provided in algorithm above

CF = Coincident factor defined as summer kW/average kW

= 1.081 for Refrigerators

= 1.028 for Freezers[547]

> For example, the program averages for AIC's ARP in PY4 produce the following equation:
>
> ΔkW = 806/8760 * 1.081
>
> = 0.099 kW

[546] Weighted average of Part Use factors from Ameren PY2-PY4 and ComEd PY2-PY4, weighted by units recycled. See 'Appliance Recycling Part Use Calc.xlsx'

[547] Cadmus memo, February 12, 2013; "Appliance Recycling Update"

NATURAL GAS SAVINGS

n/a

WATER IMPACT DESCRIPTIONS AND CALCULATION

n/a

DEEMED O&M COST ADJUSTMENT CALCULATION

n/a

MEASURE CODE: RS-APL-RFRC-V02-130601

5.1.9 Room Air Conditioner Recycling

Description

This measure describes the savings resulting from running a drop off service taking existing residential, inefficient Room Air Conditioner units from service, prior to their natural end of life. This measure assumes that though a percentage of these units will be replaced this is not captured in the savings algorithm since it is unlikely that the incentive made someone retire a unit that they weren't already planning to retire. The savings therefore relate to the unit being taken off the grid as opposed to entering the secondary market. The Net to Gross factor applied to these units should incorporate adjustments that account for those participants who would have removed the unit from the grid anyway.

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

Definition of Efficient Equipment

N/A. This measure relates to the retiring of an existing inefficient unit.

Definition of Baseline Equipment

The baseline condition is the existing inefficient room air conditioning unit.

Deemed Lifetime of Efficient Equipment

The assumed remaining useful life of the existing room air conditioning unit being retired is 4 years[548].

Deemed Measure Cost

The actual implementation cost for recycling the existing unit should be used.

Deemed O&M Cost Adjustments

N/A

Loadshape

Loadshape R08 - Residential Cooling

Coincidence Factor

The coincidence factor for this measure is assumed to be 30%[549].

[548] A third of assumed measure life for Room AC.
[549] Consistent with coincidence factors found in: RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008 (http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf)

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$\Delta kWh = ((FLH_{RoomAC} * BtuH * (1/EERexist))/1000)$

Where:

FLH_{RoomAC} = Full Load Hours of room air conditioning unit

= dependent on location[550]:

Climate Zone (City based upon)	FLH_{RoomAC}
1 (Rockford)	220
2 (Chicago)	210
3 (Springfield)	319
4 (Belleville)	428
5 (Marion)	374
Weighted Average[551]	248

Btu/H = Size of retired unit

= Actual. If unknown assume 8500 BTU/hour [552]

EERexist = Efficiency of existing unit

= 7.7[553]

[550] The average ratio of FLH for Room AC (provided in RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008: http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf) to FLH for Central Cooling for the same location (provided by AHRI: http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls) is 31%. This ratio is applied to those IL cities that have FLH for Central Cooling provided in the Energy Star calculator. For other cities this is extrapolated using the FLH assumptions VEIC have developed for Central AC. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

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

[552] Based on maximum capacity average from the RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008

[553] Based on Nexus Market Research Inc, RLW Analytics, December 2005; "Impact, Process, and Market Study of the Connecticut Appliance Retirement Program: Overall Report."

For example for an 8500 BTU/h unit in Springfield:

$$\Delta kWh = ((319 * 8500 * (1/7.7)) / 1000)$$

$$= 352 \text{ kWh}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = (BtuH * (1/EERexist))/1000) * CF$$

Where:

CF = Summer Peak Coincidence Factor for measure

= 0.3[554]

For example an 8500 BTU/h unit:

$$\Delta kW = (8500 * (1/7.7)) / 1000) * 0.3$$

$$= 0.33 \text{ kW}$$

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-APL-RARC-V01-120601

[554] Consistent with coincidence factors found in:
RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008 (http://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/117_RLW_CF%20Res%20RAC.pdf)

5.2 Consumer Electronics End Use

5.2.1 Smart Strip

DESCRIPTION

This measure relates to Controlled Power Strips (or Smart Strips) which are multi-plug power strips with the ability to automatically disconnect specific connected loads depending upon the power draw of a control load, also plugged into the strip. Power is disconnected from the switched (controlled) outlets when the control load power draw is reduced below a certain adjustable threshold, thus turning off the appliances plugged into the switched outlets. By disconnecting, the standby load of the controlled devices, the overall load of a centralized group of equipment (i.e. entertainment centers and home office) can be reduced. Uncontrolled outlets are also provided that are not affected by the control device and so are always providing power to any device plugged into it. This measure characterization provides savings for a 5-plug strip and a 7-plug strip.

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

DEFINITION OF EFFICIENT EQUIPMENT

The efficient case is the use of a 5 or 7-plug smart strip.

DEFINITION OF BASELINE EQUIPMENT

The assumed baseline is a standard power strip that does not control connected loads.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The assumed lifetime of the smart strip is 4 years[555].

DEEMED MEASURE COST

The incremental cost of a smart strip over a standard power strip with surge protection is assumed to be $16 for a 5-plug and $26 for a 7-plug[556].

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape R13 - Residential Standby Losses – Entertainment
Loadshape R14 - Residential Standby Losses - Home Office

[555] David Rogers, Power Smart Engineering, October 2008; “Smart Strip electrical savings and usability”, p22.
[556] Price survey performed in NYSERDA Measure Characterization for Advanced Power Strips, p4

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is assumed to be 80%[557].

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$\Delta kWh_{5\text{-}Plug}$ = 56.5 kWh [558]

$\Delta kWh_{7\text{-}Plug}$ = 103 kWh [559]

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$\Delta kW = \Delta kWh / Hours * CF$

Where:

Hours = Annual number of hours during which the controlled standby loads are turned off by the Smart Strip.

= 7,129 [560]

CF = Summer Peak Coincidence Factor for measure

= 0.8 [561]

$\Delta kW_{5\text{-}Plug}$ = 56.5 / 7129 * 0.8

= 0.00634 kW

[557] Efficiency Vermont coincidence factor for smart strip measure –in the absence of empirical evaluation data, this was based on assumptions of the typical run pattern for televisions and computers in homes.

[558] NYSERDA Measure Characterization for Advanced Power Strips. Study based on review of:

I. Smart Strip Electrical Savings and Usability, Power Smart Engineering, October 27, 2008.
II. Final Field Research Report, Ecos Consulting, October 31, 2006. Prepared for California Energy Commission's PIER Program.
III. Developing and Testing Low Power Mode Measurement Methods, Lawrence Berkeley National Laboratory (LBNL), September 2004. Prepared for California Energy Commission's Public Interest Energy Research (PIER) Program.
IV. 2005 Intrusive Residential Standby Survey Report, Energy Efficient Strategies, March, 2006.
V. Smart Strip Portfolio of the Future, Navigant Consulting for San Diego G&E, March 31, 2009.

[559] Ibid.

[560] Average of hours for controlled TV and computer from; NYSERDA Measure Characterization for Advanced Power Strips

[561] Efficiency Vermont coincidence factor for smart strip measure –in the absence of empirical evaluation data, this was based on assumptions of the typical run pattern for televisions and computers in homes.

$$\Delta kW_{7\text{-}Plug} = 102.8 / 7129 * 0.8$$

$$= 0.0115 \text{ kW}$$

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-CEL-SSTR-V01-120601

5.3 HVAC End Use

5.3.1 Air Source Heat Pump

DESCRIPTION

A heat pump provides heating or cooling by moving heat between indoor and outdoor air.

This measure characterizes:

a) Time of Sale:
   a. The installation of a new residential sized (<= 65,000 BTU/hr) air source heat pump that is more efficient than required by federal standards. This could relate to the replacement of an existing unit at the end of its useful life, or the installation of a new system in a new home.

b) Early Replacement:
   a. The early removal of functioning electric heating and cooling (SEER 10 or under if present) systems from service, prior to its natural end of life, and replacement with a new high efficiency air source heat pump unit. Savings are calculated between existing unit and efficient unit consumption during the remaining life of the existing unit, and between new baseline unit and efficient unit consumption for the remainder of the measure life.
   b. The assumption of the existing unit efficiency in the Early Replacement section of this TRM is based upon the average efficiency of units that were classified in Ameren's PY3-PY4 as functioning and SEER <=10. Therefore it is only appropriate to use these Early Replacement assumptions where those conditions are met. The TAC defined "functioning" as the unit is fully operational – providing sufficient space conditioning (i.e. heat exchanger, compressors, pumps work effectively) and/or the cost of repair is under 20% of the new baseline replacement cost. Therefore in order to apply early replacement assumptions the programs should apply the following eligibility criteria: SEER <=10 and cost of any repairs <$249 per ton.

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

DEFINITION OF EFFICIENT EQUIPMENT

A new residential sized (<= 65,000 BTU/hr) air source heat pump with specifications to be determined by program.

DEFINITION OF BASELINE EQUIPMENT

A new residential sized (<= 65,000 BTU/hr) air source heat pump meeting federal standards.

The baseline for the Time of Sale measure is based on the current Federal Standard efficiency level; 13 SEER and 7.7HSPF.

The baseline for the early replacement measure is the efficiency of the existing equipment for the assumed remaining useful life of the unit and the new baseline as defined above[562] for the remainder of the measure life.

[562] Baseline SEER and EER should be updated when new minimum federal standards become effective.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 18 years[563].

Remaining life of existing equipment is assumed to be 6 years[564].

DEEMED MEASURE COST

Time of sale: The incremental capital cost for this measure is dependent on the efficiency and capacity of the new unit[565]. Note these costs are per ton of unit capacity:

Efficiency (SEER)	Incremental Cost per Ton of Capacity ($/ton)
14	$137
15	$274
16	$411
17	$548
18	$685

Early replacement: The capital cost for this measure is the actual cost of removing the existing unit and installing the new one. If this is unknown, assume the following (note these costs are per ton of unit capacity)[566]:

Efficiency (SEER)	Full Retrofit Cost (including labor) per Ton of Capacity ($/ton)
14	$1,381
15	$1,518
16	$1,655
17	$1,792
18	$1,929

Assumed deferred cost (after 6 years) of replacing existing equipment with new baseline unit is assumed to be $1,244 per ton of capacity[567]. This cost should be discounted to present value using the utilities discount rate.

563 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

564 Assumed to be one third of effective useful life

565 Based on costs derived from DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com).

566 Ibid. See 'ASHP_Revised DEER Measure Cost Summary.xls' for calculation.

567 Ibid.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

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%[568]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)
= 46.6%[569]

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Time of sale:

ΔkWh = ((FLH_cooling * Capacity_cooling * (1/SEER_base - 1/SEER_ee)) / 1000) + ((FLH_heat * Capacity_heating * (1/HSPF_base - 1/HSFP_ee)) / 1000)

Early replacement[570]:

ΔkWH for remaining life of existing unit (1st 6 years):

= ((FLH_cooling * Capacity_cooling * (1/SEER_exist - 1/SEER_ee)) / 1000) + ((FLH_heat * Capacity_heating * (1/HSPF_exist - 1/HSFP_ee)) / 1000)

ΔkWH for remaining measure life (next 12 years):

[568] 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.

[569] 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.

[570] The two equations are provided to show how savings are determined during the initial phase of the measure (existing to efficient) and the remaining phase (new baseline to efficient). In practice, the screening tools used may either require a First Year savings (using the first equation) and then a "number of years to adjustment" and "savings adjustment" input which would be the (new base to efficient savings)/(existing to efficient savings).

= ((FLH_cooling * Capacity_cooling * (1/SEER_base - 1/SEER_ee)) / 1000) + ((FLH_heat * Capacity_heating * (1/HSPF_base - 1/HSFP_ee)) / 1000)

Where:

FLH_cooling = Full load hours of air conditioning

= dependent on location[571]:

Climate Zone (City based upon)	FLH_cooling (single family)	FLH_cooling (multi family)
1 (Rockford)	512	467
2 (Chicago)	570	506
3 (Springfield)	730	663
4 (Belleville)	1,035	940
5 (Marion)	903	820
Weighted Average[572]	629	564

Capacity_cooling = Cooling Capacity of Air Source Heat Pump (Btu/h)

= Actual (1 ton = 12,000Btu/h)

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

= Use actual SEER rating where it is possible to measure or reasonably estimate.

Existing Cooling System	SEER_exist[573]
Air Source Heat Pump	9.12
Central AC	8.60
No central cooling[574]	Make '1/SEER_exist' = 0

[571] 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.
[572] Weighted based on number of occupied residential housing units in each zone.
[573] Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren PY3-PY4.
[574] If there is no central cooling in place but the incentive encourages installation of a new ASHP with cooling, the added cooling load should be subtracted from any heating benefit.

SEER_base = Seasonal Energy Efficiency Ratio of baseline Air Source Heat Pump (kBtu/kWh)

= 13 [575]

SEER_ee = Seasonal Energy Efficiency Ratio of efficient Air Source Heat Pump (kBtu/kWh)

= Actual

FLH_heat = Full load hours of heating

= Dependent on location[576]:

Climate Zone (City based upon)	FLH_heat
1 (Rockford)	1,969
2 (Chicago)	1,840
3 (Springfield)	1,754
4 (Belleville)	1,266
5 (Marion)	1,288
Weighted Average[577]	1,821

Capacity_heating = Heating Capacity of Air Source Heat Pump (Btu/h)

= Actual (1 ton = 12,000Btu/h)

HSPF_exist =Heating System Performance Factor of existing heating system (kBtu/kWh)

= Use actual HSPF rating where it is possible to measure or reasonably estimate. If not available use:

[575] Based on Minimum Federal Standard; http://www1.eere.energy.gov/buildings/appliance_standards/residential/residential_cac_hp.html.

[576] Full load heating hours for heat pumps are provided for Rockford, Chicago and Springfield in the Energy Star Calculator. Estimates for the other locations were calculated based on the FLH to Heating Degree Day (from NCDC) ratio. VEIC consider Energy Star estimates to be high due to oversizing not being adequately addressed. Using average Illinois billing data (from http://www.icc.illinois.gov/ags/consumereducation.aspx) VEIC estimated the average gas heating load and used this to estimate the average home heating output (using 83% average gas heat efficiency). Dividing this by a typical 36,000 Btu/h ASHP gives an estimate of average ASHP FLH_heat of 1821 hours. We used the ratio of this value to the average of the locations using the Energy Star data (1994 hours) to scale down the Energy Star estimates. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

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

Existing Heating System	HSPF_exist
Air Source Heat Pump	5.44 [578]
Electric Resistance	3.41[579]

HSPF_base =Heating System Performance Factor of baseline Air Source Heat Pump (kBtu/kWh)

= 7.7 [580]

HSFP_ee =Heating System Performance Factor of efficient Air Source Heat Pump (kBtu/kWh)

= Actual

[578] This is estimated based on finding the average HSPF/SEER ratio from the AHRI directory data (using the least efficient models – SEER 12 and SEER 13) – 0.596, and applying to the average nameplate SEER rating of all Early Replacement qualifying equipment in Ameren PY3-PY4. This estimation methodology appears to provide a result within 10% of actual HSPF.

[579] Electric resistance has a COP of 1.0 which equals 1/0.293 = 3.41 HSPF.

[580] Based on Minimum Federal Standard; http://www1.eere.energy.gov/buildings/appliance_standards/residential/residential_cac_hp.html.

Time of Sale:

For example, a three ton, 15 SEER, 12EER, 9 HSPF Air Source Heat Pump installed in Marion:

ΔkWh = ((903 * 36,000 * (1/13 - 1/15)) / 1000) + ((1,288 * 36,000 * (1/7.7 - 1/9)) / 1000)

= 1,203 kWh

Early Replacement:

For example, a three ton, 15 SEER, 12EER, 9 HSPF Air Source Heat Pump replaces an existing working Air Source Heat Pump with unknown efficiency ratings in Marion:

ΔkWH for remaining life of existing unit (1st 6 years):

= ((903 * 36,000 * (1/9.12 - 1/15)) / 1000) + ((1,288 * 36,000 * (1/5.44 - 1/9)) / 1000)

= 4769 kWh

ΔkWH for remaining measure life (next 12 years):

= ((903 * 36,000 * (1/13 - 1/15)) / 1000) + ((1,288 * 36,000 * (1/7.7 - 1/9)) / 1000)

= 1,203 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

Time of sale:

ΔkW = (Capacity_cooling * (1/EER_base - 1/EER_ee)) / 1000) * CF

Early replacement[581]:

ΔkW for remaining life of existing unit (1st 6 years):

= ((Capacity_cooling * (1/EERexist - 1/EERee))/1000 * CF);

ΔkW for remaining measure life (next 12 years):

= ((Capacity_cooling * (1/EERbase - 1/EERee))/1000 * CF)

Where:

[581] The two equations are provided to show how savings are determined during the initial phase of the measure (existing to efficient) and the remaining phase (new baseline to efficient). In practice, the screening tools used may either require a First Year savings (using the first equation) and then a "number of years to adjustment" and "savings adjustment" input which would be the (new base to efficient savings)/(existing to efficient savings).

EER_exist = Energy Efficiency Ratio of existing cooling system (kBtu/h / kW)

= Use actual EER rating where it is possible to measure or reasonably estimate. If EER unknown but SEER available convert using the equation:

EER_base = (-0.02 * SEER_base^2) + (1.12 * SEER) [582]

If SEER rating unavailable use:

Existing Cooling System	EER_exist[583]
Air Source Heat Pump	8.55
Central AC	8.15
No central cooling[584]	Make ‘1/EER_exist’ = 0

EER_base = Energy Efficiency Ratio of baseline Air Source Heat Pump (kBtu/h / kW)

= 11.2 [585]

EER_ee = Energy Efficiency Ratio of baseline Air Source Heat Pump (kBtu/h / kW)

= Actual, If not provided convert SEER to EER using this formula:[586]

= (-0.02 * SEER^2) + (1.12 * SEER)

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

= 91.5%[587]

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

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[582] From Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder.

[583] Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren PY3-PY4.

[584] If there is no central cooling in place but the incentive encourages installation of a new ASHP with cooling, the added cooling load should be subtracted from any heating benefit.

[585] The Federal Standard does not include an EER requirement, so it is approximated with this formula: (-0.02 * SEER2) + (1.12 * SEER) Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder. Note this is appropriate for single speed units only.

[586] Based on Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder. Note this is appropriate for single speed units only.

[587] 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%[588]

Time of Sale:

For example, a three ton, 15 SEER, 12EER, 9 HSPF Air Source Heat Pump installed in Marion:

ΔkW_{SSP} = ((36,000 * (1/11.2 – 1/12)) / 1000) * 0.915

= 0.196 kW

ΔkW_{PJM} = ((36,000 * (1/11.2 – 1/12)) / 1000) * 0.466

= 0.100 kW

Early Replacement:

For example, a three ton, 15 SEER, 12EER, 9 HSPF Air Source Heat Pump replaces an existing working Air Source Heat Pump with unknown efficiency ratings in Marion:

ΔkW_{SSP} for remaining life of existing unit (1st 6 years):

= ((36,000 * (1/8.55 - 1/12)) / 1000) * 0.915

= 1.11 kW

ΔkW_{SSP} for remaining measure life (next 12 years):

= ((36,000 * (1/11.2 – 1/12)) / 1000) * 0.915

= 0.196 kW

ΔkW_{PJM} for remaining life of existing unit (1st 6 years):

= ((36,000 * (1/8.55 - 1/12)) / 1000) * 0.466

= 0.564 kW

ΔkW_{PJM} for remaining measure life (next 12 years):

= ((36,000 * (1/11.2 – 1/12)) / 1000) * 0.466

= 0.100 kW

[588] 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.

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-ASHP-V02-130601

5.3.2 Boiler Pipe Insulation

DESCRIPTION

This measure describes adding insulation to un-insulated boiler pipes in un-conditioned basements or crawlspaces.

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

DEFINITION OF EFFICIENT EQUIPMENT

The efficient case is installing pipe wrap insulation to a length of boiler pipe.

DEFINITION OF BASELINE EQUIPMENT

The baseline is an un-insulated boiler pipe.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life is assumed to be 15 years[589].

DEEMED MEASURE COST

The measure cost including material and installation is assumed to be $3 per linear foot[590].

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

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[589] 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
[590] Consistent with DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com).

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS SAVINGS

$$\Delta Therm = (((1/R_{exist} * C_{exist}) - (1/R_{new} * C_{new})) * FLH\_heat * L * \Delta T) / \eta Boiler / 100{,}000$$

Where:

R_{exist} = Pipe heat loss coefficient of uninsulated pipe (existing) [(hr-°F-ft^2)/Btu]

= 0.5[591]

R_{new} = Pipe heat loss coefficient of insulated pipe (new) [(hr-°F-ft^2)/Btu]

= Actual (0.5 + R value of insulation)

FLH_heat = Full load hours of heating

= Dependent on location[592]:

Climate Zone (City based upon)	FLH_heat
1 (Rockford)	1,969
2 (Chicago)	1,840
3 (Springfield)	1,754
4 (Belleville)	1,266
5 (Marion)	1,288
Weighted Average[593]	1,821

L = Length of boiler pipe in unconditioned space covered by pipe wrap (ft)

= Actual

[591] Assumption based on data obtained from the 3E Plus heat loss calculation software provided by the NAIMA (North American Insulation Manufacturer Association) and derived from Table 15 and Table 16 of 2009 ASHRAE Fundamentals Handbook, Chapter 23 Insulation for Mechanical Systems, page 23.17.

[592] Full load heating hours for heat pumps are provided for Rockford, Chicago and Springfield in the Energy Star Calculator. Estimates for the other locations were calculated based on the FLH to Heating Degree Day (from NCDC) ratio. VEIC consider Energy Star estimates to be high due to oversizing not being adequately addressed. Using average Illinois billing data (from http://www.icc.illinois.gov/ags/consumereducation.aspx) VEIC estimated the average gas heating load and used this to estimate the average home heating output (using 83% average gas heat efficiency). Dividing this by a typical 36,000 Btu/h ASHP gives an estimate of average ASHP FLH_heat of 1821 hours. We used the ratio of this value to the average of the locations using the Energy Star data (1994 hours) to scale down the Energy Star estimates. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

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

C_{exist} = Circumference of bare pipe (ft) (Diameter (in) * π/12)

= Actual (0.5" pipe = 0.131ft, 0.75" pipe = 0.196ft)

C_{new} = Circumference of pipe with insulation (ft) (Diameter (in) * π/12)

= Actual

ΔT = Average temperature difference between circulated heated water and unconditioned space air temperature (°F) [594]

Pipes in unconditioned basement:

Outdoor reset controls	ΔT (°F)
Boiler without reset control	110
Boiler with reset control	70

Pipes in crawl space:

Climate Zone (City based upon)	ΔT (°F)	
	Boiler without reset control	Boiler with reset control
1 (Rockford)	127	87
2 (Chicago)	126	86
3 (Springfield)	122	82
4 (Belleville)	120	80
5 (Marion)	120	80
Weighted Average[595]	125	85

ηBoiler = Efficiency of boiler

= 0.819 [596]

[594] Assumes 160°F water temp for a boiler without reset control, 120°F for a boiler with reset control, and 50°F air temperature for pipes in unconditioned basements and the following average heating season outdoor temperatures as the air temperature in crawl spaces: Zone 1 – 33.1, Zone 2 – 34.4, Zone 3 – 37.7, Zone 4 – 40.0, Zone 5 – 39.8, Weighted Average – 35.3 (NCDC 1881-2010 Normals, average of monthly averages Nov – Apr for zones 1-3 and Nov-March for zones 4 and 5).

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

[596] Average efficiency of boiler units found in Ameren PY3-PY4 data.

For example, insulating 10 feet of 0.75” pipe with R-3 wrap (0.75” thickness) in a crawl space of a Marion home with a boiler without reset control:

ΔTherm = (((1/0.5 * 0.196) – (1/3.5 * 0.589)) * 10 * 120 * 1288) / 0.819 / 100,000

= 4.2 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-PINS-V01-130601

5.3.3 Central Air Conditioning > 14.5 SEER

Description

This measure characterizes:

a) Time of Sale:
   a. The installation of a new residential sized (<= 65,000 BTU/hr) Central Air Conditioning ducted split system meeting ENERGY STAR efficiency standards presented below. This could relate to the replacement of an existing unit at the end of its useful life, or the installation of a new system in a new home.

b) Early Replacement:
   a. The early removal of an existing residential sized (<= 65,000 BTU/hr) inefficient Central Air Conditioning unit from service, prior to its natural end of life, and replacement with a new ENERGY STAR qualifying unit. Savings are calculated between existing unit and efficient unit consumption during the remaining life of the existing unit, and between new baseline unit and efficient unit consumption for the remainder of the measure life.
   b. The assumption of the existing unit efficiency in the Early Replacement section of this TRM is based upon the average efficiency of units that were classified in Ameren's PY3-PY4 as functioning and SEER <=10. Therefore it is only appropriate to use these Early Replacement assumptions where those conditions are met. The TAC defined "functioning" as the unit is fully operational – providing sufficient space conditioning (i.e. heat exchanger, compressors, pumps work effectively) and/or the cost of repair is under 20% of the new baseline replacement cost. Therefore in order to apply early replacement assumptions the programs should apply the following eligibility criteria: SEER <=10 and cost of any repairs <$190 per ton.

This measure was developed to be applicable to the following program types: TOS, NC, EREP. 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 a ducted split central air conditioning unit meeting the minimum ENERGY STAR efficiency level standards; 14.5 SEER and 12 EER.

Definition of Baseline Equipment

The baseline for the Time of Sale measure is based on the current Federal Standard efficiency level; 13 SEER and 11 EER.

The baseline for the early replacement measure is the efficiency of the existing equipment for the assumed remaining useful life of the unit and the new baseline as defined above[597] for the remainder of the measure life.

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 18 years [598].

[597] Baseline SEER and EER should be updated when new minimum federal standards become effective.
[598] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June

Remaining life of existing equipment is assumed to be 6 years[599].

DEEMED MEASURE COST

Time of sale: The incremental capital cost for this measure is dependent on equipment size and efficiency. Assumed costs per ton of cooling capacity are provided below[600]:

Efficiency Level	Cost per Ton
SEER 14	$119
SEER 15	$238
SEER 16	$357
SEER 17	$476
SEER 18	$596
SEER 19	$715
SEER 20	$834
SEER 21	$908
Average	$530

Early replacement: The incremental capital cost for this measure is the actual cost of removing the existing unit and installing the new one. If this is unknown, assume $3,413[601].

Assumed deferred cost (after 6 years) of replacing existing equipment with new baseline unit is assumed to be $2,857[602]. This cost should be discounted to present value using the utilities discount rate.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape R08 - Residential Cooling

2007.
http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf
The "lifespan" of a central air conditioner is about 15 to 20 years (US DOE: http://www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12440).

599 Assumed to be one third of effective useful life

600 DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com)

601 Based on 3 ton initial cost estimate for an ENERGY STAR unit from ENERGY STAR Central AC calculator (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls).

602 Based on 3 ton initial cost estimate for a conventional unit from ENERGY STAR Central AC calculator (http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls). While baselines are likely to shift in the future, there is currently no good indication of what the cost of a new baseline unit will be in 6 years. In the absence of this information, assuming a constant federal baseline cost is within the range of error for this prescriptive measure.

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 system peak hour)

= 91.5%[603]

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

= 46.6%[604]

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Time of sale:

ΔkWH = (FLHcool * BtuH * (1/SEERbase - 1/SEERee))/1000

Early replacement[605]:

ΔkWH for remaining life of existing unit (1st 6 years):

=((FLHcool * Capacity * (1/SEERexist - 1/SEERee))/1000);

ΔkWH for remaining measure life (next 12 years):

= ((FLHcool * Capacity * (1/SEERbase - 1/SEERee))/1000)

Where:

[603] 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.

[604] 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.

[605] The two equations are provided to show how savings are determined during the initial phase of the measure (existing to efficient) and the remaining phase (new baseline to efficient). In practice, the screening tools used may either require a First Year savings (using the first equation) and then a "number of years to adjustment" and "savings adjustment" input which would be the (new base to efficient savings)/(existing to efficient savings).

FLHcool = Full load cooling hours

= dependent on location and building type[606]:

Climate Zone (City based upon)	FLHcool (single family)	FLHcool (multi family)
1 (Rockford)	512	467
2 (Chicago)	570	506
3 (Springfield)	730	663
4 (Belleville)	1035	940
5 (Marion)	903	820
Weighted Average[607]	629	564

Capacity = Size of new equipment in Btuh (note 1 ton = 12,000Btuh)

= Actual installed, or if actual size unknown 33,600Btuh for single-family buildings[608]

SEERbase = Seasonal Energy Efficiency Ratio of baseline unit (kBtu/kWh)

= 13[609]

SEERexist = Seasonal Energy Efficiency Ratio of existing unit (kBtu/kWh)

= Use actual SEER rating where it is possible to measure or reasonably estimate. If unknown assume 10.0[610].

SEERee = Seasonal Energy Efficiency Ratio of ENERGY STAR unit (kBtu/kWh)

= Actual installed or 14.5 if unknown

[606] 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.

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

[608] Actual unit size required for multi-family building, no size assumption provided because the unit size and resulting savings can vary greatly depending on the number of units.

[609] Based on Minimum Federal Standard; http://www1.eere.energy.gov/buildings/appliance_standards/residential/residential_cac_hp.html.

[610] VEIC estimate based on Department of Energy Federal Standard between 1992 and 2006. 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.

Time of sale example: a 3 ton unit with SEER rating of 14.5, in unknown location:

ΔkWH = (629 * 36,000 * (1/13 – 1/14.5)) / 1000

= 180 kWh

Early replacement example: a 3 ton unit, with SEER rating of 14.5 replaces an existing unit in unknown location:

ΔkWH(for first 6 years) = (629 * 36,000 * (1/10 – 1/14.5)) / 1000

= 702 kWh

ΔkWH(for next 12 years) = (629 * 36,000 * (1/13 – 1/14.5)) / 1000

= 180 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

Time of sale:

ΔkW = (Capacity * (1/EERbase - 1/EERee))/1000 * CF

Early replacement[611]:

ΔkW for remaining life of existing unit (1st 6 years):

= ((Capacity * (1/EERexist - 1/EERee))/1000 * CF);

ΔkW for remaining measure life (next 12 years):

= ((Capacity * (1/EERbase - 1/EERee))/1000 * CF)

Where:

EERbase = EER Efficiency of baseline unit

= 11.2 [612]

EERexist = EER Efficiency of existing unit

[611] The two equations are provided to show how savings are determined during the initial phase of the measure (existing to efficient) and the remaining phase (new baseline to efficient). In practice, the screening tools used may either require a First Year savings (using the first equation) and then a “number of years to adjustment” and “savings adjustment” input which would be the (new base to efficient savings)/(existing to efficient savings).

[612] The federal Standard does not currently include an EER component. The value is approximated based on the SEER standard (13) and equals EER 11.2. To perform this calculation we are using this formula: (-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).

= Actual EER of unit should be used, if EER is unknown, use 9.2[613]

EERee = EER Efficiency of ENERGY STAR unit

= Actual installed or 12 if unknown

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

= 91.5%[614]

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

= 46.6%[615]

Time of sale example: a 3 ton unit with EER rating of 12:

ΔkW_{SSP} = (36,000 * (1/11.2– 1/12)) / 1000 * 0.915

= 0.196 kW

ΔkW_{PJM} = (36,000 * (1/11.2– 1/12)) / 1000 * 0.466

= 0.100 kW

Early replacement example: a 3 ton unit with EER rating of 12 replaces an existing unit:

ΔkW_{SSP} (for first 6 years) = (36,000 * (1/9.2– 1/12)) / 1000 * 0.915

= 0.835 kW

ΔkW_{SSP} (for next 12 years) = (36,000 * (1/11.2– 1/12)) / 1000 * 0.915

= 0.196 kW

ΔkW_{PJM} (for first 6 years) = (36,000 * (1/9.2– 1/12)) / 1000 * 0.466

= 0.425 kW

ΔkW_{PJM} (for next 12 years) = (36,000 * (1/11.2– 1/12)) / 1000 * 0.466

= 0.100 kW

[613] Based on SEER of 10,0, using formula above to give 9.2 EER.
[614] 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.
[615] 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.

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-CAC1-V02-130601

5.3.4 Duct Insulation and Sealing

Description

This measure describes evaluating the savings associated with performing duct sealing using mastic sealant or metal tape to the distribution system of homes with either central air conditioning or a ducted heating system.

Two methodologies for estimating the savings associate from sealing the ducts are provided. The first preferred method requires the use of a blower door and the second requires careful inspection of the duct work.

1. **Modified Blower Door Subtraction** – this technique is described in detail on p.44 of the Energy Conservatory Blower Door Manual; http://www.energyconservatory.com/download/bdmanual.pdf

2. **Evaluation of Distribution Efficiency** – this methodology requires the evaluation of three duct characteristics below, and use of the Building Performance Institutes 'Distribution Efficiency Look-Up Table';

   http://www.bpi.org/files/pdf/DistributionEfficiencyTable-BlueSheet.pdf

   a. Percentage of duct work found within the conditioned space

   b. Duct leakage evaluation

   c. Duct insulation evaluation

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

The efficient condition is sealed duct work throughout the unconditioned space in the home.

Definition of Baseline Equipment

The existing baseline condition is leaky duct work within the unconditioned space in the home.

Deemed Lifetime of Efficient Equipment

The assumed lifetime of this measure is 20 years[616].

Deemed Measure Cost

The actual duct sealing measure cost should be used.

[616] 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

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 (Shell Measures)

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%[617]

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

= 46.6%[618]

Algorithm

Calculation of Savings

Electric Energy Savings

Methodology 1: Modified Blower Door Subtraction

a) Determine Duct Leakage rate before and after performing duct sealing:

Duct Leakage ($CFM50_{DL}$) = ($CFM50_{Whole\ House}$ – $CFM50_{Envelope\ Only}$) * SCF

Where:

$CFM50_{Whole\ House}$ = Standard Blower Door test result finding Cubic Feet per Minute at 50 Pascal pressure differential

$CFM50_{Envelope\ Only}$ = Blower Door test result finding Cubic Feet per Minute at 50 Pascal pressure differential with all supply and return registers sealed.

617 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.
618 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.

SCF = Subtraction Correction Factor to account for underestimation of duct leakage due to connections between the duct system and the home. Determined by measuring pressure in duct system with registers sealed and using look up table provided by Energy Conservatory.

b) Calculate duct leakage reduction, convert to $CFM25_{DL}$ and factor in Supply and Return Loss Factors

Duct Leakage Reduction ($\Delta CFM25_{DL}$) = (Pre $CFM50_{DL}$ – Post $CFM50_{DL}$) * 0.64 * (SLF + RLF)

Where:

0.64 = Converts CFM50 to CFM25[619]

SLF = Supply Loss Factor

= % leaks sealed located in Supply ducts * 1 [620]

Default = 0.5[621]

RLF = Return Loss Factor

= % leaks sealed located in Return ducts * 0.5[622]

Default = 0.25[623]

c) Calculate Energy Savings:

$\Delta kWh_{cooling}$ = (($\Delta CFM25_{DL}$)/ ((Capacity/12,000) * 400)) * FLHcool * Capacity) / 1000 / ηCool

Where:

$\Delta CFM25_{DL}$ = Duct leakage reduction in CFM25

[619] 25 Pascals is the standard assumption for typical pressures experienced in the duct system under normal operating conditions. To convert CFM50 to CFM25 you multiply by 0.64 (inverse of the “Can’t Reach Fifty” factor for CFM25; see Energy Conservatory Blower Door Manual).

[620] Assumes that for each percent of supply air loss there is one percent annual energy penalty. This assumes supply side leaks are direct losses to the outside and are not recaptured back to the house. This could be adjusted downward to reflect regain of usable energy to the house from duct leaks. For example, during the winter some of the energy lost from supply leaks in a crawlspace will probably be regained back to the house (sometimes 1/2 or more may be regained). More information provided in “Appendix E Estimating HVAC System Loss From Duct Airtightness Measurements” from http://www.energyconservatory.com/download/dbmanual.pdf

[621] Assumes 50% of leaks are in supply ducts.

[622] Assumes that for each percent of return air loss there is a half percent annual energy penalty. Note that this assumes that return leaks contribute less to energy losses than do supply leaks. This value could be adjusted upward if there was reason to suspect that the return leaks contribute significantly more energy loss than “average” (e.g. pulling return air from a super heated attic), or can be adjusted downward to represent significantly less energy loss (e.g. pulling return air from a moderate temperature crawl space) . More information provided in “Appendix E Estimating HVAC System Loss From Duct Airtightness Measurements” from http://www.energyconservatory.com/download/dbmanual.pdf

[623] Assumes 50% of leaks are in return ducts.

= calculated above

Capacity = Capacity of Air Cooling system (Btu/H)

=Actual

12,000 = Converts Btu/H capacity to tons

400 = Converts capacity in tons to CFM (400CFM / ton)

FLHcool = Full load cooling hours

= Dependent on location as below[624]:

Climate Zone (City based upon)	FLHcool Single Family	FLHcool Multifamily
1 (Rockford)	512	467
2 (Chicago)	570	506
3 (Springfield)	730	663
4 (Belleville)	1,035	940
5 (Marion)	903	820
Weighted Average[625]	629	564

1000 = Converts Btu to kBtu

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

= Actual. If unknown assume the following[626]:

Age of Equipment	SEER Estimate
Before 2006	10
After 2006	13

[624] 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.
[625] Weighted based on number of occupied residential housing units in each zone.
[626] 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.

For example, duct sealing in a single family house in Springfield with a 36,000 Btu/H, SEER 11 central air conditioning and the following blower door test results:

Before: $CFM50_{Whole\ House}$ = 4800 CFM50

$CFM50_{Envelope\ Only}$ = 4500 CFM50

House to duct pressure of 45 Pascals. = 1.29 SCF (Energy Conservatory look up table)

After: $CFM50_{Whole\ House}$ = 4600 CFM50

$CFM50_{Envelope\ Only}$ = 4500 CFM50

House to duct pressure of 43 Pascals = 1.39 SCF (Energy Conservatory look up table)

Duct Leakage:

$CFM50_{DL\ before}$ = (4800 – 4500) * 1.29

= 387 CFM

$CFM50_{DL\ after}$ = (4600 – 4500) * 1.39

= 139 CFM

Duct Leakage reduction at CFM25:

$\Delta CFM25_{DL}$ = (387 – 139) * 0.64 * (0.5 + 0.25)

= 119 CFM25

Energy Savings:

$\Delta kWh_{cooling}$ = ((119 / ((36,000/12,000) * 400)) * 730 * 36,000) / 1000 / 11

= 237 kWh

<u>Heating savings for homes with electric heat (Heat Pump):</u>

$\Delta kWh_{heating}$ = ((($\Delta CFM25_{DL}$ /((Capacity/12,000) * 400)) * FLHheat * Capacity) / ηHeat / 3412

Where:

FLHheat = Full load heating hours

= Dependent on location as below[627]:

Climate Zone (City based upon)	FLH_heat
1 (Rockford)	1,969
2 (Chicago)	1,840
3 (Springfield)	1,754
4 (Belleville)	1,266
5 (Marion)	1,288
Weighted Average[628]	1,821

ηHeat = Efficiency in COP of Heating equipment

= Actual. If not available use[629]:

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

3412 = Converts Btu to kWh

For example, duct sealing in a 36,000 Btu/H 2.5 COP heat pump heated single family house in Springfield with the blower door results described above:

$\Delta kWh_{heating}$ = (((119 / ((36,000/12,000) * 400)) * 1,754 * 36,000) / 2.5 / 3412

= 734 kWh

Methodology 2: Evaluation of Distribution Efficiency

Determine Distribution Efficiency by evaluating duct system before and after duct sealing using Building Performance Institute "Distribution Efficiency Look-Up Table"

$$\Delta kWh_{cooling} = ((DE_{after} – DE_{before})/ DE_{after})) * FLHcool * Capacity)/1000 / \eta Cool$$

[627] Heating EFLH based on ENERGY Star EFLH for Rockford, Chicago, and Springfield and on NCDC/NOAA HDD for the other two cities. In all cases, the hours were adjusted based on average natural gas heating consumption in IL.

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

[629] 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.

Where:

DE_{after} = Distribution Efficiency after duct sealing

DE_{before} = Distribution Efficiency before duct sealing

FLHcool = Full load cooling hours

= Dependent on location as below[630]:

Climate Zone (City based upon)	FLHcool Single Family	FLHcool Multifamily
1 (Rockford)	512	467
2 (Chicago)	570	506
3 (Springfield)	730	663
4 (Belleville)	1,035	940
5 (Marion)	903	820
Weighted Average[631]	629	564

Capacity = Capacity of Air Cooling system (Btu/H)

=Actual

1000 = Converts Btu to kBtu

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

= Actual. If unknown assume[632]:

Age of Equipment	SEER Estimate
Before 2006	10
After 2006	13

[630] 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.
[631] Weighted based on number of occupied residential housing units in each zone.
[632] 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.

For example, duct sealing in a single family house in Springfield, with 36,000 Btu/H SEER 11 central air conditioning and the following duct evaluation results:

DE_{before} = 0.85

DE_{after} = 0.92

Energy Savings:

$\Delta kWh_{cooling}$ = ((0.92 – 0.85)/0.92) * 730 * 36,000) / 1000 / 11

= 182 kWh

<u>Heating savings for homes with electric heat (Heat Pump or resistance):</u>

$\Delta kWh_{heating}$ = $((DE_{after} – DE_{before})/ DE_{after}))$ * FLHheat * Capacity) / ηHeat / 3412

Where:

FLHheat = Full load heating hours

= Dependent on location as below[633]:

Climate Zone (City based upon)	FLH_heat
1 (Rockford)	1,969
2 (Chicago)	1,840
3 (Springfield)	1,754
4 (Belleville)	1,266
5 (Marion)	1,288
Weighted Average[634]	1,821

[633] Heating EFLH based on ENERGY Star EFLH for Rockford, Chicago, and Springfield and on NCDC/NOAA HDD for the other two cities. In all cases, the hours were adjusted based on average natural gas heating consumption in IL.
[634] Weighted based on number of occupied residential housing units in each zone.

COP = Coefficient of Performance of electric heating system[635]

= Actual. If not available use[636]:

System Type	Age of Equipment	HSPF Estimate	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, duct sealing in a 36,000 Btu/H, 2.5 COP heat pump heated single family house in Springfield with the following duct evaluation results:

DE_{after} = 0.92

DE_{before} = 0.85

Energy Savings:

$\Delta kWh_{heating}$ = ((0.92 – 0.85)/0.92) * 1,967 * 36,000) / 2.5) / 3412

= 632 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$\Delta kW = \Delta kWh_{cooling} / FLHcool * CF$

Where:

FLHcool = Full load cooling hours:

= Dependent on location as below[637]:

[635] Note that the HSPF of a heat pump is equal to the COP * 3.413.

[636] 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.

[637] 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.

Climate Zone (City based upon)	FLHcool Single Family	FLHcool Multifamily
1 (Rockford)	512	467
2 (Chicago)	570	506
3 (Springfield)	730	663
4 (Belleville)	1,035	940
5 (Marion)	903	820
Weighted Average[638]	629	564

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

= 91.5%[639]

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

= 46.6%[640]

Natural Gas Savings

For homes with Natural Gas Heating:

Methodology 1: Modified Blower Door Subtraction

$\Delta Therm = (((\Delta CFM25_{DL} / (Capacity * 0.0123)) * FLHheat * Capacity) / 100{,}000 / \eta Heat$

Where:

$\Delta CFM25_{DL}$ = Duct leakage reduction in CFM25

Capacity = Capacity of Air Cooling system (Btu/H)

=Actual

0.0123 = Conversion of Capacity to CFM (0.0123CFM / Btu/h)[641]

FLHheat = Full load heating hours

=Dependent on location as below[642]:

[638] Weighted based on number of occupied residential housing units in each zone.
[639] 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.
[640] 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.
[641] Based on Natural Draft Furnaces requiring 100 CFM per 10,000 BTU, Induced Draft Furnaces requiring 130CFM per 10,000BTU and Condensing Furnaces requiring 150 CFM per 10,000 BTU (rule of thumb from http://contractingbusiness.com/enewsletters/cb_imp_43580/). Data provided by GAMA during the federal rule-making process for furnace efficiency standards, suggested that in 2000, 24% of furnaces purchased in Illinois were condensing units. Therefore a weighted average required airflow rate is calculated assuming a 50:50 split of natural v induced draft non-condensing furnaces, as 123 per 10,000BTU or 0.0123/Btu.

Climate Zone (City based upon)	FLH_heat
1 (Rockford)	1,969
2 (Chicago)	1,840
3 (Springfield)	1,754
4 (Belleville)	1,266
5 (Marion)	1,288
Weighted Average[643]	1,821

100,000 = Converts Btu to therms

ηHeat = Average Net Heating System Efficiency (Equipment Efficiency * Distribution Efficiency)[644]

= Actual. If not available use 70%[645].

[642] Heating EFLH based on ENERGY Star EFLH for Rockford, Chicago, and Springfield and on NCDC/NOAA HDD for the other two cities. In all cases, the hours were adjusted based on average natural gas heating consumption in IL.

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

[644] The System Efficiency can 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. If there are more than one heating systems, the weighted (by consumption) average efficiency should be used. If the heating system or distribution is being upgraded within a package of measures together with the insulation upgrade, the new average heating system efficiency should be used.

[645] 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

For example, duct sealing in a house in Springfield with an 80% AFUE, 105,000 Btu/H natural gas furnace and the following blower door test results:

Before: $CFM50_{Whole\ House}$ = 4800 CFM50

$CFM50_{Envelope\ Only}$ = 4500CFM50

House to duct pressure of 45 Pascals = 1.29 SCF (Energy Conservatory look up table)

After: $CFM50_{Whole\ House}$ = 4600 CFM50

$CFM50_{Envelope\ Only}$ = 4500CFM50

House to duct pressure of 43 Pascals = 1.39 SCF (Energy Conservatory look up table)

Duct Leakage:

$CFM50_{DL\ before}$ = (4800 – 4500) * 1.29

= 387 CFM

$CFM50_{DL\ after}$ = (4600 – 4500) * 1.39

= 119 CFM

Duct Leakage reduction at CFM25:

$\Delta CFM25_{DL}$ = (387 – 139) * 0.64 * (0.5 + 0.25)

= 119 CFM25

Energy Savings:

ΔTherm = ((119/ (105,000 * 0.0123)) * 1,754 * 105,000) / 100,000 / 0.80

= 212 therms

Methodology 2: Evaluation of Distribution Efficiency

$$\Delta Therm = ((DE_{after} - DE_{before}) / DE_{after})) * FLHheat * Capacity) / 100{,}000 / \eta Heat$$

Where:

DE_{after} = Distribution Efficiency after duct sealing

DE_{before} = Distribution Efficiency before duct sealing

Other variables as defined above

For example, duct sealing in a house in Springfield an 80% AFUE, 105,000 Btu/H natural gas furnace and the following duct evaluation results:

DE_{after} = 0.92

DE_{before} = 0.85

Energy Savings:

ΔTherm = ((0.92 – 0.85)/0.92) * 1,754 * 105,000) / 100,000 / 0.80

= 175 therm

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-DINS-V01-120601

5.3.5 Furnace Blower Motor

Description

A new furnace with a brushless permanent magnet (BPM) blower motor is installed instead of a new furnace with a lower efficiency motor. This measure characterizes only the electric savings associated with the fan and could be coupled with gas savings associated with a more efficient furnace. Savings decrease sharply with static pressure so duct improvements, and clean, low pressure drop filters can maximize savings. Savings improve when the blower is used for cooling as well and when it is used for continuous ventilation, but only if the non-BPM motor would have been used for continuous ventilation too. If the resident runs the BPM blower continuously because it is a more efficient motor and would not run a non-BPM motor that way, savings are near zero and possibly negative. This characterization uses a 2009 Focus on Energy study of BPM blower motor savings in Wisconsin, which accounted for the effects of this behavioral impact.

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

A furnace with a brushless permanent magnet (BPM) blower motor, also known by the trademark ECM, BLDC, and other names.

Definition of Baseline Equipment

A furnace with a non-BPM blower motor.

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 20 years[646].

Deemed Measure Cost

The capital cost for this measure is assumed to be $97[647].

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

[646] Consistent with assumed life of a new gas furnace. 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
[647] Adapted from Tables 8.2.3 and 8.2.13 in http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/hvac_ch_08_lcc_2011-06-24.pdf

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%[648]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)
= 46.6%[649]

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh = Heating Savings + Cooling Savings + Shoulder Season Savings

Where:

Heating Savings = Blower motor savings during heating season

= 418 kWh[650]

Cooling Savings = Blower motor savings during cooling season

If Central AC = 263 kWh

If No Central AC = 175 kWh

If unknown (weighted average)

= 241 kWh[651]

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648 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.

649 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.

650 To estimate heating, cooling and shoulder season savings for Illinois, VEIC adapted results from a 2009 Focus on Energy study of BPM blower motor savings in Wisconsin. This study included effects of behavior change based on the efficiency of new motor greatly increasing the amount of people that run the fan continuously. The savings from the Wisconsin study were adjusted to account for different run hour assumptions (average values used) for Illinois. See: FOE to IL Blower Savings.xlsx.

651 The weighted average value is based on assumption that 75% of homes installing BPM furnace blower motors have Central AC. 66% of IL housing units have CAC and 66% have gas furnaces. It is logical these two groups

Shoulder Season Savings = Blower motor savings during shoulder seasons

= 51 kWh

For example, a blower motor in a home where Central AC presence is unknown:

ΔkWh = Heating Savings + Cooling Savings + Shoulder Season Savings

= 418 +251 + 51

= 721 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = Cooling Savings / FLH_cooling * CF

Where:

FLH_cooling = Full load hours of air conditioning

= Dependent on location[652]:

Climate Zone (City based upon)	FLH_cooling
1 (Rockford)	512
2 (Chicago)	570
3 (Springfield)	730
4 (Belleville)	1,035
5 (Marion)	903
Weighted Average[653]	629

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

= 91.5%[654]

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

overlap to a large extent (like the 95% in the FOE study above).

652 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.

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

654 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%[655]

For example, a blower motor in a home of unknown location where Central AC prevalence is unknown:

ΔkW_{SSP} = 251 / 629 * 0.915

= 0.365 kW

ΔkW_{SSP} = 251 / 629 * 0.466

= 0.186 kW

NATURAL GAS SAVINGS

Δtherms[656] = - Heating Savings * 0.03412 therms/kWh

= - (418 * 0.03412)

= - 14.3 therms[657]

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-FBMT-V01-120601

[655] 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.

[656] The blower fan is in the heating duct so all, or very nearly all, of its waste heat is delivered to the conditioned space.

[657] Negative value since this measure will increase the heating load due to reduced waste heat.

5.3.6 Gas High Efficiency Boiler

Description

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 characterizes:

a) Time of Sale:
   a. The installation of a new high efficiency, gas-fired hot water boiler in a residential location. This could relate to the replacement of an existing unit at the end of its useful life, or the installation of a new system in a new home.

b) Early Replacement:
   a. The early removal of an existing functional AFUE 75% or less boiler from service, prior to its natural end of life, and replacement with a new high efficiency unit. Savings are calculated between existing unit and efficient unit consumption during the remaining life of the existing unit, and between new baseline unit and efficient unit consumption for the remainder of the measure life.
   b. The assumption of the existing unit efficiency in the Early Replacement section of this TRM is based upon the average efficiency of units that were classified in Ameren's PY3-PY4 as functioning and AFUE <=75%. Therefore it is only appropriate to use these Early Replacement assumptions where those conditions are met. The TAC defined "functioning" as the unit is fully operational – providing sufficient space conditioning (i.e. heat exchanger, compressors, pumps work effectively) and/or the cost of repair is under 20% of the new baseline replacement cost. Therefore in order to apply early replacement assumptions the programs should apply the following eligibility criteria: AFUE <=75% and cost of any repairs <$709.

This measure was developed to be applicable to the following program types: TOS, NC, EREP. 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

Time of sale: 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[658]	80%
June 2013 on	82%

[658] There will be some delay to the baseline shift while existing stocks of lower efficiency equipment is sold.

Early replacement: The baseline for this measure is the efficiency of the existing equipment for the assumed remaining useful life of the unit and the new baseline as defined above for the remainder of the measure life.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 25 years[659].

Early replacement: Remaining life of existing equipment is assumed to be 8 years[660].

DEEMED MEASURE COST

Time of sale: The incremental install cost for this measure is dependent on tier[661]:

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

Early Replacement: The full installation cost is provided in the table above. The assumed deferred cost (after 8 years) of replacing existing equipment with a new baseline unit is assumed to be $3543. This cost should be discounted to present value using the utilities discount rate.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

659 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
660 Assumed to be one third of effective useful life
661 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.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS SAVINGS

Time of Sale:

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

Early replacement[662]:

ΔTherms for remaining life of existing unit (1st 8 years):

= Gas_Boiler_Load * (1/AFUE(exist) - 1/AFUE(eff)))

ΔTherms for remaining measure life (next 17 years):

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

Where:

Gas_Boiler_Load[663]

= Estimate of annual household Load for gas boiler heated single-family homes. If location is unknown, assume the average below[664].

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

[662] The two equations are provided to show how savings are determined during the initial phase of the measure (existing to efficient) and the remaining phase (new baseline to efficient). In practice, the screening tools used may either require a First Year savings (using the first equation) and then a "number of years to adjustment" and "savings adjustment" input which would be the (new base to efficient savings)/(existing to efficient savings).

[663] 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)

[664] 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[665].

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(exist) = Existing Boiler Annual Fuel Utilization Efficiency Rating

= Use actual AFUE rating where it is possible to measure or reasonably estimate.

If unknown, assume 61.6 AFUE% .

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[667] on tier as listed below:

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

[665] 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.

[666] Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren PY3-PY4.

[667] 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.

Time of Sale:

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

Early Replacement:

For example, an existing function boiler with unknown efficiency is replaced with an ENERGY STAR boiler purchased and installed in Springfield in 2013.

ΔTherms for remaining life of existing unit (1st 8 years):

= 1043 * (1/0.616 – 1/0.875)

= 501 Therms

ΔTherms for remaining measure life (next 17 years):

= (1043) * (1/0.82 - 1/0.875)

= 80.0 Therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-GHEB-V02-130601

5.3.7 Gas High Efficiency Furnace

Description

High efficiency furnace features may include improved heat exchangers and modulating multi-stage burners.

This measure characterizes:

b) Time of sale:
   a. The installation of a new high efficiency, gas-fired condensing furnace in a residential location. This could relate to the replacement of an existing unit at the end of its useful life, or the installation of a new system in a new home.

c) Early Replacement:
   a. The early removal of an existing functioning AFUE 75% or less furnace from service, prior to its natural end of life, and replacement with a new high efficiency unit. Savings are calculated between existing unit and efficient unit consumption during the remaining life of the existing unit, and between new baseline unit and efficient unit consumption for the remainder of the measure life. At time of writing, the DOE had rescinded the next Federal Standard change for furnaces, however it is likely that a new standard will be in effect after the assumed remaining useful life of the existing unit. For the purposes of this measure- the new baseline is assumed to be 90%.
   b. The assumption of the existing unit efficiency in the Early Replacement section of this TRM is based upon the average efficiency of units that were classified in Ameren's PY3-PY4 as functioning and AFUE <=75%. Therefore it is only appropriate to use these Early Replacement assumptions where those conditions are met. The TAC defined "functioning" as the unit is fully operational – providing sufficient space conditioning (i.e. heat exchanger, compressors, pumps work effectively) and/or the cost of repair is under 20% of the new baseline replacement cost. Therefore in order to apply early replacement assumptions the programs should apply the following eligibility criteria: AFUE <=75% and cost of any repairs <$528.

This measure was developed to be applicable to the following program types: TOS, NC, EREP. 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) natural gas fired furnace with an Annual Fuel Utilization Efficiency (AFUE) rating exceeding the program requirements.

Definition of Baseline Equipment

Time of Sale: 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.

Early replacement: The baseline for this measure is the efficiency of the existing equipment for the assumed remaining useful life of the unit and a new baseline unit for the remainder of the measure life. As discussed above we estimate that the new baseline unit that could be purchased in the year the existing unit would have needed replacing is 90%.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 20 years[668].

For early replacement: Remaining life of existing equipment is assumed to be 6 years[669].

DEEMED MEASURE COST

Time of sale: The incremental capital cost for this measure depends on efficiency as listed below[670]:

AFUE	Installation Cost	Incremental Install Cost
80%	$2011	n/a
90%	$2641	$630
91%	$2727	$716
92%	$2813	$802
93%	$3025	$1014
94%	$3237	$1226
95%	$3449	$1438
96%	$3661	$1650

Early Replacement: The full installation cost is provided in the table above. The assumed deferred cost (after 6 years) of replacing existing equipment with a new baseline unit is assumed to be $2641. This cost should be discounted to present value using the utilities discount rate.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

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[668] 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

[669] Assumed to be one third of effective useful life

[670] 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.

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

Time of Sale:

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

Early replacement[671]:

ΔTherms for remaining life of existing unit (1st 6 years):

= Gas_Furnace_Heating_Load * (1/AFUE(exist) - 1/AFUE(eff)))

ΔTherms for remaining measure life (next 14 years):

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

Where:

Gas_Furnace_Heating_Load

= Estimate of annual household heating load [672] for gas furnace heated single-family homes. If location is unknown, assume the average below[673].

= Actual if informed by site-specific load calculations, ACCA Manual J or equivalent[674].

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[671] The two equations are provided to show how savings are determined during the initial phase of the measure (existing to efficient) and the remaining phase (new baseline to efficient). In practice, the screening tools used may either require a First Year savings (using the first equation) and then a "number of years to adjustment" and "savings adjustment" input which would be the (new base to efficient savings)/(existing to efficient savings).

[672] Heating load is used to describe the household heating need, which is equal to (gas consumption * AFUE)

[673] 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.

[674] 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 are

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(exist) = Existing Furnace Annual Fuel Utilization Efficiency Rating

= Use actual AFUE rating where it is possible to measure or reasonably estimate.

If unknown, assume 64.4 AFUE% .

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

= Dependent on program type as listed below[676]:

Program Year	AFUE(base)
Time of Sale	80%
Early Replacement	90%

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

= Actual. If unknown, assume 95%[677]

commonly completed by contractors during the selection process and may be readily available for program data purposes.

[675] Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren PY3-PY4.

[676] Though the Federal Minimum AFUE is 78%, there were only 50 models listed in the AHRI database at that level. At AFUE 79% the total rises to 308. There are 3,548 active furnace models listed with AFUE ratings between 78 and 80.

[677] Minimum ENERGY STAR efficiency after 2.1.2012.

Time of Sale:

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

ΔTherms = 843 * (1/0.8 - 1/0.95)

=166 therms

Early Replacement:

For example, an existing function furnace with unknown efficiency is replaced with an 95% furnace purchased and installed in Rockford in 2013.

ΔTherms for remaining life of existing unit (1st 6 years):

= 843 * (1/0.644 – 1/0.95)

= 422 therms

ΔTherms for remaining measure life (next 14 years):

= 843 * (1/0.9 - 1/0.95)

=49.3 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-GHEF-V02-130601

5.3.8 Ground Source Heat Pump

DESCRIPTION

This measure characterizes:

a) Time of sale:
    a. The installation of a new residential sized Ground Source Heat Pump system meeting ENERGY STAR efficiency standards presented below. This could relate to the replacement of an existing unit at the end of its useful life, or the installation of a new system in a new home.
b) Early Replacement:
    a. The early removal of functioning electric heating and cooling (SEER 10 or under if present) systems from service, prior to the natural end of life, and replacement with a new high efficiency Ground Source Heat Pump system. Savings are calculated between existing unit and efficient unit consumption during the remaining life of the existing unit, and between new baseline unit and efficient unit consumption for the remainder of the measure life.
    b. The assumption of the existing unit efficiency in the Early Replacement section of this TRM is based upon the average efficiency of units that were classified in Ameren's PY3-PY4 as functioning and <=SEER 10. Therefore it is only appropriate to use these Early Replacement assumptions where those conditions are met. The TAC defined "functioning" as the unit is fully operational – providing sufficient space conditioning (i.e. heat exchanger, compressors, pumps work effectively) and/or the cost of repair is under 20% of the new baseline replacement cost. Therefore in order to apply early replacement assumptions the programs should apply the following eligibility criteria: SEER <=10 and cost of any repairs <$249 per ton.

The ENERGY STAR efficiency standards are presented below.

ENERGY STAR Requirements (Effective January 1, 2012)

Product Type	EER	COP
Water-to-air		
Closed Loop	17.1	3.6
Open Loop	21.1	4.1
Water-to-Water		
Closed Loop	16.1	3.1
Open Loop	20.1	3.5
DGX	16	3.6

This measure was developed to be applicable to the following program types: TOS, NC, EREP. 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 must be a Ground Source Heat Pump unit meeting the minimum ENERGY STAR efficiency level standards effective at the time of installation as detailed above.

DEFINITION OF BASELINE EQUIPMENT

Time of Sale: The baseline equipment is assumed to be an Air Source Heat Pump meeting the Federal Standard efficiency level; 13 SEER, 7.7 HSPF and 11 EER.

Early replacement: The baseline for this measure is the efficiency of the existing equipment for the assumed remaining useful life of the unit and the new baseline as defined above for the remainder of the measure life.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 18 years[678].

Remaining life of existing equipment is assumed to be 6 years[679].

DEEMED MEASURE COST

The actual installed cost of the Ground Source Heat Pump should be used, minus the assumed installation cost of a 3 ton standard baseline Air Source Heat Pump of $3,609[680].

Early Replacement: The full installation cost of the Ground Source Heat Pump should be used. The assumed deferred cost (after 6 years) of replacing existing equipment with a new baseline unit is assumed to be $3609 (corresponding to a new baseline Air Source Heat Pump). This cost should be discounted to present value using the utilities discount rate.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

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

[678] Lifetime for an air source heat pump. The ground loop has a much longer life, but the compressor and other mechanical components are the same as an ASHP. The more moderate operating conditions for a GSHP may extend the life of these components beyond the life of an ASHP. 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

[679] Assumed to be one third of effective useful life

[680] Based on DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com). Material cost of 13 SEER AC is $796 per ton, and labor cost of $407 per ton. For a 3 ton unit this would be (796+407) *3 = $3609.

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%[681]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)
= 46.6%[682]

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Time of sale:

ΔkWh = (FLHcool * Capacity_cooling * (1/SEERbase – (1/(EERee * 1.02))/1000 + (FLHheat * Capacity_heating * (1/HSPFbase – (1/COPee * 3.412))/1000

Early replacement[683]:

ΔkWH for remaining life of existing unit (1st 6 years):

= (FLHcool * Capacity_cooling * (1/SEERexist – (1/(EERee * 1.02))/1000 + (FLHheat * Capacity_heating * (1/HSPFexist – (1/COPee * 3.412))/1000

ΔkWH for remaining measure life (next 12 years):

= (FLHcool * Capacity_cooling * (1/SEERbase – (1/(EERee * 1.02))/1000 + (FLHheat * Capacity_heating * (1/HSPFbase – (1/COPee * 3.412))/1000

Where:

FLHcool = Full load cooling hours

Dependent on location as below[684]:

[681] 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.
[682] 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.
[683] The two equations are provided to show how savings are determined during the initial phase of the measure (existing to efficient) and the remaining phase (new baseline to efficient). In practice, the screening tools used may either require a First Year savings (using the first equation) and then a "number of years to adjustment" and "savings adjustment" input which would be the (new base to efficient savings)/(existing to efficient savings).
[684] Based on Full Load Hours from ENERGY Star with adjustments made in a Navigant Evaluation, other cities were

Climate Zone (City based upon)	FLHcool Single Family	FLHcool Multifamily
1 (Rockford)	512	467
2 (Chicago)	570	506
3 (Springfield)	730	663
4 (Belleville)	1,035	940
5 (Marion)	903	820
Weighted Average[685]	629	564

Capacity_cooling = Cooling Capacity of Ground Source Heat Pump (Btu/h)

= Actual (1 ton = 12,000Btu/h)

SEERexist = SEER Efficiency of existing cooling unit

= Use actual SEER rating where it is possible to measure or reasonably estimate.

Existing Cooling System	SEER_exist[686]
Air Source Heat Pump	9.12
Central AC	8.60
No central cooling[687]	Make '1/SEER_exist' = 0

SEERbase = SEER Efficiency of baseline ASHP unit

= 13 [688]

EERee = EER Efficiency of efficient GSHP unit

= Actual installed

1.02 = Constant used to estimate the equivalent air conditioning SEER based on the GSHP unit's EER[689].

FLHheat = Full load heating hours

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.

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

686 Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren PY3-PY4.

687 If there is no central cooling in place but the incentive encourages installation of a new ASHP with cooling, the added cooling load should be subtracted from any heating benefit.

688 Minimum Federal Standard; Federal Register, Vol. 66, No. 14, Monday, January 22, 2001/Rules and Regulations, p. 7170-7200.

689 Note that EERs of GSHPs are measured differently than EERs of air source heat pumps (focusing on entering water temperatures rather than ambient air temperatures). The equivalent SEER of a GSHP can be estimated by multiplying EER by 1.02, based on VEIC extrapolation of manufacture data.

Dependent on location as below[690]:

Climate Zone (City based upon)	FLH_heat
1 (Rockford)	1,969
2 (Chicago)	1,840
3 (Springfield)	1,754
4 (Belleville)	1,266
5 (Marion)	1,288
Weighted Average[691]	1,821

Capacity_heating = Heating Capacity of Ground Source Heat Pump (Btu/h)

= Actual (1 ton = 12,000Btu/h)

HSPF_exist =Heating System Performance Factor of existing heating system (kBtu/kWh)

= Use actual HSPF rating where it is possible to measure or reasonably estimate.

Existing Cooling System	HSPF_exist
Air Source Heat Pump	5.44
Electric Resistance	3.41[693]

HSPFbase =Heating Season Performance Factor for baseline unit

=7.7 [694]

COPee = Coefficient of Performance of efficient unit

= Actual Installed

3.412 = Constant to convert the COP of the unit to the Heating Season Performance Factor (HSPF).

[690] Heating EFLH based on ENERGY Star EFLH for Rockford, Chicago, and Springfield and on NCDC/NOAA HDD for the other two cities. In all cases, the hours were adjusted based on average natural gas heating consumption in IL. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.

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

[692] This is estimated based on finding the average HSPF/SEER ratio from the AHRI directory data (using the least efficient models – SEER 12 and SEER 13) – 0.596, and applying to the average nameplate SEER rating of all Early Replacement qualifying equipment in Ameren PY3-PY4. This estimation methodology appears to provide a result within 10% of actual HSPF.

[693] Electric resistance has a COP of 1.0 which equals 1/0.293 = 3.41 HSPF.

[694] Minimum Federal Standard; Federal Register, Vol. 66, No. 14, Monday, January 22, 2001/Rules and Regulations, p. 7170-7200.

Time of Sale:

For example, a 3 ton unit with EER rating of 16 and COP of 3.5 in single family house in Springfield:

ΔkWh = (FLHcool * Btu/H * (1/SEERbase – (1/(EERee * 1.02))/1000+ (FLHheat * Btu/H * (1/HSPFbase – (1/COPee * 3.412))/1000

ΔkWh = (730 * 36,000 * (1/13 – 1/ (16*1.02))) / 1000 + (1967 * 36,000 * (1/7.7 – 1/ (3.5*3.412)) / 1000

= 3680 kWh

Early Replacement:

For example, a 3 ton unit with EER rating of 16 and COP of 3.5 in single family house in Springfield replaces an existing working Air Source Heat Pump with unknown efficiency ratings:

ΔkWH for remaining life of existing unit (1st 6 years):

= (730* 36,000 * (1/9.12 - 1/(16*1.02))) / 1000) + ((1,967 * 36,000 * (1/5.44 - 1/(3.5 * 3.412))) / 1000)

= 8359 kWh

ΔkWH for remaining measure life (next 12 years):

= (730 * 36,000 * (1/13 – 1/ (16*1.02))) / 1000 + (1967 * 36,000 * (1/7.7 – 1/ (3.5*3.412)) / 1000

= 1,203 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

Time of sale:

$$\Delta kW = (Capacity\_cooling * (1/EERbase - 1/EERee_{AC\ equivalent}))/1000) * CF$$

Early replacement[695]:

ΔkW for remaining life of existing unit (1st 6 years):

$$= (Capacity\_cooling * (1/EERexist - 1/EERee_{AC\ equivalent}))/1000) * CF$$

ΔkW for remaining measure life (next 12 years):

[695] The two equations are provided to show how savings are determined during the initial phase of the measure (existing to efficient) and the remaining phase (new baseline to efficient). In practice, the screening tools used may either require a First Year savings (using the first equation) and then a “number of years to adjustment” and “savings adjustment” input which would be the (new base to efficient savings)/(existing to efficient savings).

= (Capacity_cooling * (1/EERexist - 1/$EERee_{AC\ equivalent}$))/1000) * CF

Where:

EERexist = Energy Efficiency Ratio of existing cooling unit (kBtu/h / kW)

= Use actual EER rating where it is possible to measure or reasonably estimate. If EER unknown but SEER available convert using the equation:

EER_base = (-0.02 * SEER_base^2) + (1.12 * SEER) [696]

If SEER rating unavailable use:

Existing Cooling System	EER_exist[697]
Air Source Heat Pump	8.55
Central AC	8.15
No central cooling[698]	Make '1/EER_exist' = 0

EERbase = EER Efficiency of baseline ASHP unit

= 11 [699]

$EERee_{AC\ equivalent}$ = Equivalent Air Conditioning EER Efficiency of ENERGY STAR GSHP unit[700]

To calculate this, the actual EER of the GSHP is converted to an air conditioning SEER equivalent by multiplying by 1.02 [701]

This is then converted to the air conditioning EER equivalent resulting in the following algorithm:

$EERee_{AC\ equivalent}$= (-0.02 * (EERee * 1.02)^2 + (1.12 * (EERee * 1.02)) [702]

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

= 91.5%[703]

[696] From Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder.
[697] Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren PY3-PY4.
[698] If there is no central cooling in place but the incentive encourages installation of a new ASHP with cooling, the added cooling load should be subtracted from any heating benefit.
[699] Minimum Federal Standard; as above.
[700] EERs of GSHPs are measured differently than EERs of air source heat pumps (focusing on entering water temperatures rather than ambient air temperatures).
[701] Based on VEIC extrapolation of manufacturer data.
[702] Air conditioning SEER to EER algorithm based on Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder. Note this is appropriate for single speed units only.
[703] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC

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

= 46.6%[704]

load during the utility's peak hour is divided by the maximum AC load during the year.

[704] 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.

Time of Sale:

For example, a 3 ton unit with EER rating of 16:

ΔkW_{SSP} = ((36,000 * (1/11 – 1/(-0.02 * (16 * 1.02)^2 + (1.12 * (16 * 1.02))))/1000) * 0.915

= 0.451 kW

ΔkW_{PJM} = ((36,000 * (1/11 – 1/(-0.02 * (16 * 1.02)^2 + (1.12 * (16 * 1.02))))/1000) * 0.466

= 0.230 kW

Early Replacement:

For example, a 3 ton 16 EER replaces an existing working Air Source Heat Pump with unknown efficiency ratings in Marion:

ΔkW_{SSP} for remaining life of existing unit (1st 6 years):

= ((36,000 * (1/8.55 – 1/(-0.02 * (16 * 1.02)^2 + (1.12 * (16 * 1.02))))/1000) * 0.915

= 1.98 kW

ΔkW_{SSP} for remaining measure life (next 12 years):

= ((36,000 * (1/11 – 1/(-0.02 * (16 * 1.02)^2 + (1.12 * (16 * 1.02))))/1000) * 0.915

= 0.451 kW

ΔkW_{PJM} for remaining life of existing unit (1st 6 years):

= ((36,000 * (1/8.55 – 1/(-0.02 * (16 * 1.02)^2 + (1.12 * (16 * 1.02))))/1000) * 0.466

= 1.01 kW

ΔkW_{PJM} for remaining measure life (next 12 years):

= ((36,000 * (1/11 – 1/(-0.02 * (16 * 1.02)^2 + (1.12 * (16 * 1.02))))/1000) * 0.466

= 0.230 kW

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-GSHP-V02-130601

5.3.9 High Efficiency Bathroom Exhaust Fan

DESCRIPTION

This market opportunity is defined by the need for continuous mechanical ventilation due to reduced air-infiltration from a tighter building shell. In retrofit projects, existing fans may be too loud, or insufficient in other ways, to be operated as required for proper ventilation. This measure assumes a fan capacity of 50 CFM rated at a sound level of less than 2.0 sones at 0.1 inches of water column static pressure. This measure may be applied to larger capacity, up to 130 CFM, efficient fans with bi-level controls because the savings and incremental costs are very similar. All eligible installations shall be sized to provide the mechanical ventilation rate indicated by ASHRAE 62.2.

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

DEFINITION OF EFFICIENT EQUIPMENT

New efficient (average CFM/watt of 8.3 [705]) exhaust-only ventilation fan, quiet (< 2.0 sones) Continuous operation in accordance with recommended ventilation rate indicated by ASHRAE 62.2[706]

DEFINITION OF BASELINE EQUIPMENT

New standard efficiency (average CFM/Watt of 3.1[707]) exhaust-only ventilation fan, quiet (< 2.0 sones) operating in accordance with recommended ventilation rate indicated by ASHRAE 62.2 [708]

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 19 years[709].

DEEMED MEASURE COST

Incremental cost per installed fan is $43.50 for quiet, efficient fans[710].

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape R11 - Residential Ventilation

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[705] VEIC analysis looking at average efficient fan (i.e. Brushless Permanent Magnet) efficacies at static pressures of 0.1 and 0.25 inches of water column for quiet fans rated for 50 CFM.
[706] Bi-level controls may be used by efficient fans larger than 50 CFM
[707] VEIC analysis looking at average baseline fan (i.e. non-Brushless Permanent Magnet) efficacies at static pressures of 0.1 and 0.25 inches of water column for quiet fans rated for 50 CFM.
[708] On/off cycling controls may be required of baseline fans larger than 50CFM.
[709] Conservative estimate based upon GDS Associates Measure Life Report "Residential and C&I Lighting and HVAC measures" 25 years for whole-house fans, and 19 for thermostatically-controlled attic fans.
[710] VEIC analysis using cost data collected from wholesale vendor; http://www.westsidewholesale.com/ .

COINCIDENCE FACTOR

The summer Peak Coincidence Factor is assumed to be 100% because the fan runs continuously.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$\Delta kWh = (CFM * (1/\eta_{,BASELINE} - 1/\eta_{EFFICIENT})/1000) * Hours$

Where:

CFM = Nominal Capacity of the exhaust fan

= 50 CFM[711]

$\eta_{BASELINE}$ = Average efficacy for baseline fan

= 3.1 CFM/Watt[712]

$\eta_{EFFCIENT}$ = Average efficacy for efficient fan

= 8.3 CFM/Watt[713]

Hours = assumed annual run hours,

= 8766 for continuous ventilation.

$\Delta kWh = (50 * (1/3.1 – 1/8.3)/1000) * 8766$

= 88.6 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$\Delta kW = (CFM * (1/\eta_{BASELINE} - 1/\eta_{EFFICIENT})/1000) * CF$

Where:

[711] 50CFM is the closest available fan size to ASHRAE 62.2 Section 4.1 Whole House Ventilation rates based upon typical square footage and bedrooms.
[712] VEIC analysis looking at average baseline fan (i.e. non-Brushless Permanent Magnet) efficacies at static pressures of 0.1 and 0.25 inches of water column for quiet fans rated for 50 CFM.
[713] VEIC analysis looking at average efficient fan (i.e. Brushless Permanent Magnet) efficacies at static pressures of 0.1 and 0.25 inches of water column for quiet fans rated for 50 CFM.

CF = Summer Peak Coincidence Factor

= 1.0 (continuous operation)

Other variables as defined above

$$\Delta kW = (50 * (1/3.1 – 1/8.3)/1000) * 1.0$$

$$= 0.0101 \text{ kW}$$

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-BAFA-V01-120601

5.3.10 HVAC Tune Up (Central Air Conditioning or Air Source Heat Pump)

DESCRIPTION

This measure involves the measurement of refrigerant charge levels and airflow over the central air conditioning or heat pump unit coil, correction of any problems found and post-treatment re-measurement. Measurements must be performed with standard industry tools and the results tracked by the efficiency program.

Savings from this measure are developed using a reputable Wisconsin study. It is recommended that future evaluation be conducted in Illinois to generate a more locally appropriate characterization.

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

N/A

DEFINITION OF BASELINE EQUIPMENT

This measure assumes that the existing unit being maintained is either a residential central air conditioning unit or an air source heat pump that has not been serviced for at least 3 years.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

THE MEASURE LIFE IS ASSUMED TO BE 2 YEARS[714].

DEEMED MEASURE COST

If the implementation mechanism involves delivering and paying for the tune up service, the actual cost should be used. If however the customer is provided a rebate and the program relies on private contractors performing the work, the measure cost should be assumed to be $175[715].

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape R08 - Residential 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.

[714] Based on VEIC professional judgment.
[715] Based on personal communication with HVAC efficiency program consultant Buck Taylor or Roltay Inc., 6/21/10, who estimated the cost of tune up at $125 to $225, depending on the market and the implementation details.

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

= 91.5%[716]

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

= 46.6%[717]

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$\Delta kWh_{Central\ AC}$ = (FLHcool * Capacity_cooling* (1/$SEER_{CAC}$))/1000 * MFe

$\Delta kWh_{Air\ Source\ Heat\ Pump}$ = ((FLHcool * Capacity_cooling * (1/$SEER_{ASHP}$))/1000 * MFe) + (FLHheat * Capacity_heating * (1/$HSPF_{ASHP}$))/1000 * MFe)

Where:

FLHcool = Full load cooling hours

Dependent on location as below:[718]

Climate Zone (City based upon)	FLHcool Single Family	FLHcool Multifamily
1 (Rockford)	512	467
2 (Chicago)	570	506
3 (Springfield)	730	663
4 (Belleville)	1,035	940
5 (Marion)	903	820
Weighted Average[719]	629	564

Capacity_cooling = Cooling cpacity of equipment in Btu/h (note 1 ton = 12,000 Btu/h)

= Actual

$SEER_{CAC}$ = SEER Efficiency of existing central air conditioning unit receiving maintenence

716 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.

717 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.

718 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.

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

= Actual. If unknown assume 10 SEER [720]

MFe = Maintenance energy savings factor

= 0.05[721]

$SEER_{ASHP}$ = SEER Efficiency of existing air source heat pump unit receiving maintenence

= Actual. If unknown assume 10 SEER [722]

FLHheat = Full load heating hours

Dependent on location:[723]

Climate Zone (City based upon)	FLHheat
1 (Rockford)	2208
2 (Chicago)	2064
3 (Springfield)	1967
4 (Belleville)	1420
5 (Marion)	1445
Weighted Average[724]	1821

Capacity_heating = Heating cpacity of equipment in Btu/h (note 1 ton = 12,000 Btu/h)

= Actual

HSPFbase = Heating Season Performance Factor of existing air source heat pump unit receiving maintenence

= Actual. If unknown assume 6.8 HSPF [725]

[720] Use actual SEER rating where it is possible to measure or reasonably estimate. Unknown default of 10 SEER is a VEIC estimate of existing unit efficiency, based on minimum federal standard between the years of 1992 and 2006.
[721] Energy Center of Wisconsin, May 2008; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research."
[722] Use actual SEER rating where it is possible to measure or reasonably estimate. Unknown default of 10 SEER is a VEIC estimate of existing unit efficiency, based on minimum federal standard between the years of 1992 and 2006.
[723] Full load heating hours for heat pumps are provided for Rockford, Chicago and Springfield in the Energy Star Calculator. Estimates for the other locations were calculated based on the FLH to Heating Degree Day (from NCDC) ratio. VEIC consider Energy Star estimates to be high due to oversizing not being adequately addressed. Using average Illinois billing data (from http://www.icc.illinois.gov/ags/consumereducation.aspx) VEIC estimated the average gas heating load and used this to estimate the average home heating output (using 83% average gas heat efficiency). Dividing this by a typical 36,000 Btu/h ASHP gives an estimate of average ASHP FLH_heat of 1821 hours. We used the ratio of this value to the average of the locations using the Energy Star data (1994 hours) to scale down the Energy Star estimates. There is a county mapping table in the Appendix providing the appropriate city to use for each county of Illinois.
[724] Weighted based on number of occupied residential housing units in each zone.
[725] Use actual HSPF rating where it is possible to measure or reasonably estimate. Unknown default of 6.8 HSPF is a

For example, maintenance of a 3-ton, SEER 10 air conditioning unit in a single family house in Springfield:

ΔkWh_{CAC} = (730 * 36,000 * (1/10))/1000 * 0.05

= 131 kWh

For example, maintenance of a 3-ton, SEER 10, HSPF 6.8 air source heat pump unit in a single family house in Springfield:

ΔkWh_{ASHP} = ((730 * 36,000 * (1/10))/1000 * 0.05) + (1967 * 36,000 * (1/6.8))/1000 * 0.05)

= 652 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = Capacity_cooling * (1/EER)/1000 * MFd * CF

Where:

EER = EER Efficiency of existing unit receiving maintenance in Btu/H/Watts

= Calculate using Actual SEER

= - 0.02*$SEER^2$ + 1.12*SEER [726]

MFd = Maintenance demand savings factor

= 0.02 [727]

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

= 91.5%[728]

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

= 46.6%[729]

VEIC estimate based on minimum Federal Standard between 1992 and 2006.

[726] Based on Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder. Note this is appropriate for single speed units only.

[727] Based on June 2010 personal conversation with Scott Pigg, author of Energy Center of Wisconsin, May 2008; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research" suggesting the average WI unit system draw of 2.8kW under peak conditions, and average peak savings of 50W.

[728] 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.

[729] 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, maintenance of 3-ton, SEER 10 (equals EER 9.2) unit:

ΔkW_{SSP} = 36,000 * 1/(9.2)/1000 * 0.02 * 0.915

= 0.0716 kW

ΔkW_{PJM} = 36,000 * 1/(9.2)/1000 * 0.02 * 0.466

= 0.0365 kW

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

Conservatively not included

MEASURE CODE: RS-HVC-TUNE-V01-120601

5.3.11 Programmable Thermostats

DESCRIPTION

This measure characterizes the household energy savings from the installation of a new or reprogramming of an existing Programmable Thermostat for reduced heating energy consumption through temperature set-back during unoccupied or reduced demand times. Because a literature review was not conclusive in providing a defensible source of prescriptive cooling savings from programmable thermostats, cooling savings from programmable thermostats are assumed to be zero for this version of the measure. It is not appropriate to assume a similar pattern of savings from setting a thermostat down during the heating season and up during the cooling season. Note that the EPA's EnergyStar program is developing a new specification for this project category, and if/when evaluation results demonstrate consistent cooling savings, subsequent versions of this measure will revisit this assumption[730].

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

DEFINITION OF EFFICIENT EQUIPMENT

The criteria for this measure are established by replacement of a manual-only temperature control, with one that has the capability to adjust temperature setpoints according to a schedule without manual intervention. This category of equipment is broad and rapidly advancing in regards to the capability, and usability of the controls and their sophistication in setpoint adjustment and information display, but for the purposes of this characterization, eligibility is perhaps most simply defined by what it isn't: a manual only temperature control.

For the thermostat reprogramming measure, the auditor consults with the homeowner to determine an appropriate set back schedule, reprograms the thermostat and educates the homeowner on its appropriate use.

DEFINITION OF BASELINE EQUIPMENT

For new thermostats the baseline is a non-programmable thermostat requiring manual intervention to change temperature setpoint.

For the purpose of thermostat reprogramming, an existing programmable thermostat that an auditor determines is being used in override mode or otherwise effectively being operated like a manual thermostat.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life of a programmable thermostat is assumed to be 10 years[731] based upon equipment life only[732]. For the purposes of claiming savings for a new programmable thermostat, this is reduced by a 50% persistence factor to give final measures life of 5 years. For reprogramming, this is reduced further to give a measure life of 2 years.

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[730] The EnergyStar program discontinued its support for this measure category effective 12/31/09, and is presently developing a new specification for 'Residential Climate Controls'.

731 Table 1, HVAC Controls, Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

732 Future evaluation is strongly encouraged to inform the persistence of savings to further refine measure life assumption. As this characterization depends heavily upon a large scale but only 2-year study of the energy impacts of programmable thermostats, the longer term impacts should be assessed.

DEEMED MEASURE COST

Actual material and labor costs should be used if the implementation method allows. If unknown (e.g. through a retail program) the capital cost for the new installation measure is assumed to be $30[733]. The cost for reprogramming is assumed to be $10 to account for the auditors time to reprogram and educate the homeowner.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape R09 - Residential Electric Space Heat

COINCIDENCE FACTOR

N/A due to no savings attributable to cooling during the summer peak period.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh[734] = %ElectricHeat * Elec_Heating_Consumption * Heating_Reduction * HF * Eff_ISR + (ΔTherms * F_e * 29.3)

Where:

%ElectricHeat = Percentage of heating savings assumed to be electric

Heating fuel	%ElectricHeat
Electric	100%
Natural Gas	0%
Unknown	13%[735]

Elec_Heating_ Consumption

= Estimate of annual household heating consumption for electrically heated single-

733 Market prices vary significantly in this category, generally increasing with thermostat capability and sophistication. The basic functions required by this measure's eligibility criteria are available on units readily available in the market for the listed price.

734 Note the second part of the algorithm relates to furnace fan savings if the heating system is Natural Gas.

735 Average (default) value of 13% electric space heating from 2010 Residential Energy Consumption Survey for Illinois. 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.

family homes[736]. If location and heating type is unknown, assume 17,734 kWh[737]

Climate Zone (City based upon)	Electric Resistance Elec_Heating_ Consumption (kWh)	Electric Heat Pump Elec_Heating_ Consumption (kWh)
1 (Rockford)	26,038	13,019
2 (Chicago)	24,875	12,438
3 (Springfield)	21,304	10,652
4 (Belleville)	16,434	8,217
5 (Marion)	16,726	8,363
Average	23,645	11,822

Heating_Reduction = Assumed percentage reduction in heating energy consumption due to programmable thermostat

= 6.2%[738]

HF = Household factor, to adjust heating consumption for non-single-family households.

Household Type	HF
Single-Family	100%
Multi-Family	65%[739]
Actual	Custom[740]

Eff_ISR = Effective In-Service Rate, the percentage of thermostats installed and programmed effectively

[736] Values in table are based on converting an average household heating consumption (849 therms) for Chicago based on 'Table 3-4, Program Sample Analysis, Nicor R29 Res Rebate Evaluation Report 092611_REV FINAL to Nicor', to an electric heat consumption (divide by 0.03413 and assuming efficiencies of 100% for resistance and 200% for HP) and then adjusting to a statewide average using relative HDD assumptions 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.

[737] Assumption that 1/2 of electrically heated homes have electric resistance and 1/2 have Heat Pump, based on 2010 Residential Energy Consumption Survey for Illinois.

[738] The savings from programmable thermostats are highly susceptible to many factors best addressed, so far for this category, by a study that controlled for the most significant issues with a very large sample size. To the extent that the treatment group is representative of the program participants for IL, this value is suitable. Higher and lower values would be justified based upon clear dissimilarities due to program and product attributes. Future evaluation work should assess program specific impacts associated with penetration rates, baseline levels, persistence, and other factors which this value represents.

[739] Multifamily household heating consumption relative to single-family households is affected by overall household square footage and exposure to the exterior. This 65% reduction factor is applied to MF homes with electric resistance, based on professional judgment that average household size, and heat loads of MF households are smaller than single-family homes

[740] Program-specific household factors may be utilized on the basis of sufficiently validated program evaluations.

Program Delivery	Eff_ISR
Direct Install	100%
Other, or unknown	56%[741]

ΔTherms = Therm savings if Natural Gas heating system

= See calculation in Natural Gas section below

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

= 3.14%[742]

29.3 = kWh per therm

For example, a programmable thermostat directly installed in an electric resistance heated, single-family home in Springfield:

ΔkWH = 1 * 20,214* 0.062 * 100% * 100% + (0 * 0.0314 * 29.3)

= 1253 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A due to no savings from cooling during the summer peak period.

NATURAL GAS ENERGY SAVINGS

ΔTherms = %FossilHeat * Gas_Heating_Consumption * Heating_Reduction * HF * Eff_ISR

Where:

%FossilHeat = Percentage of heating savings assumed to be Natural Gas

Heating fuel	%FossilHeat
Electric	0%
Natural Gas	100%
Unknown	87%[743]

Gas_Heating_Consumption

[741]"Programmable Thermostats. Report to KeySpan Energy Delivery on Energy Savings and Cost Effectiveness," GDS Associates, Marietta, GA. 2002GDS

[742] 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.

[743] Average (default) value of 87% electric space heating from 2010 Residential Energy Consumption Survey for Illinois. 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.

= Estimate of annual household heating consumption for gas heated single-family homes. If location is unknown, assume the average below[744].

Climate Zone (City based upon)	Gas_Heating_ Consumption (therms)
1 (Rockford)	889
2 (Chicago)	849
3 (Springfield)	727
4 (Belleville)	561
5 (Marion)	571
Average	807

For example, a programmable thermostat directly-installed in a gas heated single-family home in Chicago:

ΔTherms = 1.0 * 849* 0.062 * 100% * 100%

= 52.6 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-PROG-V02-130601

[744] Values are based on adjusting the average household heating consumption (849 therms) for Chicago based on '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 assumptions 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.

5.4 Hot Water End Use

5.4.1 Domestic Hot Water Pipe Insulation

Description

This measure describes adding insulation to un-insulated domestic hot water pipes. The measure assumes the pipe wrap is installed to the first length of both the hot and cold pipe up to the first elbow. This is the most cost effective section to insulate since the water pipes act as an extension of the hot water tank up to the first elbow which acts as a heat trap. Insulating this length therefore helps reduce standby losses. Default savings are provided per 3ft length and are appropriate up to 6ft of the hot water pipe and 3ft of the cold.

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

Definition of Efficient Equipment

The efficient case is installing pipe wrap insulation to a length of hot water pipe.

Definition of Baseline Equipment

The baseline is an un-insulated hot water pipe.

Deemed Lifetime of Efficient Equipment

The measure life is assumed to be 15 years[745].

Deemed Measure Cost

The measure cost including material and installation is assumed to be $3 per linear foot[746].

Deemed O&M Cost Adjustments

N/A

Loadshape

Loadshape C53 - Flat

Coincidence Factor

This measure assumes a flat loadshape since savings relate to reducing standby losses and as such the coincidence factor is 1.

Algorithm

[745] 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
[746] Consistent with DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com).

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

For electric DHW systems:

$$\Delta kWh = ((1/Rexist - 1/Rnew) * (L * C) * \Delta T * 8{,}766) / \eta DHW / 3413$$

Where:

Rexist = Pipe heat loss coefficient of uninsulated pipe (existing) [(hr-°F-ft)/Btu]

= 1.0[747]

Rnew = Pipe heat loss coefficient of insulated pipe (new) [(hr-°F-ft)/Btu]

= Actual (1.0 + R value of insulation)

L = Length of pipe from water heating source covered by pipe wrap (ft)

= Actual

C = Circumference of pipe (ft) (Diameter (in) * π/12)

= Actual (0.5” pipe = 0.131ft, 0.75” pipe = 0.196ft)

ΔT = Average temperature difference between supplied water and outside air temperature (°F)

= 60°F [748]

8,766 = Hours per year

ηDHW = Recovery efficiency of electric hot water heater

= 0.98 [749]

3412 = Conversion from Btu to kWh

[747] Navigant Consulting Inc., April 2009; “Measures and Assumptions for Demand Side Management (DSM) Planning; Appendix C Substantiation Sheets”, p77.

[748] Assumes 125°F water leaving the hot water tank and average temperature of basement of 65°F.

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

For example, insulating 5 feet of 0.75" pipe with R-5 wrap:

$$\Delta kWh = ((1/Rexist – 1/Rnew) * (L * C) * \Delta T * 8,766) / \eta DHW / 3412$$

$$= ((1/1– 1/5) * (5 * 0.196) * 60 * 8766) / 0.98 /3412$$

$$= 123 \text{ kWh}$$

If inputs above are not available the following default per 3ft R-5 length can be used for up to 6 ft length on the hot pipe and 3 ft on the cold pipe.

$$\Delta kWh = ((1/Rexist – 1/Rnew) * (L * C) * \Delta T * 8,766) / \eta DHW / 3412$$

$$= ((1/1– 1/5) * (3 * 0.196) * 60 * 8766) / 0.98 /3412$$

$$= 74.0 \text{ kWh per 3ft length}$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = \Delta kWh / 8766$$

Where:

ΔkWh = kWh savings from pipe wrap installation

8766 = Number of hours in a year (since savings are assumed to be constant over year).

For example, insulating 5 feet of 0.75" pipe with R-5 wrap:

$$\Delta kW = 123/8766$$

$$= 0.014kW$$

If inputs above are not available the following default per 3ft R-4 length can be used for up to 6 ft length on the hot pipe and 3 ft on the cold pipe.

$$\Delta kW = 73.9/8766$$

$$= 0.0084 \text{ kW}$$

NATURAL GAS SAVINGS

For Natural Gas DHW systems:

$$\Delta Therm = ((1/Rexist – 1/Rnew) * (L * C) * \Delta T * 8,766) / \eta DHW /100,000$$

Where:

ηDHW = Recovery efficiency of gas hot water heater

= 0.78 [750]

Other variables as defined above

For example, insulating 5 feet of 0.75" pipe with R-5 wrap:

ΔTherm = ((1/1– 1/5) * (5 * 0.196) * 60 * 8766) / 0.78 / 100,000

= 5.29 therms

If inputs above are not available the following default per 3ft R-4 length can be used for up to 6ft length on the hot pipe and 3ft on the cold pipe.

ΔTherm = ((1/Rexist – 1/Rnew) * (L * C) * ΔT * 8,766) / ηDHW / 100,000

= ((1/1– 1/5) * (3 * 0.196) * 60 * 8766) / 0.78 /100,000

= 3.17 therms per 3ft length

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HWE-PINS-V01-120601

[750] 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 78%

5.4.2 Gas Water Heater

Description

This measure characterizes the purchase and installation of a new efficient gas-fired water heater, in place of a Federal Standard unit in a residential setting. Savings are provided for power-vented, condensing storage, and whole-house tankless units meeting specific EF criteria.

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 efficient equipment must be a water heater rated with the following minimum efficiency ratings:

Water heater Type	Minimum Energy Factor
Gas Storage	0.67
Condensing gas storage	0.80
Tankless whole-house unit	0.82

Definition of Baseline Equipment

The baseline condition is assumed to be a standard gas storage water heater of the same capacity as the efficient unit, rated at the federal minimum (0.67 – 0.0019 * storage size in gallons)[751]. For a 40-gallon storage water heater this would be 0.594 EF.

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 13 years[752].

[751] Federal Standard as of January 2004, http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/water_heater_fr.pdf

[752] DOE, 2010 Residential Heating Products Final Rule Technical Support Document, Table 8.2.14 http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/htgp_finalrule_ch8.pdf Note: This source is used to support this category in aggregate. For all water heaters, life expectancy will depend on local variables such as water chemistry and homeowner maintenance. Some categories, including condensing storage and tankless water heaters do not yet have sufficient field data to support separate values. Preliminary data show lifetimes may exceed 20 years, though this has yet to be sufficiently demonstrated.

DEEMED MEASURE COST

The incremental capital cost for this measure is dependent on the type of water heater as listed below[753]:

Water heater Type	Incremental Cost
Gas Storage	$400
Condensing gas storage	$685
Tankless whole-house unit	$605

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 ENERGY SAVINGS

$$\Delta Therms = (1/ EF_{BASE} - 1/EF_{EFFICIENT}) * (GPD * 365.25 * \gamma Water * (T_{OUT} – T_{IN}) * 1.0)/100,000$$

Where:

[753] Source for cost info; DOE, 2010 Residential Heating Products Final Rule Technical Support Document, Table 8.2.14 (http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/htgp_finalrule_ch8.pdf)

EF_Baseline = Energy Factor rating for baseline equipment

= (0.67 – 0.0019 * tank_size) [754]

Tank_size (gallons)	EF_Baseline
40	0.594
50	0.575
60	0.556

= If tank size unknown assume 40 gallons and EF_Baseline of 0.594

EF_Efficient = Energy Factor Rating for efficient equipment

= Actual. If Tankless whole-house multiply rated efficiency by 0.91[755]. If unknown assume values in look up in table below

Water Heater Type	EF_Efficient
Condensing Gas Storage	0.80
Gas Storage	0.67
Tankless whole-house	0.82 * 0.91 = 0.75

GPD = Gallons Per Day of hot water use per household

= 50 [756]

365.25 = Days per year, on average

γWater = Specific Weight of water

= 8.33 pounds per gallon

T_{OUT} = Tank temperature

= 125°F

---

[754] Algorithm based on current Federal Standard; http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/water_heater_fr.pdf
Note that changes to the Federal Standard will be applied from April 16, 2015, see link below for more details: http://www1.eere.energy.gov/buildings/appliance_standards/residential/heating_products_fr.html.

[755] The disconnect between rated energy factor and in-situ energy consumption is markedly different for tankless units due to significantly higher contributions to overall household hot water usage from short draws. In tankless units the large burner and unit heat exchanger must fire and heat up for each draw. The additional energy losses incurred when the mass of the unit cools to the surrounding space in-between shorter draws was found to be 9% in a study prepared for Lawrence Berkeley National Laboratory by Davis Energy Group, 2006. "Field and Laboratory Testing of Tankless Gas Water Heater Performance" Due to the similarity (storage) between the other categories and the baseline, this derating factor is applied only to the tankless category.

[756] Federal Register, Test Procedures for Water Heaters, Comments on "Test Conditions," http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/wtrhtr.pdf

T_{IN} = Incoming water temperature from well or municipal system

= 54°F[757]

1.0 = Heat Capacity of water (1 Btu/lb*°F)

For example, a 40 gallon condensing gas storage water heater, with an energy factor of 0.80:

ΔTherms = (1/0.594) - 1/0.8) * (50 * 365.25* 8.33 * (125 – 54) * 1) / 100,000

= 46.8 therms

Water Impact Descriptions and Calculation

N/A

Deemed O&M Cost Adjustment Calculation

N/A

Measure Code: RS-HWE-GWHT-V01-120601

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

5.4.3 Heat Pump Water Heaters

Description

The installation of a heat pump domestic hot water heater in place of a standard electric water heater in a home. Savings are presented dependent on the heating system installed in the home due to the impact of the heat pump water heater on the heating loads.

This measure was developed to be applicable to the following program types: TOS, NC, 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 Heat Pump domestic water heater.

Definition of Baseline Equipment

The baseline condition is assumed to be a new electric water heater meeting federal minimum efficiency standards.

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 13 years[758].

Deemed Measure Cost

The incremental capital cost for this measure is $1,000, for a HPWH with an energy factor of 2.0. The full cost, applicable in a retrofit, is $1,575. For a HPWH with an energy factor of 2.35, these costs are $1,134 and $1,703 respectively[759].

Deemed O&M Cost Adjustments

N/A

Loadshape

Loadshape R03 - Residential Electric DHW

Coincidence Factor

The summer Peak Coincidence Factor is assumed to be 12%[760].

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[758] DOE, 2010 Residential Heating Products Final Rule Technical Support Document, Page 8-52 http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/htgp_finalrule_ch8.pdf

[759] DOE, 2010 Residential Heating Products Final Rule Technical Support Document, Table 8.2.14 http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/htgp_finalrule_ch8.pdf

[760] Calculated from Figure 8 "Combined six-unit summer weekday average electrical demand" in FEMP study; Field Testing of Pre-Production Prototype Residential Heat Pump Water Heaters http://www1.eere.energy.gov/femp/pdfs/tir_heatpump.pdf as (average kW usage during peak period * hours in peak period) / [(annual kWh savings / FLH) * hours in peak period] = (0.1 kW * 5 hours) / [(2100 kWh (default assumptions) / 2533 hours) * 5 hours] = 0.12

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh = $(((1/EF_{BASE} – 1/EF_{EFFICIENT})$ * GPD * 365.25 * γWater * $(T_{OUT} – T_{IN})$ * 1.0) / 3412) + kWh_cooling - kWh_heating

Where:

EF_{BASE} = Energy Factor (efficiency) of standard electric water heater according to federal standards:

= 0.93 – (0.00132 * rated volume in gallons)[761]

= 0.904 for a 50 gallon tank, the most common size for HPWH

$EF_{EFFICIENT}$ = Energy Factor (efficiency) of Heat Pump water heater

= Actual

GPD = Gallons Per Day of hot water use per household

= 50 [762]

365.25 = Days per year

γWater = Specific weight of water

= 8.33 pounds per gallon

T_{OUT} = Tank temperature

= 125°F

T_{IN} = Incoming water temperature from well or municiple system

= 54°F[763]

1.0 = Heat Capacity of water (1 Btu/lb*°F)

3412 = Conversion from BTU to kWh

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[761] Current Federal Standard EF, since 2004, for a 50-gal electric storage WH, Federal Register Vol. 66, No. 11/1/17/2001, page 4497, http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/water_heater_fr.pdf

[762] Federal Register, Test Procedures for Water Heaters, Comments on "Test Conditions," http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/wtrhtr.pdf

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

kWh_cooling[764] = Cooling savings from conversion of heat in home to water heat

$=(([(GPD * 365.25 * \gamma Water * (T_{OUT} – T_{IN}) * 1.0) / 3412) – (GPD * 365.25 * \gamma Water * (T_{OUT} – T_{IN}) * 1.0) / 3412) / EF_{NEW}] * LF * 27\%) / COP_{COOL}) * LM$

Where:

LF = Location Factor

= 1.0 for HPWH installation in a conditioned space

= 0.5 for HPWH installation in an unknown location

= 0.0 for installation in an unconditioned space

27% = Portion of reduced waste heat that results in cooling savings[765]

COP_{COOL} = COP of central air conditioning

= Actual, if unknown, assume 3.08 (10.5 SEER / 3.412)

LM = Latent multiplier to account for latent cooling demand

= 1.33 [766]:

kWh_heating = Heating cost from conversion of heat in home to water heat (dependent on heating fuel)

For Natural Gas heating, kWh_heating = 0

For electric heating:

$= ([(GPD * 365.25 * \rho * (T_{OUT} – T_{IN}) * 1.0) / 3412) – (GPD * 365.25 * \rho * (T_{OUT} – T_{IN}) * 1.0) / 3412) / EF_{NEW}] * LF * 49\%) / COP_{HEAT}$

Where:

[764] This algorithm calculates the heat removed from the air by subtracting the HPWH electric consumption from the total water heating energy delivered. This is then adjusted to account for location of the HP unit and the coincidence of the waste heat with cooling requirements, the efficiency of the central cooling and latent cooling demands.

[765] REMRate determined percentage (27%) of lighting savings that result in reduced cooling loads (lighting is used as a proxy for hot water heating since load shapes suggest their seasonal usage patterns are similar).

[766] A sensible heat ratio (SHR) of 0.75 corresponds to a latent multiplier of 4/3 or 1.33. SHR of 0.75 for typical split system from page 10 of “Controlling Indoor Humidity Using Variable-Speed Compressors and Blowers” by M. A. Andrade and C. W. Bullard, 1999: www.ideals.illinois.edu/bitstream/handle/2142/11894/TR151.pdf

49% = Portion of reduced waste heat that results in increased heating load[767]

COP_{HEAT} = COP of electric heating system

= actual. If not available use[768]:

System Type	Age of Equipment	HSPF Estimate	COP_{HEAT} (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 2.0 EF heat pump water heater, in a conditioned space in a home with gas space heat and central air conditioning (SEER 10.5) in Belleville:

ΔkWh = [(1 / 0.904 – 1 / 2.0) * 50 * 365.25* 8.33 * (125 – 54)] / 3412 + 185 - 0

= 2100 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh / Hours * CF

Where:

Hours = Full load hours of water heater

= 2533 [769]

CF = Summer Peak Coincidence Factor for measure

= 0.12 [770]

[767] REMRate determined percentage (49%) of lighting savings that result in increased heating loads (lighting is used as a proxy for hot water heating since load shapes suggest their seasonal usage patterns are similar).
[768] 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.
[769] Full load hours assumption based on Efficiency Vermont analysis of Itron eShapes.
[770] Calculated from Figure 8 "Combined six-unit summer weekday average electrical demand" in FEMP study; Field Testing of Pre-Production Prototype Residential Heat Pump Water Heaters http://www1.eere.energy.gov/femp/pdfs/tir_heatpump.pdf as (average kW usage during peak period * hours in peak period) / [(annual kWh savings / FLH) * hours in peak period] = (0.1 kW * 5 hours) / [(2100 kWh / 2533 hours) * 5 hours] = 0.12

For example, a 2.0 COP heat pump water heater, in a conditioned space in a home with gas space heat and central air conditioning in Belleville: kW = 2100 / 2533 * 0.12 = 0.099 kW

NATURAL GAS SAVINGS

ΔTherms = - ((((GPD * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 3412) – (((GPD * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 3412) / $EF_{EFFICIENT}$)) * LF * 49% * 0.03412) / (ηHeat * % Natural Gas)

Where:

ΔTherms = Heating cost from conversion of heat in home to water heat for homes with Natural Gas heat.[771]

0.03412 = conversion factor (therms per kWh)

ηHeat = Efficiency of heating system

= Actual.[772] If not available use 70%.[773]

[771] This is the additional energy consumption required to replace the heat removed from the home during the heating season by the heat pump water heater. kWh_heating (electric resistance) is that additional heating energy for a home with electric resistance heat (COP 1.0). This formula converts the additional heating kWh for an electric resistance home to the MMBtu required in a Natural Gas heated home, applying the relative efficiencies.

[772] 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.

[773] 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

% Natural Gas = Factor dependent on heating fuel:

Heating System	%Natural Gas
Electric resistance or heat pump	0%
Natural Gas	100%
Unknown heating fuel[774]	87%

Other factors as defined above

For example, a 2.0 COP heat pump water heater in conditioned space, in a home with gas space heat (70% system efficiency):

ΔTherms = - (1582.9 * 1 * 0.49 * 0.03412) / 0.7 * 1

= - 35.1 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HWE-HPWH-V01-120601

[774] 2010 American Community Survey.

5.4.4 Low Flow Faucet Aerators

This measure relates to the installation of a low flow faucet aerator in a household kitchen or bath faucet fixture.

This measure may be used for units provided through Efficiency Kit's however the in service rate for such measures should be derived through evaluation results specifically for this implementation methodology.

This measure was developed to be applicable to the following program types: TOS, NC, RF, DI, KITS.
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 low flow 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 greater, or a standard kitchen faucet aerator rated at 2.75 GPM or greater.

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 9 years[775].

Deemed Measure Cost

The incremental cost for this measure is $8[776] or program actual.

For faucet aerators provided in Efficiency Kits, the actual program delivery costs should be utilized.

Deemed O&M Cost Adjustments

N/A

Loadshape

Loadshape R03 - Residential Electric DHW

Coincidence Factor

The coincidence factor for this measure is assumed to be 2.2%[777].

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[775] 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"
[776] 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)
[777] 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[778].

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

Where:

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

DHW fuel	%ElectricDHW
Electric	100%
Natural Gas	0%
Unknown	16%[779]

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

= 1.2[780] or custom based on metering studies[781]

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

= 0.94[782] or custom based on metering studies[783]

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total annual aerator use in peak period is 0.18*65/365 = 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 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

[778] This algorithm calculates the amount of energy saved per aerator by determining the fraction of water consumption savings for the upgraded fixture.

[779] 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

[780] Representative baseline flow rate for kitchen and bathroom faucet aerators from sources 2, 4, 5, and 7 (see source table at end of characterization). 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.

[781] 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.

[782] Average retrofit flow rate for kitchen and bathroom faucet aerators from sources 2, 4, 5, and 7(see source table at end of characterization). 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

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

= if available custom based on metering studies, if not use:

Faucet Type	Relative usage percentage[784]	L_base (min/person/day)
Kitchen	70%	6.90
Bathroom	30%	2.95
If location unknown (total)	100%	9.85[785]

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

= if available custom based on metering studies, if not use:

Faucet Type	Relative usage percentage	L_low (min/person/day)
Kitchen	70%	6.90
Bathroom	30%	2.95
If location unknown (total)	100%	9.85[786]

Household = Average number of people per household

Household Unit Type	Household
Single-Family - Deemed	2.56[787]
Multi-Family - Deemed	2.1[788]

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.

783 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.

784 A robust data source for the relative usage of kitchen v bathroom faucets could not be found. The 70v30% split is based on professional judgment. As per Navigant there is a current study that may allow a recommendation to be made, but that data is not publicly available at this time. This assumption will be revisited when it becomes available.

785 This coincides with the middle of the range (6.74 min/person/day to 13.4 min/person/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/person/day for kitchen faucets and 2.6 min/person/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.

786 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.

787 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 citing 2006-2008 American Community Survey data from the US Census Bureau for Illinois cited on p. 17 of the PY2 Evaluation report. 2.75 * 93% evaluation adjustment

788 Navigant, ComEd PY3 Multi-Family Home Energy Savings Program Evaluation Report Final, May 16, 2012.

Custom	Actual Occupancy or Number of Bedrooms[789]

365.25 = Days in a year, on average.

DF = Drain Factor

Faucet Type	Drain Factor[790]
Kitchen	75%
Bath	90%
Unknown	79.5%

FPH = Faucets Per Household

Faucet Type	FPH
Kitchen Faucets Per Home (KFPH)	1
Bathroom Faucets Per Home (BFPH): Single-Family	2.83[791]
Bathroom Faucets Per Home (BFPH): Multi-Family	1.5[792]
If location unknown (total): Single-Family	3.83
If location unknown (total): Multi-Family	2.5

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

[789] Bedrooms are suitable proxies for household occupancy, and may be preferable to actual occupancy due to turnover rates in residency and non-adult population impacts.
[790] Because faucet usages are at times dictated by volume, only usage of the sort that would go straight down the drain will provide savings. 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.
[791] Based on findings from a 2009 ComEd residential survey of 140 sites, provided by Cadmus.
[792] Ibid.

= 90F [793]

SupplyTemp = Assumed temperature of water entering house

= 54.1F [794]

RE_electric = Recovery efficiency of electric water heater

= 98% [795]

3412 = Converts Btu to kWh (btu/kWh)

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

Selection	ISR
Direct Install - Single Family	0.95[796]
Direct Install – Multi Family Kitchen	0.91[797]
Direct Install – Multi Family Bathroom	0.95[798]
Efficiency Kits	To be determined through evaluation

793 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.

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

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

796 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

797 Navigant, ComEd-Nicor Gas EPY4/GPY1 Multi-Family Home Energy Savings Program Evaluation Report DRAFT 2013-01-28

798 Ibid

For example, a direct installed kitchen low flow faucet aerator in a single-family electric DHW home:

ΔkWh = 1.0 * (((1.2 * 6.90 – 0.94 * 6.90) * 2.56 * 365.25 *0.75) / 1) * 0.0894 * 0.97

= 106.9 kWh

For example, a direct installed bath low flow faucet aerator in a multi-family electric DHW home:

ΔkWh = 1.0 * (((1.2 * 2.95 – 0.94 * 2.95) * 2.1 * 365.25 * 0.90) /1.5) * 0.0894 * 0.95

= 30.0 kWh

For example, a direct installed low flow faucet aerator in unknown faucet in a single-family electric DHW home:

ΔkWh = 1.0 * (((1.2 * 9.85 – 0.94 * 9.85) * 2.56 * 365.25 * 0.795) /3.83) * 0.0894 * 0.95

= 42.2 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh / Hours * CF

Where:

ΔkWh = calculated value above

Hours = Annual electric DHW recovery hours for faucet use per faucet

= ((GPM_base * L_base) * Household/FPH * 365.25 * DF) * 0.545[799] / GPH

Building Type	Faucet location	Calculation	Hours per faucet
Single Family	Kitchen	((1.2 * 6.9) * 2.56/1 * 365.25 * 0.75) * 0.545 / 27.51	115
	Bathroom	((1.2 * 2.95) * 2.56/2.83 * 365.25 * 0.9) * 0.545 / 27.51	21
	Unknown	((1.2 * 9.85) * 2.56/3.83 * 365.25 * 0.795) * 0.545 / 27.51	45

[799] 54.5% is the proportion of hot 120F water mixed with 54.1F supply water to give 90F mixed faucet water.

Multi Family	Kitchen	((1.2 * 6.9) * 2.1/1 * 365.25 * 0.75) * 0.545 / 27.51	94
	Bathroom	((1.2 * 2.95) * 2.1/1.5 * 365.25 * 0.9) * 0.545 / 27.51	32
	Unknown	((1.2 * 9.85) * 2.1/2.5 * 365.25 * 0.795) * 0.545 / 27.51	57

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[800].

For example, a direct installed kitchen low flow faucet aerator in a single family electric DHW home:

ΔkW = 106.9/115 * 0.022

= 0.02kW

NATURAL GAS SAVINGS

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

Where:

%FossilDHW = proportion of water heating supplied by Natural Gas heating

DHW fuel	%Fossil_DHW
Electric	0%
Natural Gas	100%
Unknown	84%[801]

EPG_gas = Energy per gallon of Hot water supplied by gas

800 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 = 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 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

801 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

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

= 0.00399 Therm/gal for SF homes

= 0.00446 Therm/gal for MF homes

RE_gas = Recovery efficiency of gas water heater

= 75% For SF homes[802]

= 67% For MF homes[803]

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

Other variables as defined above.

For example, a direct-installed kitchen low flow faucet aerator in a fuel DHW single-family home:

ΔTherms = 1.0 * (((1.2 * 6.90 – 0.94 * 6.90) * 2.56 * 365.25 *0.75) / 1) * 0.00399 * 0.95

= 4.77 Therms

For example, a direct installed bath low flow faucet aerator in a fuel DHW multi-family home:

ΔTherms = 1.0 * (((1.2 * 2.95 – 0.94 * 2.95) * 2.1 * 365.25 * 0.90) /1.5) * 0.0046 * 0.95

= 1.50 Therms

For example, a direct installed low flow faucet aerator in unknown faucet in a fuel DHW single-family home:

ΔTherms = 1.0 * (((1.2 * 9.85 – 0.94 * 9.85) * 2.56 * 365.25 * 0.795) /3.83) * 0.00399 * 0.95

= 1.88 Therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

Δgallons = ((GPM_base * L_base - GPM_low * L_low) * Household * 365.25 *DF / FPH) * ISR

Variables as defined above

[802] DOE Final Rule discusses Recovery Efficiency with an average around 0.76 for Gas Fired Storage Water heaters and 0.78 for standard efficiency gas fired tankless water heaters up to 0.95 for the highest efficiency gas fired condensing tankless water heaters. These numbers represent the range of new units however, not the range of existing units in stock. 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%.

[803] Water heating in multi-family buildings is often provided by a larger central boiler. This suggests that the average recovery efficiency is somewhere between a typical central boiler efficiency of 0.59 and the 0.75 for single family homes. An average efficiency of 0.67 is used for this analysis as a default for multi-family buildings.

For example, a direct-installed kitchen low flow aerator in a single family home

Δgallons = (((1.2 * 6.9 – 0.94 * 6.9) * 2.56 * 365.25 *0.75) / 1) * 0.95

= 1195 gallons

For example, a direct installed bath low flow faucet aerator in a multi-family home:

Δgallons = 1.0 * (((1.2 * 2.95 – 0.94 * 2.95) * 2.1 * 365.25 * 0.90) /1.5) * 0.95

= 335 gallons

For example, a direct installed low flow faucet aerator in unknown faucet in a single-family home:

Δgallons = 1.0 * (((1.2 * 9.85 – 0.94 * 9.85) * 2.56 * 365.25 * 0.795) /3.83) * 0.95

= 472 gallons

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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: RS-HWE-LFFA-V02-130601

5.4.5 Low Flow Showerheads

DESCRIPTION

This measure relates to the installation of a low flow showerhead in a single or multi-family household.

This measure may be used for units provided through Efficiency Kit's however the in service rate for such measures should be derived through evaluation results specifically for this implementation methodology.

This measure was developed to be applicable to the following program types: TOS, RF, NC, DI, KITS.
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 low flow showerhead rated at 2.0 gallons per minute (GPM) or less. Savings are calculated on a per showerhead fixture basis.

DEFINITION OF BASELINE EQUIPMENT

For Direct-install programs, the baseline condition is assumed to be a standard showerhead rated at 2.5 GPM or greater.

For retrofit and time-of-sale programs, the baseline condition is assumed to be a representative average of existing showerhead flow rates of participating customers including a range of low flow showerheads, standard-flow showerheads, and high-flow showerheads.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 10 years[804].

DEEMED MEASURE COST

The incremental cost for this measure is $12[805] or program actual.

For low flow showerheads provided in Efficiency Kits, the actual program delivery costs should be utilized.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape R03 - Residential Electric DHW

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[804] 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"

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

Coincidence Factor

The coincidence factor for this measure is assumed to be 2.78%[806].

Algorithm

Calculation of Savings

Electric Energy Savings

Note these savings are per showerhead fixture

ΔkWh = %ElectricDHW * ((GPM_base * L_base - GPM_low * L_low) * Household * SPCD * 365.25 / SPH) * EPG_electric * ISR

Where:

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

DHW fuel	%ElectricDHW
Electric	100%
Natural Gas	0%
Unknown	16%[807]

GPM_base = Flow rate of the baseline showerhead

Program	GPM_base
Direct-install	2.67[808]
Retrofit or TOS	2.35[809]

[806] 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, 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

[807] 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

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

[809] Representative value from sources 1, 2, 4, 5, 6 and 7 (See Source Table at end of measure section) adjusted slightly upward to account for program participation which is expected to target customers with existing higher flow devices rather than those with existing low flow devices.

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[810]

L_base = Shower length in minutes with baseline showerhead

= 8.20 min[811]

L_low = Shower length in minutes with low-flow showerhead

= 8.20 min[812]

Household = Average number of people per household

Household Unit Type[813]	Household
Single-Family - Deemed	2.56[814]
Multi-Family - Deemed	2.1[815]
Custom	Actual Occupancy or Number of Bedrooms[816]

SPCD = Showers Per Capita Per Day

= 0.75[817]

365.25 = Days per year, on average.

[810] 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.

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

[812] Set equal to L_base.

[813] If household type is unknown, as may be the case for time of sale measures, then single family deemed value shall be used.

[814] 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 citing 2006-2008 American Community Survey data from the US Census Bureau for Illinois cited on p. 17 of the PY2 Evaluation report. 2.75 * 93% evaluation adjustment

[815] ComEd PY3 Multi-Family Evaluation Report REVISED DRAFT v5 2011-12-08.docx

[816] Bedrooms are suitable proxies for household occupancy, and may be preferable to actual occupancy due to turnover rates in residency and non-adult population impacts.

[817] Source ID 3

SPH = Showerheads Per Household so that per-showerhead savings fractions can be determined

Household Type	SPH
Single-Family	1.79[818]
Multi-Family	1.3[819]
Custom	Actual

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 [820]

SupplyTemp = Assumed temperature of water entering house

= 54.1F [821]

RE_electric = Recovery efficiency of electric water heater

= 98% [822]

3412 = Converts Btu to kWh (btu/kWh)

ISR = In service rate of showerhead

= Dependant on program delivery method as listed in table below

[818] Based on findings from a 2009 ComEd residential survey of 140 sites, provided by Cadmus.
[819] Ibid.
[820] 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
[821] US DOE Building America Program. Building America Analysis Spreadsheet. For Chicago, IL http://www1.eere.energy.gov/buildings/building_america/analysis_spreadsheets.html.
[822] Electric water heater have recovery efficiency of 98%: http://www.ahrinet.org/ARI/util/showdoc.aspx?doc=576

Selection	ISR
Direct Install - Single Family	0.98[823]
Direct Install – Multi Family	0.93[824]
Efficiency Kits	To be determined through evaluation

For example, a direct-installed 1.5 GPM low flow showerhead in a single family home with electric DHW where the number of showers is not known:

ΔkWh = 1.0 * ((2.67 * 8.2 – 1.5 * 8.2) * 2.56 * 0.75 * 365.25 / 1.79) * 0.127 * 0.98

= 468 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) * Household * SPCD * 365.25) * 0.773[825] / GPH

= 431 for SF Direct Install; 354 for MF Direct Install

= 380 for SF Retrofit and TOS; 311 for MF Retrofit and TOS

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[826]

[823] 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.
[824] Navigant, ComEd-Nicor Gas EPY4/GPY1 Multi-Family Home Energy Savings Program Evaluation Report DRAFT 2013-01-28
[825] 77.3% is the proportion of hot 120F water mixed with 54.1F supply water to give 105F shower water.
[826] 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

For example, a direct installed 1.5 GPM low flow showerhead in a single family home with electric DHW where the number of showers is not known:

ΔkW = 468/431 * 0.0278

= 0.030 kW

NATURAL GAS SAVINGS

ΔTherms = %FossilDHW * ((GPM_base * L_base - GPM_low * L_low) * Household * SPCD * 365.25 / SPH) * EPG_gas * ISR

Where:

%FossilDHW = proportion of water heating supplied by Natural Gas heating

DHW fuel	%Fossil_DHW
Electric	0%
Natural Gas	100%
Unknown	84%[827]

EPG_gas = Energy per gallon of Hot water supplied by gas

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

= 0.0054 Therm/gal for SF homes

= 0.0063 Therm/gal for MF homes

RE_gas = Recovery efficiency of gas water heater

= 78% For SF homes[828]

= 67% For MF homes[829]

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

[827] 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

[828] DOE Final Rule discusses Recovery Efficiency with an average around 0.76 for Gas Fired Storage Water heaters and 0.78 for standard efficiency gas fired tankless water heaters up to 0.95 for the highest efficiency gas fired condensing tankless water heaters. These numbers represent the range of new units however, not the range of existing units in stock. 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 78%.

[829] Water heating in multi-family buildings is often provided by a larger central boiler. This suggests that the

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

Other variables as defined above.

For example, a direct installed 1.5 GPM low flow showerhead in a gas fired DHW single family home where the number of showers is not known:

ΔTherms = 1.0 * ((2.67 * 8.2 – 1.5 * 8.2) * 2.56 * 0.75 * 365.25 / 1.79) * 0.0054 * 0.98

= 19.9 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

Δgallons = ((GPM_base * L_base - GPM_low * L_low) * Household * SPCD * 365.25 / SPH) * ISR

Variables as defined above

For example, a direct installed 1.5 GPM low flow showerhead where the number of showers is not known:

Δgallons = ((2.67 * 8.2 – 1.5 * 8.2) * 2.56 * 0.75 * 365.25 / 1.79) * 0.98

= 3438 gallons

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

average recovery efficiency is somewhere between a typical central boiler efficiency of 0.59 and the 0.75 for single family homes. An average efficiency of 0.67 is used for this analysis as a default for multi-family buildings.

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: RS-HWE-LFSH-V02-130601

5.4.6 Water Heater Temperature Setback

Description

The thermostat setting of a hot water tank is lowered to 120 degrees. The savings are from the Connecticut TRM which considers that for some draws, the hot water flow will be increased to make up for the lower temperature, and that additional dishwasher's supplemental heating will be required.

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

Definition of Efficient Equipment

High efficiency is a hot water tank with the thermostat set at 120 degrees.

Definition of Baseline Equipment

The baseline condition is a hot water tank with a thermostat setting that is higher than 120 degrees, typically systems with settings of 130 degrees or higher, this analysis assumes a 15 degree setback. Note if there are more than one DHW tanks in the home at or higher than 130 degrees and they are all turned down, then the savings per tank can be multiplied by the number of tanks.

Deemed Lifetime of Efficient Equipment

The assumed lifetime of the measure is 2 years.

Deemed Measure Cost

The incremental cost of a setback is assumed to be $5 for contractor time.

Deemed O&M Cost Adjustments

N/A

Loadshape

Loadshape R03 - Residential Electric DHW

Coincidence Factor

The summer peak coincidence factor for this measure is assumed to be 1.

Algorithm

Calculation of Savings

Electric Energy Savings

For homes with electric DHW tanks:

ΔkWh = 86.4 kWh [830]

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW **=** ΔkWh / Hours * CF

Where:

Hours = 8766

CF = Summer Peak Coincidence Factor for measure

= 1

ΔkW = 86.4 / 8766 * 1

= 0.00986 kW

NATURAL GAS SAVINGS

For homes with gas water heaters:

ΔTherms = 6.4 therms [831]

ΔkWh = -34.2 kWh [832]

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HWE-TMPS-V02-130601

[830] All savings estimates are based on UL and CLP Program Savings Documentation, 2010. This is the net savings after taking into account increased use of dishwasher's supplemental heating. http://neep.org/uploads/EMV%20Forum/EMV%20Studies/CT-UI_CLP_2010_PSD.pdf

[831] All savings estimates are based on UL and CLP Program Savings Documentation, 2010. The Δtherms are the gross savings for a gas heater. http://neep.org/uploads/EMV%20Forum/EMV%20Studies/CT-UI_CLP_2010_PSD.pdf

[832] The ΔkWh accounts for the increased use of dishwasher's supplemental heating.

5.4.7 Water Heater Wrap

DESCRIPTION

This measure relates to a Tank Wrap or insulation "blanket" that is wrapped around the outside of a hot water tank to reduce stand-by losses. This measure applies only for homes that have an electric water heater that is not already well insulated. Generally this can be determined based upon the appearance of the tank.[833]

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

DEFINITION OF EFFICIENT EQUIPMENT

The measure is a properly installed, R-8 or greater insulating tank wrap to reduce standby energy losses from the tank to the surrounding ambient area.

DEFINITION OF BASELINE EQUIPMENT

The baseline is a standard electric domestic hot water tank without an additional tank wrap. Gas storage water heaters are excluded due to the limitations of retrofit wrapping and the associated impacts on reduced savings and safety.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life is assumed to be 5 years[834].

DEEMED MEASURE COST

The incremental cost for this measure will be the actual material cost of procuring and labor cost of installing the tank wrap.

DEEMED O&M COST ADJUSTMENTS

N/A

LOADSHAPE

Loadshape R03 - Residential Electric DHW

COINCIDENCE FACTOR

This measure assumes a flat loadshape and as such the coincidence factor is 1.

Algorithm

[833] Visually determine whether it is insulated by foam (newer, rigid, and more effective) or fiberglass (older, gives to gently pressure, and not as effective)
[834] This estimate assumes the tank wrap is installed on an existing unit with 5 years remaining life.

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

For electric DHW systems:

$$\Delta kWh = ((U_{base}A_{base} - U_{insul}A_{insul}) * \Delta T * Hours) / (3.412 * \eta DHW)$$

Where:

U_{base} = Overall heat transfer coefficient prior to adding tank wrap (Btu/Hr-F-ft2).

U_{insul} = Overall heat transfer coefficient after addition of tank wrap (Btu/Hr-F-ft2).

A_{base} = Surface area of storage tank prior to adding tank wrap (square feet)[835]

A_{insul} = Surface area of storage tank after addition of tank wrap (square feet)[836]

ΔT = Average temperature difference between tank water and outside air temperature (°F)

= 60°F [837]

Hours = Number of hours in a year (since savings are assumed to be constant over year).

= 8766

3412 = Conversion from BTU to kWh

ηDHW = Recovery efficiency of electric hot water heater

= 0.98 [838]

[835] Area includes tank sides and top to account for typical wrap coverage.
[836] Ibid.
[837] Assumes 125°F water leaving the hot water tank and average temperature of basement of 65°F.
[838] Electric water heater have recovery efficiency of 98%: http://www.ahrinet.org/ARI/util/showdoc.aspx?doc=576

The following table has default savings for various tank capacity and pre and post R-VALUES.

Capacity (gal)	Rbase	Rinsul	Abase (ft2)[839]	Ainsul (ft2)[840]	ΔkWh	ΔkW
30	8	16	19.16	20.94	171	0.0195
30	10	18	19.16	20.94	118	0.0135
30	12	20	19.16	20.94	86	0.0099
30	8	18	19.16	20.94	194	0.0221
30	10	20	19.16	20.94	137	0.0156
30	12	22	19.16	20.94	101	0.0116
40	8	16	23.18	25.31	207	0.0236
40	10	18	23.18	25.31	143	0.0164
40	12	20	23.18	25.31	105	0.0120
40	8	18	23.18	25.31	234	0.0268
40	10	20	23.18	25.31	165	0.0189
40	12	22	23.18	25.31	123	0.0140
50	8	16	24.99	27.06	225	0.0257
50	10	18	24.99	27.06	157	0.0179
50	12	20	24.99	27.06	115	0.0131
50	8	18	24.99	27.06	255	0.0291
50	10	20	24.99	27.06	180	0.0206
50	12	22	24.99	27.06	134	0.0153
80	8	16	31.84	34.14	290	0.0331
80	10	18	31.84	34.14	202	0.0231
80	12	20	31.84	34.14	149	0.0170
80	8	18	31.84	34.14	328	0.0374
80	10	20	31.84	34.14	232	0.0265
80	12	22	31.84	34.14	173	0.0198

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh / 8766 * CF

Where:

ΔkWh = kWh savings from tank wrap installation

8766 = Number of hours in a year (since savings are assumed to be constant over year).

CF = Summer Coincidence Factor for this measure

= 1.0

The table above has default kW savings for various tank capacity and pre and post R-values.

[839] Assumptions from PA TRM. Area values were calculated from average dimensions of several commercially available units, with radius values measured to the center of the insulation. Area includes tank sides and top to account for typical wrap coverage.

[840] Assumptions from PA TRM. A_{insul} was calculated by assuming that the water heater wrap is a 2" thick fiberglass material.

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HWE-WRAP-V01-120601

5.5 Lighting End Use

5.5.1 ENERGY STAR Compact Fluorescent Lamp (CFL)

DESCRIPTION

A low wattage ENERGY STAR qualified compact fluorescent screw-in bulb (CFL) is installed in place of a baseline screw-in bulb.

This characterization assumes that the CFL is installed in a residential location. If the implementation strategy does not allow for the installation location to be known (e.g. an upstream retail program), a deemed split of 96% Residential and 4% Commercial assumptions should be used[841].

Federal legislation stemming from the Energy Independence and Security Act of 2007 (EISA) will require all general-purpose light bulbs between 40W and 100W to be approximately 30% more energy efficient than current incandescent bulbs. Production of 100W, standard efficacy incandescent lamps ended 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 the 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 60W 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, DI, KITS. If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the high-efficiency equipment must be a standard ENERGY STAR qualified compact fluorescent lamp.

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is assumed to be a standard incandescent light bulb, up until when EISA regulations dictate higher efficiency baseline bulbs. A 100W baseline bulb becomes a 72W bulb in June 2012, a 75W bulb

[841] RES v C&I split is based on a weighted (by sales volume) average of ComEd PY3 and PY4 and Ameren PY5 in store intercept survey results.

becomes 53W in June 2013 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

Residential, Multi Family In unit bulbs and Unknown: The expected measure life (number of years that savings should be claimed) for bulbs installed June 2012 – May 2015 is assumed to be 5.2 years[842]. For bulbs installed June 2015 – May 2016, this would be reduced to 5 years and then for every subsequent year should be reduced by one year[843].

Multi Family Common area bulbs: The expected measure life is 1.7 years[844] for bulbs installed June 2012 –May 2017.

Exterior bulbs: The expected measure life is 4.4 years[845] for bulbs installed June 2012 – May 2015. For bulbs installed June 2016-May 2017 this would be reduced to 4 years.

DEEMED MEASURE COST

For the Retail (Time of Sale) measure, the incremental capital cost is $1.90, from June 2012 – May 2013, $1.80 from June 2013 – May 2014 and $1.50 from June 2014 – May 2015[846].

For the Direct Install measure, the full cost of $2.50 per bulb should be used, plus $5 labor cost[847] for a total of $7.50 per bulb. However actual program delivery costs should be utilized if available.

For bulbs provided in Efficiency Kits, the actual program delivery costs should be utilized.

DEEMED O&M COST ADJUSTMENTS

For those bulbs not impacted by EISA (25W incandescent equivalents), a simple O&M impact should be calculated based on baseline replacement cost of $0.50 and a lifetime of 1.07 years for Residential Interior and In-unit Multi Family, 0.17 years for Multi Family common area, 0.55years for Exterior and 1.0 year for Unknown location[848]. For bulbs impacted by EISA, an annualized baseline replacement cost is provided below

Residential Interior, in-unit Multi Family and Unknown:

[842] Jump et al 2008: "Welcome to the Dark Side: The Effect of Switching on CFL Measure Life" indicates that the "observed life" of CFLs with an average rated life of 8000 hours (8000 hours is the average rated life of ENERGY STAR bulbs (http://www.energystar.gov/index.cfm?c=cfls.pr_crit_cfls) is 5.2 years.

[843] Since the replacement baseline bulb from 2020 on will be equivalent to a CFL, no additional savings should be claimed from that point. 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.

[844] Based on using 10,000 hour rated life assumption since significantly less switching with higher use. 10,000/5950 = 1.7years.

[845] Based on using 8,000 hour rated life assumption since more switching and use ourdoors. 8,000/1825 = 4.4years

[846] Based on Northeast Regional Residential Lighting Strategy (RLS) report, prepared by EFG, D&R International, Ecova and Optimal Energy, applying sales weighting and phase-in of EISA regulations. Assumption is $2.50 for CFL over three years and $0.6 for baseline in 2012, $0.70 in 2013 and $1.00 in 2014 as more expensive EISA qualified bulbs become baseline.

[847] Based on 15 minutes at $20 an hour. Includes some portion of travel time to site.

[848] Lamp life calculated by dividing 1000 hour rated life with hours of use.

The Net Present Value of the baseline replacement costs for each CFL lumen range and installation year (2012 - 2017) are presented below[849]:

Lumen Range	NPV of baseline replacement costs				
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015	June 2015 - May 2016	June 2016 - May 2017
1490-2600	$5.41	$5.41	$5.41	$5.18	$3.99
1050-1489	$5.41	$5.41	$5.41	$5.18	$3.99
750-1049	$4.48	$5.41	$5.41	$5.18	$3.99
310-749	$4.48	$5.41	$5.41	$5.18	$3.99

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				
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015	June 2015 - May 2016	June 2016 - May 2017
1490-2600	$1.22	$1.22	$1.22	$1.16	$0.90
1050-1489	$1.22	$1.22	$1.22	$1.16	$0.90
750-1049	$1.01	$1.22	$1.22	$1.16	$0.90
310-749	$1.01	$1.22	$1.22	$1.16	$0.90

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 baseline replacement costs		
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2017
1490-2600	$13.09	$13.09	$13.09
1050-1489	$8.24	$13.09	$13.09
750-1049	$4.36	$8.24	$13.09
310-749	$4.36	$8.24	$13.09

849 See 'RES Standard CFL O&M calc.xls' for more details.

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		
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2017
1490-2600	$8.34	$8.34	$8.34
1050-1489	$5.25	$8.34	$8.34
750-1049	$2.78	$5.25	$8.34
310-749	$2.78	$5.25	$8.34

Exterior:

The Net Present Value of the baseline replacement costs for each CFL lumen range and installation year (2012 - 2017) are presented below:

Lumen Range	NPV of baseline replacement costs				
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015	June 2015 - May 2016	June 2016 - May 2017
1490-2600	$9.36	$9.36	$9.36	$9.36	$8.49
1050-1489	$8.55	$9.36	$9.36	$9.36	$8.49
750-1049	$6.85	$8.55	$9.36	$9.36	$8.49
310-749	$6.85	$8.55	$9.36	$9.36	$8.49

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				
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015	June 2015 - May 2016	June 2016 - May 2017
1490-2600	$2.45	$2.45	$2.45	$2.45	$2.22
1050-1489	$2.23	$2.45	$2.45	$2.45	$2.22
750-1049	$1.79	$2.23	$2.45	$2.45	$2.22
310-749	$1.79	$2.23	$2.45	$2.45	$2.22

LOADSHAPE

Loadshape R06 - Residential Indoor Lighting
Loadshape R07 - Residential Outdoor Lighting
Loadshape C06 - Commercial Indoor Lighting[850]

[850] For Multi Family common area lighting.

Coincidence Factor

The summer peak coincidence factor is assumed to be 9.5%[851] for Residential and in-unit Multi Family bulbs and 75%[852] for Multi Family common area bulbs.

Algorithm

Calculation of Savings

Electric Energy Savings

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

Where:

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

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
250	309	25	25	n/a

WattsEE = Actual wattage of CFL purchased / installed

ISR = In Service Rate, the percentage of units rebated that are actually in service.

851 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

852 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.

Program	Weighted Average 1st year In Service Rate (ISR)	2nd year Installations	3rd year Installations	Final Lifetime In Service Rate
Retail (Time of Sale) or Efficiency Kits	69.5%[853]	15.4%	13.1%	98.0%[854]
Direct Install	96.9%[855]			

Hours = Average hours of use per year

Installation Location	Hours
Residential and in-unit Multi Family	938 [856]
Multi Family Common Areas	5,950 [857]
Exterior	1,825 [858]
Unknown	1,000 [859]

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 [860]

[853] 1st year in service rate is based upon review of PY1-3 evaluations from ComEd and Ameren (see 'IL RES Lighting ISR.xls' for more information. The average first year ISR for each utility was calculated weighted by the number of bulbs in the each year's survey. This was then weighted by annual sales to give a statewide assumption.

[854] The 98% Lifetime ISR assumption is 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.

[855] Based upon review of the PY2 and PY3 ComEd Direct Install program surveys. This value includes bulb failures in the 1st year to be consistent with the Commission approval of annualization of savings for first year savings claims. ComEd PY2 All Electric Single Family Home Energy Performance Tune-Up Program Evaluation, Navigant Consulting, December 21, 2010. http://www.icc.illinois.gov/downloads/public/edocket/287090.pdf.

[856] Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation. http://www.icc.illinois.gov/downloads/public/edocket/323818.pdf

[857] 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.

[858] Based on secondary research conducted as part of the PY3 ComEd Residential Lighting Program evaluation. http://www.icc.illinois.gov/downloads/public/edocket/323818.pdf

[859] Assumes 7% exterior lighting, based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation. http://www.icc.illinois.gov/downloads/public/edocket/323818.pdf

[860] 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

Multi family in unit	1.04 [861]
Multi family common area	1.04 [862]
Exterior or uncooled location	1.0

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 14W CFL (60W standard incandescent and 43W EISA qualified incandescent/halogen) purchased in 2013.

$\Delta kWH_{1st\ year\ installs}$ = ((60 - 14) / 1000) * 0.695 * 1000 * 1.06

= 33.9 kWh

$\Delta kWH_{2nd\ year\ installs}$ = ((43 - 14) / 1000) * 0.154 * 1000 * 1.06

= 4.7 kWh

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

$\Delta kWH_{3rd\ year\ installs}$ = ((43 - 14) / 1000) * 0.131 * 1000 * 1.06

= 4.0 kWh

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)

[861] 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

[862] Ibid.

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 in cost-effectiveness analysis.

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 14W standard CFL purchased and *installed* during the June 2013 – May 2014 program year (i.e. for this example we are ignoring the ISR):

First Year savings:

$\Delta kWH_{1st\ year}$ = ((60 - 14) / 1000) * 1000 * 1.06

= 48.8 kWh

This value should be claimed in June 2013 – May 2014. However after one year the baseline bulb would need to be replaced. For the purpose of cost-effectiveness analysis, from June 2014 the baseline 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 bulb after 1st replacement:

$\Delta kWH_{remaining\ years}$ = ((43 - 14) / 1000) * 1000 * 1.06

= 30.7 kWh

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

= 48.8 * 0.63

= 30.7 kWh

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

Example showing both deferred bulb installs and mid life adjustment.

A 14W standard CFL is *purchased* during the June 2013 – May 2014 program year:

First year savings:

$\Delta kWH_{1st\ year\ installs}$ = ((60 - 14) / 1000) * 0.695 * 1000 * 1.06

= 33.9 kWh

Second year savings:

$\Delta kWH_{1st\ year\ installs}$ = 33.9 * 0.63

= 21.4 kWh

Plus second year installs:

$\Delta kWH_{2nd\ year\ installs}$ = ((43 - 14) / 1000) * 0.154 * 1000 * 1.06

= 4.7 kWh

ΔkWH_{Total} = 21.4 + 4.7 = 26.1 kWh

Third year savings:

$\Delta kWH_{1st\ year\ installs}$ = 21.4 kWh

$\Delta kWH_{2nd\ year\ installs}$ = 4.7 kWh

$\Delta kWH_{3rd\ year\ installs}$ = ((43 - 14) / 1000) * 0.131 * 1000 * 1.06

= 4.0 kWh

ΔkWH_{Total} = 21.4 + 4.7 + 4.0 = 30.1 kWh

Note the measure life for each year's install would begin on the year the lamp is installed (noting the backstop provision of 2020).

HEATING PENALTY

If electric heated home (if heating fuel is unknown assume gas, see Natural Gas section):

ΔkWh[863] = - (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF) / ηHeat

Where:

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

= 49%[864] for interior or unknown location

= 0% for exterior or unheated location

ηHeat = Efficiency in COP of Heating equipment

= actual. If not available use[865]:

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 14W standard CFL is purchased in 2013 and installed in home with 2.0 COP Heat Pump:

$\Delta kWh_{1st\ year}$ = - (((60 - 14) / 1000) * 0.695 * 938 * 0.49) / 2.0

= - 7.3 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:

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

[863] Negative value because this is an increase in heating consumption due to the efficient lighting.
[864] 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.
[865] 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.

lighting.

Bulb Location	WHFd
Interior single family or unknown location	1.11[866]
Multi family in unit	1.07[867]
Multi family common area	1.07 [868]
Exterior or uncooled location	1.0

CF = Summer Peak Coincidence Factor for measure.

Bulb Location	CF
Interior single family or unknown location	9.5% [869]
Multi family in unit	9.5% [870]
Multi family common area	75% [871]

Other factors as defined above

For example, a 14W standard CFL is purchased and installed in a single family interior location in 2012:

ΔkW = ((60 - 14) / 1000) * 0.695 * 1.11 * 0.095

= 0.003 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

Heating Penalty if Natural Gas heated home (or if heating fuel is unknown):

866 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.

867 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.

868 Ibid

869 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

870 Ibid.

871 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.

ΔTherms[872] = - (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF * 0.03412) / ηHeat

Where:

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

= 49%[873] for interior or unknown location

= 0% for exterior or unheated location

0.03412 =Converts kWh to Therms

ηHeat = Efficiency of heating system

=70%[874]

For example, a14 standard CFL is purchased and installed in a home in 2012:

ΔTherms = - (((60 - 14) / 1000) * 0.695 * 938 * 0.49 * 0.03412) / 0.7

= - 0.72 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

For those bulbs not impacted by EISA (25W incandescent equivalents), a simple O&M impact should be calculated based on baseline replacement cost of $0.50 and a lifetime of 1.07years for Residential Interior and In-unit Multi

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

[873] 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.

[874] 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

Family, 0.17years for Multi Family common area, 0.55years for Exterior and 1.0 year for Unknown location[875].

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 Standard CFL O&M calc.xls). The key assumptions used in this calculation are documented below:

	Standard Incandescent	EISA qualified Incandescent/Halogen
Replacement Cost	$0.50	$1.50
Component Rated Life (hrs)	1000	1000[876]

Residential, in-unit Multi Family and Unknown:

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 baseline replacement costs		
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015
1490-2600	$5.41	$5.41	$5.41
1050-1489	$5.41	$5.41	$5.41
750-1049	$4.48	$5.41	$5.41
310-749	$4.48	$5.41	$5.41

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		
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015
1490-2600	$1.22	$1.22	$1.22
1050-1489	$1.22	$1.22	$1.22
750-1049	$1.01	$1.22	$1.22
310-749	$1.01	$1.22	$1.22

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:

[875] Lamp life calculated by dividing 1000 hour rated life with hours of use.
[876] 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.

Lumen Range	NPV of baseline replacement costs		
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015
1490-2600	$13.09	$13.09	$13.09
1050-1489	$8.24	$13.09	$13.09
750-1049	$4.36	$8.24	$13.09
310-749	$4.36	$8.24	$13.09

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		
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015
1490-2600	$8.34	$8.34	$8.34
1050-1489	$5.25	$8.34	$8.34
750-1049	$2.78	$5.25	$8.34
310-749	$2.78	$5.25	$8.34

Exterior:

The Net Present Value of the baseline replacement costs for each CFL lumen range and installation year (2012 - 2017) are presented below:

Lumen Range	NPV of baseline replacement costs				
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015	June 2015 - May 2016	June 2016 - May 2017
1490-2600	$9.36	$9.36	$9.36	$9.36	$8.49
1050-1489	$8.55	$9.36	$9.36	$9.36	$8.49
750-1049	$6.85	$8.55	$9.36	$9.36	$8.49
310-749	$6.85	$8.55	$9.36	$9.36	$8.49

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				
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015	June 2015 - May 2016	June 2016 - May 2017
1490-2600	$2.45	$2.45	$2.45	$2.45	$2.22
1050-1489	$2.23	$2.45	$2.45	$2.45	$2.22
750-1049	$1.79	$2.23	$2.45	$2.45	$2.22
310-749	$1.79	$2.23	$2.45	$2.45	$2.22

MEASURE CODE: RS-LTG-ESCF-V02-130601

5.5.2 ENERGY STAR Specialty Compact Fluorescent Lamp (CFL)

Description

An ENERGY STAR qualified specialty compact fluorescent bulb is installed in place of an incandescent specialty bulb.

This characterization assumes that the specialty CFL is installed in a residential location. If the implementation strategy does not allow for the installation location to be known (e.g. an upstream retail program) a deemed split of 96% Residential and 4% Commercial assumptions should be used[877].

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

Definition of Efficient Equipment

Energy Star qualified specialty CFL bulb based upon the draft ENERGY STAR specification for lamps (http://energystar.gov/products/specs/sites/products/files/ENERGY_STAR_Lamps_V1_0_Draft%203.pdf).

Definition of Baseline Equipment

The baseline is a specialty incandescent light bulb including those exempt of the EISA 2007 standard: three-way, plant light, daylight bulb, bug light, post light, globes G40 (<40W), candelabra base (<60W), vibration service bulb, decorative candle with medium or intermediate base (<40W), shatter resistant and reflector bulbs and standard bulbs greater than 2601 lumens, and those non-exempt from EISA 2007: dimmable, globes (less than 5" diameter and >40W), candle (shapes B, BA, CA >40W, candelabra base lamps (>60W) and intermediate base lamps (>40W)..

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 6.8 year[878].

Multi Family Common area bulbs: The expected measure life is 1.7 years[879] for bulbs installed June 2012 –May 2017.

Exterior bulbs: The expected measure life is 4.4 years[880] for bulbs installed June 2012 – May 2015. For bulbs installed June 2016-May 2017 this would be reduced to 4 years.

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[877] RES v C&I split is based on a weighted (by sales volume) average of ComEd PY3 and PY4 and Ameren PY5 in store intercept survey results.

[878] The assumed measure life for the specialty bulb measure characterization was reported in "Residential Lighting Measure Life Study", Nexus Market Research, June 4, 2008 (measure life for markdown bulbs). Measure life estimate does not distinguish between equipment life and measure persistence. Measure life includes products that were installed and operated until failure (i.e., equipment life) as well as those that were retired early and permanently removed from service for any reason, be it early failure, breakage, or the respondent not liking the product (i.e., measure persistence).

[879] Based on using 10,000 hour rated life assumption since significantly less switching with higher use. 10,000/5950 = 1.7years.

[880] Based on using 8,000 hour rated life assumption since more switching and use ourdoors. 8,000/1825 = 4.4years

DEEMED MEASURE COST

For the Retail (Time of Sale) measure, the incremental capital cost for this measure is $5[881].

For the Direct Install measure, the full cost of $8.50 should be used plus $5 labor[882] for a total of $13.50. However actual program delivery costs should be utilized if available.

For bulbs provided in Efficiency Kits, the actual program delivery costs should be utilized..

DEEMED O&M COST ADJUSTMENTS

For those bulbs types exempt from EISA the following O&M assumptions should be used: Life of the baseline bulb is assumed to be 1.07 year[883]; baseline replacement cost is assumed to be $3.5[884].

For non-exempt EISA bulb types defined above, the following baseline replacement costs (NPV and annual levelized equivalent payment) for each CFL lumen range and installation year and using the statewide real discount rate of 5.23% are presented below:

The Net Present Value of the baseline replacement costs[885]:

Lumen Range	NPV of baseline replacement costs				
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015	June 2015 - May 2016	June 2016 - May 2017
1490-2600	$23.97	$23.97	$21.08	$17.28	$13.29
1050-1489	$23.97	$23.97	$21.08	$17.28	$13.29
750-1049	$22.57	$23.97	$21.08	$17.28	$13.29
310-749	$22.57	$23.97	$21.08	$17.28	$13.29

The annual levelized baseline replacement costs:

Lumen Range	Levelized annual replacement cost savings				
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015	June 2015 - May 2016	June 2016 - May 2017
1490-2600	$4.28	$4.28	$3.76	$3.09	$2.37
1050-1489	$4.28	$4.28	$3.76	$3.09	$2.37
750-1049	$4.03	$4.28	$3.76	$3.09	$2.37
310-749	$4.03	$4.28	$3.76	$3.09	$2.37

[881] NEEP Residential Lighting Survey, 2011
[882] Based on 15 minutes at $20 per hour.
[883] Assuming 1000 hour rated life for incandescent bulb: 1000/938 = 1.07
[884] NEEP Residential Lighting Survey, 2011
[885] See 'RES Specialty CFL O&M calc.xls' for more details.

LOADSHAPE

Loadshape R06 - Residential Indoor Lighting

Loadshape R07 - Residential Outdoor Lighting

Loadshape C06 - Commercial Indoor Lighting[886]

COINCIDENCE FACTOR

Unlike standard CFLs that could be installed in any room, certain types of specialty CFLs are more likely to be found in specific rooms, which affects the coincident peak factor. Coincidence factors by bulb types are presented below[887]

Bulb Type	Peak CF
Three-way	0.081
Dimmable	0.081
Interior reflector (incl. dimmable)	0.095
Exterior reflector	0.184
Candelabra base and candle medium and intermediate base	0.122
Bug light	0.184
Post light (>100W)	0.184
Daylight	0.095
Plant light	0.095
Globe	0.116
Vibration or shatterproof	0.095
Standard spirals >= 2601 lumens	0.095
Specialty - Generic	0.095

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

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

Where:

WattsBase = Actual wattage equivalent of incandescent specialty bulb, use the tables below to obtain the incandescent bulb equivalent wattage[888]; use 60W if unknown[889]

[886] For Multi Family common area lighting.

[887] Lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation, results were used to calculate the average coincident peak factor in the rooms where the specialty bulbs are most likely to be installed. http://www.icc.illinois.gov/downloads/public/edocket/303834.pdf

[888] Based upon the draft ENERGY STAR specification for lamps (http://energystar.gov/products/specs/sites/products/files/ENERGY_STAR_Lamps_V1_0_Draft%203.pdf) and the

EISA exempt bulb types:

Bulb Type	Lower Lumen Range	Upper Lumen Range	WattsBase
Standard Spirals >=2601	2601	2999	150
	3000	5279	200
	5280	6209	300
3-Way	250	449	25
	450	799	40
	800	1099	60
	1100	1599	75
	1600	1999	100
	2000	2549	125
	2550	2999	150
Globe (medium and intermediate bases less than 750 lumens)	90	179	10
	180	249	15
	250	349	25
	350	749	40
Decorative (Shapes B, BA, C, CA, DC, F, G, medium and intermediate bases less than 750 lumens)	70	89	10
	90	149	15
	150	299	25
	300	749	40
Globe (candelabra bases less than 1050 lumens)	90	179	10
	180	249	15
	250	349	25
	350	499	40
	500	1049	60
Decorative (Shapes B, BA, C, CA, DC, F, G, candelabra bases less than 1050 lumens)	70	89	10
	90	149	15
	150	299	25
	300	499	40
	500	1049	60
Reflector with medium screw bases w/ diameter <=2.25"	400	449	40
	450	499	45
	500	649	50
	650	1199	65
R, PAR, ER, BR, BPAR or similar bulb	640	739	40

Energy Policy and Conservation Act of 2012.

[889] A 2006-2008 California Upstream Lighting Evaluation found an average incandescent wattage of 61.7 Watts (KEMA, Inc, The Cadmus Group, Itron, Inc, PA Consulting Group, Jai J. Mitchell Analytics, Draft Evaluation Report: Upstream Lighting Program. Prepared for the California Public Utilities Commission, Energy Division. December 10, 2009)

shapes with medium screw bases w/ diameter >2.5" (*see exceptions below)	740	849	45
	850	1179	50
	1180	1419	65
	1420	1789	75
	1790	2049	90
	2050	2579	100
	2580	3429	120
	3430	4270	150
R, PAR, ER, BR, BPAR or similar bulb shapes with medium screw bases w/ diameter > 2.26'' and ≤ 2.5" (*see exceptions below)	540	629	40
	630	719	45
	720	999	50
	1000	1199	65
	1200	1519	75
	1520	1729	90
	1730	2189	100
	2190	2899	120
	2900	3850	150
***ER30, BR30, BR40, or ER40**	400	449	40
	450	499	45
	500	649-1179[890]	50
***BR30, BR40, or ER40**	650	1419	65
***R20**	400	449	40
	450	719	45
***All reflector lamps below lumen ranges specified above**	200	299	20
	300	399-639[891]	30

EISA non-exempt bulb types:

Bulb Type	Lower Lumen Range	Upper Lumen Range	Incandescent Equivalent Pre-EISA 2007 (WattsBase)	Incandescent Equivalent Post-EISA 2007 (WattsBase)	Effective date from which Post – EISA 2007 assumption should be used
Dimmable Twist, Globe (less than 5" in diameter and > 749 lumens), candle (shapes B, BA, CA > 749 lumens), Candelabra Base Lamps (>1049 lumens), Intermediate Base Lamps (>749 lumens)	310	749	40	29	Jan-14
	750	1049	60	43	Jan-14
	1050	1489	75	53	Jan-13
	1490	2600	100	72	Jan-12

[890] The upper bounds for these categories depends on the lower bound of the next higher wattage, which varies by bulb type.
[891] As above.

WattsEE = Actual wattage of energy efficient specialty bulb purchased, use 15W if unknown[892]

ISR = In Service Rate, the percentage of units rebated that are actually in service.

Program	Weighted Average 1st year In Service Rate (ISR)	2nd year Installations	3rd year Installations	Final Lifetime In Service Rate
Retail (Time of Sale) or Efficiency Kits	79.5%[893]	10.0%	8.5%	98.0%[894]
Direct Install	96.9%[895]			

Hours = Average hours of use per year, varies by bulb type as presented below:[896]

Bulb Type	Annual hours of use (HOU)
Three-way	897
Dimmable	897
Interior reflector (incl. dimmable)	938
Exterior reflector	1825

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[892] An evaluation (Energy Efficiency / Demand Response Plan: Plan Year 2 (6/1/2009-5/31/2010) Evaluation Report: Residential Energy Star ® Lighting http://ilsag.org/yahoo_site_admin/assets/docs/ComEd_Res_Lighting_PY2_Evaluation_Report_2010-12-21_Final.12113928.pdf) reported 13-17W as the most common specialty CFL wattage (69% of program bulbs). 2009 California data also reported an average CFL wattage of 15.5 Watts (KEMA, Inc, The Cadmus Group, Itron, Inc, PA Consulting Group, Jai J. Mitchell Analytics, Draft Evaluation Report: Upstream Lighting Program, Prepared for the California Public Utilities Commission, Energy Division. December 10, 2009).

[893] 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.

[894] 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.

[895] Consistent with assumption for standard CFLs (in the absence of evidence that it should be different for this bulb type). Based upon review of the PY2 and PY3 ComEd Direct Install program surveys. This value includes bulb failures in the 1st year to be consistent with the Commission approval of annualization of savings for first year savings claims. ComEd PY2 All Electric Single Family Home Energy Performance Tune-Up Program Evaluation, Navigant Consulting, December 21, 2010. http://www.icc.illinois.gov/downloads/public/edocket/287090.pdf.

[896] Hours of use by specialty bulb type calculated using the average hours of use in locations or rooms where each type of specialty bulb is most commonly found. Annual hours of use by location in the home from Docket No. 10-0520, ICC Staff Exhibit 1.4, RE: Lighting Logger Study Results – Version 2, Navigant, May 27, 2011. http://www.icc.illinois.gov/downloads/public/edocket/303834.pdf

Candelabra base and candle medium and intermediate base	1328
Bug light	1825
Post light (>100W)	1825
Daylight	938
Plant light	938
Globe	1240
Vibration or shatterproof	938
Standard Spiral >2601 lumens, Residential, Multi Family in-unit or unknown	938
Standard Spiral >2601 lumens, Multi Family Common area	5950
Standard Spiral >2601 lumens, Exterior	1825
Specialty - Generic	938

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

Bulb Location	WHFe
Interior single family or unknown location	1.06 [897]
Multi family in unit	1.04 [898]
Exterior or uncooled location	1.0

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)

[897] 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)

[898] 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

assumptions active in Year 2 and 3 should be applied.

The NTG factor for the Purchase Year should be applied.

For example, for a 13W dimmable CFL impacted by EISA 2007 (60W standard incandescent and 43W EISA qualified incandescent/halogen) purchased in 2013.

$\Delta kWH_{1st\ year\ installs}$ = ((60 - 13) / 1000) * 0.795 * 897 * 1.06

= 35.5 kWh

$\Delta kWH_{2nd\ year\ installs}$ = ((43 - 13) / 1000) * 0.15 * 897 * 1.06

= 4.28 kWh

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

$\Delta kWH_{3rd\ year\ installs}$ = ((43 - 13) / 1000) * 0.085 * 897 * 1.06

= 2.4 kWh

Mid Life Baseline Adjustment

For those bulbs non-exempt from EISA 2007, during the lifetime of the CFL, the baseline incandescent bulb will change over time and so the annual savings claim must be reduced within the life of the measure to account for this baseline shift in cost-effectiveness analysis.

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.

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%	Jan, 2013
750-1049	60	43	14	46	29	63%	Jan, 2014
310-749	40	29	11	29	18	62%	Jan, 2014

Heating Penalty

If electric heated home (if heating fuel is unknown assume gas, see Natural Gas section):

ΔkWh[899] = - (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF) / ηHeat

Where:

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

= 49%[900] for interior or unknown location

= 0% for exterior location

ηHeat = Efficiency in COP of Heating equipment

= actual. If not available use[901]:

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 15W specialty CFL replacing a 60W incandescent specialty bulb installed in home with 2.0 COP Heat Pump:

$\Delta kWh_{1st\ year}$ = - (((60 - 15) / 1000) * 0.795 * 938 * 0.49) / 2.0

= - 8.2 kWh

Second and third year savings should be calculated using the appropriate ISR.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW =((WattsBase - WattsEE) / 1000) * ISR * WHFd * CF

Where:

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[902]
Multi family in unit	1.07[903]

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

900 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.

901 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.

902 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.

Exterior or uncooled location	1.0

CF = Summer Peak Coincidence Factor for measure. Coincidence factors by bulb types are presented below[904]

Bulb Type	Peak CF
Three-way	0.081
Dimmable	0.081
Interior reflector (incl. dimmable)	0.095
Exterior reflector	0.184
Candelabra base and candle medium and intermediate base	0.122
Bug light	0.184
Post light (>100W)	0.184
Daylight	0.095
Plant light	0.095
Globe	0.116
Vibration or shatterproof	0.095
Standard Spiral >=2601 lumens	0.095
Specialty - Generic	0.095

Other factors as defined above

For example, a 15W specialty CFL replacing a 60W incandescent specialty bulb:

$\Delta kW_{1st\ year}$ = ((60 - 15) / 1000) * 0.795 * 1.11 * 0.095

= 0.004 kW

Second and third year savings should be calculated using the appropriate ISR.

Natural Gas Savings

Heating Penalty if Natural Gas heated home (or if heating fuel is unknown):

ΔTherms[905] = - (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF * 0.03412) / ηHeat

Where:

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

903 As above but using estimate of 45% of multifamily 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.

904 Lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation, results were used to calculate the average coincident peak factor in the rooms where the specialty bulbs are most likely to be installed.

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

= 49%[906] for interior or unknown location

= 0% for exterior location

0.03412 =Converts kWh to Therms

ηHeat = Efficiency of heating system

=70%[907]

For example, a 15W specialty CFL replacing a 60W incandescent specialty bulb:

ΔTherms = - (((60 - 15) / 1000) * 0.795 * 938 * 0.49 * 0.03412) / 0.7

= - 0.80 Therms

Second and third year savings should be calculated using the appropriate ISR.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

For those bulbs types exempt from EISA the following O&M assumptions should be used: Life of the baseline bulb is assumed to be 1.07 year[908]; baseline replacement cost is assumed to be $3.5[909].

For non-exempt EISA bulb types defined above, 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 Specialty CFL O&M calc.xls) for each CFL lumen range and installation year and using the statewide real discount rate of 5.23%. The key assumptions used in this calculation are documented below:

	Standard	EISA Qualified

[906] 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.

[907] 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 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.)
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

[908] Assuming 1000 hour rated life for incandescent bulb: 1000/938 = 1.07

[909] NEEP Residential Lighting Survey, 2011

	Incandescent	Incandescent/Halogen
Replacement Cost	$3.50	$5.00
Component Rated Life (hrs)	1000	1000

The Net Present Value of the baseline replacement costs[910]:

Lumen Range	NPV of baseline replacement costs				
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015	June 2015 - May 2016	June 2016 - May 2017
1490-2600	$23.97	$23.97	$21.08	$17.28	$13.29
1050-1489	$23.97	$23.97	$21.08	$17.28	$13.29
750-1049	$22.57	$23.97	$21.08	$17.28	$13.29
310-749	$22.57	$23.97	$21.08	$17.28	$13.29

The annual levelized baseline replacement costs:

Lumen Range	Levelized annual replacement cost savings				
	June 2012 - May 2013	June 2013 - May 2014	June 2014 - May 2015	June 2015 - May 2016	June 2016 - May 2017
1490-2600	$4.28	$4.28	$3.76	$3.09	$2.37
1050-1489	$4.28	$4.28	$3.76	$3.09	$2.37
750-1049	$4.03	$4.28	$3.76	$3.09	$2.37
310-749	$4.03	$4.28	$3.76	$3.09	$2.37

MEASURE CODE: RS-LTG-ESCC-V02-130601

[910] See 'RES Specialty CFL O&M calc.xls' for more details.

5.5.3 ENERGY STAR Torchiere

Description

A high efficiency ENERGY STAR fluorescent torchiere is purchased in place of a baseline mix of halogen and incandescent torchieres and installed in a residential setting.

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 fluorescent torchiere must meet ENERGY STAR efficiency standards.

Definition of Baseline Equipment

The baseline is based on a mix of halogen and incandescent torchieres.

Deemed Lifetime of Efficient Equipment

The lifetime of the measure is assumed to be 8 years[911].

Deemed Measure Cost

The incremental cost for this measure is assumed to be $5[912].

Deemed O&M Cost Adjustments

Life of the baseline bulb is assumed to be 1.83 years[913] for residential and multifamily in unit and 0.34 years[914] for multifamily common area. Baseline bulb cost replacement is assumed to be $6[915].

Loadshape

Loadshape R06 - Residential Indoor Lighting
Loadshape R07 - Residential Outdoor Lighting
Loadshape C06 - Commercial Indoor Lighting[916]

Coincidence Factor

The summer peak coincidence factor for this measure is 9.5%[917] for Residential and in-unit Multi Family bulbs and

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[911] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.
[912] DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com) and consistent with Efficiency Vermont TRM.
[913] Based on assumption of baseline bulb (mix of incandescent and halogen) average rated life of 2000 hours, 2000/1095 = 1.83 years.
[914] 2000/5950 = 0.34 years
[915] Derived from Efficiency Vermont TRM.
[916] For Multi Family common area lighting.
[917] Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation.

75%[918] for Multi Family common area bulbs.

Algorithm

Calculation of Savings

Electric Energy Savings

ΔkWh = ((ΔWatts) /1000) * ISR * HOURS * WHFe

Where:

ΔWatts = Average delta watts per purchased ENERGY STAR torchiere

= 115.8 [919]

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

= 0.86 [920]

HOURS = Average hours of use per year

Installation Location	Hours
Residential and in-unit Multi Family	1095 (3.0 hrs per day)[921]
Multi Family Common Areas	5950[922]

"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

918 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.

919 Nexus Market Research, "Impact Evaluation of the Massachusetts, Rhode Island and Vermont 2003 Residential Lighting Programs", Final Report, October 1, 2004, p. 43 (Table 4-9)

920 Nexus Market Research, RLW Analytics "Impact Evaluation of the Massachusetts, Rhode Island, and Vermont 2003 Residential Lighting Programs" table 6-3 on p63 indicates that 86% torchieres were installed in year one. http://publicservice.vermont.gov/energy/ee_files/efficiency/eval/marivtreportfinal100104.pdf

921 Nexus Market Research, "Impact Evaluation of the Massachusetts, Rhode Island and Vermont 2003 Residential Lighting Programs", Final Report, October 1, 2004, p. 104 (Table 9-7)

922 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.

WHFe = Waste Heat Factor for Energy to account for cooling savings from efficient lighting.

Bulb Location	WHFe
Interior single family or unknown location	1.06 [923]
Multi family in unit	1.04 [924]
Multi family common area	1.04 [925]
Exterior or uncooled location	1.0

For single family buildings:

ΔkWh = (115.8 /1000) * 0.86 * 1095 * 1.06

= 116 kWh

For multi family in unit:

ΔkWh = (115.8 /1000) * 0.86 * 1095 * 1.04

= 113 kWh

For multi family common area:

ΔkWh = (115.8 /1000) * 0.86 * 5950 * 1.04

= 616 kWh

HEATING PENALTY

If electric heated home (if heating fuel is unknown assume gas, see Natural Gas section):

ΔkWh[926] = - ((ΔWatts) /1000) * ISR * HOURS * HF) / ηHeat

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[923] 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)

[924] 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

[925] Ibid.

Where:

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

= 49%[927] for interior or unknown location

ηHeat = Efficiency in COP of Heating equipment

= Actual. If not available use defaults provided below[928]:

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, an ES torchiere installed in a house with a newer heat pump:

ΔkWh = - ((115.8) / 1000) * 0.86 * 1095 * 0.49) / 2.26

= - 23.6 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ((ΔWatts) /1000) * ISR * WHFd * CF

Where:

[926] Negative value because this is an increase in heating consumption due to the efficient lighting.
[927] 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.
[928] 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[929]
Multi family in unit	1.07[930]
Multi family common area	1.07 [931]
Exterior or uncooled location	1.0

CF = Summer Peak Coincidence Factor for measure

Bulb Location	CF
Interior single family or unknown location	9.5% [932]
Multi family in unit	9.5% [933]
Multi family common area	75% [934]

For single family buildings:

ΔkW = (115.8 / 1000) * 0.86 * 1.11 * 0.095

= 0.011kW

For multi family in unit:

ΔkW = (115.8 / 1000) * 0.86 * 1.07 * 0.095

= 0.010 kW

For multi family common area:

ΔkW = (115.8 / 1000) * 0.86 * 1.07 * 0.75

[929] 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.

[930] 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.

[931] Ibid

[932] 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

[933] Ibid.

[934] 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.

= 0.080 kW

NATURAL GAS SAVINGS

Heating penalty if Natural Gas heated home, or if heating fuel is unknown.

$\Delta Therms_{WH}$ = - (((ΔWatts) /1000) * ISR * HOURS * 0.03412 * HF) / ηHeat

Where:

$\Delta Therms_{WH}$ = gross customer annual heating fuel increased usage for the measure from the reduction in lighting heat in therms.

0.03412 = conversion from kWh to therms

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

= 49% [935]

ηHeat = average heating system efficiency

= 70% [936]

$\Delta Therms_{WH}$ = - ((115.8 / 1000) * 0.86 * 1095 * 0.03412 * 0.49) / 0.70

= - 2.60 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

Life of the baseline bulb is assumed to be 1.83 years[937] for residential and multifamily in unit and 0.34 years[938] for

[935] 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.

[936] 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: 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

[937] Based on VEIC assumption of baseline bulb (mix of incandescent and halogen) average rated life of 2000 hours, 2000/1095 = 1.83 years.

[938] 2000/5950 = 0.34 years

multifamily common area. Baseline bulb cost replacement is assumed to be $6.[939]

MEASURE CODE: RS-LTG-ESTO-V01-120601

[939] Derived from Efficiency Vermont TRM.

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[940]. 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[941].

DEEMED MEASURE COST

The incremental cost for an interior fixture is assumed to be $17[942].

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[943]:

	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	$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:

	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	$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	

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[940] 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.

[941] 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.

[942] 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)

[943] 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%[944].

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh =((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

[944] 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%[945]	5.7%	4.8%	98.0%[946]
Direct Install	96.9[947]			

Hours = Average hours of use per year

=1643 (4.5 hrs per day)[948]

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.

945 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.

946 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.

947 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.

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

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

= 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 1st 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%[949]

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[950]:

	Standard Incandescent	Efficient Incandescent	CFL
Replacement Cost	$0.50	$1.50	$2.50
Component Rated Life (hrs)	1000	1000[951]	8000

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	$18.34	$16.28	$14.12	$1.90

[949] 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.

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

[951] 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.

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	

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[952]. However due to the backstop provision in the Energy

[952] 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

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[953].

DEEMED MEASURE COST

The incremental cost for an interior fixture is assumed to be $32[954].

DEEMED O&M COST ADJUSTMENTS[955]

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:

fluorescent fixture.

[953] 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.

[954] 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)

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

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	
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[956]

COINCIDENCE FACTOR

The summer peak coincidence factor is assumed to be 9.5%[957] for Residential and in-unit Multi Family bulbs and 75%[958] for Multi Family common area bulbs.

[956] For Multi Family common area lighting.

[957] 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

[958] 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.

Algorithm

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%[959]	5.7%	4.8%	98.0%[960]
Direct Install	96.9[961]			

[959] 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.

[960] 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.

[961] 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.

Hours = Average hours of use per year

Installation Location	Hours
Residential and in-unit Multi Family	938 [962]
Multi Family Common Areas	5950[963]

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 [964]
Multi family in unit	1.04 [965]
Multi family common area	1.04 [966]

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.

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[962] Based on lighting logger study conducted as part of the PY3 ComEd Residential Lighting Program evaluation.
[963] 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.
[964] 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)
[965] 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
[966] Ibid.

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

= 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[967] = - (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF) / ηHeat

Where:

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

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

= 49%[968] for interior or unknown location

= 0% for unheated location

ηHeat = Efficiency in COP of Heating equipment

= actual. If not available use[969]:

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:

[968] 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.

[969] 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[970]
Multi family in unit	1.07[971]
Multi family common area	1.07 [972]
Exterior or uncooled location	1.0

CF = Summer Peak Coincidence Factor for measure.

Bulb Location	CF
Interior single family or unknown location	9.5% [973]
Multi family in unit	9.5% [974]
Multi family common area	75% [975]

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.

970 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.

971 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 .

972 Ibid

973 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

974 Ibid.

975 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.

NATURAL GAS SAVINGS

ΔTherms[976] = - (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF * 0.03412) / ηHeat

Where:

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

= 49%[977] for interior or unknown location

= 0% for unheated location

0.03412 =Converts kWh to Therms

ηHeat = Efficiency of heating system

=70%[978]

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

[976] Negative value because this is an increase in heating consumption due to the efficient lighting.
[977] 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.
[978] 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

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[979]	8000 (or 10,000 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:

	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 - 2016) are presented below:

[979] 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.

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	

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

5.5.6 LED Downlights

Description

This measure describes savings from a variety of LED downlight lamp types. Other LED lamp types are currently available (e.g. A-lamps) but the significant incremental cost and minimal efficacy improvements over CFLs mean that they are unlikely to represent a viable measure at this time. As prices continue to drop and improvements in efficacy continue, this will be revisited in future versions.

This characterization assumes that the LED lamp or fixture is installed in a residential location. Where the implementation strategy does not allow for the installation location to be known (e.g. an upstream retail program) evaluation data could be used to determine an appropriate residential v commercial split. If this is not available, it is recommended to use this residential characterization for all installs in unknown locations to be appropriately conservative in savings assumptions.

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 an ENERGY STAR LED lamp or fixture.

Definition of Baseline Equipment

The baseline condition is assumed to be an incandescent/halogen lamp for all lamp types.

Deemed Lifetime of Efficient Equipment

The expected measure life is given in the following table.[980]

Bulb Type	Measure Life (yr)
PAR20, PAR30, PAR38 screw-in lamps	10
MR16/PAR16 pin-based lamps	10
Recessed downlight luminaries	15
Track lights	15

[980] Limited by persistence. NEEP EMV Emerging Technologies Research Report (December 2011)

DEEMED MEASURE COST

The price of LED lamps is falling quickly. Where possible the actual cost should be used and compared to the baseline cost provided below. If the incremental cost is unknown, assume the following[981]:

Bulb Type	Baseline Cost	LED Cost	Incremental Cost
PAR20, PAR30, PAR38 screw-in lamps	$4.00	$44.00	$40.00
MR16/PAR16 pin-based lamps	$3.00	$28.00	$25.00
Recessed downlight luminaries	$4.00	$94.00	$90.00
Track lights	$4.00	$60.00	$56.00

DEEMED O&M COST ADJUSTMENTS

The life of the baseline bulb and the cost of its replacement is presented in the following table:

Lamp Type	Baseline Lamp Life (hours)	Baseline Life (years) (Single Family and in unit Multifamily - 1010 hours)	Baseline Life (years) (Common Area Multifamily - 5950 hours)	Baseline Replacement Cost
PAR20, PAR30, PAR38 screw-in lamps	2000	2.0	0.3	$4.00
MR16/PAR16 pin-based lamps	2000	2.0	0.3	$3.00
Recessed downlight luminaries	2000	2.0	0.3	$4.00
Track lights	2000	2.0	0.3	$4.00

LOADSHAPE

Loadshape R06 - Residential Indoor Lighting

Loadshape R07 - Residential Outdoor Lighting

Loadshape C06 - Commercial Indoor Lighting[982]

COINCIDENCE FACTOR

The summer Peak Coincidence Factor is assumed to be 9.5%[983] for Residential and in-unit Multi Family bulbs and 75%[984] for Multi Family common area bulbs.

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[981] Costs are provided as the best estimate from VEIC and are based on review of available product and of price reports provided to Efficiency Vermont by a number of manufacturers and retailers.

[982] For Multi Family common area lighting.

[983] 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

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[984] 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.

Algorithm

Calculation of Savings

Electric Energy Savings

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

Where:

WattsBase = Baseline lamp wattage of equivalent lumens, see "Bulb Types" table – default baseline assumption (incandescent/halogen) is in bold and highlighted yellow

WattsEE = Actual wattage of energy efficient LED lamp purchased

Bulb Type	Efficacy (lumen/Watt)[985]	Lumens	LED Watts (WattsEE)	Incandescent/ Halogen Watts	EISA compliant Incandescent Watts	CFL Watts
PAR20 screw-in lamps	10-15 (incandescent/halogen) 35-45 (CFL reflector) 40-60 (LED)	460-810	13	**46**		18
PAR30 screw-in lamps		600-1005	15	**67**		20
PAR38 screw-in lamps		630-1170	18	**78**		23
MR16/PAR16 pin-based lamps	15-25 (Incandescent) 50 (LED)	300-500	8	**20**		
		525-875	14	**35**		
		750-1250	20	**50**		
Recessed downlight luminaries	35 (fixture efficacy with a CFL lamp) 42-86 (LED fixture)	540	11	**50**		15
		500-650	12	**65**		18
		1000	13	**100**		25
Track lights (R20)	10-15 [986] (incandescent/halogen) 35-45 (CFL reflector) 40-60 (LED)	320-675	8	**45**		10
Track lights (BR30 and BR40)		440-975	11	**65**		18

[985] Data source for most efficacies: Energy Savings Estimates of Light Emitting Diodes in Niche Lighting Applications, Navigrant Consulting, January 2011, http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/nichefinalreport_january2011.pdf

[986] The exemption to EISA for reflector bulbs is expected to expire in 2014 for the following wattage and bulb type: 45 W (R20 and BR 19); 50W (R30, ER 30, BR 40, and ER 40); 65W (BR30, BR40, and ER 404)

ISR = In Service Rate or the percentage of units rebated that get installed[987]

Bulb Type	ISR
PAR20, PAR30, PAR38 screw-in lamps	0.95
MR16/PAR16 pin-based lamps	0.95
Recessed downlight luminaries	1.0
Track lights	1.0

Hours = Average hours of use per year

Installation Location	Hours
Residential and in-unit Multi Family	1,010 [988]
Multi Family Common Areas	5950[989]

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

Bulb Location	WHFe
Interior single family or unknown location	1.06 [990]
Multi family in unit	1.04 [991]
Multi family common area	1.04 [992]
Exterior or uncooled location	1.0

For example, a 13W PAR20 LED is installed in place of a 46W PAR20 incandescent screw-in lamp installed in single family interior location:

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[987] NEEP EMV Emerging Technologies Research Report (December 2011)

[988] NEEP EMV Emerging Technologies Research Report (December 2011)

[989] Multifamily 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.

[990] 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)

[991] 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

[992] Ibid.

ΔkWh = ((46 - 13) / 1000) * 0.95 * 1010 * 1.06

= 33.6 kWh

HEATING PENALTY

If electric heated home (if heating fuel is unknown assume gas, see Natural Gas section):

ΔkWh[993] = - (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF) / ηHeat

Where:

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

= 49%[994] for interior or unknown location

= 0% for exterior location

ηHeat = Efficiency in COP of Heating equipment

= Actual. If not available use:[995]

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 13W PAR20 LED is installed in place of a 46W PAR20 incandescent screw-in lamp installed in single family interior location:

ΔkWh = - ((46 - 13) / 1000) * 0.95 * 1010 * 0.49) / 2.26

= - 6.87 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ((WattsBase - WattsEE) / 1000) * ISR * WHFd * CF

Where:

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

994 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.

995 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[996]
Multi family in unit	1.07[997]
Multi family common area	1.07 [998]
Exterior or uncooled location	1.0

CF = Summer Peak Coincidence Factor for measure, see above for values.

Bulb Location	CF
Interior single family or unknown location	9.5% [999]
Multi family in unit	9.5% [1000]
Multi family common area	75% [1001]

Other factors as defined above

For example, a 13W PAR20 LED is installed in place of a 46W PAR20 incandescent screw-in lamp installed in single family interior location:

ΔkW = ((46 - 13) / 1000) * 0.95 * 1.11* 0.095

= 0.0033 kW

NATURAL GAS SAVINGS

Heating penalty if Natural Gas heated home, or if heating fuel is unknown.

Δtherms = - (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF * 0.03412) / ηHeat

[996] 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.

[997] 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.

[998] Ibid

[999] 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

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[1000] Ibid.

[1001] 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 lighting savings that must be replaced by heating system.

= 49% [1002] for interior or unknown location

= 0% for exterior location

0.03412 = Converts kWh to Therms

ηHeat = Average heating system efficiency.

= 0.70 [1003]

Other factors as defined above

For example, a 13W PAR20 LED is installed in place of a 46W PAR20 incandescent screw-in lamp installed in single family interior location with gas heating at 70% total efficiency:

Δtherms = - (((46 - 13) / 1000) * 0.95 * 1010 * 0.49* 0.03412) / 0.70

= - 0.756 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

The life of the baseline bulb and the cost of its replacement is presented in the following table:

Lamp Type	Baseline Lamp Life (hours)	Baseline Life (Single Family and in unit Multifamily - 1010 hours)	Baseline Life (Common Area Multifamily - 5950 hours)	Baseline Replacement Cost
PAR20, PAR30, PAR38 screw-in lamps	2000	2.0	0.3	$4.00
MR16/PAR16 pin-based lamps	2000	2.0	0.3	$3.00
Recessed downlight luminaries	2000	2.0	0.3	$4.00
Track lights	2000	2.0	0.3	$4.00

1002 Average result from REMRate modeling of several different configurations and IL locations of homes

1003 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

MEASURE CODE: RS-LTG-LEDD-V01-120601

5.5.7 LED Exit Signs

DESCRIPTION

This measure characterizes the savings associated with installing a Light Emitting Diode (LED) exit sign in place of a fluorescent or incandescent exit sign in a MultiFamily building. Light Emitting Diode exit signs have a string of very small, typically red or green, glowing LEDs arranged in a circle or oval. The LEDs may also be arranged in a line on the side, top or bottom of the exit sign. LED exit signs provide the best balance of safety, low maintenance, and very low energy usage compared to other exit sign technologies.

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

DEFINITION OF EFFICIENT EQUIPMENT

The efficient equipment is assumed to be an exit sign illuminated by LEDs.

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is assumed to be a fluorescent or incandescent model.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life is assumed to be 16 years[1004].

DEEMED MEASURE COST

The incremental cost for this measure is assumed to be $30[1005].

DEEMED O&M COST ADJUSTMENTS

The annual O&M Cost Adjustment savings is calculated using component costs and lifetimes presented below.

LOADSHAPE

Loadshape C53 - Flat

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is assumed to be 100%[1006].

[1004] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values", California Public Utilities Commission, December 16, 2008.
[1005] NYSERDA Deemed Savings Database, Labor cost assumes 25 minutes @ $18/hr.
[1006] Assuming continuous operation of an LED exit sign, the Summer Peak Coincidence Factor is assumed to equal 1.0.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = ((WattsBase - WattsEE) / 1000) * HOURS * WHF_e$$

Where:

WattsBase = Actual wattage if known, if unknown assume the following:

Baseline Type	WattsBase
Incandescent	35W[1007]
Fluorescent	11W[1008]
Unknown (e.g. time of sale)	11W

WattsEE = Actual wattage if known, if unknown assume 2W[1009]

HOURS = Annual operating hours

= 8766

WHF_e = Waste heat factor for energy; accounts for cooling savings from efficient lighting.

= 1.04[1010] for multi family buildings

Default if replacing incandescent fixture

ΔkWH = (35 – 2)/1000 * 8766 * 1.04

= 301 kWh

[1007] Based on review of available product.

[1008] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010

[1009] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010

[1010] The value is estimated at 1.04 (calculated as 1 + (0.45*(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 3.1 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 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

Default if replacing fluorescent fixture

ΔkWH = (11 – 2)/1000 * 8766 * 1.04

= 82 kWh

HEATING PENALTY

If electric heated building (if heating fuel is unknown assume gas, see Natural Gas section):

ΔkWh[1011] = - (((WattsBase - WattsEE) / 1000) * Hours * HF) / ηHeat

Where:

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

= 49%[1012]

ηHeat = Efficiency in COP of Heating equipment

= Actual. If not available use:[1013]

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 2.0COP Heat Pump heated building:

If incandescent fixture: ΔkWH = -((35 – 2)/1000 * 8766 * 0.49) / 2

= -71 kWh

If fluorescent fixture ΔkWH = -((11 – 2)/1000 * 8766 * 0.49) / 2

= -19 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = ((WattsBase - WattsEE) / 1000) * WHF_d * CF$$

[1011] Negative value because this is an increase in heating consumption due to the efficient lighting.
[1012] 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.
[1013] 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.

Where:

WHF_d = Waste heat factor for demand to account for cooling savings from efficient lighting. The cooling savings are only added to the summer peak savings.

=1.07[1014] for multi family buildings

CF = Summer Peak Coincidence Factor for measure

= 1.0

Default if incandescent fixture

ΔkW = (35 – 2)/1000 * 1.07 * 1.0

= 0.035 kW

Default if fluorescent fixture

ΔkW = (11 – 2)/1000 * 1.07 * 1.0

= 0.0096 kW

NATURAL GAS SAVINGS

Heating penalty if Natural Gas heated building, or if heating fuel is unknown.

Δtherms = - (((WattsBase - WattsEE) / 1000) * Hours * HF * 0.03412) / ηHeat

Where:

HF = Heating factor, or percentage of lighting savings that must be replaced by heating system.

= 49% [1015]

0.03412 = Converts kWh to Therms

ηHeat = Average heating system efficiency.

= 0.70 [1016]

[1014] The value is estimated at 1.11 (calculated as 1 + (0.45 * 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.

[1015] Average result from REMRate modeling of several different configurations and IL locations of homes

[1016] 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))

Other factors as defined above

Default if incandescent fixture

$$\Delta therms = - (((35 - 2) / 1000) * 8766 * 0.49 * 0.03412) / 0.70$$

$$= -6.9 \text{ therms}$$

Default if fluorescent fixture

$$\Delta therms = - (((11 - 2) / 1000) * 8766 * 0.49 * 0.03412) / 0.70$$

$$= -1.9 \text{ therms}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

The annual O&M Cost Adjustment savings should be calculated using the following component costs and lifetimes.

	Baseline Measures	
Component	Cost	Life (yrs)
Lamp	$7.00[1017]	1.37 years[1018]

MEASURE CODE: RS-LTG-LEDE-V01-120601

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

[1017] Consistent with assumption for a Standard CFL bulb with an estimated labor cost of $4.50 (assuming $18/hour and a task time of 15 minutes).

[1018] Assumes a lamp life of 12,000 hours and 8766 run hours 12000/8766 = 1.37 years.

5.6 Shell End Use

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.[1019]

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

[1019] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

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%[1020]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)
= 46.6%[1021]

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:[1022]

[1020] 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.
[1021] 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.
[1022] 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.

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
	Exposed	19.4

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

CDD = Cooling Degree Days

= Dependent on location[1023]:

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 [1024]

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[1025]:

Age of Equipment	SEER Estimate
Before 2006	10
After 2006	13

[1023] National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 65°F.
[1024] 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.
[1025] 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.

LM = Latent multiplier to account for latent cooling demand

= dependent on location: [1026]

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:[1027]

	# 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:[1028]

[1026] 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 total by the sensible load. Where this specialized data was not available, a nearby city was chosen.

[1027] 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.

[1028] 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.

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

ηHeat = Efficiency of heating system

= Actual. If not available refer to default table below[1029]:

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%[1030]

[1029] 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.

[1030] F_e is not one of the AHRI certified ratings provided for residential furnaces, but can be reasonably estimated

29.3 = kWh per therm

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[1031]:

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%[1032]

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

= 46.6%[1033]

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.

[1031] 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.

[1032] 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.

Other factors as defined above

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[1034]:

	# 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[1035]:

[1033] 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.
[1034] 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.
[1035] 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..

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

ηHeat = Efficiency of heating system

= Equipment efficiency * distribution efficiency

= Actual[1036]. If not available use 70%[1037].

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

[1036] 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.

[1037] 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

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-SHL-AIRS-V01-120601

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[1038].

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,

[1038] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

calibrated to Illinois loads, supplied by Ameren.

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during utility peak hour)
= 91.5%[1039]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)
= 46.6%[1040]

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Where available savings from shell insulation measures should be determined through a custom analysis. When that is not feasible for the program the following engineering algorithms can be used with the inclusion of a to be determined adjustment factor to de-rate the savings.

ΔkWh = (ΔkWh_cooling + ΔkWh_heating) * ADJ

Where:

ADJ = Adjustment to account for prescriptive engineering algorithms overclaiming savings.

=TBD[1041]

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 [1042]

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

[1039] 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.

[1040] 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.

[1041] As discussed in the Technical Advisory Committee call on 2/19/2013 and 2/26/2013, this adjustment factor will be determined and agreed upon through ongoing analysis.

[1042] 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

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[1043]

24 = Converts hours to days

CDD = Cooling Degree Days

= Dependent on location and whether basement is conditioned:[1044]

Climate Zone (City based upon)	Conditioned CDD 65	Unconditioned CDD 65[1045]
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[1046]	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 [1047]

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:[1048]

Age of Equipment	ηCool Estimate

[1043] Based on Oak Ridge National Lab, Technology Fact Sheet for Wall Insulation.
[1044] 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.
[1045] 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.
[1046] Weighted based on number of occupied residential housing units in each zone.
[1047] 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.
[1048] 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.

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 the earth) [1049]

= 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[1050]:

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

[1049] Adapted from Table 1, page 24.4, of the 1977 ASHRAE Fundamentals Handbook

[1050] 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.

5 (Marion)	3,438	1,796
Weighted Average[1051]	4,860	2,895

ηHeat = Efficiency of heating system

= Actual. If not available refer to default table below[1052]:

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) * ADJ

= [(((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)] * ADJ

= (49.3 + 1435) * ADJ

= 1480 * ADJ 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%[1053]

29.3 = kWh per therm

1051 Weighted based on number of occupied residential housing units in each zone.

1052 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.

1053 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 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 * ADJ) * 0.0314 * 29.3

= 123 * ADJ kWh

SUMMER COINCIDENT PEAK DEMAND

ΔkW = (ΔkWh_cooling / FLH_cooling) * CF * ADJ

Where:

FLH_cooling = Full load hours of air conditioning

= dependent on location[1054]:

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[1055]	629	564

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

= 91.5%[1056]

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

= 46.6%[1057]

1054 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.

1055 Weighted based on number of occupied residential housing units in each zone.

1056 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.

1057 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

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 * ADJ

= 0.0791 * ADJ kW

ΔkW_{PJM} = 49.3 / 570 * 0.466 * ADJ

= 0.0403 * ADJ kW

NATURAL GAS SAVINGS

If Natural Gas heating:

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)] * ADJ

ηHeat = Efficiency of heating system

= Equipment efficiency * distribution efficiency

= Actual. If unknown assume 70%[1058]

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) * ADJ

= 134 * ADJ therms

during the year.

[1058] 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-BINS-V03-130601

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[1059].

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

[1059] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

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%[1060]

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

= 46.6%[1061]

Algorithm

CALCULATION OF SAVINGS

Electric **ENERGY SAVINGS**

Where available savings from shell insulation measures should be determined through a custom analysis. When that is not feasible for the program the following engineering algorithms can be used with the inclusion of a to be determined adjustment factor to de-rate the savings.

ΔkWh = (ΔkWh_cooling + ΔkWh_heating) * ADJ

Where:

ADJ = Adjustment to account for prescriptive engineering algorithms overclaiming savings.

=TBD[1062]

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

[1060] 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.
[1061] 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.
[1062] As discussed in the Technical Advisory Committee calls on 2/19/2013 and 2/26/2013, this adjustment factor will be determined and agreed upon through ongoing analysis.

= 4.94 [1063]

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% [1064]

24 = Converts hours to days

CDD = Cooling Degree Days

Climate Zone (City based upon)	Unconditioned CDD[1065]
1 (Rockford)	263
2 (Chicago)	281
3 (Springfield)	436
4 (Belleville)	538
5 (Marion)	570
Weighted Average[1066]	325

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

= 0.75 [1067]

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:[1068]

[1063] 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
[1064] Based on Oak Ridge National Lab, Technology Fact Sheet for Wall Insulation.
[1065] 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.
[1066] Weighted based on number of occupied residential housing units in each zone.
[1067] Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research", p31.
[1068] 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.

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[1069]

Climate Zone (City based upon)	Unconditioned HDD
1 (Rockford)	3,322
2 (Chicago)	3,079
3 (Springfield)	2,550
4 (Belleville)	1,789
5 (Marion)	1,796
Weighted Average[1070]	2,895

ηHeat = Efficiency of heating system

= Actual. If not available refer to default table below:[1071]

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

[1069] 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.

[1070] Weighted based on number of occupied residential housing units in each zone.

[1071] 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.

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) * ADJ

= [(((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)] * ADJ

= (35.6 + 833) * ADJ

= 869 * ADJ 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%[1072]

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 * ADJ) * 0.0314 * 29.3

= 32 * ADJ kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = (ΔkWh_cooling / FLH_cooling) * CF * ADJ

Where:

FLH_cooling = Full load hours of air conditioning

= Dependent on location[1073]:

1072 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.

1073 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

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[1074]	629	564

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

= 91.5%[1075]

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

= 46.6%[1076]

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 * ADJ

= 0.057 kW

ΔkW_{SSP} = 35.6 / 570 * 0.466 * ADJ

= 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) * ADJ

ηHeat = Efficiency of heating system

= Equipment efficiency * distribution efficiency

Appendix providing the appropriate city to use for each county of Illinois.

1074 Weighted based on number of occupied residential housing units in each zone.

1075 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.

1076 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.

= Actual. If unknown assume 70%[1077]

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) * ADJ

= 78.0 * ADJ therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-SHL-FINS-V03-130601

[1077] 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

5.6.4 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[1078].

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.

[1078] 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%[1079]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)
= 46.6%[1080]

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Where available savings from shell insulation measures should be determined through a custom analysis. When that is not feasible for the program the following engineering algorithms can be used with the inclusion of a to be determined adjustment factor to de-rate the savings.

ΔkWh = (ΔkWh_cooling + ΔkWh_heating) * ADJ

Where:

ADJ = Adjustment to account for prescriptive engineering algorithms overclaiming savings.

=TBD[1081]

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[1082])

1079 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.

1080 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.

1081 As discussed in the Technical Advisory Committee calls on 2/19/2013 and 2/26/2013, this adjustment factor will be determined and agreed upon through ongoing analysis.

1082 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).

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%[1083]

24 = Converts hours to days

CDD = Cooling Degree Days

= dependent on location[1084]:

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[1085]	947

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

= 0.75 [1086]

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[1087]:

[1083] 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.

[1084] 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.

[1085] Weighted based on number of occupied residential housing units in each zone.

[1086] 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.

[1087] 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.

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[1088]:

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[1089]	4,860

ηHeat = Efficiency of heating system

= Actual. If not available refer to default table below[1090]:

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

[1088] 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.
[1089] Weighted based on number of occupied residential housing units in each zone.
[1090] 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.

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) * ADJ

= [(((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) * ADJ

= (295 + 3826) * ADJ

= 4120 * ADJ 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%[1091]

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 * ADJ) * 0.0314 * 29.3

= 350 * ADJ kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = (ΔkWh_cooling / FLH_cooling) * CF * ADJ

Where:

FLH_cooling = Full load hours of air conditioning

= Dependent on location as below[1092]:

[1091] 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.

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[1093]	629	564

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

= 91.5%[1094]

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

= 46.6%[1095]

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 * ADJ

= 0.474 * ADJ kW

ΔkW_{PJM} = 295 / 570 * 0.466 * ADJ

= 0.241 * ADJ 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) * ADJ

Where:

[1092] 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.

[1093] Weighted based on number of occupied residential housing units in each zone.

[1094] 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.

[1095] 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.

HDD = Heating Degree Days

= Dependent on location[1096]:

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[1097]	4,860

ηHeat = Efficiency of heating system

= Equipment efficiency * distribution efficiency

= Actual[1098]. If unknown assume 70% [1099].

Other factors as defined above

[1096] 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.

[1097] Weighted based on number of occupied residential housing units in each zone.

[1098] 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.

[1099] 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

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) * ADJ

= 380 * ADJ therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

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