MEMORANDUM

TO: **TECHNICAL ADVISORY COMMITTEE**

FROM: CHERYL JENKINS, PROJECT MANAGER and SAM DENT, TECHNICAL LEAD - VEIC

SUBJECT: V4.0 ERRATA MEASURES EFFECTIVE 06/01/2015

DATE: 01/22/2016

Cc: ANNETTE BEITEL, SAG

This memo documents thirteen errata changes to version 4.0 of the Illinois Technical Reference Manual (TRM) that the Technical Advisory Committee (TAC) recommends be made effective 06/01/2015.

VEIC has provided a summary table showing the errata measures and a brief summary of what was changed, followed by the measures themselves.

TRM Policy Document, Section 3.2.1, states that,

> "TAC participants should notify the TAC when a TRM mistake or omission is found. If a significant mistake or omission is found in the TRM that results in an unreasonable savings estimate, the Program Administrators, Evaluators, TRM Administrator, and TAC will strive to reach consensus on a solution that will result in a reasonable savings estimate. For example, an unreasonable savings estimate may result from an error or omission in the TRM.
>
> "In these limited cases where consensus is reached, the TRM Administrator shall inform the Evaluators to use corrected TRM algorithms and inputs to calculate energy and capacity savings, in addition to using the Commission-approved TRM algorithms and inputs to calculate savings. If the corrected TRM algorithms and inputs are stipulated for acceptance by all the parties in the Program Administrator's savings docket, then the corrected TRM savings verification values may be used for the purpose of measuring savings toward compliance with the Program Administrator's energy savings goals. Errors and omissions found in the TRM will be officially corrected through the annual TRM Update proceeding."

It is our belief and understanding that the following measures have consensus errata by the Program Administrators, Evaluators and the entire TAC. The term 'errata' is used to describe these measures, and in accordance with the TRM Policy Document, the Evaluators may use this version of the measures during evaluation of the current program year (in addition to the measures currently in Version 4.0 of the TRM). Note many of these measures have additional edits that are not considered errata so a second version including the errata changes and the additional revisions is included within Version 5.0 of the TRM.

Summary of Errata Measures

Section	Measure Name	Measure Code	Brief Summary of Change
4.4.11	High Efficiency Furnace	CI-HVC-FRNC-V05-150601	Future deferred baseline replacement cost increased in line with inflation
4.4.13	Package Terminal Air Conditioner (PTAC) and Package Terminal Heat Pump (PTHP)	CI-HVC-PTAC-V06-150601	Future deferred baseline replacement cost increased in line with inflation
5.1.6	ENERGY STAR and CEE Tier 2 Refrigerator	RS-APL-ESRE-V03-150601	Future deferred baseline replacement cost increased in line with inflation
5.1.7	ENERGY STAR and CEE Tier 1 Room Air Conditioner	RS-APL-ESRA-V04-150601	Future deferred baseline replacement cost increased in line with inflation
5.3.1	Air Source Heat Pump	RS-HVC-ASHP-V05-150601	Future deferred baseline replacement cost increased in line with inflation
5.3.3	Central Air Conditioning >14.5 SEER	RS-HVC-CAC1-V05-150601	Future deferred baseline replacement cost increased in line with inflation
5.3.6	Gas High Efficiency Boiler	RS-HVC-GHEB-V04-150601	Future deferred baseline replacement cost increased in line with inflation Addition of HF (household factor) in algorithm and variable list to account for lower multifamily heating load on average as compared with single family.
5.3.7	Gas High Efficiency Furnace	RS-HVC-GHEF-V05-150601	Future deferred baseline replacement cost increased in line with inflation Addition of HF (household factor) in algorithm and variable list to account for lower multifamily heating load on average as compared with single family.
5.3.8	Ground Source Heat Pump	RS-HVC-GSHP-V05-150601	Future deferred baseline replacement cost increased in line with inflation
5.3.12	Ductless Heat Pumps	RS-HVC-DHP-V03-150601	Removed '/1000' from kW calculation since capacity is already in kBtu.
5.4.2	Gas Water Heater	RS-HWE-GWHT-V05-150601	Future deferred baseline replacement cost increased in line with inflation
5.5.6	LED Specialty Lamps	RS-LTG-LEDD-V05-150601	Changed name of existing measure ("LED Downlight") to LED Specialty Lamps. Made consistent with CFL Specialty assumptions. Removed default efficient wattages as actuals always used. Adjusted language for PAR, MR, and MRX Lamps.
5.6.1	Air Sealing	RS-SHL-AIRS-V04-150601	Changing Latent Multiplier assumption to be based on calculation of 8760 hours sensible and total loads. Agreement that existing assumption was an error.

4.4.11 High Efficiency Furnace

DESCRIPTION

This measure covers the installation of a high efficiency gas furnace in lieu of a standard efficiency gas furnace in a commercial or industrial space. High efficiency gas furnaces achieve savings through the utilization of a sealed, super insulated combustion chamber, more efficient burners, and multiple heat exchangers that remove a significant portion of the waste heat from the flue gasses. Because multiple heat exchangers are used to remove waste heat from the escaping flue gasses, most of the flue gasses condense and must be drained. Furnaces equipped with ECM fan motors can save additional electric energy

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

Time of sale:

a. The installation of a new high efficiency, gas-fired condensing furnace in a commercial 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.

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.

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the installed equipment must be a furnace with input energy less than 225,000 Btu/hr rated natural gas fired furnace with an Annual Fuel Utilization Efficiency (AFUE) rating and fan electrical efficiency 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%

DEFINITION OF MEASURE LIFE

The expected measure life is assumed to be 16.5 years[1]

Remaining life of existing equipment is assumed to be 5.5 years[2].

DEEMED MEASURE COST

Time of Sale: The incremental capital cost for this measure depends on efficiency as listed below[3]:

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

Early Replacement: The full installation cost is provided in the table above. The assumed deferred cost (after 5.5 years) of replacing existing equipment with a new baseline unit is assumed to be $~~2641~~2876[4]. This cost should be discounted to present value using the utilities' discount rate.

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

[1] Average of 15-18 year lifetime estimate made by the Consortium for Energy Efficiency in 2010.
[2] Assumed to be one third of effective useful life
[3] 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.
[4] $2641 inflated using 1.91% rate.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh = Heating Savings + Cooling Savings + Shoulder Season Savings

Where:

Heating Savings = Brushless DC motor or Electronically commutated motor (ECM)
= 418 kWh[5]

Cooling Savings = Brushless DC motor or electronically commutated motor (ECM) savings during cooling season

If air conditioning = 263 kWh

If no air conditioning = 175 kWh

If unknown (weighted average)= 241 kWh[6]

Shoulder Season Savings = Brushless DC motor or electronically commutated motor (ECM) savings during shoulder seasons

= 51 kWh

EXAMPLE

For example, a blower motor in an office building where air conditioning presence is unknown:

ΔkWh = Heating Savings + Cooling Savings + Shoulder Season Savings

= 418 +263 + 51

SUMMER COINCIDENT PEAK DEMAND SAVINGS

For units that have evaporator coils and condensing units and are cooling in the summer in addition to heating in the winter the summer coincident peak demand savings should be calculated. If the unit is not equipment with coils or condensing units, the summer peak demand savings will not apply.

ΔkW = (ΔkWh/HOURSyear) * CF

[5] 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.

[6] The weighted average value is based on assumption that 75% of buildings installing BPM furnace blower motors have Central AC.

Where:

HOURSyear = Actual hours per year if known, otherwise use hours from Table below for building type[7].

Building Type	Pumps and fans (h/yr)
College/University	4216
Grocery	5840
Heavy Industry	3585
Hotel/Motel	6872
Light Industry	2465
Medical	6871
Office	2301
Restaurant	4654
Retail/Service	3438
School(K-12)	2203
Warehouse	3222
Average=Miscellaneous	4103

CF =Summer Peak Coincidence Factor for measure is provided below for different building types[8]:

Location	CF
Restaurant	0.80
Office	0.66
School (K-12)	0.22
College/University	0.56
Medical	0.75

[7] ComEd Trm June 1, 2010 page 139. The Office hours is based upon occupancy from the eQuest model developed for EFLH, since it was agreed the ComEd value was too low.

[8] Based on DEER 2008 values

EXAMPLE

For example, a blower motor in an office building where air conditioning presence is unknown:

ΔkW = (732 / 2301) * 0.66

NATURAL GAS ENERGY SAVINGS

Time of Sale:

ΔTherms = EFLH * Capacity * ((AFUE(eff) – AFUE(base)/AFUE(base))/ 100,000 Btu/Therm

Early replacement[9]:

ΔTherms for remaining life of existing unit (1st 5.5 years):

ΔTherms = EFLH * Capacity * (AFUE(eff) – AFUE(exist)/ AFUE(exist)) / 100,000 Btu/Therm

ΔTherms for remaining measure life (next 11 years):

ΔTherms = EFLH * Capacity * (AFUE(eff) - AFUE(base)/AFUE(base)) / 100,000 Btu/Therm

Where:

EFLH = Equivalent Full Load Hours for heating are provided in section 4.4 HVAC End Use

Capacity = Nominal Heating Input Capacity Furnace Size (Btu/hr) for efficient unit not existing unit

= custom Furnace input capacity in Btu/hr

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% [10].

AFUE(base) = Baseline Furnace Annual Fuel Utilization Efficiency Rating, dependant on year as listed below:

Dependent on program type as listed below[11]:

[9] 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).

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

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%[12]

EXAMPLE

For example, a 150,000 btu/hr 92% efficient furnace at a low rise office building in Rockford, in the year 2012

ΔTherms = 1428 * 150,000 * ((0.92-0.80)/0.80)/ 100,000

= 321 Therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-FRNC-~~V04~~V05-150601

[11] 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.
[12]Minimum ENERGY STAR efficiency after 2.1.2012.

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

Description

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

This measure characterizes:

a) Time of Sale: the purchase and installation of a new efficient PTAC or PTHP.
b) Early Replacement: the early removal of an existing PTAC or PTHP from service, prior to its natural end of life, and replacement with a new efficient PTAC or PTHP 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. The measure is only valid for non-fuel switching installations – for example replacing a cooling only PTAC with a PTHP can currently not use the TRM.

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 PTACs or PTHPs that exceed baseline efficiencies.

Definition of Baseline Equipment

Time of Sale: the baseline conditions is provided in the Federal Baseline reference table provided below.

Early Replacement: the baseline is the existing PTAC or PTHP 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 15 years. [13]

Remaining life of existing equipment is assumed to be 5 years[14]

Deemed Measure Cost

Time of Sale: The incremental capital cost for this equipment is estimated to be $84/ton.[15]

Early Replacement: The measure cost is the full cost of removing the existing unit and installing a new one. The actual program cost should be used. If unknown assume $1,047 per ton[16].

The assumed deferred cost (after 5 years) of replacing existing equipment with new baseline unit is assumed to be $~~963~~ 1,039 per ton[17]. This cost should be discounted to present value using the utilities' discount rate.

[13] Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, Inc., June 2007
[14] Standard assumption of one third of effective useful life.
[15] DEER 2008. This assumes that baseline shift from IECC 2006 to IECC 2012 carries the same incremental costs. Values should be verified during evaluation
[16] Based on DCEO – IL PHA Efficient Living Program data.
[17] Based on subtracting TOS incremental cost from the DCEO data and incorporating inflation rate of 1.91%.

LOADSHAPE

Loadshape C03 - Commercial Cooling

COINCIDENCE FACTOR

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

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

= 91.3% [18]

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

= 47.8% [19]

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

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

ENERGY SAVINGS

Time of Sale:

PTAC ΔkWh[20] = Annual kWh $Savings_{cool}$

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

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

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

Early Replacement:

ΔkWh for remaining life of existing unit (1^{st} 5years) = Annual kWh $Savings_{cool}$ + Annual kWh $Savings_{heat}$

[18] 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.

[19] 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

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

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

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

ΔkWh for remaining measure life (next 10 years) = Annual kWh $Savings_{cool\,+}$ Annual kWh $Savings_{heat}$

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

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

Where:

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

= Actual installed

$EFLH_{cool}$ = Equivalent Full Load Hours for cooling are provided in section 4.4 HVAC End Use:

$EFLH_{heat}$ = Equivalent Full Load Hours for heating are provided in section 4.4 HVAC End Use

EERexist = Energy Efficiency Ratio of the existing equipment

= Actual. If unknown assume 8.1 EER[21]

EERbase = Energy Efficiency Ratio of the baseline equipment; see the table below for values.

Copy of Table C403.2.3(3), IECC 2012: Minimum Efficiency Reguirements: Electrically operated packaged terminal air conditioners, packaged terminal heat pumps

Equipment Type	Minimum Efficiency as of 10/08/2012
PTAC (Cooling mode) New Construction	13.8 – (0.300 x Cap/1000) EER
PTAC (Cooling mode) Replacements	10.9 – (0.213 x Cap/1000) EER
PTHP (Cooling mode) New Construction	14.0 – (0.300 x Cap/1000) EER
PTHP (Cooling mode)	10.8 – (0.213 x Cap/1000) EER

[21] Estimated using the IECC building energy code up until year 2003 (p107; https://law.resource.org/pub/us/code/ibr/icc.iecc.2000.pdf) and assuming a 1 ton unit; EER = 10 – (0.16 * 12,000/1,000) = 8.1.

Replacements	
PTHP (Heating mode) New Construction	3.2 – (0.026 x Cap/1000) COP
PTHP (Heating mode) Replacements	2.9 – (0.026 x Cap/1000) COP

"Cap" = The rated cooling capacity of the project in Btu/hr. If the units capacity is less than 7000 Btu/hr, use 7,000 Btu/hr in the calculation. If the unit's capacity is greater than 15,000 Btu/hr, use 15,000 Btu/hr in the calculations.

Replacement unit shall be factory labeled as follows "MANUFACTURED FOR REPLACEMENT APPLICATIONS ONLY; NOT TO BE INSTALLED IN NEW CONSTRUCTION PROJECTS", Replacement efficiencies apply only to units with existing sleeves less than 16 inches (406mm) in height and less than 42 inches (1067 mm) in width.

EERee = Energy Efficiency Ratio of the energy efficient equipment. For air-cooled air conditioners < 65 kBtu/hr, if the actual EERee is unknown, assume the following conversion from SEER to EER: EER≈SEER/1.1.

= Actual installed

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

= Actual installed

3.412 = Btu per Wh.

COPexist = coefficient of performance of the existing equipment

= Actual. If unknown assume 1.0 COP for PTAC units and 2.6 COP[22] for PTHPs.

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

COPee = coefficient of performance of the energy efficient equipment.

= Actual installed

[22] Estimated using the IECC building energy code up until year 2003 (p107; https://law.resource.org/pub/us/code/ibr/icc.iecc.2000.pdf) and assuming a 1 ton unit; COP = 2.9 – (0.026 * 12,000/1,000) = 2.6

Time of Sale (assuming new construction baseline):

For example a 1 ton PTAC with an efficient EER of 12 at a hotel in Rockford saves:

$$= [(12) * [(1/10.2) – (1/12)] * 1,042$$

$$= 184 \text{ kWh}$$

Early Replacement (assuming replacement baseline for deferred replacement in 5 years):

For example a 1 ton PTHP with an efficient EER of 12, COP of 3.0 in Rockford replaces a PTAC unit (with electric resistance heat) with unknown efficiency.

ΔkWh for remaining life of existing unit (1st 5years)

$$= (12 * (1/8.1 – 1/12) * 1,042) + (12/3.412 * (1/1.0 – 1/3.0) * 1,758)$$

$$= 502 + 4,122$$

$$= 4,624 \text{ kWh}$$

ΔkWh for remaining measure life (next 10 years)

$$= (12 * (1/8.3 – 1/12) * 1,042) + (12/3.412 * (1/1.0 – 1/3.0) * 1,758)$$

SUMMER COINCIDENT PEAK DEMAND SAVINGS

Time of Sale:

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

Early Replacement:

ΔkW for remaining life of existing unit (1st 5years) $= (kBtu/hr_{cool}) * [(1/EERexist) – (1/EERee)] *CF$

ΔkWh for remaining measure life (next 10 years) $= (kBtu/hr_{cool}) * [(1/EERbase) – (1/EERee)] *CF$

Where:

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

= 91.3% [23]

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

= 47.8% [24]

[23] 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.

[24] 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 1 ton replacement cooling unit with no heating with an efficient EER of 12 at a hotel in Rockford saves

ΔkW_{SSP} = (12 * (1/10.2 – 1/12) *0.913

= 0.16 kW

For example a 1 ton PTHP with an efficient EER of 12, COP of 3.0 in Rockford replaces a PTAC unit with unknown efficiency.

ΔkW for remaining life of existing unit (1st 5years):

ΔkW_{SSP} = 12 * (1/8.1 – 1/12) * 0.913

= 0.44 kW

ΔkW for remaining measure life (next 10 years):

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-PTAC-~~V05~~V06-150601

5.1.6 ENERGY STAR and CEE Tier 2 Refrigerator

DESCRIPTION

This measure relates to:

a) Time of Sale: the purchase and installation of a new refrigerator meeting either ENERGY STAR or CEE TIER 2 specifications.

b) Early Replacement: the early removal of an existing residential inefficient Refrigerator from service, prior to its natural end of life, and replacement with a new ENERGY STAR or CEE Tier 2 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.

Energy usage specifications are defined in the table below (note, Adjusted Volume is calculated as the fresh volume + (1.63 * Freezer Volume):

Product Category	Existing Unit	Assumptions up to September 2014		Assumptions after September 2014	
	Based on Refrigerator Recycling algorithm	Federal Baseline Maximum Energy Usage in kWh/year[25]	ENERGY STAR Maximum Energy Usage in kWh/year[26]	Federal Baseline Maximum Energy Usage in kWh/year[27]	ENERGY STAR Maximum Energy Usage in kWh/year[28]
1. Refrigerators and Refrigerator-freezers with manual defrost	Use Algorithm in 5.1.8 Refrigerator and Freezer Recycling measure to estimate existing unit consumption	8.82*AV+248.4	7.056*AV+198.72	6.79AV + 193.6	6.11 * AV + 174.2
2. Refrigerator-Freezer--partial automatic defrost		8.82*AV+248.4	7.056*AV+198.72	7.99AV + 225.0	7.19 * AV + 202.5
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	8.07AV + 233.7	7.26 * AV + 210.3
4. Refrigerator-Freezers--automatic defrost with side-mounted freezer without through-the-door ice service		4.91*AV+507.5	3.928*AV+406	8.51AV + 297.8	7.66 * AV + 268.0
5. Refrigerator-Freezers--automatic		4.60*AV+459	3.68*AV+367.2	8.85AV + 317.0	7.97 * AV + 285.3

[25] http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/43
[26] http://www.energystar.gov/ia/products/appliances/refrig/NAECA_calculation.xls?c827-f746
[27] http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/43
[28] http://www.energystar.gov/products/specs/sites/products/files/ENERGY%20STAR%20Final%20Version%205.0%20Residential%20Refrigerators%20and%20Freezers%20Specification.pdf

Product Category	Existing Unit	Assumptions up to September 2014		Assumptions after September 2014	
	Based on Refrigerator Recycling algorithm	Federal Baseline Maximum Energy Usage in kWh/year[25]	ENERGY STAR Maximum Energy Usage in kWh/year[26]	Federal Baseline Maximum Energy Usage in kWh/year[27]	ENERGY STAR Maximum Energy Usage in kWh/year[28]
defrost with bottom-mounted freezer without through-the-door ice service					
5A Refrigerator-freezer—automatic defrost with bottom-mounted freezer with through-the-door ice service		N/A	N/A	9.25AV + 475.4	8.33 * AV * 436.3
6. Refrigerator-Freezers--automatic defrost with top-mounted freezer with through-the-door ice service		10.20*AV+356	8.16*AV+284.8	8.40AV + 385.4	7.56 * AV + 355.3
7. Refrigerator-Freezers--automatic defrost with side-mounted freezer with through-the-door ice service		10.10*AV+406	8.08*AV+324.8	8.54AV + 432.8	7.69 * AV + 397.9

Note CEE Tier 2 standard criteria is 25% less consumption than a new baseline unit. It is assumed that after September 2014 when the Federal Standard and ENERGY STAR specifications change, the CEE Tier 2 will remain set at 25% less that the new baseline assumption.

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

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

Time of Sale: baseline 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 September 1, 2014.

Early Replacement: the baseline is the existing refrigerator 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 measure life is assumed to be 12 years.[29]

Remaining life of existing equipment is assumed to be 4 years[30]

DEEMED MEASURE COST
Time of Sale: The incremental cost for this measure is assumed to be $40[31] for an ENERGY STAR unit and $140[32] for a CEE Tier 2 unit.

Early Replacement: The measure cost is the full cost of removing the existing unit and installing a new one. The actual program cost should be used. If unavailable assume $451 for ENERGY STAR unit and $551 for CEE Tier 2 unit[33].

The avoided replacement cost (after 4 years) of a baseline replacement refrigerator is $~~390~~413[34].

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:

Time of Sale: $\Delta kWh = UEC_{BASE} - UEC_{EE}$

Early Replacement:

ΔkWh for remaining life of existing unit (1st 4 years) $= UEC_{EXIST} - UEC_{EE}$

ΔkWh for remaining measure life (next 8 years) $= UEC_{BASE} - UEC_{EE}$

Where:

[29] From ENERGY STAR calculator: http://www.energystar.gov/buildings/sites/default/uploads/files/appliance_calculator.xlsx?7224-046c=&7224-__046ceiling_fan_calculator_xlsx=&f7d8-39dd&f7d8-39dd
[30] Standard assumption of one third of effective useful life.
[31] From ENERGY STAR calculator linked above.
[32] 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
[33] ENERGY STAR full cost is based upon IL PHA Efficient Living Program data on sample size of 910 replaced units finding average cost of $430 plus an average recycling/removal cost of $21. The CEE Tier 2 estimate uses the delta from the Time of Sale estimate.
[34] Calculated using incremental cost from Time of Sale measure and applying inflation rate of 1.91%.

UEC_{EXIST} = Annual Unit Energy Consumption of existing unit as calculated in algorithm from 5.1.8 Refrigerator and Freezer Recycling measure.

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.

If volume is unknown, use the following defaults, based on an assumed Adjusted Volume of 25.8[35]:

<u>Assumptions prior to standard changes on September 1st, 2014:</u>

Product Category	Existing Unit UEC_{EXIST} [36]	New Baseline UEC_{BASE}	New Efficient UEC_{EE}		Early Replacement (1st 4 years) ΔkWh		Time of Sale and Early Replacement (last 8 years) ΔkWh	
			ENERGY STAR	CEE T2	ENERGY STAR	CEE T2	ENERGY STAR	CEE T2
1. Refrigerators and Refrigerator-freezers with manual defrost	1027.7	475.7	380.5	356.8	647.2	671.0	95.1	118.9
2. Refrigerator-Freezer--partial automatic defrost	1027.7	475.7	380.5	356.8	647.2	671.0	95.1	118.9
3. Refrigerator-Freezers--automatic defrost with top-mounted freezer without through-the-door ice service and all-refrigerators--automatic defrost	814.5	528.5	422.8	396.4	391.7	418.1	105.7	132.1
4. Refrigerator-Freezers--automatic defrost with side-mounted freezer without through-the-door ice service	1241.0	634.0	507.2	475.5	733.7	765.4	126.8	158.5
5. Refrigerator-Freezers--automatic defrost with bottom-mounted freezer without	814.5	577.5	462.0	433.2	352.5	381.4	115.5	144.4

[35] Volume is based on the ENERGY STAR calculator average assumption of 14.75 ft^3 fresh volume and 6.76 ft^3 freezer volume.
[36] Estimates of existing unit consumption are based on using the 5.1.8 Refrigerator and Freezer Recycling algorithm and the inputs described here: Age = 10 years, Pre-1990 = 0, Size = 21.5 ft3 (from ENERGY STAR calc and consistent with AV of 25.8), Single Door = 0, Side by side = 1 for classifications stating side by side, 0 for classifications stating top/bottom, and 0.5 for classifications that do not distinguish, Primary appliances = 1, unconditioned = 0, Part use factor = 0.

Product Category	Existing Unit UEC_{EXIST} [36]	New Baseline UEC_{BASE}	New Efficient UEC_{EE}		Early Replacement (1st 4 years) ΔkWh		Time of Sale and Early Replacement (last 8 years) ΔkWh	
			ENERGY STAR	CEE T2	ENERGY STAR	CEE T2	ENERGY STAR	CEE T2
through-the-door ice service								
6. Refrigerator-Freezers--automatic defrost with top-mounted freezer with through-the-door ice service	814.5	618.8	495.1	464.1	319.5	350.4	123.8	154.7
7. Refrigerator-Freezers--automatic defrost with side-mounted freezer with through-the-door ice service	1241.0	666.3	533.0	499.7	707.9	741.3	133.3	166.6

Assumptions after standard changes on September 1st, 2014:

Product Category	Existing Unit UEC_{EXIST} [37]	New Baseline UEC_{BASE}	New Efficient UEC_{EE}		Early Replacement (1st 4 years) ΔkWh		Time of Sale and Early Replacement (last 8 years) ΔkWh	
			ENERGY STAR	CEE T2	ENERGY STAR	CEE T2	ENERGY STAR	CEE T2
1. Refrigerators and Refrigerator-freezers with manual defrost	1027.7	368.6	331.6	276.4	696.1	751.3	36.9	92.1
2. Refrigerator-Freezer--partial automatic defrost	1027.7	430.9	387.8	323.2	640.0	704.6	43.1	107.7
3. Refrigerator-Freezers--automatic defrost with top-mounted freezer without through-the-door ice service and all-refrigerators--automatic defrost	814.5	441.7	397.4	331.2	417.2	483.3	44.3	110.4

[37] Estimates of existing unit consumption are based on using the 5.1.8 Refrigerator and Freezer Recycling algorithm and the inputs described here: Age = 10 years, Pre-1990 = 0, Size = 21.5 ft3 (from ENERGY STAR calc and consistent with AV of 25.8), Single Door = 0, Side by side = 1 for classifications stating side by side, 0 for classifications stating top/bottom, and 0.5 for classifications that do not distinguish, Primary appliances = 1, unconditioned = 0, Part use factor = 0.

Product Category	Existing Unit UEC_{EXIST} [37]	New Baseline UEC_{BASE}	New Efficient UEC_{EE}		Early Replacement (1st 4 years) ΔkWh		Time of Sale and Early Replacement (last 8 years) ΔkWh	
			ENERGY STAR	CEE T2	ENERGY STAR	CEE T2	ENERGY STAR	CEE T2
4. Refrigerator-Freezers--automatic defrost with side-mounted freezer without through-the-door ice service	1241.0	517.1	465.4	387.8	775.6	853.1	51.7	129.3
5. Refrigerator-Freezers--automatic defrost with bottom-mounted freezer without through-the-door ice service	814.5	545.1	490.7	408.8	323.9	405.8	54.4	136.3
5A Refrigerator-freezer—automatic defrost with bottom-mounted freezer with through-the-door ice service	814.5	713.8	651.0	535.3	163.6	279.2	62.8	178.4
6. Refrigerator-Freezers--automatic defrost with top-mounted freezer with through-the-door ice service	814.5	601.9	550.1	451.4	264.4	363.2	51.7	150.5
7. Refrigerator-Freezers--automatic defrost with side-mounted freezer with through-the-door ice service	1241.0	652.9	596.1	489.6	644.9	751.3	56.8	163.2

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = (\Delta kWh/8766) * TAF * LSAF$$

Where:

TAF = Temperature Adjustment Factor

= 1.25 [38]

LSAF = Load Shape Adjustment Factor

[38] 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 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)

= 1.057 [39]

If volume is unknown, use the following defaults:

Product Category	Assumptions prior to September 2014 standard change ΔkW				Assumptions after September 2014 standard change ΔkW			
	Early Replacement (1st 4 years)		Time of Sale and Early Replacement (last 8 years)		Early Replacement (1st 4 years)		Time of Sale and Early Replacement (last 8 years)	
	ENERGY STAR	CEE T2	ENERGY STAR	CEE T2	ENERGY STAR	CEE T2	ENERGY STAR	CEE T2
1. Refrigerators and Refrigerator-freezers with manual defrost	0.098	0.101	0.014	0.018	0.105	0.113	0.006	0.014
2. Refrigerator-Freezer--partial automatic defrost	0.098	0.101	0.014	0.018	0.096	0.106	0.006	0.016
3. Refrigerator-Freezers--automatic defrost with top-mounted freezer without through-the-door ice service and all-refrigerators--automatic defrost	0.059	0.063	0.016	0.020	0.063	0.073	0.007	0.017
4. Refrigerator-Freezers--automatic defrost with side-mounted freezer without through-the-door ice service	0.111	0.115	0.019	0.024	0.117	0.129	0.008	0.019
5. Refrigerator-Freezers--automatic defrost with bottom-mounted freezer without through-the-door ice service	0.053	0.057	0.017	0.022	0.049	0.061	0.008	0.021
5A Refrigerator-freezer—automatic defrost with bottom-mounted freezer with through-the-door ice service	n/a	n/a	n/a	n/a	0.025	0.042	0.009	0.027
6. Refrigerator-Freezers--automatic defrost with top-mounted freezer with through-the-door ice service	0.048	0.053	0.019	0.023	0.040	0.055	0.008	0.023
7. Refrigerator-Freezers--automatic defrost with side-mounted freezer with through-the-door ice service	0.107	0.112	0.020	0.025	0.097	0.113	0.009	0.025

NATURAL GAS SAVINGS

N/A

[39] 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)

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-APL-ESRE-~~V02~~V03-~~140601~~150601

5.1.7 ENERGY STAR and CEE Tier 1 Room Air Conditioner

DESCRIPTION

This measure relates to:

a) Time of Sale 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) or CEE Tier 2 minimum qualifying efficiency specifications, in place of a baseline unit. The baseline is equivalent to ENERGY STAR Version 2.0 efficiency ratings presented below since according to ENERGY STAR Shipment Data the estimated market penetration of ENERGY STAR Room AC went from 33%[40] in 2010 to 62%[41] in 2011 and a 2012 Illinois program evaluation found a net-to-gross ratio of just 1% for a Version 2.0 ENERGY STAR unit.

Product Type and Class (Btu/hr)		ENERGY STAR v2.0 with louvered sides (EER)[42]	ENERGY STAR v2.0 without louvered sides (EER)	ENERGY STAR v3.0 / CEE Tier 1 with louvered sides (EER)[43]	ENERGY STAR v3.0 / CEE Tier 1 without louvered sides (EER)	CEE TIER 2 (EER)[44]
Without Reverse Cycle	< 8,000	10.7	9.9	11.2	10.4	11.6
	8,000 to 10,999	10.8	9.9	11.3	9.8	11.8
	11,000 to 13,999	10.8	9.4	11.3	9.8	11.8
	14,000 to 19,999	10.7	9.4	11.2	9.8	11.6
	20,000 to 24,999	9.4	9.4	9.8	9.8	10.2
	>=25,000	9.4	9.4	9.8	9.8	10.2
With Reverse Cycle	<14,000	9.9	9.4	10.4	9.8	11.8
	14,000 to 19,999	9.9	8.8	10.4	9.2	11.6
	>=20,000	9.4	8.8	9.8	9.2	10.2
Casement only		9.6		10.0		
Casement-Slider		10.5		10.9		

Side louvers 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.

[40] http://www.energystar.gov/ia/partners/downloads/unit_shipment_data/2010_USD_Summary_Report.pdf?3193-51e7
[41] http://www.energystar.gov/ia/partners/downloads/unit_shipment_data/2011_USD_Summary_Report.pdf?3193-51e7
[42] http://www.energystar.gov/ia/partners/prod_development/revisions/downloads/roomac/RAC_ProgramRequirements_1105.pdf?c2df-6034
[43] http://www.energystar.gov/index.cfm?c=roomac.pr_crit_room_ac
[44] http://library.cee1.org/sites/default/files/library/9296/CEE_ResApp_RoomAirConditionerSpecification_2003_Updated.pdf

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.

b) Early Replacement: the early removal of an existing residential inefficient Room AC unit from service, prior to its natural end of life, and replacement with a new ENERGY STAR or CEE Tier 1 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.

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 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.

DEFINITION OF BASELINE EQUIPMENT

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

Early Replacement: the baseline is the existing Room AC 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 measure life is assumed to be 12 years[45].

Remaining life of existing equipment is assumed to be 4 years[46]

DEEMED MEASURE COST

Time of Sale: The incremental cost for this measure is assumed to be $40 for a CEE TIER 1 unit and $100 for a CEE Tier 2 unit[47].

Early Replacement: The measure cost is the full cost of removing the existing unit and installing a new one. The actual program cost should be used. If unavailable assume $448 for CEE Tier 1 unit and $548 for CEE Tier 2 unit[48].

The avoided replacement cost (after 4 years) of a baseline replacement ~~refrigerator~~ unit is $~~376~~432.[49]

LOADSHAPE

Loadshape R08 - Residential Cooling

[45] 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

[46] Standard assumption of one third of effective useful life.

[47] CEE Tier 1 based on field study conducted by Efficiency Vermont and Tier 2 based on professional judgement.

[48] Based on IL PHA Efficient Living Prgroam Data for 810 replaced units showing $416 per unit plus $32 average recycling/removal cost.

[49] Estimate based upon Time of Sale incremental costs and applying inflation rate of 1.91%.

COINCIDENCE FACTOR

The coincidence factor for this measure is assumed to be 0.3[50].

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Time of Sale: ΔkWh = $(FLH_{RoomAC}$ * Btu/H * (1/EERbase - 1/EERee))/1000

Early Replacment:

ΔkWh for remaining life of existing unit (1st 4 years) = $(FLH_{RoomAC}$ * Btu/H * (1/EERexist - 1/EERee))/1000

ΔkWh for remaining measure life (next 8 years) = $(FLH_{RoomAC}$ * Btu/H * (1/EERbase - 1/EERee))/1000

Where:

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

= dependent on location[51]:

Climate Zone (City based upon)	FLH_{RoomAC}
1 (Rockford)	220
2 (Chicago)	210
3 (Springfield)	319
4 (Belleville)	428
5 (Marion)	374
Weighted Average[52]	248

Btu/H = Size of rebated unit

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[50] 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)

[51] 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%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.

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

= Actual. If unknown assume 8500 Btu/hr[53]

EERexist = Efficiency of existing unit

= Actual. If unknown assume 7.7[54]

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

Time of Sale:

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

Early Replacement:

A 7.7EER, 9000Btu/h unit is removed from a home in Springfield and replaced with a CEE T1 unit with louvered sides:

ΔkWh for remaining life of existing unit (1st 4 years) = (319 * 9000 * (1/7.7 - 1/11.3))/1000

= 118.8 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

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

Where:

CF = Summer Peak Coincidence Factor for measure

= 0.3[55]

Other variable as defined above

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

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

[55] 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)

Time of Sale:

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

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

$$= 0.010\ kW$$

Early Replacement:

A 7.7EER, 9000Btu/h unit is removed from a home in Springfield and replaced with a CEE T1 unit with louvered sides:

ΔkW for remaining life of existing unit (1^{st} 4 years) $= (9000 * (1/7.7 - 1/11.3))/1000 * 0.3$

$= 0.11$ 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-~~V03~~V04-~~140601~~150601

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.
   c. A weighted average early replacement rate is provided for use when the actual baseline early replacement rates are unknown[56].

Deemed Early Replacement Rates For ASHP

	Deemed Early Replacement Rate
Early Replacement Rate for ASHP participants	7%

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 as of January 1st 2015; 14 SEER and 8.2HSPF.

[56] Based upon research from "Home Energy Efficiency Rebate Program GPY2 Evaluation Report" which outlines early replacement rates for both primary and secondary central air cooling (CAC) and residential furnaces. This is used as a reasonable proxy for ASHP installations since ASHP specific data is not available. Report presented to Nicor Gas Company February 27, 2014, available at http://www.ilsag.info/evaluation-documents.html.

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 for the remainder of the measure life.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 18 years[57].

Remaining life of existing equipment is assumed to be 6 years[58].

DEEMED MEASURE COST

Time of sale: The incremental capital cost for this measure is dependent on the efficiency and capacity of the new unit[59]. Note these costs are per ton of unit capacity:

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

Early replacement: The full install 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)[60]:

Efficiency (SEER)	Full Retrofit Cost (including labor) per Ton of Capacity ($/ton)
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

[57] 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

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

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

[60] Ibid. See 'ASHP_Revised DEER Measure Cost Summary.xls' for calculation.

$1,~~381~~ 518 per ton of capacity[61]. This cost should be discounted to present value using the utilities' discount rate.

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.

CF_{SSP} = Summer System Peak Coincidence Factor for Heat Pumps (during utility peak hour)

= 72%%[62]

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

= 46.6%[63]

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[64]:

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):

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

[61] Ibid. $1381 per ton inflated using rate of 1.91%.
[62] Based on analysis of metering results from 24 heat pumps in Ameren Illinois service territory in PY5 coincident with AIC's 2010 system peak; 'Impact and Process Evaluation of Ameren Illinois Company's Residential HVAC Program (PY5)'.
[63] 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.
[64] 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).

Where:

FLH_cooling = Full load hours of air conditioning

= dependent on location[65]:

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[66]	629	564

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

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

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[67]
Air Source Heat Pump	9.12
Central AC	8.60
No central cooling[68]	Make '1/SEER_exist' = 0

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

[65] 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.

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

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

[68] 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.

= 14 [69]

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[70]:

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[71]	1,821

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

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

HSPF_exist =Heating System Performance Factor[72] of existing heating system (kBtu/kWh)

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

Existing Heating System	HSPF_exist

[69] Based on Minimum Federal Standard effective 1/1/2015; http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf.

[70] 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/hr 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.

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

[72] HSPF ratings for Heat Pumps account for the seasonal average efficiency of the units and are based on testing within zone 4 which encompasses most of Illinois. Furthermore, a recent Cadmus/Opinion Dynamics metering study, “Impact and Process Evaluation of Ameren Illinois Company’s Residential HVAC Program (PY5)”, found no significant variance between metered performance and that presented in the TRM

Air Source Heat Pump	5.44 [73]
Electric Resistance	3.41[74]

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

= 8.2 [75]

HSFP_ee =Heating System Performance Factor of efficient Air Source Heat Pump

(kBtu/kWh)

= Actual

Time of Sale:

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

ΔkWh = ((903 * 36,000 * (1/14 - 1/15)) / 1000) + ((1,288 * 36,000 * (1/8.2 - 1/9)) / 1000)

= 657 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

SUMMER COINCIDENT PEAK DEMAND SAVINGS

Time of sale:

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

Early replacement[76]:

[73] 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.
[74] Electric resistance has a COP of 1.0 which equals 1/0.293 = 3.41 HSPF.
[75] Based on Minimum Federal Standard effective 1/1/2015;
http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf
[76] The two equations are provided to show how savings are determined during the initial phase of the measure (existing to

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:

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

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

$EER\_base = (-0.02 * SEER\_base^2) + (1.12 * SEER)$ [77]

If SEER rating unavailable use:

Existing Cooling System	EER_exist[78]
Air Source Heat Pump	8.55
Central AC	8.15
No central cooling[79]	Make '1/EER_exist' = 0

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

= 11.8 [80]

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

= Actual, If not provided convert SEER to EER using this formula:[81]

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

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).

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

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

[79] 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.

[80] 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.

[81] 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.

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

= 72%%[82]

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

= 46.6%[83]

Time of Sale:

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

ΔkW_{SSP} = ((36,000 * (1/11.8 – 1/12)) / 1000) * 0.72

= 0.037 kW

ΔkW_{PJM} = ((36,000 * (1/11.8 – 1/12)) / 1000) * 0.466

= 0.024 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) * 0.72

= 0.872 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-ASHP-~~V04~~V05-150601

[82] Based on analysis of metering results from 24 heat pumps in Ameren Illinois service territory in PY5 coincident with AIC’s 2010 system peak; ‘Impact and Process Evaluation of Ameren Illinois Company’s Residential HVAC Program (PY5)’.
[83] 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.

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.
   c. A weighted average early replacement rate is provided for use when the actual baseline early replacement rate is unknown[84].

Deemed Early Replacement Rates For CAC Units in Combined System Replacement (CSR) Projects

Replacement Scenario for the CAC Unit	Deemed Early Replacement Rate
Early Replacement Rate for a CAC unit when the CAC unit is the Primary unit in a CSR project	14%
Early Replacement Rate for a CAC unit when the CAC unit is the Secondary unit in a CSR project	40%

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.

[84] Based upon research from "Home Energy Efficiency Rebate Program GPY2 Evaluation Report" which outlines early replacement rates for both primary and secondary central air cooling (CAC) and residential funaces. The unit (furnace or CAC unit) that initially caused the customer to contact a trade ally is defined as the "primary unit". The furnace or CAC unit that was also replaced but did not initially prompt the customer to contact a trade ally is defined as the "secondary unit". This evaluation used different criteria for early replacement due to the availability of data after the fact; cost of any repairs < $550 and age of unit < 20 years. Report presented to Nicor Gas Company February 27, 2014, available at http://www.ilsag.info/evaluation-documents.html.

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[85] for the remainder of the measure life.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 18 years [86].

Remaining life of existing equipment is assumed to be 6 years[87].

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[88]:

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

[85] Baseline SEER and EER should be updated when new minimum federal standards become effective.
[86] 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
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).
[87] Assumed to be one third of effective useful life
[88] DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com)

Early replacement: The full install 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[89].

Assumed deferred cost (after 6 years) of replacing existing equipment with new baseline unit is assumed to be $~~2,857~~3,140[90]. This cost should be discounted to present value using the utilities' discount rate.

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.

CF_{SSP} = Summer System Peak Coincidence Factor for Central A/C (during system peak hour)
= 68%[91]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Central A/C (average during PJM peak period)
= 46.6%[92]

[89] 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).

[90] Based on 3 ton initial cost estimate for a conventional unit from ENERGY STAR Central AC calculator, $2,857, and applying inflation rate of 1.91% (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.

[91] Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

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

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Time of sale:

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

Early replacement[93]:

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:

FLHcool = Full load cooling hours

= dependent on location and building type[94]:

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[95]	629	564

[93] 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).

[94] 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.

Capacity = Size of new equipment in Btu/hr (note 1 ton = 12,000Btu/hr)

= Actual installed, or if actual size unknown 33,600Btu/hr for single-family buildings[96]

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

= 13[97]

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[98].

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

= Actual installed or 14.5 if unknown

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

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

95 Weighted based on number of residential occupied housing units in each zone.
96 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.
97 Based on Minimum Federal Standard; http://www1.eere.energy.gov/buildings/appliance_standards/residential/residential_cac_hp.html.
98 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.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

Time of sale:

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

Early replacement[99]:

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 [100]

EERexist = EER Efficiency of existing unit

= Actual EER of unit should be used, if EER is unknown, use 9.2[101]

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)

= 68%[102]

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

= 46.6%[103]

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[99] 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).

[100] 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).

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

[102] Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

[103] 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 example: a 3 ton unit with EER rating of 12:

ΔkW_{SSP} = (36,000 * (1/11.2– 1/12)) / 1000 * 0.68

= 0.146 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 * 0.68

= 0.621 kW

ΔkW_{SSP} (for next 12 years) = (36,000 * (1/11.2– 1/12)) / 1000 * 0.68

= 0.146 kW

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

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-~~V04~~V05-150601

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.
   c. A weighted average early replacement rate is provided for use when the actual baseline early replacement rates are unknown[104].

Deemed Early Replacement Rates For Boilers

	Deemed Early Replacement Rate
Early Replacement Rate for Boiler participants	7%

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 Btu/hr).

[104] Based upon research from "Home Energy Efficiency Rebate Program GPY2 Evaluation Report" which outlines early replacement rates for both primary and secondary central air cooling (CAC) and residential furnaces. This is used as a reasonable proxy for boiler installations since boiler specific data is not available. Report presented to Nicor Gas Company February 27, 2014, available at http://www.ilsag.info/evaluation-documents.html.

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[105]	80%
June 2013 on	82%

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[106].

Early replacement: Remaining life of existing equipment is assumed to be 8 years[107].

DEEMED MEASURE COST

Time of sale: The incremental install cost for this measure is dependent on tier[108]:

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

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

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

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

[108] 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.

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 $4,045[109]~~3543~~. This cost should be discounted to present value using the utilities' discount rate.

LOADSHAPE
N/A

COINCIDENCE FACTOR
N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS
N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS
N/A

NATURAL GAS SAVINGS
Time of Sale:

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

Early replacement[110]:

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

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

ΔTherms for remaining measure life (next 17 years):

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

Where:

Gas_Boiler_Load[111] = Estimate of annual household Load for gas boiler heated single-family homes.

[109] $3543 inflated using 1.91% rate.

[110] 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).

[111] 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)

If location is unknown, assume the average below[112].

= or Actual if informed by site-specific load calculations, ACCA Manual J or equivalent[113].

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

HF = Household factor, to adjust heating consumption for non-single-family households.

Household Type	HF
Single-Family	100%
Multi-Family	65%[114]
Actual	Custom[115]

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% [116].

[112] 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.

[113] 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.

[114] 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 based on professional judgment that average household size, and heat loads of MF households are smaller than single-family homes

[115] Program-specific household factors may be utilized on the basis of sufficiently validated program evaluations.

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[117] on tier as listed below:

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

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):

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

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

[117] 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.

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-GHEB-~~V03~~V04-150601

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:

a) 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.

b) 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.
   c. A weighted average early replacement rate is provided for use when the actual baseline early replacement rate is unknown[118].

Deemed Early Replacement Rates For Furnaces

Replacement Scenario for the Furnace	Deemed Early Replacement Rate
Early Replacement Rate for Furnace-only participants	7%
Early Replacement Rate for a furnace when the furnace is the Primary unit in a Combined System Replacement (CSR) project	14%
Early Replacement Rate for a furnace when the furnace is the Secondary unit in a CSR project	46%

[118] Based upon research from "Home Energy Efficiency Rebate Program GPY2 Evaluation Report" which outlines early replacement rates for both primary and secondary central air cooling (CAC) and residential funaces. The unit (furnace or CAC unit) that initially caused the customer to contact a trade ally is defined as the "primary unit". The furnace or CAC unit that was also replaced but did not initially prompt the customer to contact a trade ally is defined as the "secondary unit". This evaluation used different criteria for early replacement due to the availability of data after the fact; cost of any repairs < $550 and age of unit < 20 years. Report presented to Nicor Gas Company February 27, 2014, available at http://www.ilsag.info/evaluation-documents.html.

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 Btu/hr) 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[119].

For early replacement: Remaining life of existing equipment is assumed to be 6 years[120].

DEEMED MEASURE COST

Time of sale: The incremental installed cost (retail equipment cost plus installation cost) for this measure depends on efficiency as listed below[121]:

AFUE	Installed Cost	Incremental Installed Cost
80%	$2011	n/a
90%	$2641	$630
91%	$2727	$716
92%	$2813	$802

[119] 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

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

[121] Based on data from Table E.1.1 of 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. Note that ECM furnace fan cost (refer to other measure in TRM) has been deducted from the 93%-96% AFUE values to avoid double counting.

AFUE	Installed Cost	Incremental Installed Cost
93%	$3025	$1014
94%	$3237	$1226
95%	$3449	$1438
96%	$3661	$1650

Early Replacement: The full installed 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 $2903[122]~~2641~~. This cost should be discounted to present value using the utility's discount rate.

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

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

SUMMER COINCIDENT PEAK DEMAND SAVINGS

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

NATURAL GAS SAVINGS

Time of Sale:

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

Early replacement[123]:

[122] $2641 inflated using 1.91% rate.

[123] 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

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

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

ΔTherms for remaining measure life (next 14 years):

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

Where:

Gas_Furnace_Heating_Load

= Estimate of annual household heating load [124] for gas furnace heated single-family homes. If location is unknown, assume the average below[125].

= Actual if informed by site-specific load calculations, ACCA Manual J or equivalent[126].

Climate Zone (City based upon)	Gas_Furnace_Heating_Load (therms)
1 (Rockford)	873
2 (Chicago)	834
3 (Springfield)	714
4 (Belleville)	551
5 (Marion)	561
Average	793

HF = Household factor, to adjust heating consumption for non-single-family households.

Household Type	HF

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).

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

[125] Values are based on household heating consumption values and inferred average AFUE results from Table 2-1, *Energy Efficiency / Demand Response Nicor Gas Plan Year 1 (6/1/2011-5/31/2012) Research Report: Furnace Metering Study* (August 1, 2013) (prepared by Navigant Consulting, Inc.) and 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.

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

Single-Family	100%
Multi-Family	65%[127]
Actual	Custom[128]

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% [129].

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

= Dependent on program type as listed below[130]:

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%[131]

[127] 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

[128] Program-specific household factors may be utilized on the basis of sufficiently validated program evaluations.

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

[130] 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.

[131] Minimum ENERGY STAR efficiency after 2.1.2012.

Time of Sale:

For example, a 95% AFUE furnace near Rockford and purchased in the year 2014

ΔTherms = 873 * (1/0.8 - 1/0.95)

=172 therms

Early Replacement:

For example, an existing functioning furnace with unknown efficiency is replaced with an 95% furnace purchased and installed in Rockford in 2014.

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

= 873 * (1/0.644 – 1/0.95)

= 437 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-GHEF-~~V04~~V05-150601

5.3.8 Ground Source Heat Pump

DESCRIPTION

This measure characterizes the installation of a Ground Source Heat Pump under the following scenarios:

a) New Construction:
   a. The installation of a new residential sized Ground Source Heat Pump system meeting ENERGY STAR efficiency standards presented below in a new home.
   b. Note the baseline in this case should be determined via EM&V and the algorithms are provided to allow savings to be calculated from any baseline condition.
b) Time of Sale:
   a. The planned installation of a new residential sized Ground Source Heat Pump system meeting ENERGY STAR efficiency standards presented below to replace an existing system(s) that does not meet the criteria for early replacement described in section c below.
   b. Note the baseline in this case is an equivalent replacement system to that which exists currently in the home. The calculation of savings is dependent on whether an incentive for the installation has been provided by both a gas and electric utility, just an electric utility or just a gas utility.
   c. Additional DHW savings are calculated based upon the fuel and efficiency of the existing unit.
c) Early Replacement/Retrofit:
   a. The early removal of functioning either electric or gas space heating and/or cooling systems from service, prior to the natural end of life, and replacement with a new high efficiency Ground Source Heat Pump system.
   b. Note the baseline in this case is the existing equipment being replaced. The calculation of savings is dependent on whether an incentive for the installation has been provided by both a gas and electric utility, just an electric utility or just a gas utility.
   c. Additional DHW savings are calculated based upon the fuel and efficiency of the existing unit.
   d. The definitions for when an installation can be claimed as an early replacement are provided below. Note if one system (heating or cooling) has failed or does not meet the criteria below but the other system does, then the appropriate new baseline replacement should be used for the unit not meeting early replacement criteria and the existing system efficiency for the unit that does should be used in the algorithm:

Existing System	Early Replacement Criteria
Air Source Heat Pump	SEER <=10 and cost of any repairs <$249 per ton
Central Air Conditioner	SEER <=10 and cost of any repairs <$190 per ton
Boiler	AFUE <= 75% and cost of any repairs <$709
Furnace	AFUE <= 75% and cost of any repairs <$528
Ground Source Heat Pump	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	Cooling EER	Heating 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

For these products, baseline equipment includes Air Conditioning, Space Heating and Water Heating.

New Construction:

To calculate savings with an electric baseline, the baseline equipment is assumed to be an Air Source Heat Pump meeting the Federal Standard efficiency level; 14 SEER, 8.2 HSPF and 11.8[132] EER and a Federal Standard electric hot water heater.

To calculate savings with a furnace/central AC baseline, the baseline equipment is assumed to be an 80% AFUE Furnace and central AC meeting the Federal Standard efficiency level; 13 SEER, 11 EER. If a gas water heater, the Federal Standard baseline is calculated as follows[133]; for <=55 gallon tanks = 0.675 – (0.0015 * storage size in gallons) and for tanks >55 gallon = 0.8012 – (0.00078 * storage size in gallons). For a 40-gallon storage water heater this would be 0.615 EF.

[132] 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.

[133] Minimum Federal Standard as of 4/1/2015; http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf

Time of Sale: The baseline for this measure is a new replacement unit of the same system type as the existing unit, meeting the baselines provided below.

Unit Type	Efficiency Standard
ASHP	14 SEER, 11.8 EER, 8.2 HSPF
Gas Furnace	80% AFUE
Gas Boiler	82% AFUE
Central AC	13 SEER, 11 EER

Early replacement / Retrofit: The baseline for this measure is the efficiency of the *existing* heating, cooling and hot water equipment for the assumed remaining useful life of the existing unit and a new baseline heating and cooling system for the remainder of the measure life (as provided in table above except for Gas Furnace where new baseline assumption is 90% due to pending standard change).

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 25 years[134].

For early replacement, the remaining life of existing equipment is assumed to be 8 years[135].

DEEMED MEASURE COST

New Construction and Time of Sale: The actual installed cost of the Ground Source Heat Pump should be used (default of $3957 per ton[136]), minus the assumed installation cost of the baseline equipment ($~~1936~~ 1381 per ton for ASHP[137] or $2011 for a new baseline 80% AFUE furnace or $3543 for a new 82% AFUE boiler[138] and $2,857[139] for new baseline Central AC replacement).

Early Replacement: The full installation cost of the Ground Source Heat Pump should be used (default provided above). The assumed deferred cost (after 8 years) of replacing existing equipment with a new baseline unit is assumed to be $~~1936~~ 1,518 per ton for a new baseline Air Source Heat Pump, or $2,903~~641~~~~[140]~~ for a new baseline 90% AFUE furnace or $~~3543~~ 4,045 for a new 82% AFUE boiler and $~~2,857~~3,140 for new baseline Central AC

134 System life of indoor components as per DOE estimate http://energy.gov/energysaver/articles/geothermal-heat-pumps. The ground loop has a much longer life, but the compressor and other mechanical components are the same as an ASHP. http://neep.org/uploads/EMV%20Forum/EMV%20Studies/measure_life_GDS%5B1%5D.pdf

135 Assumed to be one third of effective useful life

136 Based on data provided in 'Results of HomE geothermal and air source heat pump rebate incentives documented by IL electric cooperatives'.

137 Based on data provided on Home Advisor website, providing national average ASHP cost based on 2465 cost submittals. http://www.homeadvisor.com/cost/heating-and-cooling/install-a-heat-pump/

138 Furnace and boiler costs are 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.

139 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.

~~140 Based on data from Table E.1.1 of 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).~~

replacement[141]. This future cost should be discounted to present value using the utilities' discount rate.

LOADSHAPE

Loadshape R08 - Residential Cooling (if replacing gas heat and central AC)

Loadshape R09 - Residential Electric Space Heat (if replacing electric heat with no cooling)

Loadshape R10 - Residential Electric Heating and Cooling (if replacing ASHP)

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.

CF_{SSP} = Summer System Peak Coincidence Factor for Heat Pumps (during utility peak hour)

= 72%%[142]

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

= 46.6%[143]

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

New Construction and Time of Sale (non-fuel switch only):

ΔkWh = [Cooling savings] + [Heating savings] + [DHW savings]

$= [(FLHcool * Capacity\_cooling * (1/SEER_{base} – (1/EER_{PL})/1000] + [Elecheat * FLHheat * Capacity\_heating * (1/HSPF_{base} – (1/COP_{PL} * 3.412)))/1000] + [ElecDHW * \%DHWDisplaced * (((1/EF_{ELEC}) * GPD * Household * 365.25 * \gamma Water * (T_{OUT} – T_{IN}) * 1.0) / 3412)]$

New Construction and Time of Sale (fuel switch only):

If measure is supported by gas utility only, ΔkWH = 0

If measure is supported by gas and electric utility or electric utility only, electric utility claim savings calculated below:

141 All baseline replacement costs include inflation rate of 1.91%.

142 Based on analysis of metering results from 24 heat pumps in Ameren Illinois service territory in PY5 coincident with AIC's 2010 system peak; 'Impact and Process Evaluation of Ameren Illinois Company's Residential HVAC Program (PY5)'. http://www.icc.illinois.gov/downloads/public/edocket/368522.pdf

143 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.

ΔkWh = [Cooling savings] + [Heating savings from base ASHP to GSHP] + [DHW savings]

= [(FLHcool * Capacity_cooling * (1/$SEER_{base}$– (1/EER_{PL})/1000] + [FLHheat * Capacity_heating * (1/$HSPF_{ASHP}$ – (1/COP_{PL} * 3.412)))/1000] + [ElecDHW * %DHWDisplaced * (((1/EF_{ELEC}) * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 3412)]

Early replacement (non-fuel switch only)[144]:

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

= [Cooling savings] + [Heating savings] + [DHW savings]

= [(FLHcool * Capacity_cooling * (1/SEERexist – (1/EER_{PL})/1000] + [ElecHeat * (FLHheat * Capacity_heating * (1/HSPFexist) – (1/COP_{PL} * 3.412)))/1000] + [ElecDHW * %DHWDisplaced * (((1/ EF_{ELEC}) * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 3412)]

ΔkWH for remaining measure life (next 17 years):

= [(FLHcool * Capacity_cooling * (1/SEERbase – (1/EER_{PL})/1000] + [ElecHeat * (FLHheat * Capacity_heating * (1/HSPFbase) – (1/COP_{PL} * 3.412)))/1000] + [ElecDHW * %DHWDisplaced * (((1/ EF_{ELEC}) * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 3412)]

Early replacement - fuel switch only (see illustrative examples after Natural Gas section):

If measure is supported by gas utility only, ΔkWH = 0

If measure is supported by gas and electric utility or electric utility only, electric utility claim savings calculated below:

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

= [Cooling savings] + [Heating savings from base ASHP to GSHP] + [DHW savings]

= [(FLHcool * Capacity_cooling * (1/SEERexist – (1/EER_{PL})/1000] + [(FLHheat * Capacity_heating * (1/$HSPF_{ASHP}$ – (1/COP_{PL} * 3.412)))/1000] + [ElecDHW * %DHWDisplaced * (((1/ EF_{ELEC}) * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 3412)]

ΔkWh for remaining measure life (next 17 years):

= [Cooling savings] + [Heating savings from base ASHP to GSHP] + [DHW savings]

= [(FLHcool * Capacity_cooling * (1/$SEER_{base}$ – (1/EER_{PL})/1000] + [(FLHheat * Capacity_heating * (1/$HSPF_{ASHP}$ – (1/COP_{PL} * 3.412)))/1000] + [ElecDHW * %DHWDisplaced * (((1/ EF_{ELEC}) * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0)

[144] 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).

/ 3412)]

Where:

FLHcool = Full load cooling hours

Dependent on location as below[145]:

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[146]	629	564

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

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

SEERbase = SEER Efficiency of new replacement baseline unit

Existing Cooling System	SEERbase
Air Source Heat Pump	14[147]
Central AC	13[148]
No central cooling	13[149]

SEERexist = SEER Efficiency of existing cooling unit

= Use actual SEER rating where it is possible to measure or reasonably estimate, if unknown assume default provided below:

Existing Cooling System	SEER_exist
Air Source Heat Pump	9.12[150]
Central AC	8.60[151]

[145] 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 Section 3.7 of the TRM providing the appropriate city to use for each county of Illinois.
[146] Weighted based on number of occupied residential housing units in each zone.
[147] Minimum Federal Standard as of 1/1/2015;
http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf
[148] Minimum Federal Standard; Federal Register, Vol. 66, No. 14, Monday, January 22, 2001/Rules and Regulations, p. 7170-7200.
[149] Assumes that the decision to replace existing systems includes desire to add cooling.
[150] Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren PY3-PY4.

No central cooling	13 [152]

$SEER_{ASHP}$ = SEER Efficiency of new baseline Air Source Heat Pump unit (for fuel switch)

= 14 [153]

EER_{PL} = Part Load EER Efficiency of efficient GSHP unit[154]

= Actual installed

ElecHeat = 1 if existing building is electrically heated

= 0 if existing building is not electrically heated

FLHheat = Full load heating hours

Dependent on location as below[155]:

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[156]	1,821

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

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

$HSPF_{base}$ =Heating System Performance Factor of new replacement baseline heating system (kBtu/kWh)

Existing Heating System	HSPF_base
Air Source Heat Pump	8.2
Electric Resistance	3.41[157]

[151] Ibid.
[152] Assumes that the decision to replace existing systems includes desire to add cooling.
[153] Minimum Federal Standard as of 1/1/2015; http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf
[154] As per conversations with David Buss territory manager for Connor Co, the SEER and COP ratings of an ASHP equate most appropriately with the part load EER and COP of a GSHP.
[155] 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 Section 3.7 of the TRM providing the appropriate city to use for each county of Illinois.
[156] Weighted based on number of occupied residential housing units in each zone.
[157] Electric resistance has a COP of 1.0 which equals 1/0.293 = 3.41 HSPF.

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 unknown assume default:

Existing Heating System	HSPF_exist
Air Source Heat Pump	5.44
Electric Resistance	3.41

$HSPF_{ASHP}$ =Heating Season Performance Factor for new ASHP baseline unit (for fuel switch)

=8.2 [158]

COP_{PL} = Part Load Coefficient of Performance of efficient unit[159]

= Actual Installed

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

ElecDHW = 1 if existing DHW is electrically heated

= 0 if existing DHW is not electrically heated

%DHWDisplaced = Percentage of total DHW load that the GSHP will provide

= Actual if known

= If unknown and if desuperheater installed assume 44%[160]

= 0% if no desuperheater installed

EF_{ELEC} = Energy Factor (efficiency) of electric water heater

= Actual. If unknown or for new construction assume federal standard[161]:

For <=55 gallons: 0.96 – (0.0003 * rated volume in gallons)

For >55 gallons: 2.057 – (0.00113 * rated volume in gallons)

GPD = Gallons Per Day of hot water use per person

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[158] Minimum Federal Standard as of 1/1/2015; http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf

[159] As per conversations with David Buss territory manager for Connor Co, the SEER and COP ratings of an ASHP equate most appropriately with the part load EER and COP of a GSHP.

[160] Assumes that the desuperheater can provide two thirds of hot water needs for eight months of the year (2/3 * 2/3 = 44%). Based on input from Doug Dougherty, Geothermal Exchange Organization.

[161] Minimum Federal Standard as of 4/1/2015; http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf

= 45.5 gallons hot water per day per household/2.59 people per household[162]

= 17.6

Household = Average number of people per household

Household Unit Type	Household
Single-Family - Deemed	2.56[163]
Custom	Actual Occupancy or Number of Bedrooms[164]

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 municipal system

= 54°F[165]

1.0 = Heat Capacity of water (1 Btu/lb*°F)

3412 = Conversion from Btu to kWh

[162] Email message from Maureen Hodgins, Research Manager for Water Research Foundation, to TAC/SAG, August 26, 2014

[163] 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

[164] 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.

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

Illustrative Examples

New Construction using ASHP baseline:

For example, a 3 ton unit with Part Load EER rating of 19 and Part Load COP of 4.4 with desuperheater is installed with a 50 gallon electric water heater in single family house in Springfield:

ΔkWh = [(FLHcool * Capacity_cooling * (1/$SEER_{base}$ – (1/EER_{PL})/1000] + [(FLHheat * Capacity_heating * (1/HSPFbase – (1/COP_{PL} * 3.412)))/1000] + [ElecDHW * %DHWDisplaced * (((1/ $EF_{ELEC\ EXIST}$) * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 3412)]

ΔkWh = [(730 * 36,000 * (1/14 – 1/19)) / 1000] + [(1754* 36,000 * (1/8.2 – 1/ (4.4*3.412))) / 1000] + [1 * 0.44 * (((1/0.945) * 17.6 * 2.56 *365.25 * 8.33 * (125-54) * 1)/3412)]

= 494 + 3494 + 1328

= 5316 kWh

Early Replacement – non-fuel switch (see example after Natural gas section for Fuel switch):

For example, a 3 ton unit with Part Load EER rating of 19 and Part Load COP of 4.4 with desuperheater is installed in single family house in Springfield with a 50 gallon electric water heater replacing an existing working Air Source Heat Pump with unknown efficiency ratings:

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

= [(730 * 36,000 * (1/9.12 - 1/19)) / 1000] + [(1754 * 36,000 * (1/5.44 - 1/(4.4 * 3.412))) / 1000] + [0.44 * 1 * (((1/0.945) * 17.6 * 2.56 *365.25 * 8.33 * (125-54) * 1)/3412)]

= 1498 + 7401 + 1328

= 10,227 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

New Construction and Time of Sale:

ΔkW = (Capacity_cooling * (1/EERbase - 1/EER_{FL}))/1000) * CF

Early replacement:

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

= (Capacity_cooling * (1/EERexist - 1/EER_{FL}))/1000) * CF

ΔkW for remaining measure life (next 17 years):

= (Capacity_cooling * (1/EERbase - 1/EER_{FL}))/1000) * CF

Where:

EERbase = EER Efficiency of new replacement unit

Existing Cooling System	EER_base
Air Source Heat Pump	11.8[166]
Central AC	11 [167]
No central cooling	11[168]

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

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

EERexist = (-0.02 * $SEERexist^2$) + (1.12 * SEERexist) [169]

If SEER rating unavailable use:

Existing Cooling System	EER_exist
Air Source Heat Pump	8.55
Central AC	8.15[171]
No central cooling	11 [172]

EER_{FL} = Full Load EER Efficiency of ENERGY STAR GSHP unit [173]

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

= 72%%[174]

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

= 46.6%[175]

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[166] The Federal Standard does not include an EER requirement, so it is approximated with the conversion formula from Wassmer, M. 2003 thesis refererenced below.

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

[168] Assumes that the decision to replace existing systems includes desire to add cooling.

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

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

[171] Ibid.

[172] Assumes that the decision to replace existing systems includes desire to add cooling.

[173] As per conversations with David Buss territory manager for Connor Co, the EER rating of an ASHP equate most appropriately with the full load EER of a GSHP.

[174] Based on analysis of metering results from 24 heat pumps in Ameren Illinois service territory in PY5 coincident with AIC's 2010 system peak; 'Impact and Process Evaluation of Ameren Illinois Company's Residential HVAC Program (PY5)'. http://www.icc.illinois.gov/downloads/public/edocket/368522.pdf

[175] 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.

New Construction or Time of Sale:

For example, a 3 ton unit with Full Load EER rating of 19:

$$\Delta kW_{SSP} = ((36{,}000 * (1/11.8 – 1/19))/1000) * 0.72$$

$$= 0.83 \text{ kW}$$

$$\Delta kW_{PJM} = ((36{,}000 * (1/11 – 1/19))/1000) * 0.466$$

$$= 0.54 \text{ kW}$$

Early Replacement:

For example, a 3 ton Full Load 19 EER replaces an existing working Air Source Heat Pump with unknown efficiency ratings in Marion:

ΔkW_{SSP} for remaining life of existing unit (1st 8 years):

$$= ((36{,}000 * (1/8.55 – 1/19))/1000) * 0.72$$

$$= 1.67 \text{ kW}$$

ΔkW_{SSP} for remaining measure life (next 17 years):

$$= ((36{,}000 * (1/11.8 – 1/19))/1000) * 0.72$$

$$= 0.83 \text{ kW}$$

ΔkW_{PJM} for remaining life of existing unit (1st 8 years):

NATURAL GAS SAVINGS

New Construction and Time of Sale with baseline gas heat and/or hot water:

If measure is supported by gas utility only, gas utility claim savings calculated below:

ΔTherms = [Heating Savings] + [DHW Savings]

= [Replaced gas consumption – therm equivalent of GSHP source kWh] + [DHW Savings]

= [(1 – ElecHeat) * ((Gas_Heating_Load/AFUEbase) – (kWhtoTherm * FLHheat * Capacity_heating * 1/COP_{PL})/1000)] + [(1 – ElecDHW) * %DHWDisplaced * (1/ $EF_{GAS\ EXIST}$ * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 100,000)]

If measure is supported by electric utility only, ΔTherms = 0

If measure is supported by gas and electric utility, gas utility claim savings calculated below, (electric savings is provided in Electric Energy Savings section):

ΔTherms = [Heating Savings] + [DHW Savings]

= [Replaced gas consumption – therm equivalent of base ASHP source kWh] + [DHW Savings]

= [(1 – ElecHeat) * ((Gas_Heating_Load/AFUEbase) – (kWhtoTherm * FLHheat * Capacity_heating * 1/($HSPF_{ASHP}$/3.412))/1000)] + [(1 – ElecDHW) * %DHWDisplaced * (1/ $EF_{GAS\ EXIST}$ * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 100,000)]

Early replacement for homes with existing gas heat and/or hot water:

If measure is supported by gas utility only, gas utility claim savings calculated below:

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

= [Heating Savings] + [DHW Savings]

= [Replaced gas consumption – therm equivalent of GSHP source kWh] + [DHW Savings]

= [(1 – ElecHeat) * ((Gas_Heating_Load/AFUEexist) – (kWhtoTherm * FLHheat * Capacity_heating * 1/(COP_{PL} * 3.412))/1000)] + [(1 – ElecDHW) * %DHWDisplaced * (1/ $EF_{GAS\ EXIST}$ * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 100,000)]

ΔTherms for remaining measure life (next 17 years):

= [(1 – ElecHeat) * ((Gas_Heating_Load/AFUEbaseER) – (kWhtoTherm * FLHheat * Capacity_heating * 1//(COP_{PL} * 3.412))/1000)] + [(1 – ElecDHW) * %DHWDisplaced * (1/ $EF_{GAS\ EXIST}$ * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 100,000)]

If measure is supported by electric utility only, ΔTherms = 0

If measure is supported by gas and electric utility, gas utility claim savings calculated below:

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

ΔTherms = [Heating Savings] + [DHW Savings]

= [Replaced gas consumption – therm equivalent of base ASHP source kWh] + [DHW Savings]

= [(1 – ElecHeat) * ((Gas_Heating_Load/AFUEexist) – (kWhtoTherm * FLHheat * Capacity_heating * 1/$HSPF_{ASHP}$)/1000)] + [(1 – ElecDHW) * %DHWDisplaced * (1/ $EF_{GAS\ EXIST}$ * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 100,000)]

ΔTherms for remaining measure life (next 17 years):

= [(1 – ElecHeat) * ((Gas_Heating_Load/AFUEbaseER) – (kWhtoTherm * FLHheat * Capacity_heating * 1/$HSPF_{ASHP}$)/1000)] + [(1 – ElecDHW) * %DHWDisplaced * (1/ $EF_{GAS\ EXIST}$ * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 100,000)]

Where:

ElecHeat = 1 if existing building is electrically heated

= 0 if existing building is not electrically heated

Gas_Heating_Load

= Estimate of annual household heating load [176] for gas furnace heated single-family homes. If location is unknown, assume the average below.

= Actual if informed by site-specific load calculations, ACCA Manual J or equivalent[177].

Climate Zone (City based upon)	Gas_Heating_Load if Furnace (therms) [178]	Gas_Heating_Load if Boiler (therms) [179]
1 (Rockford)	873	1275
2 (Chicago)	834	1218

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

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

[178] Values are based on household heating consumption values and inferred average AFUE results from Table 2-1, *Energy Efficiency / Demand Response Nicor Gas Plan Year 1 (6/1/2011-5/31/2012) Research Report: Furnace Metering Study* (August 1, 2013) (prepared by Navigant Consulting, Inc.) and 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.

[179] 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. 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.

Climate Zone (City based upon)	Gas_Heating_Load if Furnace (therms)[178]	Gas_Heating_Load if Boiler (therms)[179]
3 (Springfield)	714	1043
4 (Belleville)	551	805
5 (Marion)	561	819
Average	793	1158

AFUEbase = Baseline Annual Fuel Utilization Efficiency Rating

= 80% if furnace and 82% if boiler.

AFUEexist = Existing Annual Fuel Utilization Efficiency Rating

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

If unknown, assume 64.4% if furnace and 61.6% [180] if boiler.

AFUEbaseER = Baseline Annual Fuel Utilization Efficiency Rating for early replacement measure

= 90%[181] if furnace and 82% if boiler.

kWhtoTherm = Converts source kWh to Therms

= H_{grid} / 100000

H_{grid} = Heat rate of the grid in btu/kWh based on the average fossil heat rate for the EPA eGRID subregion and includes a factor that takes into account T&D losses.

For systems operating less than 6,500 hrs per year:

Use the Non-baseload heat rate provided by EPA eGRID for RFC West region for ComEd territory (including independent providers connected to RFC West), and SERC Midwest region for Ameren territory (including independent providers connected to SERC Midwest)[182]. Also include any line losses.

For systems operating more than 6,500 hrs per year:

[180] Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren PY3-PY4.
[181] Assumes that Federal Standard will have been increased to 90% by the time the existing unit would have to have been replaced.
[182] Refer to EPA eGRID data http://www.epa.gov/chp/documents/fuel_and_co2_savings.pdf, page 24 and http://www.epa.gov/cleanenergy/documents/egridzips/eGRID_9th_edition_V1-0_year_2010_Summary_Tables.pdf, page 9. Current values are:

- Non-Baseload RFC West: 9,811 Btu/kWh * (1 + Line Losses)
- Non-Baseload SERC Midwest: 10,511 Btu/kWh * (1 + Line Losses)
- All Fossil Average RFC West: 10,038 Btu/kWh * (1 + Line Losses)
- All Fossil Average SERC Midwest: 10,364 Btu/kWh * (1 + Line Losses)

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Use the All Fossil Average heat rate provided by EPA eGRID for RFC West region for ComEd territory, and SERC Midwest region for Ameren territory. Also include any line losses.

3.412 = Converts HSPF to COP

$EF_{GAS\ EXIST}$ = Energy Factor (efficiency) of existing gas water heater

= Actual. If unknown assume federal standard[183]:

For <=55 gallons: 0.675 – (0.0015 * tank_size)

For > 55 gallons 0.8012 – (0.00078 * tank size)

= If tank size unknown assume 40 gallons and EF_Baseline of 0.615

All other variables provided above

[183] Minimum Federal Standard as of 4/1/2015; http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf

Illustrative Examples *[for illustrative purposes a Heat Rate of 10,000 Btu/kWh is used]*

New construction using gas furnace and central AC baseline, *supported by Gas utility only*:

For example, a 3 ton unit with Part Load EER rating of 19 and Part Load COP of 4.4 in single family house in Springfield with a 40 gallon gas water heater is installed in place of a natural gas furnace and 3 ton Central AC unit:

ΔkWH = 0

ΔTherms = [Heating Savings] + [DHW Savings]

= [Replaced gas consumption – therm equivalent of GSHP source kWh] + [DHW Savings]

= [(1 – ElecHeat) * ((Gas_Heating_Load/AFUEbase) – (kWhtoTherm * FLHheat * Capacity_heating * 1/(COP_{PL} * 3.412)/1000)] + [(1 – ElecDHW) * %DHWDisplaced * (1/ $EF_{GAS\ EXIST}$ * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 100,000)]

= [(1-0) * ((714/0.80) – (10000/100000 * 1754 * 36,000 * 1/(4.4 * 3.412))/1000)] + [(1 – 0) * (0.44 * (1/ 0.615 * 17.6 * 2.56 *365.25 * 8.33 * (125-54) * 1) / 100,000)]

= 472 + 70

= 542 therms

Early Replacement fuel switch, *supported by gas and electric utility*:

For example, a 3 ton unit with Part Load EER rating of 19 and Part Load COP of 4.4 in single family house in Springfield with a 40 gallon gas water heater replaces an existing working natural gas furnace and 3 ton Central AC unit with unknown efficiency ratings:

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

= [Cooling savings] + [Heating savings from base ASHP to GSHP] + [DHW savings]

= [(FLHcool * Capacity_cooling * (1/SEERexist – (1/EER_{PL})/1000] + [(FLHheat * Capacity_heating * (1/$HSPF_{ASHP}$ – (1/COP_{PL} * 3.412)))/1000] + [ElecDHW * %DHWDisplaced * (((1/ EF_{ELEC}) * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 3412)]

Illustrative Example continued

ΔkWh for remaining measure life (next 17 years):

= [Cooling savings] + [Heating savings] + [DHW savings]

= [(FLHcool * Capacity_cooling * (1/SEER$_{base}$ – (1/EER$_{PL}$)/1000] + [(FLHheat * Capacity_heating * (1/HSPF$_{ASHP}$ – (1/COP$_{PL}$ * 3.412)))/1000] + [ElecDHW * %DHWDisplaced * (((1/ EF$_{ELEC}$) * GPD * Household * 365.25 * γWater * (T$_{OUT}$ – T$_{IN}$) * 1.0) /3412)]

= [(730 * 36,000 * (1/13 – 1/19)) / 1000] + [1754 * 36,000 * (1/8.2 – 1/ (4.4 *3.412)) / 1000] + [0 * 0.44 * (((1/0.904) * 17.6 * 2.56 *365.25 * 8.33 * (125-54) *1)/3412)]

= 638 + 3494 + 0

= 4132 kWh

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

= [Heating Savings] + [DHW Savings]

= [Replaced gas consumption – therm equivalent of base ASHP source kWh] + [DHW Savings]

= [(1 – ElecHeat) * ((Gas_Heating_Load/AFUEexist) – (kWhtoTherm * FLHheat * Capacity_heating * 1/HSPF$_{ASHP}$)/1000)] + [(1 – ElecDHW) * %DHWDisplaced * (1/ EF$_{GAS\ EXIST}$ * GPD * Household * 365.25 * γWater * (T$_{OUT}$ – T$_{IN}$) * 1.0) / 100,000)]

= [(1-0) * ((714/0.644) – (10000/100000 * 1754 * 36,000 * 1/8.2)/1000)] + [(1 – 0) * (0.44 * (1/ 0.615 * 17.6 * 2.56 *365.25 * 8.33 * (125-54) * 1) / 100,000)]

= 339 + 70

= 408 therms

ΔTherms for remaining measure life (next 17 years):

= [(1 – ElecHeat) * ((Gas_Heating_Load/AFUEbaseER) – (kWhtoTherm * FLHheat * Capacity_heating * 1/HSPF$_{ASHP}$)/1000)] + [(1 – ElecDHW) * %DHWDisplaced * (1/ EF$_{GAS}$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

COST EFFECTIVENESS SCREENING AND LOAD REDUCTION FORECASTING WHEN FUEL SWITCHING

This measure can involve fuel switching from gas to electric.

For the purposes of forecasting load reductions due to fuel switch GSHP projects per Section 16-111.5B, changes in site energy use at the customer's meter (using ΔkWh algorithm below) adjusted for utility line losses (at-the-busbar savings), customer switching estimates, NTG, and any other adjustment factors deemed appropriate, should be used.

The inputs to cost effectiveness screening should reflect the actual impacts on the electric and fuel consumption at the customer meter and, for fuel switching measures, this will not match the output of the calculation/allocation methodology presented in the "Electric Energy Savings" and "Natural Gas Savings" sections above. Therefore in addition to the calculation of savings claimed, the following values should be used to assess the cost effectiveness of the measure.

ΔTherms = [Heating Consumption Replaced[184]] + [DHW Savings if gas]

= [(1 – ElecHeat) * ((Gas_Heating_Load/AFUEbase)] + [(1 – ElecDHW) * %DHWDisplaced * (1/ $EF_{GAS\ EXIST}$ * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 100,000)]

ΔkWh = - [GSHP heating consumption] + [Cooling savings[185]] + [DHW savings if electric]

= - [(FLHheat * Capacity_heating * (1/COP_{PL} * 3.412))/1000] + [(FLHcool * Capacity_cooling * (1/SEERbase - 1/EER_{PL}))/1000] + [ElecDHW * %DHWDisplaced * ((1/EF_{ELEC} * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 3412)]

Illustrative Example of Cost Effectiveness Inputs for Fuel Switching

For example, a 3 ton unit with Part Load EER rating of 19 and Part Load COP of 4.4 in single family house in Springfield with a 40 gallon gas water heater replaces an existing working natural gas furnace and 3 ton Central AC unit with unknown efficiency ratings. [Note the calculation provides the annual savings for the first 8 years of the measure life, an additional calculation (not shown) would be required to calculated the annual savings for the remaining life (years 9-25)]:

ΔTherms = [(1 – ElecHeat) * ((Gas_Heating_Load/AFUEexist)] + [(1 – ElecDHW) * %DHWDisplaced * (1/ $EF_{GAS\ EXIST}$ * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 100,000)]

= [(1-0) * (714/0.644)] + [((1 – 0) * 0.44 * (1/ 0.615 * 17.6 * 2.56 *365.25 * 8.33 * (125-54) * 1) / 100,000)]

= 1109 + 70

= 1179 therms

ΔkWh = - [(FLHheat * Capacity_heating * (1/COP_{PL} * 3.412))/1000] + [(FLHcool * Capacity_cooling * (1/SEERexist - 1/EER_{PL}))/1000] + [ElecDHW * %DHWDisplaced * (((1/EF_{ELEC}) * GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0) / 3412)]

= - [(1754 * 36,000 * (1/(4.4 * 3.412)))/ 1000] + [(730 * 36,000 * (1/8.6 - 1/19))/ 1000)] +

[184] Note AFUEbase in the algorithm should be replaced with AFUEexist for early replacement measures.
[185] Note SEERbase in the algorithm should be replaced with SEERexist for early replacement measures.

MEASURE CODE: RS-HVC-GSHP-V045-150601

5.3.12 Ductless Heat Pumps

DESCRIPTION

This measure is designed to calculate electric savings for supplementing existing electric HVAC systems with ductless heat pumps. Existing systems can include: electric resistance heating or ducted air-source heat pumps. For ducted air source heat pumps, cooling savings are also possible if there is an existing air conditioning system.

Savings are achieved by displacing some of the heating or cooling load currently provided by the existing system and meeting that load with the more efficient ductless heat pump instead. The offset of the home's heating load is likely for the milder heating periods. The limitations on heating offset increase as the outdoor temperature drops, because the DHP capacity decreases, and the point-source nature of the heater is less able to satisfy heating loads in remote rooms.

For cooling, the proposed savings calculations are aligned with those of typical replacement systems. In most cases, the DHP is expected to replace (rather than offset) a comparable amount of cooling in homes with electric resistance heat—at a much higher efficiency than the previously used cooling.

In order for this measure to apply, the control strategy for the heat pump is assumed to be chosen to maximize savings per installer recommendation.[186]

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

In order for this characterization to apply, the new equipment must be a high-efficiency, variable-capacity (typically "inverter-driven" DC motor) ductless heat pump system that exceeds the current Federal Standard. This means the unit must meet or exceed 8.2 HSPF (heating mode) and 14 SEER (cooling mode)[187].

This measure only applies to the *first* ductless heat pump installed in a residence[188].

DEFINITION OF BASELINE EQUIPMENT

In order for this characterization to apply, baseline equipment must include a permanent electric resistance heating source or a ducted air-source heat pump. For multifamily buildings, each residence must have existing individual heating equipment. Multifamily residences with central heating do not qualify for this characterization. Existing cooling equipment is assumed to be standard efficiency. Note that in order to claim cooling savings, there must be an existing air conditioning system.

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[186] The whole purpose of installing ductless heat pumps is to conserve energy, so the installer can be assumed to be capable of recommending an appropriate controls strategy. For most applications, the heating setpoint for the ductless heat pump should be at least 2F higher than any remaining existing system and the cooling setpoint for the ductless heat pump should be at least 2F cooler than the existing system (this should apply to all periods of a programmable schedule, if applicable). This helps ensure that the ductless heat pump will be used to meet as much of the load as possible before the existing system operates to meet the remaining load. Ideally, the new ductless heat pump controls should be set to the current comfort settings, while the existing system setpoints should be adjusted down (heating) and up (cooling) to capture savings.

[187] Minimum Federal Standard as of 1/1/2015;
http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf

[188] Additional heat pumps will achieve additional savings, but not as much as the first one.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 18 years[189].

DEEMED MEASURE COST

The incremental cost for this measure is provided below:

Unit Size	Incremental Cost[190]
1-Ton	$3,000
1.5-Ton	$3750
2-Ton	$4,500

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 ASHP (during utility peak hour)

= 72%%[191]

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

= 46.6%[192]

[189] Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, Inc., June 2007
[190] *Ductless Heat Pumps for Residential Customers in Connecticut*, Swift, Joseph R and Rebecca A. Meyer, The Connecticut Light & Power Company, 2010 ACEEE Summer Study on Energy Efficiency in Buildings (2-292)
[191] Based on analysis of metering results from 24 heat pumps in Ameren Illinois service territory in PY5 coincident with AIC's 2010 system peak; 'Impact and Process Evaluation of Ameren Illinois Company's Residential HVAC Program (PY5)'.
[192] 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.

Algorithms

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

Electric savings

$$\Delta kWh = \Delta kWh_{heat} + \Delta kWh_{cool}$$

$$\Delta kWh_{heat} = PLD*AHHL*HF*(1/HSPF_{exist}-1/HSPF_{ee})*3.413$$

$$\Delta kWh_{cool} = Capacity_{cool}*HF*(1/SEER_{exist}-1/SEER_{ee})*EFLH_{cool}$$

Where:

PLD = Percent Load Displaced. The average total annual heating load displaced from the existing heating system and now provided by the ductless heat pump[193]

For a first DHP installed in a given home.

	PLD5		
Climate zone	1-ton unit	1.5-ton unit	2-ton unit
Rockford	26%	39%	39%
Chicago	27%	40%	42%
Springfield	31%	47%	48%
Belleville	30%	45%	48%
Marion	31%	46%	50%

AHHL = Annual Household Heating Load in kWh[194]

[193] PLD values calculated in “DHP Savings Model 12-31-13.xls”. To verify that the proposed algorithm generates reasonable savings, we compared the results to metering studies done to measure ductless heat pump savings.
Ecotope Study, prepared for Bonneville Power Administration, “Residential Ductless Mini-Split Heat Pump Retrofit Monitoring,” Monmouth, Oregon, June, 2009.
Ecotope Study, Prepared for Bonneville Power Administration, “Ductless Heat Pump Retrofits in Multifamily and Small Commercial Buildings,” December, 2012.
KEMA Study, Prepared for NSTAR Electric and Gas Corporation et al. “Ductless Mini Pilot Study,” Middletown, Connecticut, June, 2009

[194] Values in table are based on converting an average household heating load (834 therms) for Chicago based on ‘Table E-1, Energy Efficiency/Demand Response Nicor Gas Plan Year 1: Research Report: Furnace Metering Study, Draft, Navigant, August 1 2013 to an electric heat load (divide by 0.03413) to electric resistance and ASHP heat load (resistance load reduced by 15% to account for distribution losses that occur in furnace heating but not in electric resistance while ASHP heat is assumed to suffer from similar distribution losses) (see ‘Household Heating Load Summary Calculations_11062013.xls’). Finally these values were

Climate Zone	Annual Household Heating Load Resistance (kWh)	Annual Household Heating Load ASHP (kWh)
1 (Rockford)	21,741	25,578
2 (Chicago)	20,771	24,436
3 (Springfield)	17,789	20,928
4 (Belleville)	13,722	16,144
5 (Marion)	13,966	16,431
Average	19,743	23,227

HF = Household factor, to adjust heating consumption for non-single-family households.

Household Type	HF
Single-Family	100%
Multi-Family	65%[195]
Actual	Custom[196]

$Capacity_{cool}$ = the cooling capacity of the ductless heat pump unit in kBtu/hr[197].

= Actual installed

$HSPF_{ee}$ = HSPF rating of new equipment

= Actual installed

$HSPF_{exist}$ = HSPF rating of existing equipment

Existing Equipment Type	HSPFbase

adjusted 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.

[195] 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

[196] Program-specific household factors may be utilized on the basis of sufficiently validated program evaluations.

[197] 1 Ton = 12 kBtu/hr

Existing Equipment Type	HSPFbase
Electric resistance heating	3.41[198]
Air Source Heat Pump	5.44[199]

$SEER_{ee}$ = SEER rating of new equipment

= Actual installed[200]

$SEER_{exist}$ = SEER rating of existing equipment

= Use actual value. If unknown, see table below

Equipment Type	SEERexist[201]
PTAC	7.4 SEER
PTHP	7.4 SEER
SPVAC < 65kBtu/hr	9.0 SEER
SPVHP < 65 kBtu/hr	9.0 SEER
Room AC	7.0 SEER
Ducted ASHP	13.0 SEER
No existing system	No cooling savings.

$EFLH_{cool}$ = Equivalent Full Load Hours for cooling. Depends on location. See table below[202].

Climate Zone (City based upon)	FLHRoomAC
1 (Rockford)	220
2 (Chicago)	210

[198] Electric resistance has a COP of 1.0 which equals 1/0.293 = 3.41 HSPF.
[199] This is from the ASHP measure which estimated HSPF 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.
[200] Note that if only an EER rating is available, a conversion factor of SEER=1.1*EER can be used
[201] Converted from EER using formula EER = 1.1 SEER
[202] Residential EFLH for room AC

Climate Zone (City based upon)	FLHRoomAC
3 (Springfield)	319
4 (Belleville)	428
5 (Marion)	374
Weighted Average[203]	248

For example, installing a 1.5-ton (heating and cooling capacity) ductless heat pump unit rated at 8 HSPF and 14 SEER in a single-family home in Chicago to displace electric baseboard heat and replace a window air conditioner, savings are:

ΔkWh_{heat} = 40% x 20,771kWh x 100% x (1/3.41 – 1/8) x 3.413 = 4,771kWh

ΔkWh_{cool} = 18 x 100% x (1/7 – 1/14) x 210 = 270kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = (Capacity_cooling *HF* (1/EER_exist - 1/EER_ee)) ~~/ 1000~~) * CF

Where:

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

= Use actual EER rating otherwise:

Equipment Type	EERexist
PTAC	8.1EER[204]
PTHP	8.1EER[205]
SPVAC < 65kBtu/hr	9.9 EER [206]
SPVHP < 65 kBtu/hr	9.9 EER[207]

[203] Weighted based on number of residential occupied housing units in each zone.
[204] Same EER as PTAC recycling. Estimated using the IECC building energy code up until year 2003 (p107; https://law.resource.org/pub/us/code/ibr/icc.iecc.2000.pdf) and assuming a 1 ton unit; EER = 10 – (0.16 * 12,000/1,000) = 8.1.
[205] Same method to calculate EER as PTAC recycling. Estimated using the IECC building energy code up until year 2003 (p107; https://law.resource.org/pub/us/code/ibr/icc.iecc.2000.pdf) and assuming a 1 ton unit; EER = 10 – (0.16 * 12,000/1,000) = 8.1.
[206] The quoted efficiency rating in the IECC was given in EER and was translated to SEER using a conversion factor of SEER=1.1*EER.

Equipment Type	EERexist
Room AC	7.7 EER[208]
Ducted ASHP	11.2 EER [209]
No existing system	

EER_ee = Energy Efficiency Ratio of new ductless Air Source Heat Pump (kBtu/hr / kW)

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

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

= 72%%[210]

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

= 46.6%[211]

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HVC-DHP-~~V02~~V03-150601

[207] Ibid.

[208] Same EER as Window AC recycling. Based on Nexus Market Research Inc, RLW Analytics, December 2005; "Impact, Process, and Market Study of the Connecticut Appliance Retirement Program: Overall Report."

[209] 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.

[210] Based on analysis of metering results from 24 heat pumps in Ameren Illinois service territory in PY5 coincident with AIC's 2010 system peak; 'Impact and Process Evaluation of Ameren Illinois Company's Residential HVAC Program (PY5)'.

[211] 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.

5.4.2 Gas Water Heater

DESCRIPTION

This measure characterizes:

a) Time of sale or new construction:
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.

b) Early replacement:
The early removal of an existing functioning natural gas water heater 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.

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 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

Time of Sale or New Construction: 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. For 20 to 55 gallon tanks the Federal Standard is calculated as 0.675 – (0.0015 * storage size in gallons) and for tanks 55 - 100 gallon 0.8012 – (0.00078 * storage size in gallons)[212]. For a 40-gallon storage water heater this would be 0.615 EF.

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.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 13 years.[213]

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[212] Minimum Federal Standard as of 4/1/2015;
http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf

[213] 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

For early replacement: Remaining life of existing equipment is assumed to be 4 years[214].

DEEMED MEASURE COST

Time of Sale or New Construction:

The incremental capital cost for this measure is dependent on the type of water heater as listed below[215].

Early Replacement: The full installed cost is provided in the table below. The assumed deferred cost (after 4 years) of replacing existing equipment with a new baseline unit is assumed to be $~~614~~650[216]. This cost should be discounted to present value using the utility's discount rate.

Water heater Type	Incremental Cost	Full Install Cost
Gas Storage	$400	$1014
Condensing gas storage	$685	$1299
Tankless whole-house unit	$605	$1219

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

N/A

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

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.

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

[215] 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)

[216] The deemed install cost of a Gas Storage heater is based upon DCEO Efficient Living Program Data for a sample size of 157 gas water heaters, and applying inflation rate of 1.91%~~.~~

NATURAL GAS ENERGY SAVINGS

Time of Sale or New Construction:

ΔTherms = (1/ EF_{BASE} - 1/$EF_{EFFICIENT}$) * (GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0)/100,000

Early replacement[217]:

ΔTherms for remaining life of existing unit (1st 4 years):

= (1/ $EF_{EXISTING}$ - 1/$EF_{EFFICIENT}$) * (GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0)/100,000

ΔTherms for remaining measure life (next 9 years):

= (1/ EF_{BASE} - 1/$EF_{EFFICIENT}$) * (GPD * Household * 365.25 * γWater * (T_{OUT} – T_{IN}) * 1.0)/100,000

Where:

EF_Baseline = Energy Factor rating for baseline equipment

For <=55 gallons: 0.675 – (0.0015 * tank_size)

For > 55 gallons: 0.8012 – (0.00078 * tank size)

= If tank size unknown assume 40 gallons and EF_Baseline of 0.615

EF_Efficient = Energy Factor Rating for efficient equipment

= Actual. If Tankless whole-house multiply rated efficiency by 0.91[218]. 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

EF_Existing = Energy Factor rating for existing equipment

[217] 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).

[218] 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.

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

= if unknown assume 0.52 [219]

GPD = Gallons Per Day of hot water use per person

= 45.5 gallons hot water per day per household/2.59 people per household[220]

= 17.6

Household = Average number of people per household

Household Unit Type	Household
Single-Family - Deemed	2.56[221]
Multi-Family - Deemed	2.1[222]
Custom	Actual Occupancy or Number of Bedrooms[223]

365.25 = Days per year, on average

γWater = Specific Weight of water

= 8.33 pounds per gallon

T_{OUT} = Tank temperature

= 125°F

T_{IN} = Incoming water temperature from well or municipal system

= 54°F[224]

1.0 = Heat Capacity of water (1 Btu/lb*°F)

[219] Based on DCEO Efficient Living Program Data for a sample size of 157 gas water heaters.

[220] Email message from Maureen Hodgins, Research Manager for Water Research Foundation, to TAC/SAG, August 26, 2014

[221] 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

[222] Navigant, ComEd PY3 Multi-Family Home Energy Savings Program Evaluation Report Final, May 16, 2012.

[223] 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.

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

For example, a 40 gallon condensing gas storage water heater, with an energy factor of 0.80 in a single family house:

ΔTherms = (1/0.615 - 1/0.8) * (17.6 * 2.56 * 365.25* 8.33 * (125 – 54) * 1) / 100,000

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-HWE-GWHT-~~V04~~V05-150601

5.5.6 LED ~~Downlights~~Specialty Lamps

DESCRIPTION

This measure describes savings from a variety of specialty LED ~~downlight~~ lamp types (including globe, decorative and downlights). 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) a deemed split of 96% Residential and 4% Commercial assumptions should be used[225].

~~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.

Formatted: Justified, No widow/orphan control

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

While LED rated lives are often 25,000 – 50,000 hours, all installations are assumed to be 10 years[226] except for recessed downlight and track lights at 15 years~~The expected measure life is given in the following table.~~[227]

~~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~~

DEEMED MEASURE COST

The price of LED lamps is falling quickly. Where possible the actual cost should be used and compared to the

[225] RES v C&I split is based on a weighted (by sales volume) average of ComEd PY4, PY5 and PY6 and Ameren PY5 and PY6 in store intercept survey results. See 'RESvCI Split_122014.xls'.

[226] Based on recommendation in the Dunsky Energy Consulting, Livingston Energy Innovations and Opinion Dynamics Corporation; NEEP Emerging Technology Research Report: https://www.neep.org/Assets/uploads/files/emv/emv-products/NEEP_EMV_EmergingTechResearch_Report_Final.pdf, p 6-18.

[227] Limited by persistence. NEEP EMV Emerging Technologies Research Report (December 2011)

baseline cost provided below. If the incremental cost is unknown, assume the following[228][229]:

Bulb Type	LED Wattage	LED	Incandescent	Incremental Cost
Directional Lamps	< 20W	$22.42	$6.31	$16.11
	≥20W	$70.78		$64.47
Recessed downlight luminaries	All	$94.00	$4.00	$90.00
Track lights	All	$60.00	$4.00	$56.00
Decorative and Globe	<15W	$12.76	$3.92	$8.84
	≥15	$25.00		$21.08

~~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~~

LOADSHAPE

Loadshape R06 - Residential Indoor Lighting

Loadshape R07 - Residential Outdoor Lighting

COINCIDENCE FACTOR

~~The summer Peak Coincidence Factor is assumed to be 9.1% for Residential and in-unit Multi Family bulbs, 27.3% for bulbs installed in Exterior locations, and 9.4% for bulbs installed in unknown locations~~[230]~~.~~

Unlike standard lamps that could be installed in any room, certain types of specialty lamps are more likely to be found in specific rooms, which affects the coincident peak factor. Coincidence factors by bulb types are presented below[231]

[228] ~~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.~~

[229] LED lamp costs are based on VEIC review of a year's worth of LED sales data through VEIC implemented programs and the retail cost averaged (see 2015 LED Sales Review.xls) and of price reports provided to Efficiency Vermont by a number of manufacturers and retailers. Baseline cost based on "2010-2012 WA017 Ex Ante Measure Cost Study Draft Report", Itron, February 28, 2014.

[230] ~~Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.~~

[231] Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.

Formatted Table

Bulb Type	Peak CF
Three-way	0.078[232]
Dimmable	0.078[233]
Interior reflector (incl. dimmable)	0.091
Exterior reflector	0.273
Unknown reflector	0.094
Candelabra base and candle medium and intermediate base	0.121
Bug light	0.273
Post light (>100W)	0.273
Daylight	0.081
Plant light	0.081
Globe	0.075
Vibration or shatterproof	0.081
Standard Spiral >=2601 lumens, Residential, Multi-family in unit	0.071
Standard spirals >= 2601 lumens, unknown	0.081
Standard spirals >= 2601 lumens, exterior	0.273
Specialty - Generic	0.081

Algorithm

[232] Based on average of bedroom, dining room, office and living room results from the lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.

[233] Ibid

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh = ((WattsBase - WattsEE) / 1000) * ISR * (1-Leakage) * Hours * WHFe

Where:

$Watts_{base}$ = Input wattage of the existing or baseline system. Reference the table below for default values.

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	90	179	10
(medium and intermediate bases less than 750 lumens)	180	249	15
	250	349	25
	350	749	40
Decorative	70	89	10
(Shapes B, BA, C, CA, DC, F, G,	90	149	15

Bulb Type	Lower Lumen Range	Upper Lumen Range	WattsBase
medium and intermediate bases less than 750 lumens)	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

Directional Lamps -

For Directional R, BR, and ER lamp types[234]:

Bulb Type	Lower Lumen Range	Upper Lumen Range	$Watts_{Base}$
R, ER, BR with medium screw bases w/ diameter >2.25" (*see exceptions below)	420	472	40
	473	524	45
	525	714	50
	715	937	65
	938	1259	75
	1260	1399	90
	1400	1739	100
	1740	2174	120

[234] From pg 11 of the Energy Star Specification for lamps v1.1

Bulb Type	Lower Lumen Range	Upper Lumen Range	$Watts_{Base}$
	2175	2624	150
	2625	2999	175
	3000	4500	200
*R, BR, and ER with medium screw bases w/ diameter <=2.25"	400	449	40
	450	499	45
	500	649	50
	650	1199	65
*ER30, BR30, BR40, or ER40	400	449	40
	450	499	45
	500	649	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	30

Directional lamps are exempt from EISA regulations.

For PAR, MR, and MRX Lamps Types:

For these highly focused directional lamp types, it is necessary to have Center Beam Candle Power (CBCP) and beam angle measurements to accurately estimate the equivalent baseline wattage. The formula below is based on the Energy Star Center Beam Candle Power tool.[235] If CBCP and beam angle information are not available or if the equation below returns a negative value (or undefined), use the manufacturer's recommended baseline wattage equivalent.[236] ~~, refer to the R, BR, and ER lumen based method above.~~

Wattsbase =

$$375.1 - 4.355(D) - \sqrt{227{,}800 - 937.9(D) - 0.9903(D^2) - 1479(BA) - 12.02(D * BA) + 14.69(BA^2) - 16{,}720 * \ln(CBCP)}$$

Where:

D = Bulb diameter (e.g. for PAR20 D = 20)

BA = Beam angle

[235] http://energystar.supportportal.com/link/portal/23002/23018/Article/32655/

[236] The Energy Star Center Beam Candle Power tool does not accurately model baseline wattages for lamps with certain bulb characteristic combinations – specifically for lamps with very high CBCP.

CBCP = Center beam candle power

The result of the equation above should be rounded DOWN to the nearest wattage established by Energy Star:

Diameter	Permitted Wattages
16	20, 35, 40, 45, 50, 60, 75
20	50
30S	40, 45, 50, 60, 75
30L	50, 75
38	40, 45, 50, 55, 60, 65, 75, 85, 90, 100, 120, 150, 250

EISA non-exempt bulb types:

Bulb Type	Lower Lumen Range	Upper Lumen Range	Incandescent Equivalent Post-EISA 2007 (WattsBase)
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	29
	750	1049	43
	1050	1489	53
	1490	2600	72

$Watts_{EE}$ = Actual wattage of LED purchased / installed. ~~If unknown, use default provided below:~~

~~ENERGY STAR Minimum Luminous Efficacy = 40Lm/W for lamps with rated wattages less than 20Wand 50 Lm/W for lamps with rated wattages >= 20 watts~~[237]~~.~~

~~For Directional R, BR, and ER lamp types~~[238]~~:~~

[237] ~~From pg 10 of the Energy Star Specification for lamps v1.1~~
[238] ~~From pg 11 of the Energy Star Specification for lamps v1.1~~

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~~Bulb~~	~~Lo~~	~~Up~~	~~Watt~~	~~Lumen~~	~~LED~~	~~De~~
~~R, ER,~~	~~420~~	~~472~~	~~40~~	~~446~~	~~11~~	~~29~~
	~~473~~	~~524~~	~~45~~	~~499~~	~~12~~	~~33~~
	~~525~~	~~714~~	~~50~~	~~620~~	~~15~~	~~35~~
	~~715~~	~~937~~	~~65~~	~~826~~	~~21~~	~~44~~
	~~938~~	~~125~~	~~75~~	~~1099~~	~~22~~	~~53~~

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~~Bulb~~	~~Lo~~	~~Up~~	~~Watt~~	~~Lumen~~	~~LED~~	~~De~~
	~~126~~	~~139~~	~~90~~	~~1330~~	~~27~~	~~63~~
	~~140~~	~~173~~	~~100~~	~~1570~~	~~31~~	~~69~~
	~~174~~	~~217~~	~~120~~	~~1957~~	~~39~~	~~81~~
	~~217~~	~~262~~	~~150~~	~~2400~~	~~48~~	~~10~~

~~Bulb~~	~~Lo~~	~~Up~~	~~Watt~~	~~Lumen~~	~~LED~~	~~De~~
	~~262~~	~~299~~	~~175~~	~~2812~~	~~56~~	~~11~~
	~~300~~	~~450~~	~~200~~	~~3750~~	~~75~~	~~12~~

~~Bulb~~	~~Lo~~	~~Up~~	~~Watt~~	~~Lumen~~	~~LED~~	~~De~~

~~Bulb~~	~~Lo~~	~~Up~~	~~Watt~~	~~Lumen~~	~~LED~~	~~De~~

~~Bulb~~	~~Lo~~	~~Up~~	~~Watt~~	~~Lumen~~	~~LED~~	~~De~~

~~Bulb~~	~~Lo~~	~~Up~~	~~Watt~~	~~Lumen~~	~~LED~~	~~De~~

~~Bulb~~	~~Lo~~	~~Up~~	~~Watt~~	~~Lumen~~	~~LED~~	~~De~~

~~Bulb~~	~~Lo~~	~~Up~~	~~Watt~~	~~Lumen~~	~~LED~~	~~De~~
~~*R,~~	~~400~~	~~449~~	~~40~~	~~425~~	~~11~~	~~29~~
	~~450~~	~~499~~	~~45~~	~~475~~	~~12~~	~~33~~
	~~500~~	~~649~~	~~50~~	~~575~~	~~14~~	~~36~~
	~~650~~	~~119~~	~~65~~	~~925~~	~~23~~	~~42~~

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~~Bulb~~	~~Lo~~	~~Up~~	~~Watt~~	~~Lumen~~	~~LED~~	~~De~~

~~Bulb~~	~~Lo~~	~~Up~~	~~Watt~~	~~Lumen~~	~~LED~~	~~De~~

~~Bulb~~	~~Lo~~	~~Up~~	~~Watt~~	~~Lumen~~	~~LED~~	~~De~~

~~Bulb~~	~~Lo~~	~~Up~~	~~Watt~~	~~Lumen~~	~~LED~~	~~De~~

~~Bulb~~	~~Lo~~	~~Up~~	~~Watt~~	~~Lumen~~	~~LED~~	~~De~~

~~Bulb~~	~~Lo~~	~~Up~~	~~Watt~~	~~Lumen~~	~~LED~~	~~De~~
~~*ER30,~~	~~400~~	~~449~~	~~40~~	~~425~~	~~11~~	~~29~~
	~~450~~	~~499~~	~~45~~	~~475~~	~~12~~	~~33~~
	~~500~~	~~649~~	~~50~~	~~575~~	~~14~~	~~36~~

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~~Bulb~~	~~Lo~~	~~Up~~	~~Watt~~	~~Lumen~~	~~LED~~	~~De~~

~~Bulb~~	~~Lo~~	~~Up~~	~~Watt~~	~~Lumen~~	~~LED~~	~~De~~
~~*BR30~~	~~650~~	~~141~~	~~65~~	~~1035~~	~~21~~	~~44~~

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~~Bulb~~	~~Lo~~	~~Up~~	~~Watt~~	~~Lumen~~	~~LED~~	~~De~~

~~Bulb~~	~~Lo~~	~~Up~~	~~Watt~~	~~Lumen~~	~~LED~~	~~De~~
~~*R20~~	~~400~~	~~449~~	~~40~~	~~425~~	~~11~~	~~29~~
	~~450~~	~~719~~	~~45~~	~~585~~	~~15~~	~~30~~
~~*All~~	~~200~~	~~299~~	~~20~~	~~250~~	~~6~~	~~14~~

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~~Bulb~~	~~Lo~~	~~Up~~	~~Watt~~	~~Lumen~~	~~LED~~	~~De~~
	~~300~~	~~39~~	~~30~~	~~350~~	~~9~~	~~21~~

~~Bulb~~	~~Lo~~	~~Up~~	~~Watt~~	~~Lumen~~	~~LED~~	~~De~~

~~Bulb~~	~~Lo~~	~~Up~~	~~Watt~~	~~Lumen~~	~~LED~~	~~De~~

~~Bulb~~	~~Lo~~	~~Up~~	~~Watt~~	~~Lumen~~	~~LED~~	~~De~~

~~Bulb~~	~~Lo~~	~~Up~~	~~Watt~~	~~Lumen~~	~~LED~~	~~De~~

~~Bulb~~	~~Lo~~	~~Up~~	~~Watt~~	~~Lumen~~	~~LED~~	~~De~~

~~Directional lamps are exempt from EISA regulations.~~

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~~For PAR, MR, and MRX Lamps Types:~~

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~~For these highly focused directional lamp types, it is necessary to have Center Beam Candle Power (CBCP) and beam angle measurements to accurately estimate the equivalent baseline wattage. The formula below is based on the Energy Star Center Beam Candle Power tool.[239] If CBCP and beam angle information are not available, refer to the R, BR, and ER lumen based method above.~~

~~Wattsbase =~~

$$\cancel{375.1 - 4.355(D) - \sqrt{227{,}800 - 937.9(D) - 0.9903(D^2) - 1479(BA) - 12.02(D * BA) + 14.69(BA^2) - 16{,}720 * \ln(CBCP)}}$$

~~Where:~~

~~D = Bulb diameter (e.g. for PAR20 D = 20)~~

~~BA = Beam angle~~

~~CBCP = Center beam candle power~~

~~The result of the equation above should be rounded DOWN to the nearest wattage established by Energy Star:~~

~~Diameter~~	~~Permitted Wattages~~
~~16~~	~~20, 35, 40, 45, 50, 60, 75~~
~~20~~	~~50~~
~~30S~~	~~40, 45, 50, 60, 75~~
~~30L~~	~~50, 75~~
~~38~~	~~40, 45, 50, 55, 60, 65, 75, 85, 90, 100, 120, 150, 250~~

ISR = In Service Rate or the percentage of units rebated that get installed[~~240~~]

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Program	Bulb Type	ISR
Retail (Time of Sale)	Recessed downlight luminaries and Track Lights	~~1.0~~100%[241]
	~~Track lights~~All other lamps	~~1.0~~95%
Direct Install	All lamps	96.9%[242]

~~[239] http://energystar.supportportal.com/link/portal/23002/23018/Article/32655/~~
~~[240] NEEP EMV Emerging Technologies Research Report (December 2011)~~
[241] NEEP EMV Emerging Technologies Research Report (December 2011)
[242] 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.

Leakage = Adjustment to account for the percentage of bulbs purchased that move out (and in if deemed appropriate) of the Utility Jurisdiction.

Upstream (TOS) Lighting programs = Determined through evaluation[243].

All other programs = 0

Hours = Average hours of use per year [244] ~~r~~

~~Installation Location~~	~~Hours~~[245]
~~Residential and in-unit Multi Family~~	~~861~~
~~Unknown location~~	~~891~~
~~Exterior~~	~~2475~~

Bulb Type	Annual hours of use (HOU)
Three-way	850
Dimmable	850
Interior reflector (incl. dimmable)	861
Exterior reflector	2475
Unknown reflector	891
Candelabra base and candle medium and intermediate base	1190
Bug light	2475
Post light (>100W)	2475
Daylight	847

http://www.icc.illinois.gov/downloads/public/edocket/287090.pdf.

243 Using a leakage estimate from the current program year evaluation, from past evaluation results, or a rolling average of leakage estimates from previous years.

244 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. Values for Reflector, Decorative and Globe are taken directly from the lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation. All other hours have been updated based on the room specific hours of use from the PY5/PY6 logger study.

~~245 Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluations.~~

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Bulb Type	Annual hours of use (HOU)
Plant light	847
Globe	639
Vibration or shatterproof	847
Standard Spiral >2601 lumens, Residential, Multi Family in-unit	759
Standard Spiral >2601 lumens, unknown	847
Standard Spiral >2601 lumens, Exterior	2475
Specialty – Generic Interior	847
Specialty – Generic Exterior	2475

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 [246]
Multi family in unit	1.04 [247]
Exterior or uncooled location	1.0

For example, a 13W PAR20 LED is installed in place of a 750 lumen PAR20 incandescent screw-in lamp with medium screw base, diameter >2.5", installed in single family interior location:

$$\Delta kWh = ((45 - 13) / 1000) * 0.95 * 861 * 1.06$$

$$= 27.7 \text{ kWh}$$

[246] 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)

[247] 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

HEATING PENALTY

If electric heated home (if heating fuel is unknown assume gas, see Natural Gas section):

ΔkWh[248] = - (((WattsBase - WattsEE) / 1000) * ISR * Hours * HF) / ηHeat

Where:

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

= 49%[249] for interior or unknown location

= 0% for exterior location

ηHeat = Efficiency in COP of Heating equipment

= Actual. If not available use:[250]

System Type	Age of Equipment	HSPF Estimate	ηHeat (COP Estimate)
Heat Pump	Before 2006	6.8	2.00
	After 2006 - 2014	7.7	2.26
	2015 on	8.2	2.40
Resistance	N/A	N/A	1.00

For example, a 13W PAR20 LED is installed in place of a 750 lumen PAR20 incandescent screw-in lamp with medium screw base, diameter >2.5",installed in single family interior location:

ΔkWh = - ((45 - 13) / 1000) * 0.95 * 861 * 0.49) / 2.26

5.67 kWh

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.

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

[249] 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.

[250] 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.

Bulb Location	WHFd
Interior single family or unknown location	1.11[251]
Multi family in unit	1.07[252]
Exterior or uncooled location	1.0

CF = Summer Peak Coincidence Factor for measure, see above for values.[253]

Bulb Type	Peak CF
Three-way	0.078[254]
Dimmable	0.078[255]
Interior reflector (incl. dimmable)	0.091
Exterior reflector	0.273
Unknown reflector	0.094
Candelabra base and candle medium and intermediate base	0.121
Bug light	0.273
Post light (>100W)	0.273
Daylight	0.081
Plant light	0.081
Globe	0.075
Vibration or shatterproof	0.081
Standard Spiral >=2601 lumens, Residential, Multi-family in unit	0.071

[251] 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.

[252] 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.

[253] Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.

[254] Based on average of bedroom, dining room, office and living room results from the lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.

[255] Ibid

Bulb Type	Peak CF
Standard spirals >= 2601 lumens, unknown	0.081
Standard spirals >= 2601 lumens, exterior	0.273
Specialty - Generic	0.081

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~~Bulb Location~~	~~CF~~[256]
~~Interior single family or Multi-family in unit~~	~~9.1%~~
~~Unknown Location~~	~~9.4%~~
~~Exterior Locations~~	~~27.3%~~

Other factors as defined above

For example, a 13W PAR20 LED is installed in place of a 750 lumen PAR20 incandescent screw-in lamp with medium screw base, diameter >2.5", installed in single family interior location:

ΔkW = ((45 - 13) / 1000) * 0.95 * 1.11* 0.091

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

Where:

HF = Heating factor, or percentage of lighting savings that must be replaced by heating system.

= 49% [257] for interior or unknown location

= 0% for exterior location

0.03412 = Converts kWh to Therms

ηHeat = Average heating system efficiency.

~~[256] Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.~~

[257] Average result from REMRate modeling of several different configurations and IL locations of homes

= 0.70 [258]

Other factors as defined above

For example, a 13W PAR20 LED is installed in place of a 750 lumen PAR20 incandescent screw-in lamp with medium screw base, diameter >2.5", installed in single family interior location with gas heating at 70% total efficiency:

Δtherms = - (((45 - 13) / 1000) * 0.95 * 861 * 0.49* 0.03412) / 0.70

= - 0.63 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:~~For those bulbs types exempt from EISA (except for reflectors) the following O&M assumptions should be used: Life of the baseline bulb is assumed to be 1.32 year[259]; baseline replacement cost is assumed to be $3.5[260].

For reflectors ~~T~~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 Replacement Cost
PAR20, PAR30, PAR38 screw-in lamps	2000	2.0	$4.00
MR16/PAR16 pin-based lamps	2000	2.0	$3.00
Recessed downlight luminaries	2000	2.0	$4.00

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[258] 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

[259] Assuming 1000 hour rated life for incandescent bulb: 1000/759 = 1.32

[260] NEEP Residential Lighting Survey, 2011

Lamp Type	Baseline Lamp Life (hours)	Baseline Life (Single Family and in unit Multifamily - 1010 hours)	Baseline Replacement Cost
Track lights	2000	2.0	$4.00

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For non-exempt EISA bulb types defined above, the following O&M assumptions should be used: Life of the baseline bulb is assumed to be 1.32 year[261]; baseline replacement cost is assumed to be $5[262].

MEASURE CODE: RS-LTG-LEDD-~~V04~~V05-150601

[261] Assuming 1000 hour rated life for halogen bulb: 1000/759 = 1.32
[262] NEEP Residential Lighting Survey, 2011

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.[263]

DEEMED MEASURE COST

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

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.

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

= 68%[264]

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

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

[264] Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

= 72%%[265]

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

= 46.6%[266]

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:[267]

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

[265] Based on analysis of metering results from 24 heat pumps in Ameren Illinois service territory in PY5 coincident with AIC's 2010 system peak; 'Impact and Process Evaluation of Ameren Illinois Company's Residential HVAC Program (PY5)'.

[266] 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.

[267] 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
	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[268]:

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 [269]

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[270]:

Age of Equipment	SEER Estimate

[268] National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 65°F.
[269] 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.
[270] 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	SEER Estimate
Before 2006	10
2006 - 2014	13
Central AC After 1/1/2015	13
Heat Pump After 1/1/2015	14

LM = Latent multiplier to account for latent cooling demand[271]

~~= dependent on location:[272]~~

~~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~~

Climate Zone (City based upon)	LM
1 (Rockford)	3.3
2 (Chicago)	3.2
3 (Springfield)	3.7
4 (St Louis, MO)	3.6
5 (Paducah, KY)	3.7

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[271] Derived by calculating the sensible and total loads in each hour. For more information see Bruce Harley, CLEAResult "Infiltration Factor Calculations Methodology.doc".

~~[272] 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.~~

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:[273]

	# 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:[274]

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

[273] 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.

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

ηHeat = Efficiency of heating system

= Actual. If not available refer to default table below[275]:

System Type	Age of Equipment	HSPF Estimate	ηHeat (Effective COP Estimate)= (HSPF/3.413)*0.85
Heat Pump	Before 2006	6.8	1.7
	2006 - 2014	7.7	1.92
	2015 on	8.2	2.40
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~~3.5] + [((3,400 – 2,250) / 17.8)) * 60 * 24 * 6339 * 0.018 / (1.92 * 3,412)]

= ~~501~~283 + 1620

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%[276]

275 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.

276 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.

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[277]:

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)

= 68%[278]

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

= 72%%[279]

[277] 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.

[278] Based on metering of 24 homes with central AC during PY4 and PY5 in Ameren Illinois service territory.

[279] Based on analysis of metering results from 24 heat pumps in Ameren Illinois service territory in PY5 coincident with AIC’s 2010 system peak; ‘Impact and Process Evaluation of Ameren Illinois Company’s Residential HVAC Program (PY5)’.

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

= 46.6%[280]

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~~283 / 570 * 0.68

= 0.~~60~~34 kW

ΔkW_{PJM} = 283~~501~~ / 570 * 0.466

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[281]:

	# 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[282]:

[280] 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.

[281] 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.

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[283]. If not available use 70%[284].

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)

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

[282] 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..

[283] 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.

[284] 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

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