### Air Source Heat Pump

###### Description

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

This measure characterizes:

1. Time of Sale:
   1. 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.
2. Early Replacement:

Early Replacement determination will be based on meeting the following conditions:

* + - The existing unit is operational when replaced, or
    - The existing unit requires minor repairs (<$918)[[1]](#footnote-1).
    - All other conditions will be considered Time of Sale.

The Baseline SEER of the existing unit replaced:

* + - If the SEER of the existing unit is known and <=10, the Baseline SEER is the actual SEER value of the unit replaced. If the SEER is >10, the Baseline SEER = 14.
    - If the SEER of the existing unit is unknown and the install date of the existing unit is <2007, the Baseline SEER = 10.
    - If the operational status, repair cost or SEER of the existing unit is unknown, the Baseline SEER = 14.

A weighted average early replacement rate is provided for use when the actual baseline early replacement rates are unknown.[[2]](#footnote-2)

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.

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.[[3]](#footnote-3)

Remaining life of existing equipment is assumed to be 6 years.[[4]](#footnote-4)

###### Deemed Measure Cost

Time of sale: The incremental capital cost for this measure is dependent on the efficiency of the new unit[[5]](#footnote-6).

|  |  |
| --- | --- |
| **Efficiency (SEER)** | **Incremental Cost** |
| 15 | $849 |
| 16 | $1701 |
| 17 | $2209 |
| 18 | $2797 |

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[[6]](#footnote-8):

|  |  |
| --- | --- |
| **Efficiency (SEER)** | **Full Retrofit Cost (including labor)** |
| 15 | $5,437 |
| 16 | $6,289 |
| 17 | $6,797 |
| 18 | $7,385 |

Assumed deferred cost (after 6 years) of replacing existing equipment with new baseline unit is assumed to be $4,588 [[7]](#footnote-9). 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.

CFSSP SF = Summer System Peak Coincidence Factor for Heat Pumps in single-family homes (during utility peak hour)

= 72%%[[8]](#footnote-10)

CFPJM SF  = PJM Summer Peak Coincidence Factor for Heat Pumps in single-family homes (average during PJM peak period)

= 46.6%[[9]](#footnote-11)

CFSSP, MF = Summer System Peak Coincidence Factor for Heat Pumps in multi-family homes (during system peak hour)

= 57%[[10]](#footnote-12)

CFPJM, MF = PJM Summer Peak Coincidence Factor for Heat Pumps in multi-family homes (average during peak period)

= 22.5%9

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[[11]](#footnote-13):

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)

Where:

FLH\_cooling = Full load hours of air conditioning

= dependent on location:

|  |  |  |  |
| --- | --- | --- | --- |
| **Climate Zone**  **(City based upon)** | **FLH\_cooling (single family) [[12]](#footnote-15)** | **FLH\_cooling (general multi family)** [[13]](#footnote-16) | **FLH\_cooling (weatherized multi family)** [[14]](#footnote-17) |
| 1 (Rockford) | 512 | 467 | 243 |
| 2 (Chicago) | 570 | 506 | 263 |
| 3 (Springfield) | 730 | 663 | 345 |
| 4 (Belleville) | 1,035 | 940 | 489 |
| 5 (Marion) | 903 | 820 | 426 |
| Weighted Average[[15]](#footnote-18) | 629 | 564 | 293 |

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[[16]](#footnote-19)** |
| Air Source Heat Pump | 9.12 |
| Central AC | 8.60 |
| No central cooling[[17]](#footnote-20) | Make ‘1/SEER\_exist’ = 0 |

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

= 14 [[18]](#footnote-21)

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 and home type:

|  |  |  |
| --- | --- | --- |
| **Climate Zone**  **(City based upon)** | **FLH\_heat[[19]](#footnote-23)** | **FLH heat (weatherized multi family)** |
| 1 (Rockford) | 1,969 | 748 |
| 2 (Chicago) | 1,840 | 699 |
| 3 (Springfield) | 1,754 | 667 |
| 4 (Belleville) | 1,266 | 481 |
| 5 (Marion) | 1,288 | 489 |
| Weighted Average[[20]](#footnote-24) | 1,821 | 692 |

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

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

HSPF\_exist =Heating System Performance Factor[[21]](#footnote-25) 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** |
| Air Source Heat Pump | 5.44 [[22]](#footnote-26) |
| Electric Resistance | 3.41[[23]](#footnote-27) |

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

= 8.2 [[24]](#footnote-28)

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 a single family home 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 a single family home in Marion:

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

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

= 4769 kWh

ΔkWH for remaining measure life (next 12 years):

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

= 657 kWh

###### Summer Coincident Peak Demand Savings

Time of sale:

ΔkW = (Capacity\_cooling \* (1/EER\_base - 1/EER\_ee)) / 1000) \* CF

Early replacement[[25]](#footnote-29):

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\_exist2) + (1.12 \* SEER\_exist) [[26]](#footnote-30)

If SEER or EER rating unavailable use:

|  |  |
| --- | --- |
| **Existing Cooling System** | **EER\_exist[[27]](#footnote-31)** |
| Air Source Heat Pump | 8.55 |
| Central AC | 8.15 |
| No central cooling[[28]](#footnote-32) | Make ‘1/EER\_exist’ = 0 |

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

= 11.8 [[29]](#footnote-33)

EER\_ee = Energy Efficiency Ratio of efficient Air Source Heat Pump (kBtu/hr / kW)

= Actual, If not provided convert SEER to EER using this formula:[[30]](#footnote-34)

= (-0.02 \* SEER\_ee2) + (1.12 \* SEER\_ee)

CFSSP SF = Summer System Peak Coincidence Factor for Heat Pumps in single-family homes (during system peak hour)

= 72%%[[31]](#footnote-35)

CFPJM SF = PJM Summer Peak Coincidence Factor for Heat Pumps in single-family homes (average during peak period)

= 46.6%[[32]](#footnote-36)

CFSSP, MF = Summer System Peak Coincidence Factor for Heat Pumps in multi-family homes (during system peak hour)

= 57%[[33]](#footnote-37)

CFPJM, MF = PJM Summer Peak Coincidence Factor for Heat Pumps in multi-family homes (average during peak period)

= 22.5%35

Time of Sale:

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

ΔkWSSP = ((36,000 \* (1/11.8 – 1/12)) / 1000) \* 0.72

= 0.037 kW

ΔkWPJM = ((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 single-family home in Marion:

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

= ((36,000 \* (1/8.55 - 1/12)) / 1000) \* 0.72

= 0.872 kW

ΔkWSSP for remaining measure life (next 12 years):

= ((36,000 \* (1/11.8 – 1/12)) / 1000) \* 0.72

= 0.037 kW

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

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

= 0.564 kW

ΔkWPJM for remaining measure life (next 12 years):

= ((36,000 \* (1/11.8 – 1/12)) / 1000) \* 0.466

= 0.024 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-V05-160601

1. The Technical Advisory Committee agreed that if the cost of repair is less than 20% of the new baseline replacement cost it can be considered early replacement. [↑](#footnote-ref-1)
2. 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. [↑](#footnote-ref-2)
3. 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> [↑](#footnote-ref-3)
4. Assumed to be one third of effective useful life [↑](#footnote-ref-4)
5. PY7 HVAC and Ductless Mini-Split Heat Pump Incremental Cost Analysis memo to Ameren Illinois and ICC Staff dated November 18, 2015, assuming 3-ton unit. [↑](#footnote-ref-6)
6. PY7 HVAC and Ductless Mini-Split Heat Pump Incremental Cost Analysis memo to Ameren Illinois and ICC Staff dated November 18, 2015, assuming 3-ton unit. [↑](#footnote-ref-8)
7. Implied by subtracting incremental cost from the higher SEER unit full cost. [↑](#footnote-ref-9)
8. 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)’. [↑](#footnote-ref-10)
9. 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. [↑](#footnote-ref-11)
10. *All-Electric Homes PY6 Metering Results: Multifamily HVAC Systems*, Cadmus, October 2015 [↑](#footnote-ref-12)
11. 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). [↑](#footnote-ref-13)
12. 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. [↑](#footnote-ref-15)
13. Ibid. [↑](#footnote-ref-16)
14. *All-Electric Homes PY6 Metering Results: Multifamily HVAC Systems*, Cadmus, October 2015 [↑](#footnote-ref-17)
15. Weighted based on number of occupied residential housing units in each zone. [↑](#footnote-ref-18)
16. Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren PY3-PY4. [↑](#footnote-ref-19)
17. 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. [↑](#footnote-ref-20)
18. 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. [↑](#footnote-ref-21)
19. 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. [↑](#footnote-ref-23)
20. Weighted based on number of occupied residential housing units in each zone. [↑](#footnote-ref-24)
21. 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 [↑](#footnote-ref-25)
22. 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. [↑](#footnote-ref-26)
23. Electric resistance has a COP of 1.0 which equals 1/0.293 = 3.41 HSPF. [↑](#footnote-ref-27)
24. 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 [↑](#footnote-ref-28)
25. 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). [↑](#footnote-ref-29)
26. From Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder. [↑](#footnote-ref-30)
27. Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren PY3-PY4. [↑](#footnote-ref-31)
28. 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. [↑](#footnote-ref-32)
29. 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. [↑](#footnote-ref-33)
30. 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. [↑](#footnote-ref-34)
31. 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)’. [↑](#footnote-ref-35)
32. 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. [↑](#footnote-ref-36)
33. *All-Electric Homes PY6 Metering Results: Multifamily HVAC Systems*, Cadmus, October 2015 [↑](#footnote-ref-37)