### Ductless Heat Pumps

**Description**

This measure is designed to calculate electric savings for supplementing existing electric HVAC systems with ductless mini-split heat pumps (DMSHPs). DMSHPs save energy in heating mode because they provide heat more efficiently than electric resistance heat and central ASHP systems. Additionally, DMSHPs use less fan energy to move heat and don’t incur heat loss through a duct distribution system. Often DMSHPs are installed in addition to (do not replace) existing heating equipment because at extreme cold conditions, many DMSHPs cannot provide enough heating capacity, although cold-climate heat pumps can continue to perform at sub-zero temperatures.

For cooling, the proposed savings calculations are aligned with those of typical replacement systems. DHPs save energy in cooling mode because they provide cooling capacity more efficiently than other types of unitary cooling equipment. A DMSHP installed in a home with a central ASHP system will save energy by offsetting some of the cooling energy of the ASHP. 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.[[1]](#footnote-2)

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 program minimum efficiency requirements.

**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.

**Deemed Lifetime of Efficient Equipment**

The expected measure life is assumed to be 18 years[[2]](#footnote-3).

**Deemed Measure Cost**

The incremental cost for this measure is the full installation cost, as is provided below: [[3]](#footnote-4)

|  |  |  |
| --- | --- | --- |
| **Unit Capacity (BTU/h)** | **Equivalent Capacity (tons)** | **Total Installation Cost** |
| 12,000 | 1.00 | $3,051 |
| 15,000 | 1.25 | $4,093 |
| 18,000 | 1.50 | $5,182 |
| 20,000 | 1.67 | $5,897 |
| 22,000 | 1.83 | $6,637 |
| 24,000 | 2.00 | $7,310 |
| 28,000 | 2.33 | $8,209 |
| 35,000 | 2.92 | $10,814 |

**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 metering data for 40 DHPs in Ameren Illinois service territory[[4]](#footnote-5).

CFSSP = Summer System Peak Coincidence Factor for DMSHP (during utility peak hour)

= 43.1%%[[5]](#footnote-6)

CFPJM = PJM Summer Peak Coincidence Factor for DMSHP (average during PJM peak period)

= 28.0%[[6]](#footnote-7)

**Algorithms**

**Calculation of Savings**

**Electric Energy Savings**

Electric savings

ΔkWh = ΔkWhheat + ΔkWhcool

ΔkWhheat = (Capacityheat \* EFLHheat \* (1/HSPFexist - 1/HSPFee)) / 1000

ΔkWhcool = (Capacitycool\* EFLHcool \*(1/SEERexist - 1/SEERee)) / 1000

Where:

Capacityheat  = Heating capacity of the ductless heat pump unit in Btu/hr

= Actual

EFLHheat = Equivalent Full Load Hours for heating. Depends on location. See table below

|  |  |
| --- | --- |
| **Climate Zone (City based upon)** | **EFLHheat[[7]](#footnote-8)** |
| 1 (Rockford) | 1,520 |
| 2 (Chicago) | 1,421 |
| 3 (Springfield) | 1,347 |
| 4 (Belleville) | 977 |
| 5 (Marion) | 994 |
| Weighted Average | 1,406 |

HSPFexist = HSPF rating of existing equipment (kbtu/kwh)

| **Existing Equipment Type** | **HSPFexist** |
| --- | --- |
| Electric resistance heating | 3.412[[8]](#footnote-9) |
| Air Source Heat Pump | 5.44[[9]](#footnote-10) |

HSPFee = HSPF rating of new equipment (kbtu/kwh)

= Actual installed

Capacitycool = the cooling capacity of the ductless heat pump unit in Btu/hr[[10]](#footnote-11).

= Actual installed

SEERee = SEER rating of new equipment (kbtu/kwh)

= Actual installed[[11]](#footnote-12)

SEERexist = SEER rating of existing equipment (kbtu/kwh)

= Use actual value. If unknown, see table below

|  |  |
| --- | --- |
| **Existing Cooling System** | **SEER\_exist[[12]](#footnote-13)** |
| Air Source Heat Pump | 9.12 |
| Central AC | 8.60 |
| Room AC | 8.0[[13]](#footnote-14) |
| No existing cooling[[14]](#footnote-15) | Make ‘1/SEER\_exist’ = 0 |

EFLHcool = Equivalent Full Load Hours for cooling. Depends on location. See table below[[15]](#footnote-16).

| **Climate Zone**  **(City based upon)** | **EFLHcool** |
| --- | --- |
| 1 (Rockford) | 323 |
| 2 (Chicago) | 308 |
| 3 (Springfield) | 468 |
| 4 (Belleville) | 629 |
| 5 (Marion) | 549 |
| Weighted Average[[16]](#footnote-17) | 364 |

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 of unknown efficiency, savings are:

ΔkWhheat = (18000 \* 1421 \* (1/3.412 – 1/8))/1000 = 4,299 kWh

ΔkWhcool = (18000 \* 308 \*(1/8.0 – 1/14)) /1000 = 297 kWh

ΔkWh = 4,299 + 297 = 4,596 kWh

**Summer Coincident Peak Demand Savings**

ΔkW = (Capacitycool \* (1/EERexist - 1/EERee)) / 1000) \* CF

Where:

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

= Use actual EER rating otherwise:

|  |  |
| --- | --- |
| **Existing Cooling System** | **EER\_exist** |
| Air Source Heat Pump | 8.55**[[17]](#footnote-18)** |
| Central AC | 8.15[[18]](#footnote-19) |
| Room AC | 7.7 EER[[19]](#footnote-20) |
| No existing cooling[[20]](#footnote-21) | Make ‘1/EER\_exist’ = 0 |

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: [[21]](#footnote-22)

= (-0.02 \* SEER2) + (1.12 \* SEER)

CFSSP = Summer System Peak Coincidence Factor for DMSHP (during system peak hour)

= 43.1%%[[22]](#footnote-23)

CFPJM = PJM Summer Peak Coincidence Factor for DMSHP (average during peak period)

= 28.0%[[23]](#footnote-24)

**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-V03-160601**

1. 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. [↑](#footnote-ref-2)
2. Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, Inc., June 2007 [↑](#footnote-ref-3)
3. Cadmus, Opinion Dynamics; ‘PY7 HVAC and Ductless Mini-Split Heat Pump Incremental Cost Analysis’ memo to Ameren Illinois and ICC Staff dated September 4, 2015 [↑](#footnote-ref-4)
4. *All-Electric Homes PY6 Metering Results: Multifamily HVAC Systems*, Cadmus, October 2015 [↑](#footnote-ref-5)
5. 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-6)
6. 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-7)
7. *All-Electric Homes PY6 Metering Results: Multifamily HVAC Systems*, Cadmus, October 2015. FLH values are based on metering of multi-family units that were used as the primary heating source to the whole home, and in buildings that had received weatherization improvements. A DHP installed in a single-family home may be used more sporadically, especially if the DHP serves only a room, and buildings that have not been weatherized may require longer hours. Additional evaluation is recommended to refine the EFLH assumptions for the general population. [↑](#footnote-ref-8)
8. Electric resistance has a COP of 1.0 which equals 1/0.293 = 3.41 HSPF. [↑](#footnote-ref-9)
9. 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. [↑](#footnote-ref-10)
10. 1 Ton = 12 kBtu/hr [↑](#footnote-ref-11)
11. Note that if only an EER rating is available, use the following conversion equation; EER\_base = (-0.02 \* SEER\_base2) + (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. [↑](#footnote-ref-12)
12. Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren PY3-PY4. [↑](#footnote-ref-13)
13. Estimated by converting the EER assumption using the conversion equation; EER\_base = (-0.02 \* SEER\_base2) + (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. [↑](#footnote-ref-14)
14. If there is no existing cooling in place but the incentive encourages installation of a new DMSHP with cooling, the added cooling load should be subtracted from any heating benefit. [↑](#footnote-ref-15)
15. *All-Electric Homes PY6 Metering Results: Multifamily HVAC Systems*, Cadmus, October 2015. FLH values are based on metering of multi-family units, and in buildings that had received weatherization improvements.Additional evaluation is recommended to refine the EFLH assumptions for the general population. [↑](#footnote-ref-16)
16. Weighted based on number of residential occupied housing units in each zone. [↑](#footnote-ref-17)
17. Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren PY3-PY4. [↑](#footnote-ref-18)
18. Average nameplate efficiencies of all Early Replacement qualifying equipment in Ameren PY3-PY4. [↑](#footnote-ref-19)
19. 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.” [↑](#footnote-ref-20)
20. If there is no central cooling in place but the incentive encourages installation of a new DMSHP with cooling, the added cooling load should be subtracted from any heating benefit. [↑](#footnote-ref-21)
21. 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-22)
22. 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-23)
23. 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-24)