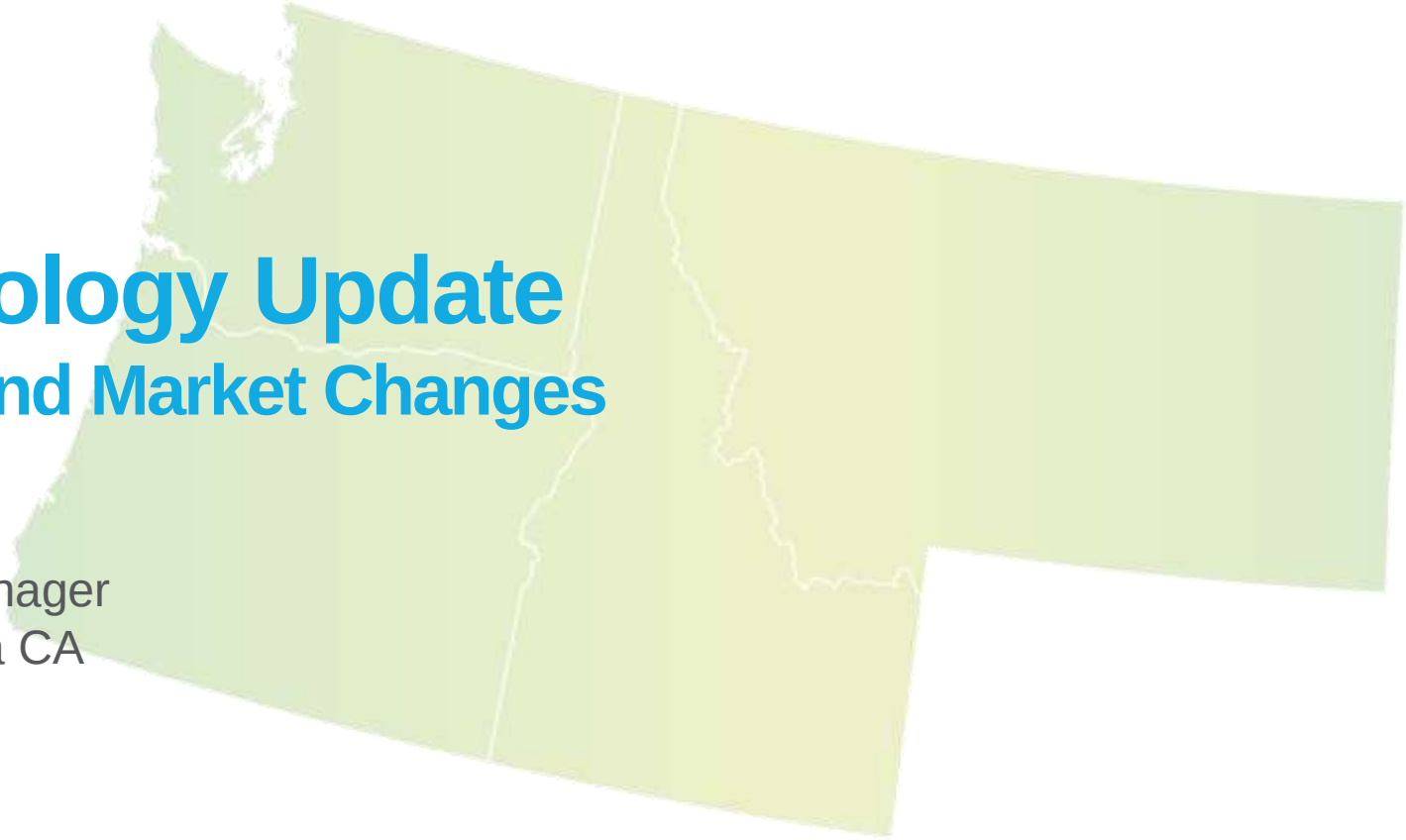
# Heat Pump Technology Update

## Advanced Heat Pumps and Market Changes



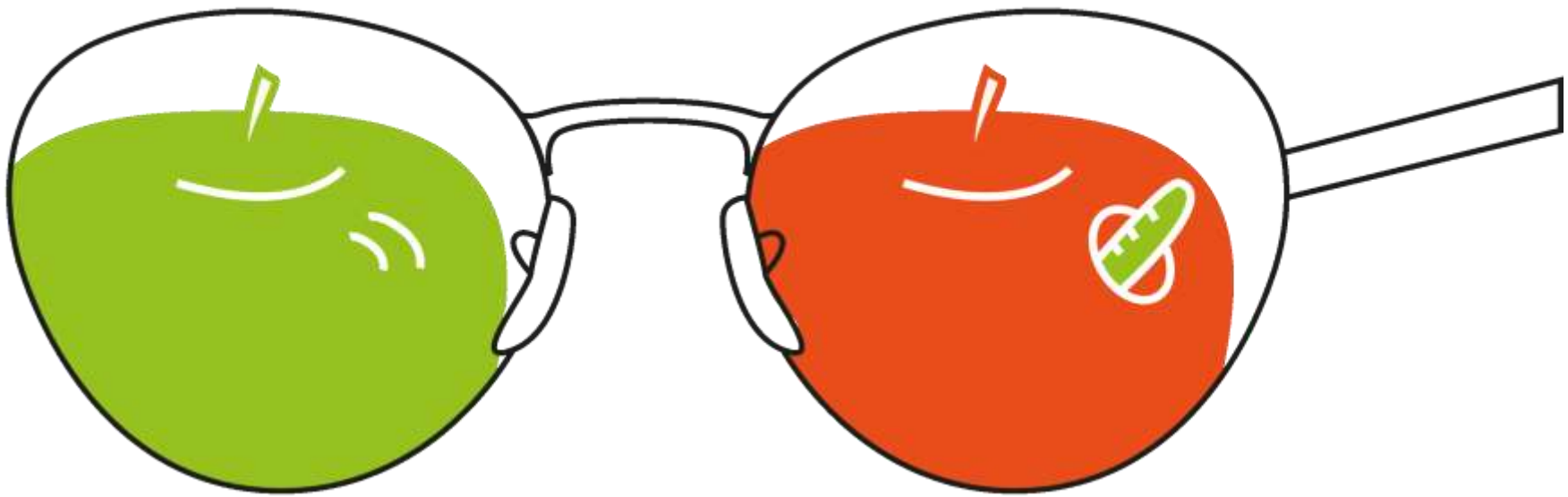
Christopher Dymond, Sr Product Manager
2024 Utility Energy Forum – Cambria CA

# Outline

- Test Procedure and Rating Changes
- New Product – Room Heat Pumps
- Advanced Features and Capabilities
  - Low-Load Efficient
  - Connected Commissioning
- Tax Credit Criteria Changes for 2025

# *Test Procedure and Rating Changes*

# *Heat Pump Ratings are Imperfect Proxies*



# Ratings Don't Correlate Well with Performance

- Lots of examples
- Improving rating representativeness is not easy

Figure 50. Summer 2015 Observed SEER vs. Rated SEER, N=113

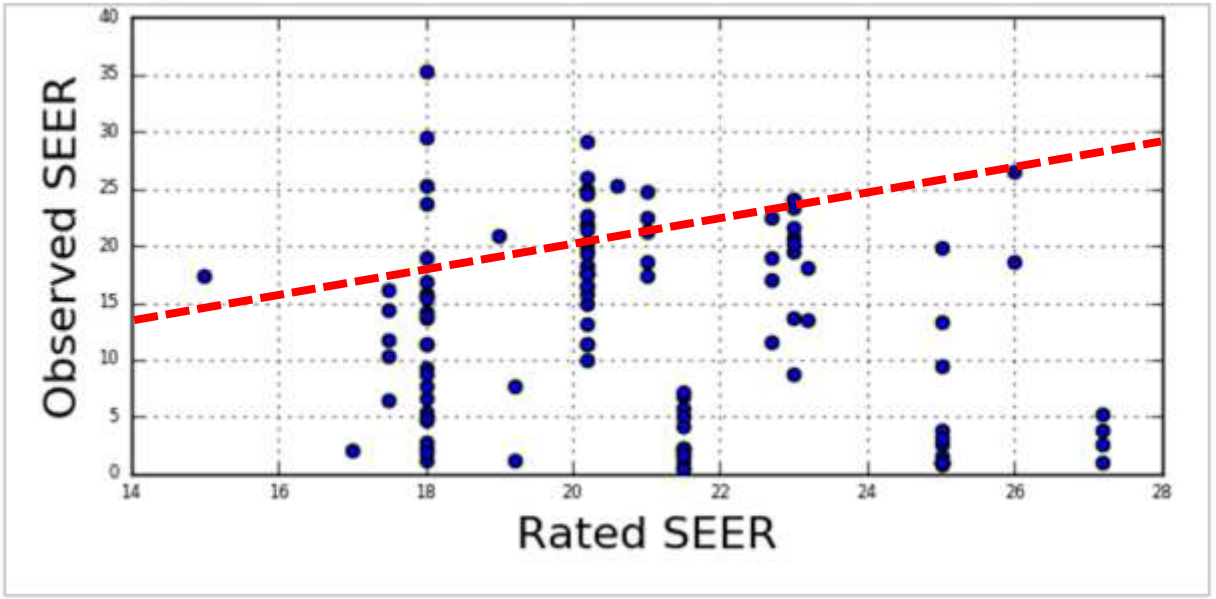
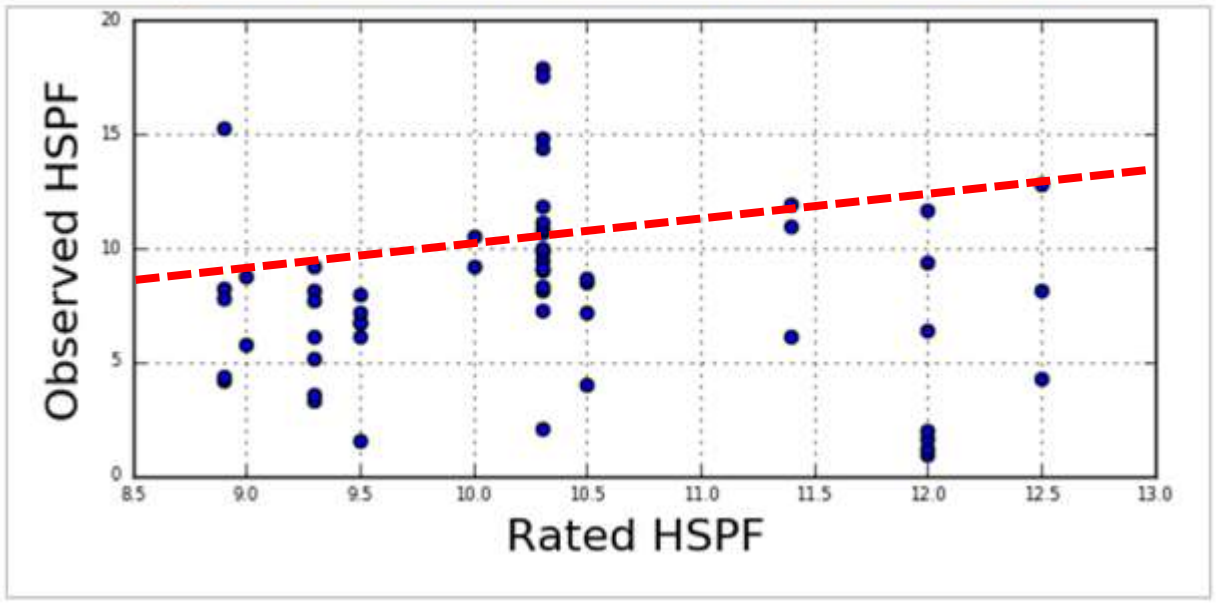



Figure 51. Winter 2015 Observed HSPF vs. Rated HSPF, N=57




2016 Cadmus – Minisplit Impact Analysis

 | 

# *AHRI 210/240 Test Procedure and Rating*

*Federal Rule Making is Currently In Progress*

- 2025? – Minor Tweaks
  - Controls Verification Procedure
  - Cold Climate Heat Pump Definition
  - Dual Fuel Metric
- 2029? – Big Changes
  - Name Change: AHRI 1600
  - Updated Load Lines and Bin Hours
  - Rating Metric Change: SEER ⇨ SCORE, HSPF ⇨ SHORE
  - Defrost Penalty if supplemental heat can be used
  - Sensible Heat Ratio Constraint – Fan Limit

# *New Product – Room Heat Pump*

# Room Heat Pumps Both Heat & Cool

- Twice as efficient in heating compared to electric resistance
- Limited to mild climates

## Saddlebag

*Image courtesy Gradient*

## Window AC

w/reverse cycle

*Images courtesy Midea*

## Portable

(dual hose*)

*Dual hose is very important to performance

# Cold Climate Room Heat Pumps

- Key innovation is use of an atomizer to get rid of condensate and melt water without need of melt water system or risk of freezing water dribbling down the side of the building.
- Two new products are entering the market that can operate below 5F
- These systems are available in limited production runs at a cost of $3000-$4000

# Midea PWHP

*Image courtesy Midea*

| | Outdoor Condition | Capacity (BTU/hr) | Efficiency |
|---|---|---|---|
| Cooling Mode | 95 °F (35 °C) | 9010 | 11.81 EER |
| Heating Mode | 47 °F (8.3 °C) | 9050 | 4.05 COP |
| | 17 °F (-8.3 °C) | 9060 | 2.42 COP |
| | 5 °F (-15 °C) | 9000 | 2.0 COP |
| Min Temp | -13 °F (-25 °C) | 5050 | 1.41 COP |
| CEER | 16 | | |
| SEER2 | 18.76 | | |
| HSPF2 | 10.12 | | |
| Indoor Sound Pressure Level | High | Low | Silent |
| | 51 dB(A) | 43 dB(A) | 26 dB(A) |
| Unit Weight | 130 lbs | | |

Specs subject to change

# Gradient All Weather Unit

*Image courtesy Gradient*

| | | | |
|---|---|---|---|
| **Electrical Requirement** | **Voltage** | **Phase** | **Circuit Amps** |
| | 120 VAC | 60 Hz | 15 A |
| **Thermal Performance** | **Outdoor Temp** | **Capacity** | **Efficiency** |
| | 95 °F (35 °C) | 9000 BTU/h | 10.0 (EER) |
| | 47 °F (8.3 °C) | 9000 BTU/h | 4.00 (COP) |
| | 17 °F (-8.3 °C) | 9000 BTU/h | 2.60 (COP) |
| | 5 °F (-15 °C) | 7200 BTU/h | 2.35 (COP) |
| | -7 °F (-21.7 °C) | 4900 BTU/h | 1.71 (COP) |
| **Weight** | 125 lbs | | |
| **Refrigerant** | R32 | | |
| **Indoor Sound Level** | **High** | **Medium** | **Low** |
| | 47 dB(A) | 44 dB(A) | 38 dB(A) |

*Specifications are subject to change.

Specs subject to change

# Room Heat Pump Climate Categories

| | Category | Heating Range (outdoor Temp) | Active Defrost | Notes |
|---|---|---|---|---|
| | AC with Electric Heater | 5 - 75°F | - | Inefficient during heating |
| | AC with Heat Pump | 40 - 75°F | NO | Very limited heating range |
| “Type 3” | Mild Climate Heat Pump | 17 - 75°F | YES | Not yet available |
| “Type 4” | Cold Climate Heat Pump | 5 - 75°F | YES | Available Q4 2024+ |

**NO** seasonal efficiency rating for window heat pumps. Consequently, they could not qualify for a 30% federal heat pump tax credit

# EPA's New Room HP Test Procedure and Rating


**ENERGY STAR® Program Requirements**
**Product Specification for Room Air Conditioners**

**Draft Final Test Method to Determine**
**Room Air Conditioner Heating Mode Performance**
**April 2024**

Final version likely published in Q3 2024

Room heat pump: A room air conditioner as defined at 10 CFR 430.2 that utilizes reverse cycle refrigeration as its prime source for heating the indoor space.

- Type 1 heat pump: A room heat pump that does not have active defrost or for which the specified compressor cut-in and cut-out temperatures are not both less than 40°F.
- Type 2 heat pump: A room heat pump that has active defrost and for which the specified compressor cut-in and cut-out temperatures are both less than 40°F but not both less than 17°F.
- Type 3 heat pump: A room heat pump that has active defrost and for which the specified compressor cut-in and cut-out temperatures are both less than 17°F but not both less than 5°F.
- Type 4 heat pump: A room heat pump that has active defrost and for which the specified compressor cut-in and cut-out temperatures are both less 5°F.

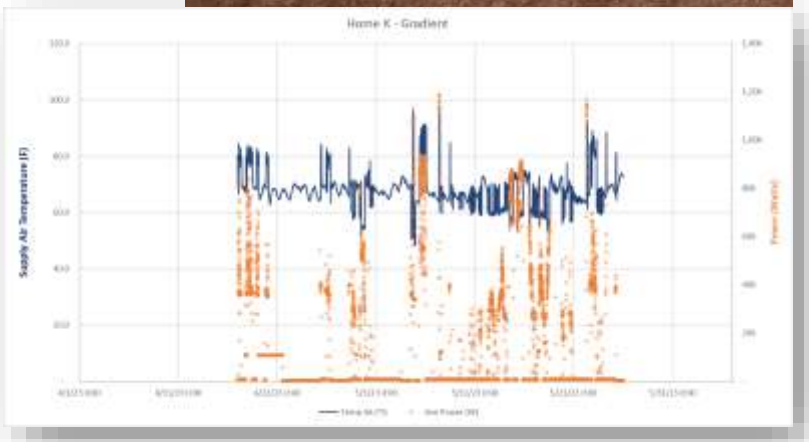
 

# 2023 NEEA Room HP Research

1. Understand the **customer experience** installing, operating and their expectations of what a window heat pump is and does.

2. **Understand, installation, noise,** and any mechanical limitations that may impact performance or customer experience.

3. Understand how **users changed behavior** such that the window HP displaced heating and cooling from preexisting sources.


Aug 1 - Product Council Presentation Recording

[Northwest Energy Efficiency Alliance (NEEA) | Product Council]

 | 

# Phase 1 Findings

- Energy and Comfort top priorities
  (Note – efficiency was not top priority once installed)
- Customers already use multiple products to heat and cool their homes – most are familiar with portable products
- 72% completely agree the concept of a dual heat/cool window unit is appealing
- Portability and 120V outlet compatibility drive interest
- Intended use will likely be to improve comfort in rooms or areas not currently well served by existing heating system

# Phase 2 Observations

- Most participants were at least somewhat satisfied across all attributes. Participants were most satisfied with the ease of use, followed by overall heating performance, then noise level
- Units worked as expected
- Although installation was considered easy overall, there were some issues
- Once instructed, participants used product for primary heat in space, but w/o guidance they didn’t.
- Potential deal breakers: 40°F limit, aesthetics, physical barriers, noise level

# *Next Steps – 2024-2026*

- Lab testing to new test procedure
- Utility Field Pilots and Customer Use tests
- Develop Savings Estimates
- Develop Program Recommendations
- Stack utility incentives with IRA rebate dollars
- Attract new manufacturers and build competitive marketplace to drive price down

# *Advanced Features and Capabilities*

# *Low Load Efficient (LLE) Heat Pumps*

***When sized right, a variable speed heat pump spends most of its time running at part load.***

***Good VSHPs are 40+% more efficient when running at minimum output than at full output. (lots of potential benefit)***

# LLE is great in Mild Climates

| | Annual Savings |
|---|---|
| Portland | 7.9% |
| Boise | 7.4% |
| Bozeman | 4.4% |
| Sacramento | 8.4% |
| Denver | 6.8% |
| Minneapolis | 3.8% |
| New York City | 8.6% |
| Washington DC | 8.2% |

*Based on MN CEE modeling work of 2024 for part load efficiency improvement*

- Increasing part load efficiency by 12.5% in a mild climate should produce a 7-8% decrease in annual energy use.
- 2020 sales data shows roughly a quarter of sales already achieve this target.
- 250-500 kWh/yr incremental savings for typical existing home

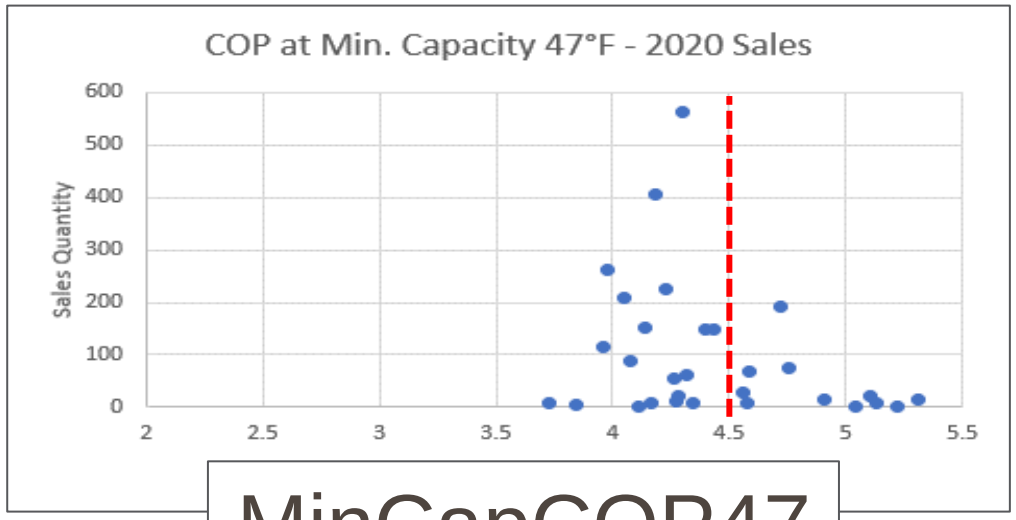
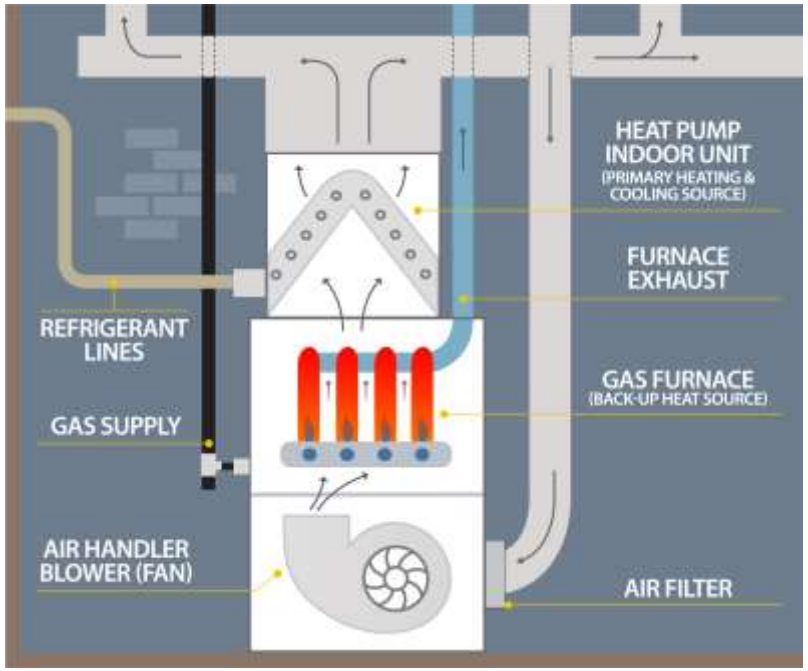



*Image © NEEA*

# Dual Fuel Systems Need LLE Heat Pumps

- Dual fuel heat pumps cannot operate the heat pump and the gas furnace at the same time*
- The heat pump never runs at full load, it always runs at part load




*Graphic by Slipstream Inc.*

A VSHP with a MinCapCOP = 5.0 will use about 20-30% less electricity for heating than a single speed with the same HSPF

* Because the gas burner is upstream of the heat pump coil

# Dual Fuel with a LLE Heat Pump

- Better savings than a cold climate heat pump*
- No additional cost
- No change in system design
- Same crossover temperature

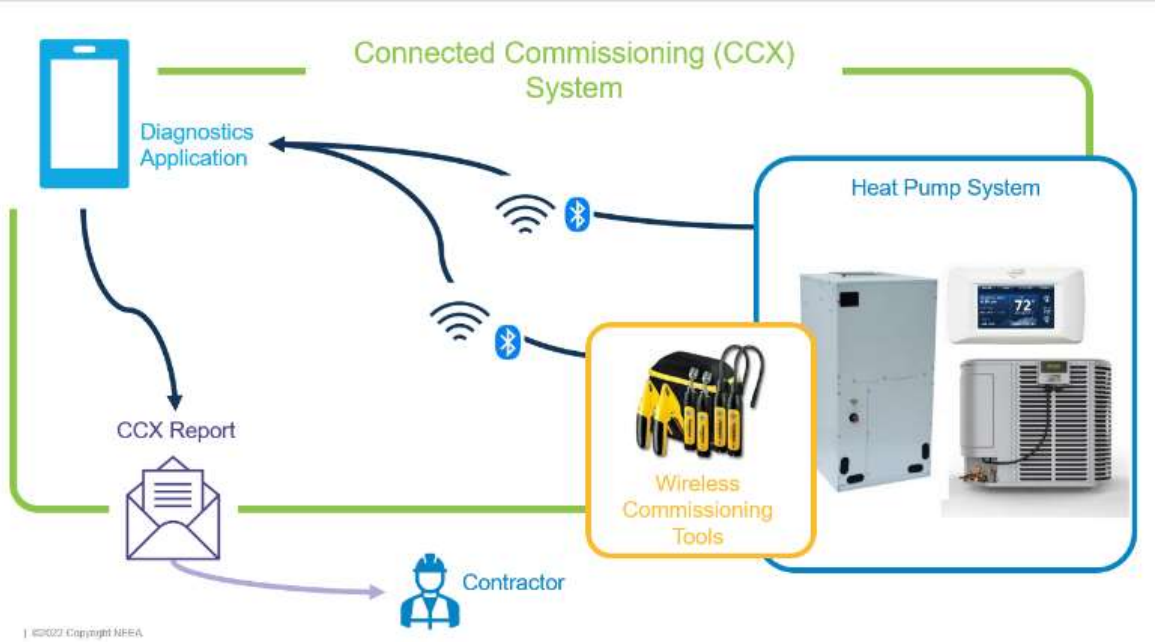
| Type | Relative Savings |
|---|---|
| Single Speed | - |
| Ave VSHP | 12% |
| Low Load Efficient | 17% |
| Cold Climate | 15% |

These preliminary results based on simple bin-hour model in climate zone 4, with cross over temperature of 32F and similar HSPF2 values. More careful analysis and field or lab testing is needed.

* crossover point = 32F

# Commissioning is Changing




- HP guides commissioning and generates a report that confirms it setup and operating correctly
- Data collected during commissioning is be stored remotely so that it can be retrieved during service visits and aid diagnosis of system operation
- Systems will last longer and perform better

# Potential Savings

| | Fault Name | Estimated Savings[1,2] | Likelihood of Error[3] |
|---|---|---|---|
| Commissioning faults | Reduced Indoor Coil Airflow | 5% | 33% |
| | Refrigerant Undercharge/ Overcharge | 10% | 28% |
| | Refrigerant Subcooling | 8% | Missing Data |
| | Non-Condensable Gases | 2% | Missing Data |
| Control Settings | Appropriate Aux heat control settings | 8% | 57% |

$$Commisioning\ Savings = \sum_{Fault=i}^{n} Savings_i * Likelihood_i = \mathbf{9\%}$$

(5%*10% + 10%*28% + 8%*57%)

1. 2014 NIST fault impact study
2. 2023 Ben Larson Research memo
3. 2019 BPA's CC&S ASHP field study

# *Conservative Estimate of Savings*

The fraction of CCX systems that are *actually* commissioned using a certified verification report

9% x 80% x 75% ~ **5%**

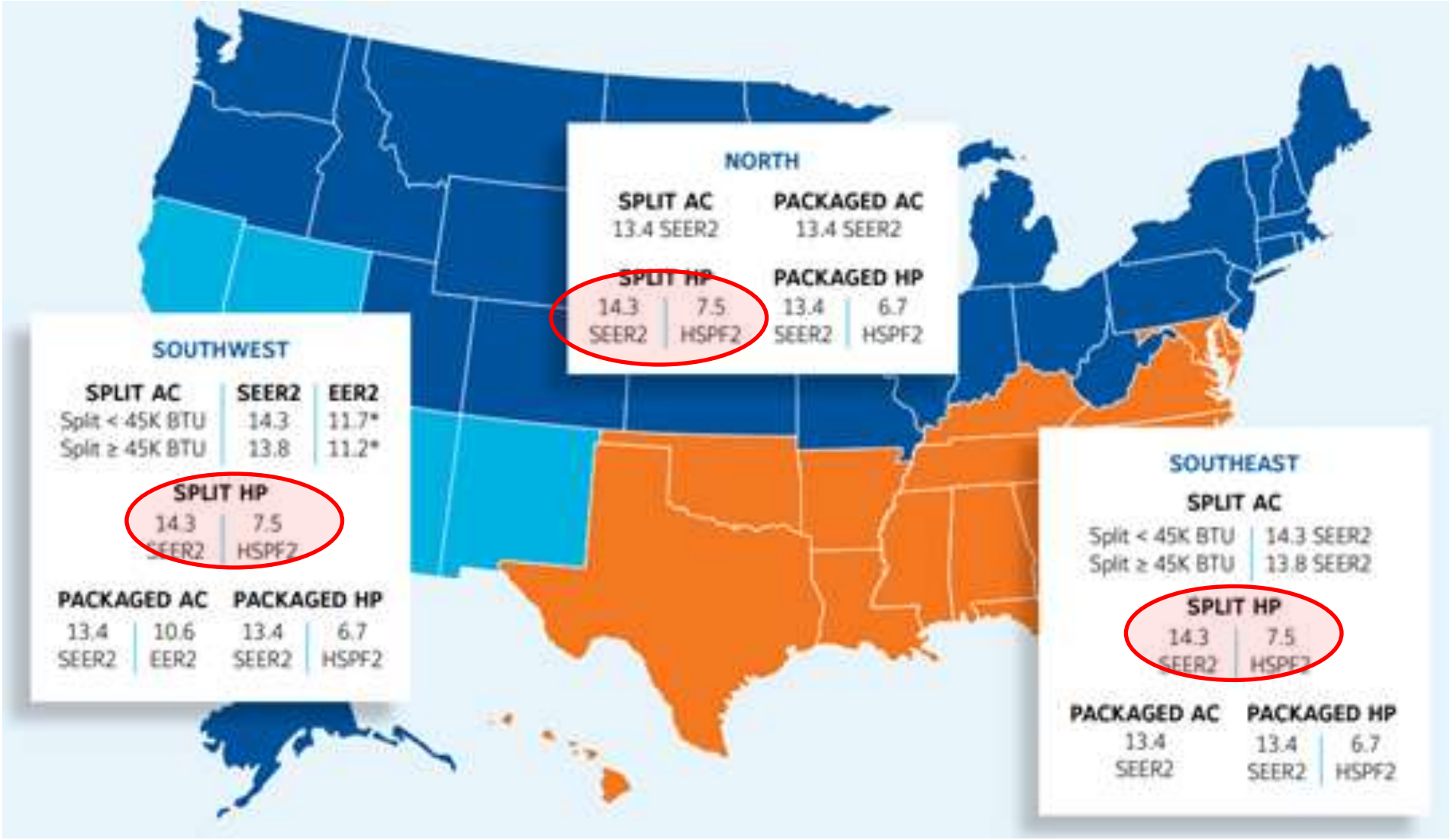
Potential savings assuming that all faults are fixed

The fraction of faults that CCX systems correctly identified and resolved during commissioning

# *National Standards and Tax Credit Criteria*

# Federal Minimum Standard




 | 

# 2023-2024 Tax Credit Criteria

## CEE AIR SOURCE HEAT PUMPS – South

+4%

| CEE Split Ducted ASHP Specifications – South | | | | |
|---|---|---|---|---|
| Level | SEER2 | EER2 | HSPF2 | Connectivity |
| CEE Tier 1 | ≥ 15.2 | ≥ 11.7 | ≥ 7.8 | N/A |
| CEE Advanced Tier | ≥ 17.0 | ≥ 12.0 | ≥ 8.0 | CEE Demand Response Criteria Level 2 |

+20%

| CEE Non-Ducted ASHP Specification – South | | | | |
|---|---|---|---|---|
| Level | SEER2 | EER2 | HSPF2 | Connectivity |
| CEE Tier 1 | ≥ 15.2 | ≥ 11.7 | ≥ 7.8 | N/A |
| CEE Tier 2 | ≥ 16.0 | ≥ 12.0 | ≥ 9.0 | N/A |
| CEE Advanced Tier | ≥ 17.0 | ≥ 13.0 | ≥ 9.0 | CEE Demand Response Criteria Level 2 |

| CEE Packaged ASHP Specification – South | | | | |
|---|---|---|---|---|
| Level | SEER2 | EER2 | HSPF2 | Connectivity |
| CEE Tier 1 | ≥ 15.2 | ≥ 10.6 | ≥ 7.2 | N/A |
| CEE Advanced Tier | ≥ 16.0 | ≥ 11.0 | ≥ 8.0 | CEE Demand Response Criteria Level 2 |

ENERGY MANAGEMENT CRITERIA

Scope: Electric and Gas, Any System

| Energy Management Capability Requirements | |
|---|---|
| A | The ability to report operational status of the product or system upon request. |
| B | The ability for remote operation[1] of the product or system by a customer-authorized third party. |
| C | The ability for the customer to override[2] remote changes of load states. |
| D | The ability for firmware updates to the product or connected control for a system, to ensure that reliability and cybersecurity remain current with little to no consumer interaction. |

[1] The ability to ramp up, ramp down, or cycle loads through receiving signals from a control system external to the end use system via a secure connection from a remote communication interface. This can be via the consumer (e.g., via a smartphone app or website), or a customer-authorized third party, such as the utility, manufacturer, or home energy management operator.

[2] The ability for a consumer to cancel a grid request sent to the equipment via a secure connection no more than a set certain timeline (e.g., 72 hours).

DEMAND RESPONSE CRITERIA

Scope: Electric Variable Capacity HVAC Systems, as defined in AHRI Standard 1380

| Level | Requirements |
|---|---|
| CEE Level 1 | AHRI Standard 1380 as is.<br>Either ANSI/CTA-2045-A OR OpenADR 2.0 communication interfaces. |
| CEE Level 2 | Both ANSI/CTA-2045-A AND OpenADR 2.0 communication interfaces;<br>An open modular physical interface of ANSI/CTA-2045-A; and<br>a secondary communication interface to facilitate customer interactions. |

## CEE AIR SOURCE HEAT PUMPS – North and Canada

+8%

| CEE Split Ducted ASHP Specifications – North and Canada | | | | | | |
|---|---|---|---|---|---|---|
| Level | SEER2 | EER2 | HSPF2 | COP at 5°F* | Capacity Ratio^ | Connectivity |
| CEE Tier 1 | ≥ 15.2 | ≥ 10.0 | ≥ 8.1 | ≥ 1.75 | ≥ 58% at 17°F/47°F or ≥ 70% at 5°F/47°F | N/A |
| CEE Advanced Tier** | ≥ 17.0 | N/A | ≥ 8.1 | ≥ 1.75 | | CEE Demand Response Criteria Level 2 |

+26%

| CEE Non-Ducted ASHP Specification – North and Canada | | | | | | |
|---|---|---|---|---|---|---|
| Level | SEER2 | EER2 | HSPF2 | COP at 5°F* | Capacity Ratio^ | Connectivity |
| CEE Tier 1 | ≥ 15.2 | ≥ 9.0 | ≥ 8.5 | ≥ 1.75 | ≥ 58% at 17°F/47°F or ≥ 70% at 5°F/47°F | N/A |
| CEE Tier 2 | ≥ 16.0 | ≥ 9.0 | ≥ 9.5 | ≥ 1.75 | | N/A |
| CEE Advanced Tier** | ≥ 17.0 | N/A | ≥ 10.0 | ≥ 1.75 | | CEE Demand Response Criteria Level 2 |

| CEE Packaged ASHP Specification – North and Canada | | | | | | |
|---|---|---|---|---|---|---|
| Level | SEER2 | EER2 | HSPF2 | COP at 5°F* | Capacity Ratio^ | Connectivity |
| CEE Tier 1 | ≥ 15.2 | ≥ 10.0 | ≥ 8.1 | ≥ 1.75 | ≥ 58% at 17°F/47°F or ≥ 70% at 5°F/47°F | N/A |
| CEE Advanced Tier** | ≥ 16.0 | N/A | ≥ 9.0 | ≥ 1.75 | | CEE Demand Response Criteria Level 2 |

^ 5°F, 17°F and 47°F are rated capacity data points as determined per the Appendix M1 tests.

* For the duration of the 2023 calendar year, COP at 5°F ≥ 1.75 may be met using Appendix M1 test method OR via DOE sanctioned calculation methodology based on COP at 17°F and COP at 47°F. Starting January 1, 2024, COP at 5°F must be met using the Appendix M1 test method.

** For the Advanced Tier, must perform the ENERGY STAR Cold Climate Heat Pump Controls Verification Procedure (CVP) to confirm that the above performance metrics measured at the Appendix M1 low ambient test point at 5° F are achieved by the native controls operating as they would in a customer's home.

# *Tax Credit for Heat Pumps ($2000)*

*IRA defined this as CEE's highest non-advanced tier*

DRAFT
NOT FINALIZED
But likely in 2025+

**2025+ TAX CREDIT CRITERIA (3 different heat pump types – These are not finalized)**

- Split System — HSPF2 ≥ 8.0, SEER2 ≥ 16.0, EER2 ≥ 9.0
- Packaged System — HSPF2 ≥ 7.5, SEER2 ≥ 16.0, EER2 ≥ 9.0
- Room HP — HEER ≥ tbd, $COP_{17}$ ≥ 1.75 Type 3 or Type 4

**ADDITIONAL DESIGNATION (current CEE thinking)**

- Advanced Tier — HSPF2 ≥ 8.0, SEER2 ≥ 17.0, EER2 ≥ 9.0, OpenADR & CTA2045B
- Cold Climate — HSPF2 ≥ 8.5, SEER2 ≥ 17.0, EER2 ≥ 9.0, COP@5 ≥ 1.75, CapRatio5 ≥ 70%
- Adv. Cold Climate — HSPF2 ≥ tbd, SEER2 ≥ 17.0, EER2 ≥ 9.0, COP@5 ≥ tbd, CapRatio5 ≥ tbd%

**ADDITIONAL DESIGNATION (Proposed by NEEA to CEE)**

- Hot Climate — Tax Credit + EER2 ≥ 11.7
- Dual Fuel — Tax Credit + MinCapCOP47 ≥ 4.5

# *Questions and Discussion*

 | 