ACEEE
International Energy Efficiency Symposium

The case for (Inverter) Cold Climate Heat Pumps

April 6th, 2022

Daikin U.S. Corporation

Agenda:

1. Market Conditions, Heat Pumps in North America

    - Heat Pump Penetration
    - Factors affecting Heat Pump trust

2. DOE Cold Climate Heat Pump Challenge

    - Objectives and Scope
    - Initial Specification Hypothesis
    - Final Specification
    - Progress, Participants and Execution Timeline
    - Requests

Market Conditions : Heat Pumps in North America

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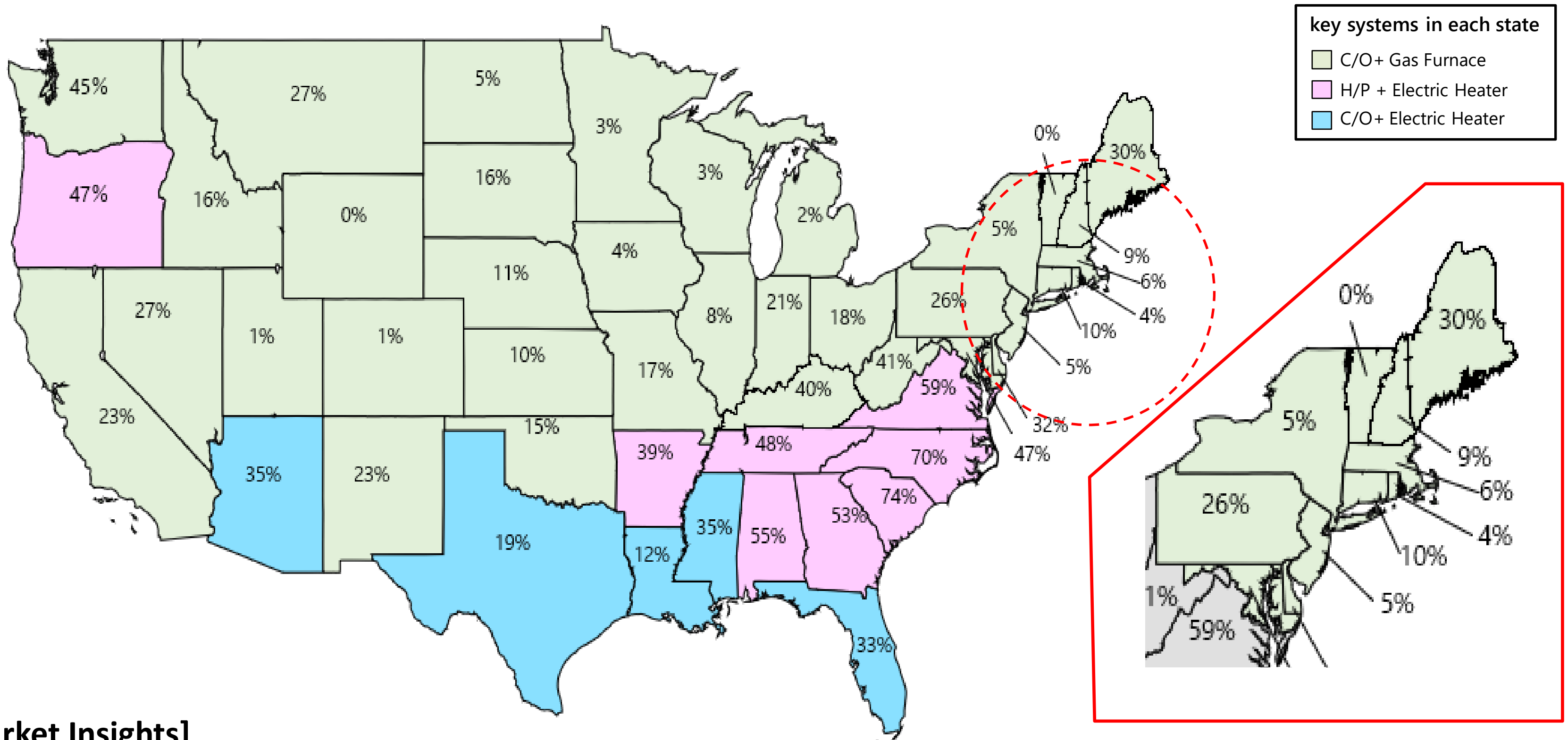
【Figure 1 -1：Unitary H/P penetration % and Market Insights】



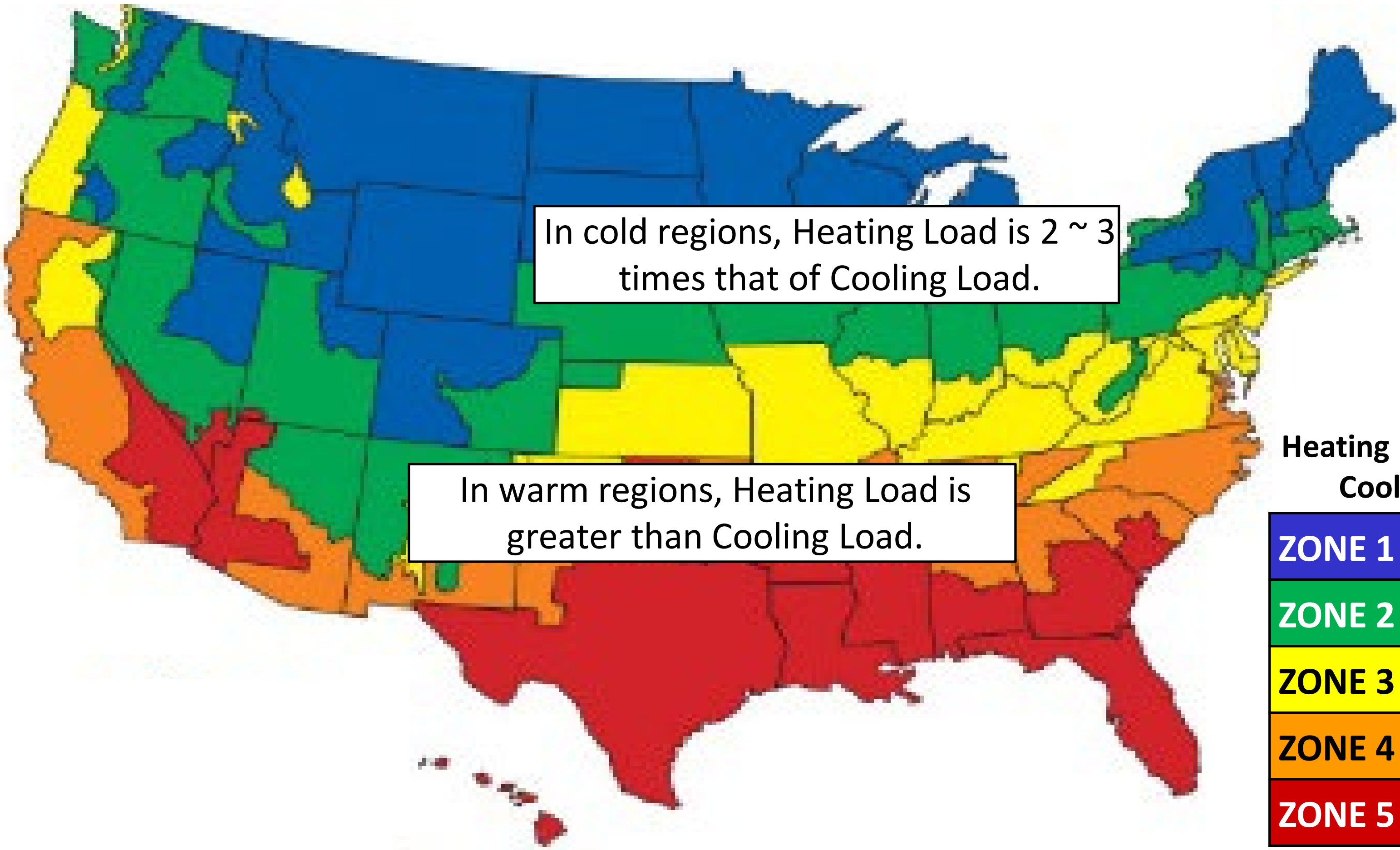
[Market Insights]

- Even in warm regions, **many dealers do not trust H/P and are challenged with determining accurate heating load.** Also, they don't think there is a running cost advantage compared to gas solutions.
- **H/P is recommended when there is no gas infrastructure regardless of the region.**
- **Hybrid / Dual Fuel solutions are mainly used in areas where propane use is prevalent.**
- Additional power supply conversion costs at the time of retrofit from gas furnace to H/P are also a problem.
- In NY, sales of mini-splits are growing because of high incentives**, the distrut of H/Ps is disappearing.**
- **In CA** there is growing efforts to expand **promotion of Inverter H/P in on-gas area** through energy conservation and comfort.

Market Conditions : Heat Pumps in North America

【Figure 1 -2：Factors that stimulate lack of Heat Pump trust】

- **The load calculation tool results typically require large heating load**
- Even in warm regions, Heat Pump capacity is seen as insufficient



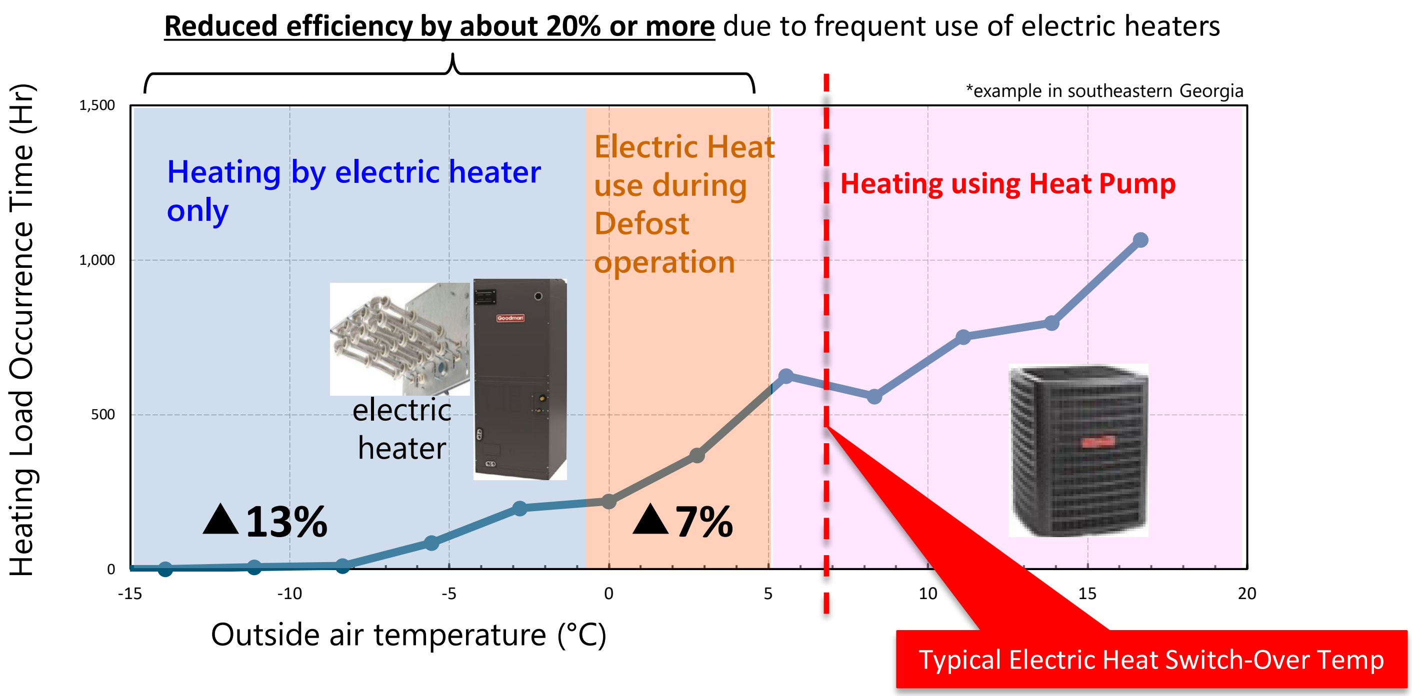
Heating load ratio to Cooling load

ZONE 1	250%
ZONE 2	200%
ZONE 3	180%
ZONE 4	140%
ZONE 5	120%

Market Conditions : Heat Pumps in North America

【Figure 1 -3：Factors that stimulate lack of Heat Pump trust】

- **Non-Inverter Heat Pumps use electric heaters, so running cost is high.**
- Non-Inverter Heat Pumps technically do not operate in heating mode without electric heater.



- **In cold regions, electricity costs 4 ~ 6 times more than gas.**
- Gas prices are particularly low in the Midwest and Northeast, which are cold regions. Hybrid / Dual Fuel solutions with gas furnace have no merit. Many of the incentives for H/Ps are less impactful and inconsistency make them more cumbersome to utilize.

DOE Residential Cold-Climate Heat Pump Technology Challenge

【Objectives and Scope】

Objectives

Accelerate the development and deployment of cold climate heat pump (CCHP) technologies by:

- Developing a new technology specification for a high-performance CCHP that meets consumer needs in partnership with heat pump manufacturers
- Demonstrating the CCHP performance in the lab and in the field
- Launching pilot programs with partners, such as utilities, to identify and alleviate installation challenges

Scope

Residential, centrally ducted, electric-only HPs that perform better than today'sproducts:

- Nominal cooling capacity 24,000 – 65,000 Btu/hr.
- Comply with all applicable federal and state standards
- Perform efficiently in cold climates (separate capacity and COP challenge specifications for 5°F [-15°C] and -15°F [-26°C] outdoor temperatures)
- Employ low-GWP refrigerants (< 750 GWP, AR4 100 year)
- Incorporate advanced controls and grid interactive capabilities
- Out of Scope: Non-Ducted, Multi-Split, Hybrid/Dual Fuel, Commercial

【Initial Specification Hypothesis Proposed】

- **CCHP Challenge #1 & 2 – Seasonal Heating and Cooling Performance:**
  - Unit(s) shall have a minimum heat pump HSPF2 of 8.5 (Region V)
  - Capacity turndown of at least 70% of nominal capacity at 47°F (8°C) of nominal heating capacity at 47°F (8°C) (turndown to a 30% capacity ratio)
- **CCHP Challenge #1 – Heating at 5°F (-15°C):**
  - Unit(s) shall have a minimum ratio of heating capacity at 5°F (-15°C) to nominal heating capacity* at 47°F (8°C) equal to 1.0
  - Unit(s) shall have a minimum heat pump Coefficient of Performance ("COP") of 2.8 at 5°F (-15°C) when operating at the maximum capacity*.
  - Unit(s) shall have a low-temperature compressor cutout no higher than -10°F (-23°C)
- **CCHP Challenge #2 – Heating at -15°F (-26°C):**
  - Unit(s) shall have a minimum ratio of heating capacity at -15°F (-26°C) to nominal heating capacity* at 47°F (8°C) equal to 0.7.
  - Unit(s) shall have a minimum heat pump COP of 2.3 at -15°F (-26°C) when operating at the maximum capacity*.
  - Unit(s) shall have a low-temperature compressor cutout no higher than -25°F (-32°C).

*Capacity corresponding to the highest compressor speed allowed for extended periods of operation at the specified ambient temperature.

【Final Specification】

HP nominal capacity (Btu/h)[1]	Seasonal Heating Performance		Heating at 5°F (-15°C)				Heating at -15°F (-26°C) *(optional)*	
	Minimum HSPF2	Min. Turndown ratio	COP at 5°F (-15°C)	Capacity Ratio	Low-temperature compressor cut-out at 5°F (-15°C)	Low-temperature compressor cut-in at 5°F (-15°C)	Low-temperature compressor cut-out at -15°F (-26°C)	Low-temperature compressor cut-in at -15°F (-26°C)
≥24,000 and ≤36,000	8.5 * (1 + Capacity factor[2]) * (1 + COP factor[3])	30%	2.4	100%	≤ -10°F (-23°C)	≤ -5°F (-21°C)	≤ -20 °F (-29°C)	≤ -15 °F (-26°C)
>36,000 and ≤48,000			2.4	100%				
>48,000			2.1	100%				

[1] Capacity for the A2 test of Appendix M1 for a heating/cooling heat pump. Capacity of the $H1_N$ test of Appendix M1 for a heating-only heat pump.

[2] Capacity factor: 1 percent for every 10% $H1_1/H1_N$ gap. The capacity factor for northern triple capacity HPs is 0.

[3] COP factor: 2 percent for every 10% excess COP gap between the expected COP reduction and the measured COP reduction from the $H1_1$ verification test and the $H1_1$ regulatory test

Additional Requirements:

(1)	Unit(s) shall comply with electric heat staging requirements as set out in Table II-1
(2)	Unit(s) refrigerant shall have a GWP no greater than 750 (AR4 100-year).
(3)	Unit shall comply with Sections 3C, 4B, 4C, and 4D of the ENERGY STAR CACHP specification.

【Final Specification】

3 C. **Installation Capabilities**: To certify as ENERGY STAR, all CAC/HPs that have three or more capacities, or are continuously variable, must be capable of providing at least three of the following capabilities to aid in quality installation. For purposes of this section, a thermostat or controller can be considered part of the system. Items a, b, and c are understood to be measured at maximum fan speed and capacity.

a. **Refrigerant charge** – System can verify that the refrigerant charge is within manufacturer recommended tolerances at a range of conditions including outdoor temperatures at least as low as 55º F.

b. **Airflow measurement or external static pressure** – System shall have some capability to display airflow and confirm that it is within the OEM recommended settings, or to display external static pressure and fan speed setting. For split systems, this capability may be contingent on the recognized product being paired with a specific furnace or air handler. (Capability not applicable to ductless units.)

c. **Blower fan power draw** – System shall have the capability to measure and report the watt draw of the blower fan. For split systems, this capability may be contingent on the recognized product being paired with a specific furnace or air handler.

d. If systems DO NOT include any of the capabilities in a, b (if applicable), or c, and have multiple or variable capacities, the system provides an easily accessible test mode that locks the system into the highest fan speed and compressor capacity setting available in that installation, such that a technician can measure the quantities in a, b, and c with external equipment.

e. **Automatic system discovery** – System is capable of automatically recognizing compatible communicating indoor/outdoor units, furnaces. Automatic discovery of humidifiers and dehumidifiers is encouraged.

f. **Preprogrammed system tests** – System shall automatically prompt the installer to run preconfigured system tests following the initial setup. These tests should verify, at a minimum, fan blower, cooling-mode, defrost mode, heat pump only heating, and auxiliary heating tests as applicable to the product and season of installation. The test shall require installer correction of all faults before exiting test mode.

4 B. **Communications -** Bi-directional data transfers, use of Open Standards and providing proper documentation.

4 C. **Consumer Feedback**

a. **User Alerts -** on product or through communication link (e.g., fault reporting, filter replacements).

b. **Energy Reporting** - energy reporting for measured or estimated instantaneous power draw.

4 D. **Demand Response (DR) -** Open ADR 2.0 or CTA-2045A, or both, including ability for consumer override of DR event participation.

DOE Residential Cold-Climate Heat Pump Technology Challenge

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【Progress, Participants and Execution Timeline】

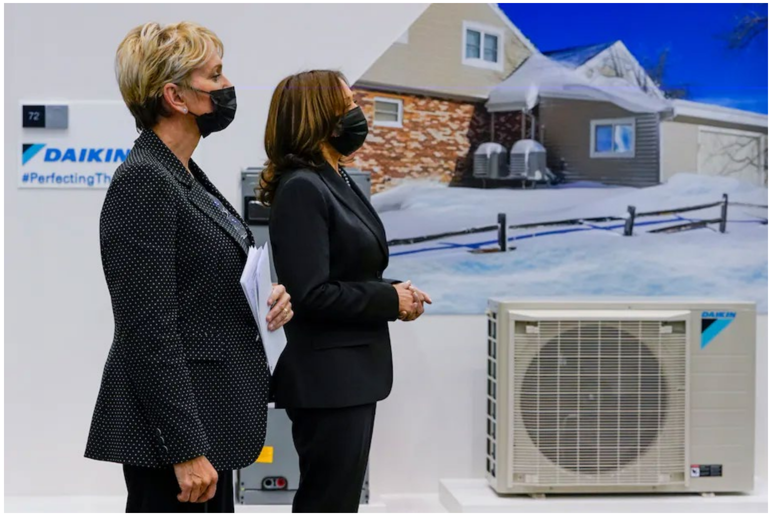
*As of April 2022

Specification Development

1st Workshop *this meeting* **(June 2021)** → Workshops / Discussions with Manufacturers ***(June – July)*** → Commitments & Public Announcement ***(August)*** → ***Ongoing Progress Updates***

Final Participants*

Carrier,
Daikin,
JCI,
Lennox,
LG
Midea
Mitsubishi,
Midea,
Rheem and
Trane Technologies



Vice President Harris and Energy Secretary Jennifer Granholm listen to a presentation on heat pumps last year in New York

Product Development & Deployment

Product Prototype ***(Late 2021/ Early 2022)*** → Lab Testing (***Early- mid 2022)*** → Field Testing ***(Winter 2022-2023)*** → Deployment Programs/ Commercialization ***(2023+)***

The case for (Inverter) Cold Climate Heat Pumps

【Requests】

- Heat Pumps continue to be marginalized stemming from their legacy performance, deployment and reputation.

  - ➢ Focus your discussion, activities and actions on Inverter (Variable Speed) Heat Pumps.

- The pathway to Decarbonization and eventual electrification of Space Heating requires a much more dynamic and integrated approach.

  - ➢ Focus your discussion, activities and actions on complete communicating & connected systems.

- There is inconsistent engagement in meaningful Market Transformation acceleration initiatives.

  - ➢ Incentives and Rebates, with consistent eligibility criteria and performance metrics targeting the most appropriate technologies like Inverter Heat Pumps with communicating controls are essential.

Thank you for joining.

Now for Questions and Discussion.