

U.S. DEPARTMENT OF
ENERGY

Office of
ENERGY EFFICIENCY &
RENEWABLE ENERGY

Cold Climate Heat Pumps

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DOE Goals and Research Strategy

***We Have a Clear Directive:* Put the U.S. on an irreversible pathway to achieve a carbon-free electricity sector by 2035 and a 100% clean energy economy by 2050**

Goal

- ✓ Decarbonize the buildings sector (65% reduction from 2005 levels by 2030 and 90% by 2050)

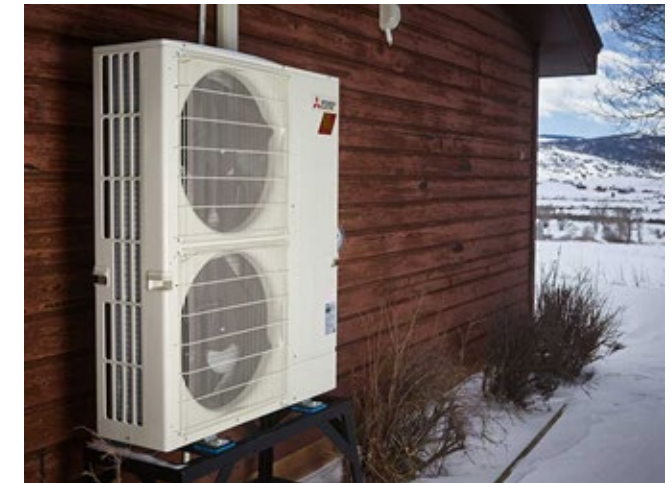
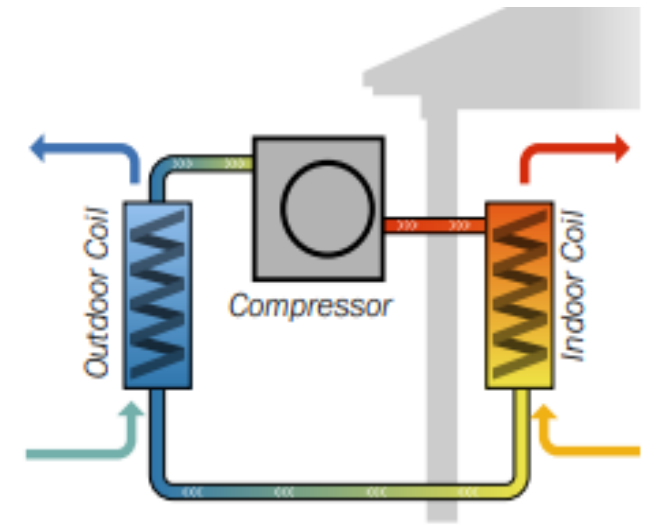
At the same time, we will:

- ✓ Improve affordability, resilience and performance of buildings
- ✓ Provide workforce training and support creation of good-paying, quality clean energy jobs
- ✓ Advance diversity, equity, and inclusion in STEM
- ✓ Ensure overall benefits of investments are delivered to disadvantaged communities



BTO Cold-Climate Heat Pump Goals

- Space conditioning and water heating consume over 40% of the nation's primary energy used in buildings and are a major source of GHG emissions.
- In recent years, manufacturers have developed specialized cold-climate heat pumps (CCHPs) which incorporate advanced designs to operate with greater capacity and efficiency at low outdoor temperatures (below 32°F).
- CCHPs are gaining acceptance in some regions, with support from government, industry, and utility initiatives.
- **Additional efforts are needed to address common technical and market barriers and achieve wider adoption by consumers, including:**
 - Improving performance at temperatures of 5°F and below to reduce or eliminate the need for electric resistance backup heating
 - Alleviating system sizing, design, and installation challenges
 - Mitigating electric grid impacts on peak days.



ORNL, Mitsubishi

Common CCHP Challenges

Technical

- **Limited CCHP products** for key applications (ducted; steam/hot water; RTUs)
- **Sizing, selection, installation, and controls** are different
- **Added winter electricity demand** may pose challenges and require large investments
- **Older buildings** may face electrical infrastructure and envelope challenges

Market

- **Relatively low natural gas rates** may lead to unfavorable economics (*more favorable against fuel oil, propane, and electric resistance*)
- **Higher product cost** for CCHPs when compared to a furnace + AC baseline
- **Low contractor familiarity** with CCHPs solutions in many regions
- Overcoming trend for **emergency replacements**

Policy

- **Limited policy support in some states/regions**
- **Current fuel mix in some states** is not currently favorable to GHG reduction (*future fuel mix is more favorable for many states*)
- **For multi-family, shifting the responsibility for heating bills** to residents, where heating was previously included within rent.

Ongoing Activities with CCHPs

Government, utility, and industry stakeholders supporting CCHP deployment, including both ducted and ductless products.

Technology Development & Demonstration

- HVAC manufacturer product R&D
- DOE / NRCan emerging technology programs
- **DOE Residential CCHP Technology Challenge**
- Utility / state agency / industry emerging technology programs

Market Transformation Programs

- DOE / NRCan building integration programs
- EPA ENERGY STAR CAC/CHP Spec. v6.1
- Industry and regional energy efficiency organization CCHP specifications (NEEP, CEE, etc.)

Pilot & Incentive Programs

- Utility and state agency heat pump and electrification incentive programs
- **Wide variety of organizations that support the design, implementation, and evaluation of incentive programs**

DOE Residential CCHP Challenge

- DOE's Energy, Emissions and Equity (E3) Initiative supports RD&D initiatives to increase the adoption of next generation heat pump technologies ([Link](#)).
- **Residential Cold-Climate Heat Pump Challenge** aims to develop, test, and commercialize products by 2024 that are designed for 5°F and -15°F operation with performance beyond current best-in-class products.
 - DOE, NRCAN, and EPA
 - HVAC Manufacturers (9 commitments to date)
 - Utilities, State agencies, and other EE organizations (27 commitments to date)



Objectives & Scope of the CCHP Challenge

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's products:

- Nominal cooling capacity 24,000 – 65,000 Btu/hr.
- Comply with all applicable federal and state standards
- Perform efficiently in cold climates (capacity and COP challenge specification for 5°F [-15°C] and operational challenge for -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 (may be considered in the future)

CCHP Technology Challenge Public Launch

- At the Nov. 1st launch event, VP Harris and Sec. Granholm recognized six leading HVAC manufacturers for their commitment to the Challenge. Three other manufacturers have subsequently joined.
- DOE conducted roundtable discussions in MA and then the Upper Midwest, including DOE leadership, members of Congress, manufacturer partners, state/utility partners, and other stakeholders.
 - Secretary Granholm also announced the state and utility partners participating in the Challenge.

Nov. 1st Launch with VP Harris and Sec. Granholm in NY



Dec. 3rd Event in Massachusetts



Jan. 26th Event with Leaders in MN and Other Midwest States



List of State and Utility Partners ([Link](#))

- 9 State Agencies



- 18 Utilities and Cooperatives



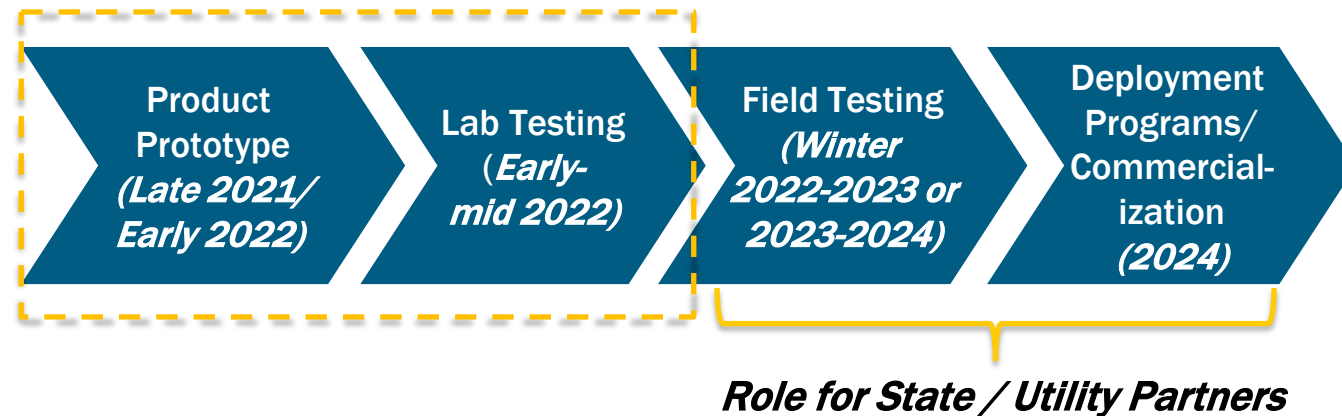
CCHP Technology Challenge Timeline

Specification Development



- Several manufacturers have prototypes ready to undergo performance testing at ORNL, which began in mid March.
- Following successful lab testing, prototypes can move forward with field testing over winter '22-'23 and/or '23-'24.
- In summer '22, DOE will begin coordinating with partners to identify material and resource needs to support deployment.

Product Development & Deployment



Collaboration on CCHP Deployment

Achieving high market penetration of heat pumps, especially in cold climates, will require coordination and collaboration across the industry.

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Pilot & Incentive Programs

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Role of Heat Pumps in Decarbonization in Buildings

September 19, 2022

Lennox Overview

HISTORY

Founded: 1895
NYSE LII



OVERVIEW

HQ: Richardson, TX



Residential Heating & Cooling



Commercial Heating & Cooling

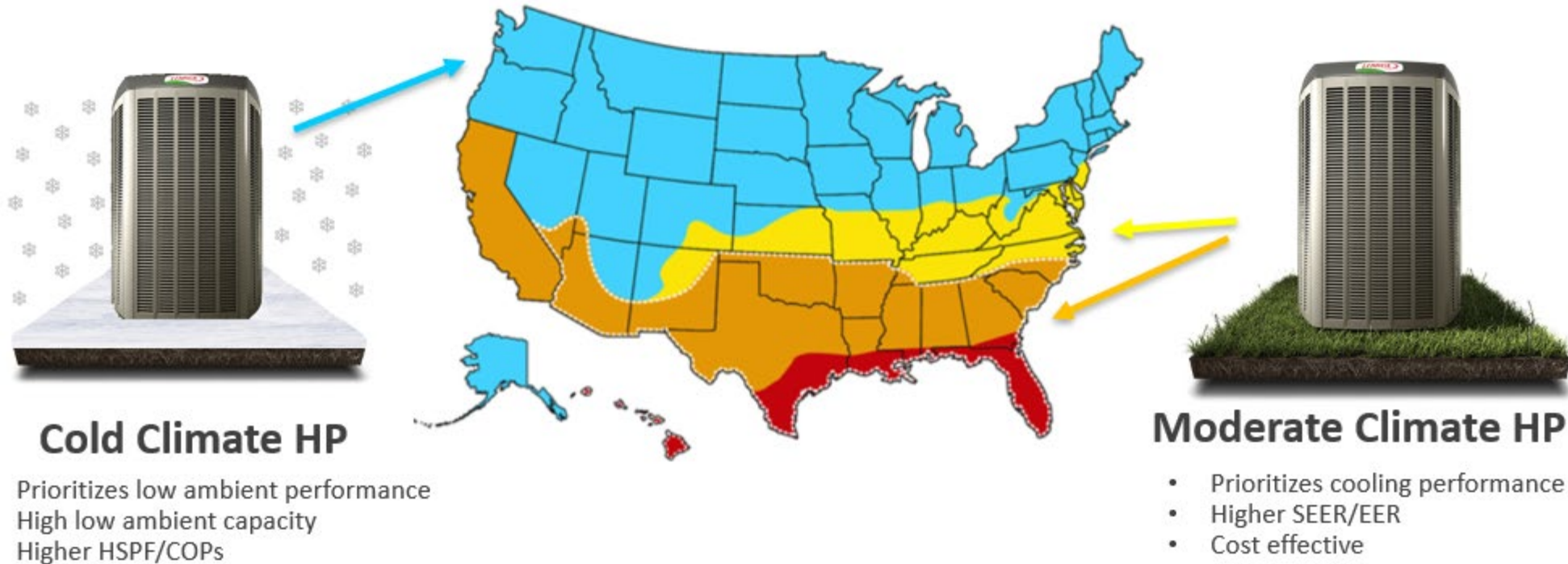


Refrigeration



Heat Pump Performance in Cold Climates

- Air – Air Heat Pumps are the predominate product type in the U.S.
- U.S. market is trending toward Region Specific Heat Pump Products



Competing Specifications for Definition of Cold Climate Heat Pump

DOE Cold Climate Heat Pump Challenge

Heat Pump Specifications and Cold Climate Criteria		SEER2	EER2	HSPF2	COP @ 5°F	Capacity Ratio (5°/47°F)	Operation @ -15°F	Variable Speed Required
2023 DOE Split Heat Pump Efficiency Standard		≥ 14.3		≥ 7.5				No
Energy Star 6.1		≥ 15.2		≥ 8.1	≥ 1.75	≥ 70%		Yes
CEE Tier 1 Proposal	North and Canada	≥ 15.2		≥ 8.1	≥ 1.75	≥ 70%		No
	South & SW	≥ 15.2	≥ 11.7	≥ 7.8	n/a			No
CEE Tier 2 Proposal	North and Canada	≥ 17.1		≥ 8.5	≥ 1.75	≥ 70%		No
	South & SW	≥ 17.1	≥ 12.3	≥ 8.0				No
DOE Cold Climate Heat Pump Challenge – Ducted Air Source Heat Pump				≥ 8.5	≥ 2.40	≥ 100%	Yes Optional	Yes



DOE Cold Climate Heat Pump Specification is Step Function improvement in HP Performance





DOE Cold Climate Heat Pump Challenge

- Lennox First to Demonstrate Performance to Challenge Specification
- Challenge also includes;
 - Validation of Performance with Specified System Controls
 - Demonstrating Efficient Performance in Mild Weather conditions in both Heating and Cooling modes of operation
 - Demonstrating minimization of Supplemental Heat during Heating and Defrost operation
- Test Results confirming Performance meeting or exceeding the Challenge Specifications confirmed at Oak Ridge National Laboratories
- Field Validations including Performance Monitoring to be conducted 2022 – 2024

Why Heat Pumps are Important to Decarbonization

- Heat Pump efficiently convert Electrical Energy to Heat and Cool
 - A Heat Pump can transfer over 4 times more Energy to Heat than it consumes
- Heat Pumps can significantly reduce total CO2 emissions versus other Heat sources
- Expanded Heat Pump deployment encourages further development of Clean Renewable Electrical Energy sources
- Advanced Heat Pumps with improved Capacity can minimize Supplemental Heat requirements
- Dual Fuel Heat Pump systems can significantly reduce CO2 emissions while managing Peak Heating Load requirements

Heat Pump Deployment

- Application Considerations
 - Building Type
 - Heat Pumps Sizing
 - Building Weatherization
 - Supplemental Heat Source if needed
 - Electrical Application Considerations
 - Controls Integration
- Absent Incentives or Restrictions Consumers are likely to make Like for Like Replacement Decisions

Contact Information

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