IHP ALLIANCE

Webinar | *January 16, 12 - 1 pm ET*

Industrial Heat Pump Economics in the United States

Steve Koski
Cascade Energy

Ammi Amarnath
Electric Power Research Institute (EPRI)

Grace Van Horn
Center for Applied Environmental Law and Policy (CAELP)

Webinar Logistics

This webinar is being recorded. The IHP Alliance will share the recording with all registrants and post the recording on our website.

Please use the Q&A button to ask questions during the webinar.

The IHP Alliance operates in strict compliance with anti-trust rules, and, thus, our discussions are all either pre-competitive or non-competitive.

IHP ALLIANCE

Industrial Heat Pump Alliance

Launched in partnership between...

RENEWABLE THERMAL COLLABORATIVE

ACEEE

NEMA

National Electrical Manufacturers Association

...to transform the market so that facility managers, service providers, and utilities consider IHPs as an ideal option for recovering waste heat, efficiently meeting low-to-medium temperature process heat needs, and reducing industrial emissions.

IHP Procurement Toolkit

The toolkit includes a questionnaire for buyers to input their technical and budgetary requirements for IHP procurement. Providing buyers with an opportunity to indicate their needs before reaching out to suppliers will reduce iterative costs and streamline the application and bidding process.

Step 1

Buyers fill out questionnaire

Step 2

Buyers submit completed Excel file to suppliers

Step 3

Suppliers initiate competitive bid process

Recent Publications from IHP Alliance Partners

ACEEE Topic Brief

Net-zero industry by 2050: a scenario analysis of boiler replacement with industrial heat pumps

December 2024

Hellen Chen, Andrew Hoffmeister

Summary: industrial equipment replacements and technology availability need to scale rapidly to reach goals

With U.S. industry contributing 1,453 million metric tons of CO_2e emissions annually (EPA 2023), remaining competitive in the global, clean energy economy and meeting domestic economy-wide net-zero goals will require quick adoption of low- to zero-emission equipment. Process heat accounts for over 50% of U.S. industrial emissions, of which about 40% falls into the low-temperature category (McMillan 2019). There are several electrification technologies that can address this portion of emissions, one of which is an industrial heat pump (IHP). IHPs are a highly efficient and scalable technology that can help decarbonize low-temperature (typically less than 150°C) processes today and are quickly advancing to reach higher temperatures and capacities. Additionally, IHPs provide numerous co-benefits such as process modularity, reduced pollutants, future proofing, cost savings, and enhanced product quality. Replacing all fossil fuel boilers with IHPs and other electrified technologies will be necessary to reach the U.S. Long-Term Strategy goal of net-zero greenhouse gas (GHG) emissions by 2050, which includes a net-zero goal for industry (White House 2021).

However, based on the current capabilities of IHPs, a continuous rate of improvement, and assuming that boilers are not replaced before end-of-life, we found that many industrial facilities are on track to still be using fossil fuel-burning boilers in 2050. Our analysis assumed that any future installation or replacement of industrial indirect heating equipment would use an IHP system if it was available to reach the needed temperatures and capacities.

Our findings reveal that even if boiler lifetimes are as short as 10–15 years, fossil fuel boilers will still be operating in industrial facilities by 2050 (see figure 1, which includes analyses for the overall industrial boiler inventory and for key industrial subsectors). To learn about our methodology, please see Appendix A.

Therefore, supportive policies and programs are critical to expand the capabilities of IHPs and other innovative electric technologies and rapidly scale replacements before end-of-life. This brief lays out near-, mid-, and long-term solutions that include renewables, storage, and hydrogen as well as recommendations for policymakers at every level, agency decision makers, utilities and regulators, vendors and equipment manufacturers, and (most importantly) industrial managers.

RENEWABLE THERMAL COLLABORATIVE

Utility Engagement Playbook for Industrial Customers: Addressing Power Sector Barriers to Electrification

PREPARED BY SYNAPSE ENERGY ECONOMICS, INC. AND WORLD WILDLIFE FUND

December 11, 2024

Image credit: ©Magda Ehlers / Pexels

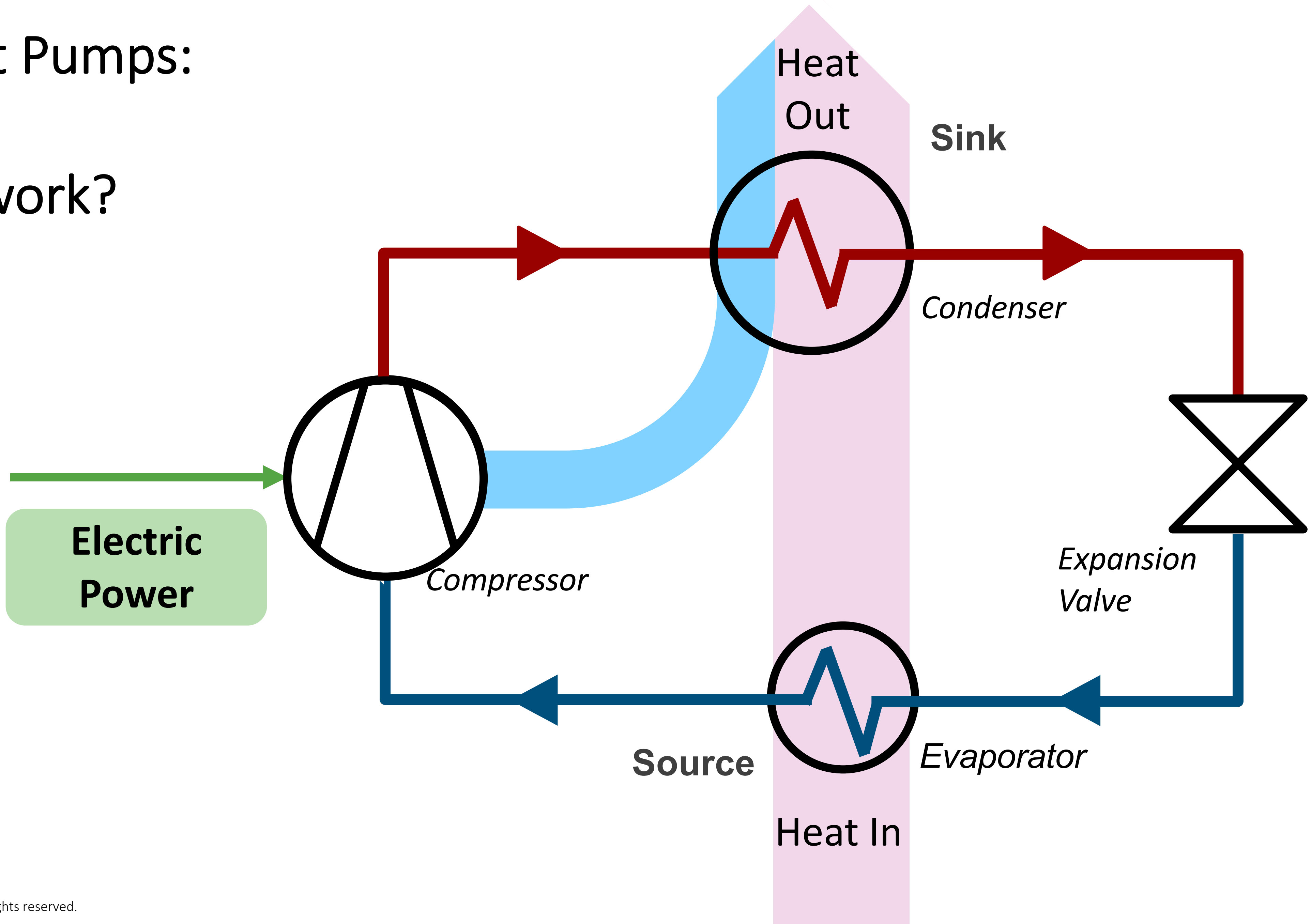
Find additional resources at industrialheatpumpalliance.org!

IHP ALLIANCE

Recent IHP Market Experience

Steve Koski

Industrial Heat Pumps:
Why?
How do they work?



IHP in Denmark

Malt Kiln/Dryer

Cascade 2024 Experience

Lots of scoping

A few projects moving forward

- Spark gap
- Cheap natural gas
- Basic economics often tough

More likely

- Good payback
- Decarb goals and aging equipment
- Incentives
- Staff, engineering support

IHP Market – Complete

TVR in Concentration & Drying

- Thermal Vapor Recompression
- Venturi type device

- Use HP steam to make MP steam from LP “waste” steam
- Reduces steam use
- No electrical input, no moving parts, compact
- Increases complexity, but well understood
- No utility incentives
- No brainer!

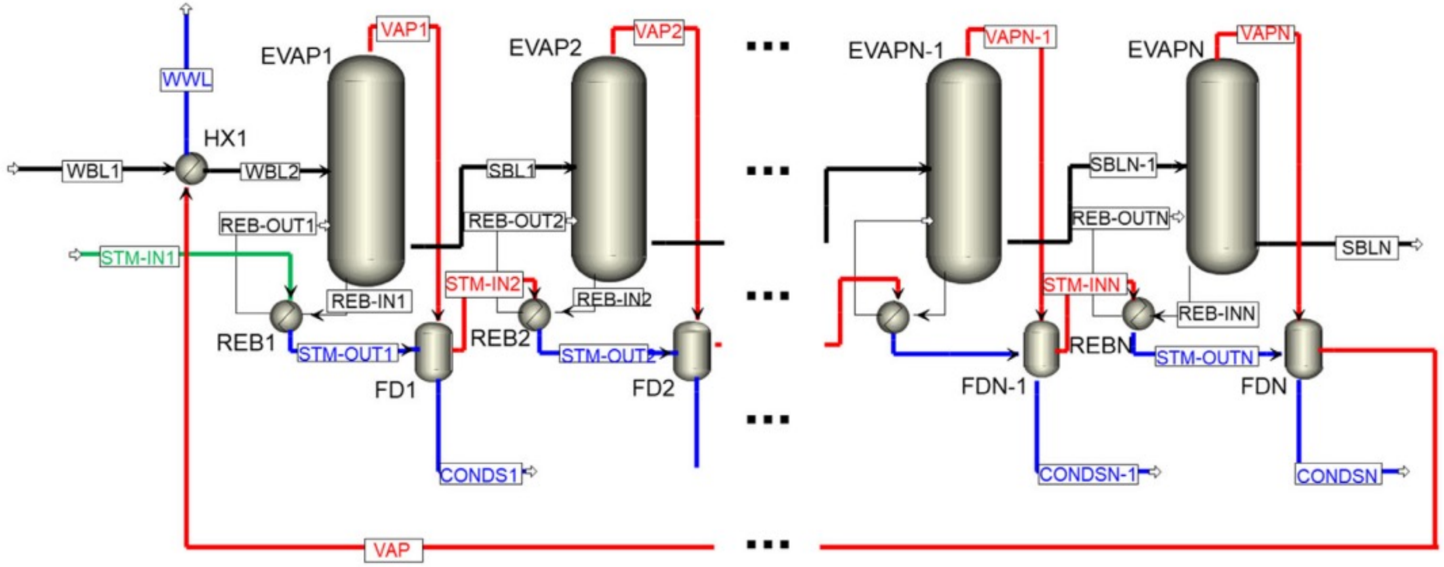


Image courtesy of Kim et al. 2021

IHP Market – Underway

Milking Parlors

- Mechanical Vapor Compression (smaller)
- Milk heat to wash water
- Propane or Gas to electric trade
- All major manufacturers
- Some utility incentives
- Most new milking parlors
- Some retrofits

Image courtesy of Pro Refrigeration

IHP Market – Starting

Dairy Plants

IHP Market – Next?

Breweries

- AtmosZero - First Quarter 2025 Boiler 2.0
- More?

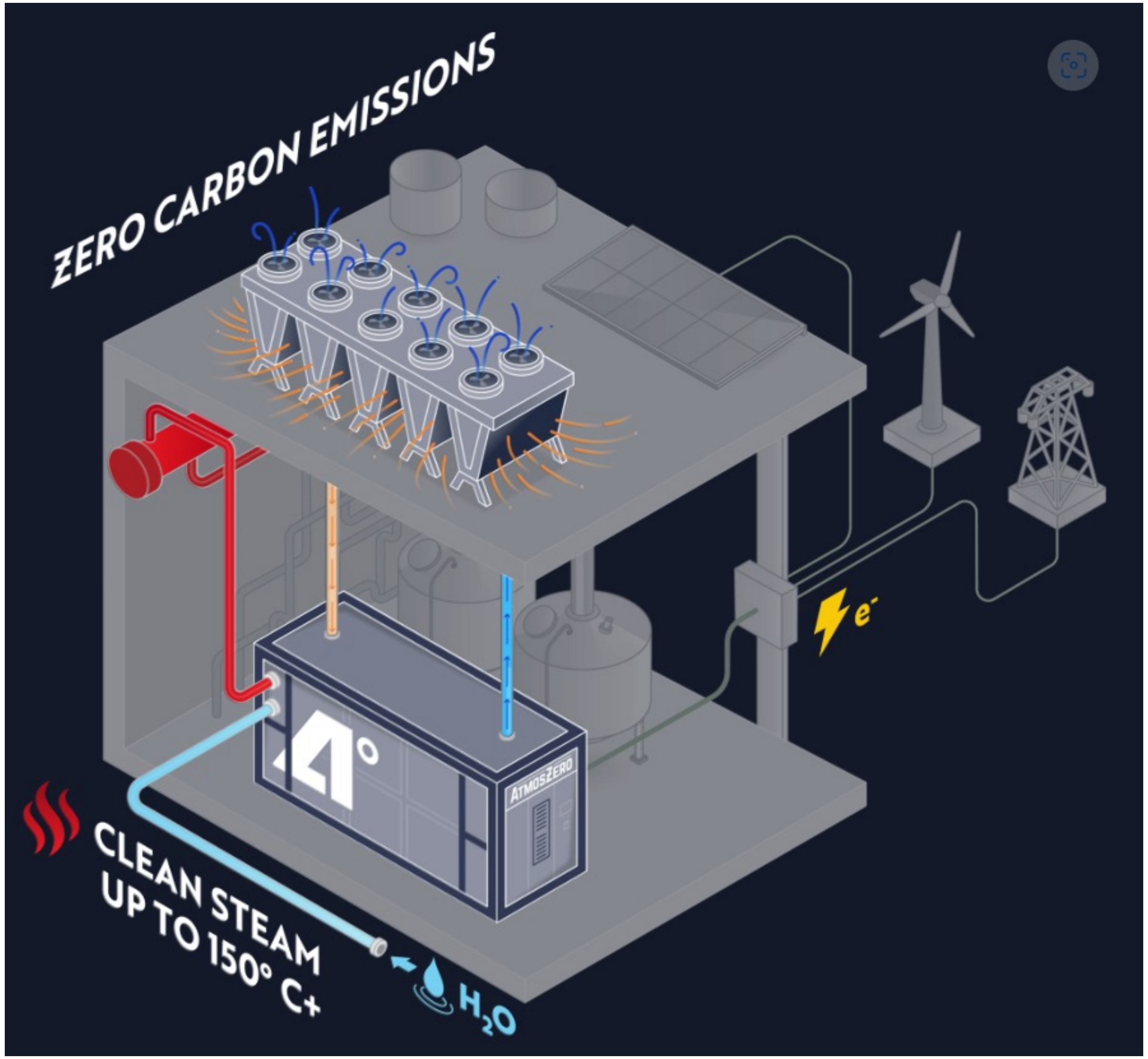


Image courtesy of AtmosZero

Thank You

Steve Koski

Cascade Energy

steve.koski@cascadeenergy.com

EPRI

Industrial Heat Pumps

Opportunities in Food & Beverage Sector

Electrification & Sustainable Energy Strategy

Ammi Amarnath
Principal Technical Executive

IHP Alliance Webinar
January 16, 2025

About EPRI

Our Mission

Advancing safe, reliable, affordable, and clean energy for society through global collaboration, science and technology innovation, and applied research.

Collaborative

Bring together scientists, engineers, academic researchers, and industry experts

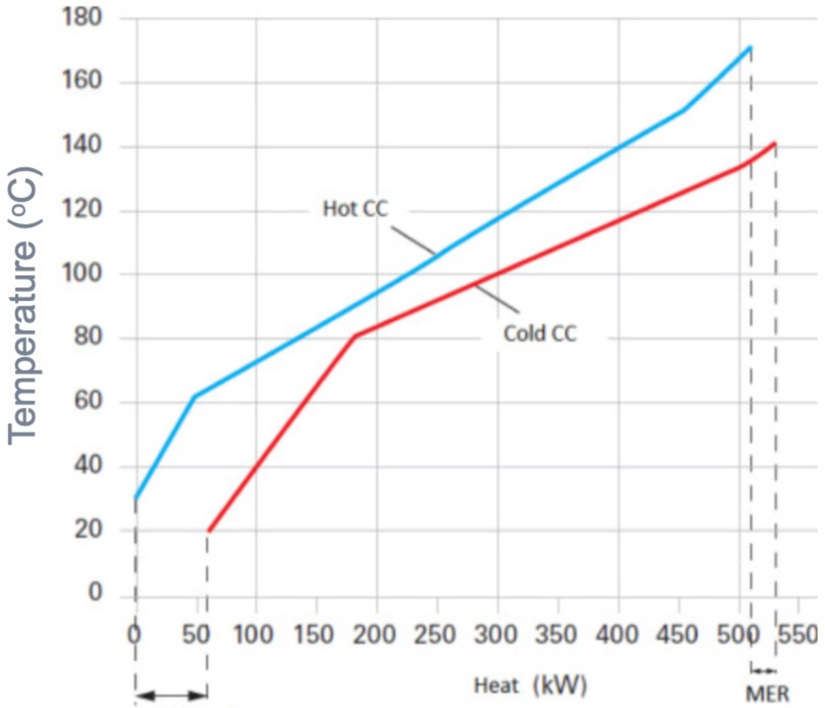
Independent

Objective, scientifically based results address reliability, efficiency, affordability, health, safety, and the environment

Nonprofit

Chartered to serve the public benefit

Industrial Heat Pumps in the U.S. – 40+ Years in the Making



EPRI

Industrial Heat Pump Manual

Technical and Applications Resource Guide for Electric Utilities

Over 40 Pinch Studies

1988 - 1992

EPRI – DOE Case Studies

EPRI

DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA

ALABAMA POWER

GEORGIA POWER

Duke Power

1980s/1990s Southeast U.S. electric utility consortium promoting industrial heat pumps

EPRI

New EPRI Study – IHP Potential in Food and Beverage

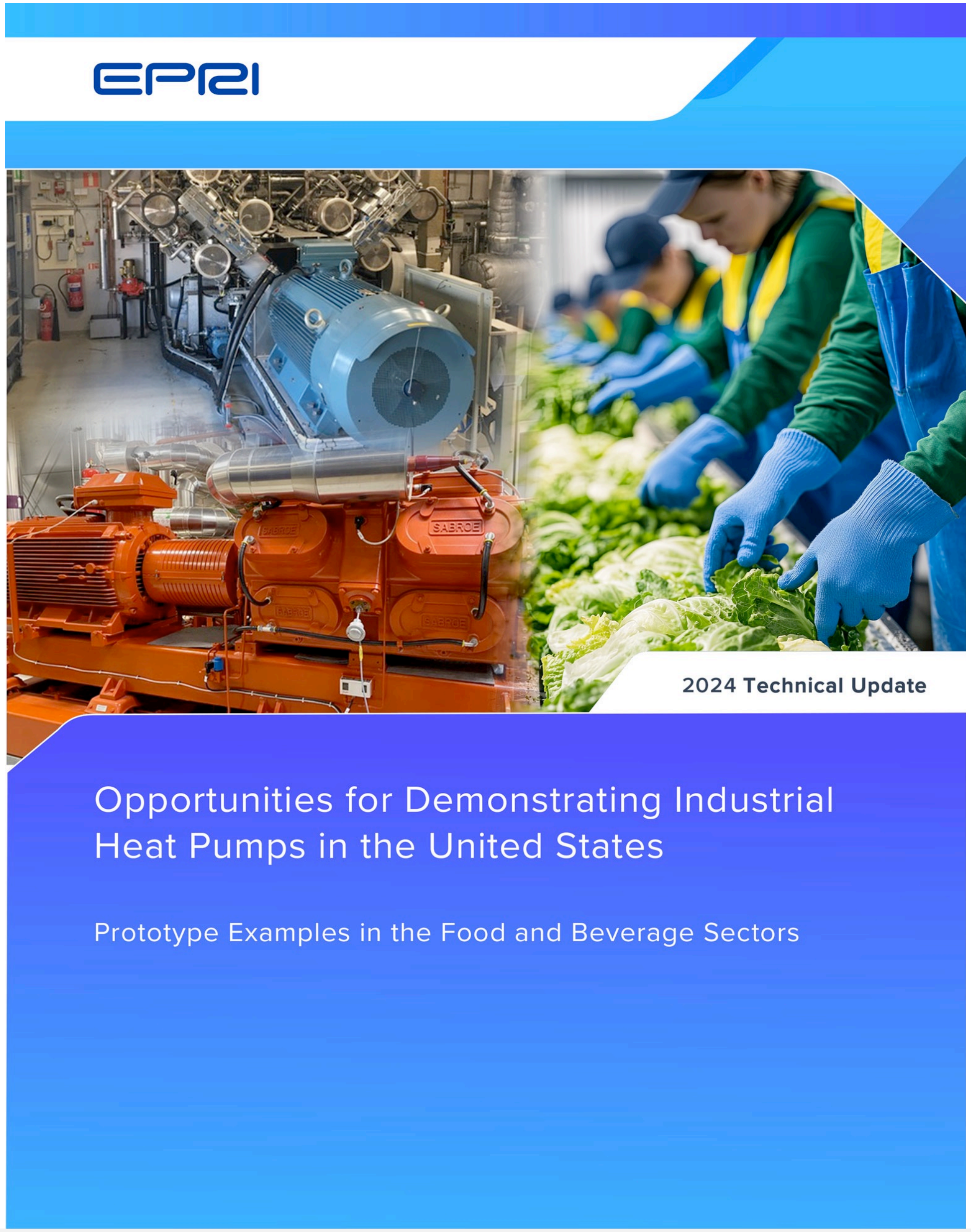
Study Title:

"Opportunities for Demonstrating Industrial Heat Pumps in the United States: Prototype Examples in the Food and Beverage Sectors"

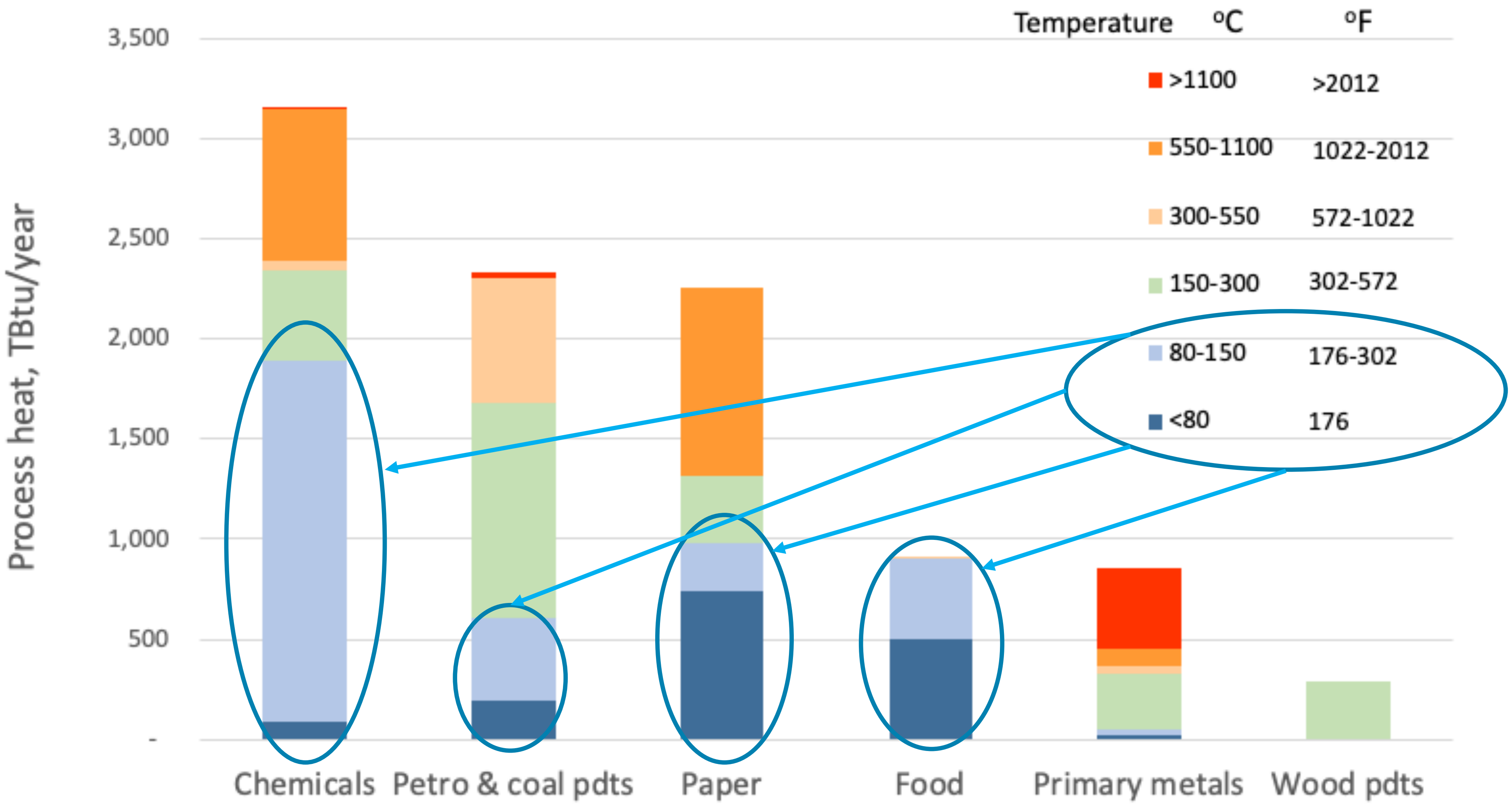
Report Objective:

- Determine the full technical potential of electrification and decarbonization of five key Food and Beverage subsectors through the replacement of steam boilers (and direct fired heaters) with industrial heat pumps.
- Assess the economics of the application of heat pumping to supply all process heat (steam) below 250°F in prototypical processes.

Link: https://www.epri.com/research/products/000000003002031135



Why F&B Sector? Significant Industrial Process Heat is Below 300°F



Data Source: McMillan 2019

Study Five Step Approach

1. Characterize five prototypical processes using publicly available data
2. Use four different heat pump types and proportion the supply heat (below 250°F)
3. Perform an economic analysis of each prototypical process
4. Perform market analysis of each prototypical process applying the four heat pump types across ALL subsector U.S. facilities
5. Determine decarbonization "opportunity spots" in U.S. states

Prototypical processes using publicly available data:

- Fruit & Vegetable Canning
- Animal Slaughtering & Processing
- Fluid Milk Manufacturing
- Bakeries
- Breweries

14,300 Facilities

(36% of Food and Beverage Establishments)

Overall U.S. Results: Food & Beverage IHP Study Results

Results to 100% Electrify Five F&B Subsectors Process Heat < 250°F

14,300 Facilities (36% of Food and Beverage Establishments)

Metric	Result	Units
Natural gas energy savings	280	TBtu/yr
Natural gas energy savings	80	% total fuel
Carbon emission reduction	10	million tons/yr
Carbon emission reduction	50	% total emissions
Electricity consumption increase	15,000	million kW-hr/yr
Electricity demand increase	1,500	MW

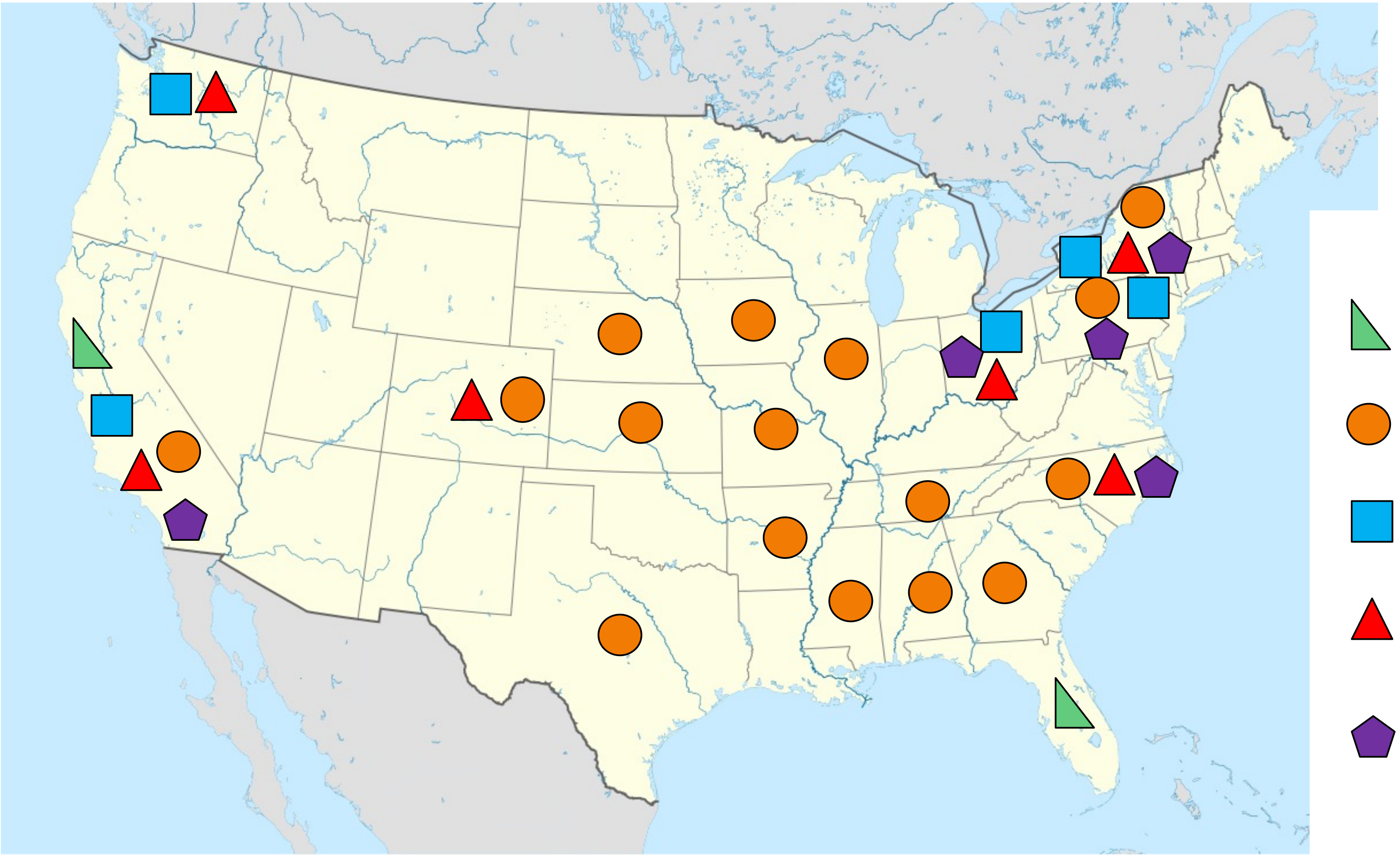
Natural gas savings equivalent to 5 million typical U.S. homes

Overall U.S. Results: Capital Investment and Paybacks

Subsector	Capital Investment ($ billion)	Payback (years), Market Energy Price	Payback (years), Renewable Natural Gas Price
Fruit & Vegetable	5	15	3
Animal Slaughter	7	7	2
Fluid Milk Manu.	2	10	2.5
Beer Brewing	1	7	2
Bakeries	1	13	3.5
Total 5 Subsectors	**16**	**9**	**3**

IHP installations are most economically attractive when compared to burning renewable natural gas in steam boilers

Carbon Reduction "Opportunity Spots" with IHPs



Opportunity spots determined by a combination of size of carbon emission reduction and/or low electric to fuel price ratio

- Fruit & Vegetable Canning
- Animal Slaughter & Meat Processing
- Fluid Milk Manufacturing
- Breweries
- Bakeries

Note: Legend icons are positioned to reflect the state's overall carbon reduction and not any specific region of the state

Engagements in EPRI's IHP Research

GOVERNMENT FUNDED RESEARCH ACTIVITIES

CALIFORNIA ENERGY COMMISSION

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

EPRI's MANUFACTURER NETWORK (Partial List)

oilon

GEA

Armstrong

TharEnergy

MAYEKAWA MYCOM

ATMOSZERO

COLLABORATION WITH NATIONAL AND INTERNATIONAL RESEARCH ORGANIZATIONS

cts4ca

50001 STRATEGIES

NEDO

EDF

ACEEE Smart Energy. Clean Planet. Better Lives.

DANISH TECHNOLOGICAL INSTITUTE

iea Annex 58

UTILITY FUNDED RESEARCH ACTIVITIES

Collaborative Utility Funded Demonstration Project

- Southern Company
- TVA
- NYPA
- Others

Contact Information:

Ammi Amarnath
aamarnath@epri.com

TOGETHER…SHAPING THE FUTURE OF ENERGY®

www.epri.com

Decarbonizing Industrial Heat: Measuring Economic Potential and Policy Mechanisms

IHPA Webinar: Industrial Heat Pump Economics in the U.S.

Grace Van Horn

January 16, 2025

Center for Applied Environmental Law and Policy

Energy+Environmental Economics

Analysis Key Questions and Overview

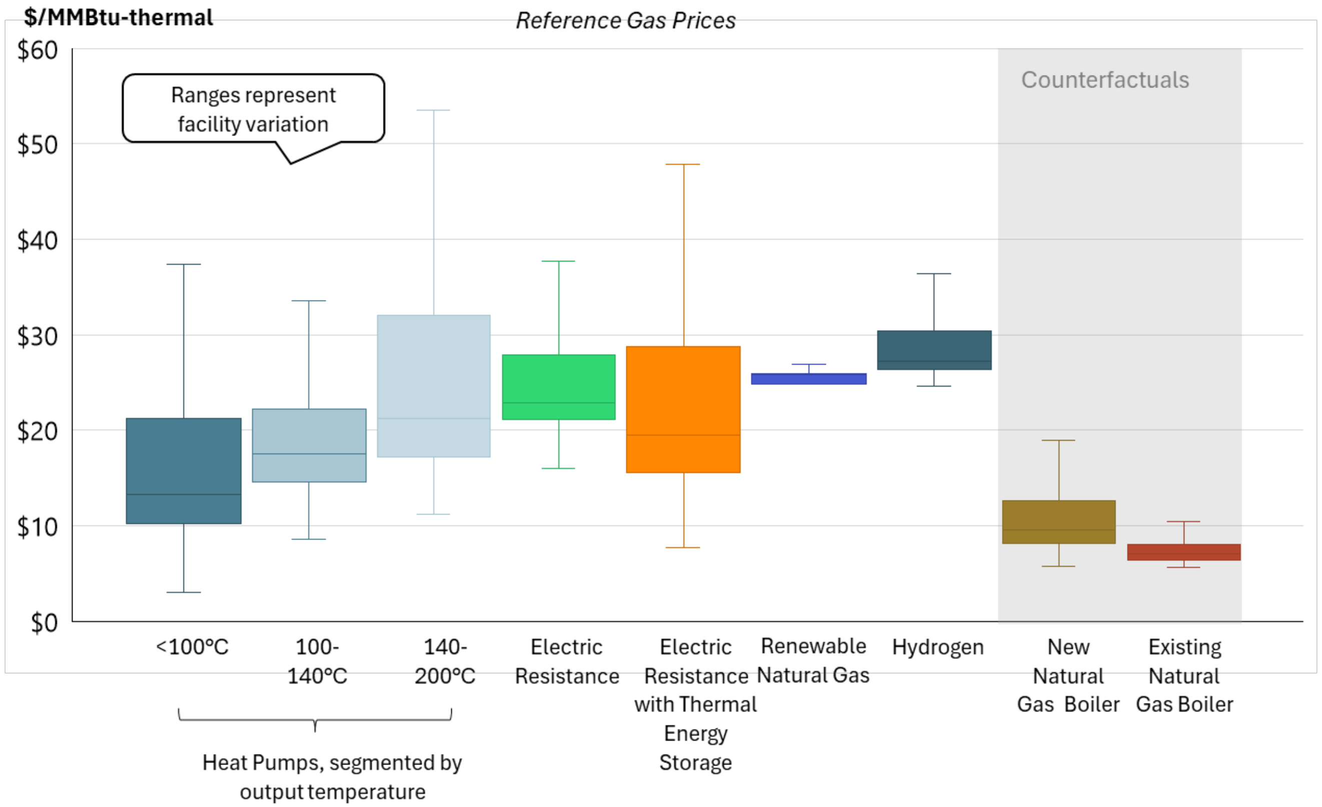
- How much natural-gas fired industrial heat can be cost-effectively replaced with lower-emitting options?
- What are the key economic drivers for this heat replacement potential at the state level?
- How can targeted policy interventions help improve the economic case for industrial heat decarbonization?

1. Construct a detailed, state-specific and facility-specific model to estimate the economics of decarbonizing indirect heat in facilities across the US
2. Conduct a calculation of economics for heat pumps, electric resistance (with and without thermal energy storage), renewable natural gas, and hydrogen as compared to the counterfactual natural gas technology.
3. Perform screening analysis of four types of policies which would help improve the economics of heat pumps relative to counterfactual natural gas boilers: low-cost loans, investment tax credits, carbon pricing, and production tax credits.

Heat pumps can be competitive with new gas boilers at low temperature requirements

+ E3 assessed the levelized cost of heat (LCOH) for several low-carbon heating alternative technologies
  - 20-year investment horizon with 10% real discount rate
  - Compared against two counterfactuals:
    - New gas boiler
    - Existing gas boiler
+ Heat pumps are cost-competitive with boilers at some facilities, largely <100C
+ Decarbonizing higher required temperatures is much more expensive than natural gas

Levelized Cost of Heat



Electricity/Gas Price Ratio is a major driver in cost effectiveness of Heat Pumps

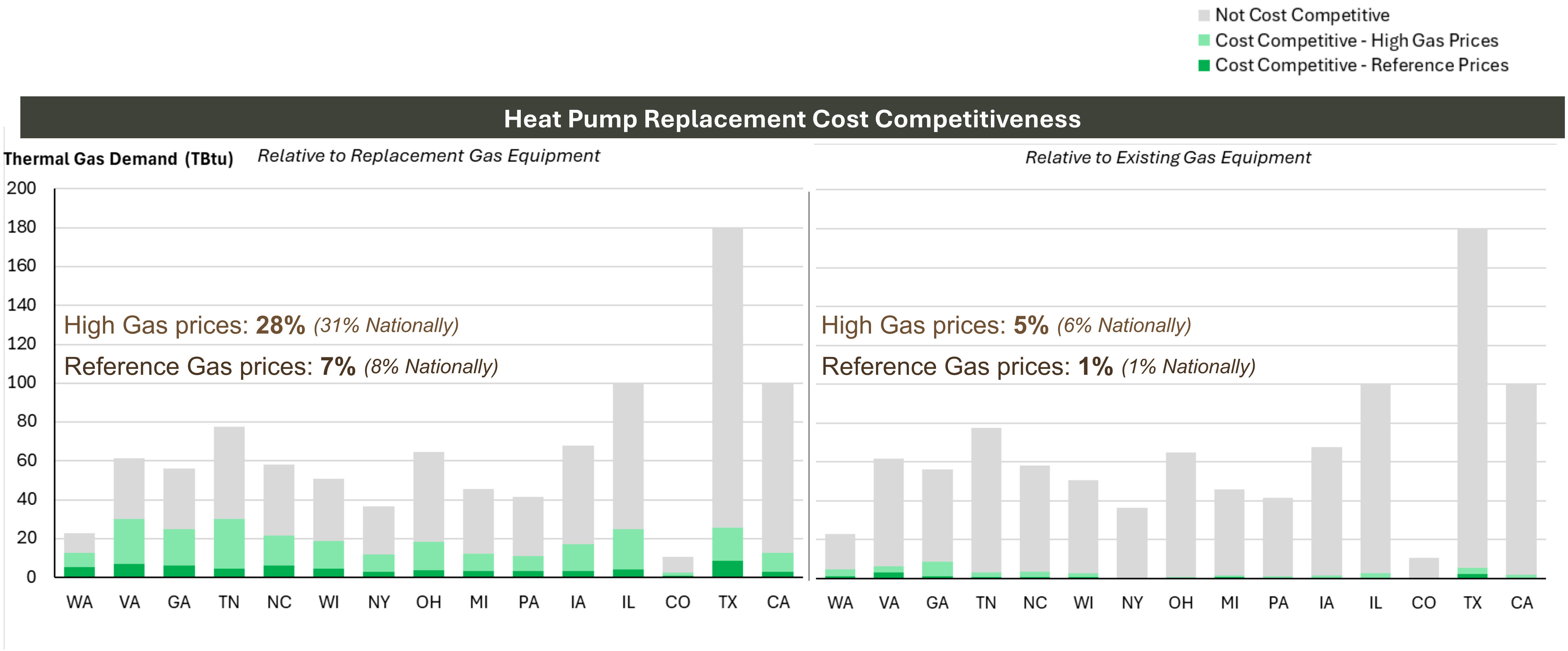
+ States with the lowest electricity/gas price ratios have the highest percentage of gas demand that is cost competitive with heat pump replacements

+ In the Reference Prices scenario, 25% of gas demand in WA is cost effective, with the lowest electricity/gas price ratio out of the states selected, due to its hydro dominated grid (rises to 55% in the High Gas Prices scenario)

+ CA has the highest electricity/gas price ratio, leading to the lowest percentage of manufacturing gas demand that is cost competitive with heat pumps

Center for Applied Environmental Law and Policy

Only a limited amount of natural gas demand is currently cost competitive to be replaced with heat pumps without policy support

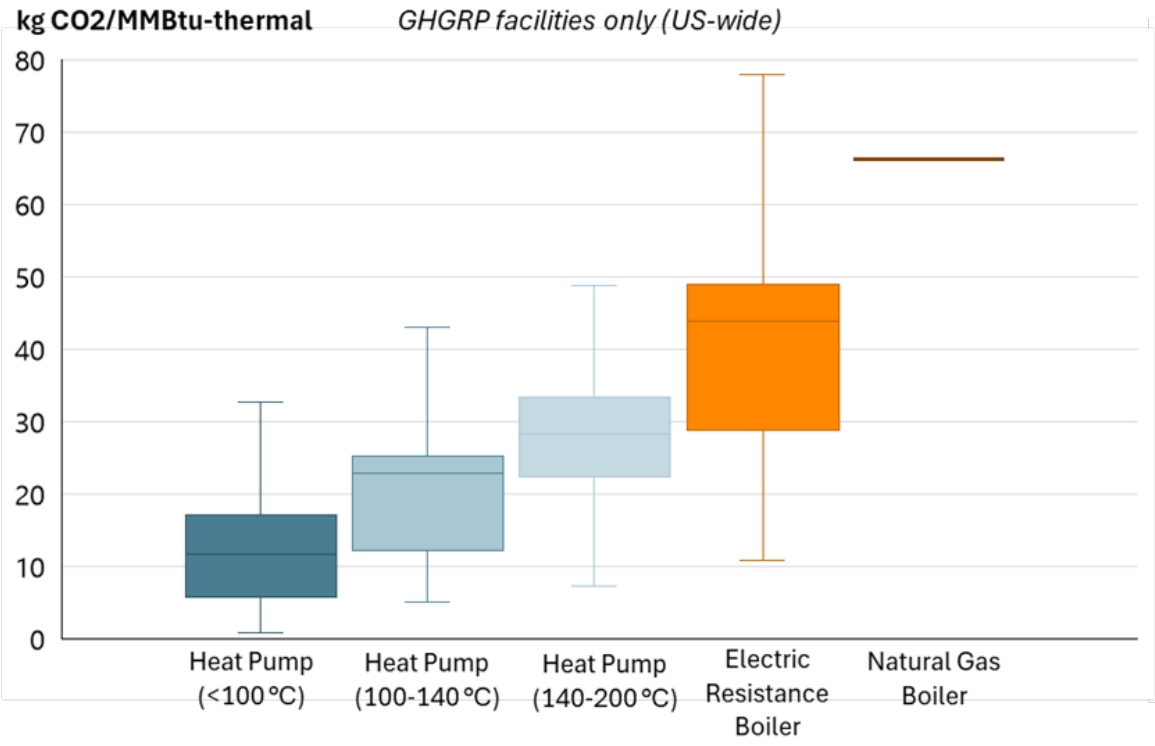


Center for Applied Environmental Law and Policy

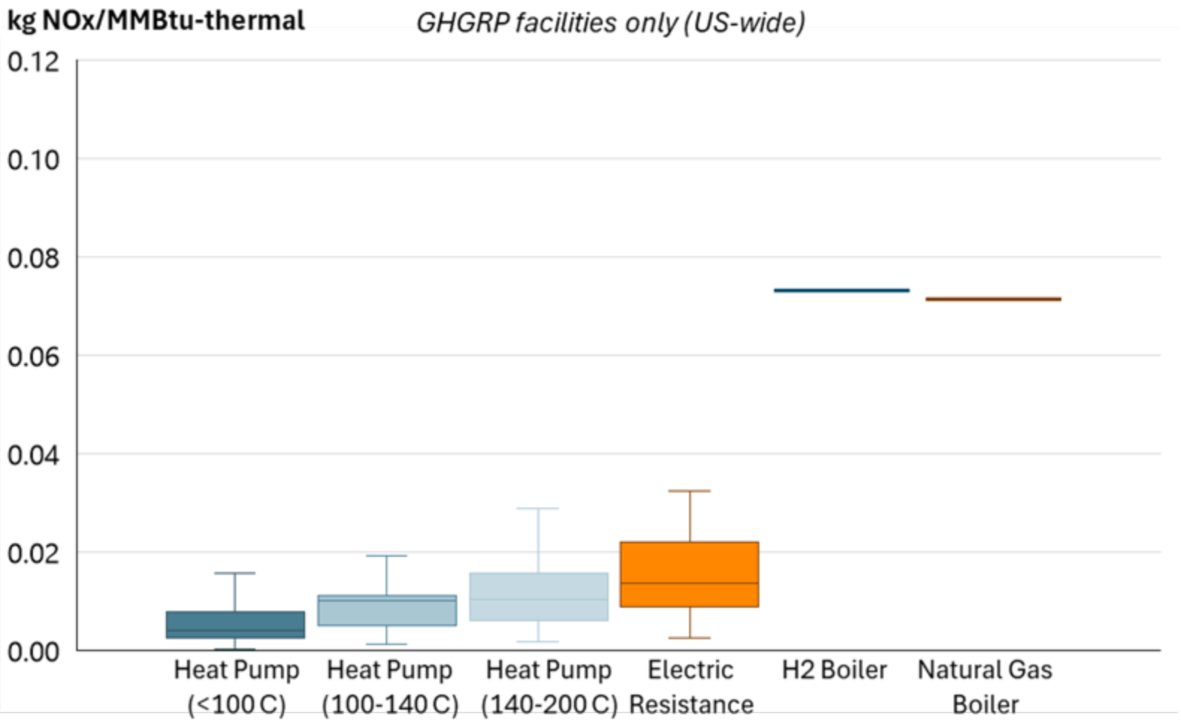
Heat pumps and electric resistance boilers decrease the emissions of delivering heat

Heat pumps always reduce CO_2 and NO_x emissions against gas boilers, even when accounting for upstream emissions of electricity generation, due much higher efficiencies (COP > 2)

Lifetime CO_2 Emissions Intensity



Lifetime NO_x Emissions Intensity



Center for Applied Environmental Law and Policy

Evaluated policies that increase cost effectiveness of heat pumps relative to natural gas

Investment Tax Credit

- Tax credit available in year 1 relative to % of heat pump capital cost

Low Cost Financing

- Capital costs can be financed at lower rate than investment discount rate

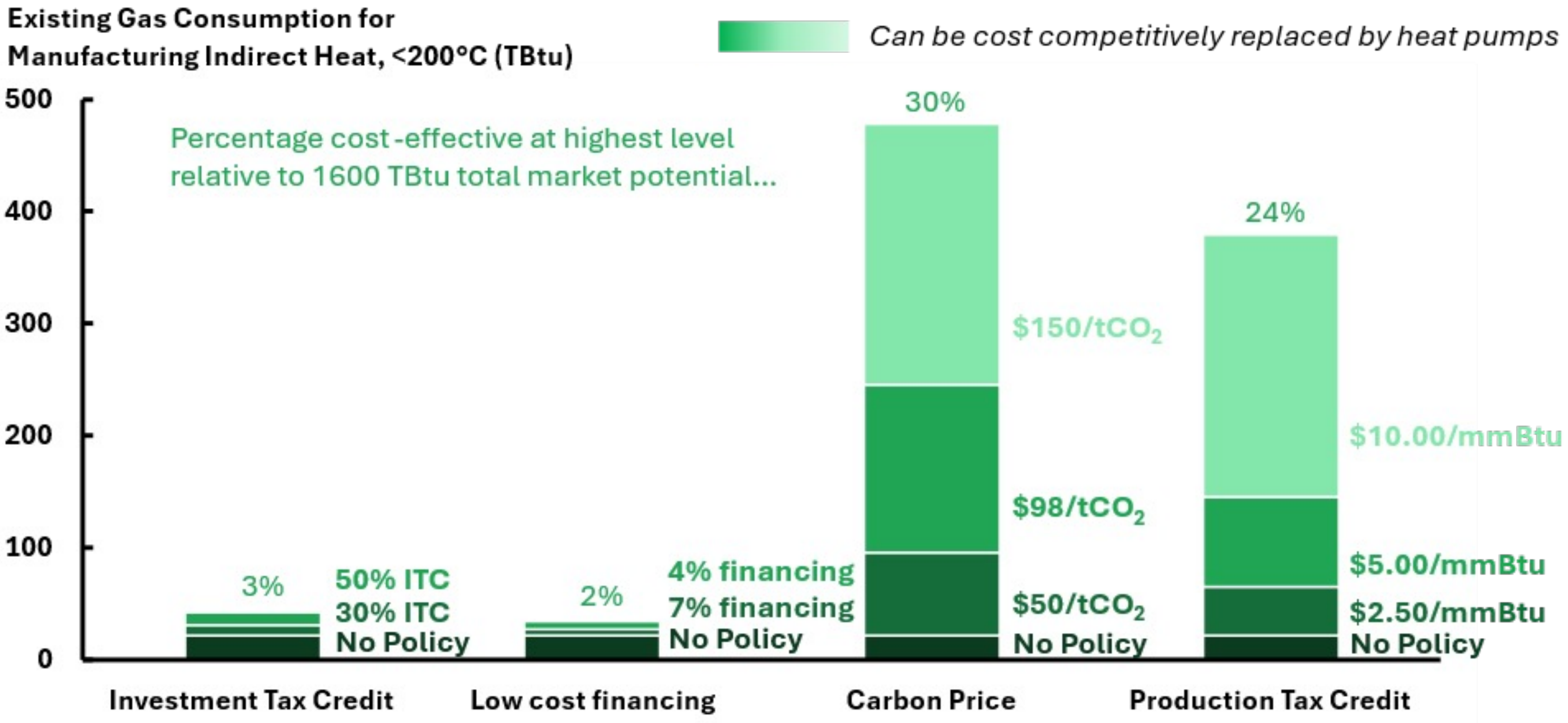
Carbon Price

- Improves relative economics of low carbon alternative by pricing emissions, including on upstream electric system

Production Tax Credit

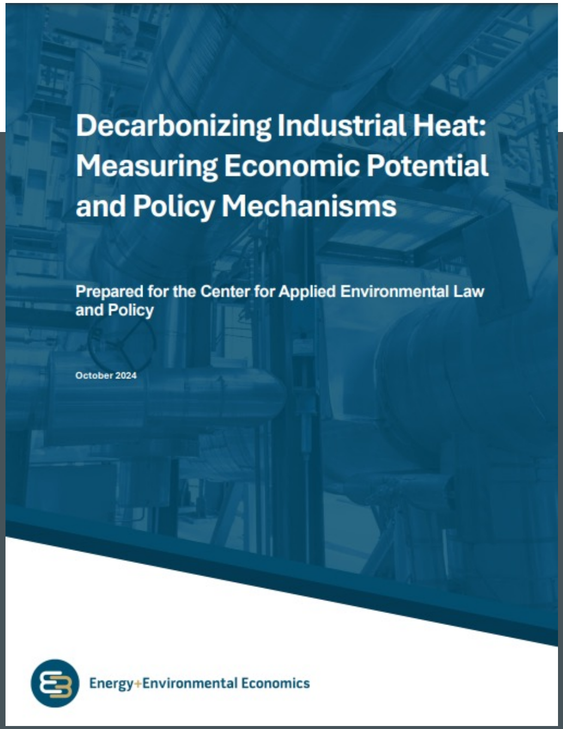
- Annual tax credit for 10 years for each unit of heat produced, scaled down from nominal value by % reduction in heating emissions

Policies that affect operational costs are more effective at making heat pumps cost competitive



Thank You!

Center for Applied Environmental Law and Policy


Decarbonizing Industrial Heat: Measuring Economic Potential and Policy Mechanisms

Prepared for the Center for Applied Environmental Law and Policy

October 2024

Energy+Environmental Economics

Grace Van Horn
grace.vanhorn@caelp.org

Full report available at caelp.org/reports


IHP ALLIANCE
Webinar | January 16, 12 - 1 pm ET
Industrial Heat Pump Economics in the United States
Steve Koski
Cascade Energy
Ammi Amarnath
Electric Power Research Institute (EPRI)
Grace Van Horn
Center for Applied Environmental Law and Policy (CAELP)

Upcoming IHP Alliance Events

January 27, 11am-12pm ET: IHP Alliance Working Group

Stay tuned for info on our 2025 Buyers Bootcamps!

Thank You!

Questions? Contact us:

ahoffmeister@aceee.org

hchen@aceee.org

steve.griffith@nema.org

ruth@dgardiner.com

APPENDIX

Dataset Development & Key Inputs

Identify Focus Units at GHGRP

- Of the 8,284 combustion units at large industrial facilities in the original GHGRP dataset, 931 (11%) of them met all the following conditions:
- Facility is in the manufacturing sector (industries with 2-digit NAICS codes between 31-33)
- Natural gas is the primary fuel of the combustion unit
- The combustion unit is either a conventional boiler or a combined heat and power system

Scale Up to Account for Small Units

- Energy consumption data for boilers and CHP in the NREL 2014 Manufacturing Thermal Energy Use dataset (*non-GHGRP facilities*) were integrated to account for smaller boilers
- Integrating these facilities added approximately 1,300 TBtu to the 800 TBtu of annual natural gas consumption from the GHGRP facilities database

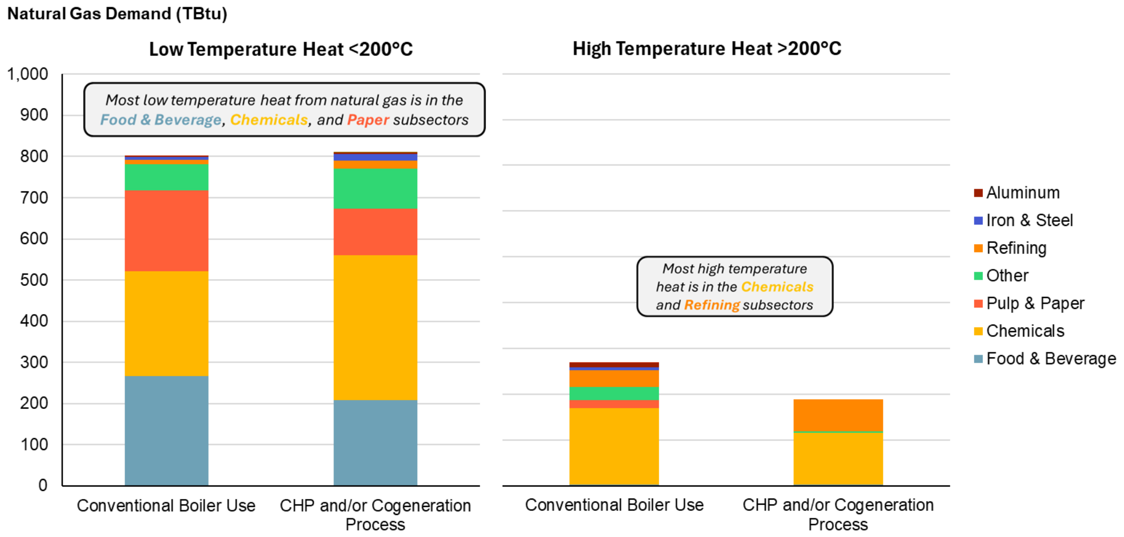
Assign Temperature Ranges

- Energy consumption data for the individual combustion units from the GHGRP was categorized by equipment type (boiler, CHP, or other) and assigned to various temperature ranges.
- Subsector-level temperature requirements were sourced from the NREL 2014 Manufacturing Thermal Energy Use database

Identify Natural Gas and Electricity Prices and Emissions

- EIA 2023 Annual Energy Outlook (AEO) was used for electricity prices, natural gas prices, and grid emissions intensity
- Two scenarios were used for gas prices: reference and a high case
- 'Low Zero-Carbon Technology Cost' scenario for electricity pricing and emissions (best aligned with EPA's final modeling including 111 power sector standards)

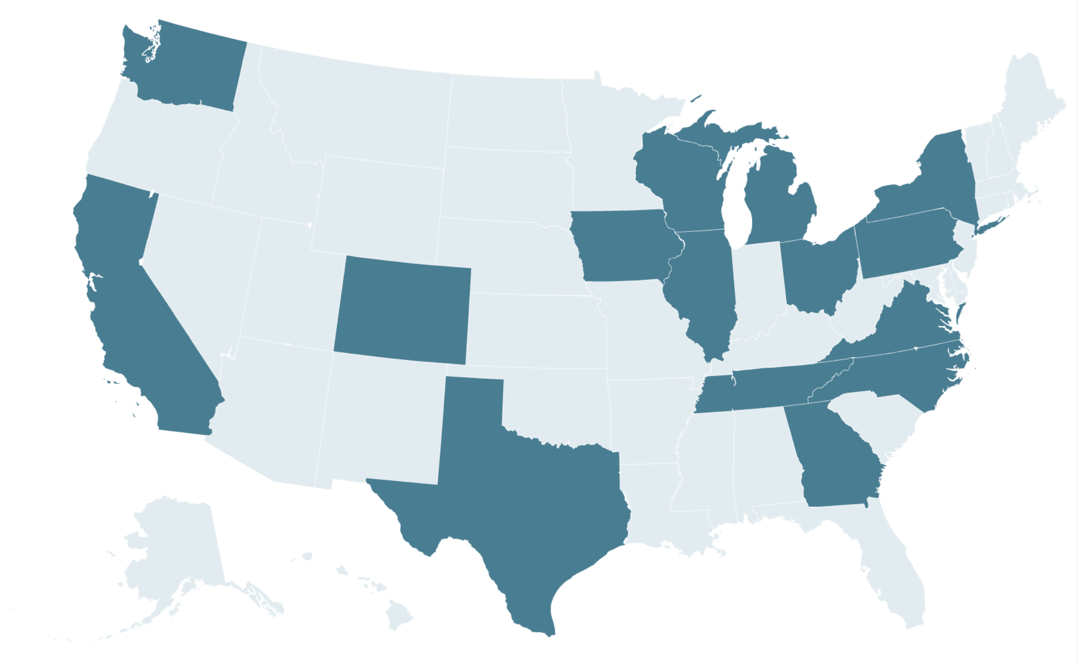
Characterization of Industrial Natural Gas Demand from E3 Database



Center for Applied Environmental Law and Policy

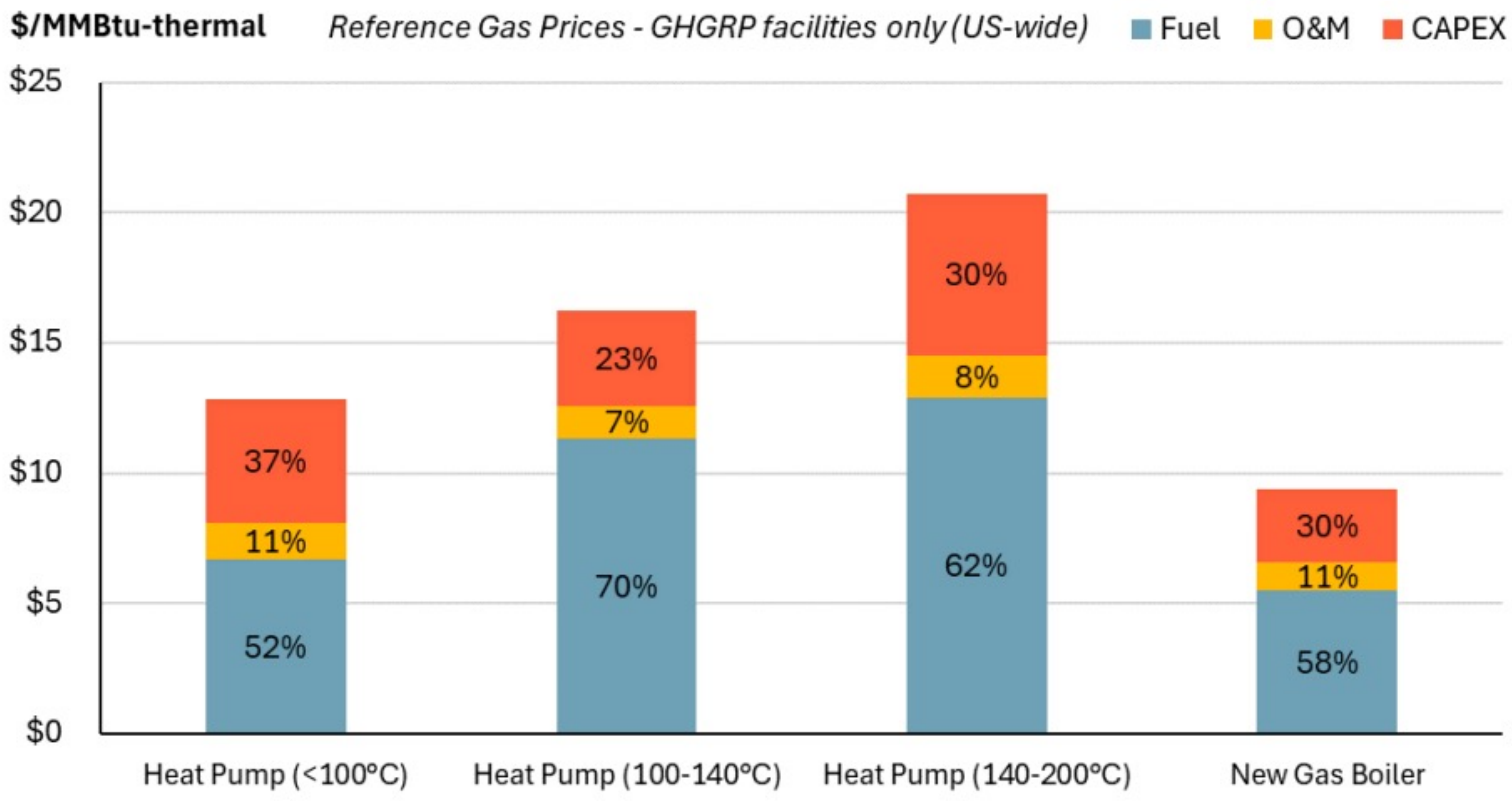
State selection

- E3 and CAELP collaborated to select fifteen states for detailed analysis
- Criteria for selecting states included:
  - Higher technical heat consumption, both <200 C and >200 C
  - Variety of electric/gas price ratios
  - Industrial subsector diversity
  - Geographic diversity
  - Preference for states with ambitious climate targets and policies



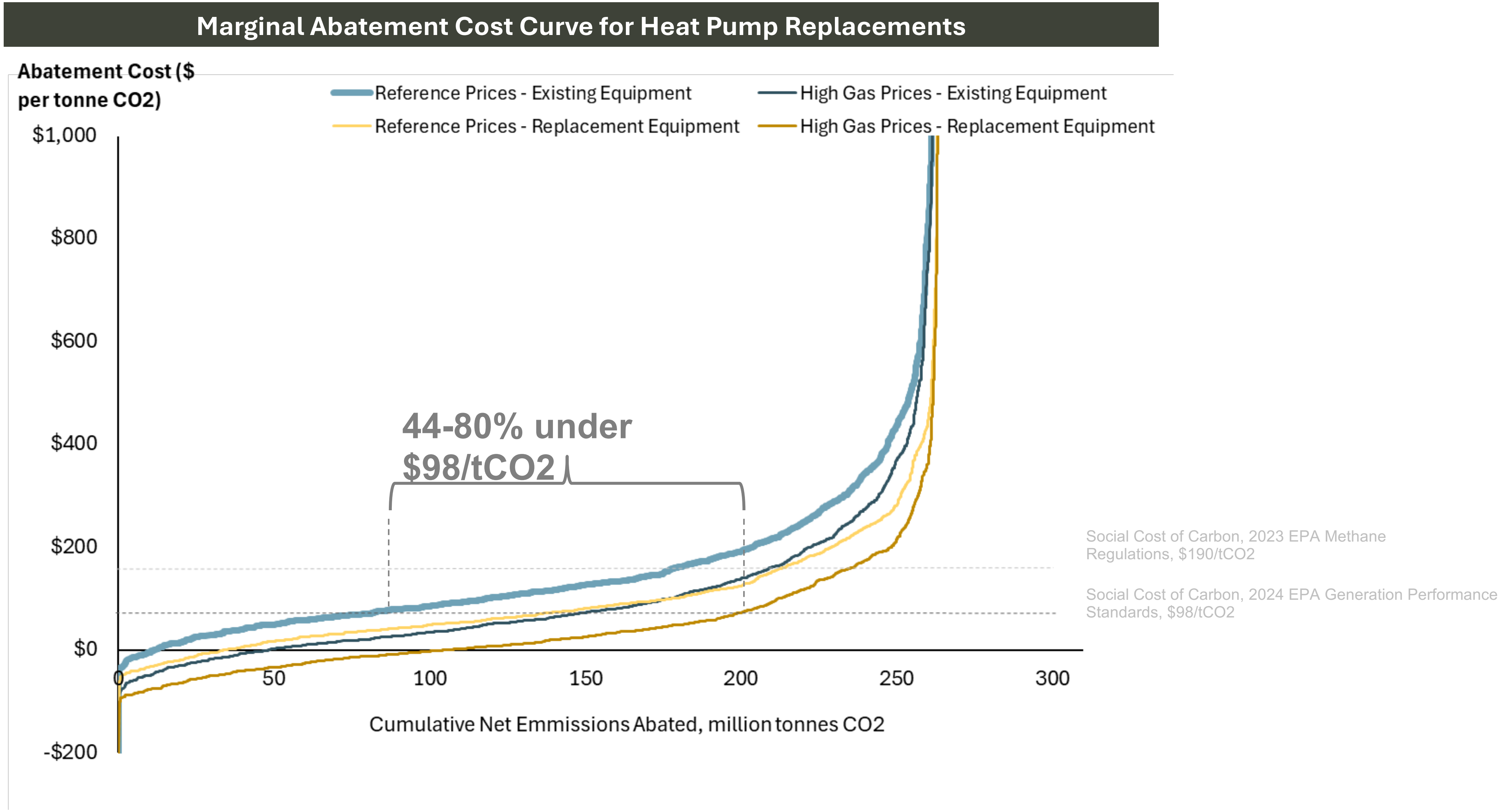
Lifetime costs of heat pumps are dominated by operating costs, especially at higher temperatures

Heat Pump and Natural Gas Cost Structure for the Average Unit



Center for Applied Environmental Law and Policy

Abatement cost of 44-80% of emissions is less than EPA's social cost of carbon of $98/tCO2



Center for Applied Environmental Law and Policy

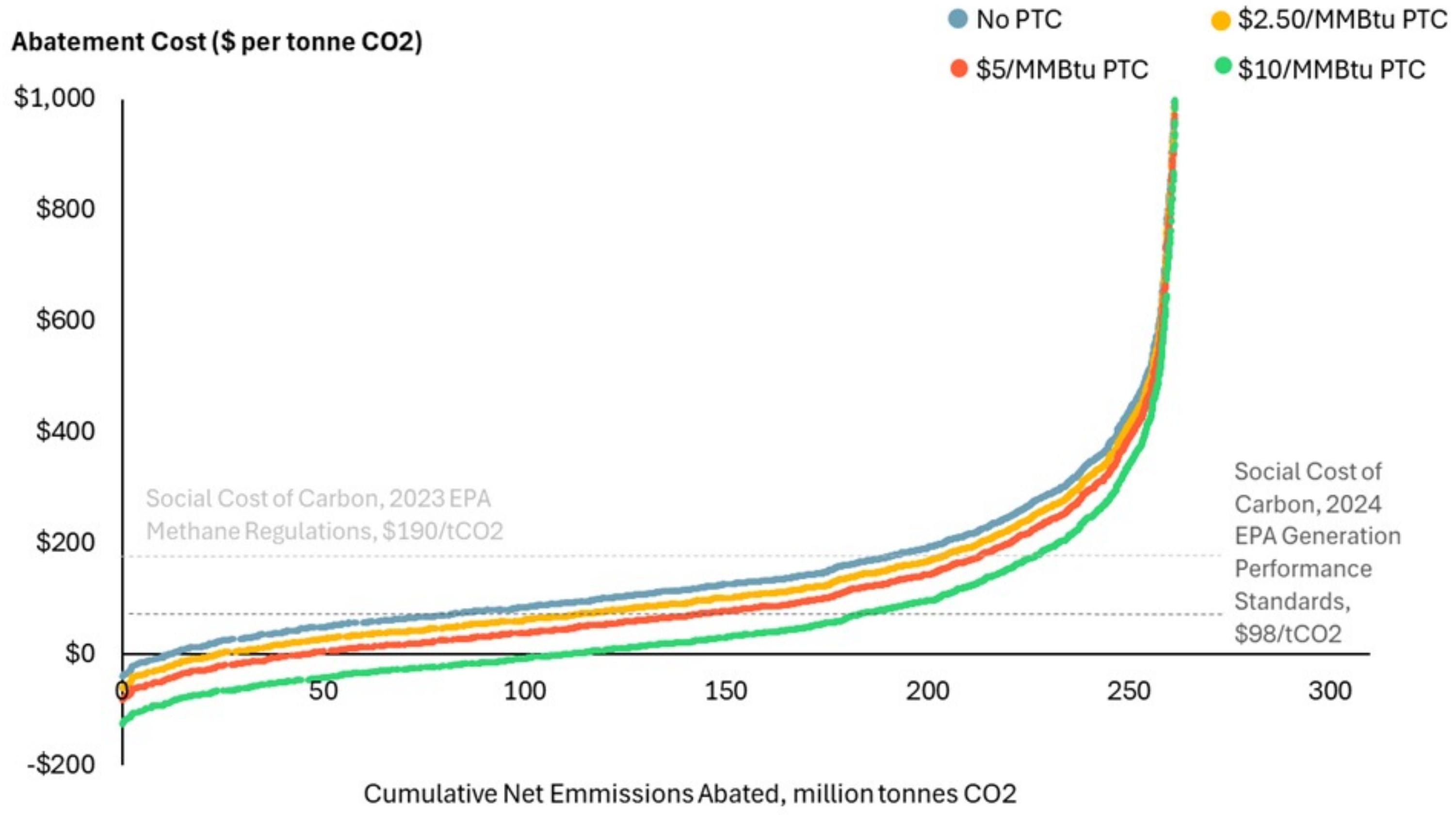
A production tax credit can significantly lower the net marginal abatement cost of adopting heat pumps

Cost Competitiveness

PTC Level	% Cost Competitive	Annual tax expenditure
$10.00/MMBtu	24%	$1,650 M
$5.00/MMBtu	8%	$336 M
$2.50/MMBtu	3%	$67 M
No PTC	1%	$0 M

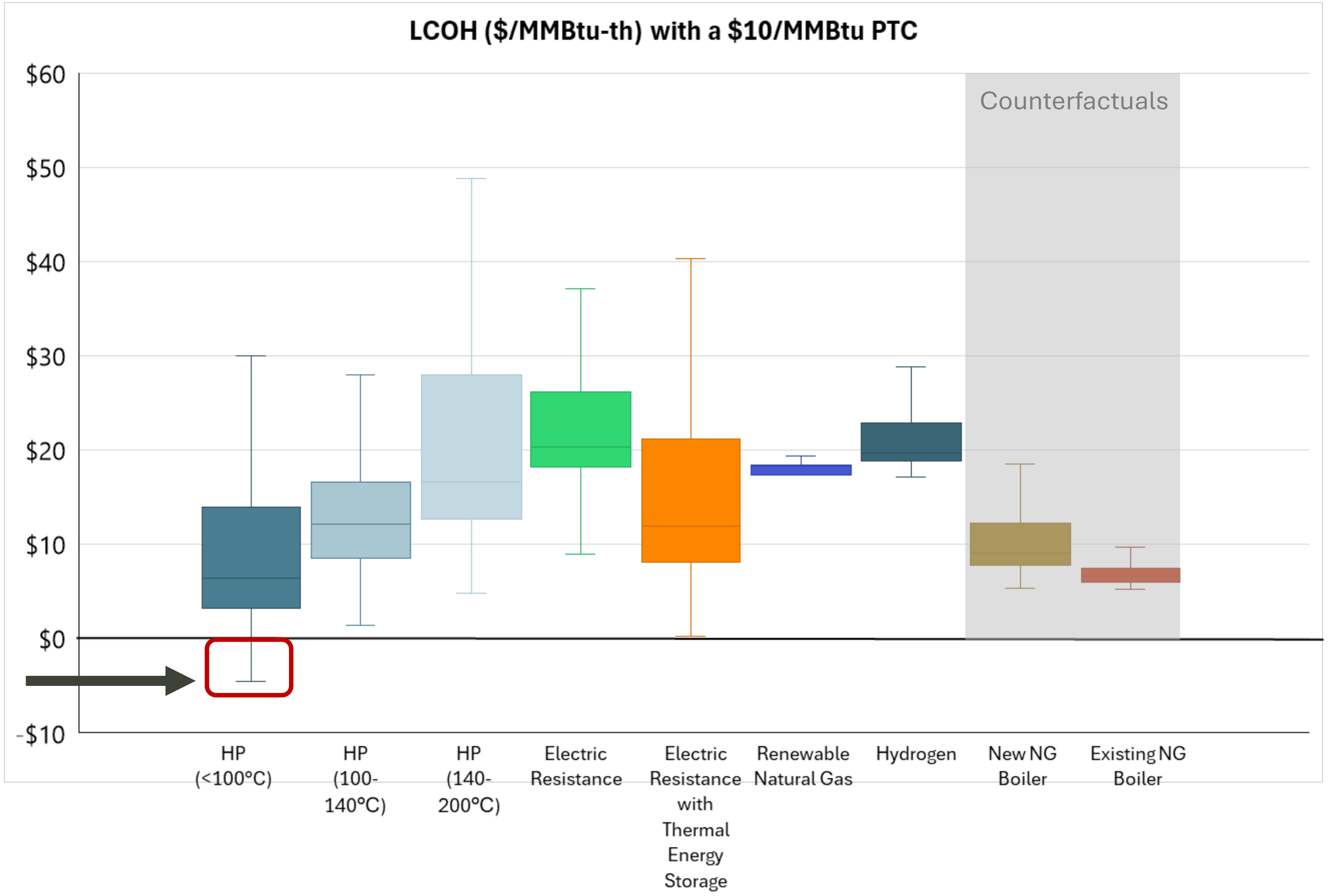
Note: Relative to Existing Gas Equipment

Net Marginal Abatement Cost (2022$)



High PTC values can substantially eliminate the cost gap between electric and natural gas technologies

At high PTCs, potential for heat to be produced at profit regardless of whether it is used. Further study on design and level is valuable to drive substantial adoption without over-subsidizing cheapest use cases.



A carbon price system can substantially improve the economics of heat pumps relative to gas equipment

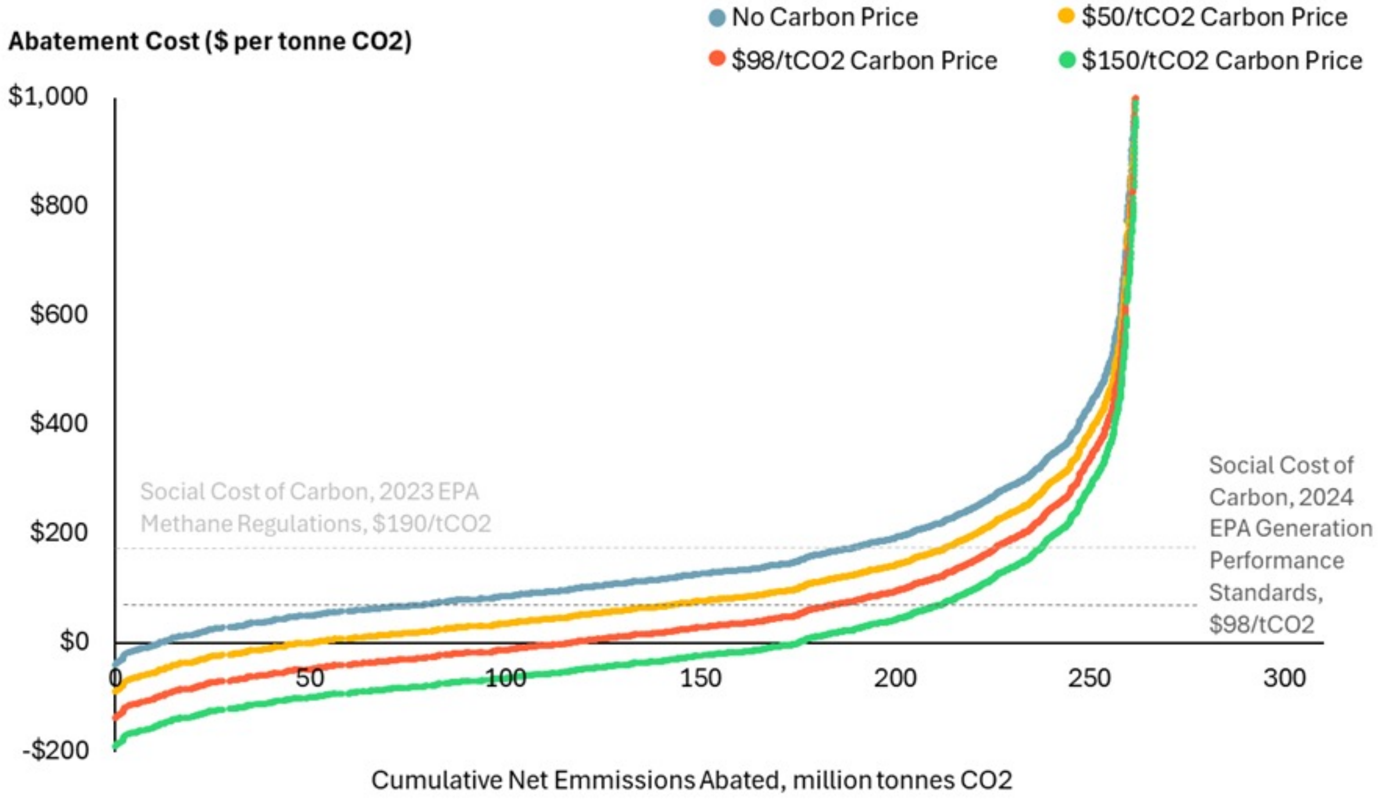
Various mechanisms are available to protect domestic industry competitiveness under a carbon pricing policy

Cost Competitiveness

Carbon Pricing Level	% Cost Competitive
$150/tCO_2$	30%
$98/tCO_2$	15%
$50/tCO_2$	5%
No price	1%

Note: Relative to Existing Gas Equipment

Net Marginal Abatement Cost (2022$)



Center for Applied Environmental Law and Policy