CalPLUG Presents

From Barriers to Breakthroughs:

Social Science Insights for Accelerating Heat Pump Adoption in California

Presented by:
Dr. Sarah Outcault
University of California, Davis

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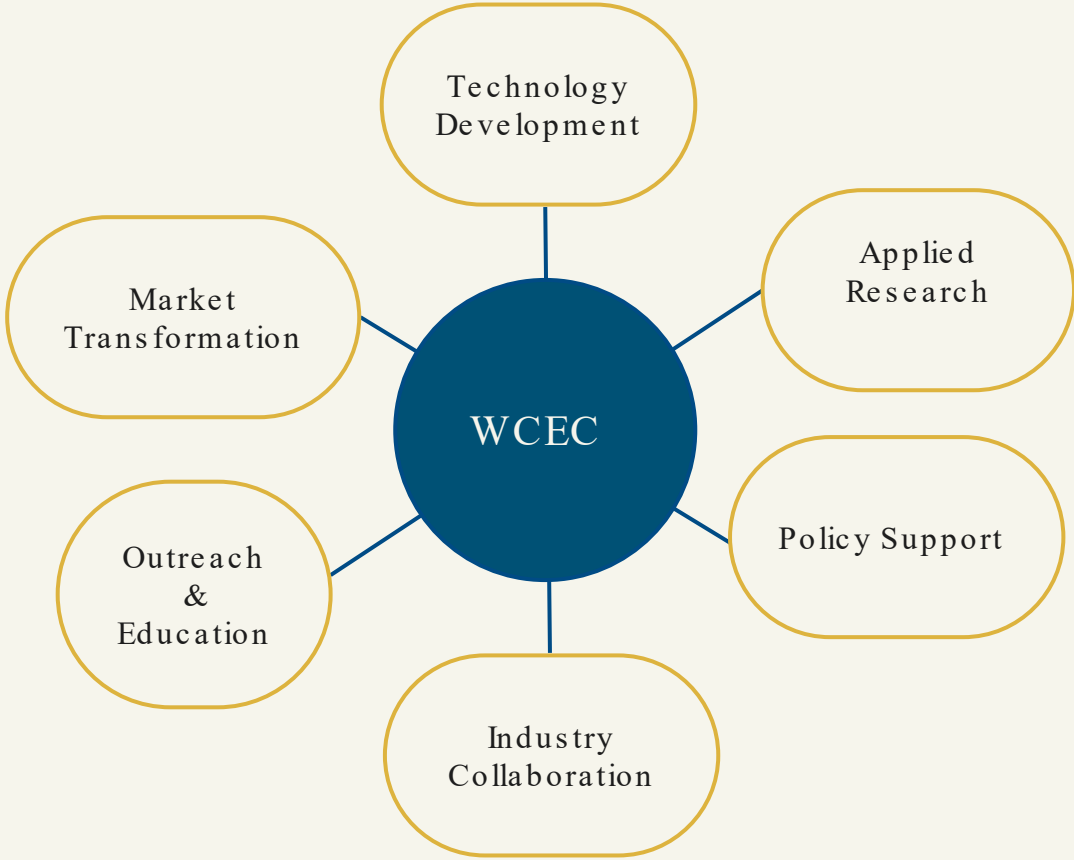
Market Transformation
Research Program

Western Cooling Efficiency Center (WCEC)



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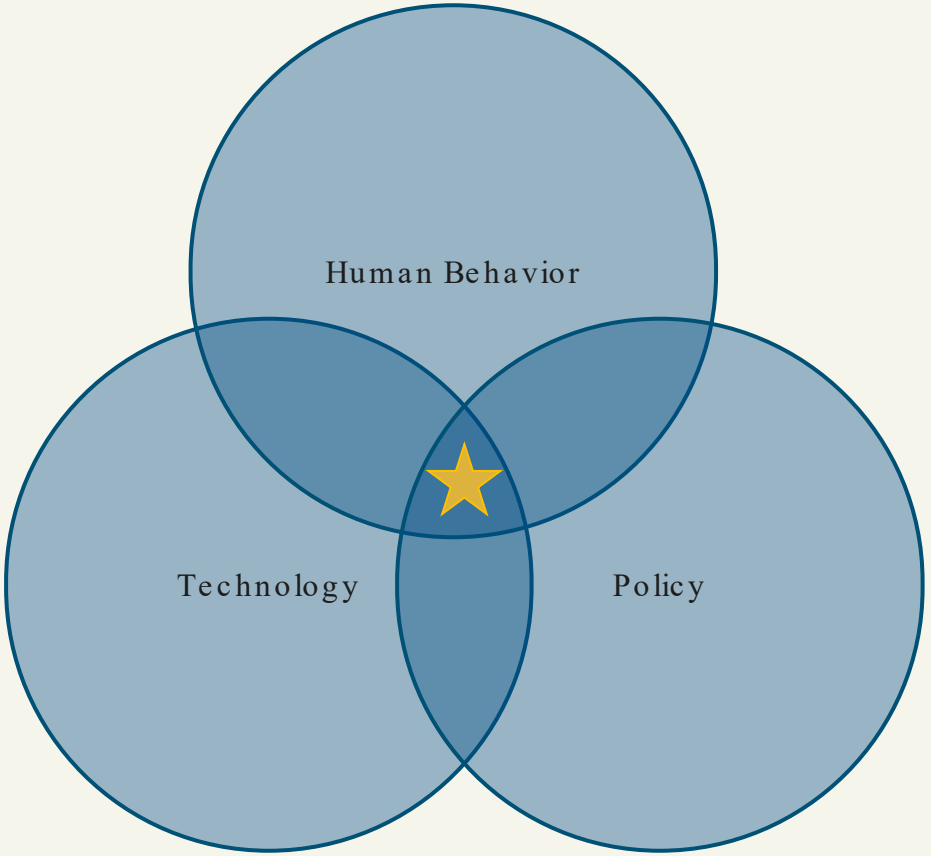
Driving transition to a clean energy society



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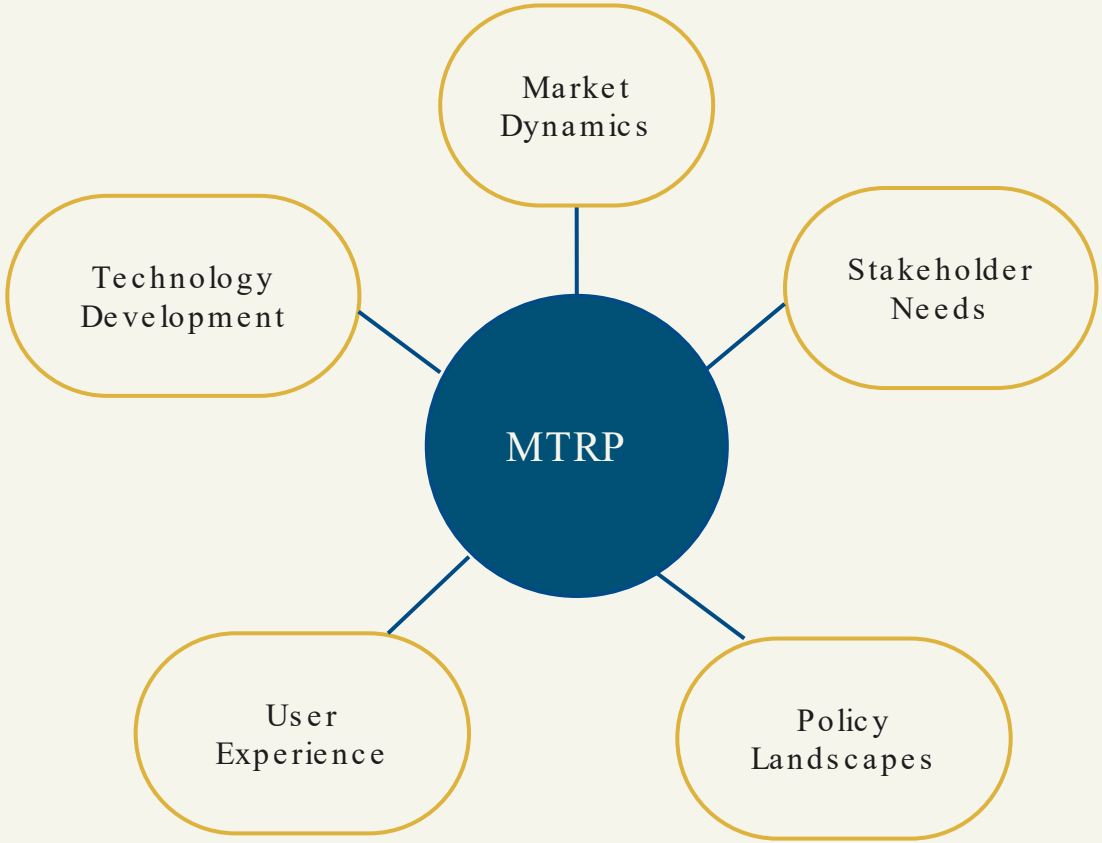
Market Transformation Research Program (MTRP)



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MTRP team

Sarah Outcault, PhD
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Angela Sanguinetti, PhD

Emily Searl

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Our heat pump studies

Topics

- Market assessment
- Utility & other programs
- Stakeholder needs
- Customer concerns
- Technology characteristics & adoptability

Methods

- Quantitative modeling
- Qualitative interviews
- Surveys
- Case studies
- Landscape & text analysis
- User experience

Deliverables

- Market reports
- Policy reports
- Conference & journal papers
- Research reports
- Databases

Funders

- California Energy Commission (CEC)
- CalNEXT
- U.S. Department of Energy
- New Energy & Industrial Technology Development (NEDO) of Japan
- Panasonic

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Agenda: What are the barriers and opportunities for heat pump adoption?

Background/ Policy

- California goals
- GHG emissions
- Heat pump & related policy

Technology Development

- Low GWP refrigerant
- Variable speed HPs
- Multi-function HPs
- Air-to-water HPs

Market Barriers

- Initial costs
- Operating costs
- Market availability

Technology Characteristics

- Trialability
- Observability
- Complexity
- Non-energy impacts

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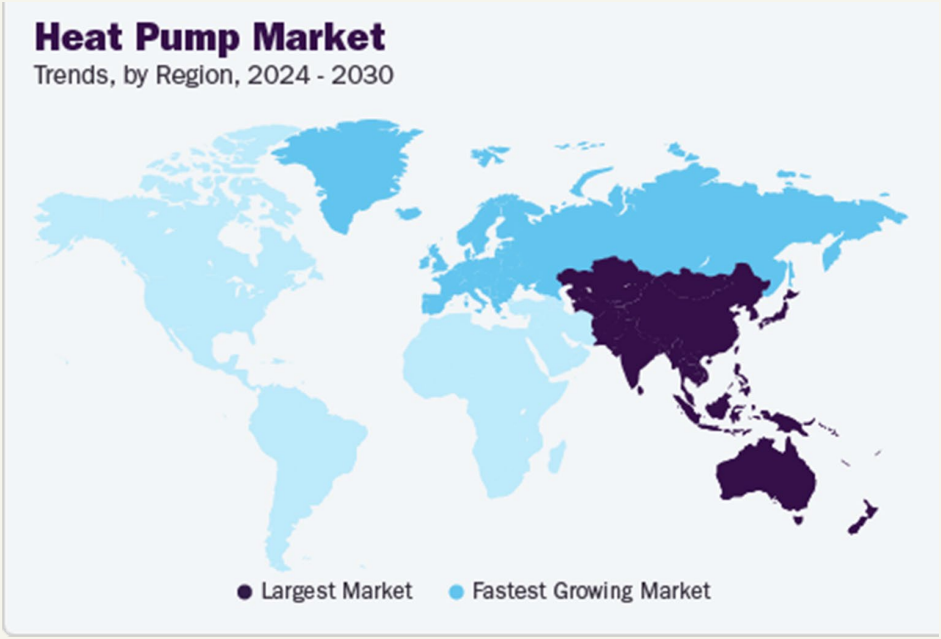
Global heat pump markets



Source: Grand View Research. Heat Pump Market Size, Share & Trends Analysis Report By Technology (Air Source, Water Source), By Capacity (Up To 10 kW, 10 To 20 kW), By Operation Type (Electric, Hybrid), By Application, By Region, And Segment Forecasts, 2024 – 2030 https://www.grandviewresearch.com/industry-analysis/heat-pump-market

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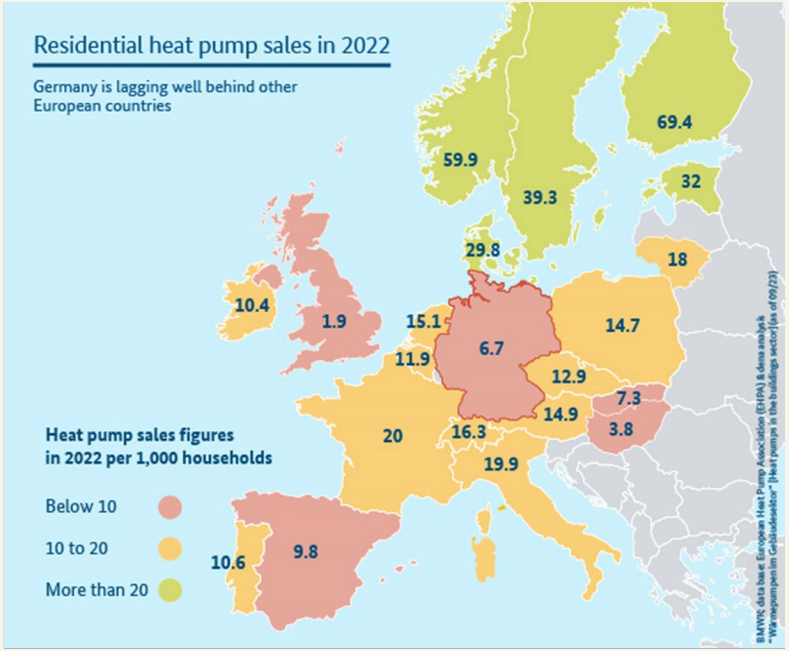
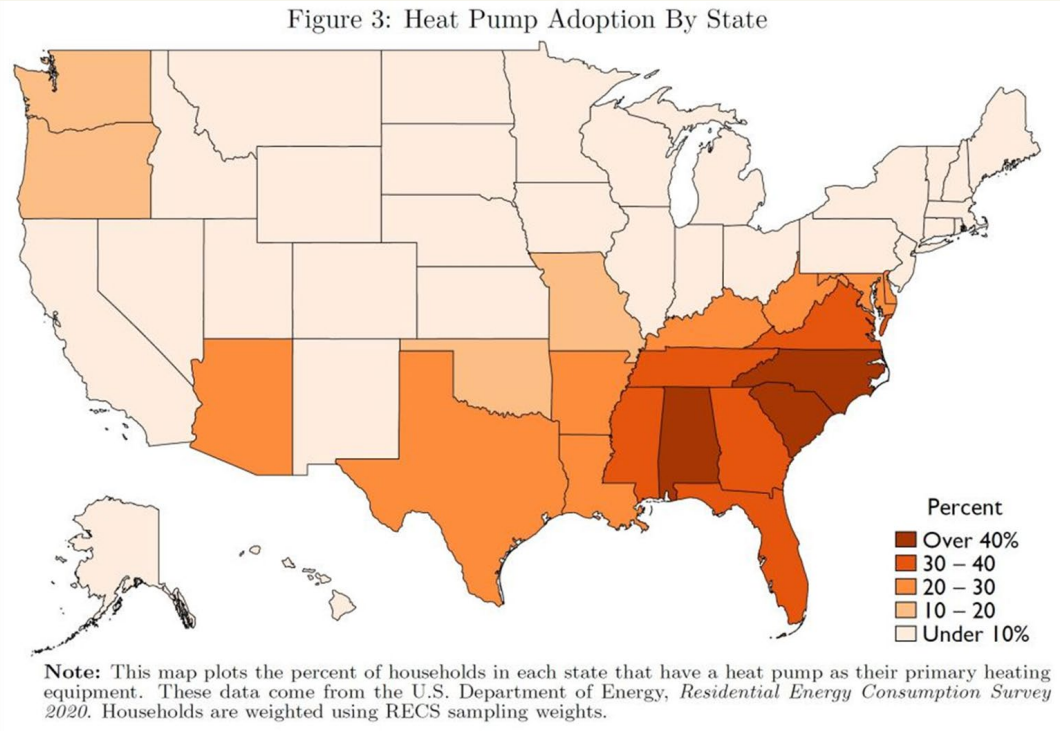


Source: Federal Ministry for Economic Affairs and Climate. https://www.bmwk-energiewende.de/EWD/Redaktion/EN/Newsletter/2023/09/Meldung/direkt_view.html

Heat pump installations vary by state



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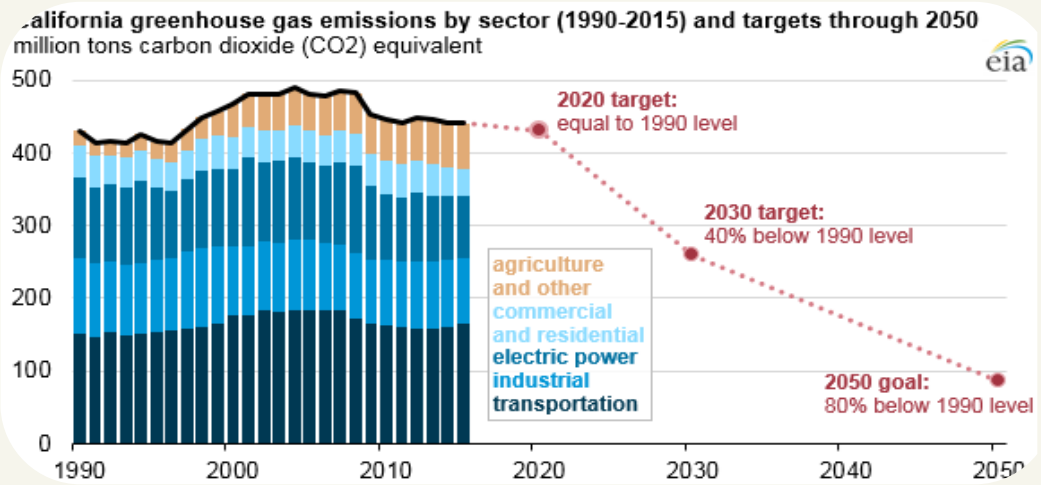
Source: Davis, L. "Are Heat Pump Subsidies Regressive?" Energy Institute Blog.
https://energyathaas.wordpress.com/2023/06/05/are-heat-pump-subsidies-regressive/

Heat pump policy & goals

- GHG emissions to 40% below 1990 levels by 2030 (AB 32; SB 32)
- Carbon neutrality by 2045 (AB 1279)
- Use load shifting to make up to 7,000 megawatts (MW) of electricity by 2030 (CEC; SB 846)



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Heat pumps = keystone

- Highly efficient all - electric systems
- Enable load flexibility
- Provide heating and cooling
- Provide hot water heating

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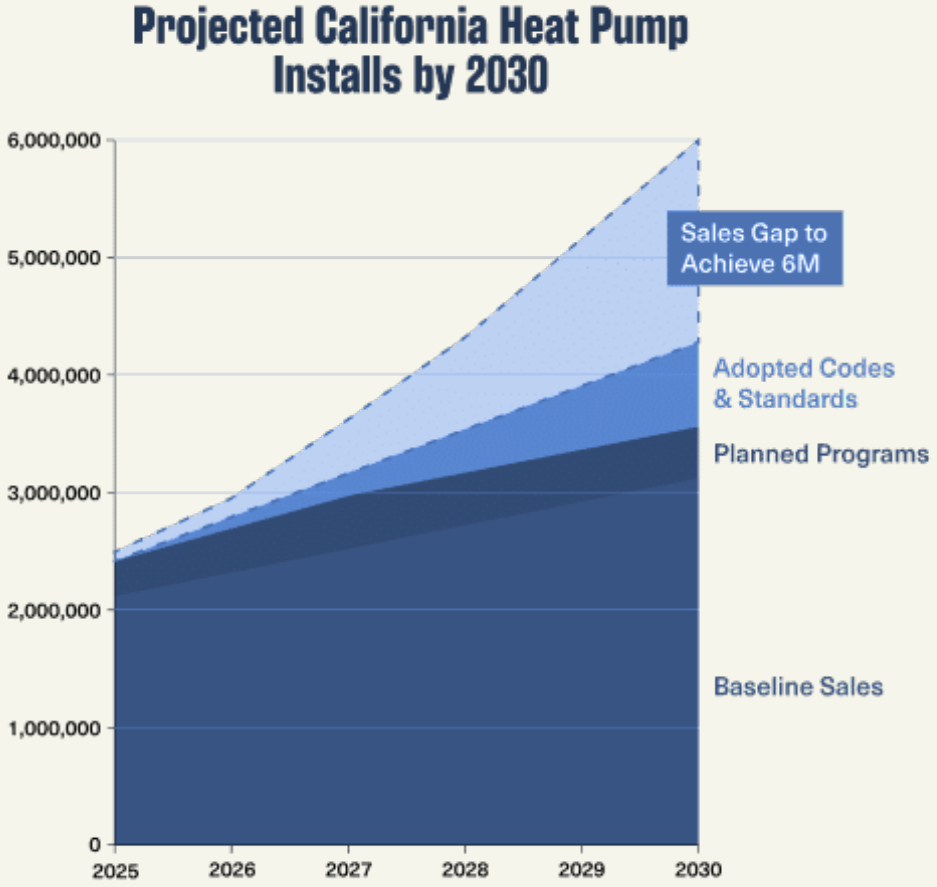
Heat pump installation rates (CA)

- 5% of CA homes have space conditioning HPs
- 2% have water heating HPs
- 2M short of 6M by 2030 goal



Source: https://heatpumppartnership.org/wp-content/uploads/2025/03/CAHPP_Blueprint_2025.pdf

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Heat pump policy

Pro-heat pump

- Goal to install 6 million heat pumps by 2030 (CAHPP)
- Targeting 80% of appliance sales in California to be electric by 2030 and 100% by 2035 (CARB 2022)

Anti-emissions

- Ban on new natural gas-powered water and space heaters by 2030 (CARB 2022)
- All appliances in new residential construction be electric starting in 2026 (CARB 2022)

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Tech Characteristics

Economic

- Initial investment
- Operating cost
- Return on investment
- Market availability

Technical

- Technical compatibility
- Performance
- Complexity of installation, use, and maintenance
- Energy Savings

Informational

- Observability
- Trialability

Externalities

- Environmental impacts
- Non-energy impacts

Outcault, S., Sanguinetti, A., & Nelson, L. (2022). Technology characteristics that influence adoption of residential distributed energy resources: Adapting Rogers' framework. *Energy Policy* , 168, 113153.

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Assessment of ASHPs

	Technology characteristics	Assessment		
Economic	Initial investment	High	Medium	Low
	Operating costs	High	Medium	Low
	Return on investment	Low	Medium	High
	Market availability	Low	Medium	High
Technical	Technical compatibility	Low	Medium	High
	Performance	Low	Medium	High
	Complexity of installation	High	Medium	Low
	Complexity of use	High	Medium	Low
	Complexity of maintenance	High	Medium	Low
	Energy savings	Low	Medium	High
Informational	Observability	Low	Medium	High
	Trialability	Low	Medium	High
Externalities	Environmental impacts (negative)	High	Medium	Low
	Non-energy impacts (positive)	Low	Medium	High

Adoptability

Economic

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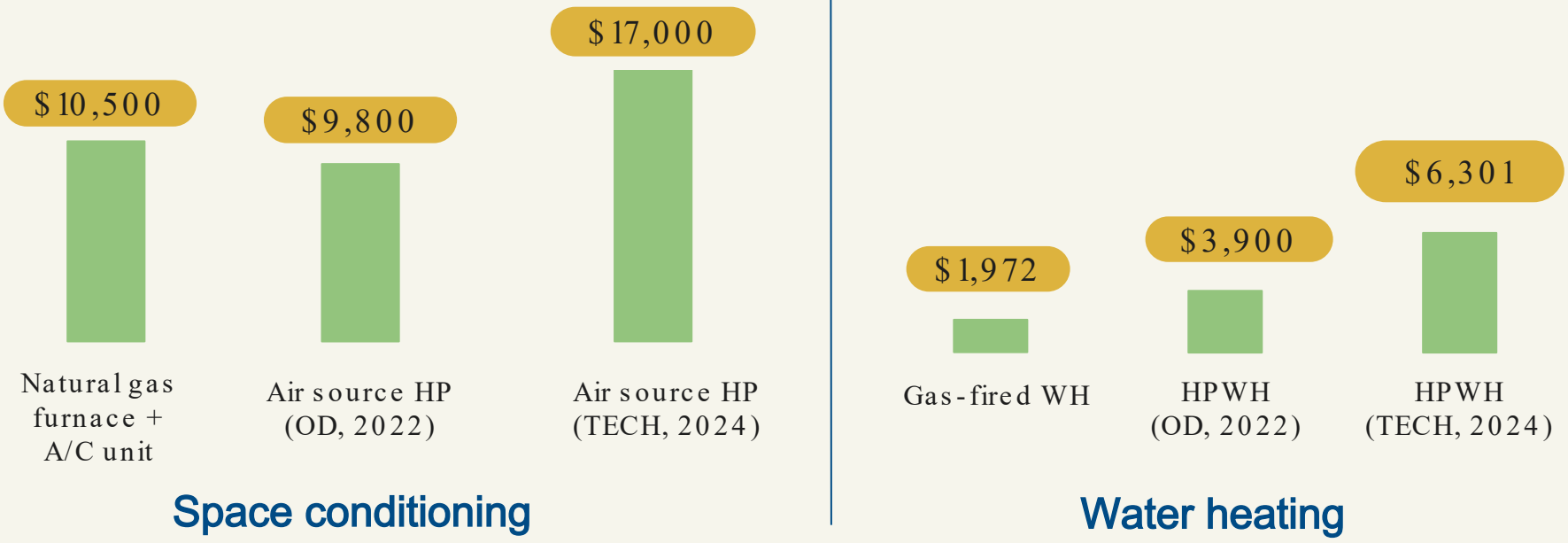
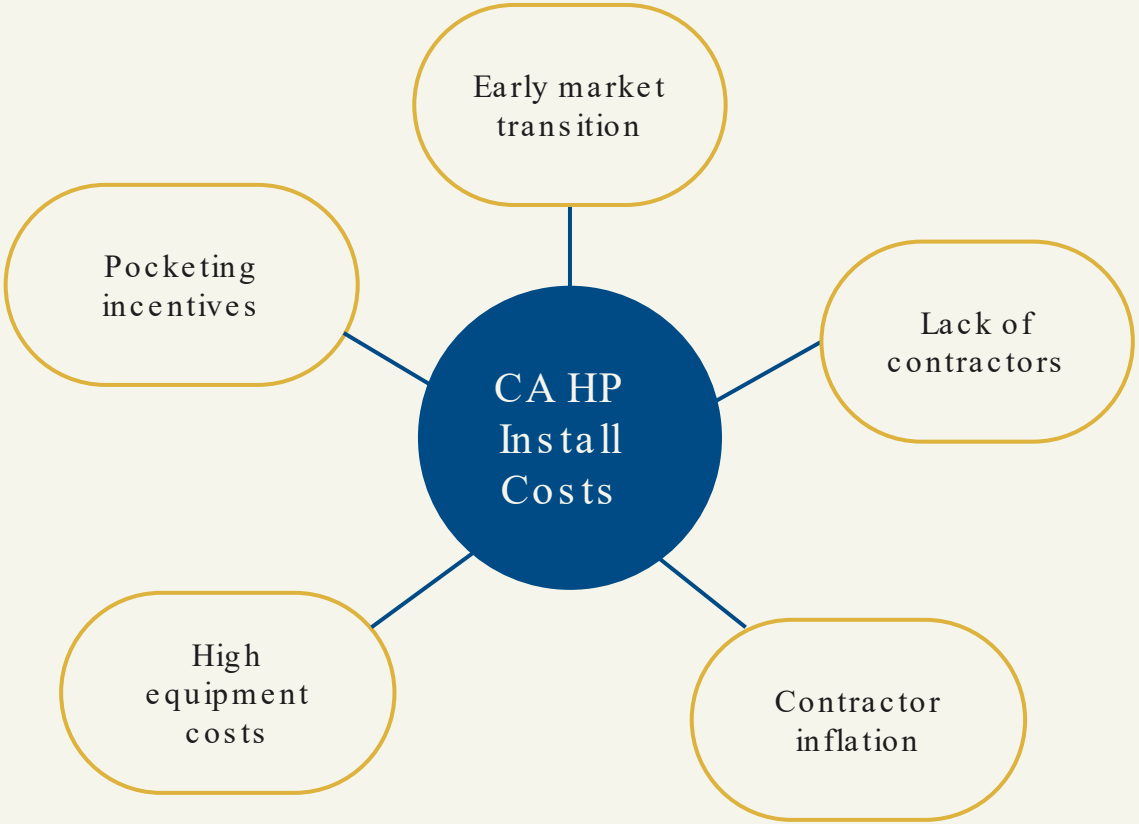
Initial cost



Economic

Why are heat pumps so expensive in CA?



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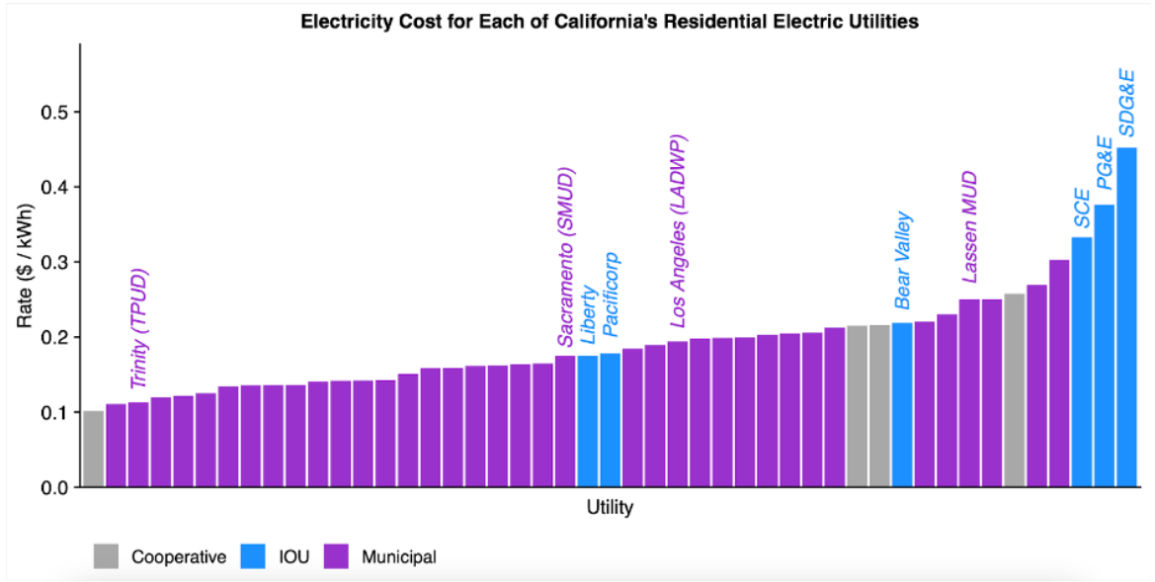
Economic

Operating cost

Mitigation strategies:

- Heat pump electricity rates
- High efficiency
- Solar



Notes: This graph reports the average cost per kWh paid by a non-CARE resident household on a standard residential rate who consumes 500 kWh/month. Ry includes volumetric prices and any fixed charges in these calculations. Links to rate structure details are included below. This link contains the source for all rate tariff information.

Source: https://energyathaas.wordpress.com/2023/07/10/not -all-of-californias -electricity -prices -are-high/

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Economic

Market availability

Workforce Engagement

Contractors are vital source of information for customers

Contractors are gatekeepers

Contractor Reluctance

Hesitant to Recommend

Contractors unwilling to recommend unfamiliar technology

Negative Perceptions

Contractors may recall older, poorly performing HPs

Workforce Shortage

More HVAC installers, electrician and plumbers (with HP training) needed

Source: https://techcleanca.com/about/news/heat-pumps-transforming-the-way-contractors-do-business/

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Technical

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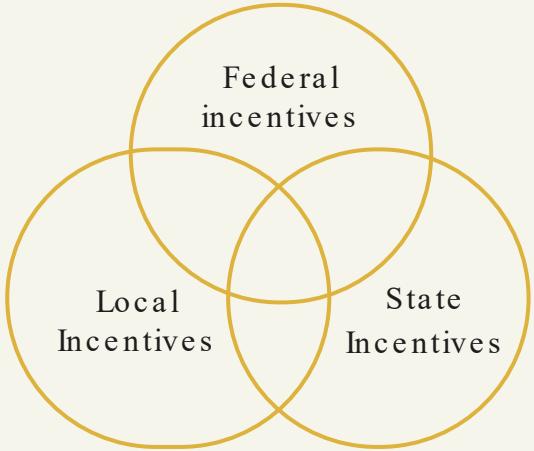
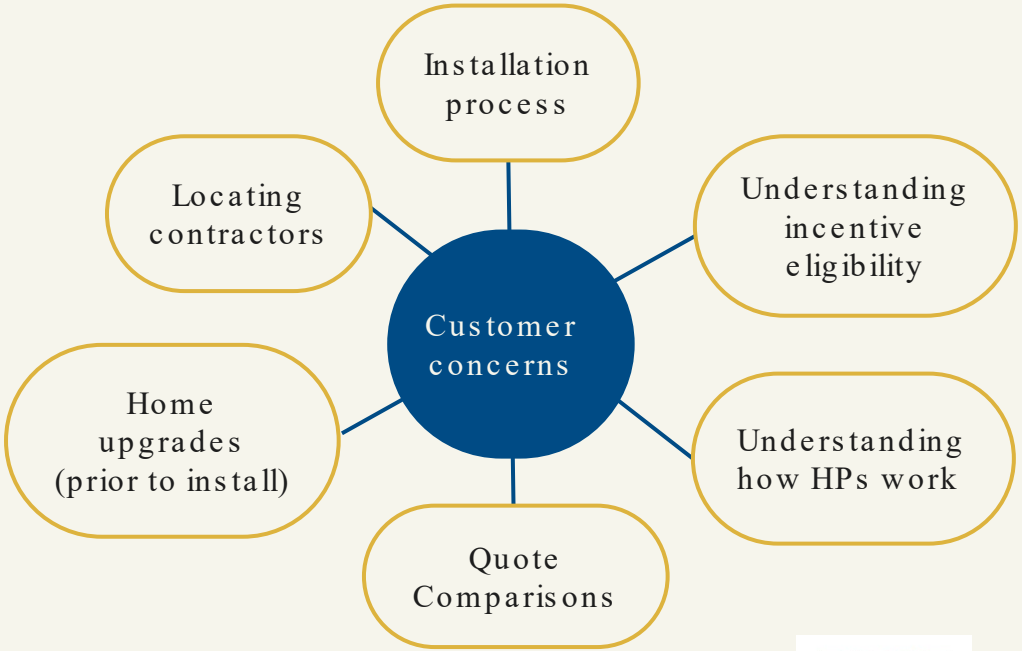
Complexity of installation





Technical

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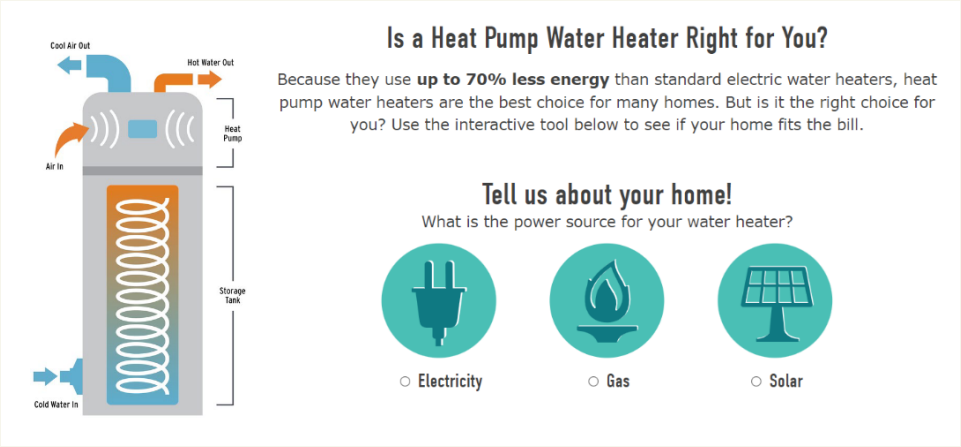
Addressing the complexity of installation

- Educational resources and tools (FAQs, tip sheets, online resources)
- Interactive decision making support (heat load calculator, rebate eligibility screening)
- Holistic service models (quote comparison, one-stop shop)



Source: http://hotwatersolutionsnw.org/is -it-right-for-you

Informational

Increasing observability

- Displaying signs in public spaces
- Educational resources explaining how HPs work
- Engaging HP owners to educate through home visits and testimonials

Background: https://singingriver.com/wp-content/uploads/2018/01/smepa_ca_bklt_12-2-2015-web-1.pdf
Top Left: https://www.visitaheatpump.com/
Bottom right: https://www.canarymedia.com/articles/heat-pumps/heat-pump-coaches-help-neighbors-ditch-fossil-heat-in-Massachusetts

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Informational

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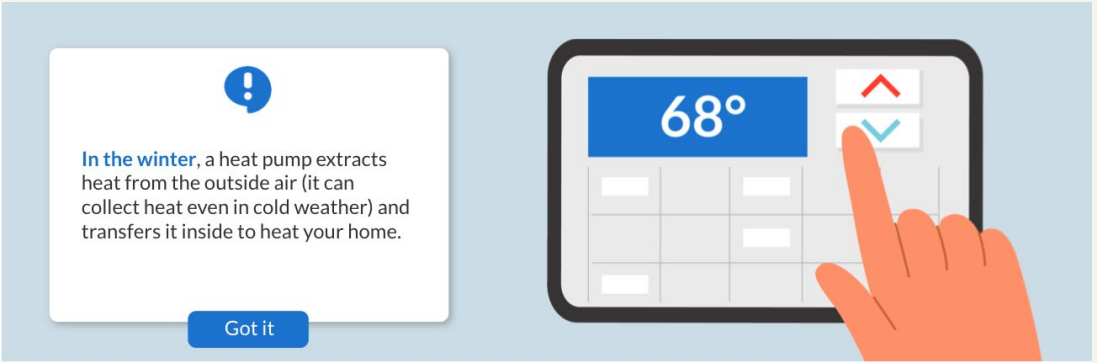
Addressing low trialability

- Passive exposure
  - AirBNB
  - Dance club
- Virtual interaction
  - online demo
- Active exposure
  - tiny home
  - home visits
  - showrooms
- Home test
  - HP rental
  - portables

Top: https://www.les.com/sustainability/educational-interactive-tiny-house
Bottom: https://wattsmarthomes.com/heat-pump-comfort/



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Non-energy impacts

…on occupants, users, community, society, and environment…

It is often the **non-energy benefits** that motivate…decisions to adopt energy-efficient technologies.

- Mills & Rosenfeld (1996)

Externalities

Non-energy impacts

		Occupant impacts				
		Physiological	Psychological	Economic	Practical	Sociological
Functional outcomes	Spatial					
	Thermal					
	Air					
	Acoustic					
	Visual					
	Building Integrity					

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Future Research

Technology Developments

Heat Pump Advancements

- Variable speed
- Multifunctional
- Ultra-low GWP refrigerants
- Air-to-water

Load Flexibility

- Optimizing heat pump controls

Workforce

Engagement

- Raising awareness
- Cultivating heat pump ambassadors

Training

- Installation
- New refrigerants
- Customer education

Customer Considerations

Ease of Access

- Customer education
- Trialability
- Affordability of installation and operation
- Financial incentives

Highlighting Benefits

- Leveraging non-energy benefits
- Promoting load flexibility

Thank you!

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Please visit our website at:
https://energy.ucdavis.edu/market-transformation-research-program/

MTRP Website

HP Programs Database

Or scan the QR codes to go directly to some of our recent research papers!

Barriers & Opportunities for HP Adoption

Tech Characteristics

Harnessing NEIs

NEI Framework Paper

HP Programs Report