UCDAVIS
Western Cooling Efficiency Center

Harnessing non-energy impacts to promote residential heat pump adoption: Examples from the U.S. and beyond

UCDAVIS
Market Transformation
Research Program

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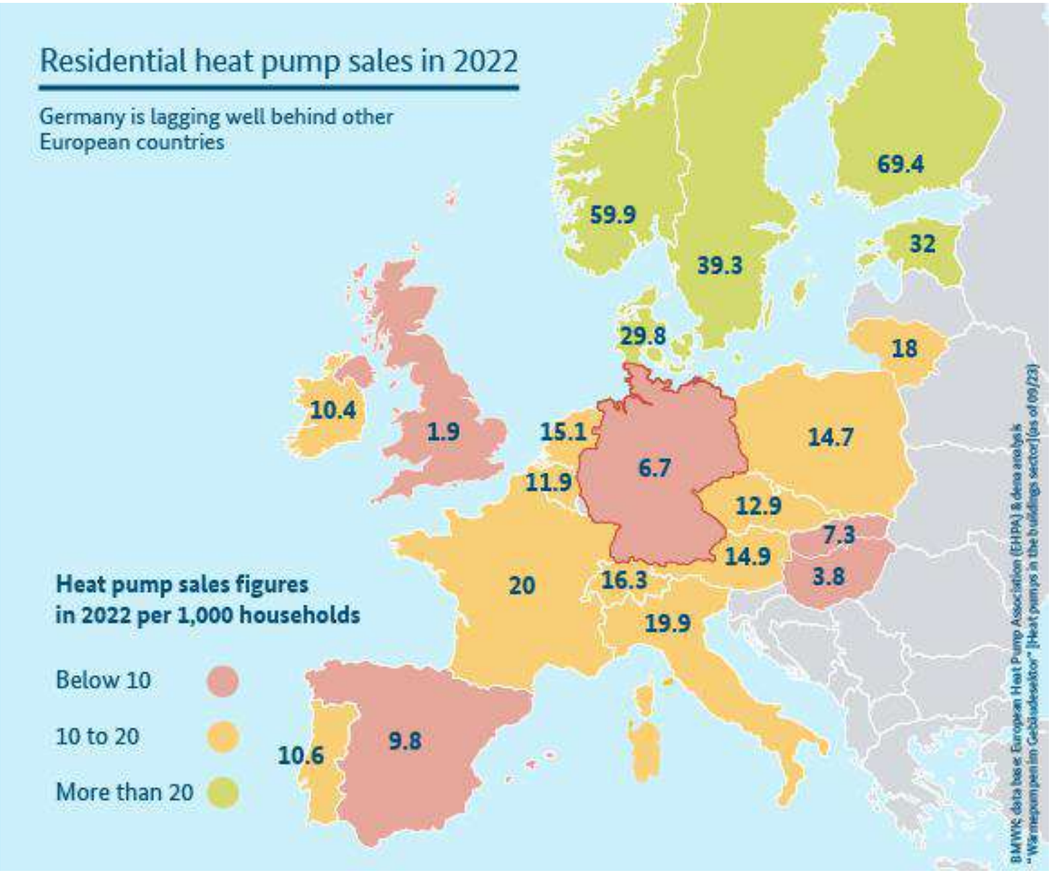
EEDAL 2024

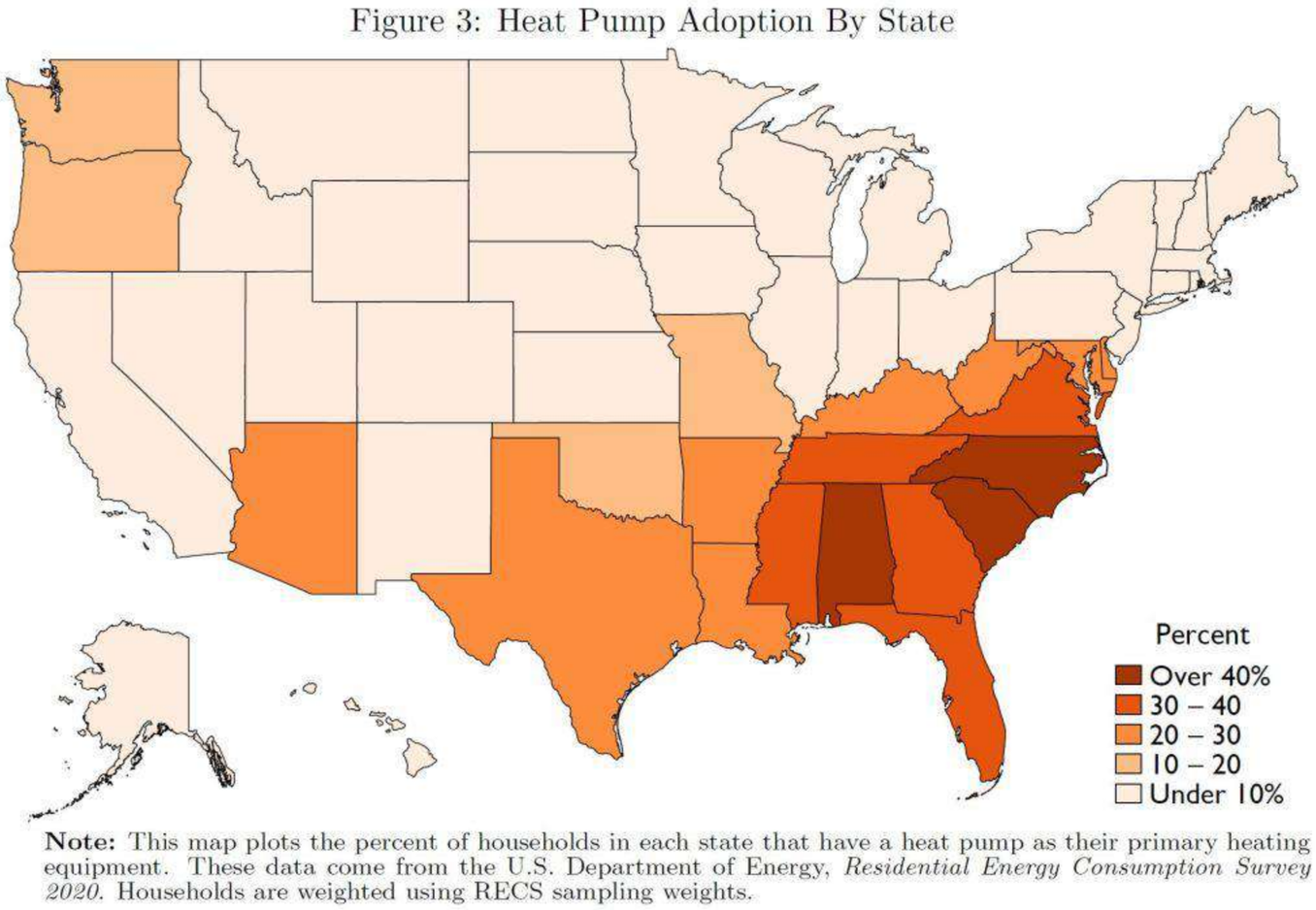
Asia-Pacific leads the market

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

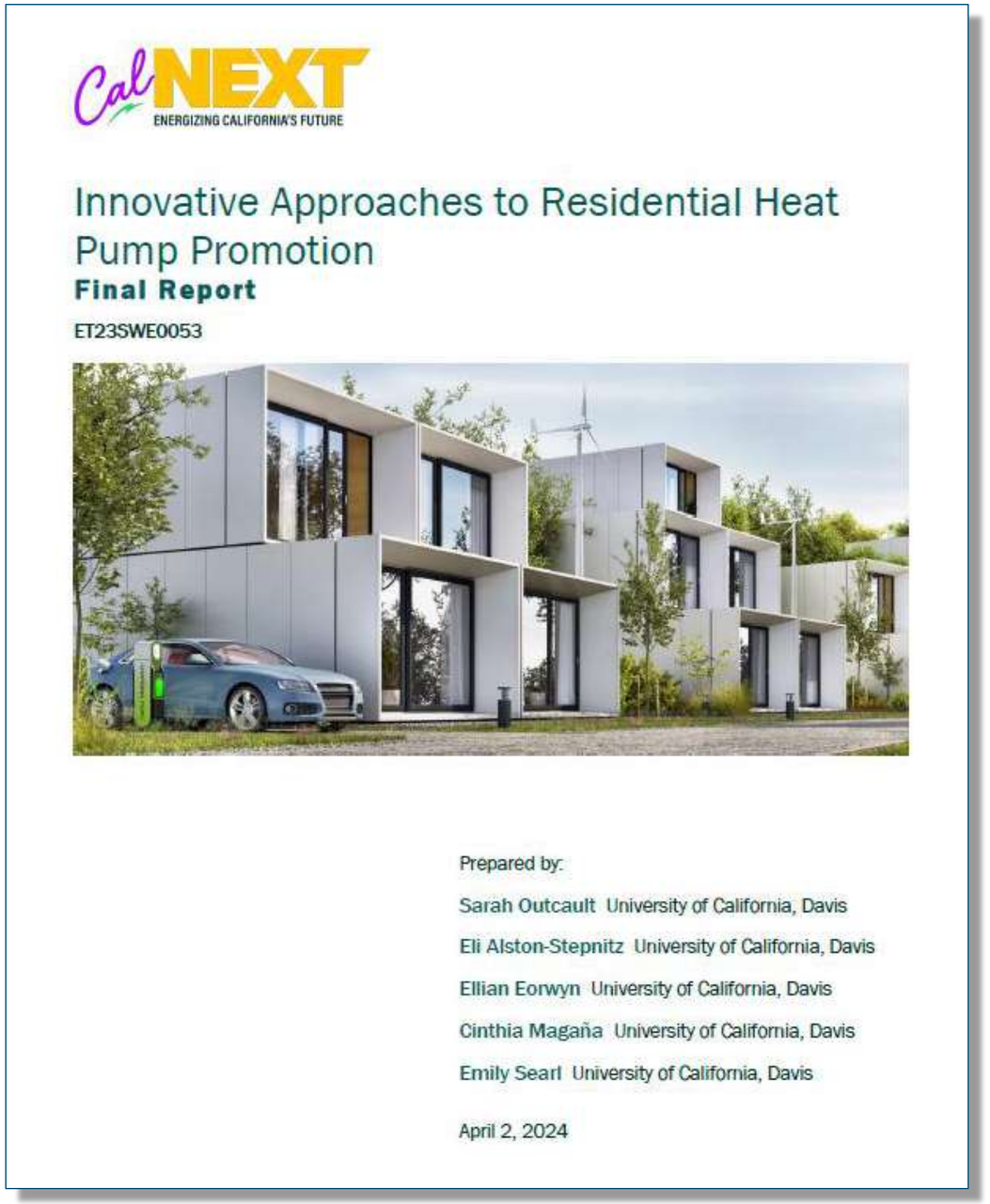
Uneven progress in Europe and U.S.



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



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



Acknowledgements

- 39 case studies of utility, government, and community programs
- New analysis on the NEIs programs leverage
- Co-authors: Emily Searl, Cinthia Magaña, Eli Alston-Stepnitz

Report

Searchable database

Non-energy impacts (NEIs) matter

- Definition: Non-energy impacts (NEIs) are effects on environmental conditions, health, comfort, convenience, etc… that are not directly related to energy. They can be impacts on occupants, users, community, society, environment…
- NEIs can promote or hinder customer adoption
  - Mills & Rosenfeld (1996, p. 707): "**It is often the non-energy benefits that motivate … decisions to adopt energy-efficient technologies**" → microwave became popular for its convenience, not energy savings
  - Azizi et al. (2019) showed that non-energy factors are *more* motivating than energy savings potential in driving decisions to select energy-efficient technologies
  - Rose et al. (2019) found customers weigh the potential for quality-of-life improvements more heavily than potential energy savings when considering home upgrades

Heat pumps have many non-energy impacts

Comfort

Lower Energy Bills

Temperature Control

Convenient

Installation Rebates

Safety and Peace of Mind

High Efficiency

Cleaner and Greener

We…have noticed an immediate difference in the ***comfort*** *of our home.* ***The temperature remains consistent*** *throughout the house… We are also looking forward to cooling and* ***better air quality*** *in the summer.*

-- Jesse Goranson, Vancouver

Sources: https://homeenergynav.ca/testimonial/jesse-goranson-vancouver/, https://cleanheat.ny.gov/central-air-source-heat-pump-for-a-one-story-home/

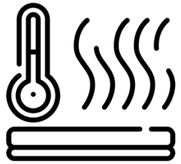
Introducing occupant NEI identification framework

- Proposes a systematic approach to identifying the broad scope of potential non-energy impacts residential energy technologies can have on occupants
- Reference:
  - Outcault, S., Sanguinetti, A., Dessouky, N., & Magaña, C. (2022). Occupant Non-Energy Impact Identification Framework: A human-centered approach to understanding residential energy retrofits. *Energy and Buildings*, 263, 112054

Functional outcomes

Spatial - e.g., space for equipment

Acoustic - e.g., sound levels



Thermal - e.g., conditioned air

Visual quality - e.g., view

Air - e.g., pollutant levels

Building integrity - e.g., quality of physical properties

**Six building performance areas borrowed from Loftness, V., Hartkopf, V., Aziz, A., Choi, J. H., & Park, J. (2018). Critical frameworks for building evaluation: user satisfaction, environmental measurements and the technical attributes of building systems (POE+ M). In *Building Performance Evaluation* (pp. 29-48). Springer, Cham.

* Icons from flaticon.com

Five types of occupant NEIs

Physiological
impact on physical body

Practical
e.g., convenience, ease

Psychological
impact on mental health

Sociological
e.g., social dynamics

Economic
costs, savings

* Icons from flaticon.com

Occupant non-energy impacts (NEI) framework

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

Method

- Identified 39 heat pump promotion efforts by government, utilities, media, and communities (excluding financial incentive-only efforts and non-English)
  - Utility programs: Database of State Incentives for Renewables & Efficiency (DSIRE), American Council for an Energy-Efficient Economy (ACEEE) and International Energy Agency (IEA) databases
  - Other programs: America's Newspapers (for U.S.-based media coverage) and Access World News (for international stories)
- Collected language related to heat pumps' non-energy impacts from programs' publicly available resources (e.g., websites, videos, outreach materials)
- Coded NEI language and systematically sorted into categories using the Occupant Non-Energy Impact Identification framework to understand which NEIs programs are leveraging (and which they are not)

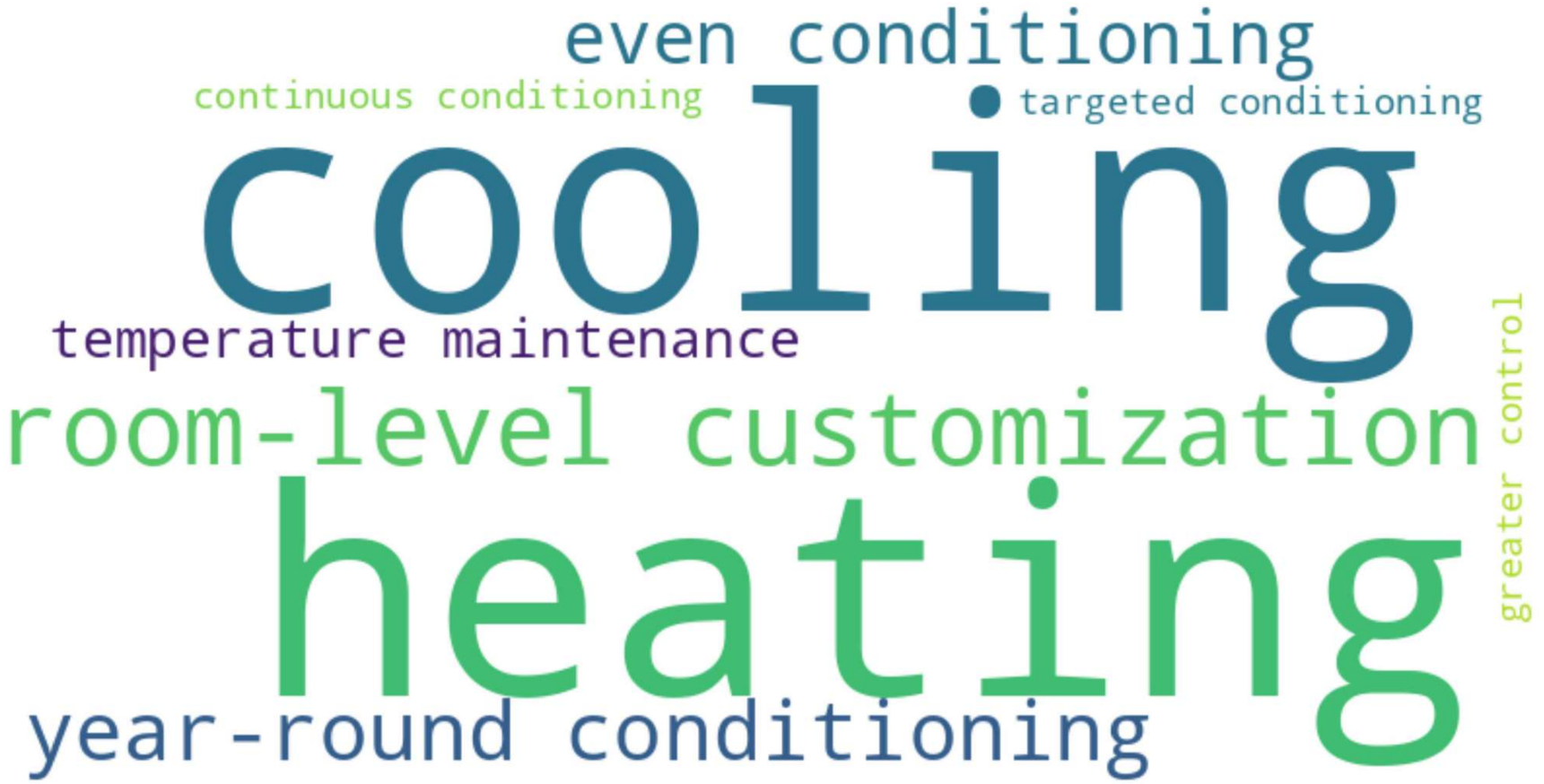
Report

Occupant non-energy impacts (NEI) framework

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

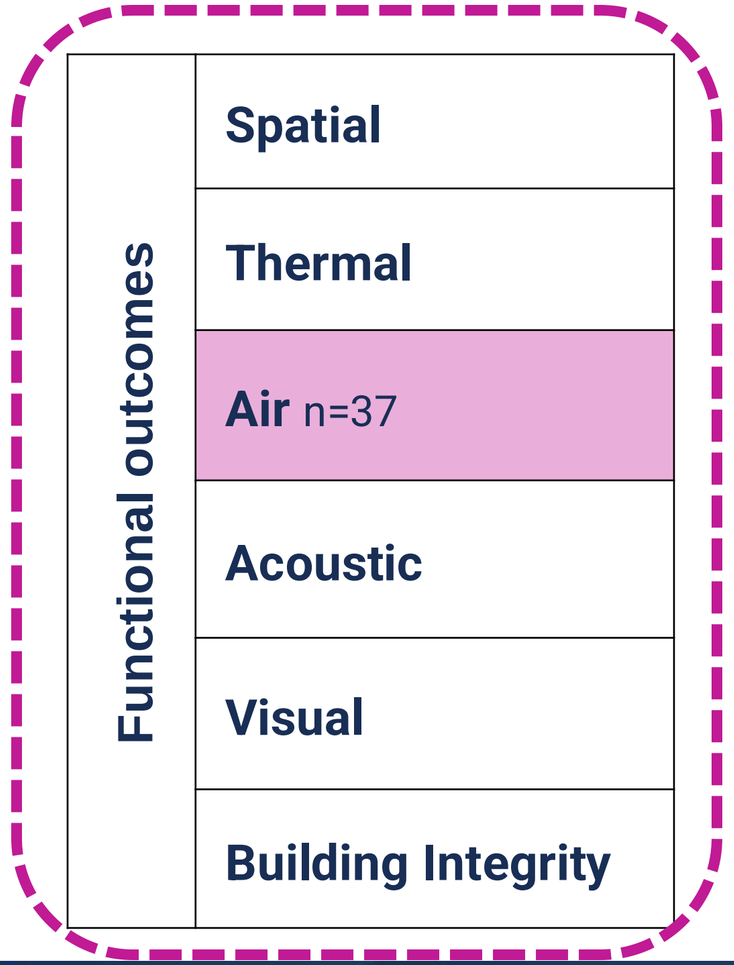
Functional outcomes: Thermal

Functional outcomes
Spatial
Thermal n=59
Air
Acoustic
Visual
Building Integrity

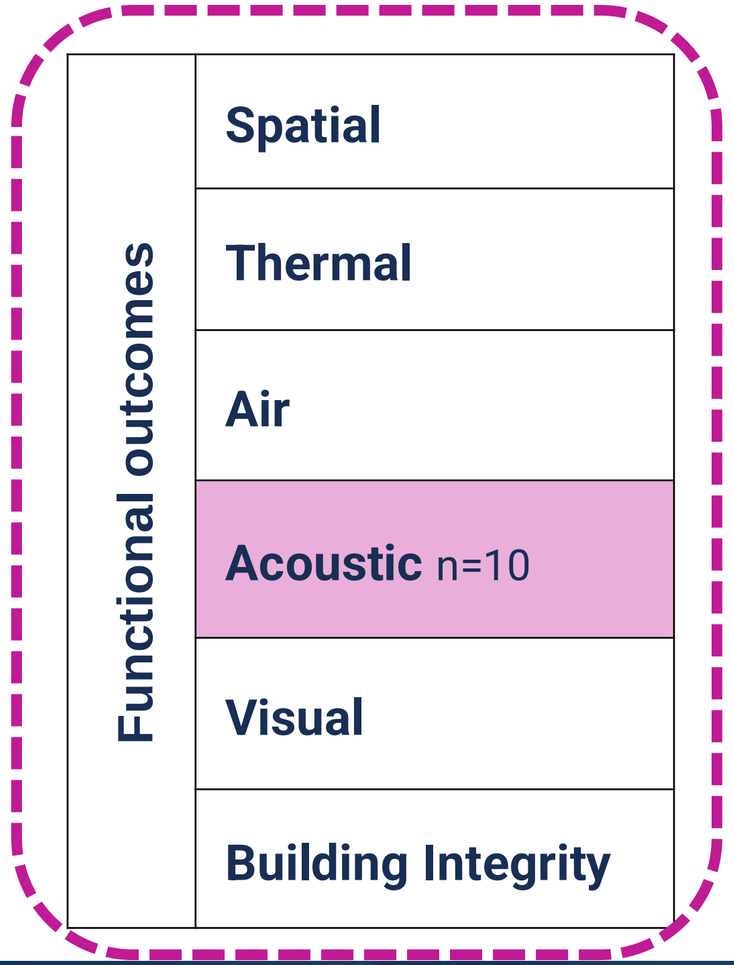


***Counts represent number of programs that mentioned outcome in the materials reviewed

Functional outcomes: Air

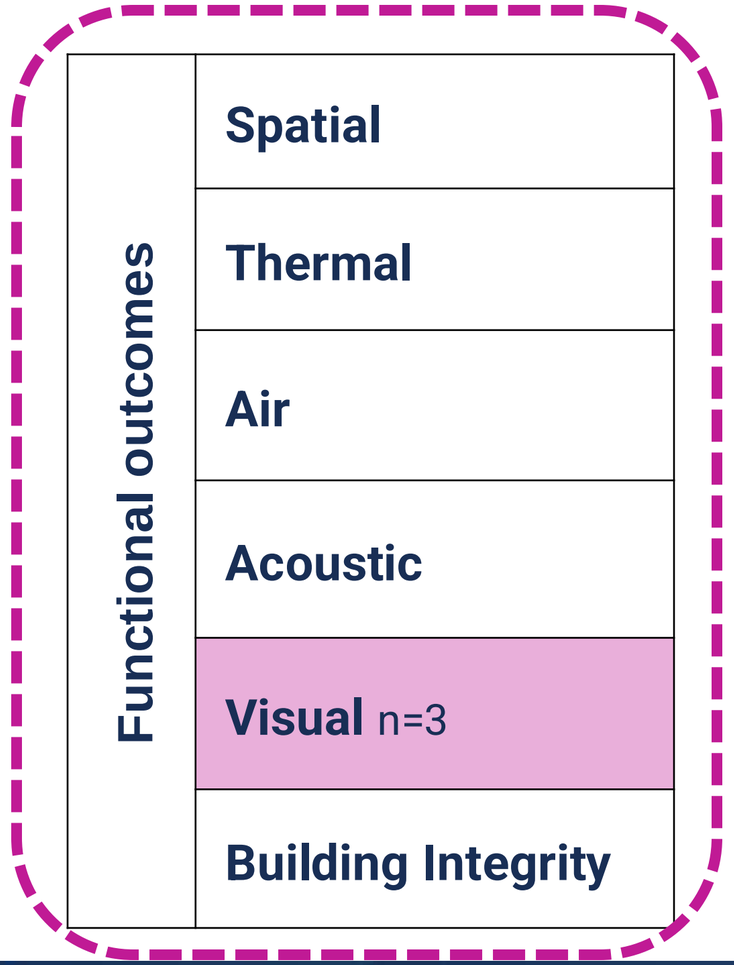


Functional outcomes: Acoustic



quiet operation

Functional outcomes: Visual



aesthetic alignment

attractive

Occupant non-energy impacts (NEI) framework

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

Occupant impacts: Physiological

Occupant impacts				
Physiological	Psychological	Economic	Practical	Sociological

n=15

***Counts represent number of programs that mentioned outcome in the materials we reviewed

Occupant impacts: Psychological

Occupant impacts				
Physiological	Psychological	Economic	Practical	Sociological

n=4

improved sense of well-being

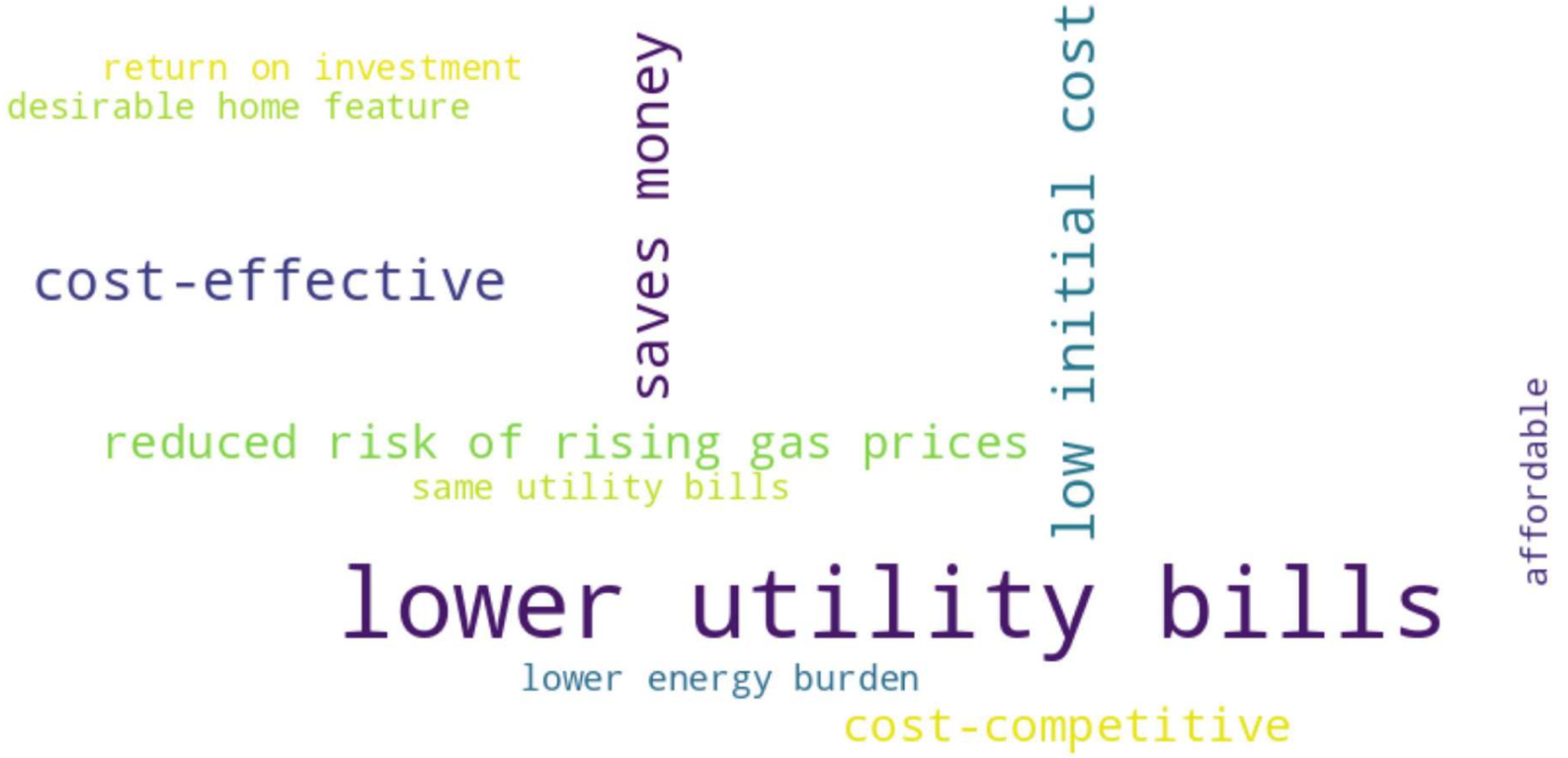
sense of environmental responsibility

peace of mind

Occupant impacts: Economic

Occupant impacts				
Physiological	Psychological	Economic	Practical	Sociological

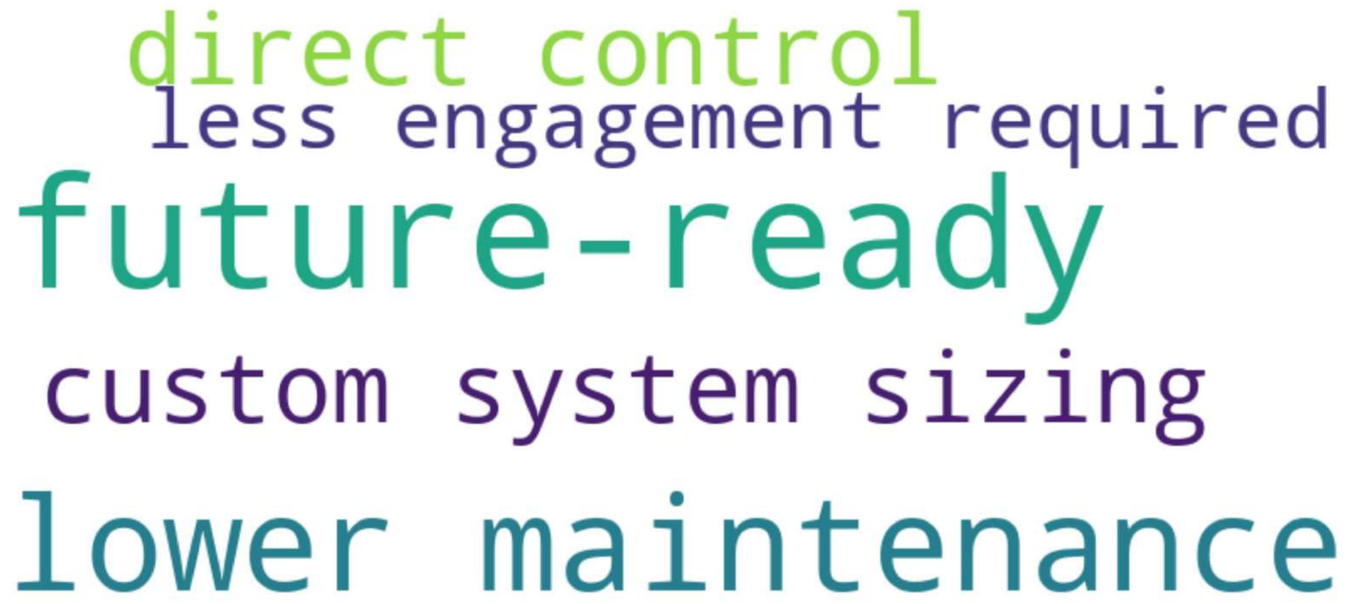
n=37



Occupant impacts: Practical

Occupant impacts				
Physiological	Psychological	Economic	Practical	Sociological

n=7



Occupant non-energy impacts (NEI) framework

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

Occupant non-energy impacts by functional outcome

		Occupant impacts				
		Physiological n=36	**Psychological** n=3	**Economic** n=4	**Practical** n=1	**Sociological** n=0
Functional outcomes	**Spatial** n=1				same equipment footprint (1)	
	Thermal n=32	comfort (23) safety in extreme heat (2) comfort in extreme cold (2) comfort in extreme heat (2) lower health risks (1)	user satisfaction (1)	cost-effective (1)		
	Air n=8	reduced risk of CO poisoning (2) allergy relief (1) comfort (1) healthier air (1) lower health risks (1)	peace of mind (1) user satisfaction (1)			
	Acoustic n=0					
	Visual n=0					
	Building Integrity n=3			higher property value (3)		

***Counts represent number of programs that mentioned outcome in materials reviewed

Discussion

- Programs cited comprehensive range of economic impacts, e.g.,
  - hedge against rising gas prices
  - return on investment
  - increasing home value
- Opportunities exist to leverage many other occupant NEIs

It will be incumbent on utilities wishing to offer energy efficiency services in this new environment to ***communicate the non-energy value*** *of those services.*

- Mills & Rosenfeld (1996)

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

Improved air quality
→ better health outcomes
→ improved cognitive function
→ higher productivity

Quiet operation

→ relaxing environment

→ better concentration

→ improved sleep

Clarification and next steps

- Coding obfuscated diversity of language used to describe NEIs → Many programs use concrete, locally relevant language to describe NEIs:
  - “improved thermal comfort” versus
  - “The difference between gas-burning and heat pump space heaters has been compared to having a bucket of extremely hot water periodically thrown at you versus taking a long warm shower.”
- Future research needed
  - Systematic inventory of heat pumps’ NEIs
  - Exploration of efficacy of generic versus highly specific language

Resources

EEDAL paper

NEI framework paper →

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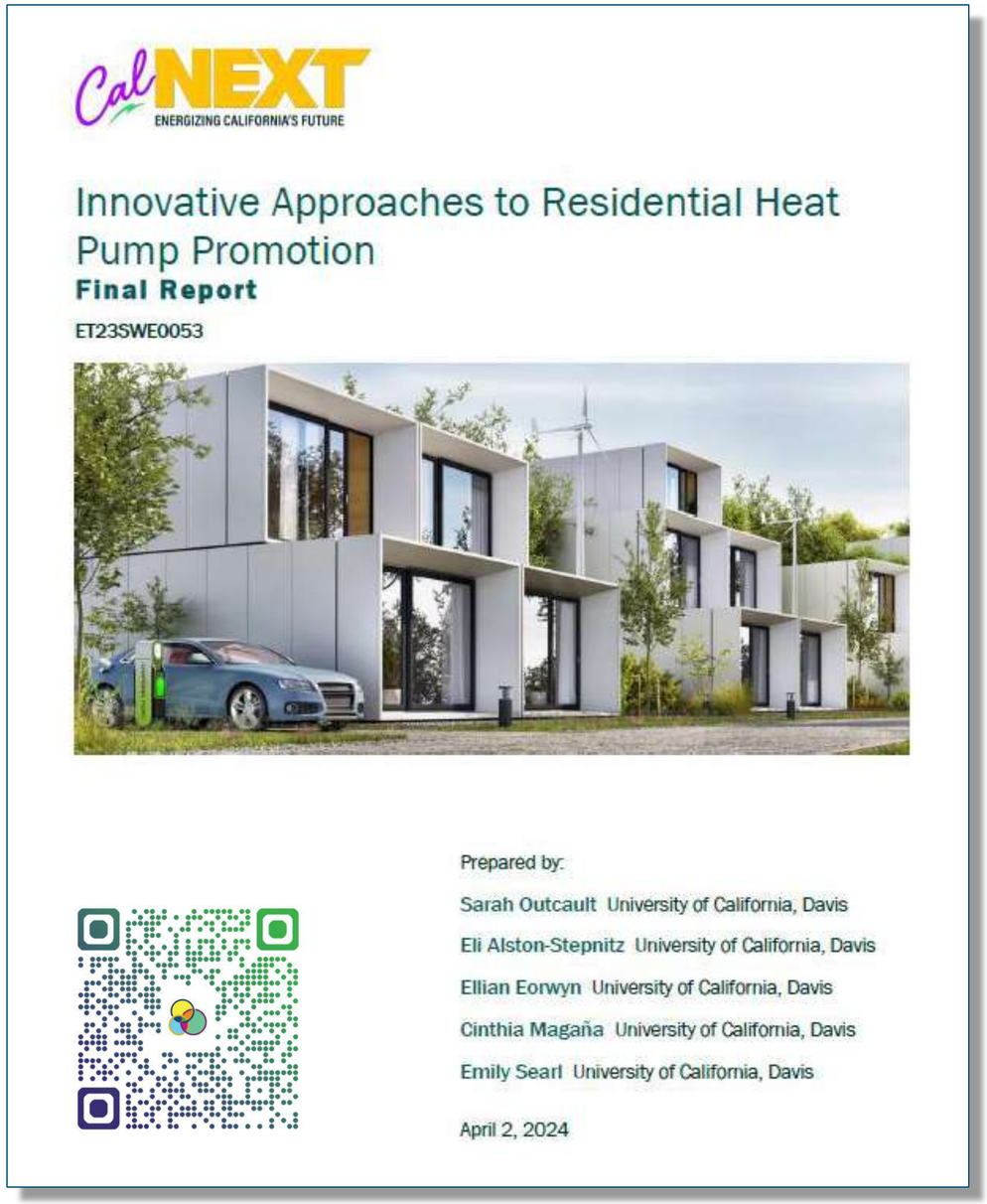
UCDAVIS Market Transformation Research Program

For more information visit:
https://energy.ucdavis.edu/market-transformation-research-program/



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