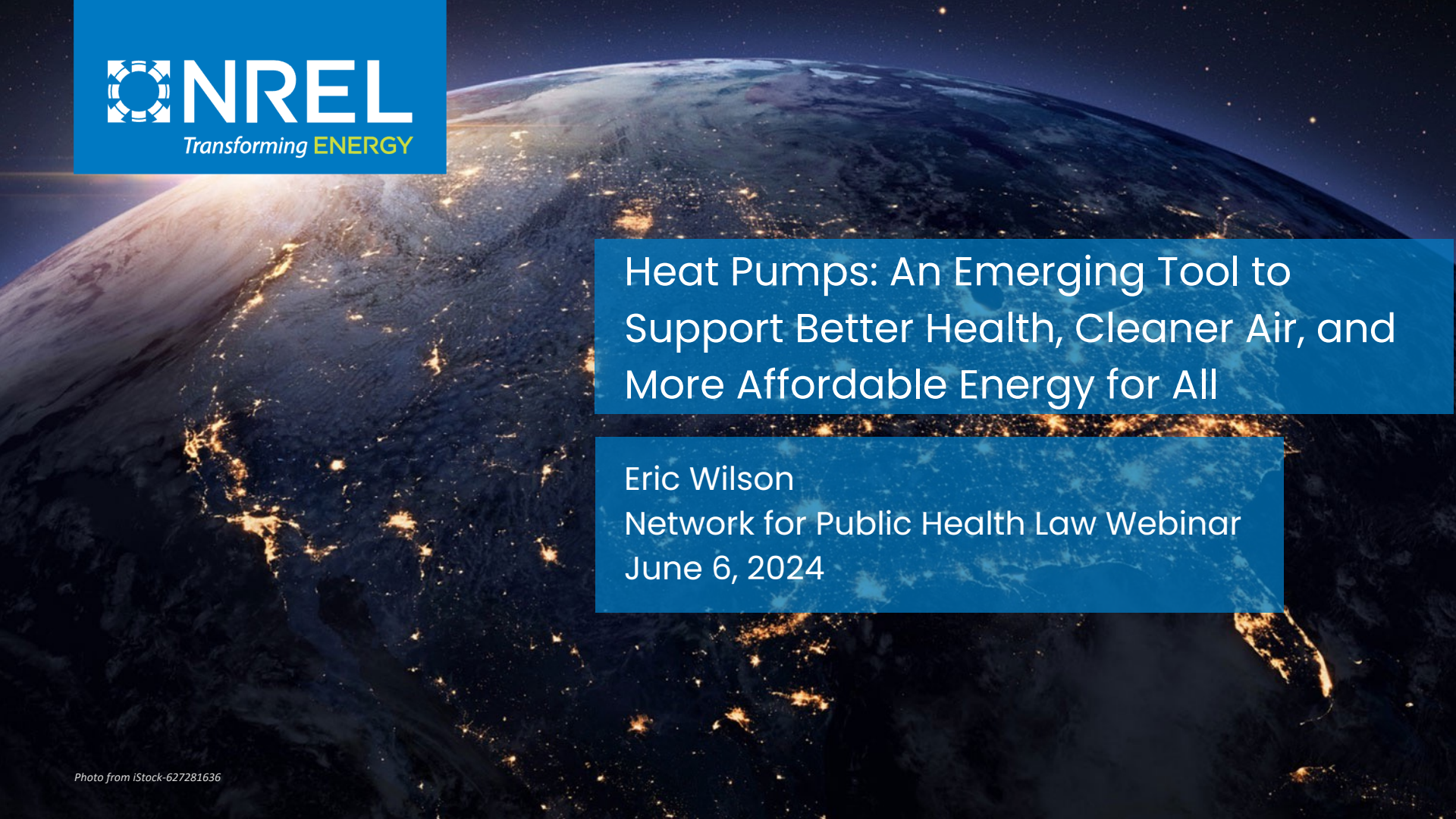


Heat Pumps: An Emerging Tool to Support Better Health, Cleaner Air, and More Affordable Energy for All

Eric Wilson

Network for Public Health Law Webinar

June 6, 2024

Photo from iStock-627281636

Contents

What is a heat pump?

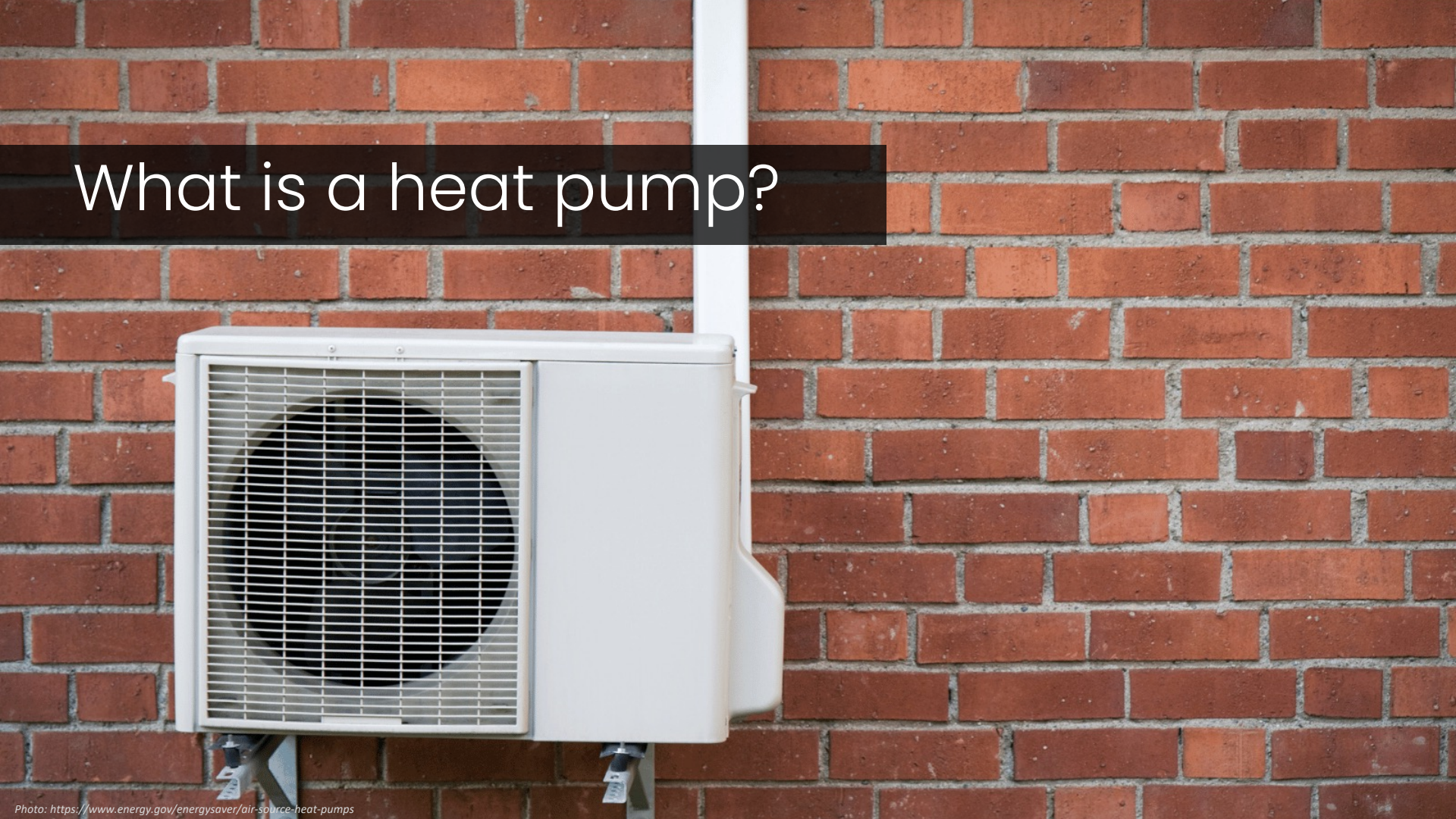
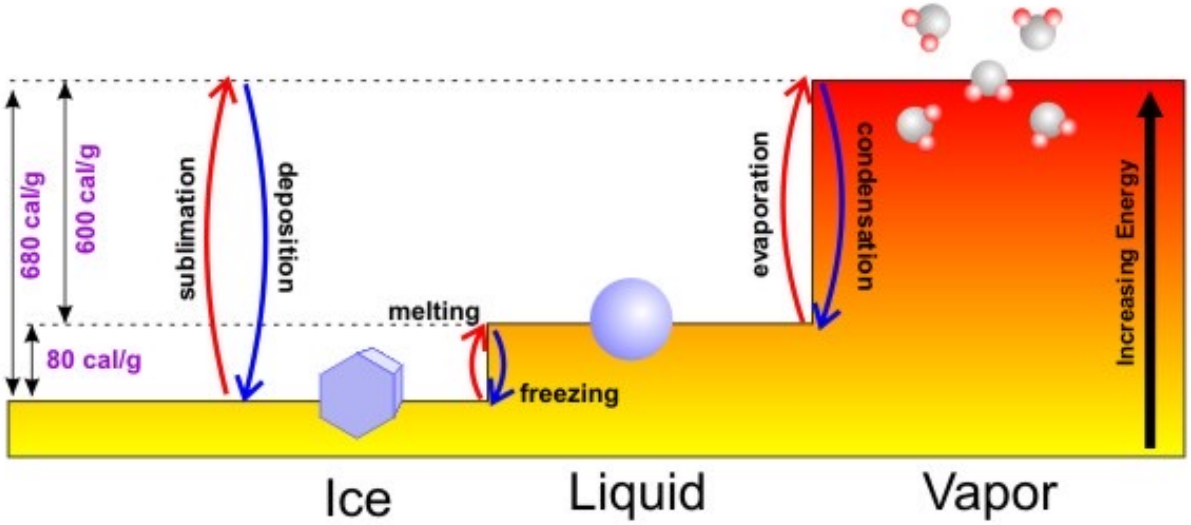


Photo: https://www.energy.gov/energysaver/air-source-heat-pumps

These are all heat pumps

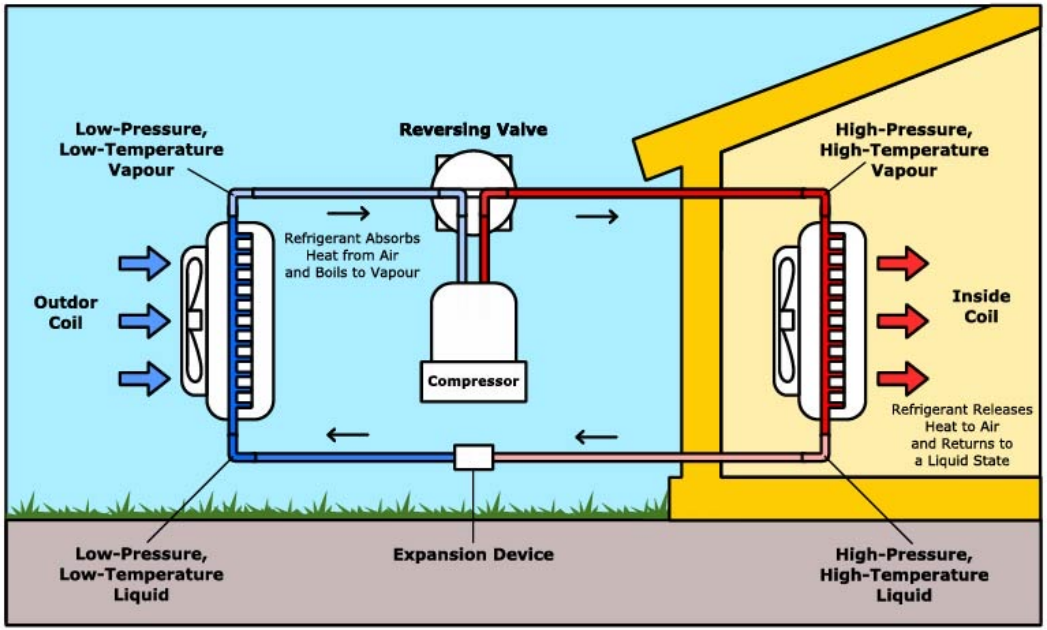
Photos:
https://www.energy.gov/energysaver/central-air-conditioning
https://www.energy.gov/energysaver/maintaining-your-air-conditioner
https://www.energy.gov/energysaver/purchasing-and-maintaining-refrigerators-and-freezers

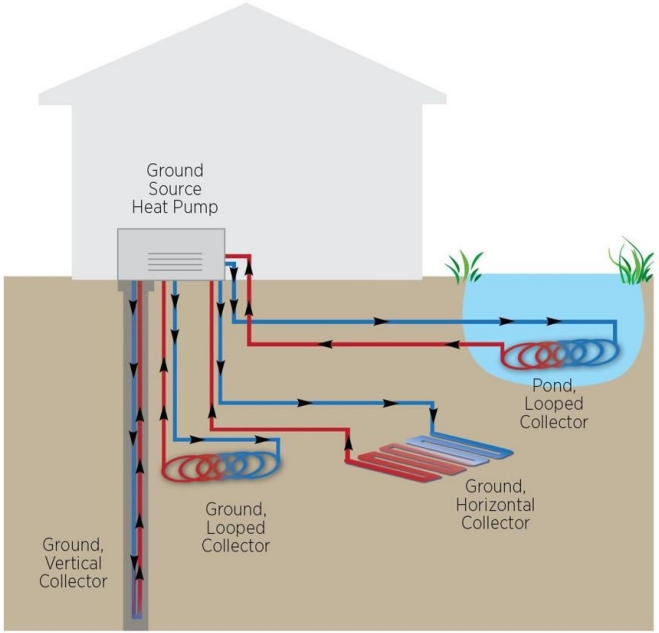
The “magic” of phase change



Source:
https://www.e-education.psu.edu/meteo3/l4_p3.html

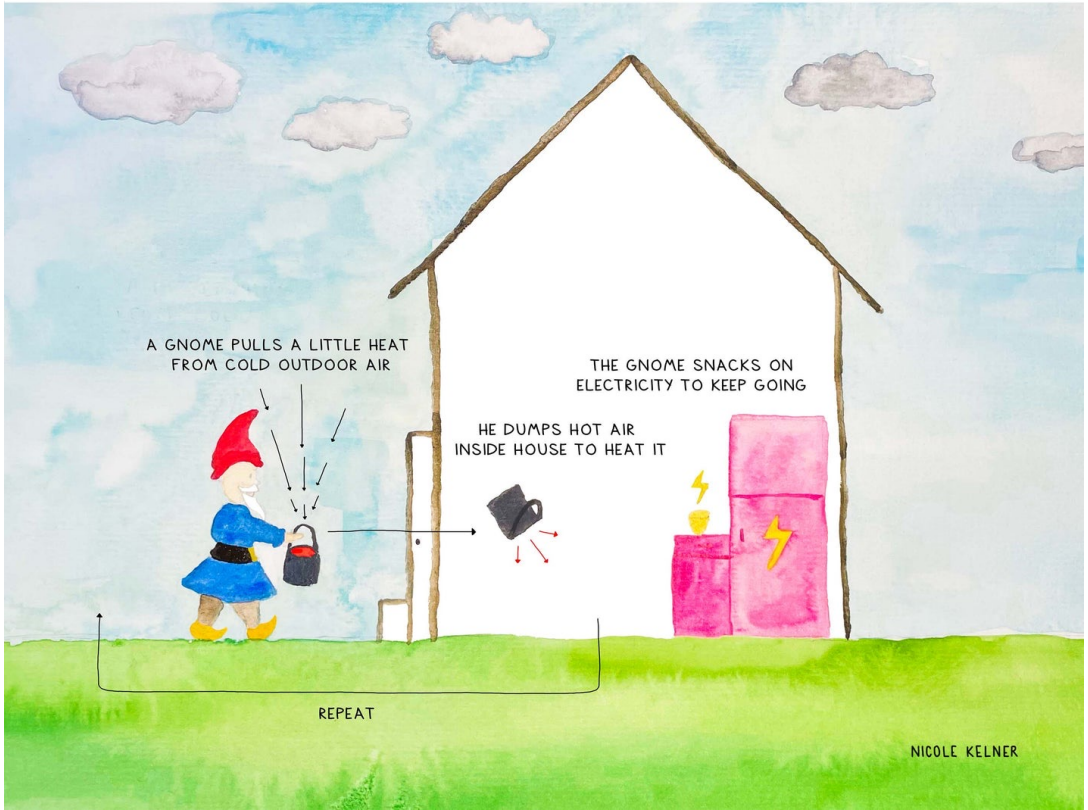
Using electricity to move heat





Source:
https://www.energy.gov/energysaver/air-source-heat-pumps
https://bsesc.energy.gov/energy-basics/hvac-geothermal-heat-pumps

EXPLAIN HOW A HEAT PUMP WORKS LIKE I'M A 5 YEAR OLD



Source:
https://nicolekelner.com/products/heat-pump-gnomes-stickers

Heat pumps for…

Space heating and cooling

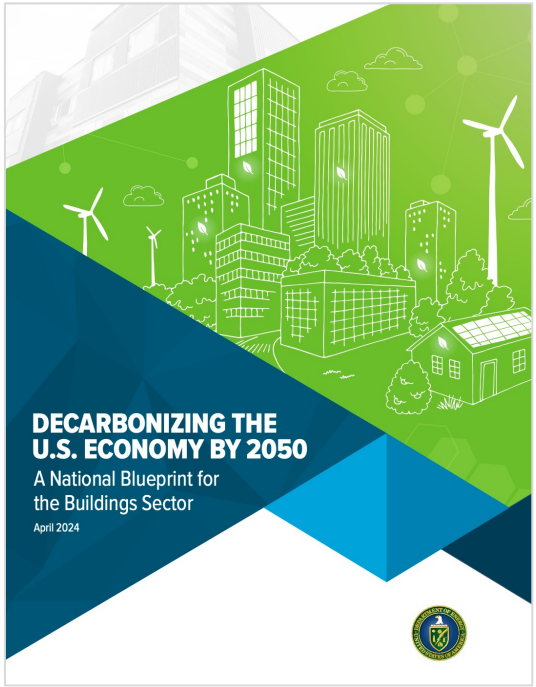
Water heating

Clothes drying

Photos:
Gradient, https://www.energystar.gov/products/heat_pump_water_heaters/benefits-savings, Bosch


Public health and equity

National Blueprint for US Buildings Sector Decarbonization:
A people-centered vision for 2050



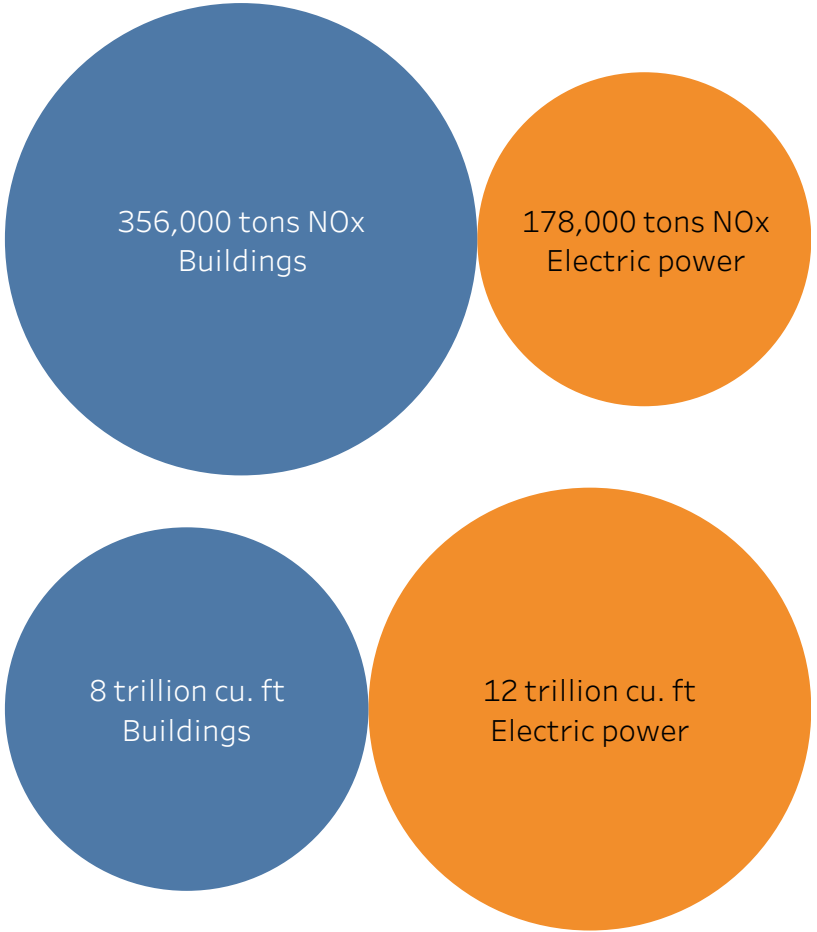
Download the Blueprint:

bit.ly/buildingsdecarb

Fossil gas combustion in buildings emits **twice as much** NO_X pollution as gas power plants

Despite using 1/3 less gas

Source:
EPA National Emissions Inventory, 2020
EIA Natural Gas Consumption by End Use, 2020
https://www.eia.gov/dnav/ng/ng_cons_sum_dcu_nus_a.htm

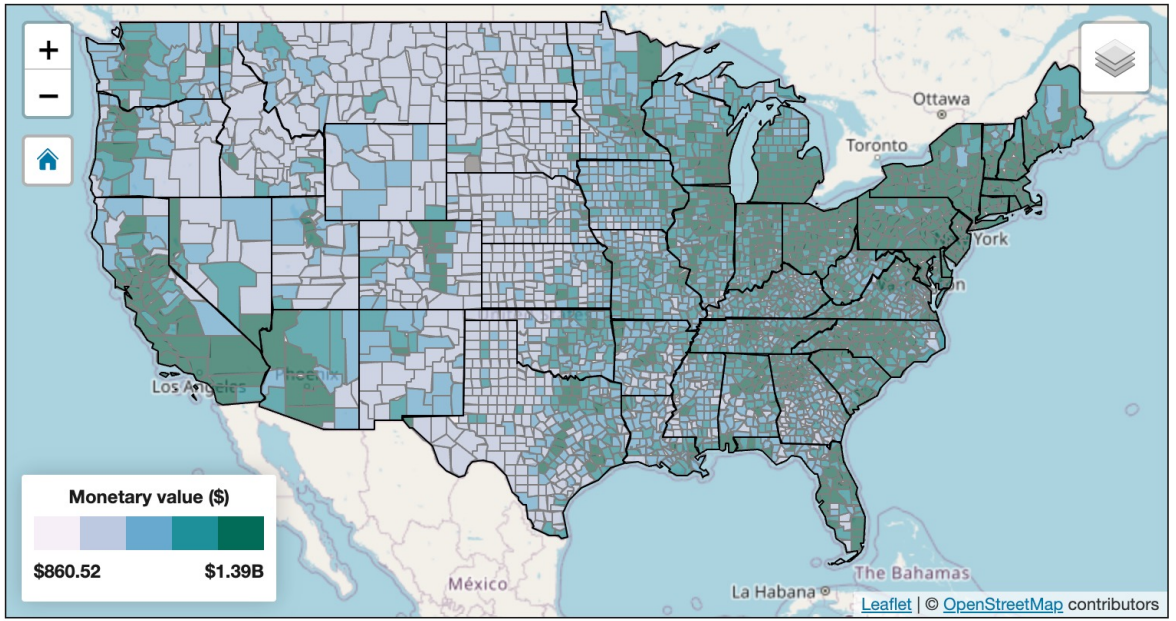


$50 billion

in annual health impacts from $PM_{2.5}$ and NO_X/ozone could be avoided if the Blueprint's goal of 75% reduction in on-site fossil combustion by 2050 is achieved

Based on U.S. Environmental Protection Agency CO-Benefits Risk Assessment (COBRA v5.0); avoided health costs of 75% reduction in residential and commercial fossil combustion in contiguous United States (range $40 billion–$59 billion). Monetized health impacts include mortality, healthcare costs, and work/school loss from asthma, heart disease, lung cancer, stroke, Alzheimers, Parkinsons, etc.

Displaying: Total Health Benefits ($, low estimate)

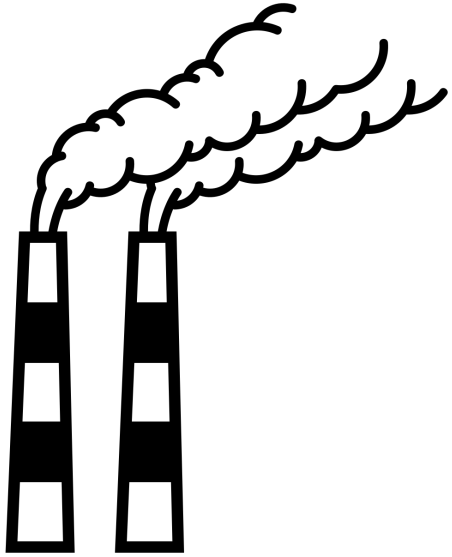


Total Health Effects from $PM_{2.5}$	$17,000,000,000	$35,000,000,000
Total Health Effects from O_3	$23,000,000,000	$23,000,000,000
Total Health Effects	$40,000,000,000	$59,000,000,000

Pollutants emitted **at ground level** typically have worse health impacts than elevated smokestack emissions from power plants and factories

Example marginal damage values for $PM_{2.5}$

Elevated:
$36,000*
per tonne



Ground:
$70,000*
per tonne

*Dollar per tonne values vary by pollutant and air quality damage model

Table S2: Emissions-weighted mean values by species and model (in USD/tonne)

	AP2		EASIUR		InMAP		Coefficient of variance	
Species	Ground	Elevated	Ground	Elevated	Ground	Elevated	Ground	Elevated
$PM_{2.5}$	70,000	36,000	120,000	69,000	100,000	110,000	21%	42%
SO_2	45,000	22,000	21,000	20,000	30,000	35,000	31%	26%
NO_x	6,400	3,800	9,800	6,300	13,000	11,000	28%	42%
NH_3	38,000	37,000	49,000	32,000	39,000	51,000	12%	20%

Gilmore, E. A., J. Heo, N. Z. Muller, C. W. Tessum, J. D. Hill, J. D. Marshall, and P. J. Adams. 2019. "An Inter-comparison of the Social Costs of Air Quality from Reduced-Complexity Models." Environmental Research Letters. https://iopscience.iop.org/article/10.1088/1748-9326/ab1ab5

People of color are exposed to **90% higher rates of ambient particulate matter ($PM_{2.5}$)** from residential gas combustion, compared to white people.

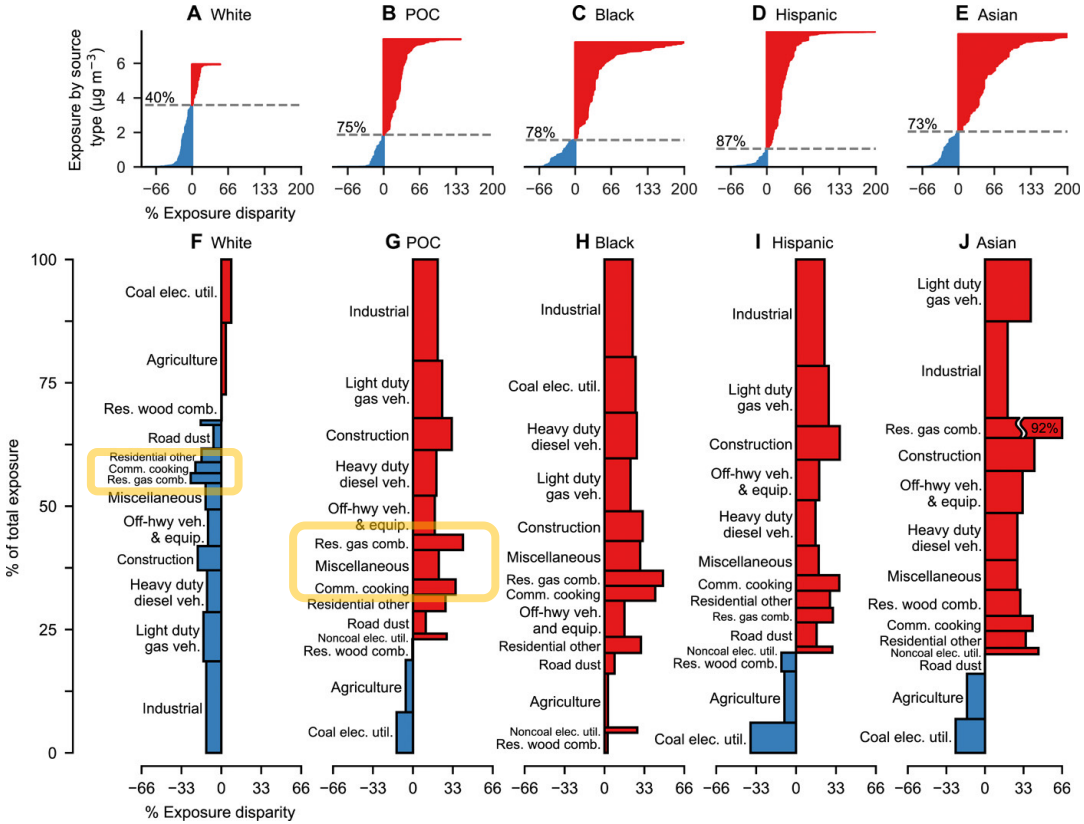


Fig. 1. Source contributions to racial-ethnic disparity in $PM_{2.5}$ exposure. (Tessum et al. 2021)

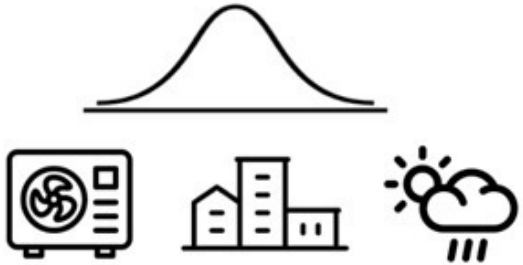
Tessum, C. W., D. A. Paolella, S. E. Chambliss, J. S. Apte, J. D. Hill, and J. D. Marshall. 2021. "PM2.5 Polluters Disproportionately and Systemically Affect People of Color in the United States." Science Advances. https://www.science.org/doi/10.1126/sciadv.abf4491

Distributions of costs and benefits

Joule

Volume 8, Issue 4, 17 April 2024, Pages 1000-1035

Heat pumps for all? Distributions of the costs and benefits of residential air-source heat pumps in the United States

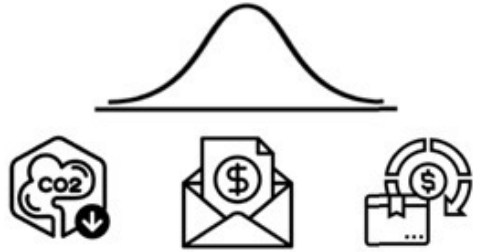


Sources of variability
- ASHP performance specifications
- Envelope, climate, behavior, and other housing characteristics

Sensitivities
- Future electric grid emissions
- Retail electricity & fuel prices
- Financial incentives

ResStock

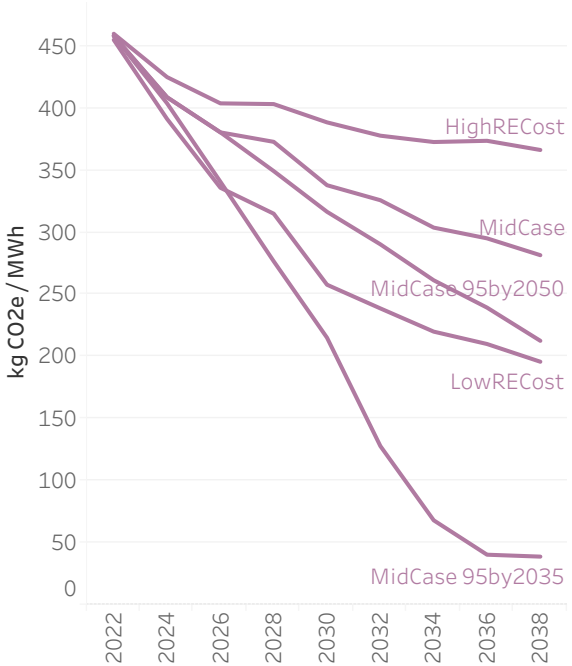
Modeling framework
- 550,000 representative U.S. homes
- Six upgrade scenarios
- Physics simulations of heat transfer and empirical ASHP performance
- Equipment sizing load calculations
- Installation cost regressions

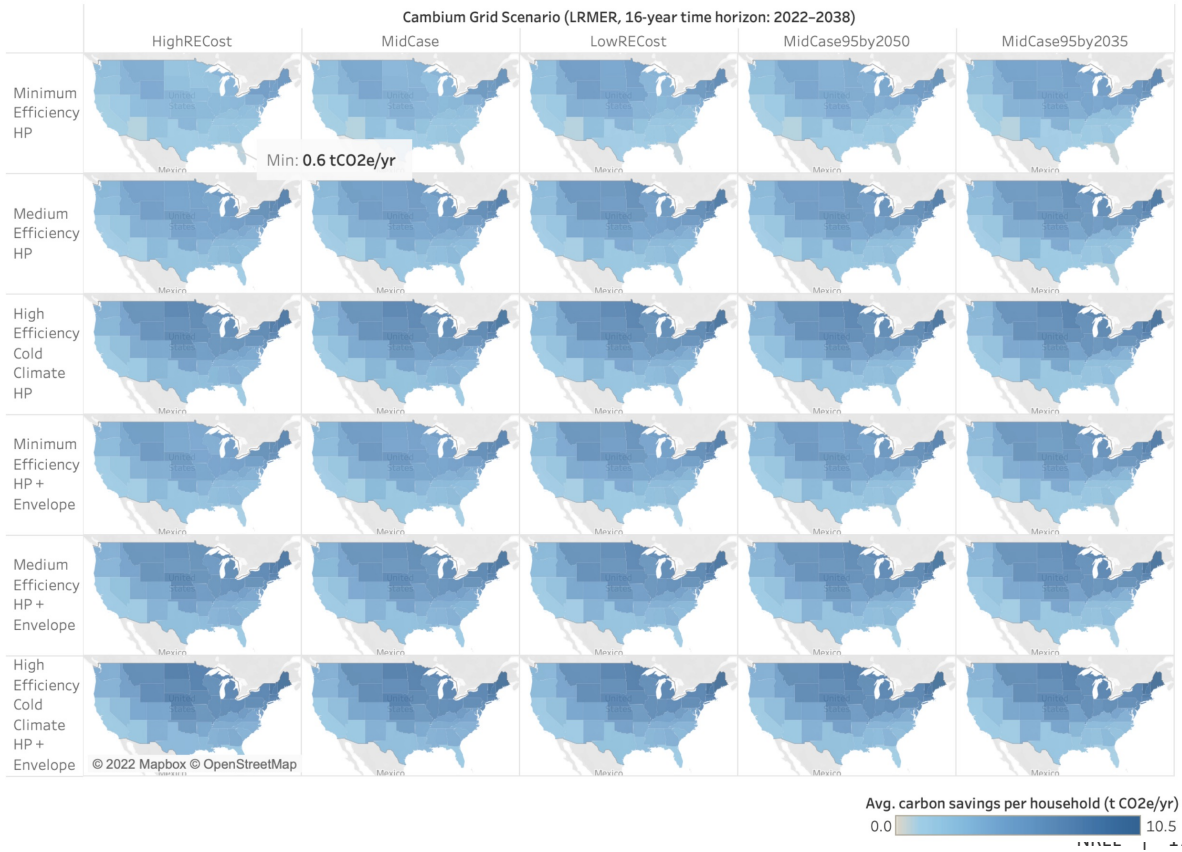


Distributions of costs and benefits
- Greenhouse gas emissions
- Energy bill savings
- Incremental upgrade cost
- Net present value

Finding 1: Electrification with heat pumps reduces lifetime GHG emissions in every contiguous US state in all scenarios

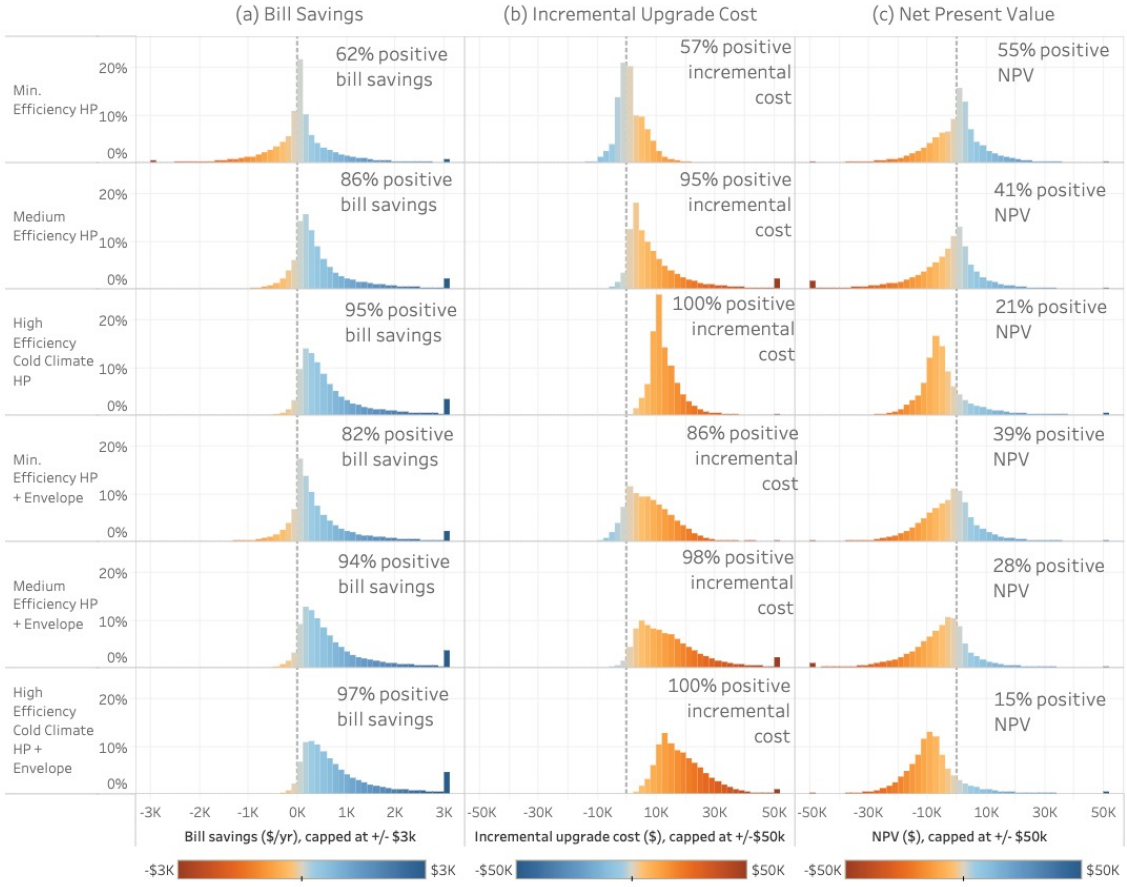
Average Emissions Rate forecasts to 2038 from Cambium 2021 (before IRA/BIL)





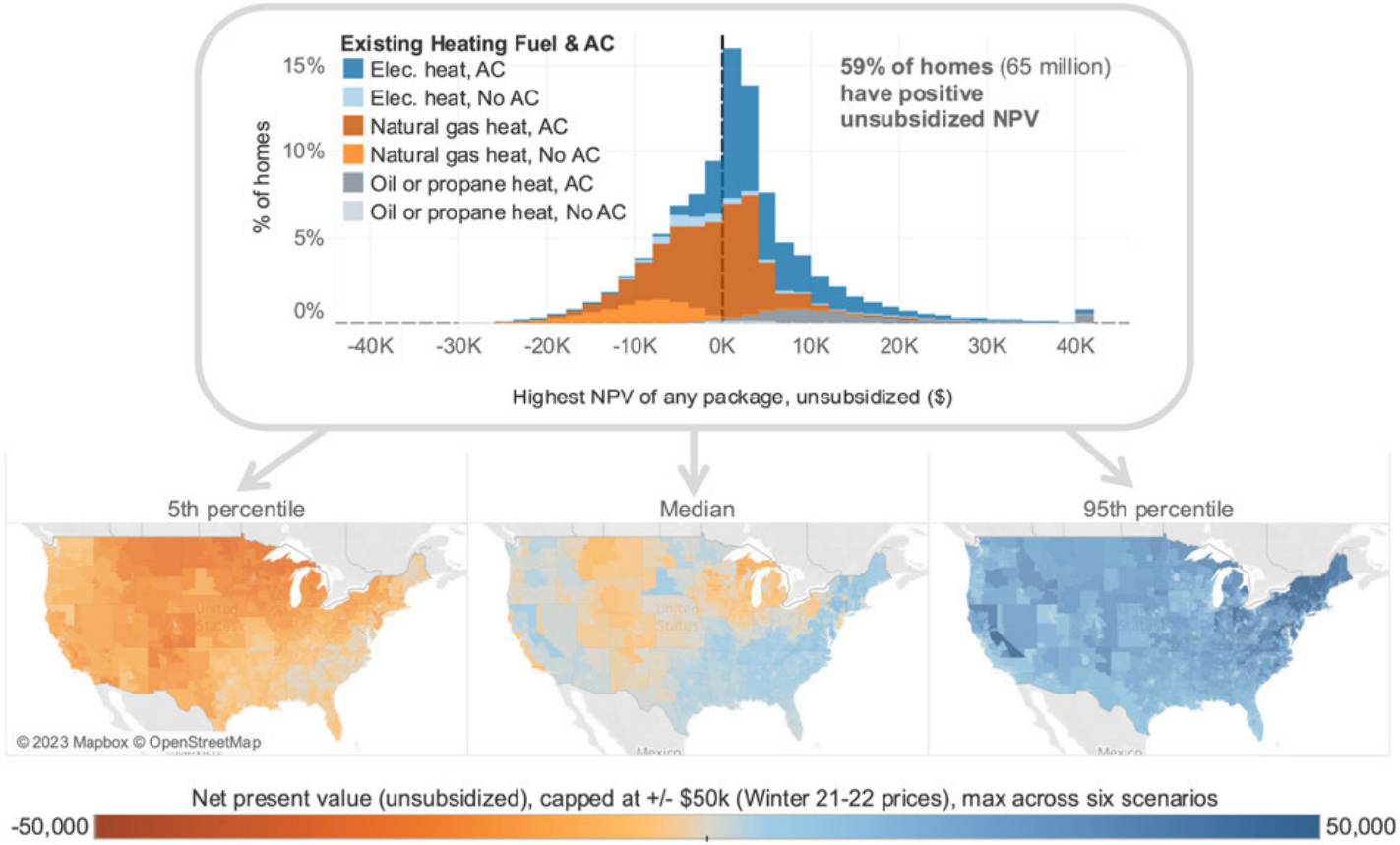
Distributions of bill savings, upfront costs, and NPVs across U.S. households

Finding 2:
Cold-climate heat pumps and/or envelope upgrades avoid most bill increases but at a higher upfront cost



- All metrics calculated relative to Reference equipment scenario
- Incremental upgrade cost assumes both heating and cooling equipment are being replaced

Finding 3: Air-source heat pumps are cost effective without subsidies in 65 million US homes



Thank you

www.nrel.gov

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