Decarbonizing Low Income Homes

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Better Buildings Residential Network

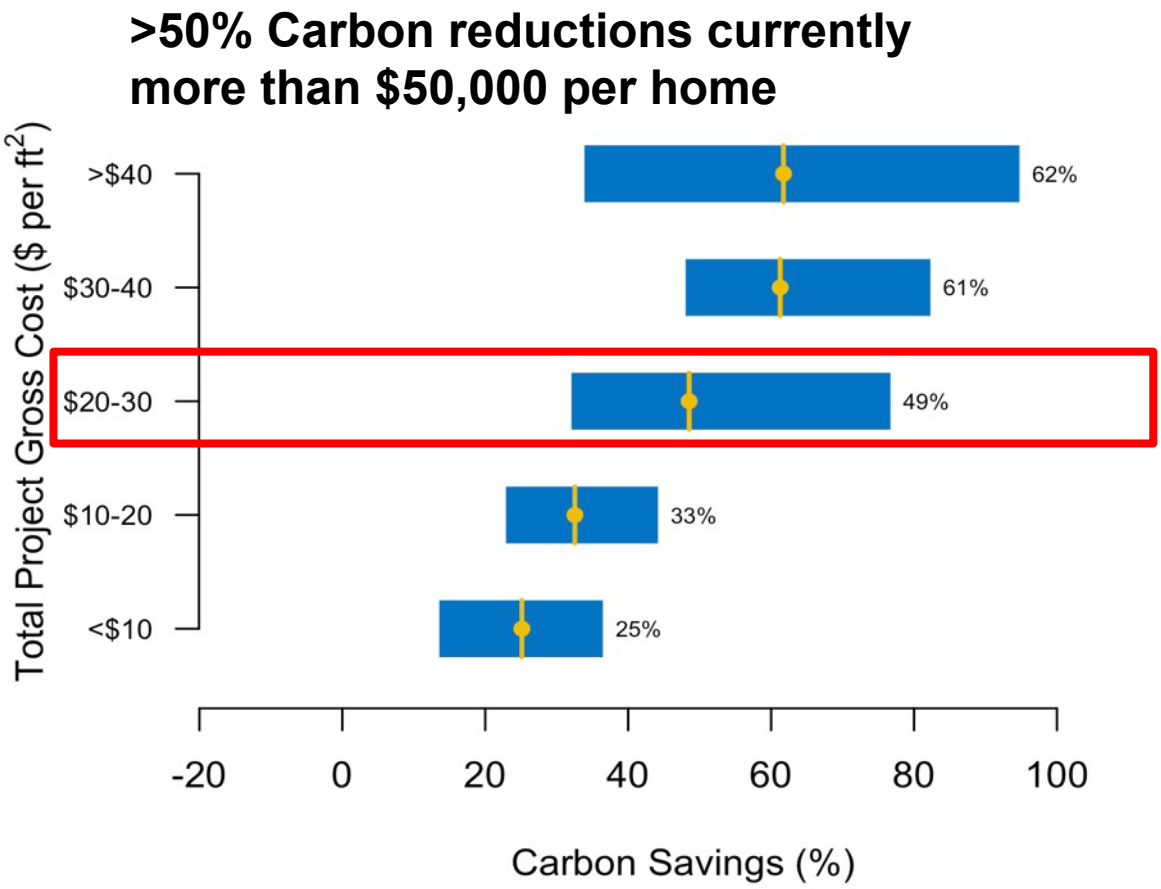
ENERGY TECHNOLOGIES AREA
BERKELEY LAB

Introduction

To decarbonize American homes and improve energy affordability nationwide, DOE launched the eighth and final Energy Earthshot—the Affordable Home Energy Shot™—to accelerate innovative retrofit solutions that reduce up-front costs, lower utility bills, improve safety and comfort, and address communities' broader needs.

Lower upfront costs

Cost data from 1700 projects



Lowest cost projects: basic air sealing/insulation with heat pumps and solar PV

CO_2 focus: $40,000

About TEN TIMES median US household savings

Costs are highly variable

- Home with A/C trivial to add heat pump
- Home with no A/C – needs new 240V circuit(s), ductwork fabrication, drains, etc.

- Newer home needs no envelope upgrades
- Older home needs air sealing, attic/wall/basement insulation

- Adding EV Charger or Solar PV?

Existing conditions – critical in lower income households

- Asbestos abatement
- Broken/missing HVAC/DHW/appliances
- Broken/missing envelope: windows, roofs, walls, doors, downspouts
- Pest control
- No physical room/access
- Not enough panel capacity or space
- Poor condition electrics

Avoiding panel/service/wiring changes

What does it cost?

- Circuits: **$500-$1,500 each**
- Panel: **$1,000-$5,000**
- Service: **$1,000-$25,000** to homeowner + similar amount for utility
- Rewiring trigger: **$10,000 - $20,000**

Time delays

- **3-6 months** project delays
- >1-year lead time on transformers
- Utility might reject your interconnection

Image courtesy of Eric Morrill

Additional ratepayer costs for:

- Utility distribution system capacity increases + new generation/storage

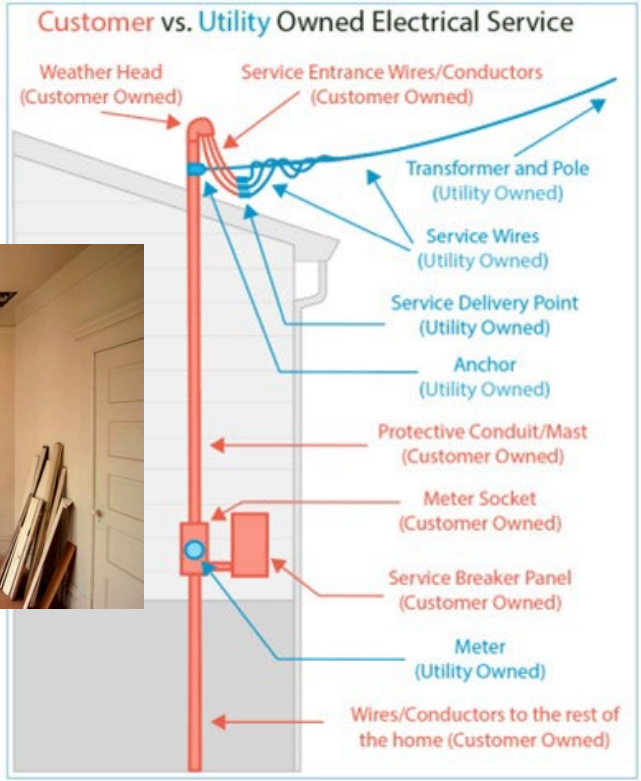


Image courtesy of Redwood Energy

Sometimes a panel replacement is needed

May be more common in older lower income less maintained/updated homes

Old, unsafe or damaged:
- Panels
- Breakers
- Wiring
- Junction boxes
- Fuse Boxes

Low Power Electrification Solutions: Smart Panels and Breakers

Smart Breakers
$200 + install

Smart Panels
$3-5k + install

Low Power Electrification Solutions: Circuit Sharing and Pausing

Circuit Sharing & Pausing
$300-900 + install, sometimes DIY
EV Charging and Hot Water

EV-PowerShare[xlii]
EV-PS Smart

SimpleSwitch[xliv]
240V / EV Circuit Switch

BSA Electronics[xli]
Dryer Buddy

Neo Charge[xlii]
Smart Splitter

Low Power Electrification Solutions: Low Power Appliances

120V plug-in heating, cooling, hot water

Battery-Integrated Cooking High cost premium

Low Power Electrification Solutions

Meter collars for EVs and PVs
$500 + install

Using the National Electric Code: "Watt Diet" FREE!!

All Electric 100 Amp Home (2,000 square feet)

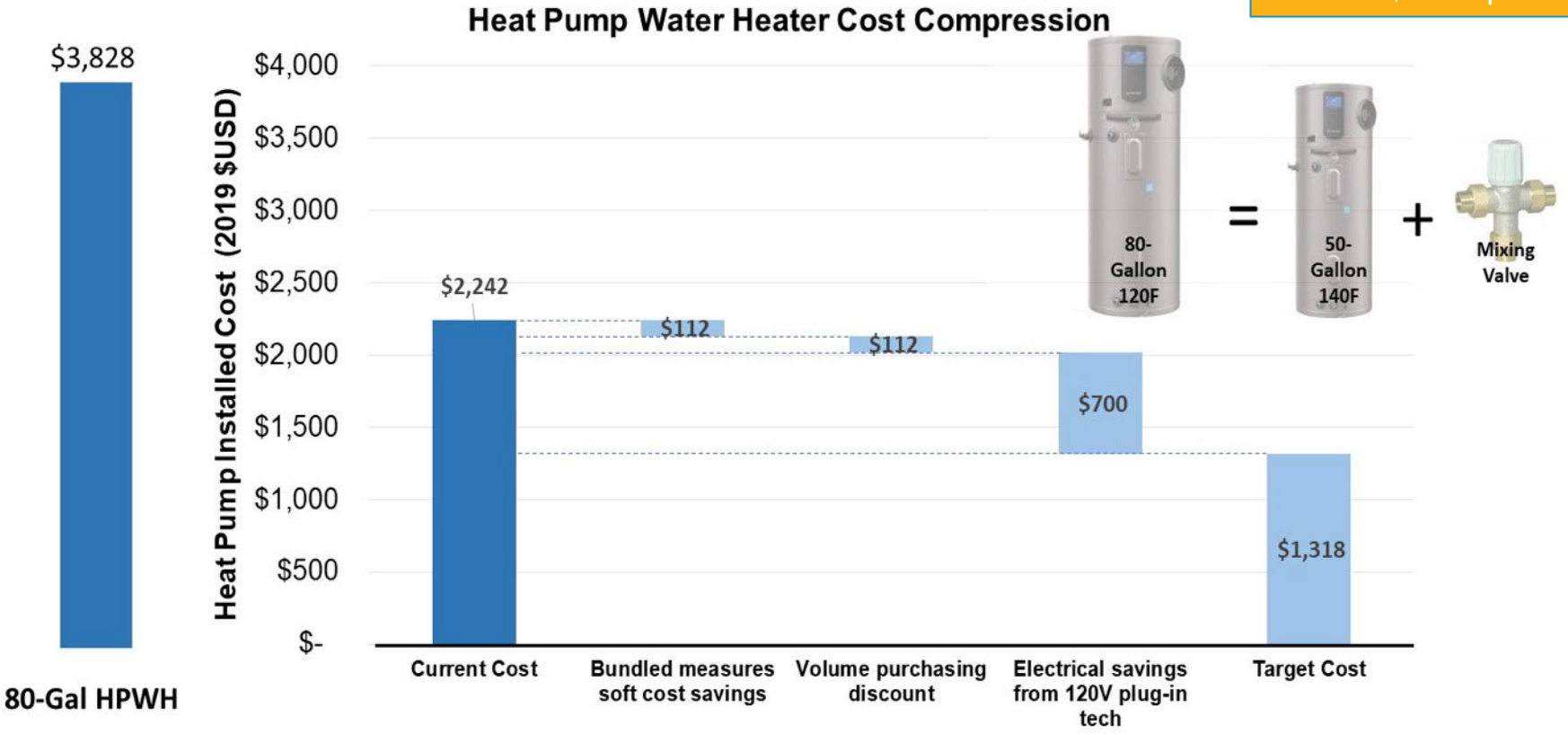
Ducted heat pump, medium power heat pump water heater, hybrid heat pump dryer

Device Volts	Device Amps	001 Amp Panel		Device Amps	Device Volts
120	8	Lights/Plug 15	Lights/Plug 15	8	120
120	8	Lights/Plug 15	Lights/Plug 15	8	120
120	8	Lights/Plug 15	Lights/Plug 15	8	120
120	10	Garbage Disposal 20	Kitchen Outlets 20	13	120
120	7	Refrigerator 20	Kitchen Outlets 20	13	120
120	0	Spare 15	Dishwasher 20	12	120
120	0	Furnace (removed) 15	Clothes Washer 20	13	120
240	20	Heat Pump Centrally Ducted 30	Hybrid Heat Pump Dryer 20	14	240
240	20	EV Charger 25	Range (cooktop +oven) 50	40	240
240	16	Solar Input 20	Heat Pump Water Heater 20	12	240

House square footage = 2000 Total Counted Panel Amps = 96.7

Appliance Cost Compression

Low income direct install program at SMUD has already proven the potential to cut costs from >$4k down to $3400 per unit



Other Affordability Ideas

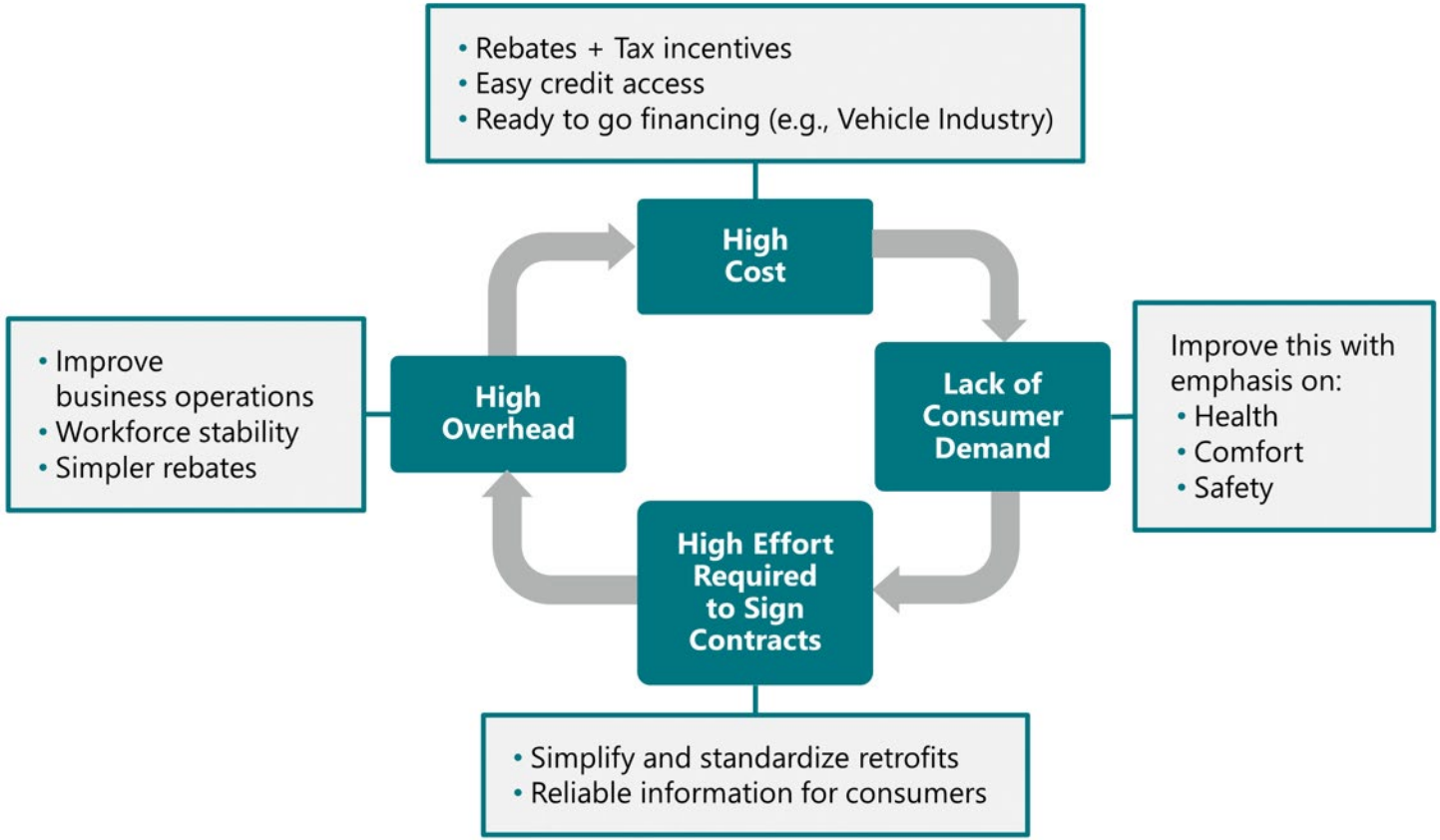
- "Affordability" - based on net monthly cost (not banking metrics of ROI, LCC, TRC, etc.)
  - Bundled financing – third party financing shares in bill reductions
  - Include added value: health, safety, comfort, etc.
- Better sizing, installation practice, commissioning = smaller, cheaper installs
- Consistent, long term rebates (not tax credits) helps business plan and organize
- Program design
  - Bulk purchasing
  - Contractors only do installs
  - Training
  - Focus on biggest carbon savings: HP, HPHW, air sealing, insulating
  - Consider DIY approaches (need more 120V plug-in solutions?)

Helping Businesses

Decarbonization upgrades have very high overhead (40%) – we need to address business models

Work is not attractive for contractors

Not enough installers/contractors – fewer electricians and plumbers every year…..

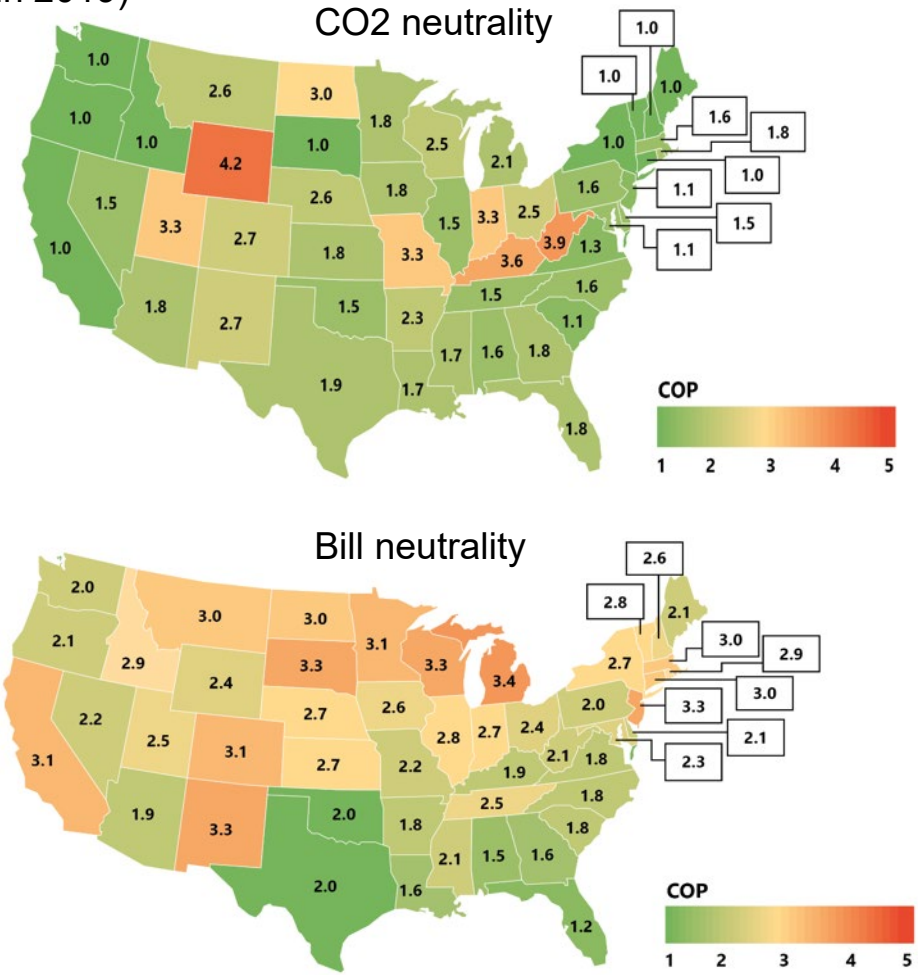


Lower utility bills

Bill Savings

1. Almost everyone saves: regional variability
2. Rate structures matter. Turn *borderline* in to *savings* using pro-Electric rates. Consistent bills through the year: avoids high bill stress
3. Completely remove gas to avoid standing charges.
4. Need protections for low income – build on existing programs.
5. Any additional grid infrastructure costs passed on in future rate increases. Vital to minimize added load.
6. Solar PV – Net Energy Metering is important.

Heat Pump compared with an 80% AFUE gas furnace (in 2019)



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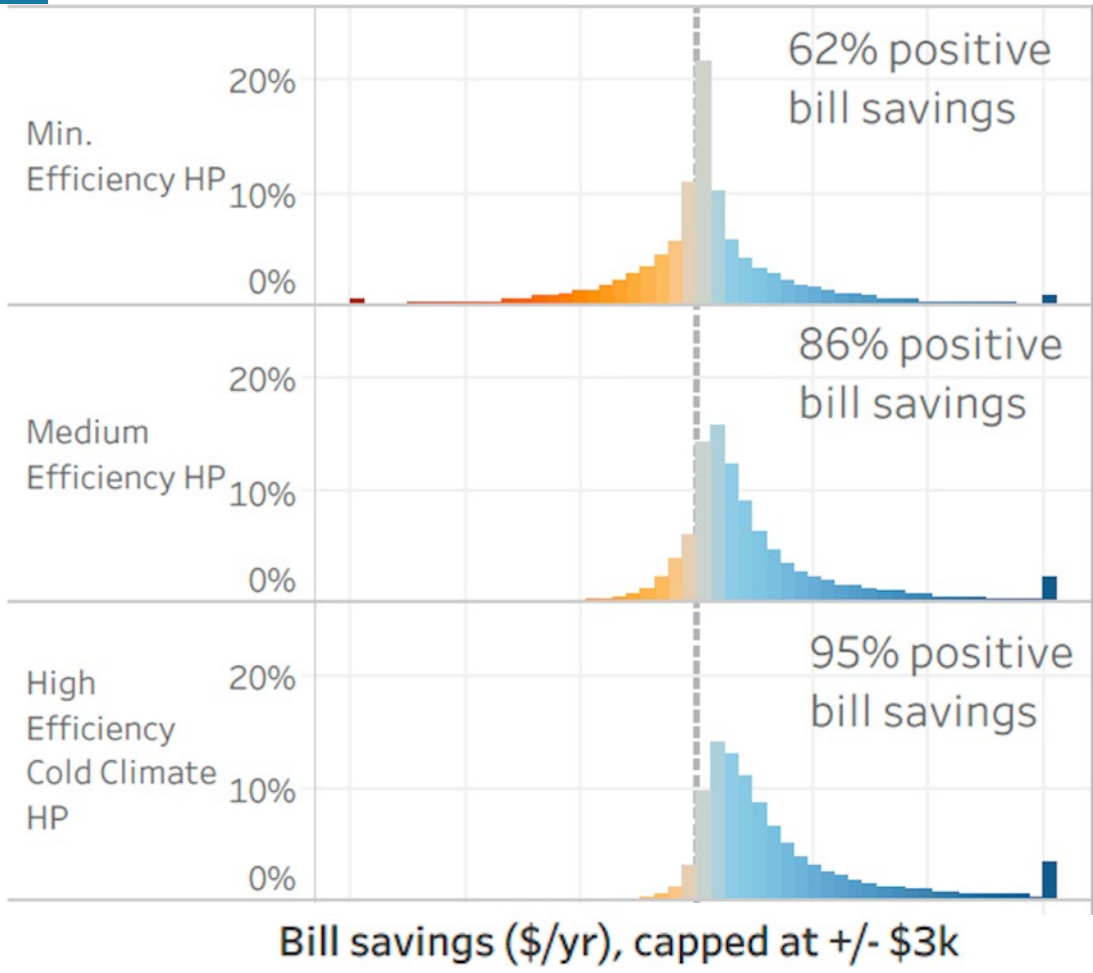
Bill Savings

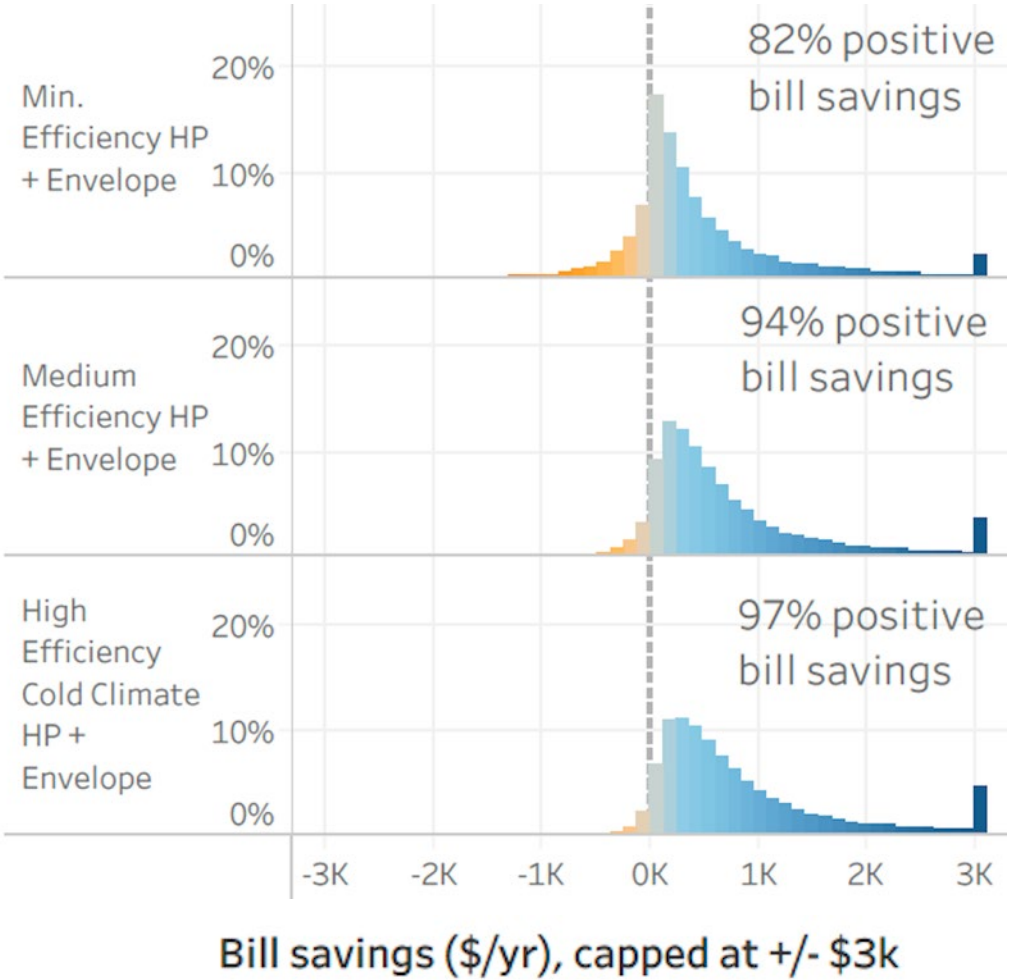
Install high efficiency equipment



Wilson, J., Munankarma, P., Less, B., Reyna, J. and Rothgeb, S. 2024. Heat Pumps for All? The distributional costs and benefits of residential air-source heat pumps in the US. Joule. doi.org/10.1016/j.joule.2024.01.022

Bill Savings

Load reduction: air sealing and insulating duct systems and older homes



Improve safety and comfort and address community needs

Non-energy benefits – considering added value

Functionality:

Comfort – steady temperatures with heat pumps + air sealing + insulation, adding ability to cool

Health & safety:

Indoor Air: main sources are cooking and poor appliance venting

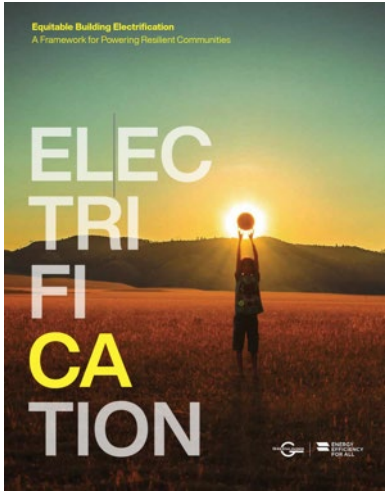
- This would serve Low-Income/Disadvantaged households the most
- More likely to have poorly vented appliances
- Smaller dwellings have higher contaminant concentrations
- Low income dwellings less likely to have ventilation systems

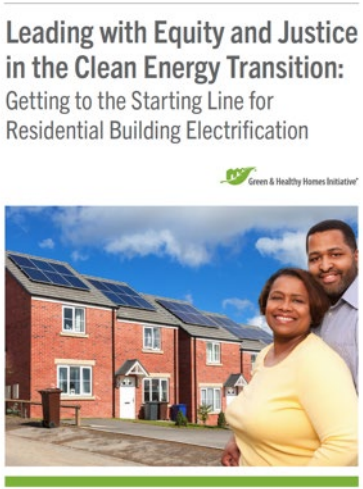
Outside air: Environmental Justice Issue – often worse in disadvantaged communities

Heat stress: Provision of cooling + more affordable heating/cooling

Solutions for renters, multi-family and low income households

- **Renters need protection form increased rents and eviction**
  - Look for solutions the do not require MF buildings to be empty – eviction and no right of return a major concern
  - In MF occupants often pay electric bill, but not gas bill if heat and hot water are central systems. How to compensate if someone starts to use a portable heat pump?
- **Develop plug-in/transportable solutions for renters**
- **Lower income households are risk averse** – can't afford to make a "mistake" – they need reassurance and low-risk, robust, "tried and true" solutions





Household interactions.. So many (good) questions….

Programs need to have ready to go, good answers to these questions:

- Will bills go up or down?
- Is it noisy?
- Will I be comfortable?
- Does it cost more to maintain?
- Who will fix it when it breaks?
- Who do you call?
- If you find someone, can they do it?
- If they can, how long do you need to wait? Many months for a contractor + many more months if a utility is involved
- What is the value?

Community and culture

Capitalize on existing culture to get to scale

Maine example:

- Bring training together at a state level – everyone on the same page
- Understand motivations and tailor solutions… e.g., “Made in America”

2. Years of ingenuity

People from Maine were upcycling before it was a Pinterest trend. We pickle watermelon rinds instead of composting them an junk into Etsy gems. This stems from our insatiable nee sufficient combined with the impressions from our thrif work hard and pride ourselves on our independence. Mai to “git ‘er done” on any budget, in any situation — wheth gerry-rigging a car repair or improvising a home remode prepared, usually with duct tape and vinegar.

3. Roughing it

Mainers take a masochistic pride in roughing it, working o budget, and being forced to find an original way to tackle a Sure, hiring someone to dig a well would make everyday life why not see how long we can make the rain cistern/hauling in water situation work? It’s not so much a matter of finance as it is a matter of pride. Even urban Mainers are well-trained in the art of survival, and we love showing it off. So much so that adversity actually makes us giddy. We perk up when a storm hits, or when the car breaks down.

4. Our heritage

Mainers can get weirdly hung up on the “How Maine are you?” competition. Questions such as, were you actually born in Maine? And what about your parents? Grandparents? These petty distinctions even come into play on the city/town level, with community bonds passing from generation to generation as people grow up with the grandkids of their grandparents’ friends. Things can get dicey when hometown loyalties are ruffled, and locals draw an invisible line to show outsiders their place.

Frugal Yankees Do Almost Anything To Save a Buck

Capitalise on

- Frugality,
- Tribalism,
- Territorialism,
- Independence,
- Self Sufficiency

Images from Naomi Beale, Retrofit Maine

What about “no income” abandoned property?

Strategies to ”decarbonize” while rebuilding:

- 20 properties at once for scale
- Utilize pooled subsidies
- Build to “code” with all-electric design
- Challenging to make a profit – needs subsidies

Images from Brendan Schreiber, Schreiber Brothers Development

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Homes.lbl.gov

Remaining Challenges

Solutions for hard to electrify homes:

- Cold climates
- All-gas homes
- Multifamily homes
- Manufactured homes
- Old/historic homes

The Pathway

1. Start now, if not sooner
2. Low power electrification of heating, hot water, cooking and laundry (using heat pumps)
3. Air seal and insulate older homes & HVAC systems
4. Optionally, add Solar PV
5. Use the best performing heat pumps you can
6. Use integrated appliances for cooking/laundry
7. Easy access to rebates/financing
8. Help contractors with new business models
9. Develop homeowner and trades guidance/reassurance/risk assessment
10. Emphasize health/safety benefits
11. Train more trades
12. New rate structures + rebates + financing
13. Make every AC replacement a heat pump

HOME DECARBONIZATION IS:

Costly
Time Consuming
Hard

HOME DECARBONIZATION NEEDS TO BE:

Affordable
Simple
Easy