



# RETROFITTING TO SUPPLEMENT NEW HOME CONSTRUCTION

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## CAN WEATHERIZATION IMPROVE SUSTAINABILITY AND EQUITY?

- One in 5 U.S. households faces a “heat or eat” dilemma [1]
- Heating electrification is essential, but could sharply raise heating bills and stress the grid [2,3]
- Weatherization is a potential solution: mixed evidence on effectiveness
- Economic analyses may ignore health benefits; in U.S., benefits constrained by WAP limitations

TABLE VII  
ESTIMATED RETURNS ON INVESTMENTS IN ENERGY EFFICIENCY

Time horizon	Ex ante (NEAT) projections (1)	Empirical estimates (2)
<b>Panel A: Private internal rate of return</b>		
10 years	7.0%	-10.6%
16 years	11.9%	-2.3%
20 years	13.0%	0.21%
<b>Panel B: Private internal rate of return, adding the avoided emissions damages</b>		
10 years	11.4%	-7.6%
16 years	15.5%	0.1%
20 years	16.4%	2.3%
<b>Panel C: Social internal rate of return</b>		
10 years	-3.9%	-17.8%
16 years	3.1%	-7.8%
20 years	5.0%	-4.6%
<b>Panel D: CO<sub>2</sub> abatement cost, 3% discount (\$/ton CO<sub>2</sub>)</b>		
10 years	\$85	\$322
16 years	\$38	\$201
20 years	\$22	\$161
<b>Panel E: CO<sub>2</sub> abatement cost, 7% discount (\$/ton CO<sub>2</sub>)</b>		
10 years	\$117	\$404
16 years	\$71	\$285
20 years	\$56	\$248

Table from Fowle et al. (2018) [4] shows that financial returns and CO<sub>2</sub> reductions from Weatherization Assistance Program are initially overestimated. Empirically-observed returns are often negative.

Table 6 | Health outcomes in trial of insulating houses

Outcome measure	Before intervention		After intervention		Odds ratio (95% CI)	
	Intervention group	Control group	Intervention group	Control group	Unadjusted	Adjusted
SF-36 self report scales (adults with data for both years)						
Low vitality (bottom 3 of 6 categories)	445 (967)	450 (954)	290 (967)	412 (954)	0.57 (0.47 to 0.68) P<0.0001*	0.51 (0.41 to 0.64) P<0.0001*
Low happiness score (bottom half of scale)	158 (960)	147 (944)	81 (960)	127 (944)	0.59 (0.44 to 0.80) P=0.0005	0.56 (0.41 to 0.77) P=0.0003*
Fair or poor general health	231 (977)	245 (964)	145 (977)	220 (964)	0.59 (0.47 to 0.74) P<0.0001	0.50 (0.38 to 0.68) P<0.0001*
Self reported symptoms						
Colds or flu (participants with data for both years + babies)	—	—	855 (1481)	1002 (1428)	0.58 (0.48 to 0.68) P<0.0001	0.54 (0.43 to 0.66) P<0.0001†
Wheezing in past 3 months (participants with data for both years)	591 (1409)	598 (1366)	412 (1409)	544 (1366)	0.63 (0.53 to 0.73) P<0.0001	0.57 (0.47 to 0.70) P<0.0001*
Morning phlegm (adults in matched set who answered in year 2)	—	—	283 (965)	376 (961)	0.65 (0.53 to 0.78) P<0.0001	0.64 (0.52 to 0.78) P<0.0001†
Sleep disturbed by wheezing (children 0-12 years, both years)	233 (512)	214 (471)	142 (512)	175 (471)	0.65 (0.50 to 0.85) P=0.0017	0.57 (0.40 to 0.81) P=0.0019†
Speech disturbed by wheezing (children 0-12 years, both years)	73 (507)	72 (468)	35 (507)	55 (468)	0.56 (0.36 to 0.87) P=0.0099	0.514 (0.31 to 0.86) P=0.0120†
Days off work						
Had days off work (adults 18-64 working in year 2)	195 (487) (101 not in work)	223 (500) (77 not in work)	149 (588)	19 (1577)	0.65 (0.50 to 0.83) P=0.0007	0.62 (0.46 to 0.83) P=0.0017*
Number of days working adults had off work\$	Count data				0.63 (0.41 to 0.96) P=0.033†	0.62 (0.47 to 0.82) P=0.001†
Number of days working adults had off work\$	Count data				0.62 (0.40 to 0.97) P=0.034,**	0.609 (0.45 to 0.82) P=0.001**
Days off school						
Had days off school (6-17 year olds in school, year 1)	175 (246)	183 (257)	149 (246)	189 (257)	0.553 (0.379 to 0.806) P=0.001	0.49 (0.31 to 0.80) P=0.004†
Number of days 6-17 year olds had off school\$	Count data				0.47 (0.27 to 0.81) P=0.007††	0.81 (1.01 to 1.51) P=0.044††

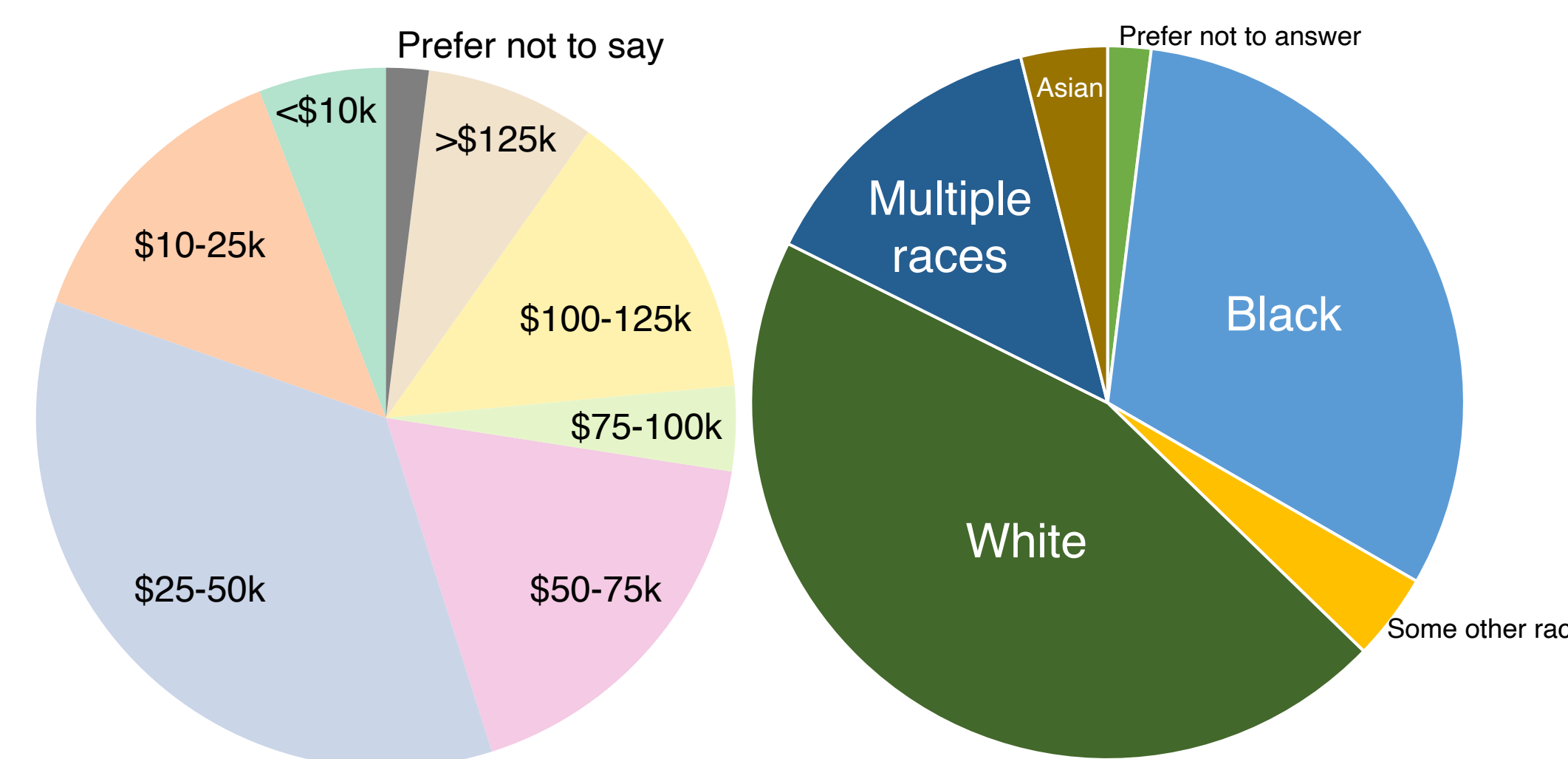
Table from Howden-Chapman et al. (2007) shows significant self-reported and observed health benefits from insulation.

## REFERENCES

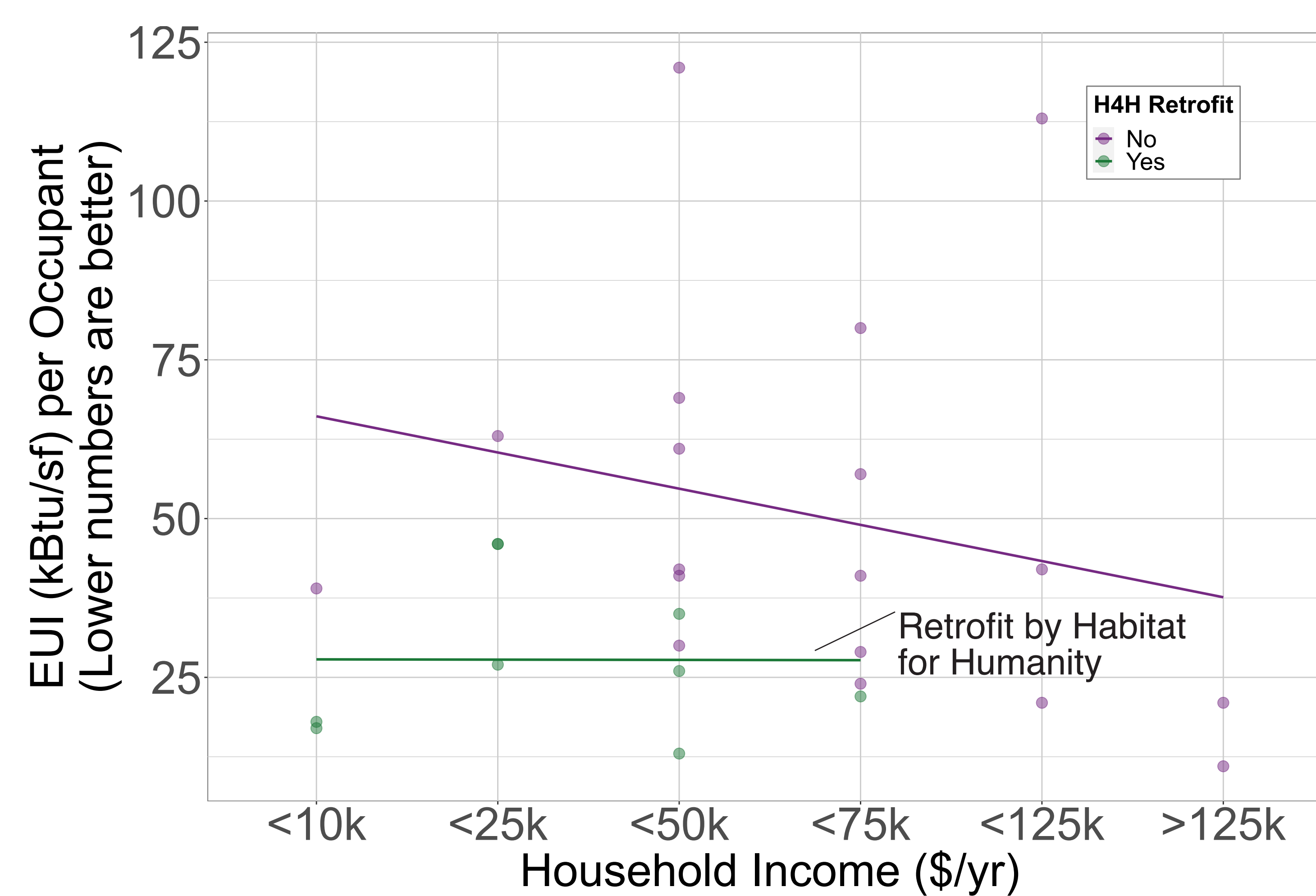
- [1] Energy Information Administration, 2018. One in three U.S. households faces a challenge in meeting energy needs [WWW Document]. URL <https://www.eia.gov/todayinenergy/detail.php?id=37072> (accessed 6.9.22).
- [2] Vaishnav, P., Fatimah, A.M., 2020. The Environmental Consequences of Electrifying Space Heating. *Environ. Sci. Technol.* <https://doi.org/10.1021/acs.est.0c02705>

## WHAT DOES EFFECTIVE WEATHERIZATION COST? IS IT AFFORDABLE?

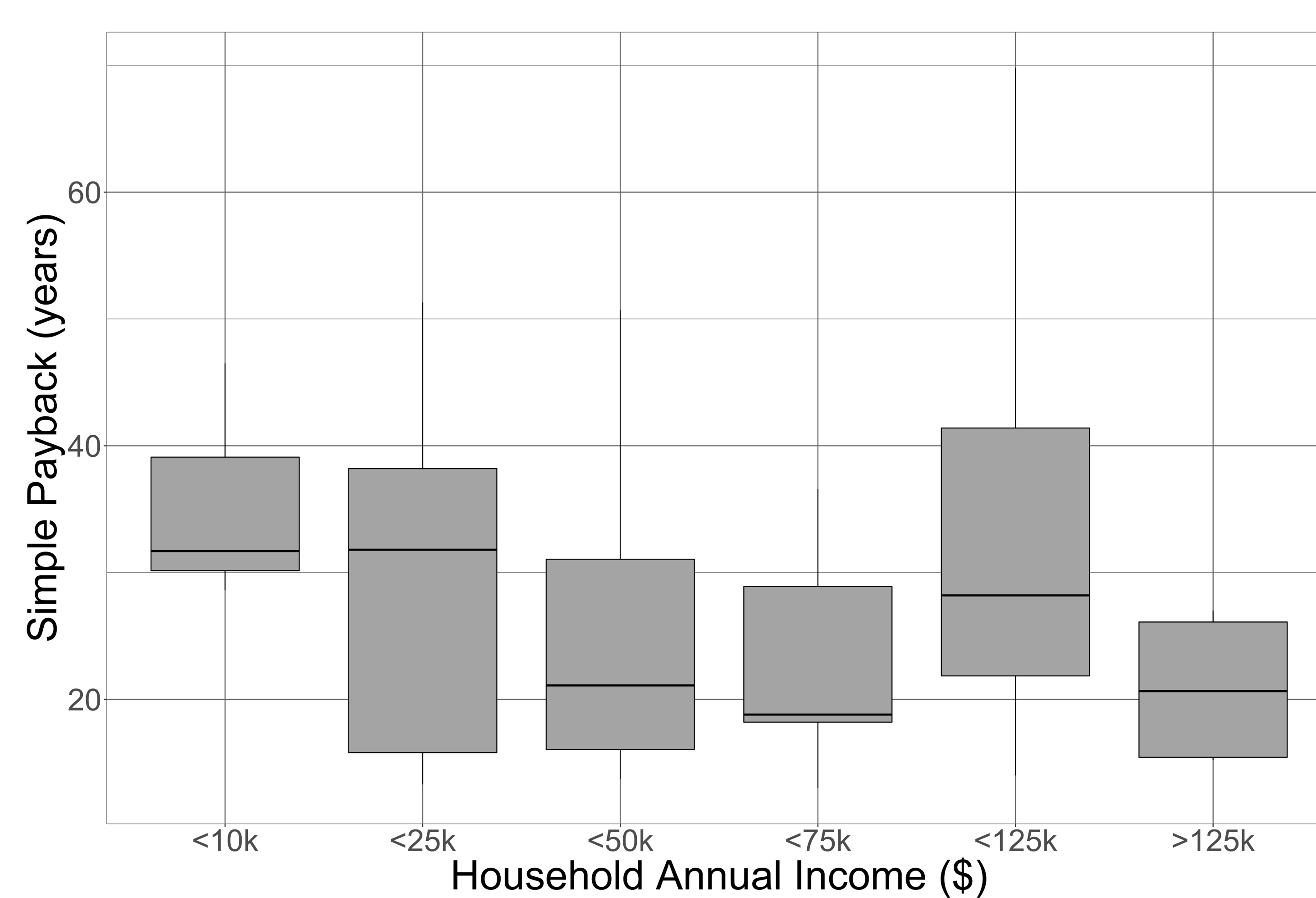
- We recruited 51 households from Washtenaw and Wayne counties
- 36% of participants are energy insecure
- 50% need additional heating or cooling due a medical condition
- 50% of participants have children



## LOW INCOME HOUSEHOLDS ARE LESS EFFICIENT UNLESS RETROFIT APPROPRIATELY



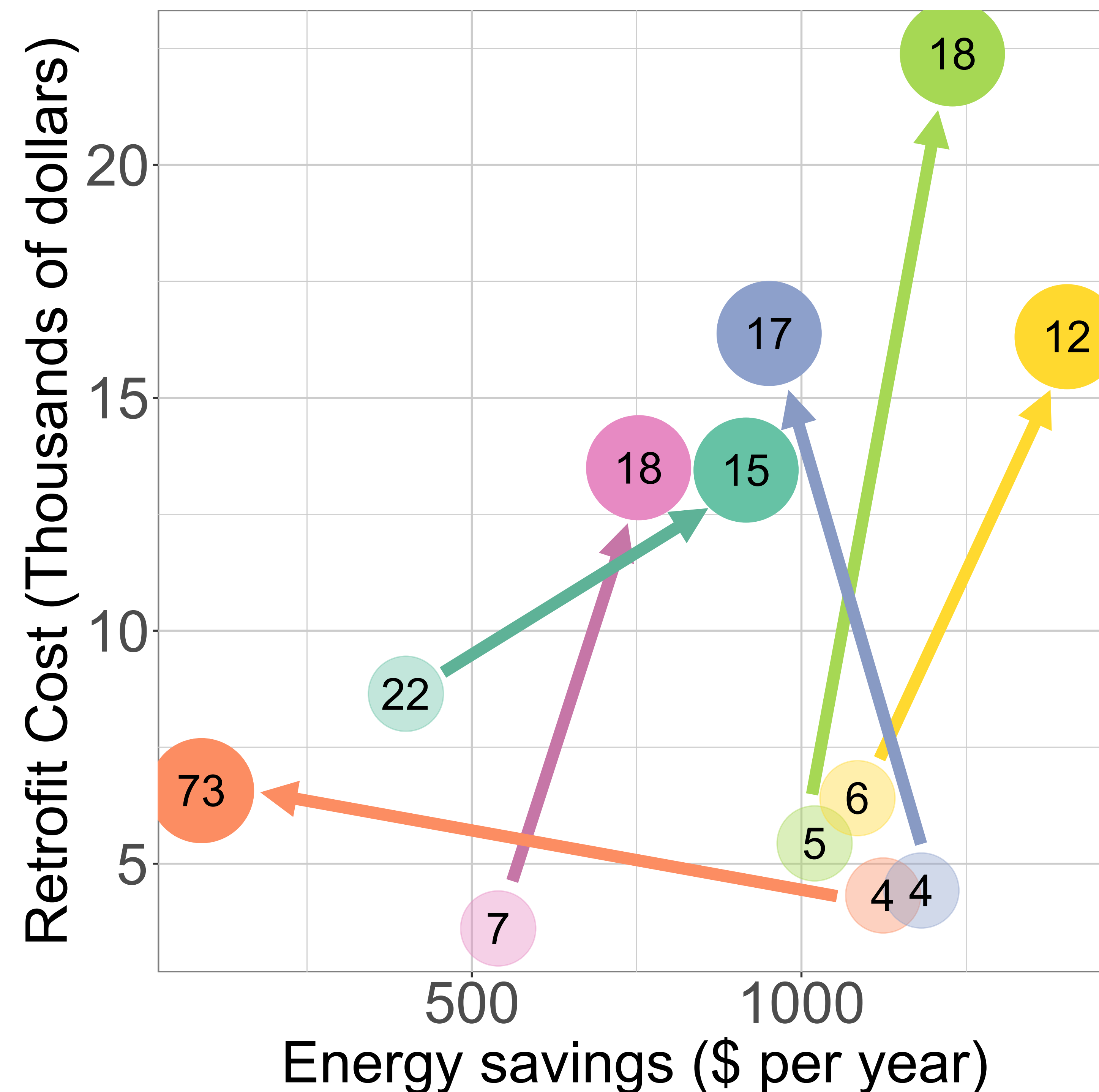
## RETROFITS HAVE LONG PROJECTED PAYBACKS PARTICULARLY FOR LOW-INCOME HOUSEHOLDS



## RETROFITS OFTEN COST MORE THAN PROJECTED

We gathered data on six homes that Habitat for Humanity retrofitted, including:

- Projected retrofit costs
- Projected energy use and cost before retrofit
- Projected energy use and cost after retrofit
- Actual energy-related retrofit costs
- Actual retrofit costs (and paybacks) greatly exceeded initial estimates

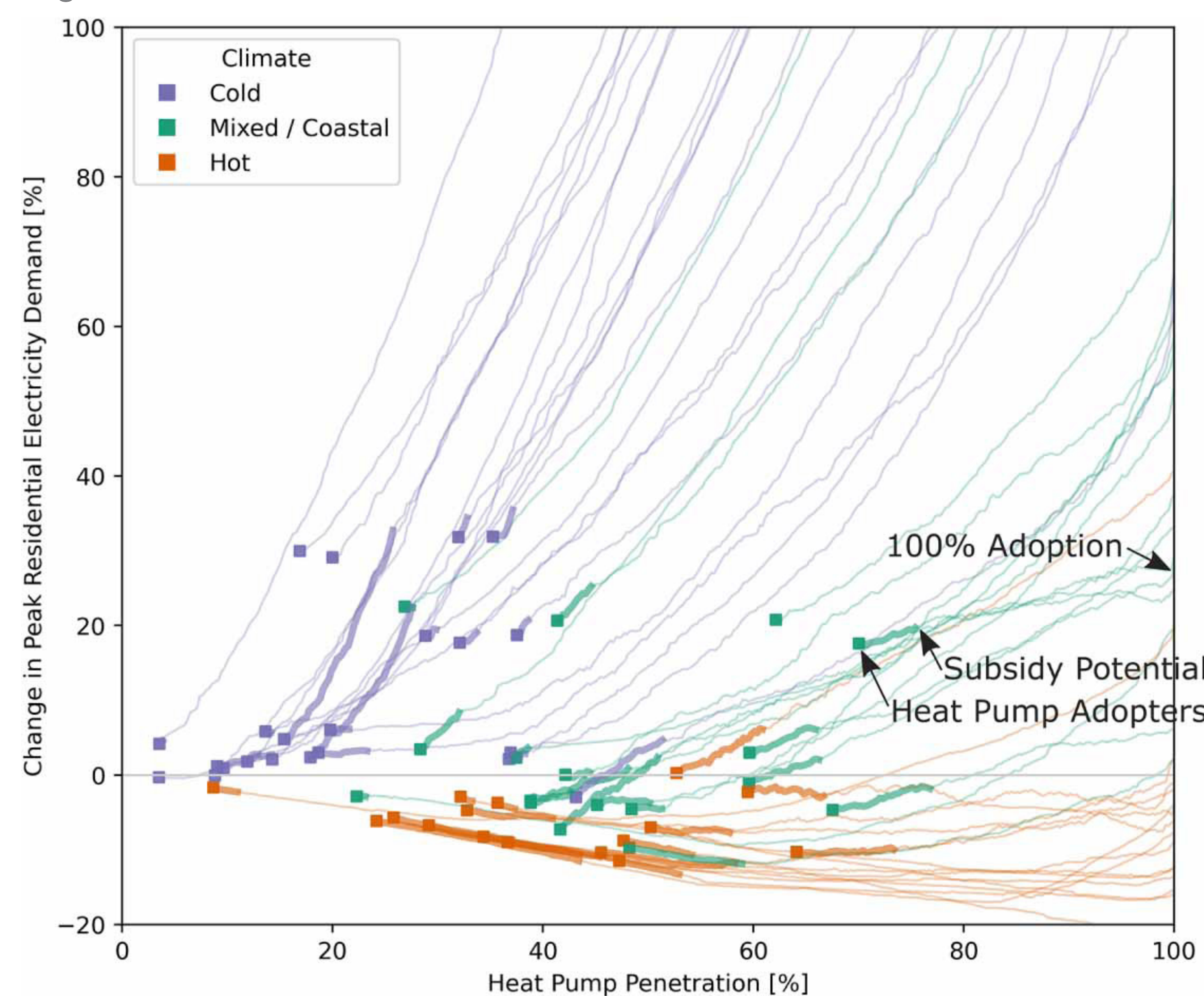


Retrofit costs and energy bill savings projections from pre- and post-retrofit assessments for six homes retrofitted by Habitat for Humanity. Light circles represent projected retrofit costs and pre-retrofit estimates of energy savings; dark circles represent actual retrofit costs and projected energy savings after the retrofit. The numbers in each circle are the simple payback times in years for each data point.

## LOW-INCOME HOUSEHOLDS NEED MORE AND MORE FLEXIBLE SUPPORT FOR EFFICIENCY RETROFITS

- Homes can clearly be retrofitted to sharply reduce energy intensity
- While we know that estimates often overstate energy savings, less work exists documenting cost overestimates and studying their causes
- Resulting mistrust is a barrier to adoption [6, 7]
- Underestimates of costs may result in underinvestment
- Non-energy benefits may be large, may accrue disproportionately to underserved communities

[3] Deetjen, T.A., Walsh, L., Vaishnav, P., 2021. US residential heat pumps: the private economic potential and its emissions, health, and grid impacts. *Environ. Res. Lett.* 16, 084024. <https://doi.org/10.1088/1748-9326/ac10dc>



[4] Fowle, M., Greenstone, M., Wolfram, C., 2018. Do energy efficiency investments deliver? Evidence from the weatherization assistance program. *The Quarterly Journal of Economics* 133, 1597–1644.

[5] Howden-Chapman, P., Matheson, A., Crane, J., Viggers, H., Cunningham, M., Blakely, T., Cunningham, C., Woodward, A., Saville-Smith, K., O’Dea, D., Kennedy, M., Baker, M., Waipara, N., Chapman, R., Davie, G., 2007. Effect of insulating existing houses on health inequality: cluster randomised study in the community. *BMJ* 334, 460. <https://doi.org/10.1136/bmj.39070.573032.80>

[6] Brown, D.; Kivimaa, P.; Rosenow, J.; Martiskainen, M. Overcoming the Systemic Challenges of Retrofitting Residential Buildings in the United Kingdom: A Herculean Task? In *Transitions in Energy Efficiency and Demand*; Routledge, 2018; pp 110–130.

[7] Stieß, I., & Dunkelberg, E. (2013). Objectives, barriers and occasions for energy efficient refurbishment by private homeowners. *Journal of Cleaner Production*, 48, 250-259.

## ACKNOWLEDGEMENTS

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