Washington Housing Electrification Analysis

Analysis on housing in Washington state and estimated reductions (cost and emissions) from various household electrification upgrades

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Notice

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Residential Housing Electrification in Beacon Hill

- The Solutions Collaborative is interested in understanding residential energy consumption and carbon emissions in their community and the potential benefits of household electrification in terms of bill and emissions reductions.
- This technical assistance aims to assist the coalition in planning electrification pathways by identifying which types of upgrades may be most beneficial and why.

Primary upgrades of interest for **energy bill** and **emissions** reductions:

1. Whole-home electrification (intensive)
2. Heat pumps, insulation, and heat pump water heaters (less intensive)
3. Appliances in large multifamily buildings: heat pump water heaters, electric cooking, and electric dryers.

Contents

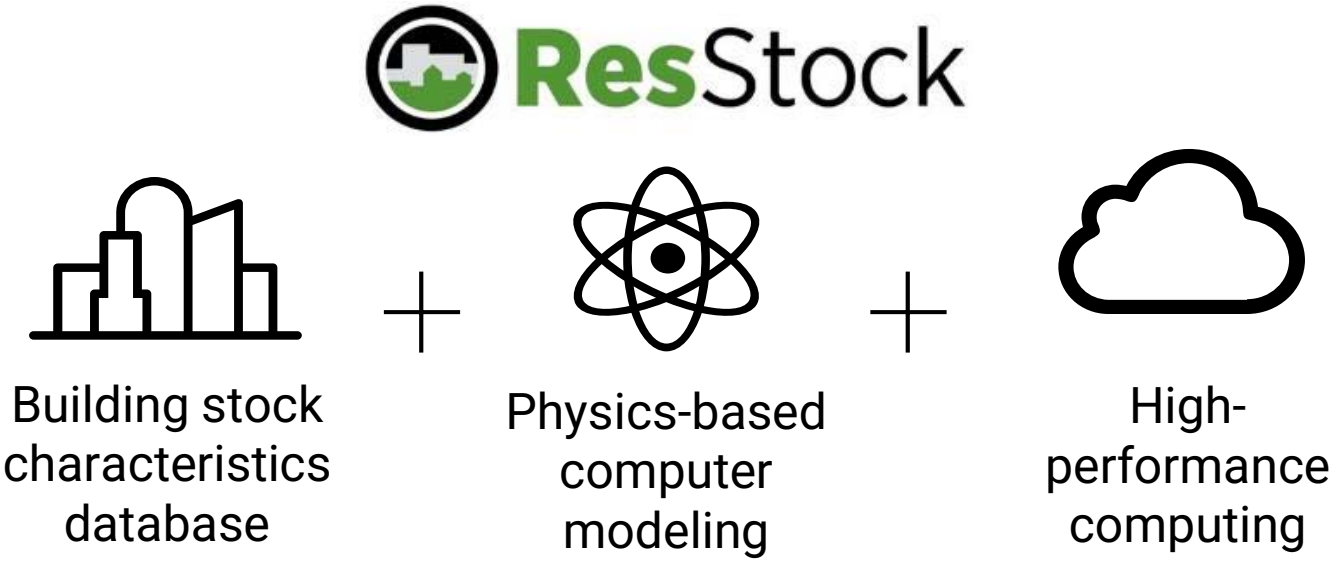
1. ResStock™ Background
2. Estimated energy and emissions reductions from various electrification and household upgrades
3. Incentive and financing opportunities for upgrades.

Background

What is ResStock

ResStock is a computer software that uses data to help federal, state, utility, city, and community-based planners understand how residential energy efficiency, electrification, and heating upgrades can help home-owners and neighborhoods reduce energy bills and carbon emissions.

What is ResStock?



- National datasets that empower analysts working for federal, state, utility, city, and manufacturer stakeholders to answer a broad range of questions
- Highly granular, data-driven, decision making for national, regional, and local building stocks
- The creation of hundreds of thousands of statistically representative dwelling unit models, and the results of modeling them using OpenStudio® and EnergyPlus™
- Appendix 2 includes more detailed background on how the ResStock model functions

How Other Communities Have Used ResStock

Examples of communities that have used ResStock in Communities LEAP:

- San Jose, California – help inform long-term residential electrification energy planning.
- Columbia, South Carolina – show local nonprofit and city housing organizations how they could be building differently to maximize energy bill reductions.
- Hill District, Pennsylvania – identify high bill reduction opportunities and then put together educational materials for local landlords and residents on these topics.

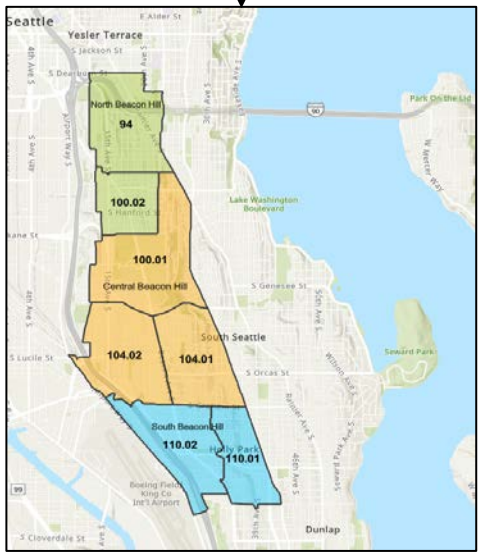
Background Information

- This analysis focuses on opportunities to reduce energy burden, energy consumption, and energy bills for both single-family homes and large multifamily buildings. It uses state-level data from ResStock that is coarser than the data provided through the Low-income Energy Affordability Data (LEAD) tool. It uses state-level data, whereas the LEAD analysis uses census tract data.
- We filtered the state-level data so that ResStock is most relevant to Beacon Hill. Thus, this content only includes single-family detached homes and large multifamily buildings in the income group 0-80% AMI, and climate zone 4c (mixed temperatures, relatively cooler summers) within Washington state. These two housing types (single-family detached homes and large multifamily buildings) were identified through the LEAD analysis, as these building types make up the majority of housing in Beacon Hill.

ResStock

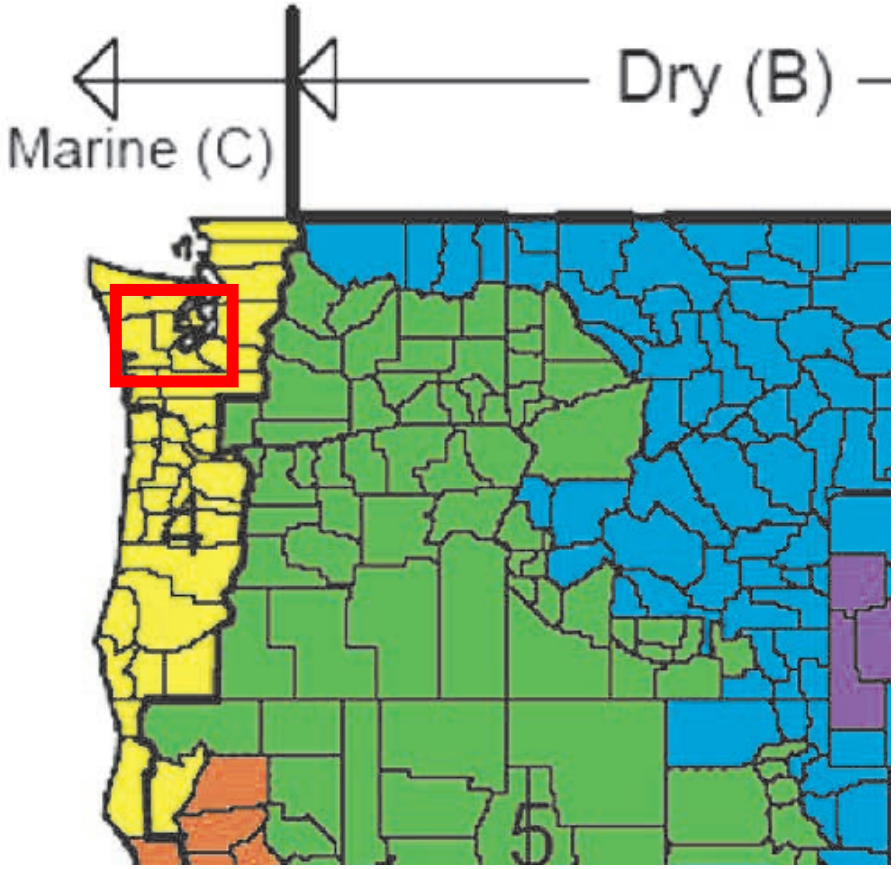
State-Level Data

LEAD
LOW-INCOME ENERGY AFFORDABILITY DATA
TOOL
U.S. DEPARTMENT OF ENERGY



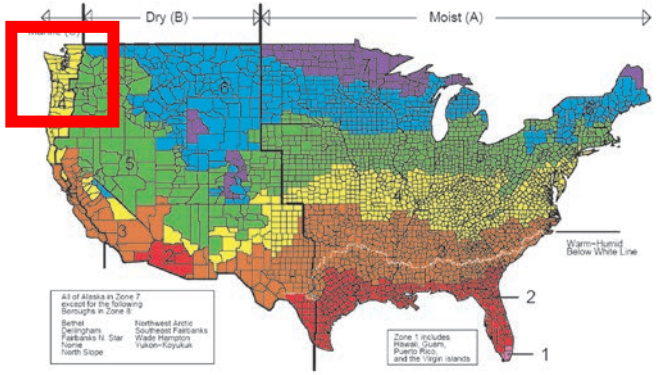
Census-Level Data

ResStock Data Filtering



Zooming into Washington, we can see that Beacon Hill is classified as climate zone 4c, characterized by mixed temperatures and cool summers. Therefore, we filtered the state-level data that ResStock uses to only focus on housing in this climate zone (4c, yellow).

In total, the filtered ResStock data only includes single-family detached homes and large multifamily buildings in the 0-80% AMI income group, and climate zone 4c in Washington state. We will refer to this as **WA State Filtered Data**.



Comparing ResStock and LEAD: Energy Burden

	ResStock (WA State Filtered Data):	LEAD Tool (Census-Level, Beacon Hill):
	Average Energy Burden at 0-80% AMI:	
Single Family	8.7%	6.6%
Large (5+) Multifamily	5.9%	2.1%
	These slides	LEAD Tool Analysis (Separate analysis conducted by Mayukh Datta in summer 2023)

- LEAD allows us to zoom in to different AMI groups: 0-30%, 30-60%, and 60-80% (ResStock 0-80% AMI only).
- The LEAD dataset and the WA State Filtered Data are different (ResStock does not specifically target Beacon Hill).
- On average, the homes included in the WA State Filtered Data are more energy-burdened than Beacon Hill.

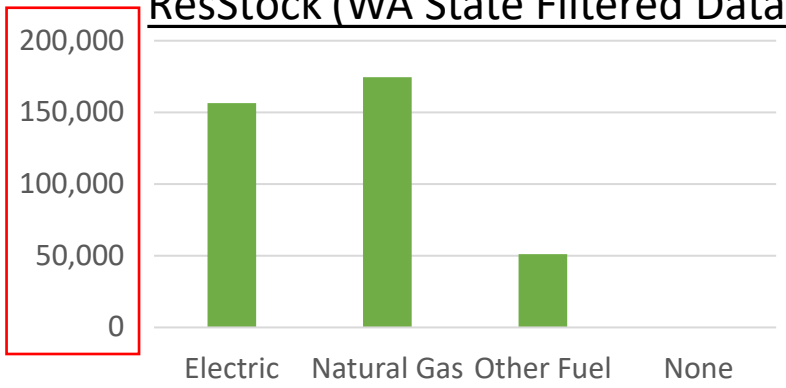
Energy burden is described as the share of income residents spend on energy.

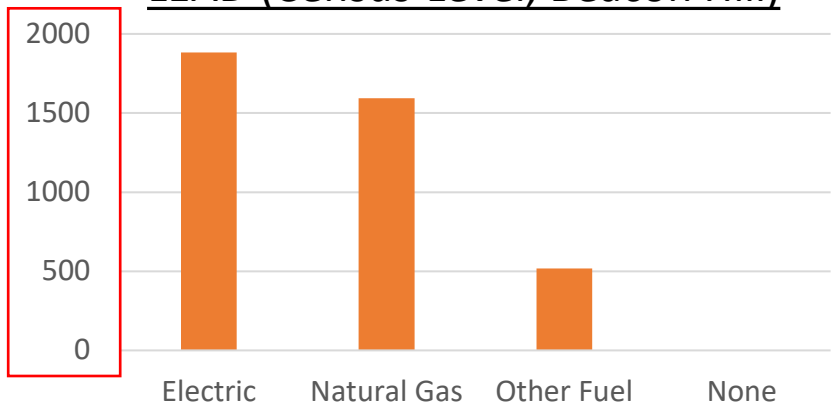
Comparing ResStock and LEAD: Space Heating Fuel Type

ResStock (WA State Filtered Data):

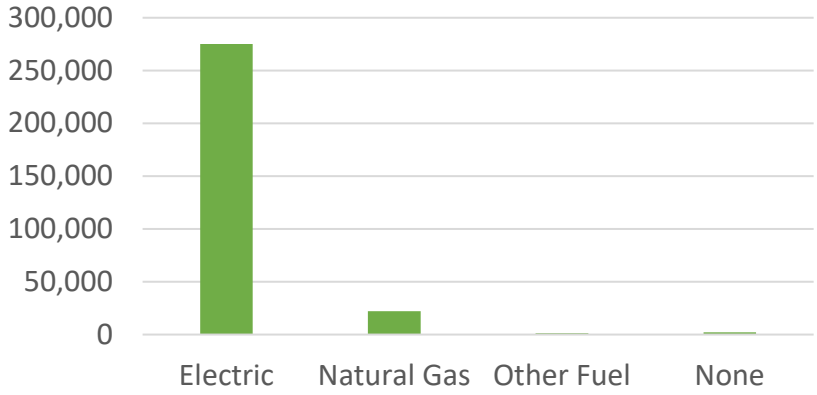
LEAD (Census-Level, Beacon Hill)

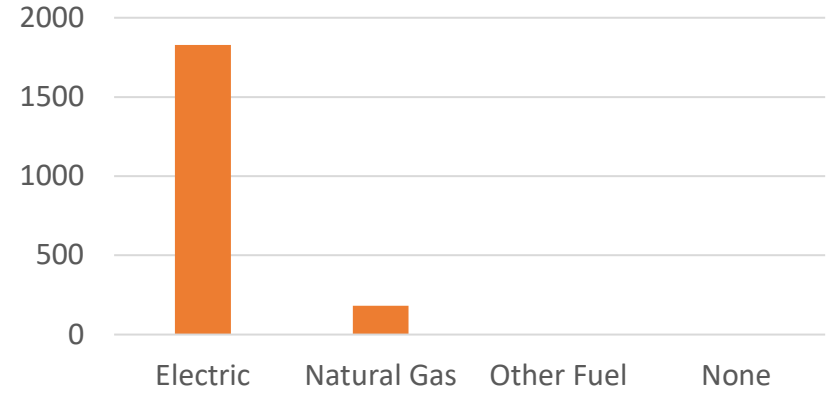
Single-Family Housing Count





Large Multifamily Housing Count





Takeaway:

Homes in each dataset have similar types of heating, with there being slightly more electric heating in Beacon Hill than the WA State Filtered Data, based on the model results.

Modeling Assumptions and Limitations

- Analysis is based on ResStock-modeled energy consumption; all models have uncertainties.
- Modeling is aggregated across collections of housing units; results for individual housing unit can vary substantially.
- For the most part, national average costs, scaled based on a local cost/inflation adjustment factor, were used; costs do not include rebates; costs for any individual project can vary substantially.
- Average state utility rates were used.
- Specific measures and measure packages were modeled (not all potential technologies/performance levels and packages).
- Heat pumps were modeled with existing heating system as backup and also separately modeled with electric backup; sized for cooling loads, which can produce more conservative estimates.

Modeling Assumptions and Limitations (cont.)

- Households without existing cooling systems were assumed to use cooling after a heat pump upgrade, which adds a new service and improved thermal comfort, but can also substantially affect the cost-effectiveness of the packages.
- Results were filtered from the state of Washington by climate zone 4c, income group 0-80% AMI, and only focused on single-family detached homes and multifamily buildings with 5 or more units.
- Building upgrades that are needed before electrification (remediation or a new electric panel) were not considered.
- Vacant housing was included in the analysis.
- Energy bill information and income are from 2019.
- Weather year used for the simulations is Actual Meteorological Year (AMY) 2018.

Estimated Energy Reductions through Efficiency Upgrades

Upgrades Evaluated, 11 out of 16 Shown

1. Basic enclosure: exterior insulation and duct sealing
2. Enhanced enclosure: extra envelope insulation and better duct sealing
3. Minimum efficiency heat pump with existing heat back up: lower* efficiency heat pump paired with heating system currently in the house
4. Minimum efficiency whole home electrification: all lower efficiency electric appliances
5. High efficiency whole home electrification: all higher efficiency electric appliances
6. Electric dryer: electric appliance
7. Heat pump dryer: electric appliance
8. Electric cooking: electric appliance
9. Induction cooking: electric appliance
10. Heat pump water heater: electric appliance
11. Basic enclosure with high efficiency whole home electrification: envelope insulation and duct sealing paired with all higher efficiency electric appliances.

*The term “lower” efficiency is used here and throughout to describe the assumed/modeled efficiency levels for these measures relative to the “higher efficiency” measures.

Upgrades for Single-Family Detached Homes in the WA State Filtered Data

All samples were filtered to:

0-80% AMI

Washington climate zone 4c.

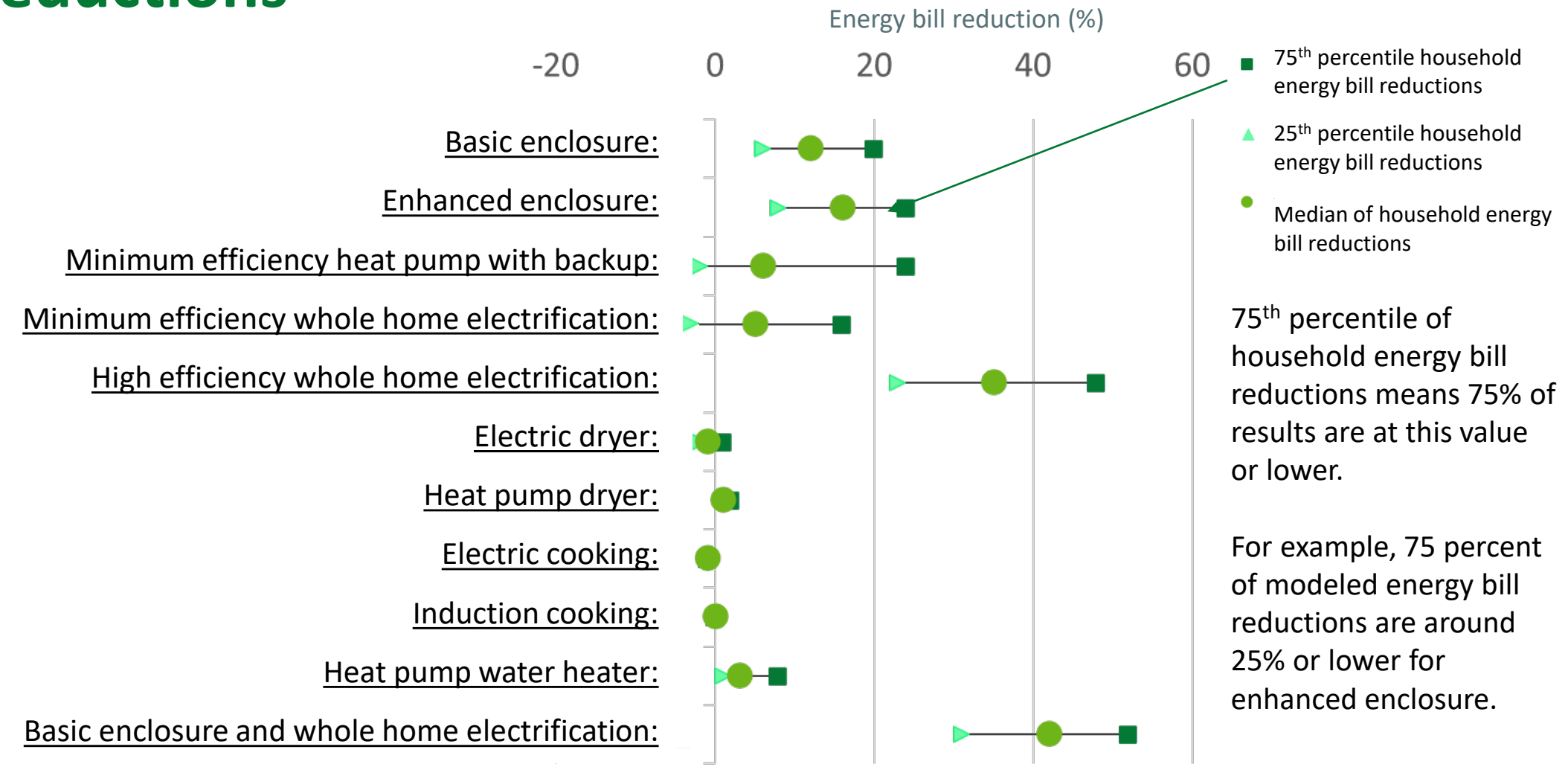
Main Takeaways: Single-Family Detached Homes

Based on modeled results in the WA State Dataset:

1. **Insulation** and **whole home electrification** result in the most possible energy and carbon reductions.
2. **Heat pumps** and **insulation** can be cost-effective ways to achieve reductions.
3. **Heat pump water heaters** can help with **emissions reductions.**
4. Keep in mind: electrification, especially when not paired with energy efficiency upgrades, can cause energy bills to rise in some cases.

The analysis complementary to these conclusions is provided in the following three slides.

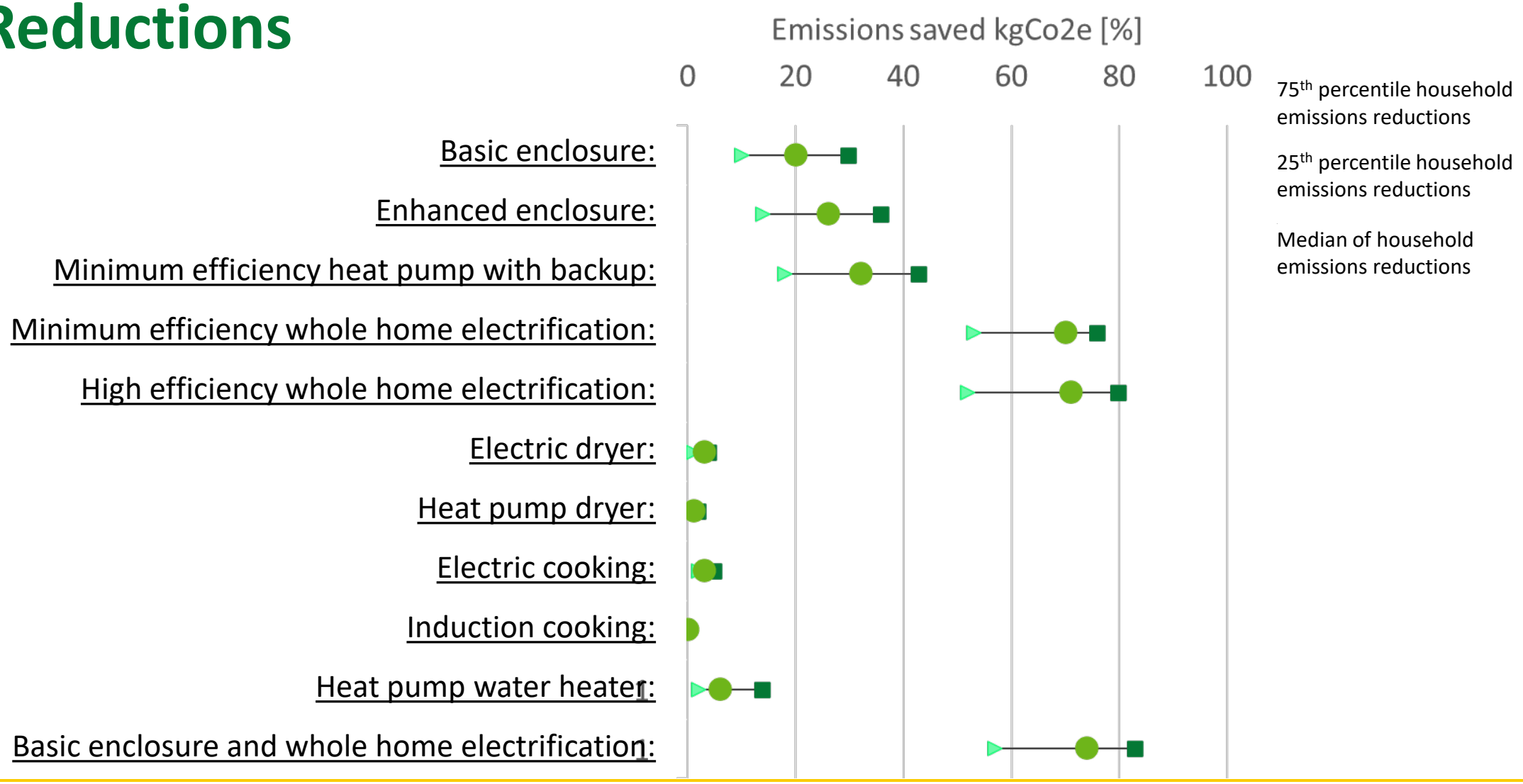
Single-Family Detached Homes: Annual Energy Bill Reductions



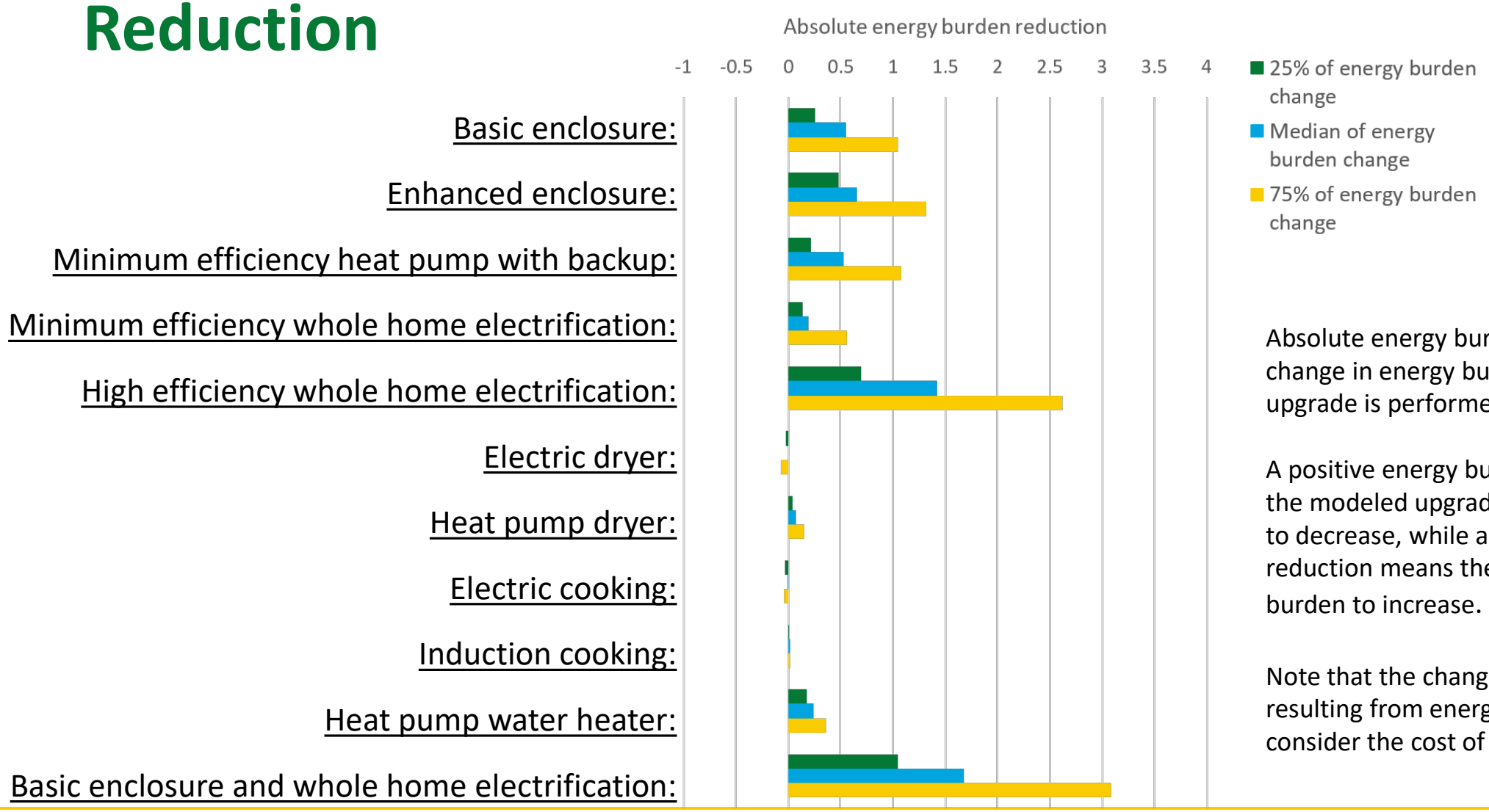
75th percentile of household energy bill reductions means 75% of results are at this value or lower.

For example, 75 percent of modeled energy bill reductions are around 25% or lower for enhanced enclosure.

Single-Family Detached Homes: Annual Energy Emission Reductions



Single-Family Detached Home: Absolute Energy Burden Reduction



Absolute energy burden reduction is the change in energy burden before and after an upgrade is performed.

A positive energy burden reduction means the modeled upgrade caused energy burden to decrease, while a negative energy burden reduction means the upgrade caused energy burden to increase.

Note that the change in energy burden resulting from energy bill reductions does not consider the cost of the upgrade strategy.

Upgrades for Large Multifamily Buildings in the WA State Filtered Data

All samples were filtered to:

0-80% AMI

Washington climate zone 4c.

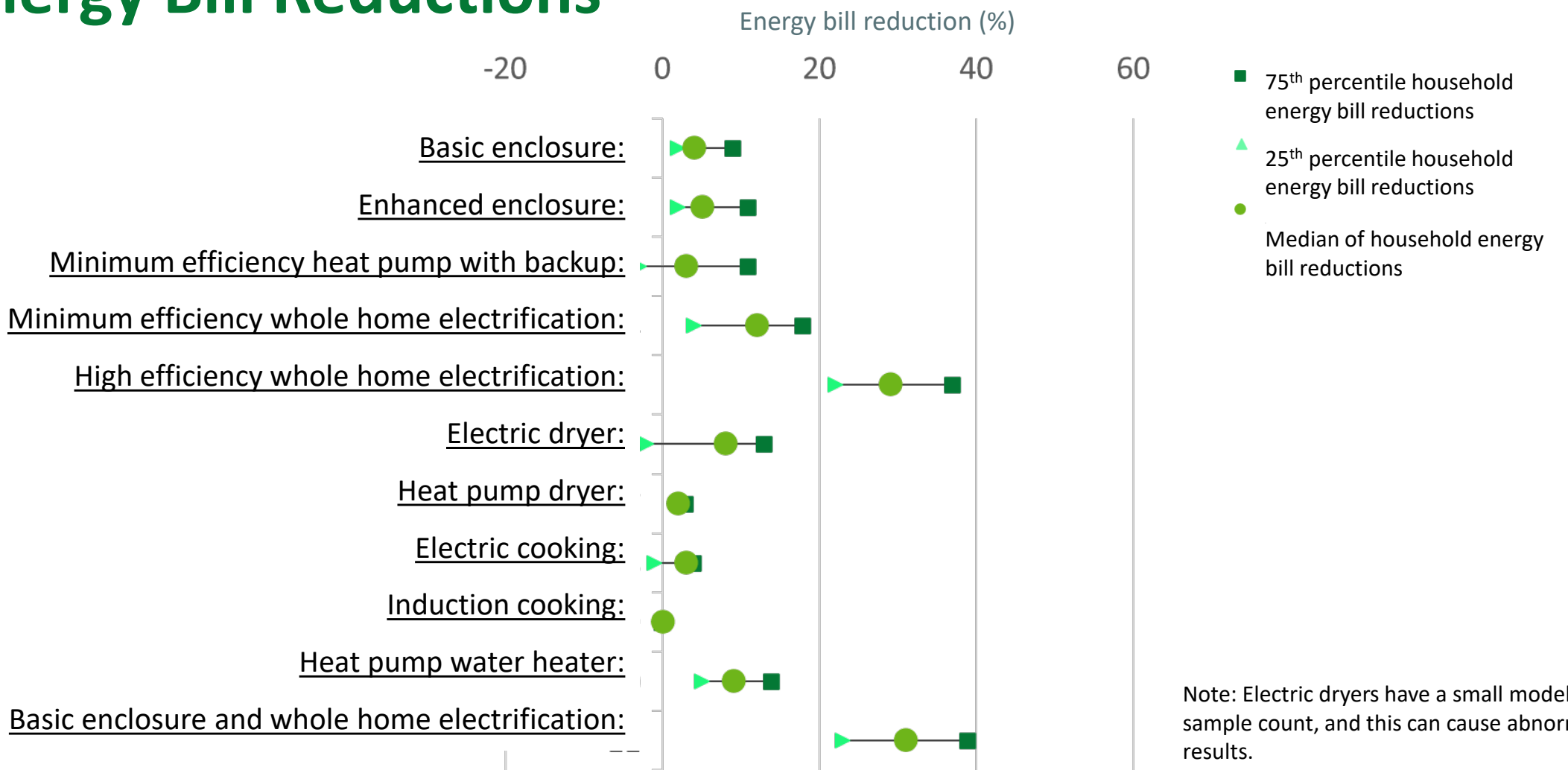
Main Takeaways: Large Multifamily

Based on modeled results in the WA State Dataset for Large Multifamily buildings:

1. **Heat pump water heaters** reduce energy costs on average when just looking at single appliance upgrades.
2. **Heat pump water heaters** and **electric cooking are two appliances that reduce emissions greatly**, though all options reduce emissions.

The analysis complementary to these conclusions is provided in the following three slides.

Large Multifamily: Energy Bill Reductions

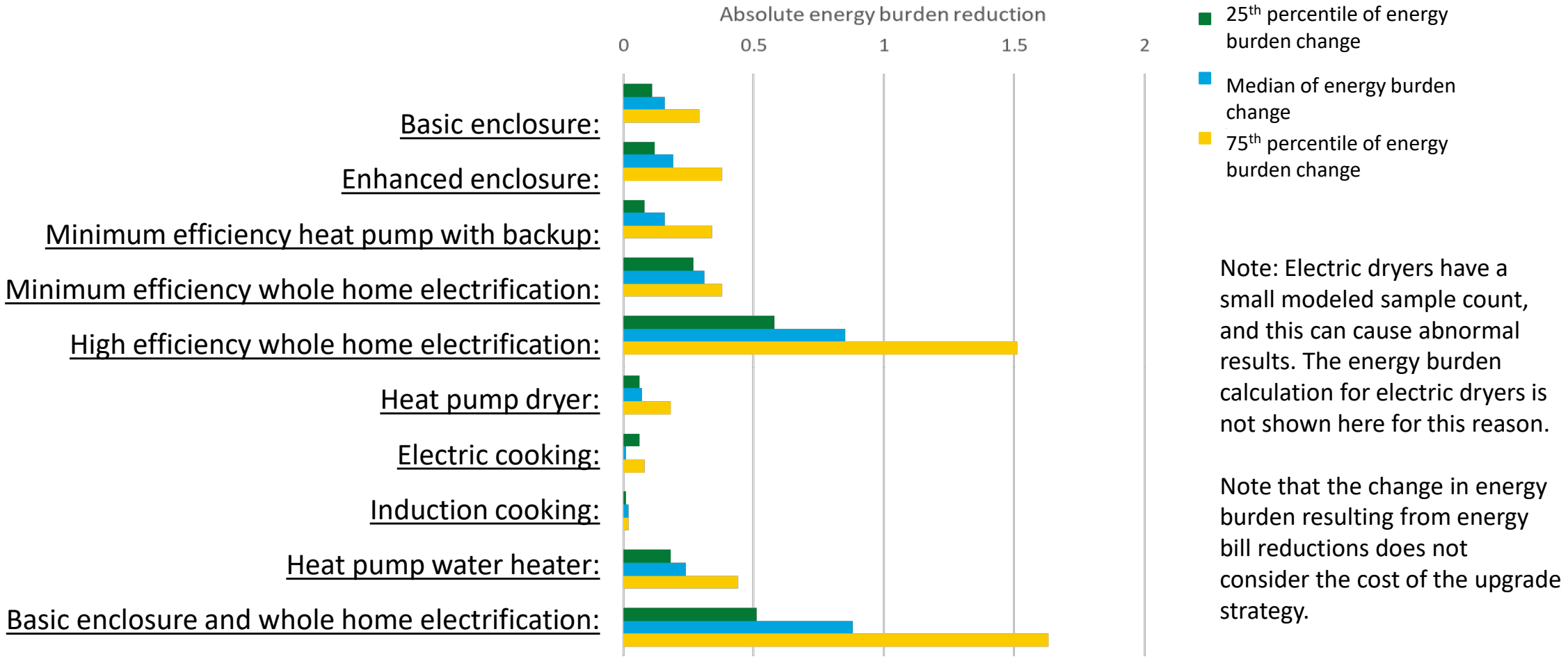


Note: Electric dryers have a small modeled sample count, and this can cause abnormal results.

Large Multifamily Emissions Reductions

Note: Electric dryers have a small modeled sample count, and this can cause abnormal results.

Large Multifamily Building: Absolute Energy Burden Reduction



Note: Electric dryers have a small modeled sample count, and this can cause abnormal results. The energy burden calculation for electric dryers is not shown here for this reason.

Note that the change in energy burden resulting from energy bill reductions does not consider the cost of the upgrade strategy.

Main Conclusions

1. This analysis uses filtered state-level data for modeled upgrades and is therefore a generalization.
2. Upgrades of interest:
    - Whole home electrification (intensive)
    - Heat pumps, insulation, and heat pump water heaters (less intensive)
    - Appliances in large multifamily buildings: heat pump water heaters, electric cooking, and electric dryers.
3. In practice, cost and emissions reductions will vary compared to the estimates provided in this analysis. In some cases, energy bills may increase from upgrades.

Incentive Programs to Research

The following resources show funding opportunities that can include electrification:

- DSIRE: NC Clean Energy Technology Center
- Communities LEAP Funding Database.

Examples:

- The Energy Efficiency and Solar Grants program in WA provides funding for building insulation and other energy efficiency measures.
- The Puget Sound Energy – Multifamily Efficiency Retrofit Program is a rebate program that includes heat pumps and insulation and duct/air sealing.
- The Puget Sound Energy – Residential Energy Efficiency Rebate Programs provides rebates for heat pumps, insulation, water heating, and duct/air sealing.

Thank You

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Appendix 1: Information On Housing in the WA State Filtered Data

Focusing only on single-family detached homes and large multifamily buildings in climate zone 4c with 0-80% AMI ("WA State Filtered Data")

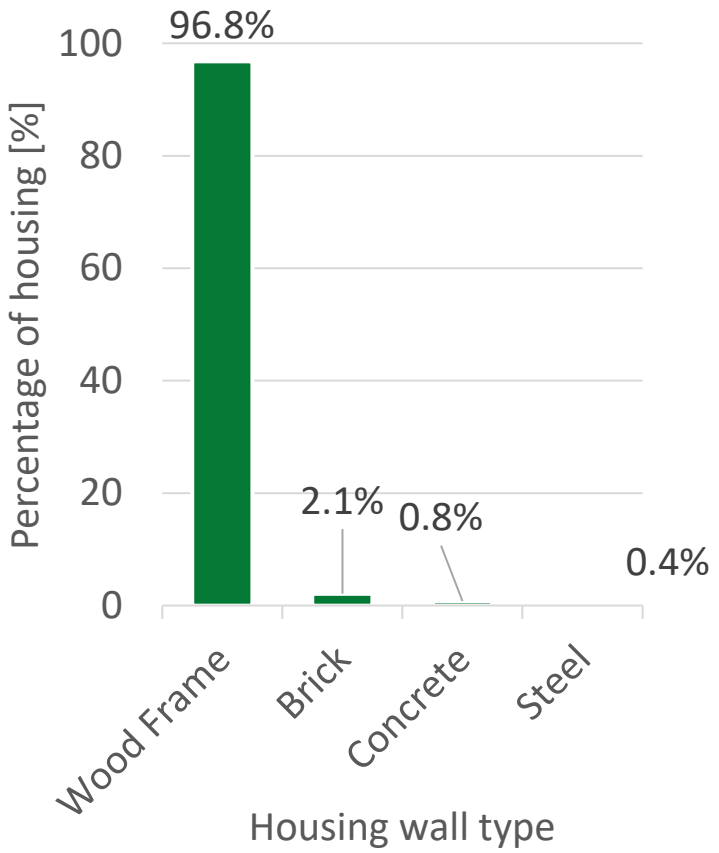
Contents

The following slides show the following information on the ResStock WA State Filtered Data:

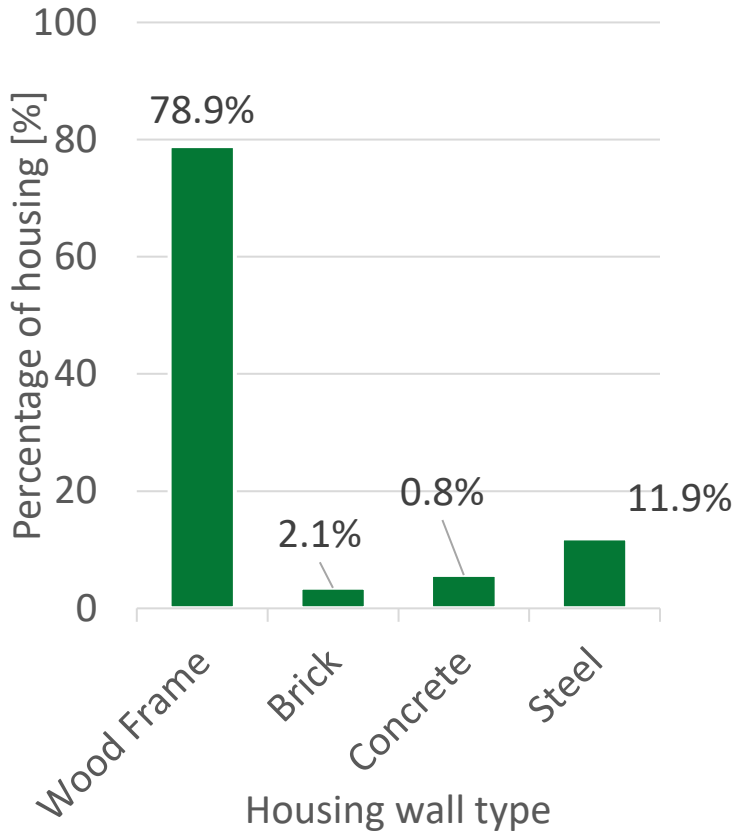
- Annual energy consumption
- Wall type
- Heating system type
- Cooling system type
- Number of windowpanes
- Water heater fuel type
- Infiltration amount
- Wall insulation level

Wall Type

Single-family detached



Multifamily with 5+ units

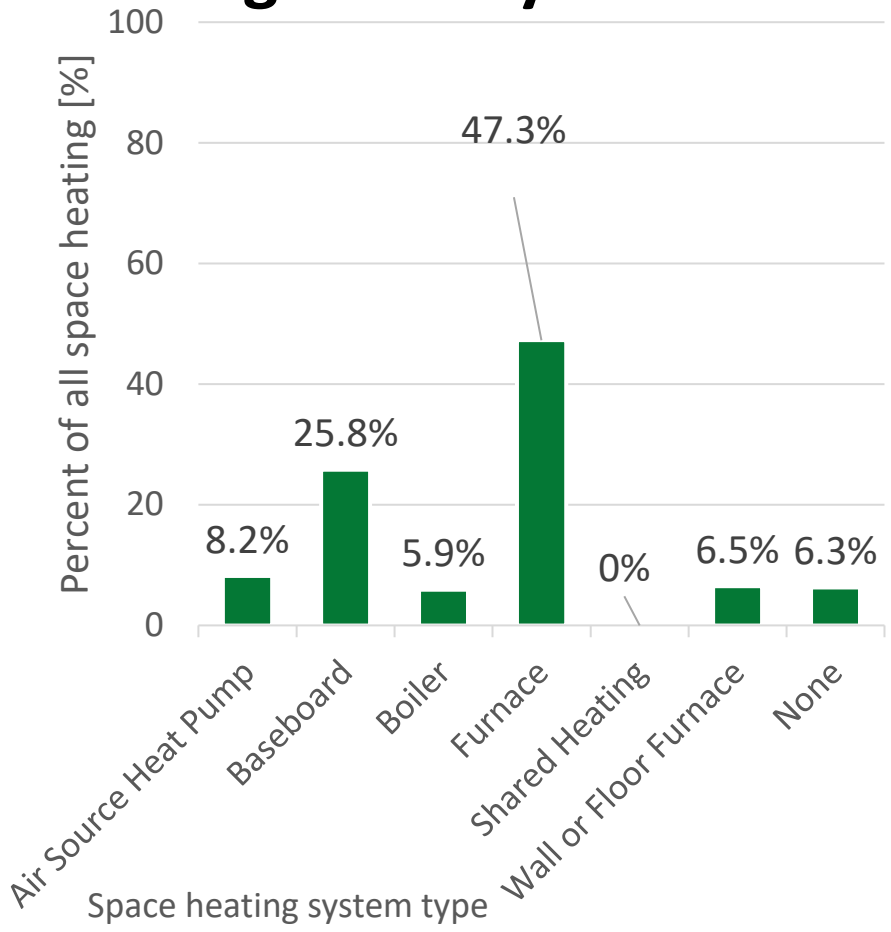


Takeaway: Almost all single-family homes in the **WA State Filtered Data** have a wood frame. Most large apartment units have wood frames, with others often using steel.

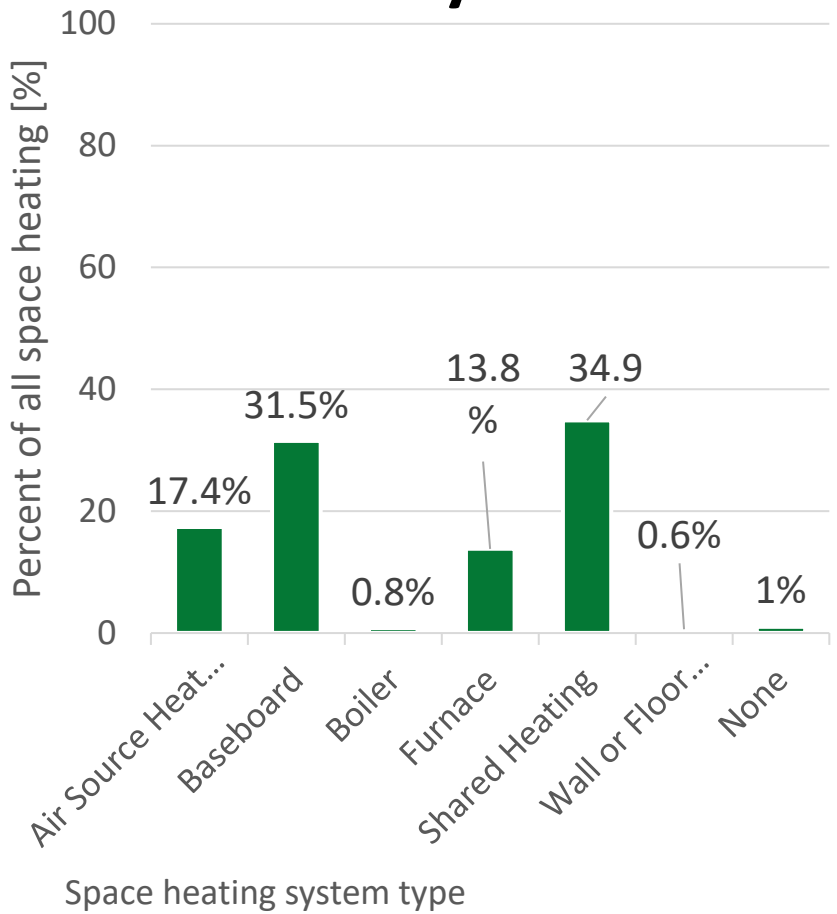
Why does this matter? Wall type can dictate how to add more insulation to a building.

Heating System Type

Single-family detached



Multifamily with 5+ units

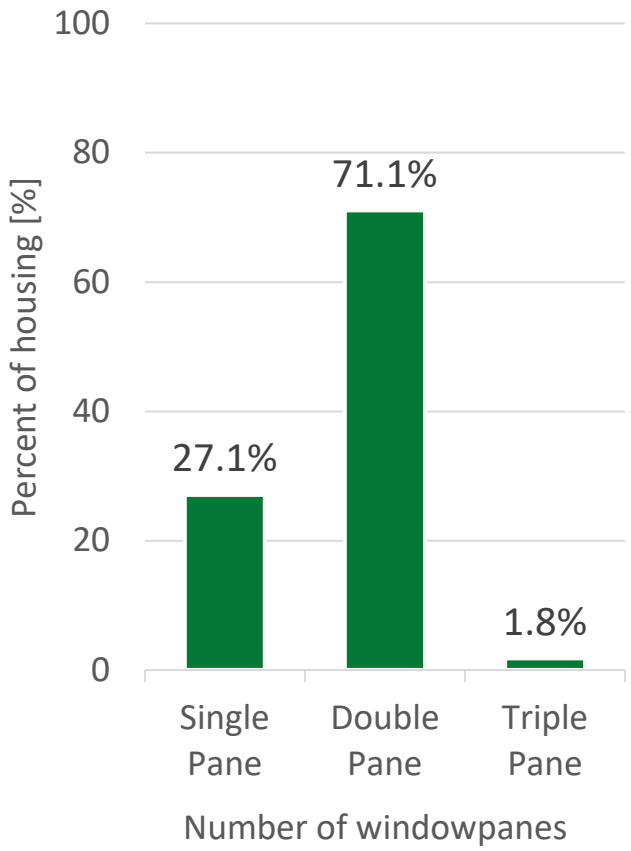


Takeaway: Homes in the **WA State Filtered Data** use a variety of heating system types.

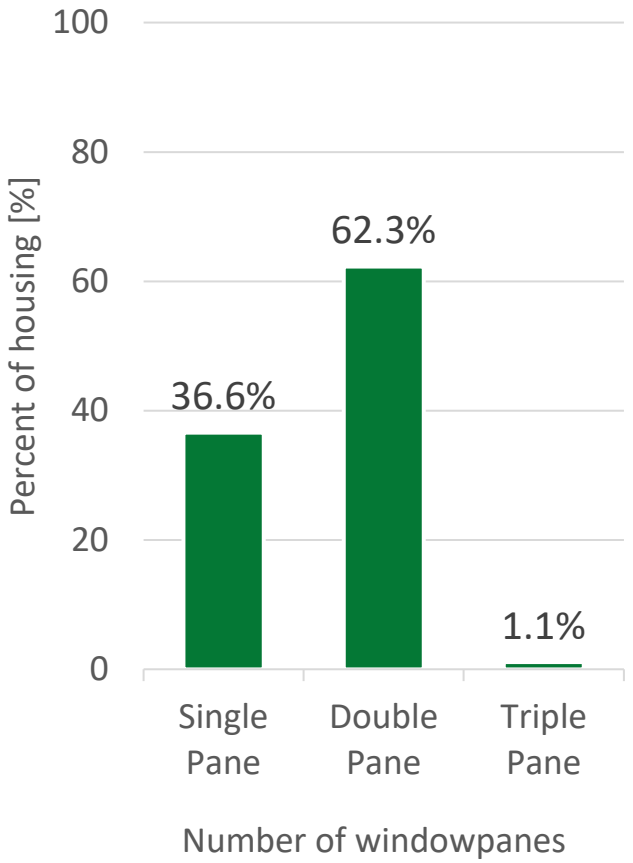
Why does this matter? This variety means there will have to be many approaches and plans in place to help upgrade heating systems. Approaches, reductions, and more will depend on what heating system is already in place.

Number of Windowpanes

Single-family detached



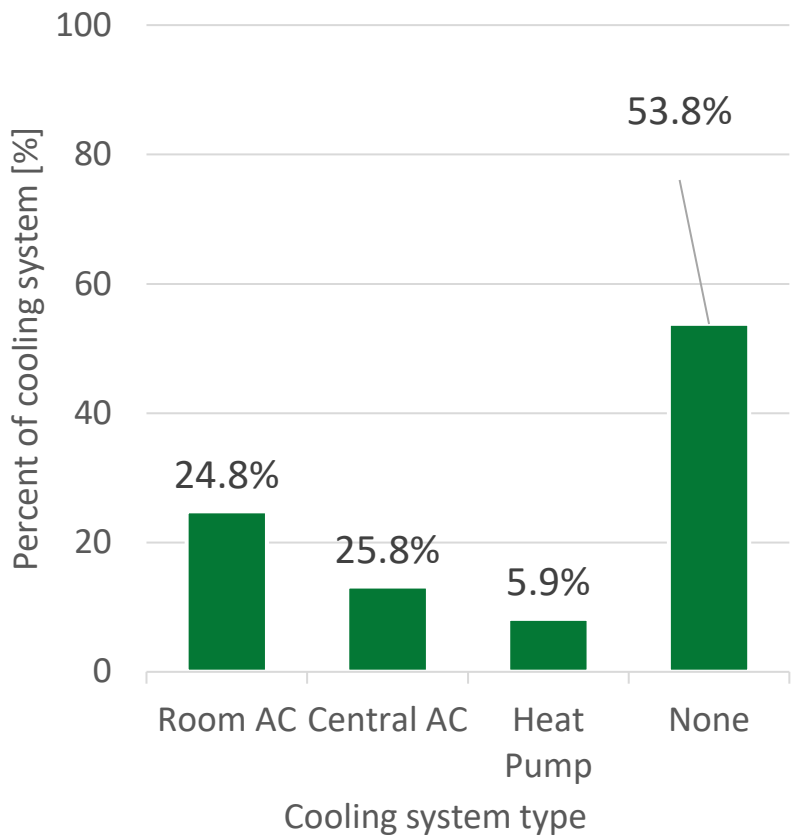
Multifamily with 5+ units



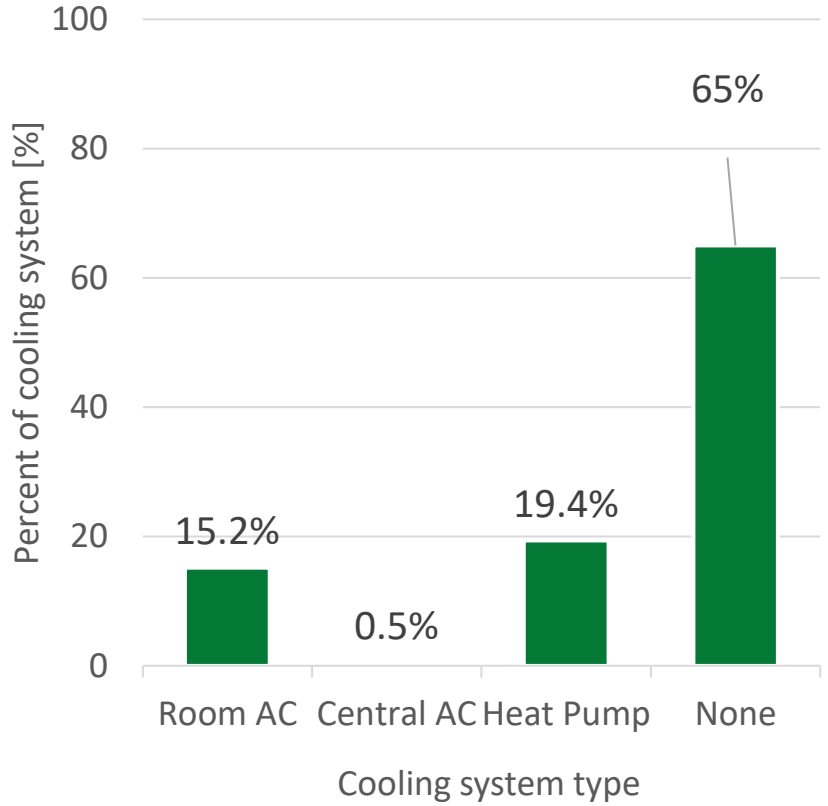
Takeaway:
Most homes and apartments in the **WA State Filtered Data** already have double-pane windows, which is good for insulation and heating/cooling efficiency. However, many single-family (27.1%) and multifamily (36.6%) homes use single-pane windows representing, opportunities for upgrade.

Cooling System Type

Single-family detached



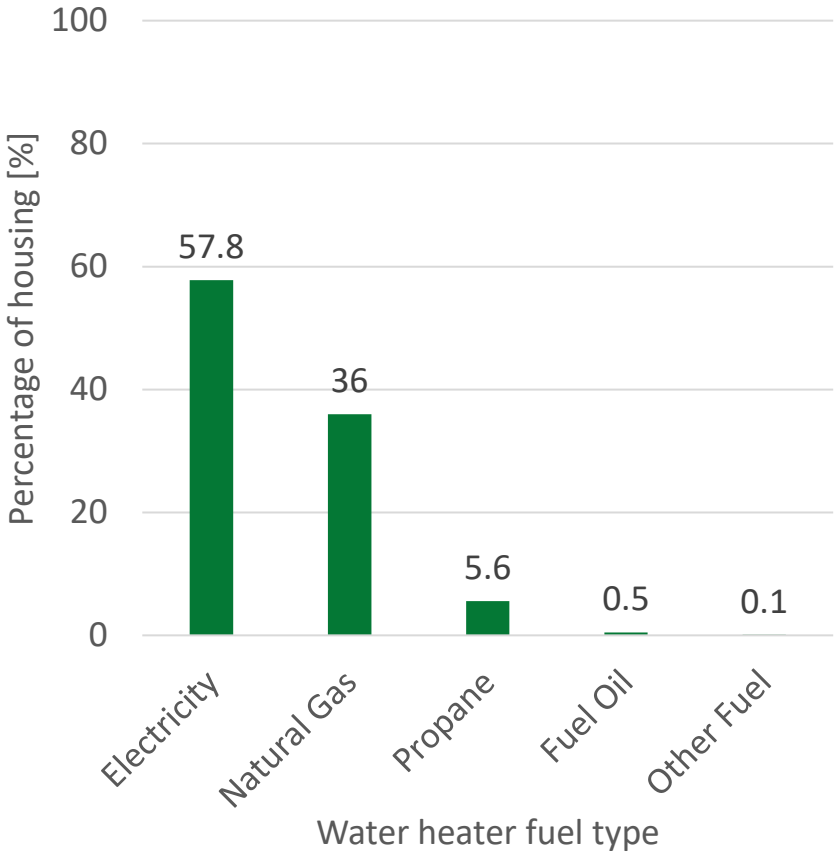
Multifamily with 5+ units



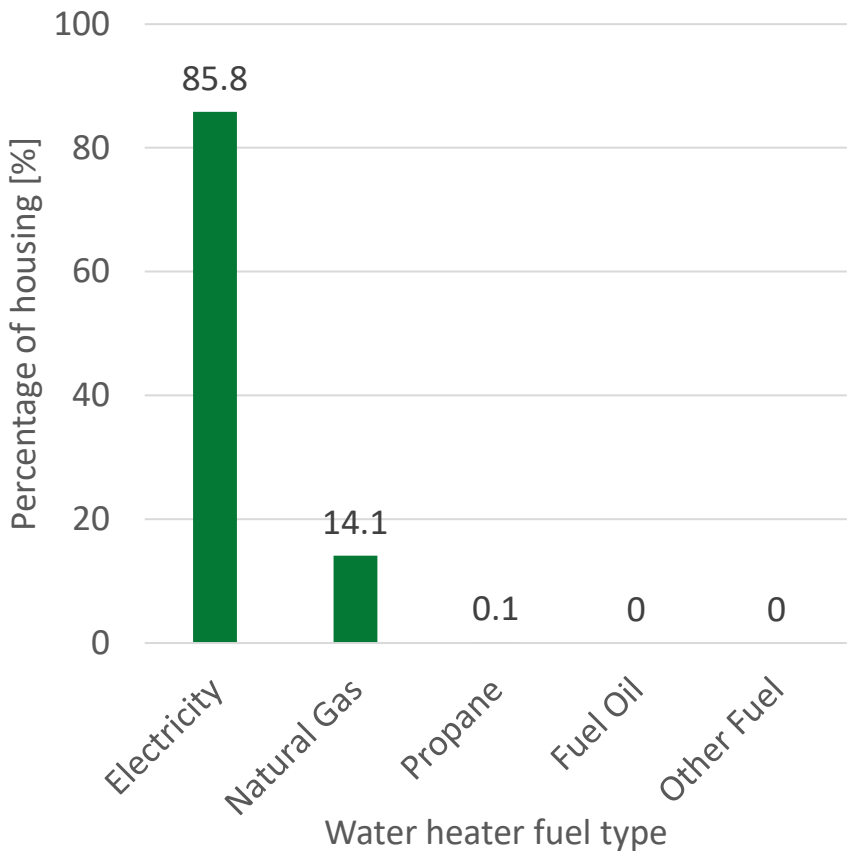
Takeaway:
Over 50% of homes and apartments in the **WA State Filtered Data** do not have air conditioning. The most popular cooling system type is room air conditioning. Lack of air conditioning is more common in multifamily units (65%) than single family homes (53.8%).

Water Heater Fuel Type

Single-family detached



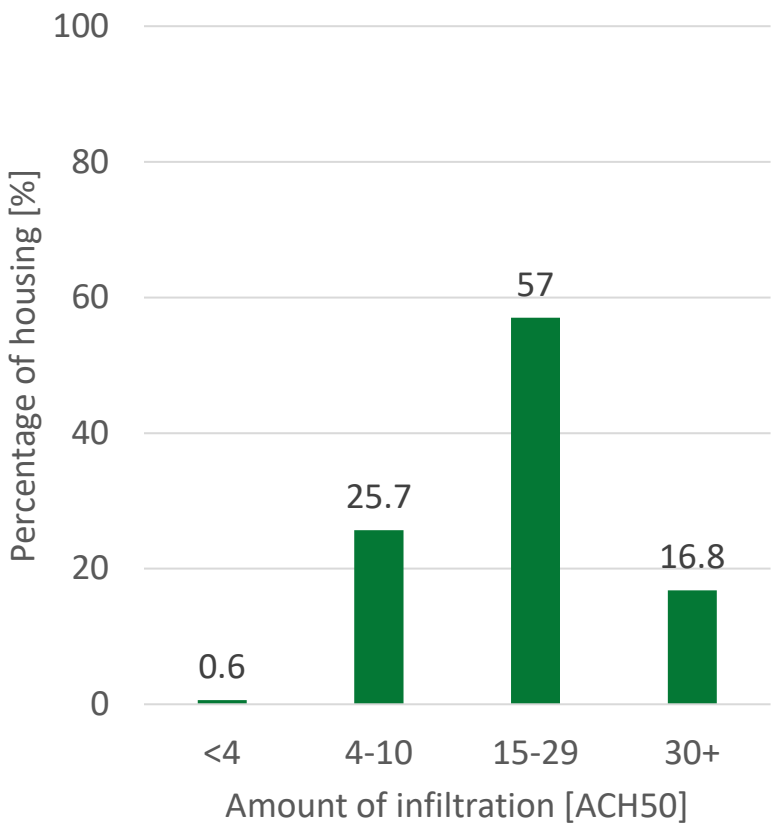
Multifamily with 5+ units



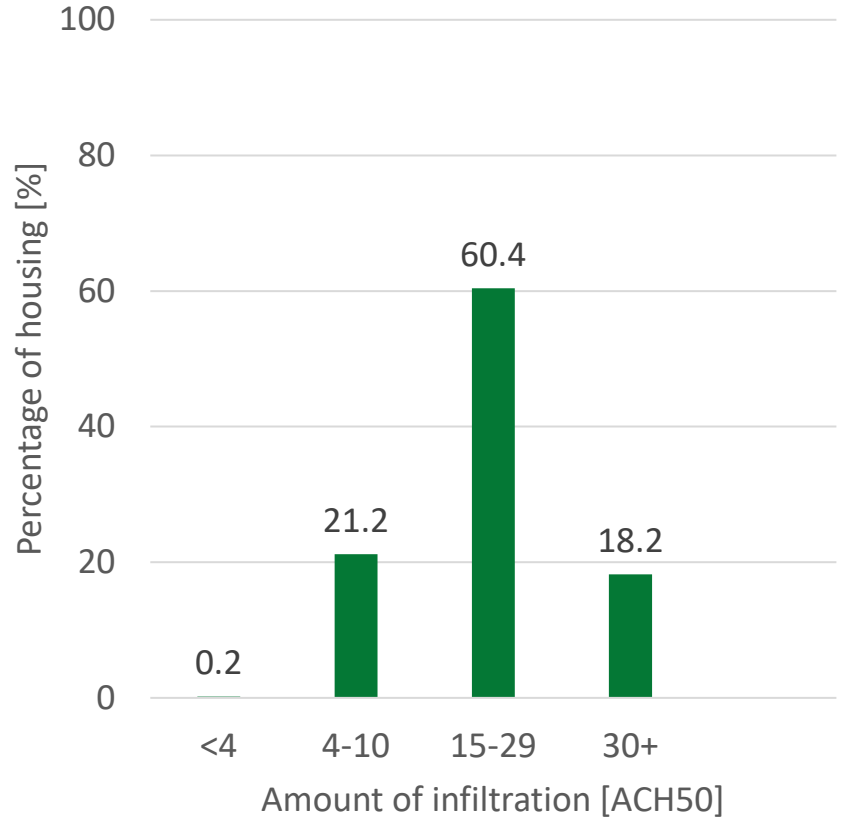
Takeaway:
In the **WA State Filtered Data,** most hot water heaters in single-family (57.4%) and multifamily (85.8%) homes use electricity. Natural gas heaters are the second most common form of hot water heating and are prevalent in single-family homes (36%). These could be replaced to reduce emissions.

Infiltration Amount

Single-family detached



Multifamily with 5+ units

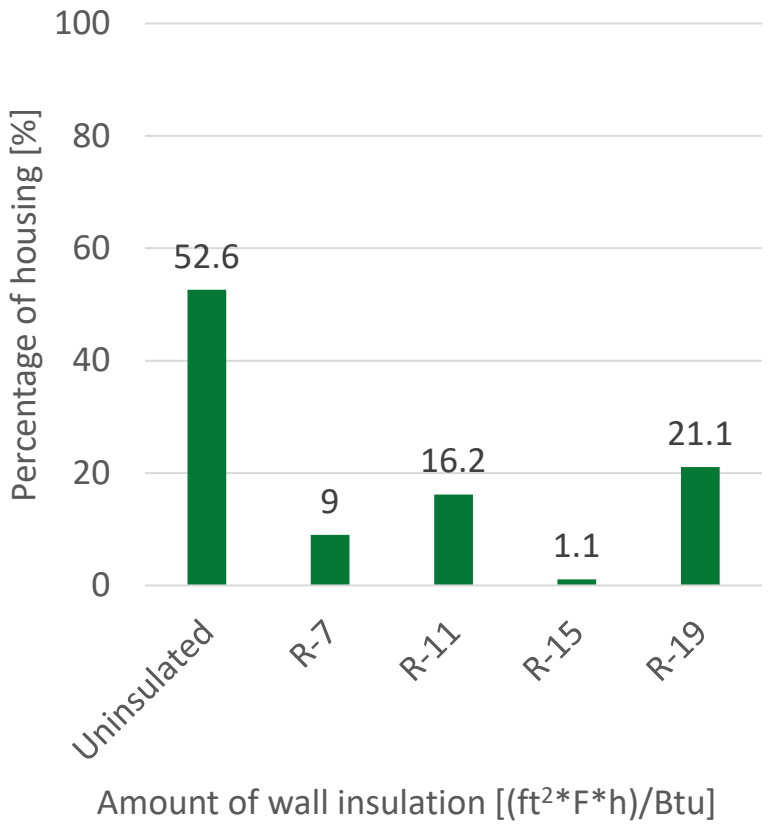


Takeaway:
Most homes and apartments in the **WA State Filtered Data** have very high levels of "infiltration," or the amount of air that leaks into the building envelope from the outside.

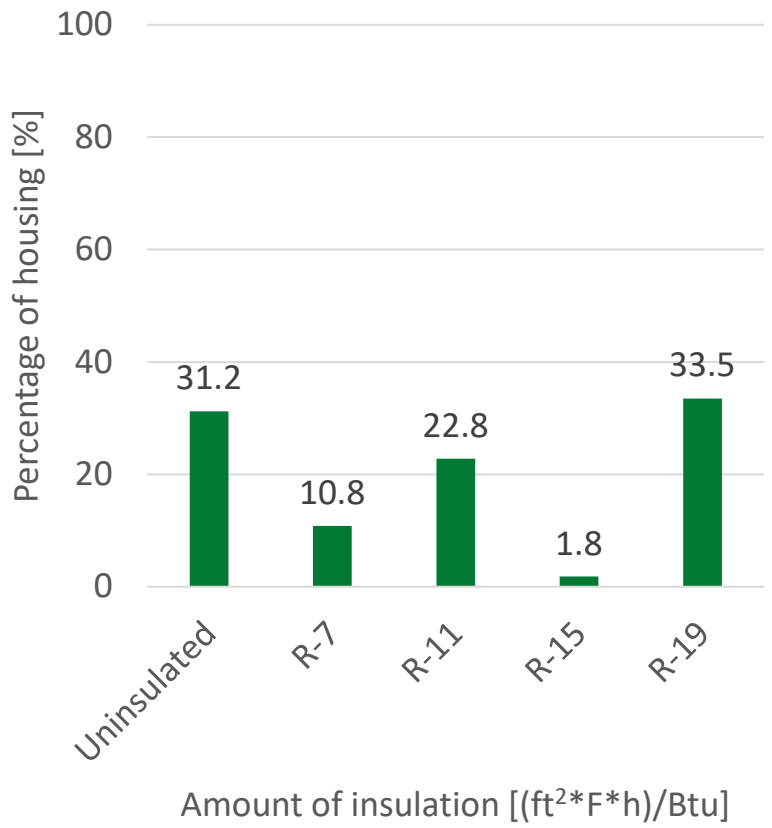
ACH stands for 'Air Changes Per Hour' and is an infiltration metric. Almost all modeled homes in this dataset have a large amount of infiltration (ACH50), meaning they are letting a lot of outside air in, and heating or cooling out. This has health, energy bill reduction, and comfort implications for many residents. These high infiltration amounts represent a big energy reductions opportunity for the community.

Wall Insulation Level

Single family detached



Multifamily with 5+ units



Takeaway:
Many homes and apartments in the **WA State Filtered Data** do not have any insulation.

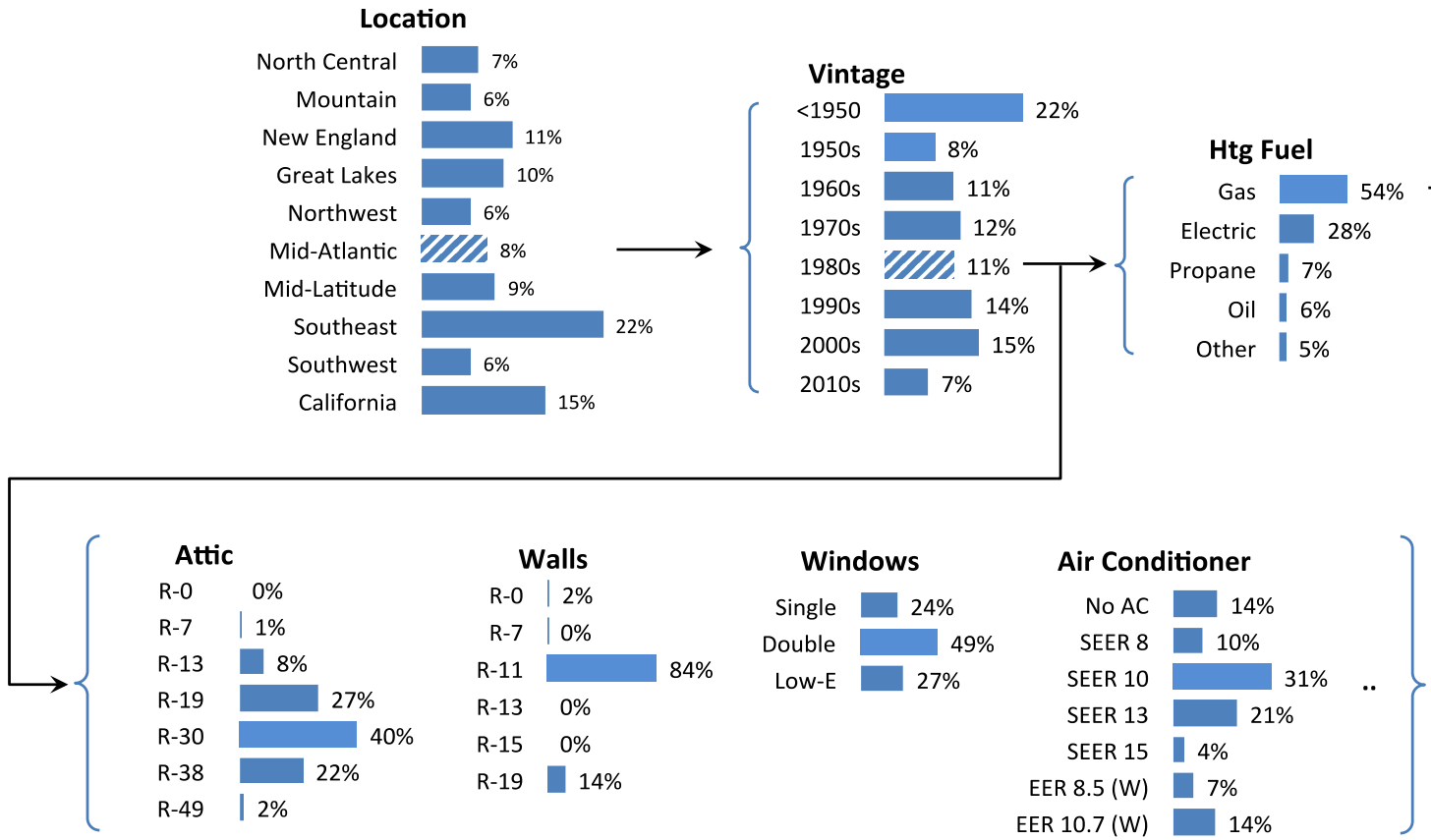
Without insulation, home or apartment heating and cooling systems have to run much more frequently to keep occupants comfortable, particularly during extreme weather. Adding insulation to these homes represents a huge opportunity to improve efficiency and reduce energy costs for residents.

Appendix 2: Detailed Background on ResStock and Model Assumptions

Detailed Background on ResStock

ResStock works at the dwelling unit level, not building level. Meaning that each apartment in an apartment building is modeled separately. Rural areas and manufactured housing data have less representative data than other building types or urban areas.

Fun fact: The average American home has 2.52 people, 0.74 garage stalls, and 0.07 hot tubs. This exact home does not exist, which is why we do a statistical distribution for our models.



- 100+ home characteristics
  - Examples of home characteristics shown on the left
  - Distributions based on best available data
- Key data sources for home information:
  - EIA Residential Energy Consumption Survey (RECS)
  - U.S. Census American Housing Survey (AHS)
  - U.S. Census American Community Survey (ACS).

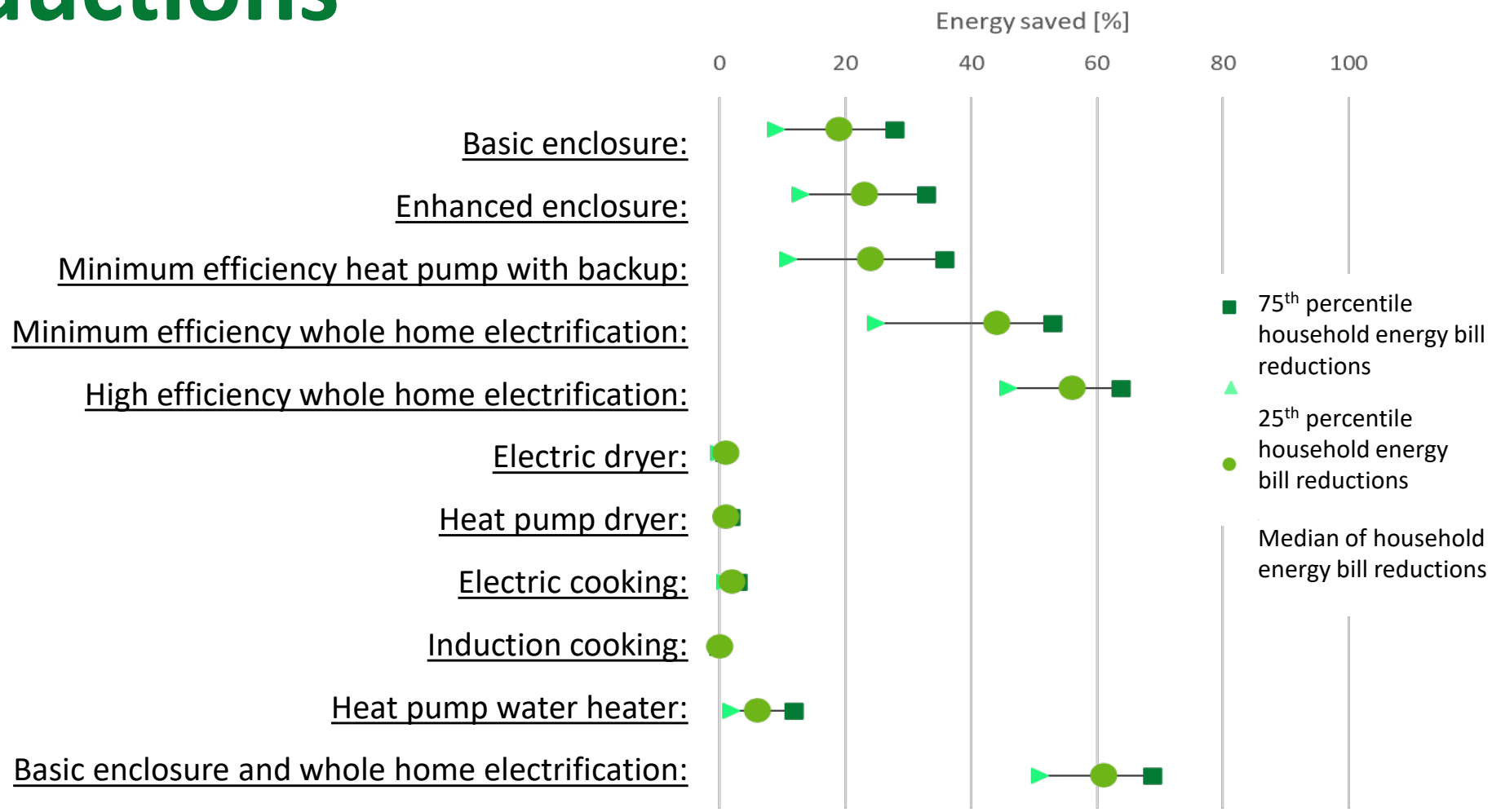
R-#: R-value
SEER: seasonal energy efficiency ratio
EER: energy efficiency ratio
AFUE: annual fuel utilization efficiency
Htg Fuel: heating fuel

Appendix 3

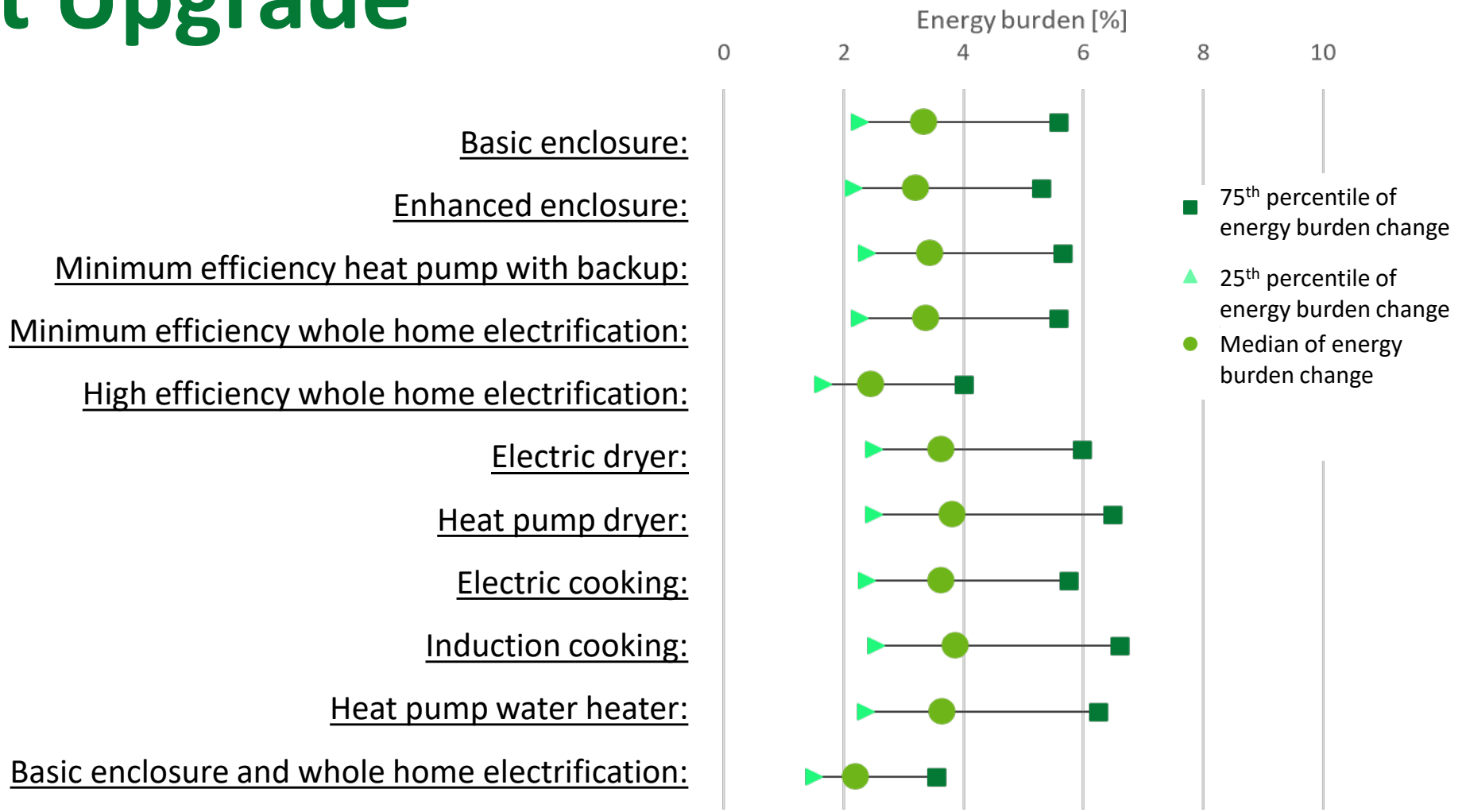
The body of these slides show upgrade results for energy bill reductions [% change in dollars spent], emissions reductions [% change in kg of carbon dioxide emitted] and energy burden [absolute change in %]. Here, percent change in energy consumption [% change in MMBtu] is presented.

Note that the change in energy burden resulting from energy bill reductions does not consider the cost of the upgrade strategy.

Single-Family Detached Homes: Energy Bill Reductions

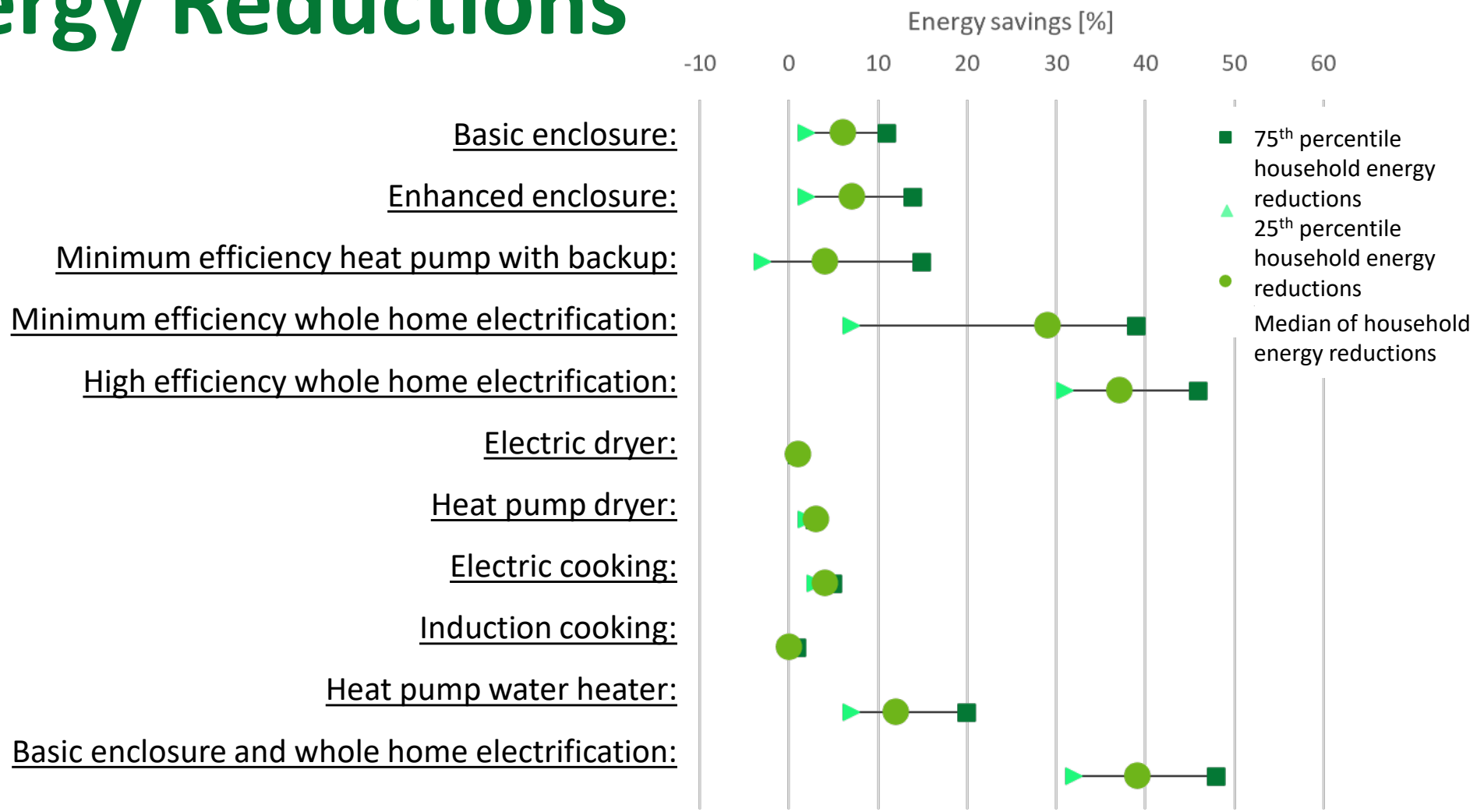


Single-Family Detached: Energy Burden Post Upgrade

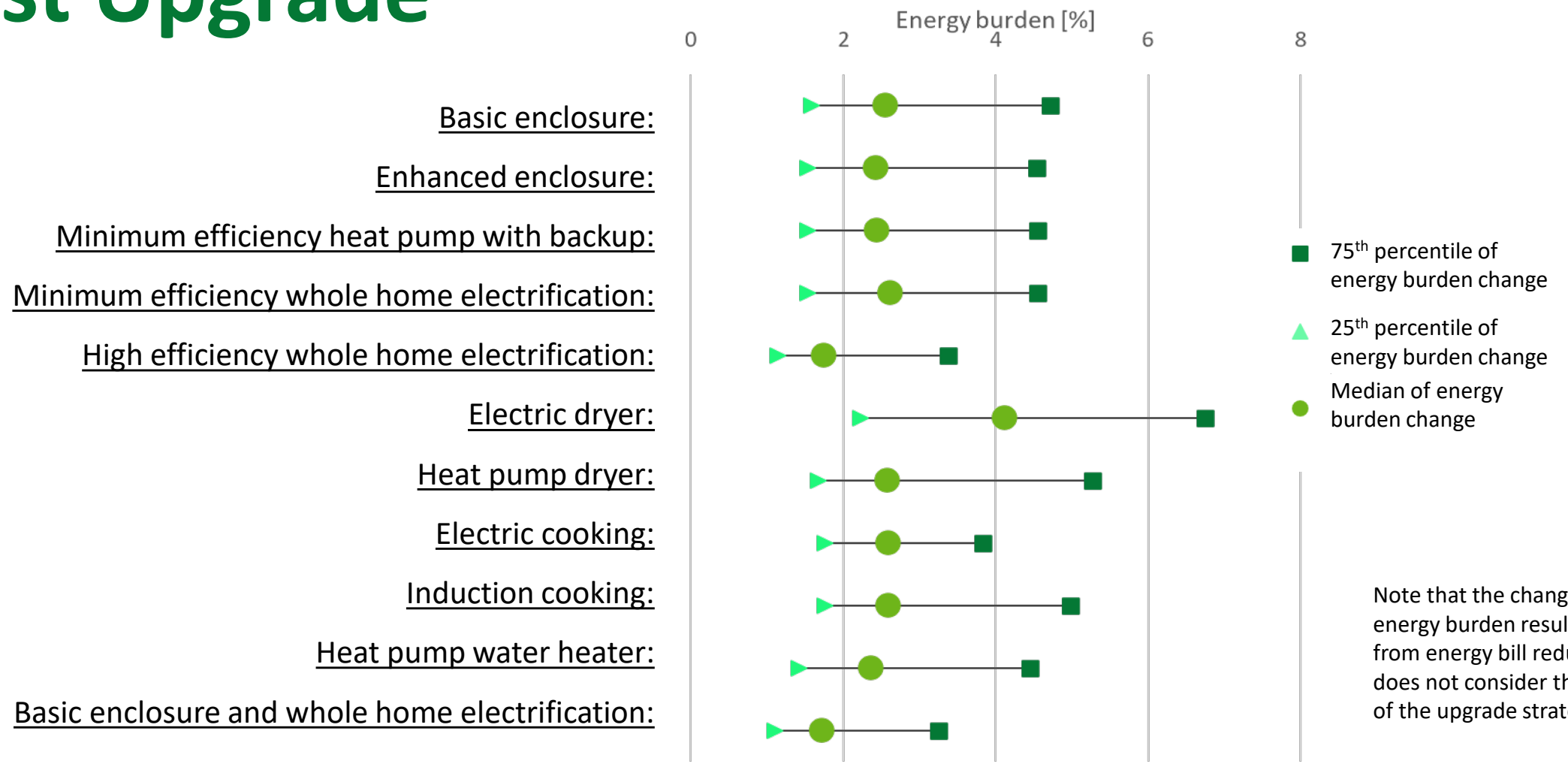


Note that the change in energy burden resulting from energy bill reductions does not consider the cost of the upgrade strategy.

Multifamily with 5+ Units: Energy Reductions



Multifamily with 5+ Units: Energy Burden Post Upgrade



Note: Electric dryers have a small modeled sample count and this can cause abnormal results.