North Birmingham Housing Energy Baseline and Upgrade Strategies

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National Renewable Energy Laboratory

June 2024

DOE/GO-102024-6256

Notice

This work was authored by the National Renewable Energy Laboratory (NREL), operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by the DOE's Communities LEAP (Local Energy Action Program) Pilot.

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Contents

Acronyms

- AC: air conditioning
- AFUE: annual fuel utilization efficiency
- AMI: area median income
- ASHP: air-source heat pump
- DOE: Department of Energy
- IRA: Inflation Reduction Act
- HPWH: heat pump water heater
- HSPF: heating season performance factor
- NREL: National Renewable Energy Laboratory
- SEER: seasonal energy efficiency ratio
- WAP: Weatherization Assistance Program

Glossary

- **Air leakage/infiltration/exfiltration:** Air leakage occurs when outside air enters and conditioned air leaves your house uncontrollably through cracks and openings. (U.S. Department of Energy [DOE] Energy Saver. https://www.energy.gov/energysaver/air-sealing-your-home)
- **Air-source heat pump (ASHP):** An air-source heat pump can provide efficient heating and cooling for a home. When properly installed, an air-source heat pump can deliver up to three times more heat energy to a home than the electrical energy it consumes. This is possible because a heat pump transfers heat rather than converting it from a fuel like combustion heating systems. (Energy Saver. https://www.energy.gov/energysaver/air-source-heat-pumps)
- **Energy efficiency:** Energy efficiency is the use of less energy to perform the same task or produce the same result. (DOE Office of Energy Efficiency and Renewable Energy. https://www.energy.gov/eere/energy-efficiency-buildings-and-industry)
- **Thermal envelope:** The thermal envelope is everything about the house that serves to shield the living space from the outdoors. It includes the wall and roof assemblies, insulation, air/vapor retarders, windows, and weatherstripping and caulking. (National Renewable Energy Laboratory [NREL]. https://www.nrel.gov/docs/fy00osti/27835.pdf)

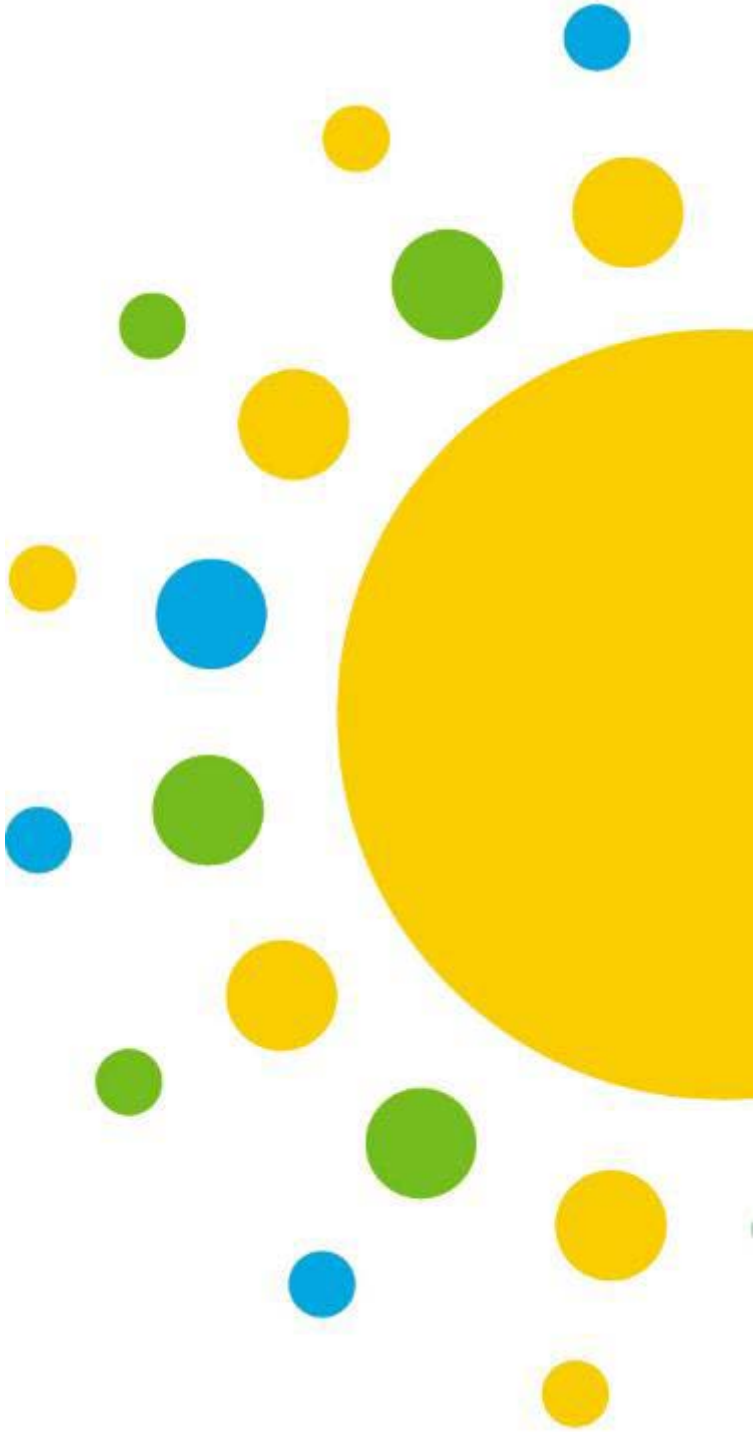
Glossary, Continued

- **Geothermal heat pump:** Geothermal (ground-source or water-source) heat pumps achieve higher efficiencies by transferring heat between a home and the ground or a nearby water source. (Energy Saver. https://www.energy.gov/energysaver/heat-pump-systems)
- **Heating season performance factor (HSPF):** The HSPF is a measure over an average heating season of the total heat provided to the conditioned space, expressed in Btu, divided by the total electrical energy consumed by the heat pump system, expressed in watt-hours. (Energy Saver. https://www.energy.gov/energysaver/air-source-heat-pumps)
- **Insulation:** Insulation provides resistance to heat flow and lowers heating and cooling costs. Properly insulating a home not only reduces heating and cooling costs, but also improves comfort. (Energy Saver. https://www.energy.gov/energysaver/insulation)
- **Mini-split heat pump:** Ductless heat pumps, or mini split heat pumps, are an alternative to radiator or baseboard heating, as well as a replacement for window units for cooling. No duct work is needed. Instead, a head unit, or multiple head units, are mounted on an interior wall or ceiling, with an accompanying unit outside. (ENERGY STAR. https://www.energystar.gov/products/ductless_heating_cooling)

Glossary, Continued

- **Retrofit:** A retrofit is the addition of new technology or features to an older system.
- **R-value:** An insulating material's resistance to conductive heat flow is measured or rated in terms of its thermal resistance, or R-value. The higher the R-value, the greater the insulating effectiveness. (Energy Saver. https://www.energy.gov/energysaver/insulation)
- **Seasonal energy efficiency ratio (SEER):** SEER is a measure over an average cooling season of the total heat removed from the conditioned space, expressed in Btu, divided by the total electrical energy consumed by the heat pump, expressed in watt-hours. (Energy Saver. https://www.energy.gov/energysaver/air-source-heat-pumps)
- **Weatherization:** Weatherization refers to improvements to a building to protect the inside from the outside weather and to increase energy efficiency. (Energy Saver. https://www.energy.gov/energysaver/weatherization)

Background



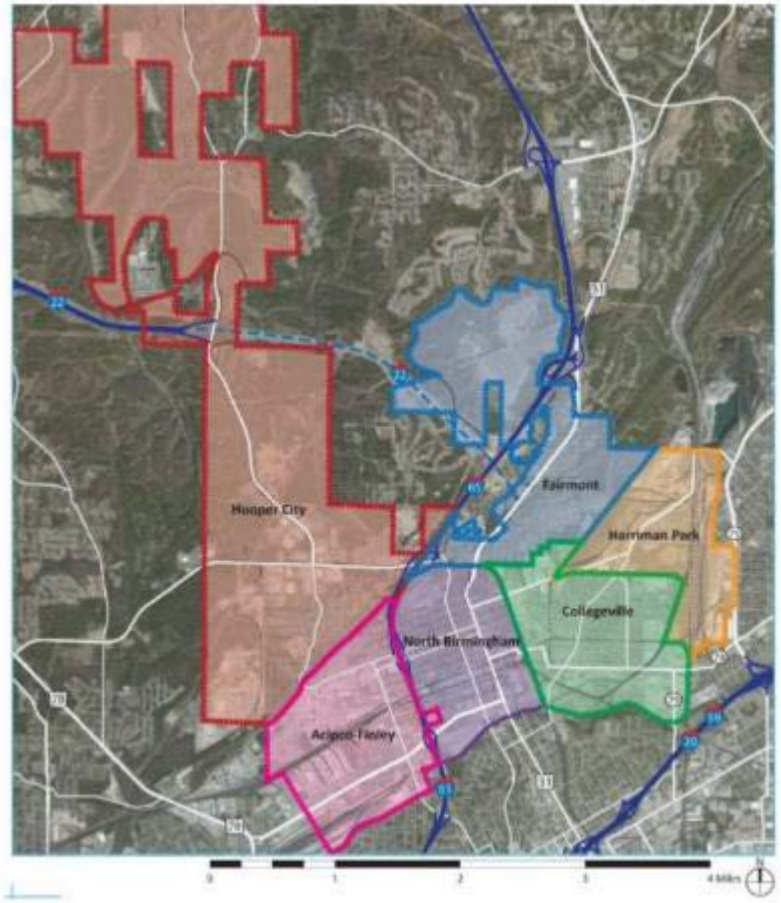
About Communities LEAP

The Communities Local Energy Action Program (LEAP) Pilot Competitive Technical Assistance opportunity aims to facilitate sustained community-wide economic empowerment through clean energy, improve local environmental conditions, and open the way for other benefits primarily through DOE's clean energy deployment work.

This opportunity was open to low-income, energy-burdened communities that are also experiencing either direct environmental justice impacts, or direct economic impacts from a shift away from historical reliance on fossil fuels.

North Birmingham, Alabama

- The community of North Birmingham comprises six neighborhoods:
  - Acipco-Finley
  - Collegeville
  - Fairmont
  - Harriman Park
  - Hooper City
  - North Birmingham
- History of environmental inequities



The neighborhoods of North Birmingham. *Image from City of Birmingham North Birmingham Framework Plan*

Communities LEAP in North Birmingham

- The City of Birmingham Planning Office applied to the Communities Local Energy Action Program (LEAP) for assistance in understanding how to jumpstart an energy efficiency transformation in North Birmingham.
- Analysis was conducted by the National Renewable Energy Laboratory (NREL), with support from the Southeast Energy Efficiency Alliance
- Project timeline: June 2022–March 2024
- Project partners: City of Birmingham Planning Office, North Birmingham Implementation Committee, and Alabama Power

The Historic Bethel Baptist Church is in North Birmingham. *Image from https://www.nps.gov/places/the-historic-bethel-baptist-church.htm*

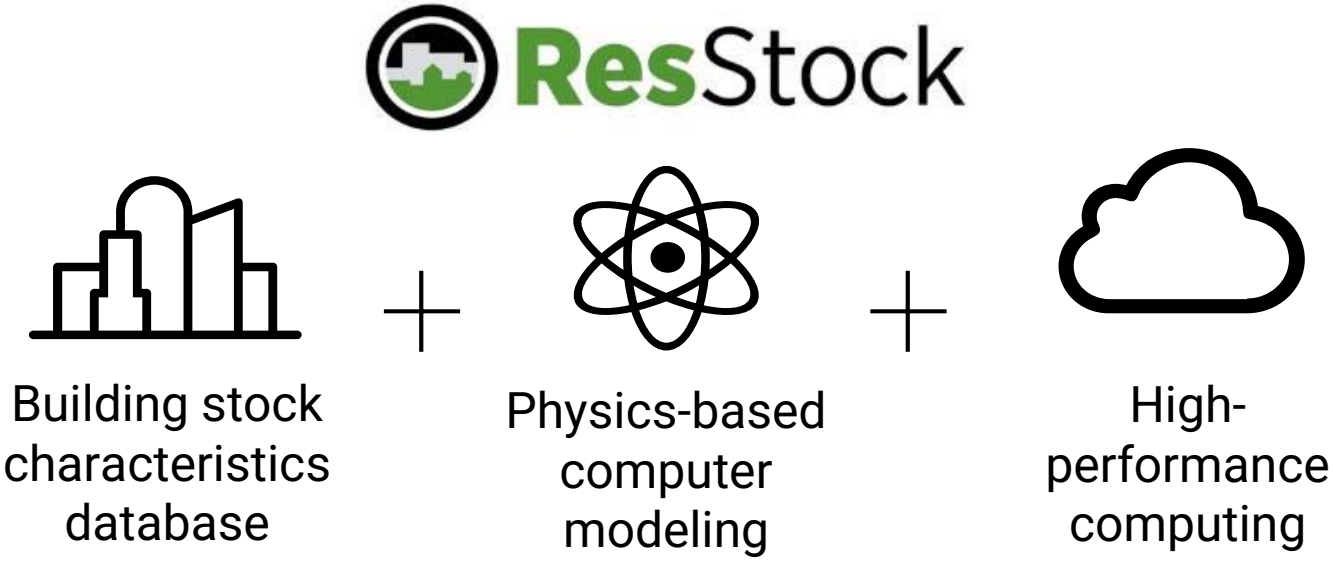
Purpose of This Presentation

1. Present a baseline assessment of the housing stock in the North Birmingham community
2. Provide information about residential energy efficiency and technologies
3. Outline potential upgrade strategies for residential energy efficiency improvements in North Birmingham
4. Highlight funding opportunities for the upgrade strategies

Housing Stock in North Birmingham, Alabama

ResStock Overview

What is ResStock?

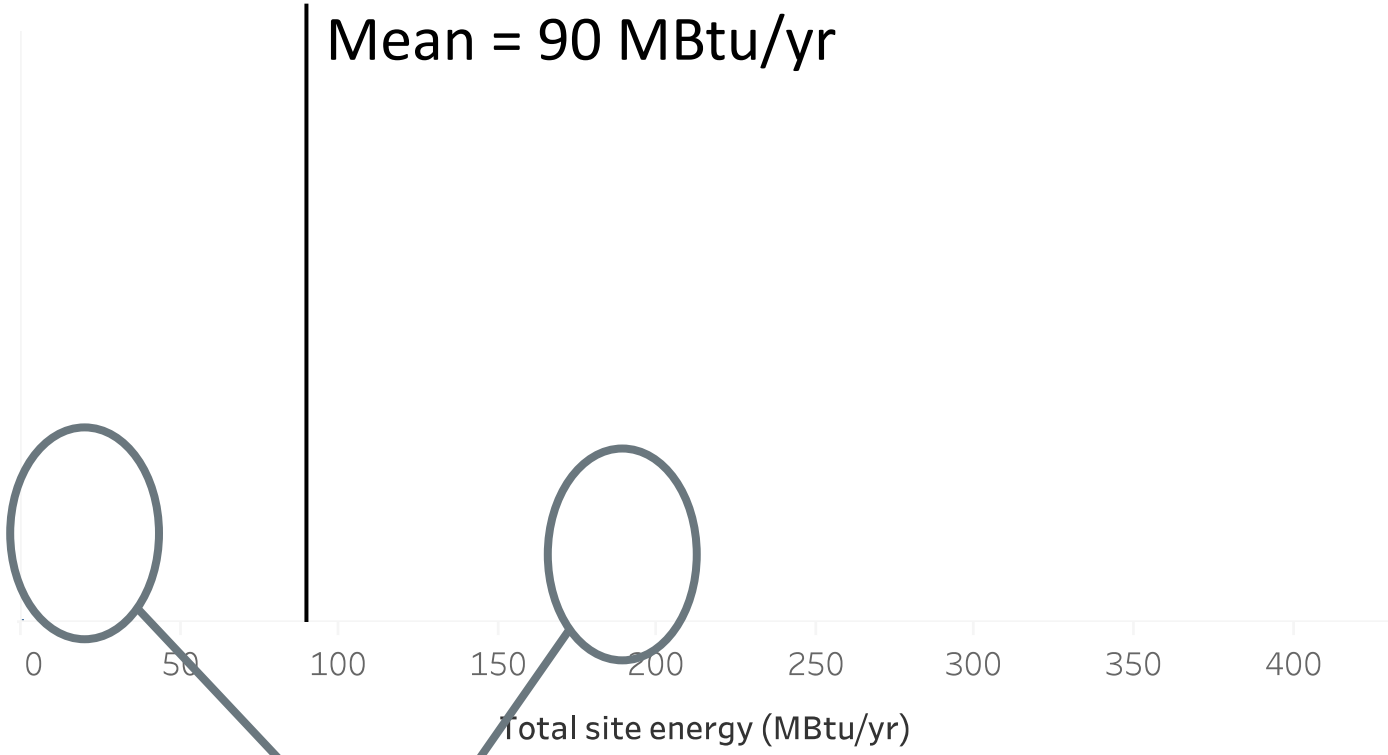


- National datasets that empower analysts working for federal, state, utility, city, and manufacturer stakeholders to answer a broad range of questions
- Highly granular, data-driven, decision making for national, regional, and local building stocks
- The creation of hundreds of thousands of statistically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

Why is granularity important?

Distribution of energy use per home

(Energy Information Administration 2009)

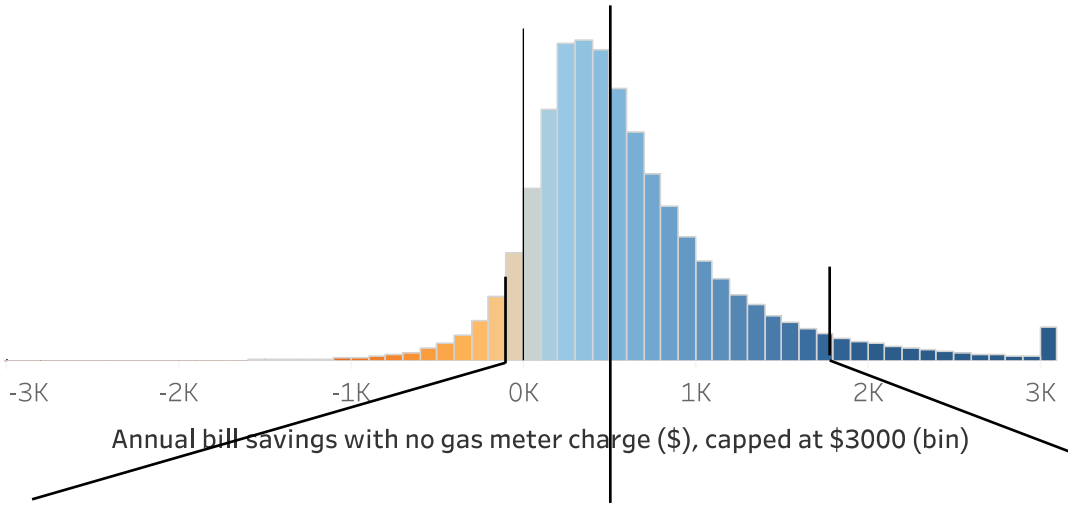


Homes and communities on each end of the distribution will respond very differently to technology deployment

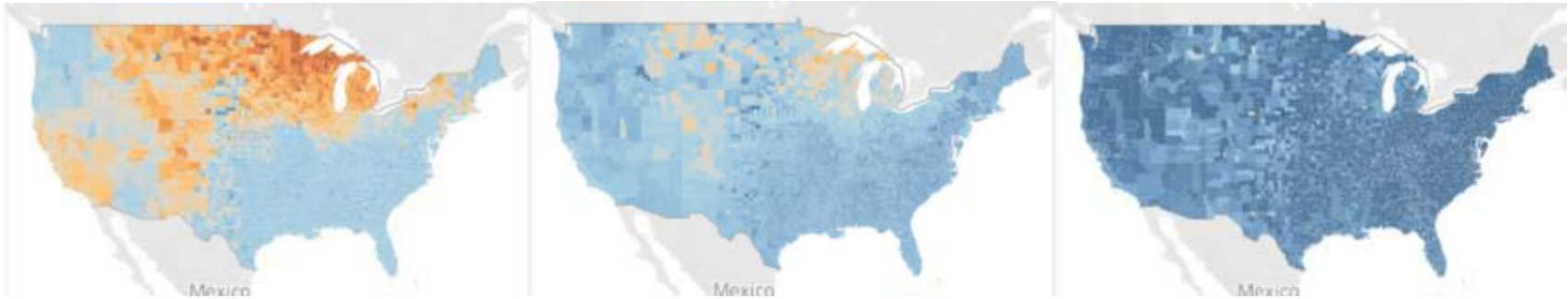
Why is granularity important?

Granularity is necessary to understand **distributional impacts** across the population, e.g., in disadvantaged communities

For example, estimated bill impacts of electrification packages: 90% save money, but 10% of homes see a bill increase.
*Average: **$500/yr** savings*



5th percentile | 50th percentile | 95th percentile



Source: Tableau Public n.d.

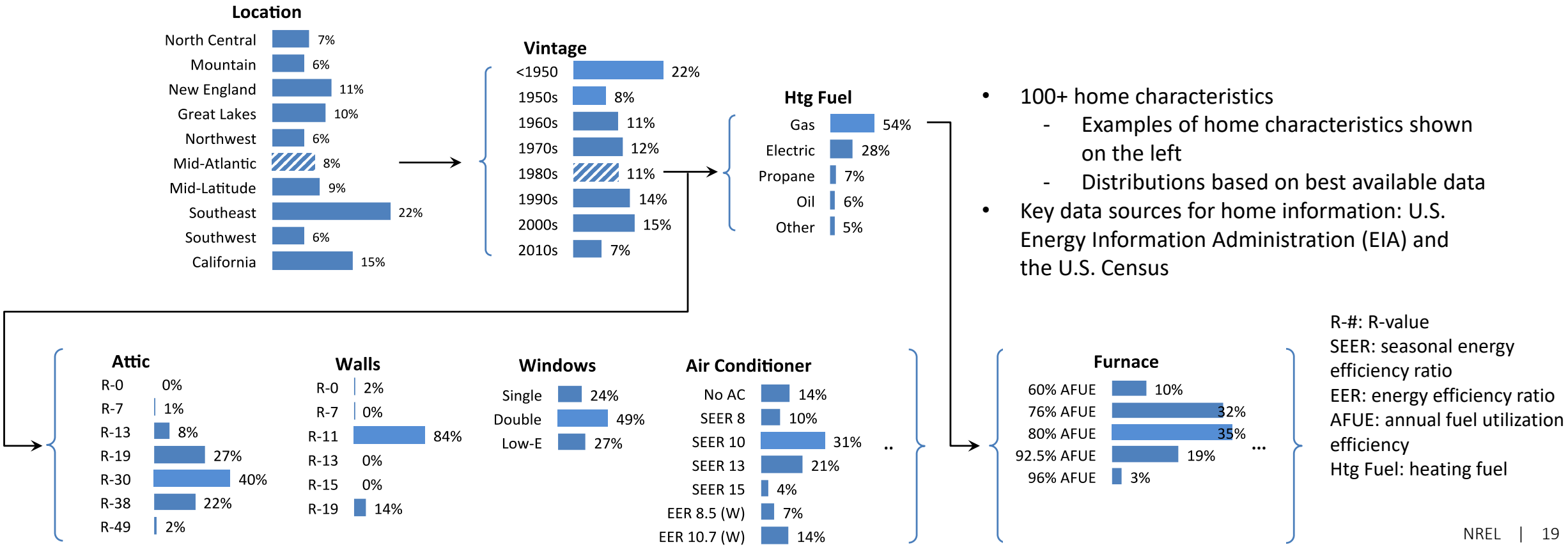
ResStock Process for Analyzing Building Upgrade Opportunities

1. Describe the U.S. housing stock quantitatively
2. Sample the description to create statistical representation—in reality, these values may be different for each community
3. Model the samples
4. Model changes to the building stock, including energy efficiency packages, electrification, etc.
5. Publish description, samples, models, results, aggregations, visualizations, and documentation

Describe the U.S. Housing Stock Quantitatively

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.

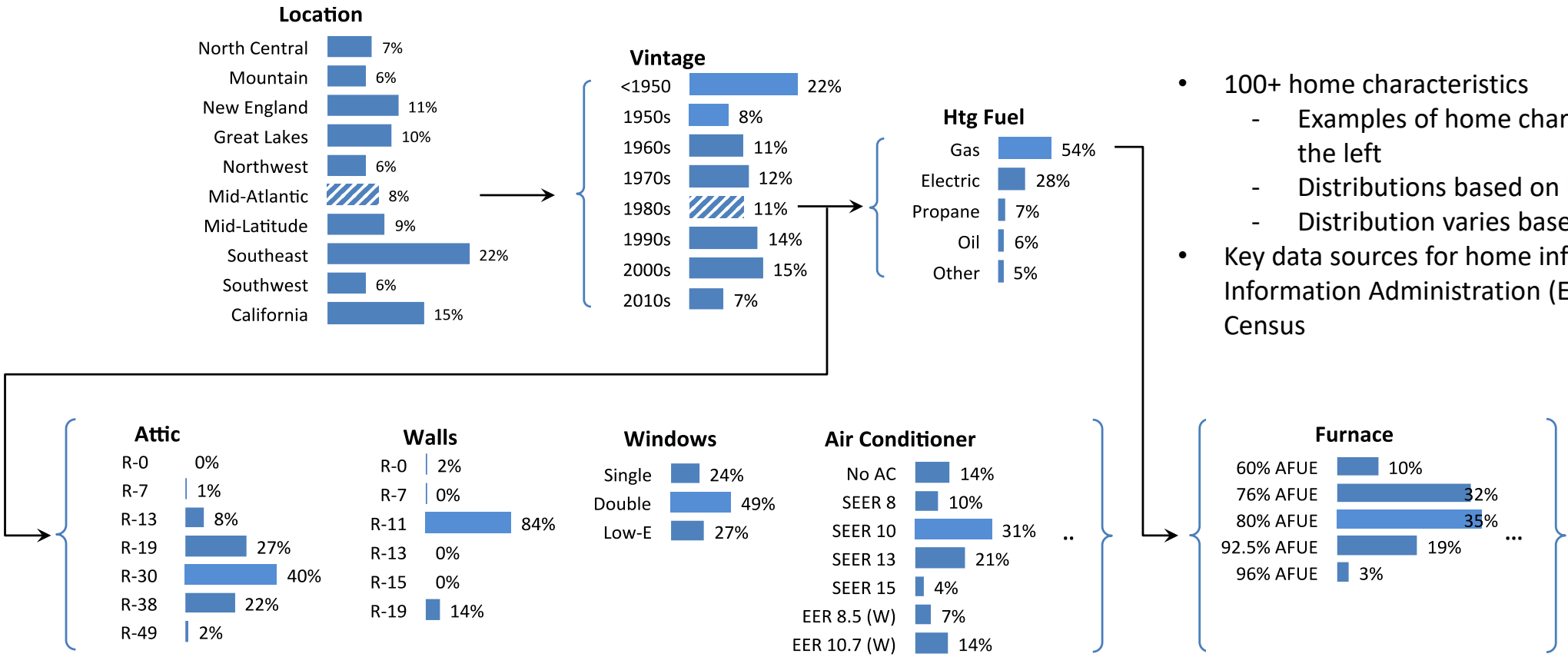


- 100+ home characteristics
  - Examples of home characteristics shown on the left
  - Distributions based on best available data
- Key data sources for home information: U.S. Energy Information Administration (EIA) and the U.S. Census

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

Describe the U.S. Housing Stock Quantitatively

1. NREL samples 550,000 homes from these distributions (1 for every 240 in the country).
2. NREL models the homes in EnergyPlus using High-Performance Computing (HPC).



- 100+ home characteristics
  - Examples of home characteristics shown on the left
  - Distributions based on best available data
  - Distribution varies based on upstream factors
- Key data sources for home information: U.S. Energy Information Administration (EIA) and the U.S. Census

Illustrative Home Sampled and Characteristics

IECC Climate Zone	5A	**Heating**	Natural gas furnace, 80% AFUE	**Wall type**	Wood stud
City	Cleveland, OH	**Cooling**	Central AC, SEER 13	**Wall insulation**	Uninsulated
Building type	Single-family detached	**Setpoints**	Heating: 70°F Cooling: 72°F	**Attic type**	Vented attic
Occupants	3	**Setpoint offsets**	Heating: 3°F Cooling: 2°F	**Attic insulation**	Uninsulated
Vintage	<1940	**Refrigerator**	EF 17.6	**Infiltration**	8 ACH50
Floor area bin	1500-1999	**Clothes washer**	ENERGY STAR, 123 rated kWh	**Foundation type**	Unheated basement
Bedrooms	3	**Dishwasher**	290 rated kWh	**Ducts**	10% Leakage, Uninsulated
Stories	2	**Cooking range**	Gas	**Windows**	Double, Clear, Nonmetal, Air

Note that there are dozens of other characteristics that the ResStock analysis includes.

Modeling Assumptions & Limitations

- Analysis is based on ResStock-modeled energy consumption; all models have uncertainties
- Modeling is aggregated across collections of housing units; results for an individual housing unit can vary substantially
- ResStock used national average technology costs from 2012, adjusted for inflation to 2019 and with a local multiplier factor reflecting differences in local cost of living relative to the national average and supplemented with local, regional, or state-wide cost estimates when possible
- Costs do not include rebates or other incentives, and costs for any individual project can vary substantially

See detailed description of ResStock C-LEAP modeling assumptions/limitations here: https://data.nrel.gov/submissions/224

Modeling Assumptions & Limitations

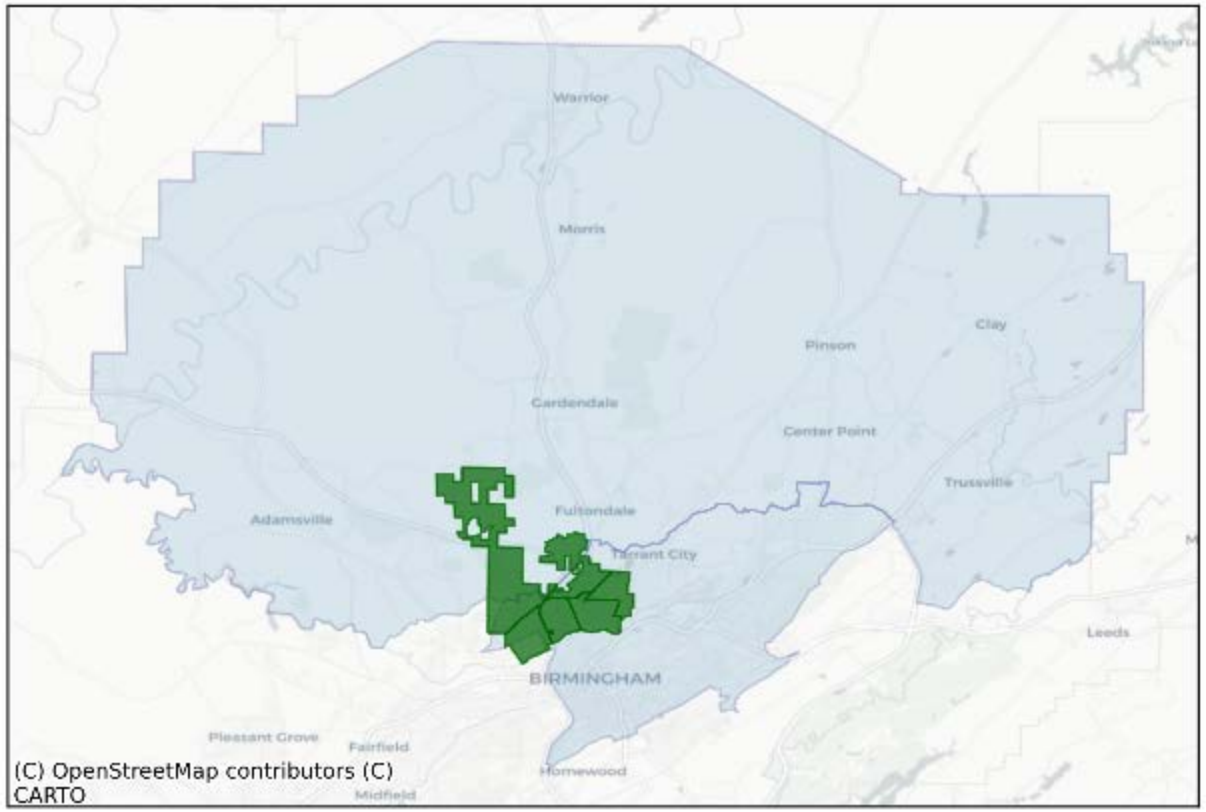
- Specific measures and measure packages were modeled (not all potential technologies/performance levels and packages)
- Heat pumps were modeled with existing heating systems as backup and also separately modeled with electric backup; sized for cooling loads, which can produce more conservative estimates
- 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 packages
- Building upgrades required for electrification (remediation, new electric panel) were not considered

See detailed description of ResStock C-LEAP modeling assumptions/limitations here: https://data.nrel.gov/submissions/224

Housing Stock Baseline of the North Birmingham Community

Housing Stock Baseline

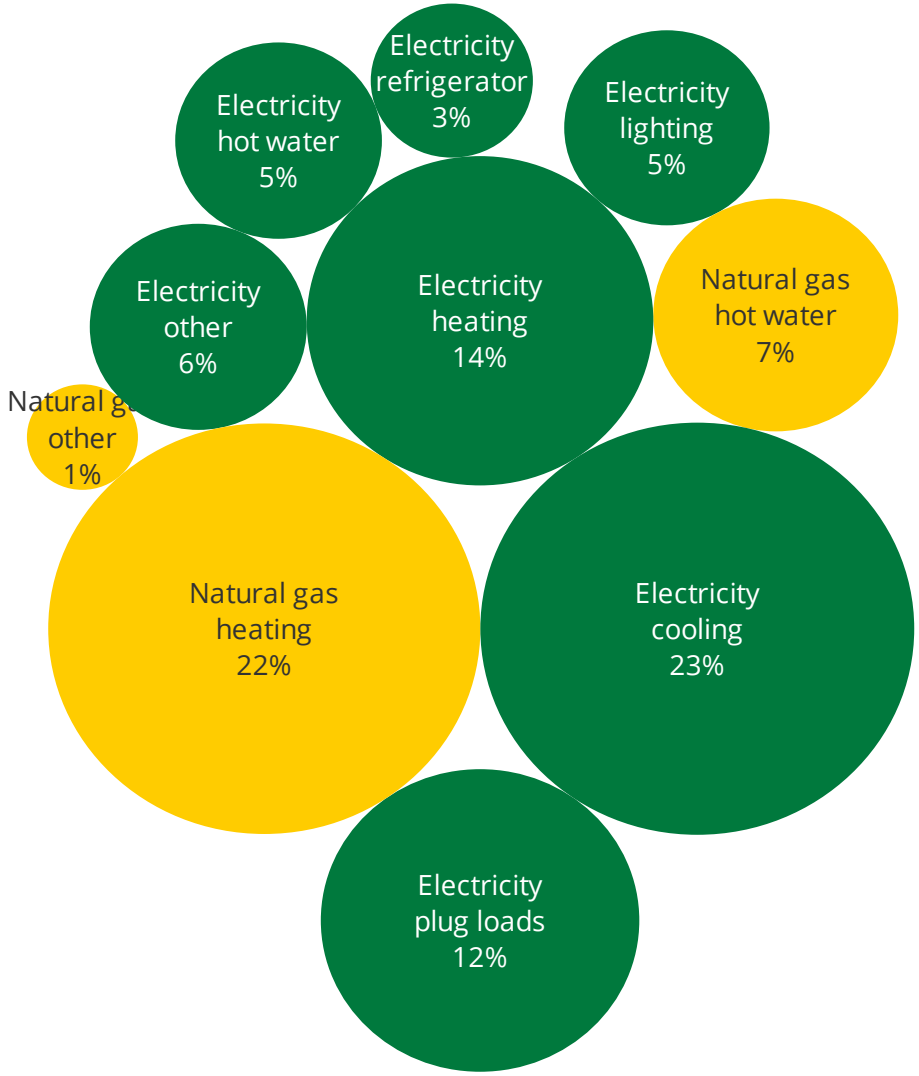
- This analysis focuses on homes in Birmingham, Alabama, and nearby, where the household income is <80% of the area median income (AMI).
- While not a direct geographical proxy for North Birmingham, this sample can be useful when trying to understand the energy use and opportunities for low- to moderate-income households in the area, including North Birmingham.



Blue is the geographic boundary of the ResStock sample. Green highlights the six North Birmingham neighborhoods.
Image from ResStock

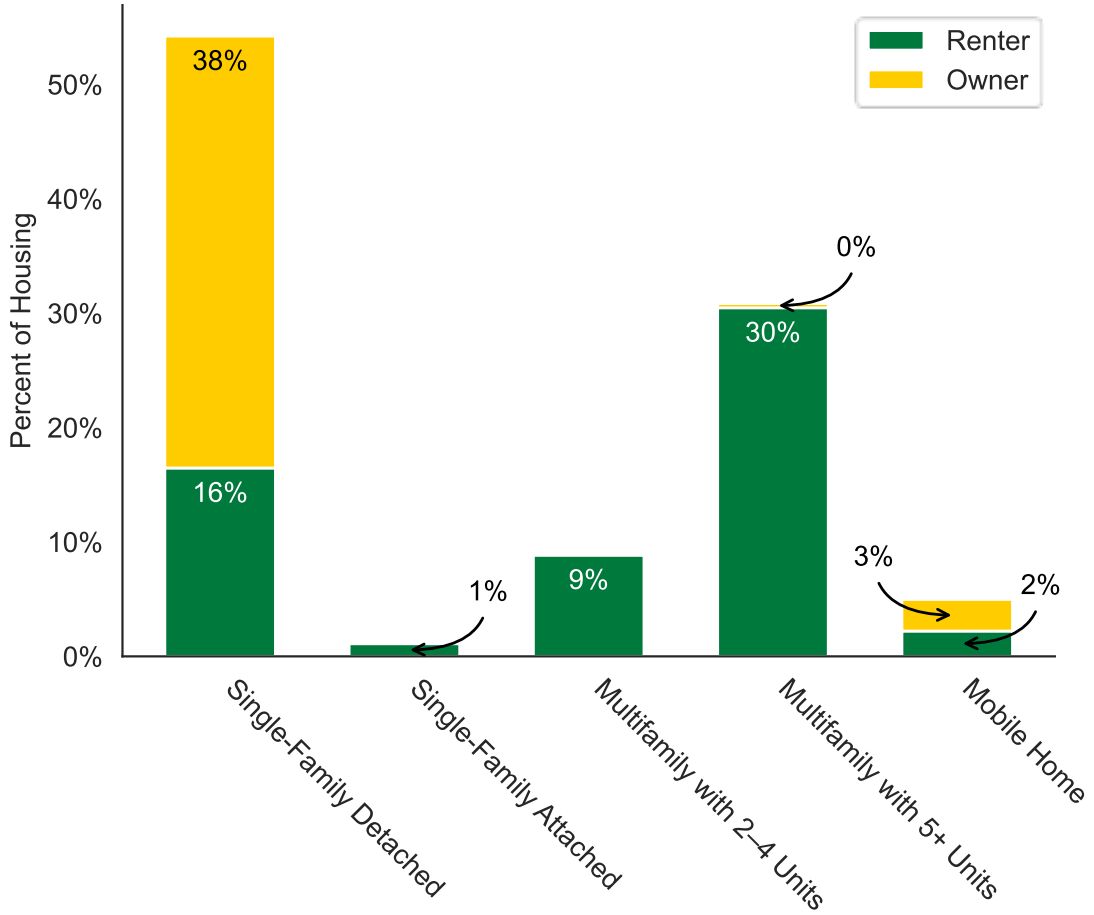
Home Energy Use in North Birmingham

- 59% of residential energy use is heating and cooling. That is where the largest energy and cost reduction potential is.
- “Other” includes appliances like dishwashers, clothes washers, clothes dryers, ovens/ranges, etc.
- Retrofit strategies investigated target all these end uses.



Percentage of community-wide residential energy use by end use.

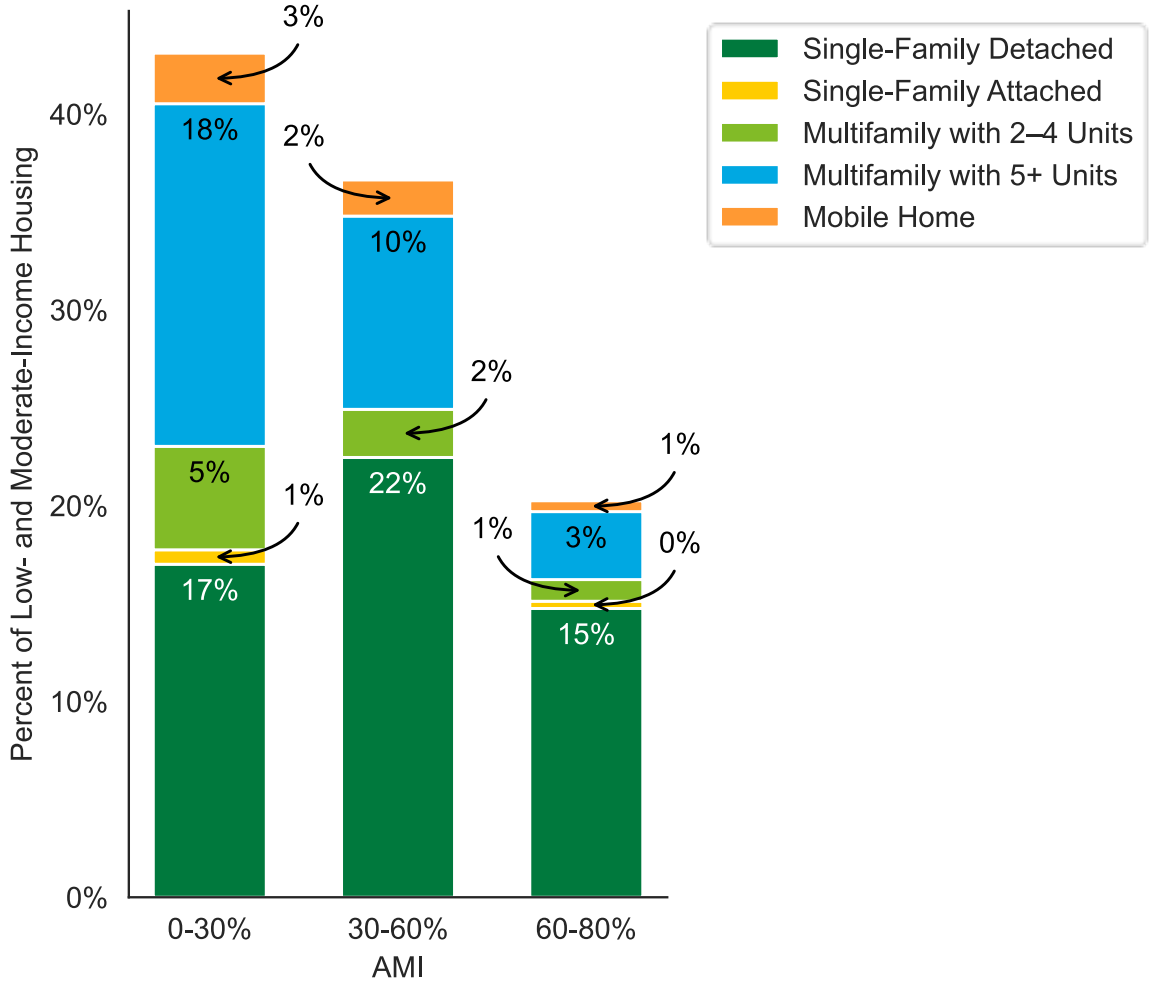
Types of Homes in North Birmingham



Largest segment is single-family detached, owner occupied.

Types of Homes by AMI in North Birmingham

- AMI: Relative measure of income. It is the median household income in a region.
- Why is the household AMI important?
  - 80% or below AMI is considered low and moderate income.
  - These households are more energy-burdened.
  - These households are eligible for more rebates.



Median Income in Context

Region (U.S. Census Bureau 2022)	Median Income
United States*	$74,580
Alabama**	$59,609
Birmingham, Alabama***	$42,464
North Birmingham, Alabama****	$27,939

*Real median household income in 2022

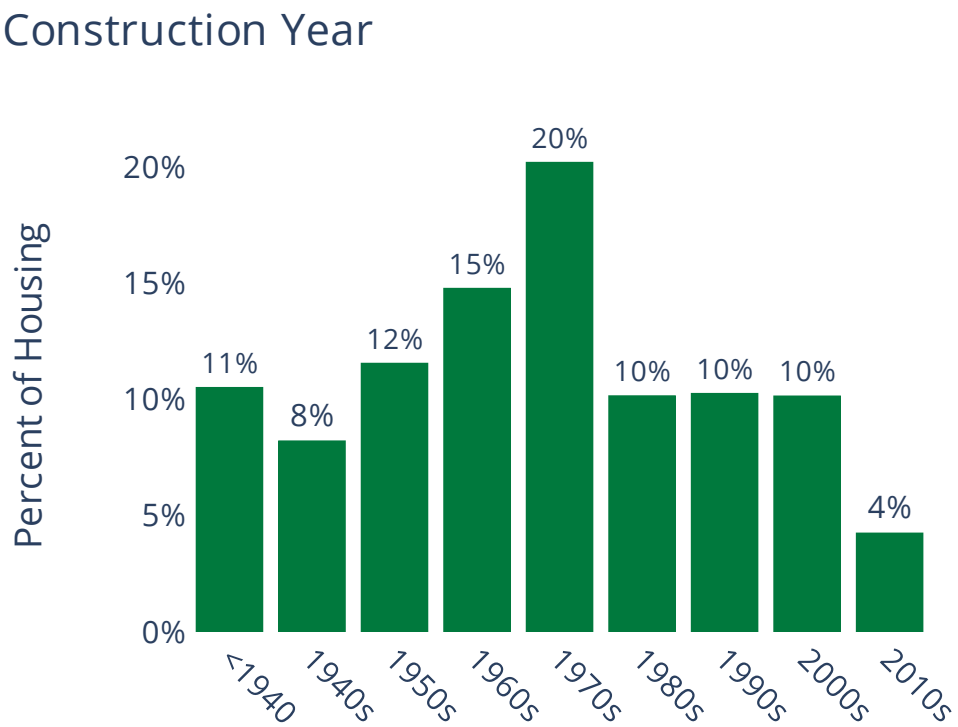
**Median household income (in 2022 dollars), 2018–2022

***Median household income (in 2022 dollars), 2018–2022

****Household median income estimate for [Zip Code Tabulation Area] ZCTA5 35207

Age of Homes

- 66% of homes in North Birmingham were built before 1980.
- Why is home age important?
  - Newer homes are built to more stringent energy codes.
  - Older homes generally have more opportunities for energy efficiency upgrades.



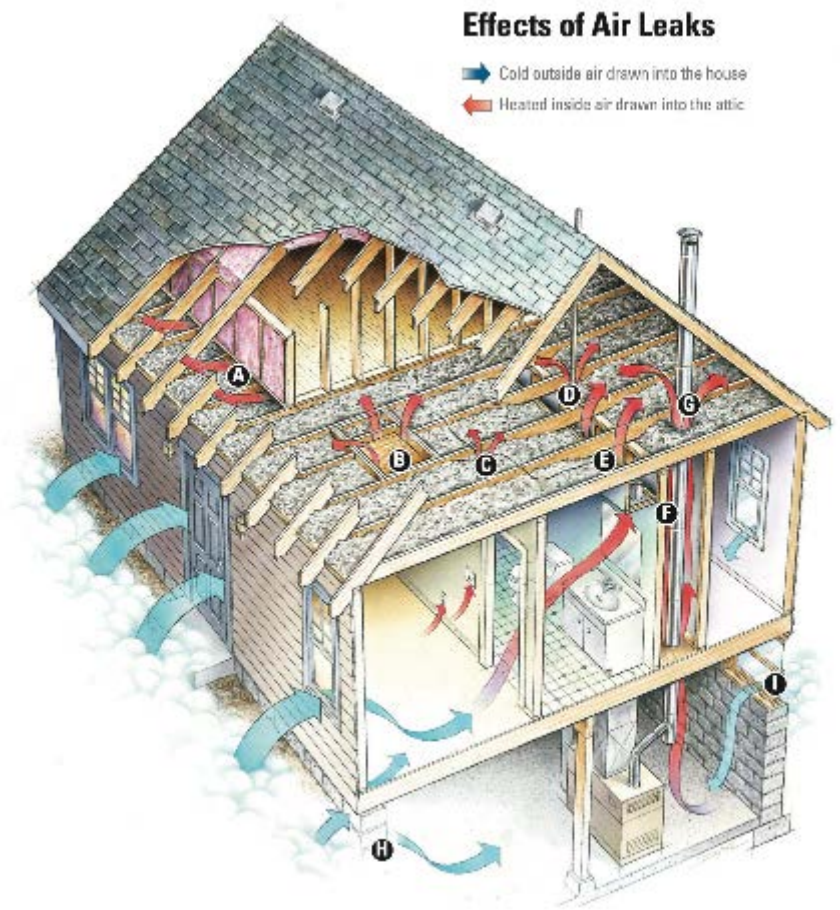
Home Envelope Overview

- Building Envelope: Everything that separates a home from the outside.
  - Walls
  - Windows
  - Attic and Roof
  - Foundation Floors and Walls

- The building envelope in North Birmingham matters because of:
  - Comfort: A well-insulated, tight home stays warmer in the winter and cooler in the summer.
  - Utility bill reductions: Heating and cooling equipment does not have to work as hard and uses less energy to maintain indoor comfort.

Home Envelope Definitions

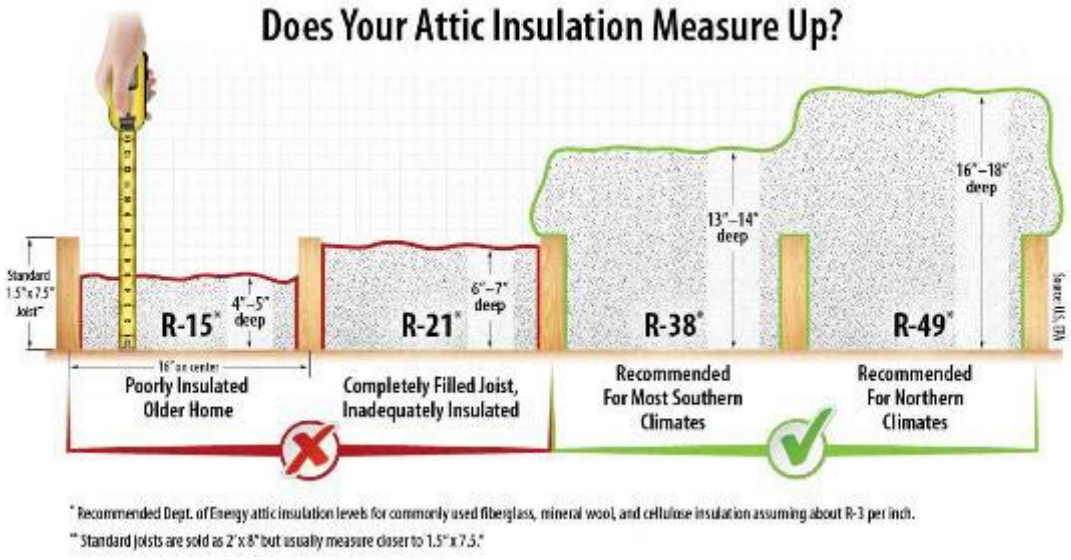
- Infiltration/Exfiltration: Air leakage into and out of a home (DOE Energy Saver. https://www.energy.gov/energysaver/air-sealing-your-home)
- Why does infiltration matter?
  - A leaky house requires more energy and is more expensive to heat and cool; it can also be less comfortable for occupants.
  - Poor infiltration is linked to home health hazards, including asthma triggers such as mold and pests (DOE, n.d.). This is important in North Birmingham, as Birmingham in 2021 was rated one of the top 20 most challenging places in the U.S. to live with asthma (Asthma and Allergy Foundation of America, 2021).



Air leaks in and out of a home.
Image from https://www.energystar.gov/saveathome/seal_insulate

Home Envelope Definitions

- Insulation: Keeps the house cooler in the summer and warmer in the winter
- R-value: Measure of insulation's ability to resist heat traveling through it
- For example, for attic insulation:
  - R-38 is required in Alabama's current state energy code (DOE Building Energy Codes Program, International Code Council [ICC] 2015)
  - R-49 is required in the latest energy codes (ICC 2021).



Ceiling insulation r-values and acceptability for residential homes based on climate. Image from https://www.energystar.gov/products/energy_star_home_upgrade/attic_insulation

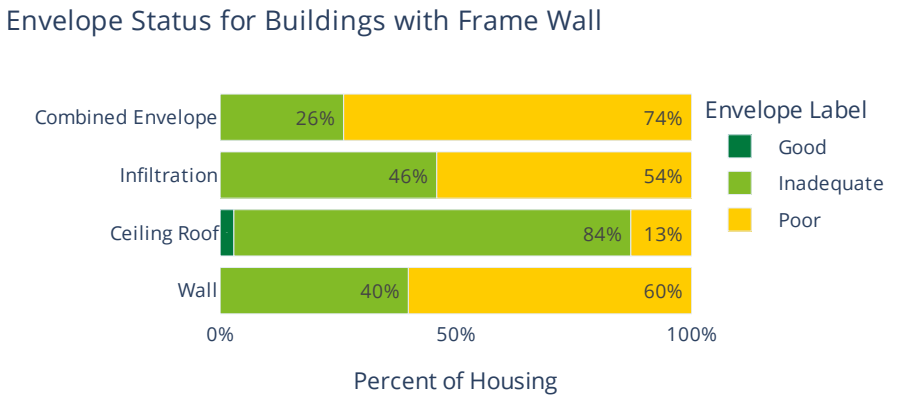
Home Envelopes in North Birmingham

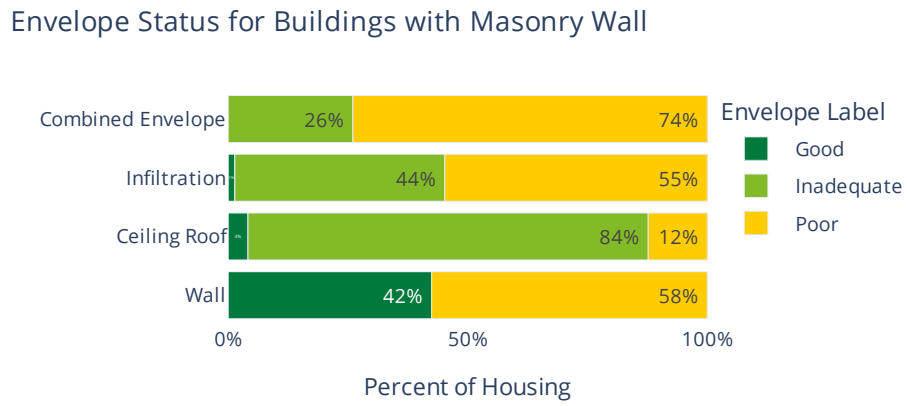
Definitions for the purpose of this analysis:

- Good: Meets International Energy Conservation Code (IECC) 2021 building code performance levels
- Inadequate: Above average for the climate, but not meeting IECC 2021
- Poor: Below average for the climate
- Frame wall: Wood framing with cavities, with or without insulation between studs, siding on the outside, and an interior finish like drywall or plaster.
- Masonry wall: Brick, cinder block, or other masonry block wall.

Most homes in the community sample could benefit from envelope improvements such as increasing insulation in the walls, ceiling, and foundation and sealing air leaks in the house. A study from the Pacific Northwest National Laboratory found low levels of code compliance in Alabama with insulation installation and envelope tightness (Bartlett et al., 2017).

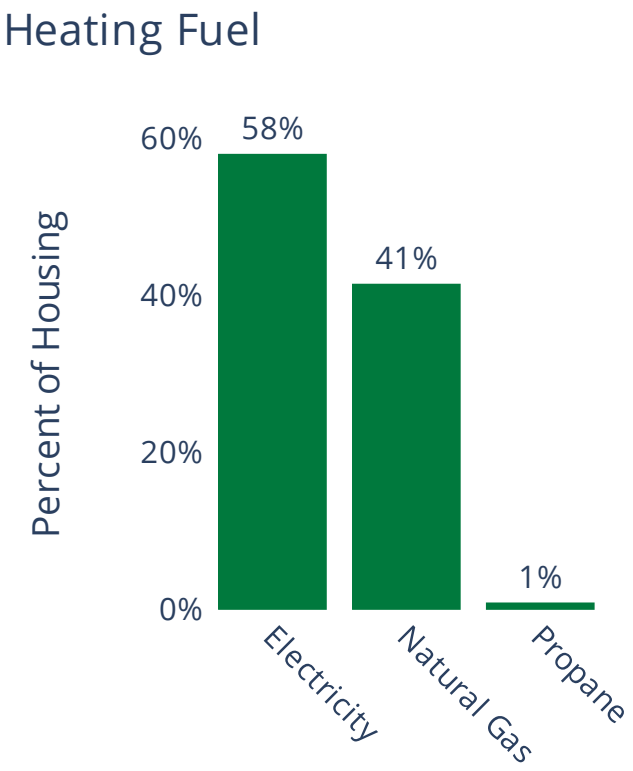
The envelope analysis does not account for critical repairs that may be needed (holes in roof, broken windows, etc.).





Home Heating: Fuel Type

- Birmingham has a mix of primarily electric and natural gas heating.
- Natural gas heated homes
  - Natural gas fuel is less expensive than electricity per unit of site energy in Birmingham, but pricing is volatile (EIA 2022)
  - Need to monitor and test for carbon monoxide, especially on older systems
- Electricity heated homes
  - Includes electric resistance and heat pumps



Types of Heating Systems

Natural Gas

Furnace: Furnaces heat air and distribute the heated air through the house using ducts.

Boiler: Boilers heat water and provide either hot water or steam for heating. Steam is distributed via pipes to steam radiators, and hot water can be distributed via baseboard radiators or radiant floor systems or can heat air via a coil.

Electric

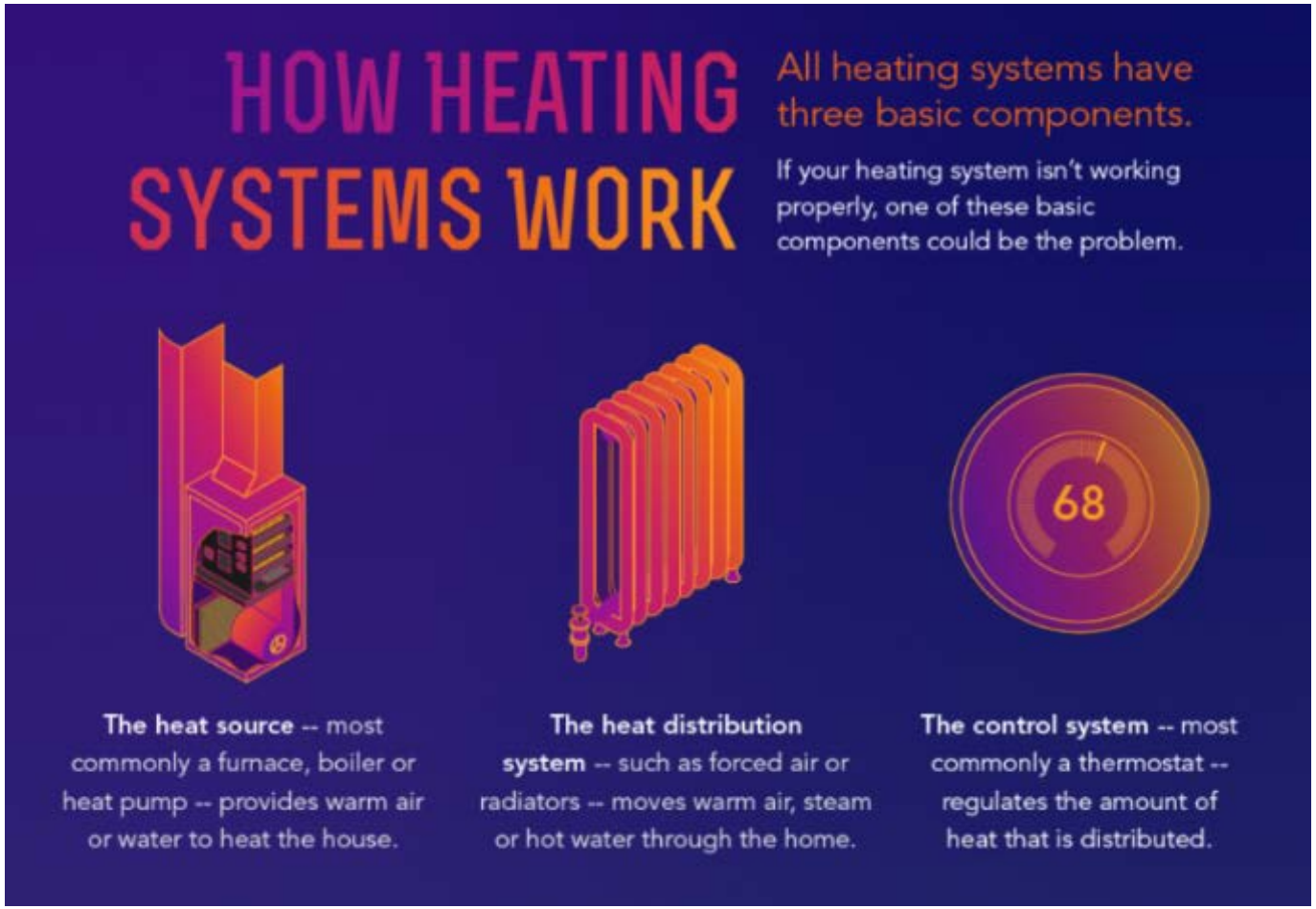
Furnace: Blowers (large fans) in electric furnaces move air over a stack of electric resistance coils called elements. Heated air is delivered throughout the home through ducts.

Baseboard: Electric baseboard heaters are electric resistance heaters controlled by thermostats located within each room.

Heat pump: Heat pumps use electricity to transfer heat from a cool space to a warm space, making the cool space cooler and the warm space warmer. Because they transfer heat rather than generate heat, heat pumps can efficiently provide comfortable temperatures for your home.

See DOE Energy Saver:
https://www.energy.gov/energysaver/furnaces-and-boilers
https://www.energy.gov/energysaver/electric-resistance-heating, https://www.energy.gov/energysaver/heat-pump-systems

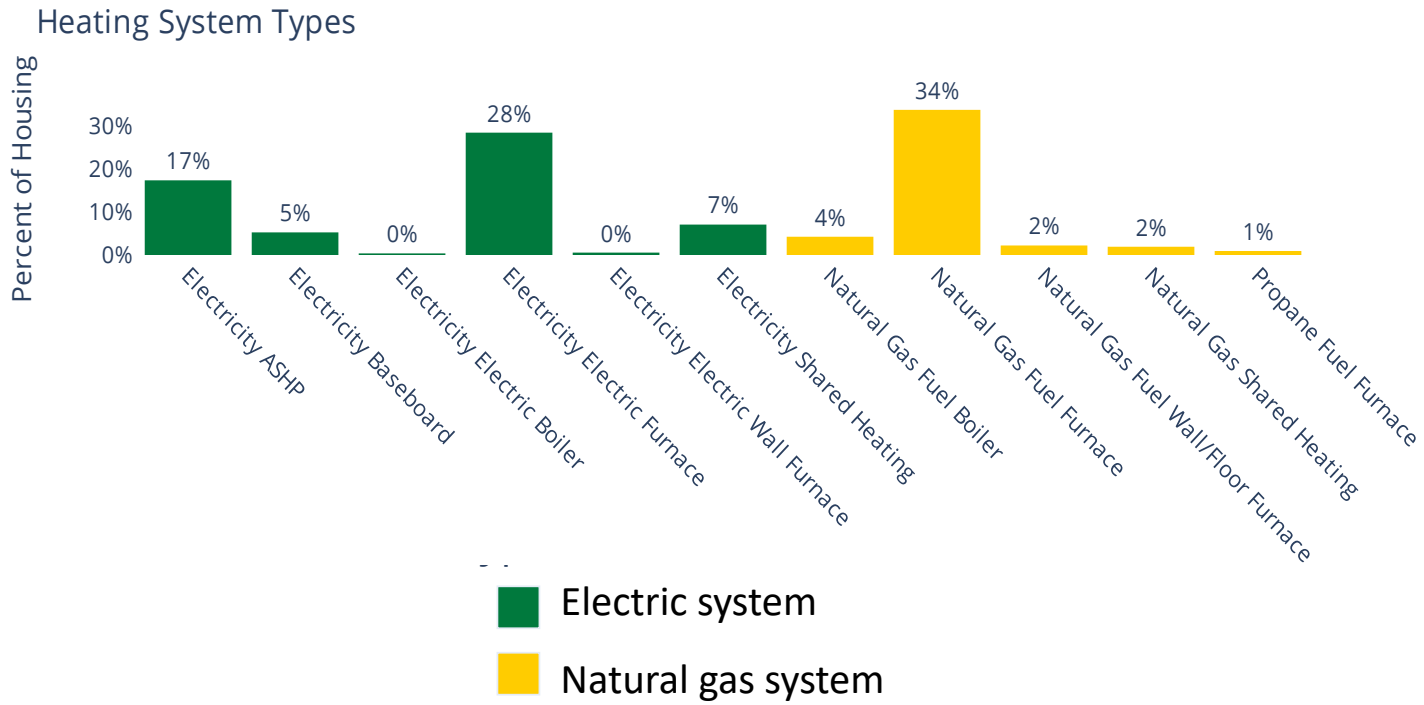
Home Heating



How heating systems work.
Image from https://www.energy.gov/energysaver/articles/energy-saver-101-infographic-home-heating

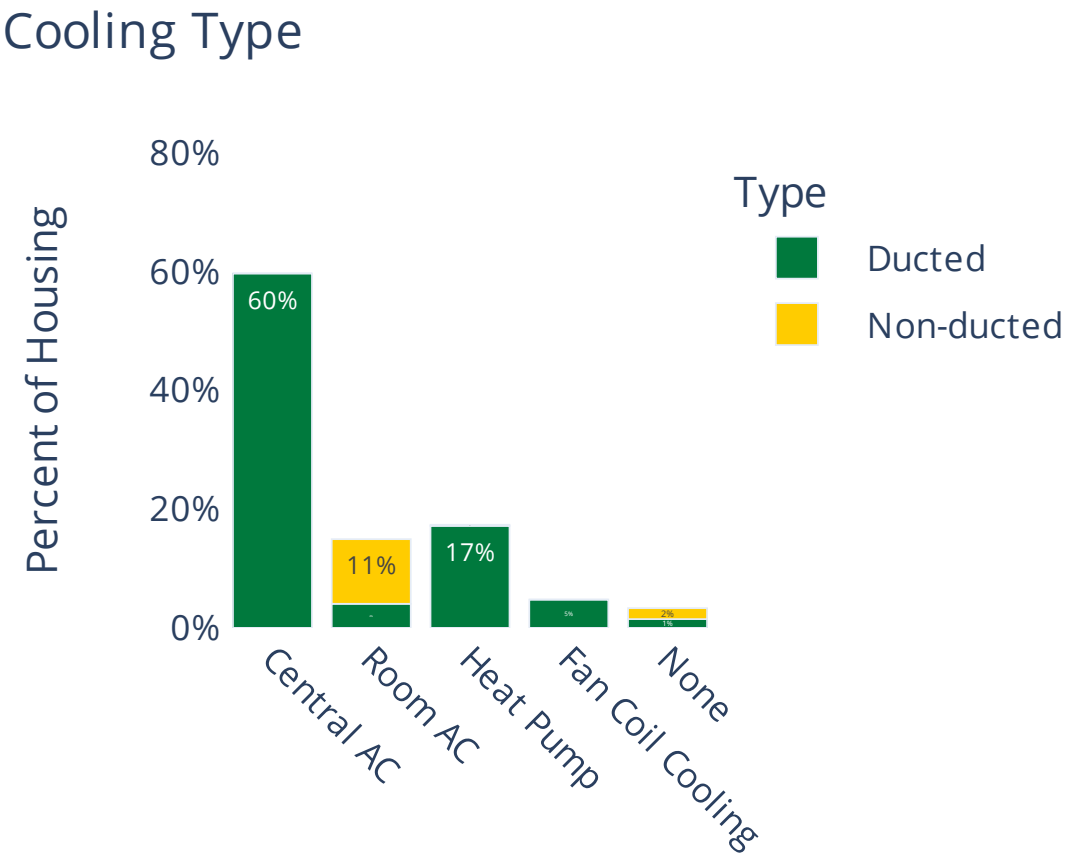
Home Heating in North Birmingham

- Retrofit strategies will need to address each heating system type.
- For example, households with electric furnaces (28% of households in the sample) can achieve significant utility bill reductions by upgrading to an ENERGY STAR air-source heat pump (ASHP), as will be shown in the retrofit analysis.



Home Cooling in North Birmingham

- Given the warm climate, most homes have cooling.
- Room air conditioners (typically window units) primarily cool the room they are installed in.
- Heat pumps work like air conditioners but also provide heating in winter.
- Fan coils are used primarily in centralized systems in multifamily buildings.



*Ducting for “None” (i.e., homes without cooling) references ducting for the heating system.

Cooling Context

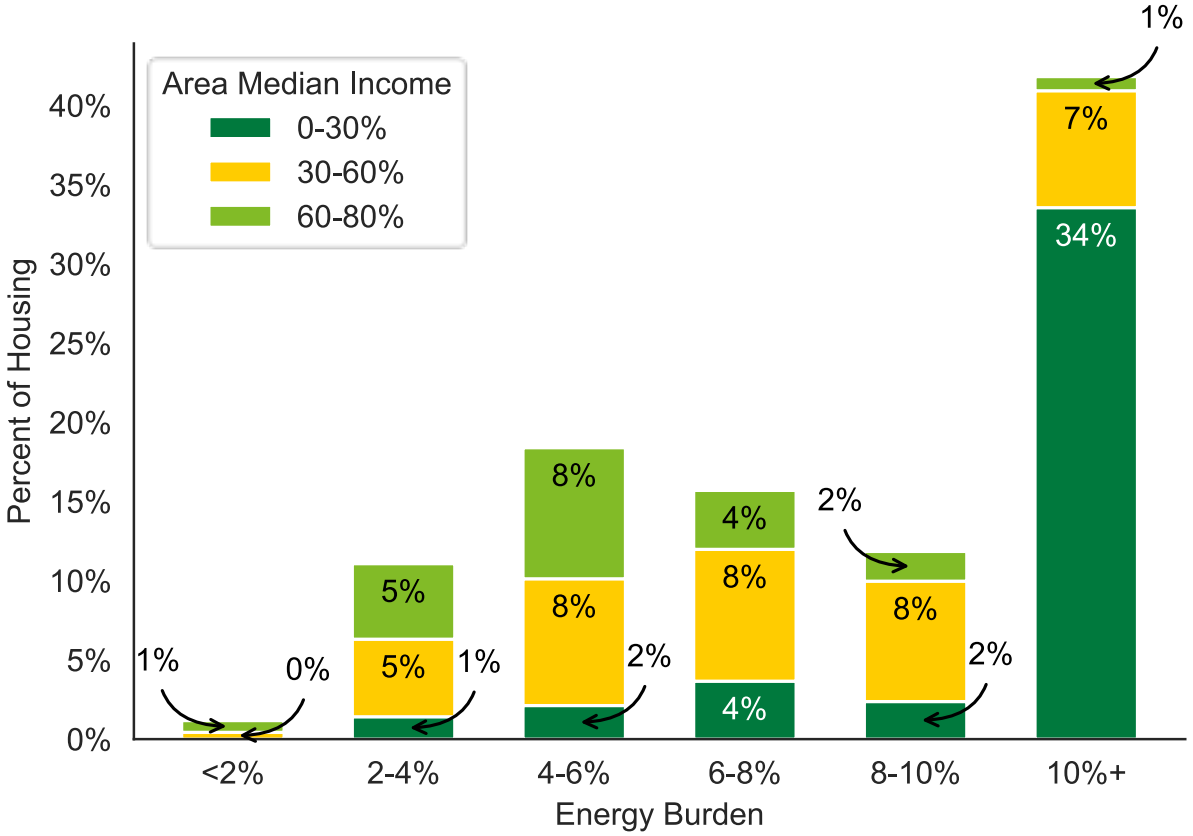
- Birmingham is estimated to have 51 days with a heat index over 100°F by 2050 (even with slow climate mitigation actions) (Dahl et al. 2019).
- Health and safety will depend on cooling efficiently and affordably.

Heat Index Above 90°F	Heat Index Above 100°F	Heat Index Above 105°F	Heat Index Off the Charts
			
Outdoor workers become more susceptible to heat-related illness.	Children, elderly adults, pregnant women, and people with underlying conditions are at heightened risk of heat-related illness.	Anyone could be at risk of heat-related illness or even death as a result of prolonged exposure.	Undetermined: any level of exposure is presumed extremely dangerous for all people and and likely to result in heat-related illness or even death.

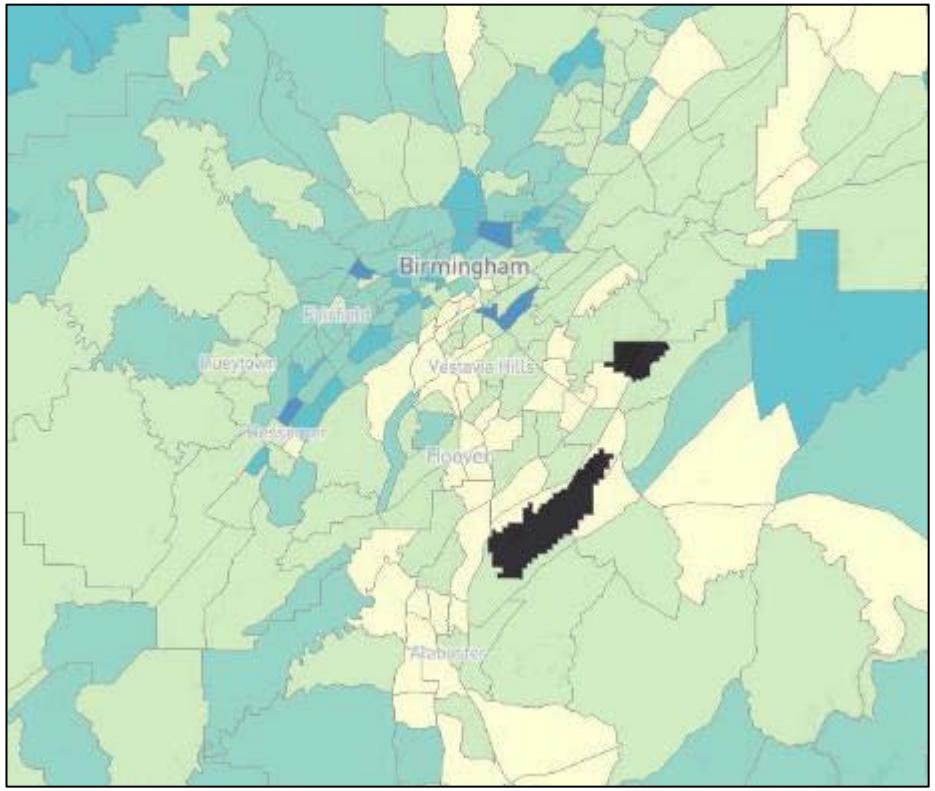
Impacts of heat indexes on the human body.

Energy Burden in Birmingham

- Energy burden is described as the share of income residents must spend on energy.
- Household energy burden above 6% is considered high (Drehobl et al. 2020).
- Based on the modeled results, households with the lowest income spend the largest portion of their income on energy, on average.



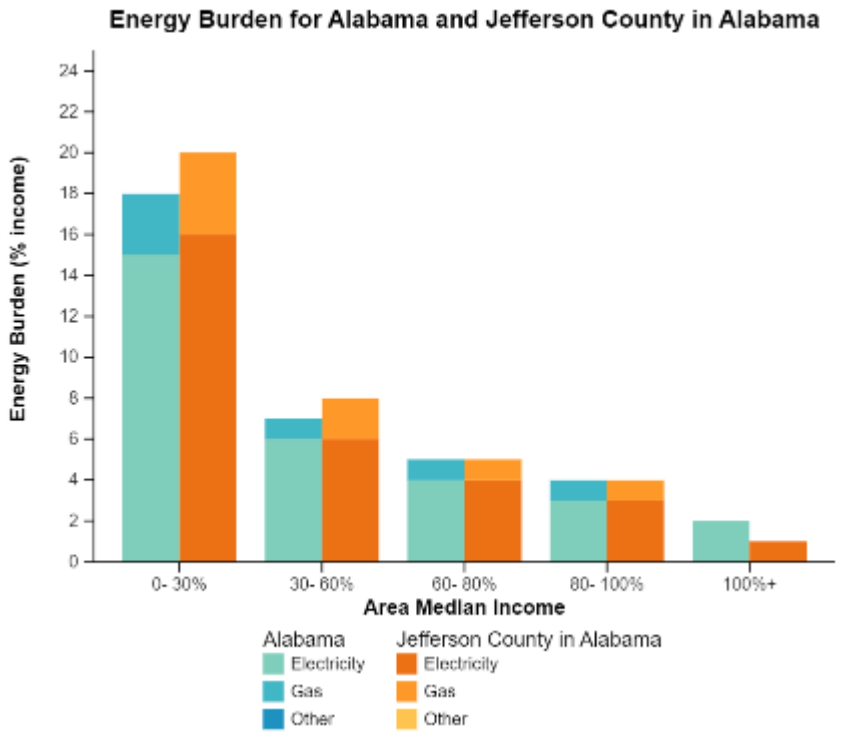
Energy Burden in Jefferson County



Average energy burden as a percentage of income spent on energy for AMI 0–80% in the Jefferson County area, Alabama, by census block. Image from https://www.energy.gov/scep/slsc/lead-tool

Energy Burden in Jefferson County, Continued

- For the lowest AMI residents (0–30%), the estimated average energy burden for Jefferson County is higher than the estimated average energy burden for Alabama (according to the DOE Low-income Energy Affordability Data (LEAD) tool)
- Average annual energy costs for 0–30% AMI:
  - Alabama: $1,823
  - Jefferson County: $1,972



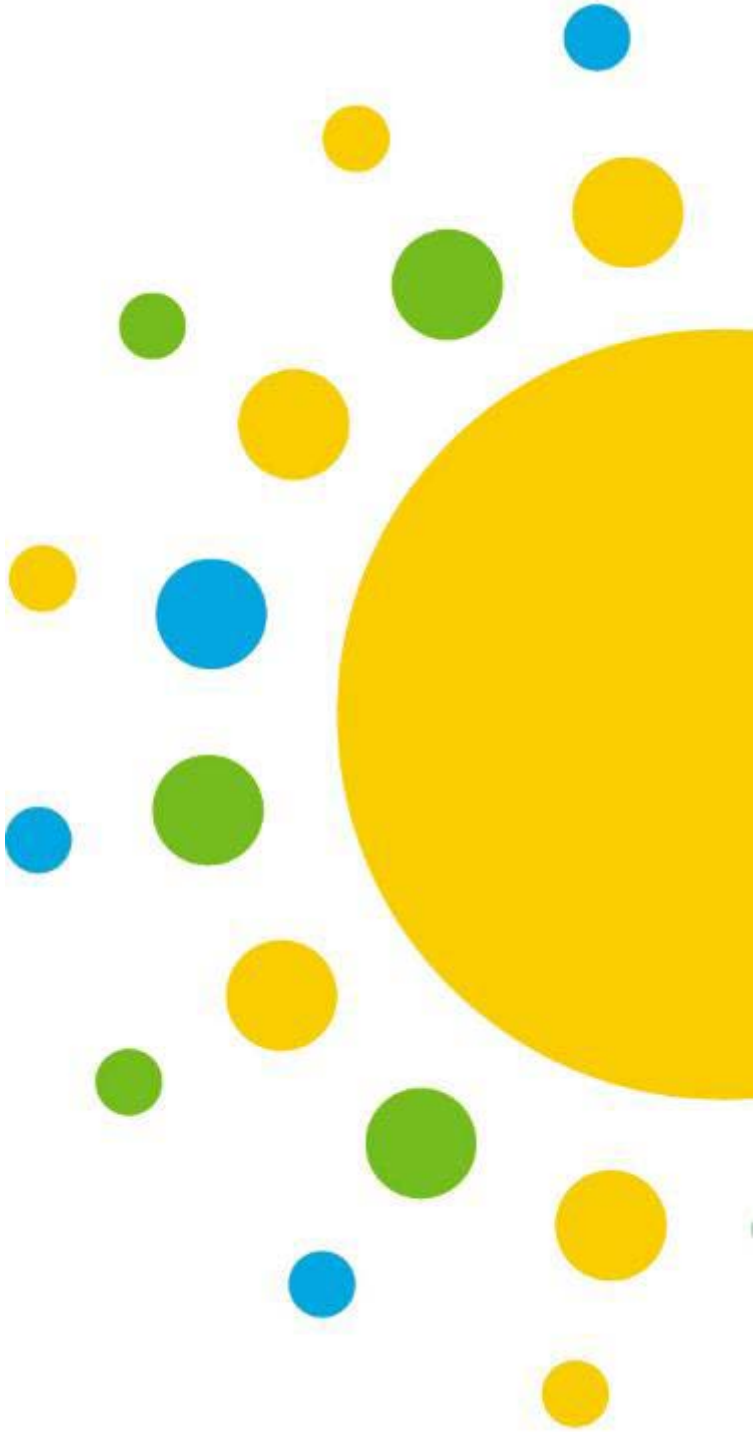
Energy burden by AMI in the Jefferson County area, Alabama, by census block. *Image from https://www.energy.gov/scep/slsc/lead-tool*

Energy Insecurity

- Energy insecurity is when households struggle to meet basic household energy needs (like heating and cooling). Energy burden is one facet of energy insecurity (SEEA 2021).
- Key Causes
  - Lack of access to efficient housing and building technologies
  - Low household incomes
  - High energy costs
- One of three residents in the Southeast have trouble paying their monthly energy bills and can be considered energy insecure (SEEA 2021).
- Resident behavior often changes under energy insecure circumstances, placing residential health and safety at risk (SEEA 2021).

Housing Energy Efficiency Upgrade Strategies in North Birmingham

Pathways for reducing energy use,
energy costs, and associated emissions



Housing Quality

Birmingham Housing Quality*

- 6,900 homes severely inadequate
- 27,900 homes moderately inadequate

Quality Issues

- Cracks in foundation
- Roof leakage
- Mold and moisture
- Pest infiltration
- Broken windows

Correlated with highest energy burdens in the city.

Will not benefit from weatherization or equipment upgrades unless addressed.

Determining how to address housing quality is an important consideration for efficiency retrofit programs intended for this community.

*Source: Census Bureau 2022b

Upgrade Strategies Overview

This section highlights seven residential building upgrade strategies that can be deployed in North Birmingham.

Each upgrade strategy presented includes:

- Measures: The improvements made to achieve the upgrade strategy
- Reductions potential: The estimated amount reduced (both dollars and energy) by implementing the upgrade strategy. The reductions change based on the home's heating system (natural gas or electric), among other factors. Utility reductions were calculated using the local rates listed in the Appendix.

Defining Reductions

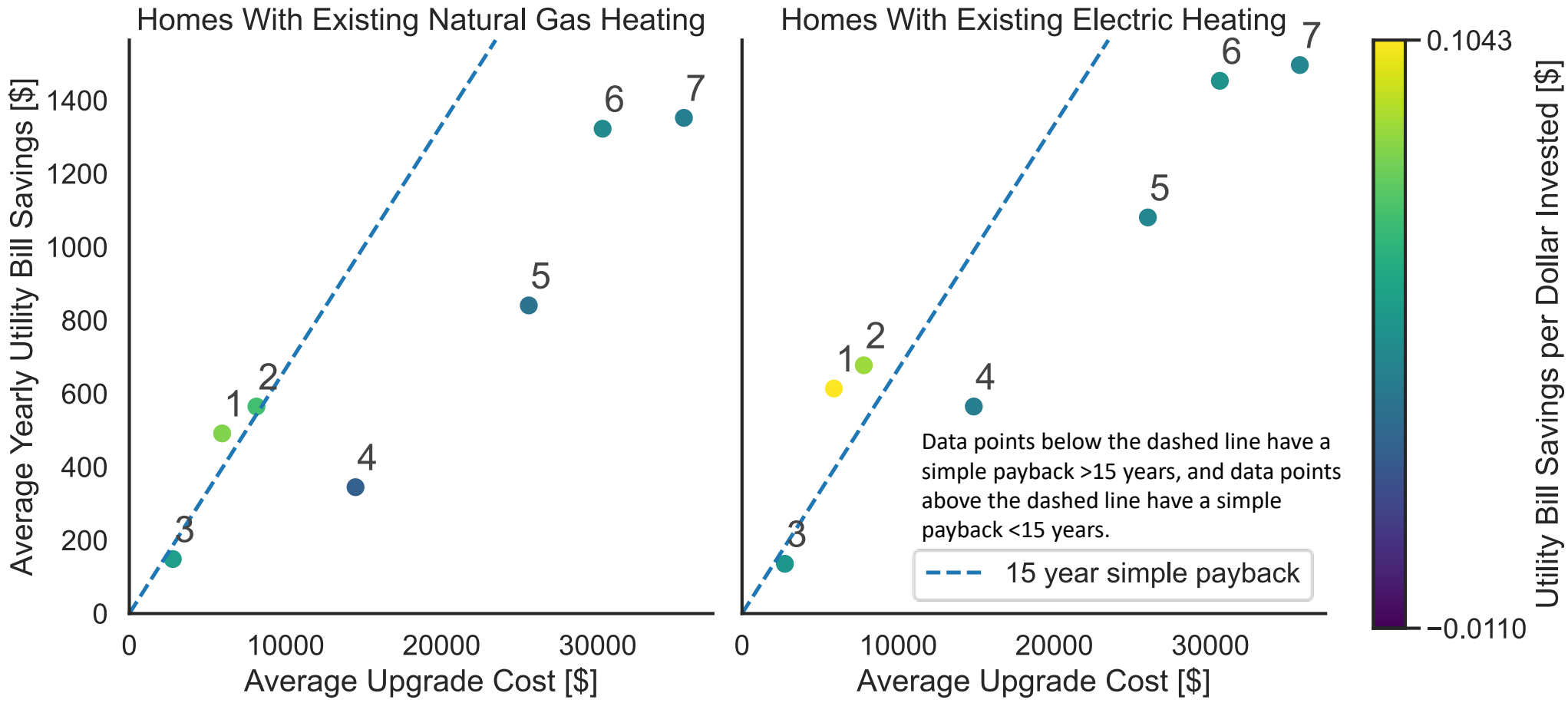
For the purposes of this North Birmingham analysis:

- Utility bill reductions: A range of modeled average yearly bill reductions per household at the 25th–75th percentile.
- Energy reductions: Percent of site energy reduced.
- Energy burden: change in energy burden resulting from energy bill reductions, does not consider the cost of the upgrade strategy.

Upgrade Strategies

1. Basic Enclosure
2. Enhanced Enclosure
3. Heat Pump Water Heater
4. Minimum Efficiency Heat Pump With Electric Heat Backup
5. High Efficiency Heat Pump With Electric Heat Backup
6. Basic Enclosure + Heat Pump Water Heater + High Efficiency Heat Pump With Electric Backup
7. Enhanced Enclosure + High Efficiency Home Electrification

Upgrade Strategies Modeled Cost Effectiveness, Birmingham (0–80% AMI)



Notes on Upgrade Strategy Modeled Results

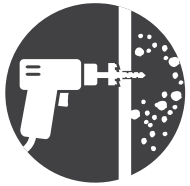
- Upgrade cost estimates are based on national data from 2012 that was adjusted for inflation to 2019 and regional cost differences. More up-to-date, regional or home-specific costs should be used when making local decisions.
- The upgrade costs presented do not account for any rebates or incentives.
- All results shown are for low- to moderate-income households (<80% AMI).

1. Basic Enclosure: Measures

Upgrade attic insulation to R-49

Reduce air leakage (infiltration) by 30%

Seal ducts to 10% leakage, add R-8 insulation



Drill and fill wall insulation to R-13

Installing attic insulation. *Image by Dennis Schroeder, NREL 28694*

Installing exterior insulation. *Image by Dennis Schroeder, NREL 28725*

1. Basic Enclosure: Modeled Average Reductions Potential in North Birmingham

Homes With Existing Natural Gas Heating

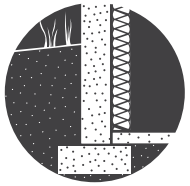
- Average upgrade cost: $5,900
- Annual bill reductions: $252–655
- Energy reductions: 23%
- Energy burden: 16% → 13%

Homes With Existing Electric Heating

- Average upgrade cost: $5,900
- Annual bill reductions: $280–880
- Energy reductions: 21%
- Energy burden: 21% → 16%

2. Enhanced Enclosure: Measures

Everything in the Basic Enclosure Package, and…



Add R-10 insulation to foundation walls and rim joists

Seal crawlspace vents

Insulate finished attic and cathedral ceilings to R-30

Installing crawlspace insulation. Image by Dennis Schroeder, NREL 17972.

Rim joist installation. Image by Corry Chovanec, NREL

2. Enhanced Enclosure: Modeled Average Reductions Potential in North Birmingham

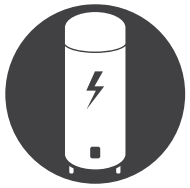
Homes With Existing Natural Gas Heating

- Average upgrade cost: $8,100
- Annual bill reductions: $297-734
- Energy reductions: 27%
- Energy burden: 16% → 12%

Homes With Existing Electric Heating

- Average upgrade cost: $7,800
- Annual bill reductions: $324-923
- Energy reductions: 24%
- Energy burden: 21% → 16%

3. Heat Pump Water Heater: Measures

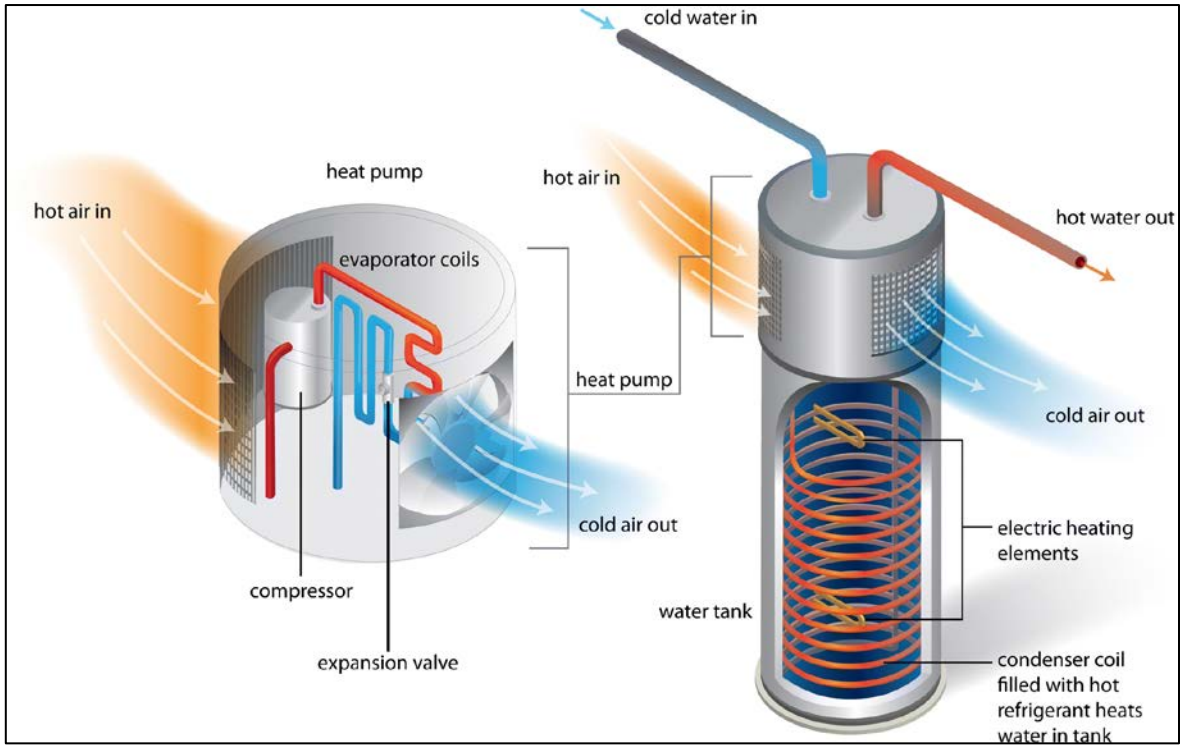


Replace existing water heater with heat pump water heater (HPWH)

Heat Pump Water Heater.
Image from Habitat for Humanity of Catawba Valley, via Building America Solution Center

Heat Pump Water Heater

- 67–75% energy reductions on water heating without sacrificing comfort (Sparn et al., 2021).
- Works by moving heat from air into the water.
- Helps reduce space cooling needs in the summer when installed in conditioned areas.
- When replacing existing gas water heating, removes risk of combustion byproducts getting into the home from an improperly installed or malfunctioning gas water heater.



How a heat pump water heater works. *Image from https://link.springer.com/article/10.1007/s40518-021-00177-5*

3. HPWH: Modeled Average Reductions Potential in North Birmingham

Homes With Existing Natural Gas Heating

- Average upgrade cost: $2,800
- Annual bill reductions: $99–208
- Energy reductions: 9%
- Energy burden: 16% → 15%

Home With Existing Electric Heating

- Average upgrade cost: $2,700
- Annual bill reductions: $60–174
- Energy reductions: 6%
- Energy burden: 22% → 21%

4. Minimum Efficiency Heat Pump With Electric Heat Backup: Measures

Air source heat pump with SEER 15 and 9.0 heating season performance factor (HSPF) ratings if the house has ducts

Mini-split heat pump with SEER 15 and 9.0 HSPF ratings if the house doesn't have ducts

Heat Pump

- What is a heat pump?
  - Heats in the winter and cools in the summer.
  - Works by moving heat rather than generating it.
  - Ducted and ductless (mini-split) options can replace furnace or boiler.
  - Especially when replacing natural gas heating, additional electrical work (e.g, panel upgrade) may be necessary.
- What are the benefits of a heat pump?
  - Can reduce your electricity use for heating by approximately 65% compared to electric resistance heating.
  - High-efficiency heat pumps also dehumidify better than standard central air conditioners, resulting in less energy usage and more cooling comfort in summer months.
  - When replacing existing gas heating with heat pump with electric backup, removes risk of combustion byproducts due to an improperly installed or malfunctioning gas furnace or boiler.
- Prices of heat pumps are changing rapidly right now, get local costs.

Source: DOE Energy Saver n.d.-a

Mini-split heat pump inside head unit. *Image from Building America Solution Center*

Ductless heat pump outside compressor. *Image from Building America Solution Center*

Ducted heat pump outside compressor. *Image from Building America Solution Center*

4. Min. Eff. Heat Pump With Electric Heat Backup: Modeled Average Reductions Potential in North Birmingham

Homes With Existing Natural Gas Heating

- Average upgrade cost: $14,000
- Annual bill reductions: $209–496
- Energy reductions: 30%
- Energy burden: 16% → 13%

Homes With Existing Electric Heating

- Average upgrade cost: $15,000
- Annual bill reductions: $265–855
- Energy reductions: 20%
- Energy burden: 21% → 17%

5. High Efficiency Heat Pump With Electric Heat Backup: Measures

Air source heat pump with SEER 24 and 13.0 HSPF ratings if the house has ducts

Mini-split heat pump with SEER 24 and 13.0 HSPF ratings if the house does not have ducts

5. High Eff. Heat Pump with Electric Heat Backup: Modeled Average Reductions in North Birmingham

Homes With Existing Natural Gas Heating

- Average upgrade cost: $26,000
- Annual bill reductions: $559–1,070
- Energy reductions: 44%
- Energy burden: 16% → 11%

Homes With Existing Electric Heating

- Average upgrade cost: $26,000
- Annual bill reductions: $597–1,461
- Energy reductions: 39%
- Energy burden: 21% → 13%

6. Basic Enclosure + HPWH + High Efficiency HP/Electric Backup: Measures

Everything in the Basic Enclosure Package, and…

Heat pump water heater

High efficiency heat pump with electric backup

Heat pump water heater. *Image from Building America Solution Center*

Heat pump outside compressor. *Image from Building America Solution Center*

6. Basic Enclosure + HPWH + High Eff. HP/Electric Backup: Average Modeled Reductions Potential

Homes With Existing Natural Gas Heating

- Average upgrade cost: $30,000
- Annual bill reductions: $972–1,592
- Energy reductions: 61%
- Energy burden: 16% → 8%

Homes With Existing Electric Heating

- Average upgrade cost: $31,000
- Annual bill reductions: $956–1,835
- Energy reductions: 53%
- Energy burden: 21% → 10%

Electrification

- Replacing fossil fuel appliances and equipment with electric versions
  - Furnace or boiler → Electric heat pump
  - Water heater → HPWH
  - Gas range and oven → Electric resistance or induction range and electric oven
  - Gas clothes dryer → Electric or heat pump clothes dryer

Electrification

Benefits

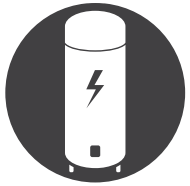
- Health and safety
  - Reduced airborne pollutants such as nitrogen oxides, carbon monoxide, and particulate matter in the home from cooking, which have been connected to respiratory irritation, asthma, etc. (Zhu et al., 2020).
  - Full electrification removes risk of carbon monoxide poisoning from gas appliances that are replaced
- Avoids natural gas price volatility
- No more fixed gas meter charge if fully electrified ($7.98/month in Birmingham)

Challenges

- Upfront cost of new equipment and appliances
- Cost of potential electric panel, service, and wiring upgrades on older homes

7. Enhanced Enclosure + High Efficiency Home Electrification: Measures

Everything in the Enhanced Enclosure Package, and…



Heat pump water heater

High efficiency heat pump with electric backup

Heat pump clothes dryer and induction range with electric oven

Electric Appliances

Electric Induction Range

- 3x more efficient than gas range*
- 10% more efficient that conventional electric range*
- Lower indoor air pollutants than gas**
- Safety: turns off when pot is removed, surface is not as hot*
- Faster, more precise cooking*
- Works with most pots or pans that a magnet will stick to*

Heat Pump Clothes Dryer

- 28% energy reductions over conventional electric clothes dryer***
- Does not need to be vented to outside***

* Source: DOE Energy Saver n.d.-b
** Source: Environmental Protection Agency n.d.
*** Source: ENERGY STAR n.d.

7. Enhanced Enclosure + High Eff. Home Electrification: Modeled Average Reductions Potential in North Birmingham

Homes With Existing Natural Gas Heating

- Average upgrade cost: $36,000
- Annual bill reductions: $998–1,641
- Energy reductions: 64%
- Energy burden: 16% → 8%

Homes With Existing Electric Heating

- Average upgrade cost: $36,000
- Annual bill reductions: $1,029–1,863
- Energy reductions: 55%
- Energy burden: 21% → 10%

Energy Efficiency Strategies for Renters

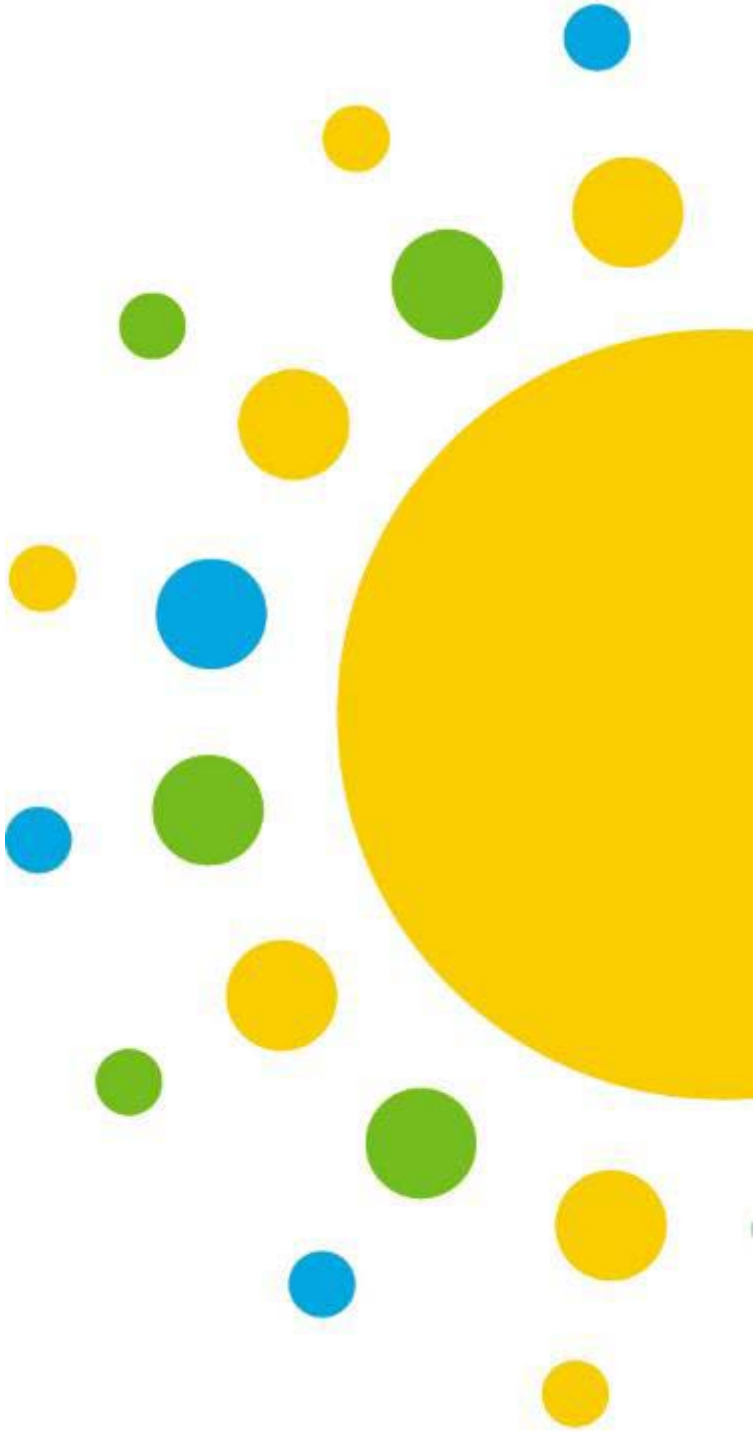
- Technologies tenants can generally apply to their homes with limited or no interaction with landlords
  - LED light bulbs
  - Methods to use less hot water: faucet aerators and showerheads
  - Weather stripping
  - Smart power strips
  - Smart thermostats
  - Window unit heat pump

Energy Efficiency Strategies for Renters

- Examples of incentives/requirements for landlords to improve energy efficiency of their units
  - Inflation Reduction Act (IRA) sections 50121 & 50122 qualify for rebates based on income of the tenants
  - Rental inspections that require a minimum level of energy efficiency: Gainesville, Florida and Berkeley, California including ”equity guardrails”*
  - Denver, Colorado offers additional funding and services for electrification to affordable housing*
  - California Energy Commission direct-install program includes requirements to minimize rent increases or evictions.*

* Source: Communities LEAP 2024

Incentive Opportunities



Key Resources for Home Retrofits

- Federal Government
  - Home Efficiency Rebates (HOMES) and Home Electrification and Appliance Rebates (HEAR) IRA rebate programs
  - Weatherization Assistance Program (WAP)
  - Low Income Home Energy Assistance Program
  - Federal Energy Efficiency Tax Credits
- Nonprofit
  - Neighborhood Housing Services' Healthy Housing Initiative
- Utility (Alabama Power)
  - Measure rebates

Incentive Programs Summary

	Occupant Status (Owner or Renter)	Income Qualified	Program Status	Notes
Home Electrification and Appliance Rebates (HEAR)	-Low to Moderate Income (LMI) Household (rent or own) -Owner of Multifamily building	Households: <80% AMI: up to 100% of project cost; 80-150% AMI: 50% of project cost Multifamily Owner: 50+% <80% AMI up to 100% project costs; 50+% 81-150% AMI up to 50% project costs	In development	The amount is currently outlined by the federal government but subject to state decision making. Households cannot use both HEAR and HOMES rebates for the same measure. Households are eligible for a total of $14,000 in HEAR rebates across all products.
HEAR Installation Rebate	Rebate is not available to resident.	Rebate is not available to resident.	In development	For governmental, philanthropic, commercial, and nonprofit (e.g., community groups) organizations that perform installations.
Federal Energy Efficiency Tax Credit	Owner	No, but enough tax liability is required to use credits	Active	Installation costs not included. To be eligible for the credit, the improvement must meet the prescriptive requirements established for it under the 2009 International Energy Conservation Code (including supplements). All insulation materials are subject to the same $1,200/yr cap, even if they insulate separate parts of the home. Home must be the primary residence.
Alabama Power	Owner	No	Active	Must switch from gas water heater to qualifying electric HPWH
WAP	LMI household (rent or own)	Available to households at or below 200% of the poverty income guidelines. Households that receive Supplemental Security Income (or Aid to Families with Dependent Children) are also eligible.	Active	WAP funds can be used to weatherize a range of home components, and to address health and safety hazards in the home. Weatherization Readiness Funding can be used for priority repairs that would otherwise disqualify a home from participation in WAP.
Neighborhood Housing Services	Owner	Households with incomes <80% of the AMI. The program is available to residents of Jefferson County, Alabama. Residents must own the single-family home and show proof that it is their primary residence as well as proof of insurance.	Active	Repairs can include but are not limited to roofs, HVAC system, electrical, plumbing, structural repairs, insulation, and weatherization.

This slide is for summary purposes only. Please refer to specific programs for official and latest requirements and details.

Inflation Reduction Act (IRA) Rebates

- Two programs:
  - Section 50121: HOMES
  - Section 50122: HEAR
- Only one program can be used for an upgrade.
- Incentives are greater for households <80% AMI.
- Final rules are still being developed (as of March 2024).
- Will be administered by the state energy office, which can add additional requirements.

This slide is for summary purposes only. Please refer to specific programs for official and latest requirements and details.

Home Efficiency Rebates (HOMES)

Rebate Category	80–150% AMI Rebate Amount	<80% AMI Rebate Amount
20% modeled energy reductions	$2,000 50% of project cost	$4,000 80% of project cost
35% modeled energy reductions	$4,000 50% of project cost	$8,000 80% of project cost
15% measured energy reductions	$2,000 50% of project cost	$4,000 80% of project cost

- Rebate amount is the lesser of the dollar amount or percentage of project cost.
- Modeled energy reductions are calculated with certified software that is calibrated to past utility bills of the home.
- Measured energy reductions are calculated by comparing pre- and post-retrofit utility bills with some statistical normalization for differences in weather.
- For a multifamily building, these rebates are *per dwelling unit* with some limitations to total building rebate amount.

Source: Inflation Reduction Act 2022

This slide is for summary purposes only. Please refer to specific programs for official and latest requirements and details.

Home Electrification and Appliance Rebates (HEAR)

Upgrade	Rebate Amount
Heat pump water heater	$1,750
Heat pump for heating and cooling	$8,000
Electric stove, cooktop, range, or oven	$840
Heat pump clothes dryer	$840
Electric panel upgrade	$4,000
Insulation, air sealing, ventilation	$1,600
Electric wiring	$2,500

Rebate Limits:

- $14,000 total
- Up to 50% of project cost for 80–150% AMI households
- Up to 100% of project cost for <80% AMI households

Source: Inflation Reduction Act 2022

This slide is for summary purposes only. Please refer to specific programs for official and latest requirements and details.

Federal Energy Efficiency Tax Credit

Clean Energy Tax Credits for Consumers: Federal tax credits are available for homeowners and renters for qualifying upgrades on their primary residence.

More information: https://www.energy.gov/sites/default/files/2023-02/Tax%20Credit%20Table.pdf

Equipment Type	Tax Credit for 2023-2032 Tax Years
Home Clean Electricity Products	
Solar (electricity)	30% of cost
Fuel Cells	30% of cost
Wind Turbine	30% of cost
Battery Storage	30% of cost
Heating, Cooling, and Water Heating	
Heat pumps	30% of cost, up to $2,000/year
Heat pump water heaters	30% of cost, up to $2,000/year
Biomass stoves	30% of cost, up to $2,000/year
Solar (water heating)	30% of cost
Efficient air conditioners	30% of cost
Efficient heating equipment	30% of cost, up to $600
Efficient water heating equipment	30% of cost, up to $600
Other Energy Efficiency Upgrades	
Electric panel or circuit upgrades for new electric equipment	30% of cost, up to $600
Insulation materials	30% of cost
Windows, including skylights	30% of cost, up to $600
Exterior doors	30% of cost, up to $500 for doors (up to $250 each)
Home energy audits	30% of cost, up to $150
Home electric vehicle charger	30% of cost, up to $1,000

This slide is for summary purposes only. Please refer to specific programs for official and latest requirements and details.

Weatherization Assistance Program

- Eligibility
  - Households at or below 200% of the poverty income guidelines
  - Households that receive Supplemental Security Income or Aid to Families with Dependent Children
- WAP funds can be used to weatherize a range of home components, including:
  - Building envelope
  - Mechanical/HVAC equipment
  - Electric and water equipment/appliances
  - Address health and safety hazards in the home.
- Covers a range of measures based on cost effectiveness, as determined by an energy audit
- Total average cost per dwelling in Alabama in 2023 is approximately $8,000
- Weatherization readiness funding can be used for priority repairs that would otherwise disqualify a home from participation in WAP.
- Alabama Weatherization Assistance Program: https://adeca.alabama.gov/weatherization/

This slide is for summary purposes only. Please refer to specific programs for official and latest requirements and details.

Neighborhood Housing Services, Healthy Housing Initiative

- Variable funding available for low-income households in Jefferson County to improve conditions of a home and major systems
  - Housing rehabilitation (roofs, HVAC system, plumbing and electrical systems, structural repairs)
  - Energy-related upgrades
  - Weatherization repairs and improvements
- Eligibility
  - Home ownership
  - 80% or below AMI
- Healthy Housing Initiative: https://nhsbham.org/healthy-housing-initiative/

This slide is for summary purposes only. Please refer to specific programs for official and latest requirements and details.

Alabama Power

Alabama Power does not offer energy efficiency assistance specifically to income-qualified customers.
The following rebates are available (as of March 2024):

Level 2 Home Electric Vehicle Charger (240V): $500 rebate

- Qualifying single-family homes must verify that they already own a battery electric vehicle or plug-in hybrid electric vehicle, and only one charger per household is eligible.

https://www.alabamapower.com/residential/save-money-and-energy/energy-saving-products/electric-vehicles/ev-home-charger-rebate.html

Smart Thermostat: $200 rebate

- Available for a range of qualified thermostats, but only for one thermostat per home.
- Only for single-family households where the resident owns the home or has permission of their landlord to install a smart thermostat.

https://www.alabamapower.com/residential/save-money-and-energy/energy-saving-products/rebates-and-incentives.html

Heat Pump Water Heater/Fuel switching: $650 rebate

- Only available for converting from an existing gas water heater to an electric heat pump water heater, with limitations on the heat pump water heater type (i.e., no tankless water heaters are eligible).
- Only available to homeowners who live in single-family homes built more than 1 year ago, and homeowners cannot have received a water heater incentive from the utility in the last 8 years.

https://www.alabamapower.com/residential/save-money-and-energy/energy-saving-products/rebates-and-incentives.html

This slide is for summary purposes only. Please refer to specific programs for official and latest requirements and details.

Funding for “Hard to Reach” Households

Neighborhood Housing Services

Healthy housing programs

HEAR (Single-Family)

Full costs for households **<80% AMI**

Half costs for households at **80–150% of AMI**

Weatherization Assistance Program

Renter/owner households **≤200% of the federal poverty level**, receive Supplemental Security Income or Aid to Families with Dependent Children.

HEAR (Multifamily)

Full costs for buildings **w/ 50% of residents with income <80% AMI**

Half costs for buildings **w/ 50% of residents 81–150% AMI**

HOMES (SF and MF)

More reductions for single-family/multifamily households at <80% of AMI; less reductions for those at 80% AMI+

*Reductions vary by energy-saving targets

SEEA
SOUTHEAST ENERGY EFFICIENCY ALLIANCE

Stacking Funds Can Achieve Deeper Retrofits

Appliances:
HEAR rebate (up to $840 per measure):

- Electric range/oven
- Heat pump clothes dryer
- Induction cooking

Heat pump water heater:
HEAR rebate (Up to $1,750)
+ installer rebate ($150)
+ AL Power rebate ($650)
+ federal tax credit (30% of remaining cost, up to $2,000/year)

Insulation:
HEAR rebate (up to $1,600)
+ installer rebate ($250)
+ federal tax credit (30% of remaining cost, up to $1,200/year)

Heat pump:
HEAR rebate (up to $8,000)
+ installer rebate ($200–$300)
+ federal tax credit (30% of remaining cost, up to $2,000/year)

Whole home weatherization and repair:
Average of $8,000 from WAP + funding through Neighborhood Housing Services Healthy Housing Initiative

This slide is for summary purposes only. Please refer to specific programs for official and latest requirements and details.

Thank You

www.energy.gov/communitiesLEAP

Produced for the U.S. Department of Energy
by the National Renewable Energy Laboratory (NREL).
DOE/GO-102024-6256 • June 2024

References

Asthma and Allergy Foundation of America. 2021. *Asthma Capitals 2021: The Most Challenging Places to Live With Asthma.* https://www.aafa.org/wp-content/uploads/2022/08/aafa-2021-asthma-capitals-report.pdf.

Bartlett, R., J Hathaway, M Halverson, Y Xie, M. Zhao, and V. Mendon. 2017. *Alabama Residential Energy Code Field Study: Baseline Report.* PNNL-26168. https://www.energycodes.gov/sites/default/files/2019-09/Alabama_Residential_Field_Study_1.pdf.

Census Bureau. 2022. American Community Survey. https://www.census.gov/programs-surveys/acs.

Census Bureau. 2022b. American Housing Survey. https://www.census.gov/programs-surveys/ahs.html.

Communities LEAP. 2024. "Introduction to Local Policy and Program Approaches for Electrifying and Decarbonizing Existing Buildings." DOE/GO-102024-6155. https://www.nrel.gov/docs/fy24osti/88439.pdf."

Dahl, Kristina, Erika Spanger-Siegfried, Rachel Licker, Astrid Caldas, John Abatzoglou, Nicholas Mailloux, Rachel Cleetus, Shana Udvardy, Juan Declet-Barreto, and Pamela Worth. 2019. *Killer Heat in the United States: Climate Choices and the Future of Dangerously Hot Days.* Cambridge, MA: Union of Concerned Scientists. https://www.ucsusa.org/sites/default/files/2020-12/UCS_extreme_heat_report_190712b_low-res_corrected12-20.pdf.

Department of Energy (DOE). n.d. "Air Sealing Your Home." Accessed March 22, 2024. https://www.energy.gov/energysaver/air-sealing-your-home.

DOE Energy Saver. n.d.-a "Gas and Electric Ovens, Stoves, and Ranges." Accessed March 22, 2024. https://www.energy.gov/energysaver/gas-and-electric-ovens-stoves-and-ranges.

DOE Energy Saver. n.d.-b "Heat Pump Systems." Accessed March 22, 2024. https://www.energy.gov/energysaver/heat-pump-systems.

DOE Office of Energy Efficiency and Renewable Energy Building Energy Codes Program. n.d. "Alabama." Accessed March 22, 2024. https://www.energycodes.gov/status/states/alabama.

Drehobl, Ariel, Lauren Ross, and Roxana Ayala. 2020. *How High Are Household Energy Burdens?* Washington, DC: American Council for an Energy-Efficient Economy. https://www.aceee.org/research-report/u2006.

References, Continued

Energy Information Administration (EIA). 2009. *Residential Energy Consumption Survey.* https://www.eia.gov/consumption/residential/index.php.

EIA. 2022. "U.S. natural gas price saw record volatility in the first quarter of 2022." Accessed March 22, 2024. https://www.eia.gov/todayinenergy/detail.php?id=53579.

ENERGY STAR. n.d. "Heat Pump Dryer." Accessed March 22, 2024. https://www.energystar.gov/products/clothes_dryers/heat-pump-dryer.

Environmental Protection Agency. n.d. "The Inside Story: A Guide to Indoor Air Equality." Accessed March 22, 2024. https://www.epa.gov/indoor-air-quality-iaq/inside-story-guide-indoor-air-quality

Inflation Reduction Act. 2022. Public Law 117-169, Section 50121. https://www.congress.gov/117/plaws/publ169/PLAW-117publ169.pdf.

International Code Council (ICC). 2015. "2015 International Energy Conservation Code." https://codes.iccsafe.org/content/IECC2015.

ICC. 2021. "2021 International Energy Conservation Code." https://codes.iccsafe.org/content/IECC2021P1.

Southeast Energy Efficiency Alliance. 2021. "Energy Insecurity in the South." https://storymaps.arcgis.com/stories/4377299f586a493984222bfc6ee84e60.

Sparn, Bethany and Jeff Maguire. 2021. "Increasing the Number of Installed Residential Heat Pump Water Heaters in the USA Through Improved Technology and Utility Programs." *Current Sustainable/Renewable Energy Reports*. Volume 8, pages 107–113. https://link.springer.com/article/10.1007/s40518-021-00177-5.

Tableau Public. n.d. "NREL Residential Building Stock Analysis." Accessed April 16, 2024. https://public.tableau.com/app/profile/nrel.buildingstock/vizzes

Zhu, Yifang, Rachel Connolly, Yan Lin, Timothy Matthews, and Zemin Wang. 2020. *Effects of Residential Gas Appliances on Indoor and Outdoor Air Quality and Public Health in California.* Los Angeles, CA: UCLA. https://coeh.ph.ucla.edu/effects-of-residential-gas-appliances-on-indoor-and-outdoor-air-quality-and-public-health-in-california/.

Appendix: Electric and Natural Gas Rates

Alabama Power Family Dwelling Residential Service	
June - September	
First 1000 kWh	12.4384
Over 1000 kWh	12.6913
October-May	
First 750 kWh	12.4384
Over 750 kWh	11.2384

Spire Natural Gas Rates		
Charge for gas used (per Ccf)	Effective rate	Rate $/therm
1st 50 Ccf	$1.97	$1.90
Next 150 Ccf	$1.70	$1.64
Over 200 Ccf	$1.65	$1.59
Customer charge	$7.98	$7.70
CCF = therms	1.036	

This slide is for summary purposes only. Please refer to specific programs for official and latest requirements and details.