Gas to Electric:
Equitable Home Electrification Policy in Michigan

Michigan Environmental Justice Coalition

Report created by the Michigan Environmental Justice Coalition, 2023

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Table of Contents

Executive Summary

Eliminating emissions associated with heating, cooling, and powering residential and commercial buildings is essential to achieving economy-wide elimination of climate-warming emissions. The State of Michigan is home to ten million people living in some four million residential buildings. To meet climate goals, Michigan must weatherize and electrify all of its homes, and power them with pollution-free, renewable energy. However, the costs of home weatherization and electrification are significant and unaffordable for many families; Michigan will not achieve building sector decarbonization if it relies upon individual families to foot the bill. Thus, Michigan policymakers must begin to design, fund, and implement equitable home electrification policies.

In the United States, housing policies and public investments in housing have historically worsened existing race and class inequities. With that in mind, this project seeks to help policymakers understand the scale of investment required to achieve equitable home electrification in Michigan. First, we estimate the cost of electrifying all residential heating systems in Michigan. Second, we estimate the cost of electrifying the homes of Michigan families earning less than 200% of the federal poverty level. To be clear, a much larger segment of the Michigan population will be unable to afford home electrification without public support. However, this represents a portion of Michigan families who are particularly vulnerable to increases in housing and energy costs. Finally, this project estimates the cost of weatherizing homes in preparation for heating, ventilation, and air conditioning (HVAC) electrification, which is necessary to keep home energy costs affordable and manage the increased demand for electricity generation.

To approximate the costs of weatherization and HVAC electrification in Michigan, we used publicly available demographic and housing data, and recent research on home retrofit costs. To determine Michigan's housing composition, we used the Department of Energy (DOE) Low-Income Energy Affordability (LEAD) tool. The total numbers of housing units were derived from LEAD for the three main types of housing in the state: single-family homes, multi-unit housing units, and mobile homes. Next, we identified the most important types of upgrades and technologies needed to adequately weatherize homes and electrify their HVAC systems using a combination of industry expertise and literature review. Finally, we applied different methods for determining the retrofit and heat pump costs, given differences in both architectural characteristics and available data on retrofit costs across the three housing types.

We estimate that the cost to electrify and weatherize Michigan residential housing is about $73.6 billion, with about 30 percent of costs allocated to weatherization and about 70 percent to HVAC electrification. About one third of the total cost ($23 billion) pertains to the homes of Michigan families earning 200 percent of the Federal Poverty Limit (FPL) or below. These cost estimates do not include the costs of pre-weatherization – critical upgrades like roof replacements, carbon monoxide proofing, lead abatement, and asbestos removal – that must precede weatherization.

While $73.6 billion may seem like an intimidating price tag, home electrification is not optional – and with thoughtful policy design and resource mobilization, it can be transformative for millions of people across Michigan by improving health and increasing access to affordable housing. Currently, households in Michigan are paying through their monthly energy bills for two energy distribution systems: gas and electric. If home electrification does not proceed quickly, with careful planning that centers racial and economic equity, Michigan will find itself paying twice: once for the repair and replacement of our retirement-age gas distribution system, and again for home electrification and electric grid investments as it slowly and inequitably rolls out. The time is now for Michigan policymakers to take on the challenge of equitably eliminating emissions from the residential building sector.

This report answers key questions to support the design of equitable home electrification policies in Michigan. Many questions remain. How will we systematically implement home electrification alongside residential gas pipeline decommissioning? How will Michigan develop the workforce to implement weatherization and electrification? To what extent will the federal government fund home electrification and associated workforce development? How will household energy bills change after home electrification? How can rooftop and community solar expansion complement equitable home electrification by offsetting high energy bills, as part of an energy planning framework that prioritizes equity, climate resilience, and highest social benefit?

Decision-makers at all levels of government must take bold action to address simultaneous crises of climate change and social inequities. With adequate funding and thoughtful program design, home electrification can mitigate both. Michigan policymakers must begin to take on the challenge today.

Acknowledgements

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Introduction

No matter what we look like or where we live, our homes are central to how we affect, and survive, the climate crisis.

They are a primary source of our fossil fuel dependency, given the state of our coal- and gas-fueled electric grids, and gas-based cooking and heating equipment. **They also determine our ability to weather worsening storms and extreme weather: Can we keep our families warm in the winter, and cool in the summer? Will our basements flood, and can we recover? When we turn on the tap, is the water safe for our children to drink? Can we breathe clean air inside and outside of our homes, or does particulate matter, mold, lead, and other toxins worsen asthma and contribute to disease? The answers vary widely by race and income.**

Twentieth-century residential segregation policies engendered immense wealth extraction from Black, Indigenous, and People of Color families and, simultaneously, enabled the concentration of pollution burdens in BIPOC and low-income communities. More recently, waves of mortgage and tax foreclosure and accelerating gentrification have contributed to an affordable housing crisis where many families cannot meet their basic housing needs, let alone make the switch away from fossil fuels or invest in their home's climate resilience. Twenty-first century Just Transition policies, particularly home electrification, are an opportunity to meaningfully repair some of these harms while staving off the worst impacts of the climate crisis. **To achieve a 100% renewable energy transition and healthy, climate-resilient homes for all Michiganders, the state must invest on a massive scale, targeted to Black, Indigenous, and energy-burdened communities, in: (1) home repair & weatherization, (2) home electrification, and (3) simultaneous addition of distributed renewable energy to meet energy needs without the addition of more fracked gas.**

How much will this cost? We urgently need our state government to begin asking and answering this question. The state's recently-released Michigan Healthy Climate Plan[1] acknowledges the need for an economy-wide transition away from fossil fuels, including in our homes and buildings, but it does not answer to the requisite pace, scale, and justice implications of home electrification. It recommends modest changes to utility energy waste reduction targets, incentives, and financing options for private investments, and acknowledges that **"Michigan must increase investment in home repairs," without suggestion of** how, how much, for what, or for whom.

Through this research study, MEJC seeks to catalyze the conversation around enacting just home electrification at scale in Michigan, particularly around the necessary scale of public investment. To start, MEJC pursued the following research questions:

1. How much are the "first costs" of residential heating electrification in Michigan – the capital costs to weatherize (e.g., sealing, insulation, ductwork) and electrify (e.g., install heat pumps) all residential homes?
2. What is the cost of doing this for the subset of Michiganders living at or below 200% of the federal poverty limit (one-third of the state population)?

This project closes multiple gaps. First, it identifies the scale of investment required to electrify all residential heating in the state of Michigan. Second, it begins to define the scale of public investment required to electrify low-income homes, ensuring equitable outcomes and complete residential electrification. We also estimate the budget required to weatherize homes in preparation for HVAC electrification, which is essential to keep home energy costs affordable and manage the increased demand for electricity generation.

[1] https://www.michigan.gov/egle/-/media/Project/Websites/egle/Documents/Offices/OCE/MI-Healthy-Climate-Plan.pdf

Understanding weatherization and heating electrification

Residential energy accounts for over 20% of energy consumption and greenhouse emissions in the U.S. and 30% of Michigan's energy consumption.[2,3,4] Of residential energy needs, space heating and air conditioning represent a substantial portion. **According to the U.S. Energy Information Administration, space heating and air conditioning accounts for 56% of energy use in Michigan.**[5] Natural gas fuels 77% of Michigan's home heating and is only expected to grow.[6] Given Michigan's cold climate, and the fact that Michigan homes are typically older than homes in other states, it may not come as a surprise that **Michigan homes use almost 40% more energy per home than the U.S. average and Michiganders spend 6% more for energy than the U.S. average**. **Energy affordability is commonly defined as spending no more than 6% of household income on gas and electricity, yet low-income families in Michigan on average spend 15% of their income on energy bills, with assistance programs out of reach for many eligible residents.**[7]

The imperative to eliminate climate-warming emissions, and ensure that all Michiganders can care for their families with affordable heating and cooling, make equitable weatherization and heating electrification essential. The federal government and scientists agree that heat pumps are the right technology to secure all-electric heating for homes. Heat pump systems are electric-powered and far more energy efficient than gas-powered furnaces and boiler systems, and can support heating needs even in cold climates. Heat pumps work by using electricity to transfer heat, rather than generating heat. So, in the winter, heat pumps move heat from the outdoors into the home; in the summer, heat pumps move heat from in the home to outside.[8]

In concert with heat pump installation, homes must be "weatherized" to minimize heating and cooling losses to the outdoors. Heat pumps work by transferring heat, and rely on the home's ability to maintain an internal environment. Proper weatherization ensures that the home will not lose heat or let in cold air during cold months, and vice versa in warm months. Proper weatherization also ensures that air temperature remains consistent and is properly distributed throughout the home.

How weatherized a home is—and therefore how ready it is to have its HVAC systems converted to electric-powered heat pumps—depends largely on when and how well it was built. There is no income threshold at which one can assume a home is properly weatherized. The extent of work needed to weatherize a home is related to housing vintage, or the year the house was first built.

The two most important avenues of weatherization include insulation and air sealing. Proper insulation creates resistance to the flow of heat between separated areas–like the outdoors and indoors–so a desired temperature can be maintained with minimal energy. Proper air sealing reduces the amount of air that can leak in and out of the home, so air that is heated or cooled does not have to be reheated or recooled constantly. HVAC duct sealing and replacement for old, drafty windows are also important for proper weatherization, since they ensure heating or cooling distribution throughout the home and minimal temperature changes associated with windows.

Even as the Midwest lags behind other regions of the country in the transition to pollution-free electricity generation, researchers forecast that use of an electric heat pump – rather than a high-efficiency gas furnace -

[2]https://www.eia.gov/state/?sid=MI#tabs-2

[3]https://www.eia.gov/analysis/studies/buildings/households/

[4]https://www.pnas.org/doi/10.1073/pnas.1922205117#:~:text=Residential%20energy%20use%20accounts%20for,emissions%20in%20the%20United%20States.

[5]https://www.eia.gov/consumption/residential/reports/2009/state_briefs/pdf/mi.pdf

[6]https://www.michigan.gov/mpsc/commission/news-releases/2022/11/21/winter-energy-appraisal-finds-growing-demand-and-prices

[7]https://www.elevatenp.org/wp-content/uploads/Energy-Burden-in-MI.pdf

[8]https://www.energy.gov/energysaver/air-source-heat-pumps

would reduce the global warming potential (GWP) of heating a single-family home in our region by 45-57% over a 20-year period.[9] This dramatic reduction is in part due to the high global warming potential of methane leakages associated with fossil gas heating. The emissions reduction potential is predicted to increase over time as renewable electricity generation replaces polluting power plants. All-electric homes work in tandem with community-based, distributed solar, as well as large-scale renewables, energy storage technologies, and decommissioning of the gas distribution system to fully eliminate climate-warming emissions and mitigate the worst of the climate crisis.

To electrify the homes of all 10 million Michiganders, the homes must be weatherized and retrofitted with heat pump technology. The cost of conversion is significant and unaffordable to many Michigan families, who already face extremely high energy bills and dangerous shutoffs by their utility providers due to inability to pay. Once retrofitted, improved weatherization and healthier heating systems may raise property values and contribute to gentrification and housing displacement. Equitable home electrification will require careful planning that accounts for housing and energy affordability, and aims to drive health and economic benefits of climate investments to communities most burdened by the current energy system. Understanding the cost of statewide residential HVAC electrification is critical to such planning.

The MI Healthy Climate Plan

In 2022, the Michigan Department of Environment, Great Lakes, and Energy released the MI Healthy Climate Plan (MHCP), *"a broad vision for fulfilling the governor's fall 2020 commitment for Michigan to achieve 100% economy-wide carbon neutrality*[10] *by midcentury,"* with a focus on 2030 objectives. This document will likely serve as a backbone for climate policy pursued by the state legislature.

The MHCP broadly acknowledges the severity of the climate crisis and the cost of inaction, and recognizes that the transition away from fossil fuels can advance economic opportunities and environmental justice. However, the plan's 2030 objectives, and recommended strategies to accomplish them, include many fossil fuel industry-promoted "solutions" that would undercut Michigan's ability to eliminate climate-warming emissions, and would further harm communities who bear the brunt of environmental burdens.

Relevant to this report, the plan calls for a 17 percent reduction of climate-warming emissions from the building sector by 2030, and states, *"We will accomplish this objective through investments in energy conservation, energy efficiency, smart consumption, cogeneration, and replacing traditional fossil fuel use with cost-effective technologies that rely on electricity and alternatives like renewable natural gas and hydrogen."* **This analysis responds to the imperative that Michigan fully eliminate emissions from our homes through equitable electrification paired with energy efficiency measures and renewable energy generation**. Therefore, it is important to explain why "renewable natural gas" and hydrogen are not viable or even safe alternatives for reducing emissions from homes and commercial buildings.

When gas utilities refer to "renewable natural gas," they mean methane that is harvested from industrial sources like landfills and confined animal feeding operations (CAFOs), and theoretically fed into the existing gas distribution system that serves homes and businesses. **Regardless of where it comes from, methane has a climate-warming potential 20 times greater than that of carbon dioxide, and the leakage of methane and co-occurring pollutants contributes significantly to the climate impacts and health problems, including cancer and respiratory problems, associated with gas-powered home heatin**g. Meanwhile, the sources of "renewable natural gas" are extremely small, expensive, and carbon-intensive – landfills and CAFOs must be ramped down to meet waste reduction and sustainable agriculture goals.[11]

[9] https://www.sciencedirect.com/science/article/pii/S0301421522000386#fig3

[10] The term "carbon neutral" is distinct from terms like "pollution-free" and "regenerative," which are used by the environmental justice movement. "Carbon neutral" can imply continued emissions of carbon dioxide and toxic co-pollutants, whose global warming emissions are supposedly neutralized by unproven carbon capture technology or widely-discredited carbon offset schemes.

[11] https://www.sightline.org/2021/03/09/the-four-fatal-flaws-of-renewable-natural-gas/

Hydrogen gas is a dangerous energy source particularly ill-suited for use in homes and businesses. It is generated using energy produced from fossil fuel combustion or renewable energy generation. Compared to utility-scale batteries and pumped-storage hydropower, which have an efficiency of roughly 80 percent [12], hydrogen stores about 30 percent of the energy used to produce it. It is also water-intensive: **The production of hydrogen from renewable energy uses 5,000 liters of water per megawatt-hour, compared to 20 liters for solar and 1 for wind.**[13] Distribution of hydrogen poses a safety risk when piped through the existing infrastructure because it embrittles gas transmission lines, aggravating small cracks and this is particularly concerning given that much of the gas distribution system is old, leakprone, and badly in need of replacement or retirement. Ruptures have led to explosions in pipelines, factories, and homes.[14,15] **Hydrogen is 14 times lighter than air, making it more likely than methane to leak, and when it does, it is 11 times worse for global warming than CO2.**[16] Burning hydrogen for home heating, and blending it with methane, will not only increase emissions but health hazards.[17] Burning hydrogen creates nitrogen dioxide, a gas which causes severe respiratory illness in already overburdened communities.[18] Thirty-two independent studies have shown that hydrogen for the home is less efficient, much more expensive, and more dangerous than using heat pumps, solar and other truly renewable options.[19]

We describe the MI Healthy Climate Plan because it represents growing political possibility for state climate action, and also a troubling obfuscation of proven climate solutions and the resources required to implement them. It is clear that in Michigan and across the country, we must equitably and systematically electrify residential buildings, decommission the gas distribution pipelines that serve them, and build out distributed, renewable energy.

Further federal action is needed, but states cannot wait to act. The Inflation Reduction Act, passed in August 2022, contains funding for two programs, the HOMES Rebate Program and the High-Efficiency Electric Home Rebate Act, to fund residential energy efficiency and electrification upgrades, for both tenant- and owner-occupied homes. The total funding for these programs averages out to roughly $70 per U.S. household. The Infrastructure Investment and Jobs Act, passed in November 2021, establishes limited new funding for energy efficiency programs that states must compete for. States must develop their own funding sources and implementation plans, starting with a clear understanding of what kinds and scale of investment are needed to power Michigan homes with pollution-free energy.

[12] https://www.eia.gov/todayinenergy/detail.php?id=46756

[13] https://www.foodandwaterwatch.org/2022/10/24/the-dirty-side-of-green-hydrogen/

[14] https://www.eenews.net/articles/hydrogen-could-fuel-u-s-energy-transition-but-is-it-safe/

[15] https://www.rechargenews.com/energy-transition/hydrogen-in-the-home-would-be-four-times-more-dangerous-than-natural-gas-government-report/2-1-1047218

[16] https://www.foodandwaterwatch.org/2022/10/24/the-dirty-side-of-green-hydrogen/

[17] https://earthjustice.org/wp-content/uploads/hydrogen_earthjustice_2021.pdf

[18] https://psr.org/hydrogen-use-in-homes-would-fuel-climate-change-increase-health-and-safety-risks-from-gas-system/. Physicians for Social Responsibility 2022 report, "Hydrogen Pipe Dreams: Why Burning Hydrogen in Buildings is Bad for Climate and Health," goes in depth about why hydrogen is particularly ill-suited for this use and in general perpetuates climate injustice.

[19] https://www.hydrogeninsight.com/policy/time-to-stop-the-fight-32-independent-studies-slam-the-widespread-use-of-hydrogen-for-heating/2-1-1325747

Methods

Approach

This analysis used publicly available demographic and housing data, and recent research on home retrofit costs, to determine the estimated cost of weatherization and HVAC electrification for the state of Michigan.

1. **Determining Michigan's housing composition:** First, this study determined the composition of Michigan housing using the Department of Energy (DOE) Low-Income Energy Affordability (LEAD) tool. The total numbers of housing units were derived from LEAD for the three main types of housing in the state: single-family homes, multi-unit housing units, and mobile homes.

2. **Identifying necessary retrofit upgrades and technology:** Next, through a combination of industry expertise and literature review, the most important types of retrofit upgrades and technology needed to adequately weatherize residential housing and electrify residential HVAC systems were identified.

3. **Calculating upgrade costs according to architectural characteristics, climate, and other factors:** Finally, given differences in both architectural characteristics and available data across the three housing types, different methods for determining the retrofit and heat pump costs were developed. It is worth noting that academic literature on weatherization and HVAC electrification focuses primarily on single-family homes.

The literature on multi-unit housing is less comprehensive, as it is largely comprised of case studies rather than statistical analyses. However, since 78% of housing units in the state are single-family homes, this gap in the literature proves less problematic (see "Michigan's Housing Composition" for more information) for providing a budgetary estimate of statewide electrification costs.

For multi-unit housing and mobile homes, this report relies heavily on the most recent residential retrofit report from the Advanced Building Construction (ABC) Initiative from the U.S. Department of Energy Building Technologies Office (BTO).[20]

[20] https://www.energy.gov/eere/buildings/advanced-building-construction-initiative

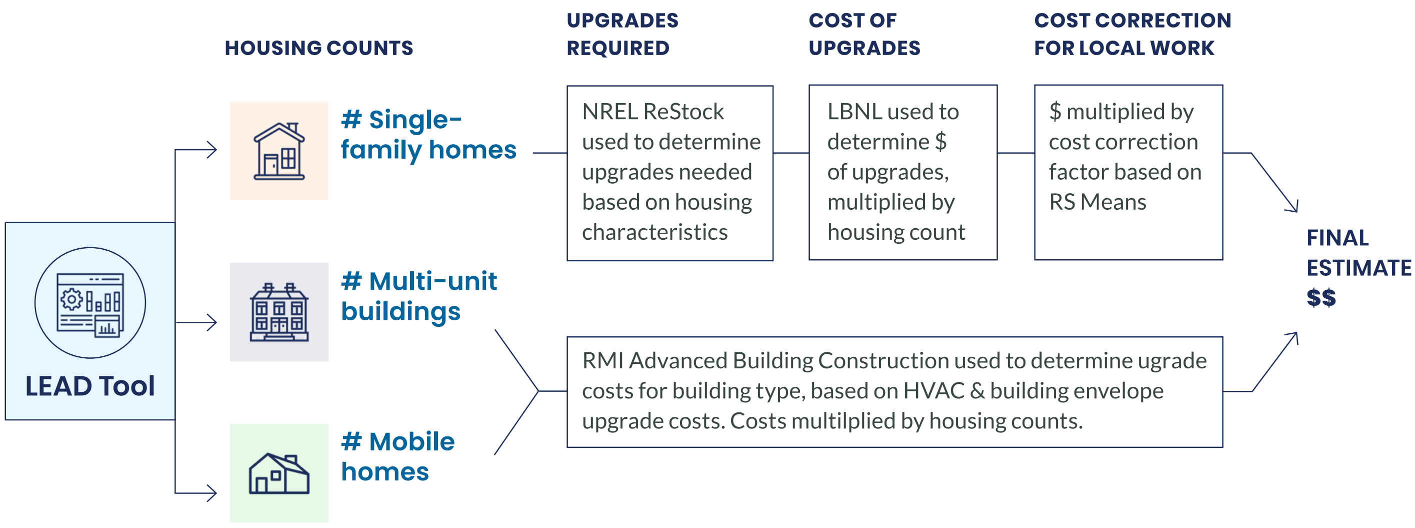
Data Sources

Overview of Data Sources

Data	Key Data Sources
Housing counts across Michigan across the following characteristics: housing type, fuel type, and vintage	Department of Energy (DOE) Low-Income Energy Affordability Data (LEAD) Tool
Percentage breakdown of single-family homes with a basement, crawlspace, or slab foundation	Pacific Northwest National Laboratory Cost-Effectiveness of the 2021 IECC for Residential Buildings in Michigan
Top ten energy efficiency upgrades for Michigan that would pay back in less than 5 years for most households	DOE National Renewable Energy Laboratory (NREL) tool, called ResStock
Costs of weatherization upgrades and heat pump installations for single-family homes based on a cross sample of retrofits across the United States	Lawrence Berkeley National Laboratory (LBNL) The Cost of Decarbonization and Energy Upgrade Retrofits for US Homes 2021 (Less, et al.)
City costs indexes for construction to create a weighted average for accounting for Michigan's regional costs	2020 RSMeans Cost Book
Costs of weatherization upgrades and heat pump installations for multi-unit housing based on analysis of national retrofit upgrade packages	ABC Modeled Package Report: Residential Sector Retrofits

More information about housing counts and characteristics is detailed in the Appendix.

Analysis Process Flow



Graphic A. Analysis Process Flow

The final estimate of heating electrification for residential homes in Michigan consists of an aggregated cost for single-family homes and a cost for multi-unit and mobile homes. Both use housing counts from the LEAD tool. Housing characteristics of single-family homes like vintage determined which upgrade types needed to be included in calculations, and their associated costs were pulled from the LBNL report. The aggregated single-family costs were then adjusted to account for Michigan construction costs. In contrast, multi-family and mobile home upgrade costs were derived from the ABC report, which already accounted for Michigan and calculated upgrade costs on a package basis, rather than by individual upgrade.

Michigan's Housing Composition

The majority of housing units in Michigan are single-family homes (78 percent), which are either detached or attached. One fourth of single-family homes represent Michiganders living at up to 200% of the Federal Poverty Limit (FPL). Multi-unit housing represents 17 percent of Michigan housing units, and mobile homes represent 4 percent. Of multi-unit housing unit types, the majority have more than 5 units (75 percent of multi-unit housing units and 13 percent of all Michigan housing units). About half of all multi-unit housing units and about half of all mobile homes are occupied by Michiganders living at up to 200% of the FPL. The final 1 percent of Michigan housing includes boats/vans/RVs. For the purpose of this analysis, this type of housing has been excluded, since boats, vans, and RVs are not eligible for housing electrification.

Housing counts for housing type, housing characteristics, and income level were derived from the LEAD tool and used in cost calculations for all three housing types, and foundation types were derived from the PNNL 2021 report completed for the DOE.

Department of Energy (DOE) Low-Income Energy Affordability Data (LEAD) Tool	
Housing Type	Single-family, small multi-unit (1-4 units), medium to large multi-unit (5+ units), mobile homes
Fuel Type[21]	Utility Gas, Electricity, Bottled Gas & Fuel Oil, Wood & Coal, Other & None
Vintage	Before 1940; 1940 - 59; 1960 - 79; 1980 - 99; 2000 - 09; 2010+

Table A. DOE LEAD Tool Specifications

Michigan housing units skew towards older construction, with the majority (65%) built before 1979, prior to the implementation of residential building energy codes. About sixty-eight percent of single-family homes were built before 1979. Within the vintage ranges requiring special weatherization upgrades (before 1979), about one-third of housing units represent Michiganders living at up to 200% of the FPL. For single-family homes built before 1979, almost thirty percent are occupied by Michiganders living at up to 200% of the FPL. Nearly one sixth of Michigan housing units and almost one sixth of Michigan single-family homes were built before 1940, a vintage that requires the most retrofit weatherization upgrades. Of the Michigan homes built before 1940, almost 40 percent are occupied by Michiganders living at up to 200% of the FPL. Of the single-family homes in Michigan built before 1940, 60 percent are occupied by Michiganders living at up to 200% of the FPL.

Retrofit Upgrades

Single-family Homes

This study narrowed down retrofit upgrades for weatherization and heating, ventilation, and air conditioning (HVAC) electrification based on a combination of industry expertise and academic literature on energy efficiency, weatherization, and electrification. The literature review for this study prioritized comprehensive national studies and cold weather U.S. case studies from the last five years.

This study uses the top ten energy efficiency upgrades for Michigan which would pay back in less than 5 years for most households.[22]

Improvements can be found in Table 3 in the Appendix organized by type of upgrade and accompanied by the rationale for their inclusion or exclusion in this analysis.

Taking into account the ResStock findings from NREL and other literature, this study decided on the following retrofit upgrades, as shown in the following table.

[21]Since this analysis is focused on HVAC electrification, those homes fueled by solar power were excluded from the housing counts and cost calculations of heat pump installations.

[22]NREL Residential Energy Efficiency Potential Report - Michigan, https://resstock.nrel.gov/factsheets/MI

PART OF THE HOME	UPGRADE	DESCRIPTION	LBNL SPECIFICATIONS
Envelope	Interior walls	Add blown cellulose cavity insulation to uninsulated wood frame walls	R-13
	Envelope sealing	Sealing joints, penetrations and other openings throughout the home using caulking, gaskets, weather-stripping, or continuous air barriers	Aggressive: 69% reduction of air leakage Typical: 37% reduction of air leakage
Attic	Attic floor	Add insulation to the attic floors	R-49
Foundation	Basement interior walls	Add insulation to basement interior walls	R-18
	Basement band joist	Sealing any leaks or holes with closed cell spray foam insulation	R-18
	Crawl space	Enclose and add insulation to crawl space	R-19
	Foundation framed floor	Insulate foundation framed floor when there is no basement or crawlspace	R-25
HVAC	Duct sealing	Sealing any leaks, holes, or poor connections in ducts	64% reduction of air leakage
	Ductless mini-split heat pump	A type of heat pump that uses a wall, floor, or ceiling mounted indoor unit instead of ductwork to distribute heated or cooled air throughout the home	16 SEER, 11EER and 9.5 HSPF
	Ducted heat pump	A type of heat pump that uses existing ducts to distribute heated or cooled air throughout the home	16 SEER, 11EER and 9.5 HSPF

Table B. Retrofit upgrades for single-family homes

Multi-unit housing and mobile homes

For multi-unit housing between two to four units, this analysis used the same upgrade specifications as single-family homes according to similarities in the housing composition. The ABC initiative for multi-unit housing greater than four units and for mobile homes. Rather than evaluating retrofit upgrades on an individual basis, the ABC initiative analyzed retrofit upgrades on a package basis. As such, this analysis selected the retrofit package that best fit the specifications of weatherization selected for single-family homes. The "Market-Ready Envelope" package was selected, since it includes upgrading the building envelope with market-ready solutions. However, the upgrades for the major fossil fuel-using end-use equipment, including swap-outs for water heating, cooking, and clothes drying, and upgrades to lighting and major appliances, were removed. The "Market-Ready Envelope" package includes the retrofits in the below table.

PART OF THE HOME	UPGRADE	DESCRIPTION	LBNL SPECIFICATIONS
Attic	Attic floor air-sealing and insulation	Sealing any leaks or holes at the attic floor, and incorporating insulation up to 2021 International Energy Conservation Code (IECC)	R-values follow 2021 IECC; R-60 nominal and R-51 effective
Envelope	Low-e storm window	Exterior storm windows can reduce the air infiltration and conductive heat transfer associated with the window	Exterior low-e storm windows (for homes with single and double pane windows)
	R-6.5 wall insulation with re-siding	About 1" of rigid polyisocyanurate board installed under new siding	R-6.5 of continuous wall insulation
HVAC	Duct sealing/ insulation	Sealing any leaks, holes, or poor connections in ducts	Sealed to 10% leakage and insulated to R-8
	Heat pump HVAC	A type of heat pump that uses a wall, floor, or ceiling mounted indoor unit instead of ductwork to distribute heated or cooled air throughout the home	MSHP, SEER 29.3, 14 HSPF

Table C. Retrofit upgrades multi-unit housing and mobile homes

Upgrade Costs

Single-family homes

After determining Michigan's housing composition and selecting appropriate retrofit upgrades, this analysis had to determine per-upgrade costs. To arrive at weatherization and HVAC electrification costs for single-family homes, the following steps were applied:

1. Determine which upgrades were required for different housing vintages and fuel types
2. Pull per-upgrade median cost data and multiply them by housing unit counts according to vintage and fuel types
3. Apply a weighted average

This analysis includes the following weatherization upgrades for single-family homes: wall insulation, attic floor insulation, basement wall and band joist insulation, foundation framed floor insulation, home envelope sealing, and duct sealing. This analysis included both ducted and mini-split ductless heat pumps for HVAC electrification.

LBNL's report included a suite of cost information based on their database, from which this analysis could choose appropriately. LBNL noted down:

- the median costs of individual upgrades;
- the cost of typical projects calculated with clusters of upgrades derived from a machine learning technique used to identify similar groups of objects in a dataset;
- typical upgrade costs for the archetypal home that best matched the typical characteristics of homes in their database.

Given the range of geographic regions and climate zones represented in the LBNL database, this analysis used the individual median upgrade costs. By using the individual median upgrade costs, this analysis was able to mitigate impacts of other specific project costs factors that might not represent needs in Michigan. Using national median costs of individual upgrades allowed for the combining of upgrades according to housing characteristics found in the LEAD tool and adjustment according to regional construction costs.

Most of the national median costs of individual upgrades were taken directly from the LBNL report. A couple items to note include:

- Wall insulation is required for houses built before 1940, because insulating homes was not a common practice up to that point. Fiberglass was not invented until 1938.[23] High energy prices drove a substantial increase in insulation in the 1970s.[24]
- Air sealing is required for all housing units, because it is not currently industry standard to seal homes efficiently. This analysis assigned aggressive air sealing to housing units constructed before 2010, since air sealing was introduced in Michigan in 2016, when the latest IECC energy efficiency residential codes were adopted.
- The costs for typical and aggressive sealing were updated to adjust infiltration rate specifications. This analysis used the median cost and associated infiltration rate to determine a cost to infiltration ratio that could be applied to the cost to increase the infiltration rate to appropriate levels, 37% air leakage and 67% air leakage respectively.
- Attic floor insulation is required for houses built before 1980 only, since homes built after 1980 are less

likely to have a vented attic suitable for attic floor insulation.[25]

- Ducted heat pumps were assigned to housing units that have natural gas heating, since they likely have air ducts for heating and cooling already. Those housing units which use wood, coal, bottled gas, or fuel oil, or were listed in the LEAD tool as "other or none" were assigned a mini-split ductless heat pump, as they are less likely to have an air duct system already installed.

PART OF THE HOME	SINGLE-FAMILY UPGRADE	COST	LBNL SPECIFICATIONS	HOUSING VINTAGE	FUEL TYPE
Envelope	**Seal envelope (aggressive)**	$1,865	69% reduction of air leakage	Before 2010	All
	Seal envelope (typical)	$1,000	37% reduction of air leakage	After 2010	All
	Insulate all walls	$2,106	R-13	Before 1940	All
Attic	**Insulate attic floor**	$1,827	R-49	Before 1980	All
Foundation	**Insulate basement interior walls**	$1,655	R-18	Not vintage dependent	All
	Seal and insulate crawl space	$2,680	R-19	Not vintage dependent	All
	Insulate foundation framed floor	$1,578	R-25	Not vintage dependent	All
	Insulate band joist for basements	$790	R-18	Not vintage dependent	All
HVAC	**Duct sealing**	$789	64% reduction of air leakage	Not vintage dependent	Utility Gas Electricity
	Install ductless mini-split heat pump	$10,631	16 SEER, 12.5 EER and 9 HSPF (North and Canada 16 SEER, 11EER and 9.5 HSPF)	Not vintage dependent	Bottled Gas & Fuel Oil, Wood & Coal, Other & None
	Install ducted heat pump	$13,384	16 SEER, 12.5 EER and 9 HSPF (North and Canada 16 SEER, 11EER and 9.5 HSPF)	Not vintage dependent	Utility Gas Electricity

Table C. Retrofit upgrade costs and specifications

To account for regional variation in construction costs for the individual upgrades, a weighted average was derived from the 2020 RSMeans cost book, which documents city cost indexes for construction. Of the Michigan cities included in the cost book, nine were selected, which ranged in size and location across all three climate zones. The selected cities included Ann Arbor, Detroit, Lansing, and Kalamazoo for Climate Zone 5A; Gaylord, Traverse City, Grand Rapids, and Saginaw for Climate Zone 6A; and Iron Mountain for Climate Zone 7. To represent city weatherization construction costs, the cost indices for ceiling and acoustic treatment; wood, plastics, and composites; thermal and moisture protection; plaster and gypsum board; and wall finishes and painting/coating were selected. The city weatherization construction cost indices were averaged within each climate zone, and then the climate zone averages were adjusted according to the percentage of housing units present in each climate zone. This resulted in an overall weighted average weatherization construction cost index for Michigan, which could be applied to the overall total costs of weatherization upgrades. The same process was applied for HVAC electrification upgrades. The HVAC construction costs used from the RSMeans cost book included fire suppression, plumbing, and HVAC, as well as electrical, communication, and utility costs.

[23] Fiberglass Insulation: History, Hazards and Alternatives - InterNACHI®

[24] When Did They Start Using Insulation in Homes? (retrofoamofmichigan.com)

[25] http://www.osti.gov/servlets/purl/1414819/

Multi-unit housing and mobile homes

For multi-unit housing between 2 and 4 units, the same methodology was used as single-family homes for consistency. For multi-unit housing over 4 units and for mobile homes, this analysis used the average mini-split heat pump cost, as well as the average “Market-Ready Envelope” cost for each of the unit ranges of multi-unit housing and for mobile homes in the different climate zones derived from the ABC report.

Climate Zones

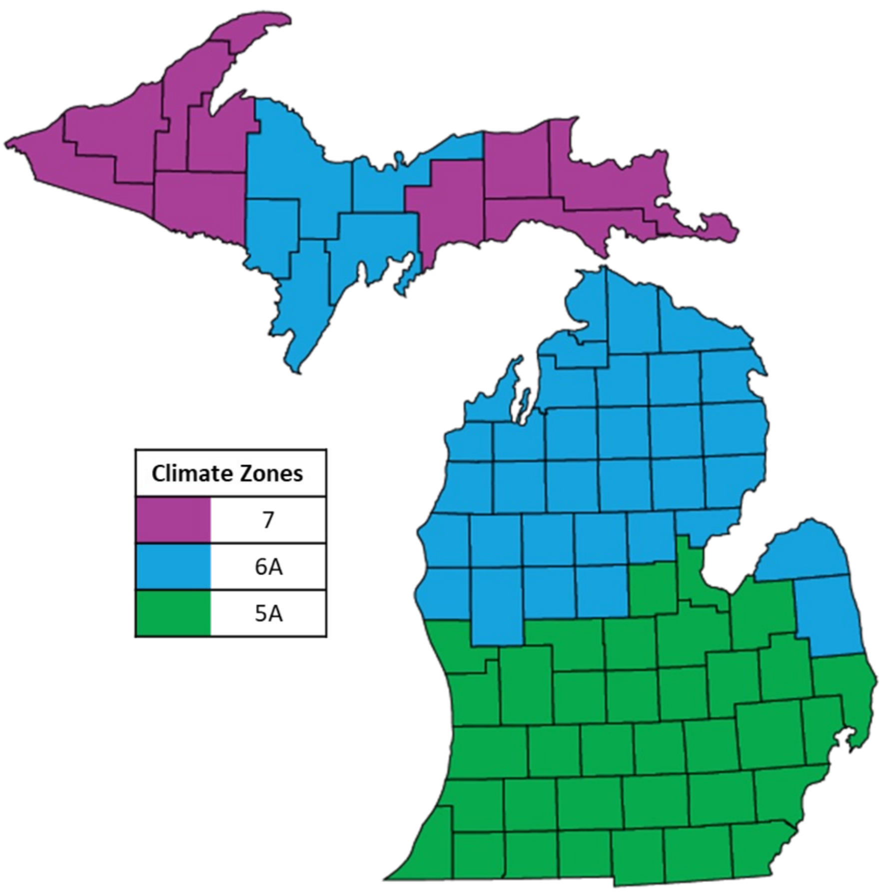
Retrofit upgrades *did not vary by climate zone* for the sake of this analysis. This is because retrofit upgrades are determined by housing vintage and type, rather than geographical location. The only retrofit upgrade that would be impacted by differences in cold weather are heat pumps, but the heat pump selected for this analysis accounts for temperature differences across the three climate zones.

Michigan's Climate Zones

According to the 2021 International Energy Conservation Code (IECC), Michigan sits in the "cold / very cold" climate zones, including climate zones 5A, 6A, and 7. According to ASHRAE, the 99% heating design temperatures for these climate zones, or the temperature equipment should be built to withstand 99% of the time, includes the following:

- **Climate Zone 5A -13.2 degrees Fahrenheit**
- **Climate Zone 6A -17.8 degrees Fahrenheit**
- **Climate Zone 7 -18 degrees Fahrenheit**

These heating design standards are served by cold climate heat pumps under industry best practice today. This analysis therefore accounts for cold climate heat pumps in retrofits across all of Michigan's climate zones. For weatherization upgrades, the age of the housing unit and housing type are the primary determinants for retrofit measures. For single-family homes, vintage determines whether wall insulation and attic floor insulation are needed and what level of air sealing for the envelope of the home is needed.



Analysis and Results

Looking across all Michigan housing units, almost a third of the investment required for housing upgrades are needed for households earning 200% of the Federal Poverty Limit (FPL) or less. The percentage of overall investment needed for households earning 200% of the FPL or below is greatest for multi-unit housing and mobile homes at almost 50% for both. However, a quarter of the investment needed for single family homes is needed for households earning 200% of the FPL or below.

Michigan homes

The total estimated cost to electrify and weatherize Michigan residential housing is about 73.6 billion dollars with about thirty percent allocated to weatherization and about seventy percent to HVAC electrification. **About a third of the total cost (23 billion dollars) pertains to the homes of Michigan families earning 200% of the Federal Poverty Limit (FPL) or below**. About seventy percent of the investment in households earning up to 200% FPL would go to replacing fossil fuel based heating with all-electric heat pumps, and about thirty percent would support weatherization services, such as air sealing and adding insulation.

RESIDENTIAL HOUSING	FOR TOTAL MI POPULATION	FOR UP TO 200% FPL
Weatherization ($)	**$23.0 billion**	$7.3 billion
HVAC Electrification ($)	**$50.5 billion**	$15.7 billion
Weatherization & HVAC	**$73.6 billion**	**$23 billion**

Table D. Cost estimates for Michigan residential housing

Of the investment needed for HVAC electrification, 31% is needed for homes of Michigan families earning 200% of the Federal Poverty Limit or below; of the investment needed for weatherization, 31% is needed for homes of Michigan families earning 200% of the Federal Poverty Limit or below.

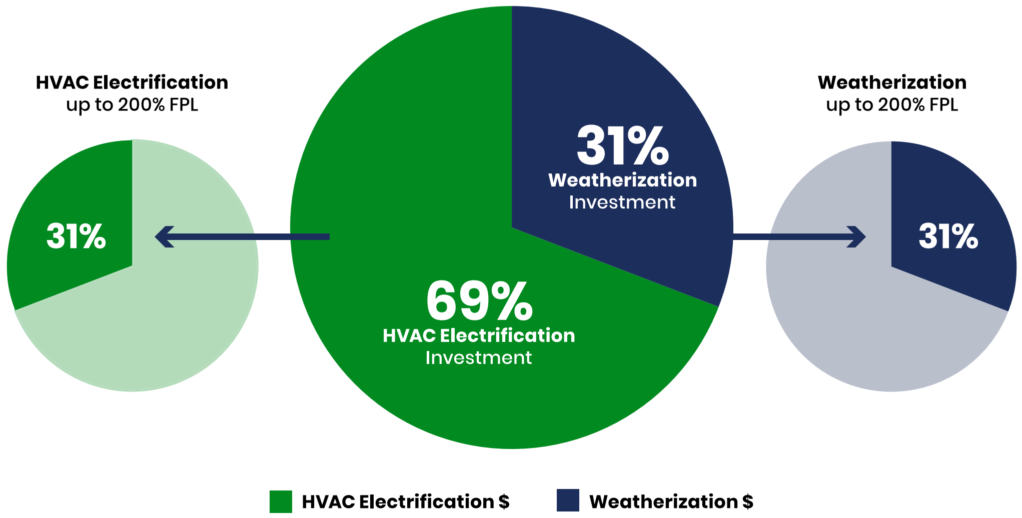


Chart 1. Cost breakdown for Michigan residential housing

Single-family homes

The total estimated cost to electrify and weatherize Michigan single-family homes is about 56.2 billion dollars with one third allocated to weatherization and two-thirds to HVAC electrification. **More than a quarter of that cost is needed for Michiganders earning up to 200% of the Federal Poverty Limit (14.4 billion dollars)**. About two thirds of investment in households under 200% FPL would go to replacing fossil fuel based heating with all-electric heat pumps, and about one third would support weatherization services, such as air sealing and adding insulation.

SINGLE-FAMILY HOMES	FOR TOTAL MI POPULATION	FOR UP TO 200% FPL
Weatherization ($)	$18.5 billion	$5 billion
HVAC Electrification ($)	$37.7 billion	$9.5 billion
Weatherization & HVAC	**$56.2 billion**	**$14.4 billion**

Table E. Cost estimates for single-family homes

Of the investment needed for HVAC electrification, 25% is needed for homes of Michigan families earning 200% of the Federal Poverty Limit or below; of the investment needed for weatherization, 27% is needed for homes of Michigan families earning 200% of the Federal Poverty Limit or below.

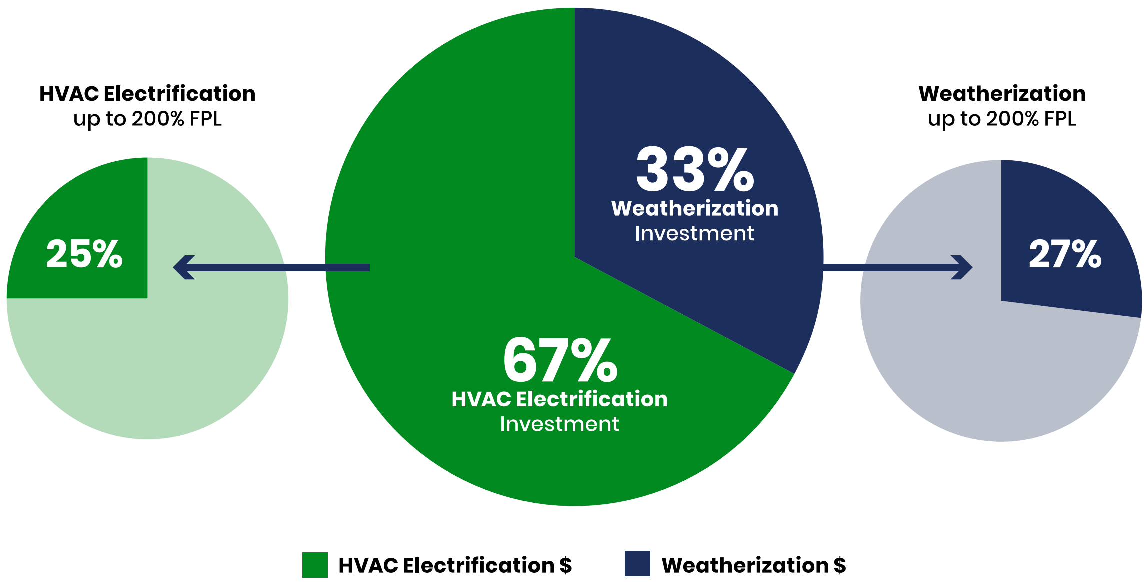


Chart 2. Cost breakdown for single-family homes

Multi-unit housing and mobile homes

Looking at both multi-unit and mobile homes, the total estimated cost to electrify and weatherize is about 17.4 billion dollars with about a quarter allocated to weatherization and three quarters to HVAC electrification. **About fifty percent of that cost is needed for Michiganders earning up to 200% of the Federal Poverty Limit (8.6 billion dollars)**. Close to three fourths of investment in households under 200% FPL would go to replacing fossil fuel based heating with all-electric heat pumps, and a little over one fourth to support weatherization services, such as air sealing and adding insulation.

MULTI-UNIT & MOBILE HOMES	FOR TOTAL MI POPULATION	FOR UP TO 200% FPL
Weatherization ($)	$4.5 billion	$2.3 billion
HVAC Electrification ($)	$12.8 billion	$6.2 billion
Weatherization & HVAC	**$17.4 billion**	**$8.6 billion**

Table H. Cost estimates for multi-unit housing and mobile homes

Of the investment needed for HVAC electrification, 48% is needed for homes of Michigan families earning 200% of the Federal Poverty Limit or below; of the investment needed for weatherization, 52% is needed for homes of Michigan families earning 200% of the Federal Poverty Limit or below.

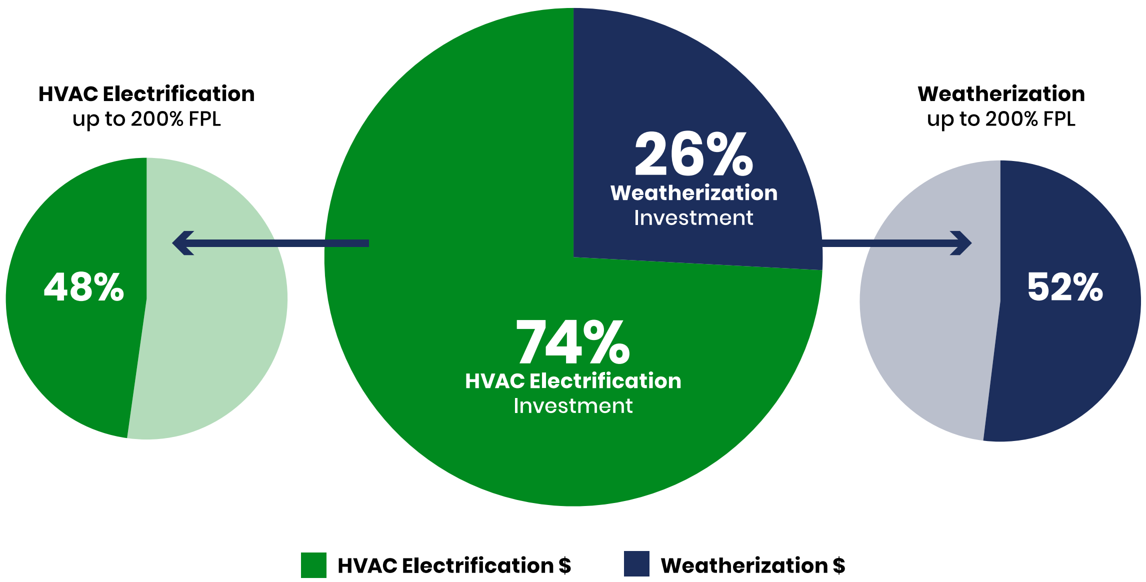


Chart 3. Cost breakdown for multi-unit housing and mobile homes

Multi-unit housing

The total estimated cost to electrify and weatherize Michigan multi-unit housing is about 13.3 billion dollars with a little over a quarter allocated to weatherization and almost three quarters to HVAC electrification. **About half of that cost is needed for Michiganders earning up to 200% of the Federal Poverty Limit (6.7 billion dollars)**. Just under three fourths of investment in households under 200% FPL would go to replacing fossil fuel based heating with all-electric heat pumps, and a little over one fourth to support weatherization services, such as air sealing and adding insulation.

MULTI-UNIT	FOR TOTAL MI POPULATION	FOR UP TO 200% FPL
Weatherization ($)	**$3.4 billion**	$1.8 billion
HVAC Electrification ($)	**$9.8 billion**	$4.8 billion
Weatherization & HVAC	**$13.3 billion**	**$6.7 billion**

Table F. Cost estimates for multi-unit housing

Of the investment needed for HVAC electrification, 49% is needed for homes of Michigan families earning 200% of the Federal Poverty Limit or below; of the investment needed for weatherization, 53% is needed for homes of Michigan families earning 200% of the Federal Poverty Limit or below.

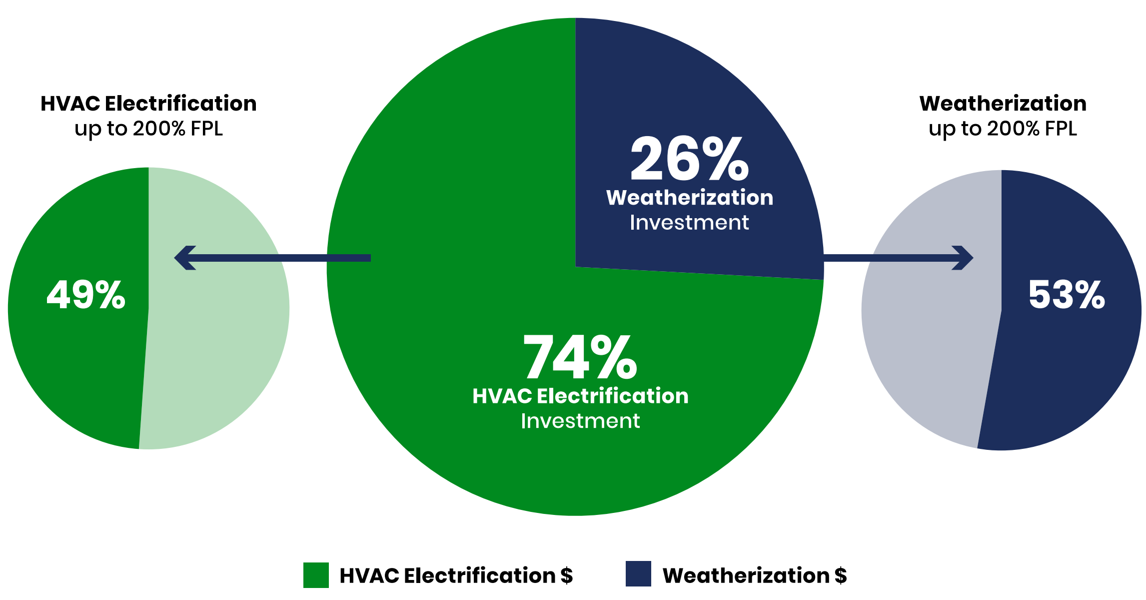


Chart 4. Cost breakdown for multi-unit housing

Mobile homes

The total estimated cost to electrify and weatherize Michigan mobile homes is about 4.1 billion dollars with a little over a quarter allocated to weatherization and almost three quarters to HVAC electrification. **Almost fifty percent of that investment is needed for Michiganders earning up to 200% of the Federal Poverty Limit (1.9 billion dollars)**. A little under three fourths of investment in households under 200% FPL would go to replacing fossil fuel based heating with all-electric heat pumps, and a little over one fourth would support weatherization services, such as air sealing and adding insulation.

MOBILE HOMES	FOR TOTAL MI POPULATION	FOR UP TO 200% FPL
Weatherization ($)	**$1.1 billion**	$500 million
HVAC Electrification ($)	**$3 billion**	$1.4 billion
Weatherization & HVAC	**$4.1 billion**	**$1.9 billion**

Table G. Cost estimates for mobile homes

Of the investment needed for HVAC electrification, 47% is needed for homes of Michigan families earning 200% of the Federal Poverty Limit or below; of the investment needed for weatherization, 46% is needed for homes of Michigan families earning 200% of the Federal Poverty Limit or below.

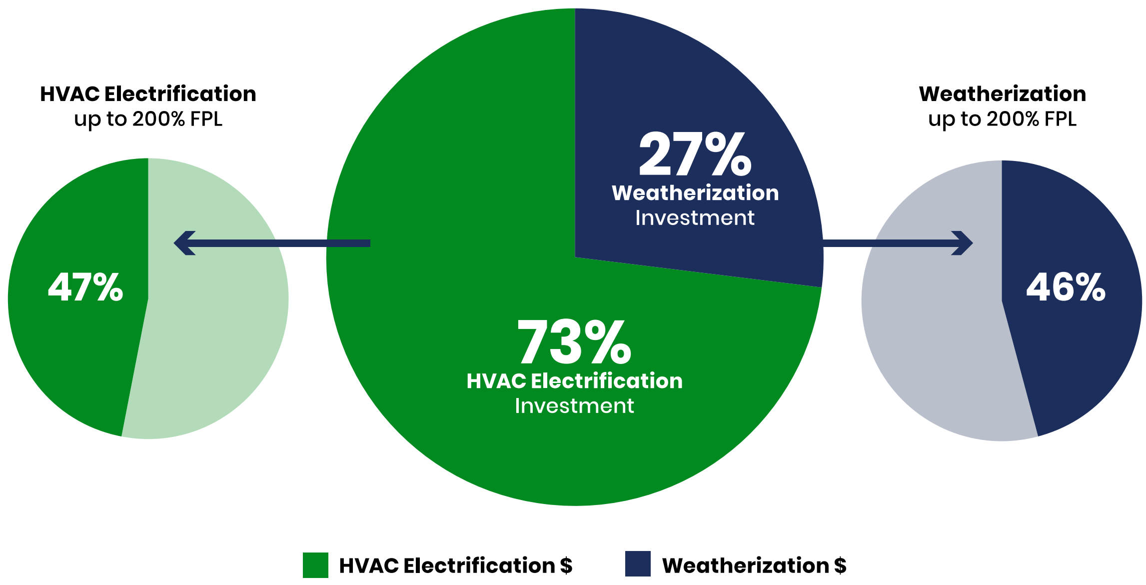


Chart 5. Cost breakdown for mobile homes

Areas for further study

As policymakers determine funding and implementation of weatherization upgrades and heat pump installations, there are a number of open questions that need to be considered.

- **Pre-weatherization:** As found in Michigan's Healthy Climate Plan, one fourth of weatherization projects in the state have to be deferred until other critical upgrades can be made to a building, including roof replacements, carbon monoxide proofing, lead abatement, and asbestos removal. In communities such as Detroit where historic redlining has shaped home investments for decades, project deferrals reach a staggering three fourths.

- **Quality control:** There needs to be quality control mechanisms for retrofit weatherization contracting to ensure retrofit upgrades create the heating results that are required to meet efficiency requirements and reduce energy burden. Quality controls, such as those implemented by Habitat for Humanity, in checking air leakage and insulation would be a good place to start.

- **Technology:** Ductless mini-split heat pump systems, which will be needed for residential buildings reliant on oil, bottled gas and fuel, or wood and coal for heating, will likely need a back-up heat system for handling peak loads in the coldest temperatures. This will be especially relevant for the most northern part of the state.

- **Timing of heat pump installations:** End of life is the key moment for replacing fossil fuel-based furnaces with clean-powered, energy efficient heating systems. On the scale of the entire state, this implies a waiting period for most heating systems in the state that are incompatible with the rate of replacement needed in the face of the climate crisis, given that the lifetime of most furnaces is about 20 years. On a case-by-case basis, waiting for a furnace to fail creates a risk of needing a replacement in the middle of the coldest months, when speed is most critical. Even in the event of truly expedient and equitable incentive policies, some families may not opt into a heat pump installation if it means facing weeks without a viable heating system in the dead of winter. The other time furnaces are often replaced are after moments of crisis, such as floods. *There must be a good mechanism in place for intervening with the right technology at times when a residential furnace has to be replaced anyways – in equitable ways that account for the impact of crises.*

Discussion

As the climate crisis grows increasingly severe, bold action is required at all levels of government to end the combustion of fossil fuels and eliminate climate-warming emissions. In the US, 10 percent of climate-warming emissions come from buildings. In Michigan, that proportion is even greater: in 2019, buildings accounted for over 18 percent of Michigan's greenhouse gas emissions, making buildings the state's third-largest emissions share after transportation and power generation. In 2022, the Michigan Healthy Climate Plan catalyzed state efforts to enact building decarbonization, establishing a goal of reducing emissions from the heating of buildings by 17% by 2030. While this is a start, much bolder action is required to fully eliminate emissions from the building sector in line with Intergovernmental Panel on Climate Change (IPCC) targets. The most recent IPCC report identified[26] that both increases in energy efficiency and sharp cuts to methane emissions, like those associated with the gas sector that heats residential buildings, are two of the most effective and critical strategies for near-term emissions reductions. Michigan needs a plan to fully electrify residential buildings, decommission the gas distribution system, and power home heating with pollution-free, renewable energy.

As the climate crisis worsens, Michigan families are also experiencing a crisis of housing affordability. According to the 2021 US Census, over 50 percent[27] of Michigan renters were cost burdened (paying more than 30 percent of their household income on rent). One quarter of Michigan renters experienced severe cost burden (paying more than half of their household income on rent), as did 9 percent of homeowners with a mortgage. Twenty-eight percent of Michigan renters are classified as extremely low-income[28] (incomes at or below 30 percent of the area median income), and of those, 72 percent experience severe cost burden. Michigan landlords file roughly 200,000 evictions each year, and some 40,000 households lose their homes as a result of court-ordered evictions.[29] Energy insecurity and high utility costs compound these burdens; studies have found that energy insecurity is associated[30] with other markers of poverty such as food insecurity and adverse health outcomes, and disproportionately affects low-income and Black and brown households.

Home electrification presents policymakers with an opportunity to address the climate and housing crises simultaneously, by choosing home electrification policies that reduce housing costs and build wealth for low-income and low-wealth families. On the other hand, if policymakers do not consider home electrification and housing affordability together, home electrification will likely exacerbate the severe inequities in today's housing and energy systems.

Regulations targeted at new construction are important but inadequate, given that 80% of residential buildings that will house Michigan residents in 2050 have already been built. Energy efficient upgrades that focus on "low-hanging fruit" like appliances and lighting, while also important, do not begin to tackle the great challenge of funding and implementing home weatherization and electrification.

Our study estimates that weatherizing and electrifying the HVAC systems of all Michigan residences will cost approximately $74 billion. We further estimate that weatherizing and electrifying HVAC systems for the subset of Michigan families earning less than 200% FPL will cost $23 billion. This second finding is important because low-income families, many of whom already struggle to afford housing and home energy costs, cannot afford to pay for home electrification either directly via home retrofit costs, or indirectly via increased rent prices. **The message is clear: The development of equitable public programs is essential to electrifying Michigan's residential buildings at scale and at pace, and we must start today.**

The level of public funding required to completely electrify Michigan's housing stock has a precedent only in New Deal and post-World War II housing policies of our grandparents' generation. Those explicitly racist policy choices expanded and entrenched racial segregation, building the wealth of white Americans while subjecting Black and brown Americans to housing displacement and economic extraction by landlords, banks, and the real estate industry. The spatialization of race enabled further concentration of environmental hazards in Black and brown communities. The legacy of New Deal and post-war housing policy continues: In 2019, a University of California-Berkeley study[31] ranked Detroit the most segregated city in the country.

Whether white, Black, or brown, there are far too many working class Michiganders who spend an unaffordable percentage of income on housing and energy costs, who experience crushing debt and housing displacement, and whose health suffers from indoor and outdoor environmental hazards. One-quarter of all single-family homes, half of all multi-family units, and nearly half of all mobile homes in Michigan are occupied by families earning less than 200% of FPL.

[26] https://www.theguardian.com/environment/2023/mar/21/methane-to-food-waste-eight-ways-to-attempt-to-stay-within-15c

[27] https://crcmich.org/affordable-housing-policies-must-address-affordability-for-the-lowest-income-households

[28] https://nlihc.org/housing-needs-by-state/michigan

[29] https://poverty.umich.edu/files/2020/05/Michigan-Eviction-Project-policy-brief.pdf

[30] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5114037/

Housing electrification policies must explicitly value racial and environmental justice and the right to affordable housing, or the benefits of such policies will likely accrue to wealthier homeowners and landlords, while burdens fall heavily upon low-wealth homeowners and renters. In Los Angeles, where city government launched decarbonization policy in 2020 with a mandate that new municipal construction be fully electric, environmental justice advocates are sounding the alarm about the threat of a worsening rent burden and housing displacement when decarbonization policies reach existing multi-family buildings.[32]

With thoughtful policy design and resource mobilization, home electrification will be transformative for millions of people across Michigan. Michiganders will live in healthier homes free from indoor air pollutants associated with gas combustion, as well as hazards like lead, mold, and asbestos that must be addressed prior to weatherization. Low-income homeowners who take advantage of weatherization and electrification programs will see their home values rise, including Black and brown homeowners whose grandparents were denied New Deal and postwar housing subsidies and subjected to extractive housing markets. Public dollars that support rental property electrification will be tied to affordability protections, protecting people who rent from displacement associated with "green gentrification." Energy bills will come down, leaving more to spend on what matters most. Families, churches, schools, and cooperatives will meet more of their energy needs through low-cost rooftop and community solar. Michiganders will breathe cleaner air and leave Michigan better for generations to come.

Funding considerations

This analysis aims to jump-start the conversation on how to electrify residential heating in Michigan. It goes without saying that the estimated $73.6 billion in funding needed to complete this effort in a timely manner is a significant amount that would likely require creative efforts to ensure full funding, and to prevent both financial burdens on communities and capture of benefits by private actors. However, given the urgent necessity of building electrification from a climate and public health perspective, we must also consider the costs of maintaining the status quo.

According to the American Gas Association, annual spending on gas distribution infrastructure ballooned from around $5 billion to $15 billion between 2009 and 2017. One quarter of gas mains in the United States are over 50 years old. The leaky, older pipes ubiquitous across the U.S. gas distribution network are responsible for costly methane leaks that threaten both the climate and public health; recent research has shown these leaks to be at least twice as large in major U.S. cities as prevailing EPA estimates[33]. Antiquated gas infrastructure also increases the threat of explosions, a significant public safety risk marked by recent high-profile disasters such as the 2018 Merrimack Valley gas explosions in Massachusetts. Independent of its deleterious climate impacts, America's fossil gas infrastructure would require significant maintenance and upgrades if it were to be safely operable in the years and decades to come; this would be an immensely expensive task.

[31] https://belonging.berkeley.edu/most-least-segregated-cities

[32] https://www.saje.net/wp-content/uploads/2021/12/LA-Building-Decarb_Tenant-Impact-and-Recommendations_SAJE_December-2021-1.pdf

[33] https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2019GL082635

Gas utility plans in other states have demonstrated this enormous cost. Illinois gas utility Peoples Gas' plan to replace all of the gas lines underneath the city of Chicago has been estimated to cost as much as $11 billion[34]. New Jersey utility PSE&G's plan to replace roughly 1000 miles of gas lines—about one third of New Jersey's total—has been conservatively estimated at $2.54 billion[35]. What's more, both these plans will rely on increasing the burden on ratepayers to cover these costs: a clear intersection of economic and environmental injustice. There are over 50,000 miles of gas distribution lines across the state of Michigan, and the requisite replacements and upgrades would easily run into the dozens of billions of dollars—money that could instead go toward electrification.

Some additional money can come from federal programs—for example, the Inflation Reduction Act (IRA) appropriates $4.3 billion to the Department of Energy for rebates for home energy efficiency retrofits, and an additional $4.28 billion specifically for home electrification rebates for low-to-moderate income households. Additionally, the Infrastructure Investment and Jobs Act (IIJA) also contains provisions such as the Energy Efficiency and Conservation Block Grant and Building Codes Implementation for Efficiency and Resilience programs, which together allocate $775 million in grants for states, local governments, tribes, and partnerships. This is a reasonable start, but Michigan's federal-level legislators must be prepared to push for additional federal funding.

In addition, Michigan's state lawmakers must secure funding for home electrification through taxation. In Fiscal Year 2020, the state of Michigan lost out on $42.92 billion in potential revenue due to state and local tax credits, deductions and exemptions[36]. Cutting out the corporate giveaways that comprise much of this sum could provide valuable funding for this funding effort and others. Reforms to Michigan's flat tax structure could also provide a significant boost. More progressive taxation would provide a significant revenue stream for public goods and infrastructure improvements, whether through a "millionaire's tax" or, appropriately for an effort concerned with environmental sustainability, a direct tax on carbon and other forms of pollution (not to be confused with an emissions-trading scheme)[37]. DTE Energy, for example, accrued $1.2 billion in profit in 2022; not only could a progressive tax scheme repurpose some of that amount for initiatives such as building electrification, but a tax on pollution could encourage the company to move away from dirtier generation, thereby achieving dual purposes of reducing environmental burden due to dirty energy generation while also funding building electrification and energy efficiency.

COMPLEMENTARY POLICIES

Residential electrification will require that new electricity demand is met with clean energy generation development. Meanwhile, for many households, electrification will mean higher total energy bills. As a minimum policy case, Michigan residents deserve public policy that ensures all Michigan families can afford their energy bills (i.e. energy bills are no more than 6% of income) without having to support an extractive fossil-fuel based industry that has put their health and climate safety at risk. To that end, Michigan must assess the margin of unaffordable costs in a future where all homes are electrified. The ideal policy case is to invest directly in rooftop & community solar that (1) ensures new energy resources are pollution-free and community-owned, and (2) supports affordable energy bills.

[34] https://chicago.suntimes.com/2019/6/21/18691113/peoples-gas-pipe-replacement-higher-costs-chicago-consumers

[35] https://www.njspotlightnews.org/2023/03/pseg-seeks-bpu-approval-for-2-5-billion-upgrades-to-cast-iron-and-steel-pipes/

[36] https://sigma.michigan.gov/EI360TransparencyApp/files/Tax%20Expenditure%20Reports/FY2020%20Tax%20Expenditure%20Report.pdf

[37] https://mlpp.org/the-millionaires-tax-a-fair-step-toward-tax-justice/

Case studies

There is precedence in other states of creating fuel-switching incentives, including programs to install commercial and residential high-performance heat pumps, legislation that supports installation of residential heat pumps, non-profit collaboration on uplifting rebate options to community members, and zero percent loan financing for energy efficiency upgrades.

Maine - Home Energy Savings Program (HESP)

The HESP program incentivized installation of 88,000 commercial and residential high-performance heat pumps over the past nine years. In FY2021, HESP provided incentives on 27,326 residential heat pump units, representing a 123% increase compared to FY2020 and a 177% increase compared to FY2019. According to the 2021 annual report, several factors fed the increase in program participation, including larger rebates, more marketing, and the launch of a new training module for vendors designed to help drive heat pump activity and ensure quality installations in a fast-growing market. Program organizers attribute their program success to a greater focus on better year-round comfort due to COVID-19 restrictions, more extreme summer heat (2020 was the third warmest in the state's history), and federal stimulus money increased their disposable income.

HESP also provides incentives for building envelope projects, but they don't tie those incentives to heat pump installations. Their weatherization services saw a relatively low demand compared to the heat pump work in 2021.

In late FY2019, the Maine Legislature enacted a Governor's bill – LD 1766 - An Act To Transform Maine's Heat Pump Market To Advance Economic Security and Climate Objectives – establishing a goal of installing 100,000 high-performance heat pumps in the state during the next five fiscal years. The low income energy efficiency program serves low income residents and multifamily. The program incentivized 1,213 heat pumps in FY2021. Weatherization services are covered at 100% for low income households.[38]

Minnesota - Air Source Heat Pump Collaborative

In 2021, Minnesota passed a law (Energy Conservation and Optimization (ECO) Act) that makes it easier for residents to install residential heat pumps. The legislation frees up utilities to make comparisons between propane and other fuels when marketing heat pumps. In addition, it allows utilities to count energy savings from fuel-switching toward their energy conservation targets.

The Minnesota Air Source Heat Pump Collaborative is a non-profit organization founded in 2019 to advance heat pump adoption in the state. They have identified rebates available to customers in nearly every utility territory ranging from $200 to $2,000. The number of rebates awarded by its members more than doubled to 3,107 in 2020 compared to 1,356 in 2019. The focus of heat pump incentives under the new law is replacing

[38] https://www.efficiencymaine.com/docs/FY21-Annual-Report_1.21.2021_final.pdf

propane heating with air source heat pumps, where Minnesota residents will see the most energy cost savings.[39]

Massachusetts - MASS SAVE HEAT Loan Program

The HEAT Loan program is a zero percent financing option for up to $25,000 for energy-efficient home upgrades like the installation of air source heat pumps (central or ductless mini-split), ground source heat pumps, heat pump water heaters, and insulation. The loan has terms up to seven years depending on the lender. Eligibility requires a no-cost energy assessment through the MASS SAVE program. The MASS CEC provides a Heat Pump Installer Network database to support homeowner contractor selection. However, only homeowners qualify for the loan.[40]

Other opportunities

Program implementation for residential weatherization and heating electrification provides opportunity for Michigan across multiple dimensions, including but not limited to enacting federal requirements around just investment, supporting affordable housing, creating green jobs, bolstering workforce development, and decoupling decarbonization from investor-owned utility monopolies in the state.

- **Just investment:**
  The federal Justice40 Initiative was enacted to fund critical investments for healthy and climate resilient communities in ways that ensure at least 40% of the overall benefits of investments go back to disadvantaged communities. Eligible investments include those for "climate change, clean energy and energy efficiency, clean transit, affordable and sustainable housing, training and workforce development, remediation and reduction of legacy pollution, and the development of critical clean water and wastewater infrastructure." Michigan has an opportunity to follow federal precedent in making environmentally just investments. If planned and implemented thoughtfully, residential weatherization and electrification could represent an investment in climate resilience, clean energy and efficiency, affordable and sustainable housing, training and workforce development, and remediation and reduction of legacy pollution. At a minimum, Michigan should follow the lead of the federal government in considering how programs for residential weatherization and electrification benefit those communities that have been "marginalized, underserved, and overburdened by pollution."

- **Affordable housing:**
  The cost of housing will only continue to rise as the effects of the climate crisis rise and the needs for retrofits become increasingly urgent. This will put yet more strain on individuals and families already struggling to meet their basic needs for food, water, energy, and housing. Given the role redlining, chronic divestment, and other policies have played in creating crises in affordable housing, the government has a role to play in reducing the impacts climate change adaptation requirements will have in exacerbating the housing crisis. Michigan has an opportunity to head off these impacts by targeting programs for weatherization and heating electrification at those living up to 200% of the Federal Poverty Limit. Furthermore, Michigan has an opportunity to make sure implementation programs actually benefit those most in need–including renters–rather than corporate landlord companies.

[39] Case Studies of Energy Efficiency Retrofits to Multifamily Affordable Housing in Minnesota | Energy Efficiency for All

[40] Mass Save® Heat Loan | Energy-Saving Loan Program

- **Green jobs and workforce development:** Pre-weatherization upgrades, home weatherization upgrades, and heat pump installations will all require a trained workforce. Programs designed by the state have an opportunity to incorporate new green jobs and a workforce development program that matches local community members with jobs that keep wealth within the communities jobs are located.

- **State-led decarbonization:**
Michigan does not have to rely on investor-owned utilities for critical energy efficiency upgrades. By developing programs that involve other community organizations, Michigan can serve community employment needs, save money on incentives paid to utilities for energy waste reduction (EWR) programs, and better control the speeds of decarbonization efforts, which might otherwise be in the hands of utilities who are incentivized to reap benefits of every increasing EWR spending while minimizing other critical changes to their energy portfolio.

Appendix

Housing counts and characteristics

The LEAD tool pulls data from the U.S. Census Bureau's American Community Survey 2018 Public Use Microdata Samples and combines it with electric and gas utility data from the U.S. Energy Information Administration utility surveys. Among other things, the LEAD tool includes data down to the county level across the following dimensions: household income level (Area Median Income or Federal Poverty Level), housing type (by number of units), housing vintage (building year of first construction), fuel type (how the housing unit is primarily heated), and tenure (renter or owner occupied). Since it is built on five year running averages, as opposed to annual data, the LEAD tool is not intended to take the place of program or policy evaluations. Instead, the LEAD tool was specially designed to provide disaggregated energy data that can be filtered, combined, and compared spatially and demographically at different scales to target energy programs and policies at low-income and other subpopulations. Based on its design and focus on understanding inequitable distributions in energy, the LEAD tool is the best source of accurate and data for this analysis.

Since the LEAD tool does not specify how many housing units have a basement, crawlspace, or slab foundation, this report calculated counts of foundation types using the distribution of foundation types found in a 2021 Pacific Northwest National Laboratory (PNNL) report completed for the DOE. PNNL derived the foundation distribution for Michigan from the Residential Energy Consumption Survey data (RECS 2013).

Single-family retrofit upgrades and costs

ResStock is a tool for granular modeling of the U.S. housing stock, which the U.S. DOE National Renewable Energy Laboratory (NREL) used to calculate the top ten energy efficiency upgrades for Michigan which would pay back in less than 5 years for most households. This analysis used the energy efficiency upgrades in determining which retrofit upgrades to include in weatherization.

This analysis pulls from the 2021 LBNL report, because it is the most up-to-date national resource available on home weatherization costs. Former comprehensive studies of national weatherization relied on cost data from the National Residential Efficiency Measures Database, which was last updated in 2010. The LBNL report derived their cost data from a database of 1739 projects from 15 states and 12 energy programs. As a sample of convenience, this database has some statistical limitations. However, it represents the costs of real projects ranging from about 2010 to 2020, which have been adjusted for inflation to 2019 USD to avoid any dollar value impacts from the COVID-19 pandemic. The database also reasonably reflects the types of housing units present in Michigan, including single-family homes with vintages ranging from 1800-2020. The cost data was compiled for both the cost of total projects as well as the costs of individual upgrades within the projects. This report used the median costs of individual upgrades as found in the database.

This analysis incorporated a construction cost correction factor to better represent Michigan. Construction costs were derived from the RS Means 2020 cost book, which is widely used and respected as a price guide for building construction estimators in North America. This analysis used a subsection of construction costs in Michigan cities to derive a weighted average that could be applied to weatherization and HVAC upgrade aggregated costs.

Multi-family and mobile home retrofit upgrades and costs

This analysis pulled retrofit costs from the 2022 report developed by the Advanced Building Construction (ABC) Initiative from the U.S. Department of Energy Building Technologies Office (BTO). The ABC Report represents the latest data on market-ready weatherization upgrades and heat pump installations for multi-unit housing, particularly in the face of a gap in the literature on multi-unit housing. The retrofit packages were defined with input from a cross section of energy experts, including RMI (formerly Rocky Mountain Institute), Association for Energy Affordability (AEA), Vermont Energy Investment Corporation (VEIC), Passive House Institute US, Inc. (PHIUS), Pacific Northwest National Laboratory (PNNL), Lawrence Berkeley National Laboratory (LBNL), National Renewable Energy Laboratory (NREL), and the U.S. Department of Energy (DOE). The ABC report then applied the packages to all residential types in the U.S., including multi-unit housing and mobile homes. Since Michigan was accounted for in the report, Michigan construction costs were not applied to weatherization and HVAC upgrade aggregated costs.

Appendix

Housing Composition

Table 1. Overview of Michigan Housing Composition

TYPE	CHARACTERISTICS	COUNTS IN MI	% OF MI HOUSING	COUNTS UP TO 200% FPL	% UP TO 200% OF FPL
Single-family	• 1 unit detached; 1 unit attached • Renter and owner occupied • Basement, crawlspace, or slab foundation • All vintages • All fuel types, apart from coal • Majority wood-framed	3,063,128	78%	769,969	25%
Small multi-unit	• 1-4 units • Renter and owner occupied • All vintages • All fuel types, apart from coal	170,928	4%	85,176	50%
Medium to large multi-unit	• 5+ units • Renter and owner occupied • All vintages • Fuel types include utility gas, electricity, bottled gas, other, and none	502,912	13%	244,588	49%
Mobile homes	• Renter and owner occupied • All vintages • All fuel types, apart from coal	171,696	4%	79,182	46%

Michigan Housing Types

Figure 1. Housing Types

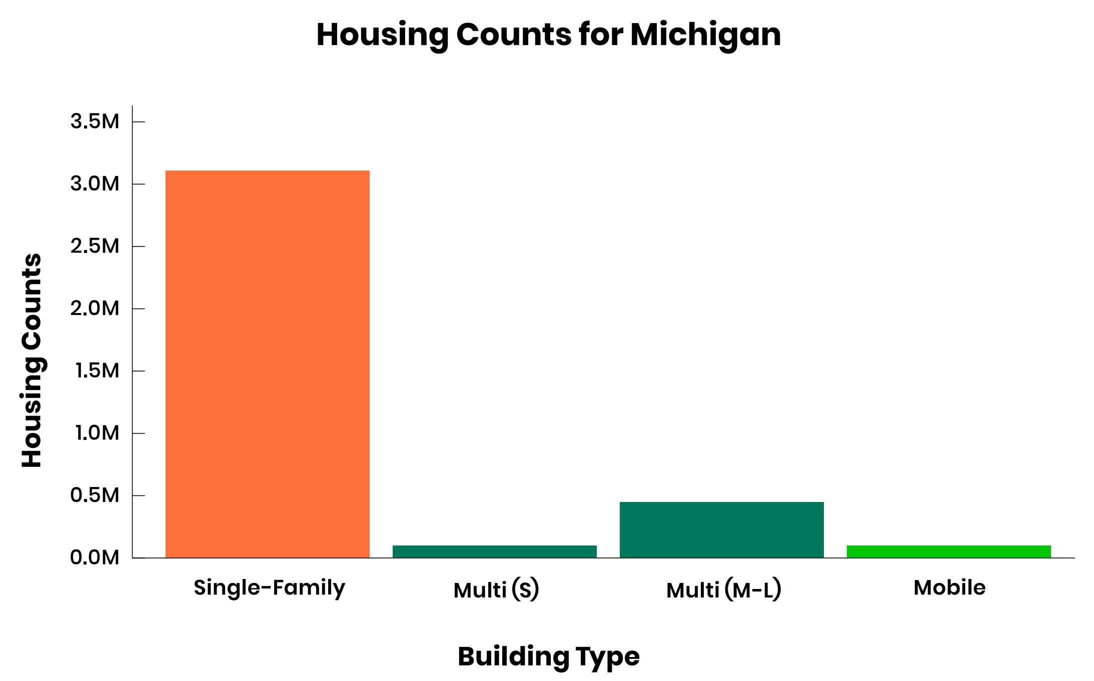
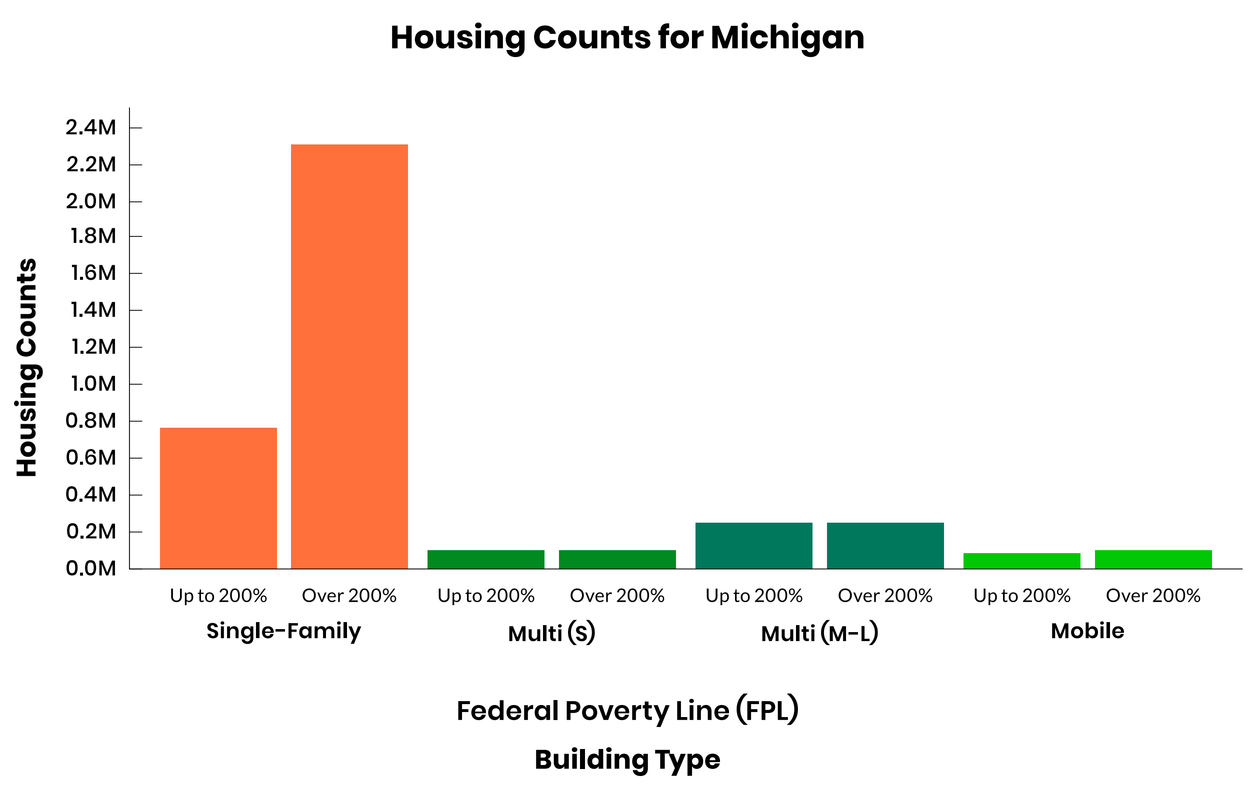


Figure 2. Housing Types by FPL



Housing Composition

Table 2. Overview of Michigan Housing Vintage

VINTAGE	% OF MI HOUSING	% UP TO 200% OF FPL	% HOUSING TYPES WITHIN VINTAGE
Before	14%	39%	Single-family: 86% Small multi-unit: 8% Medium to large multi-unit: 6%
1940 - 59	23%	34%	Single-family: 92% Small multi-unit: 3% Medium to large multi-unit: 5%
1960 - 79	28%	31%	Single-family: 73% Small multi-unit: 5% Medium to large multi-unit: 18% Mobile homes: 4%
1980 - 99	23%	26%	Single-family: 67% Small multi-unit: 4% Medium to large multi-unit: 18% Mobile homes: 10%
2000 - 09	10%	20%	Single-family: 80% Small multi-unit: 2% Medium to large multi-unit: 13% Mobile homes: 5%
2010+	2%	22%	Single-family: 71% Small multi-unit: 3% Medium to large multi-unit: 18% Mobile homes: 8%

Michigan Housing Types

Figure 3. Housing Counts for Vintage

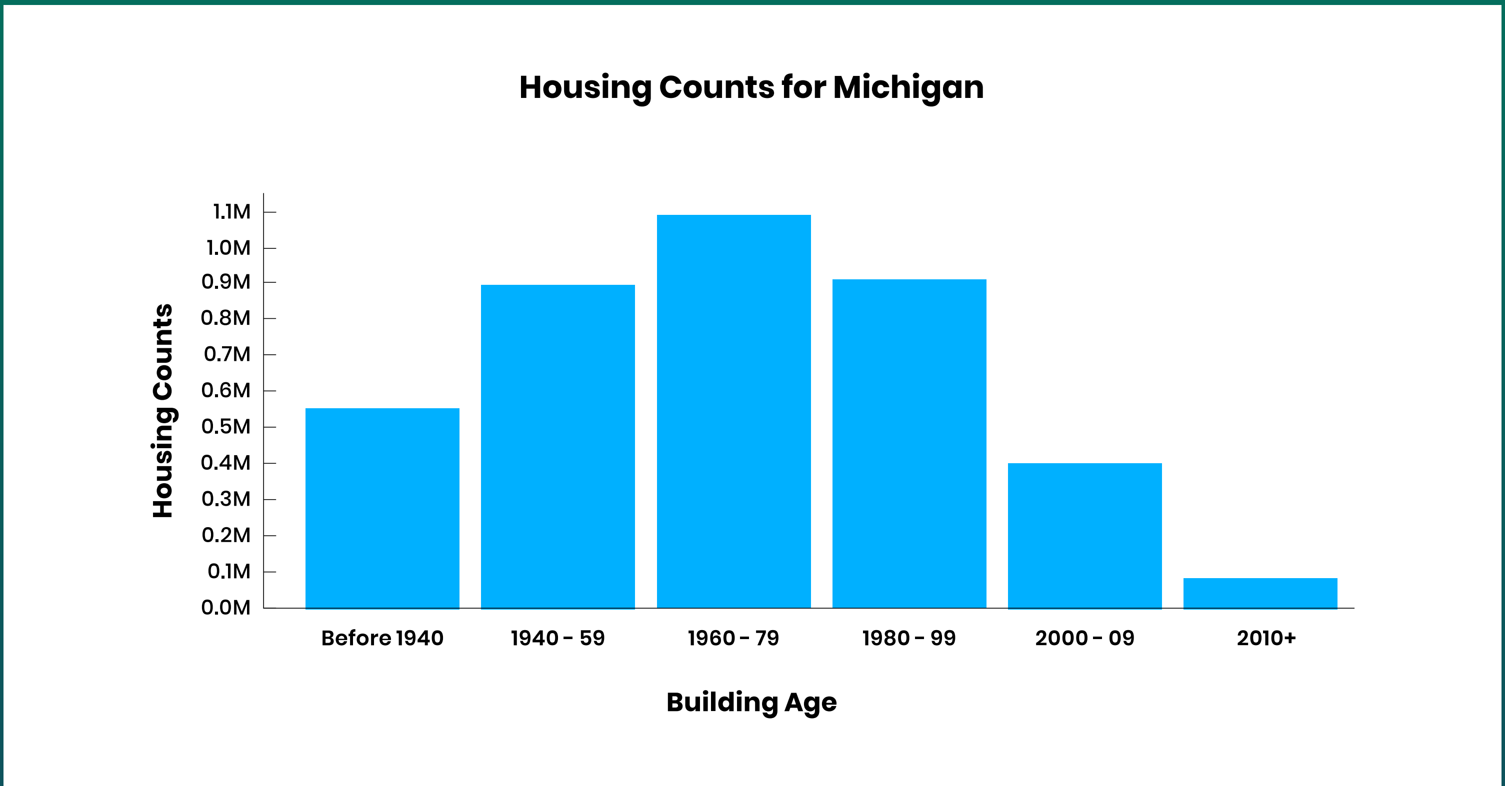
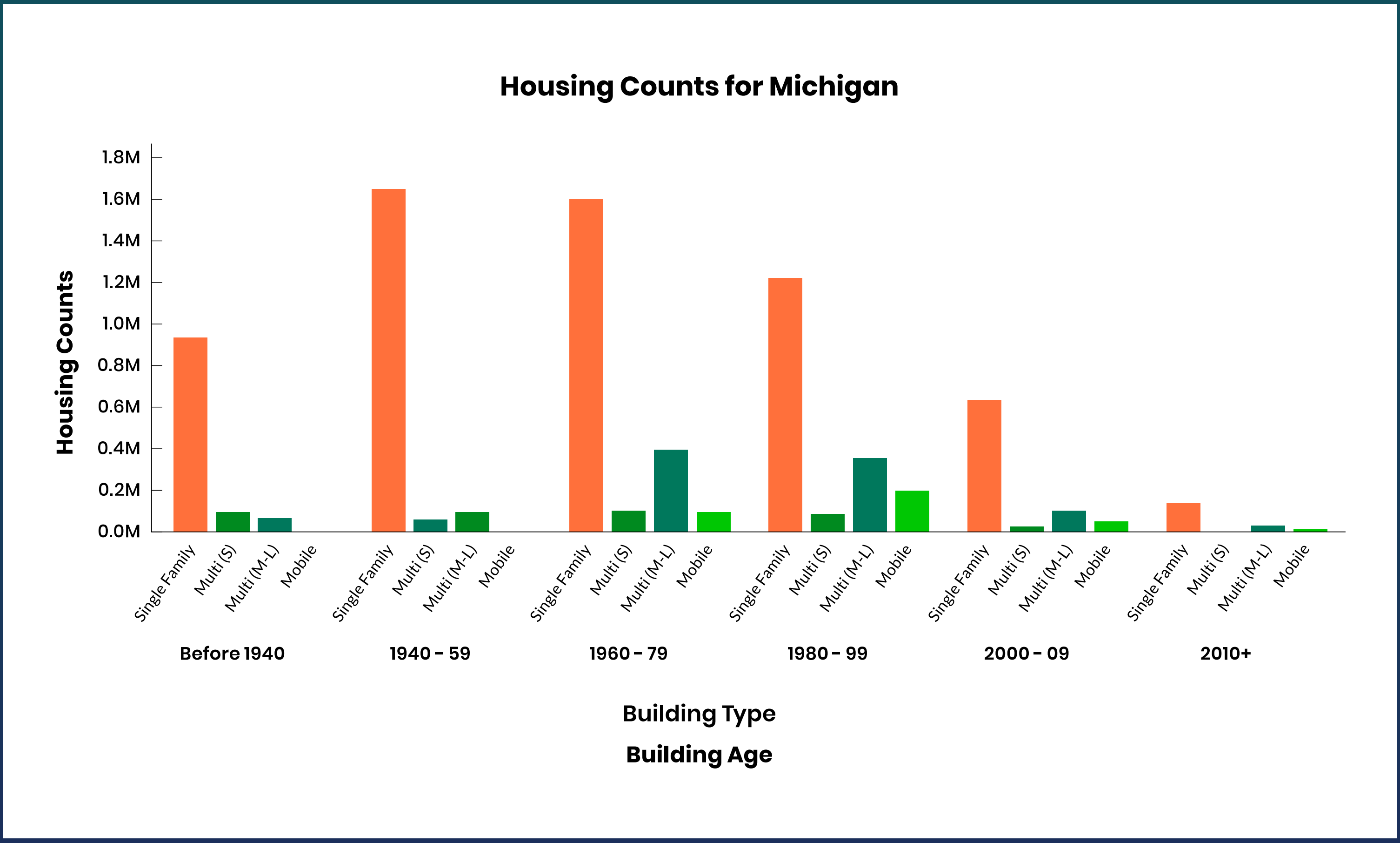


Figure 4. Housing Types across Vintage



Michigan Housing Types

Figure 5. Vintage by FPL

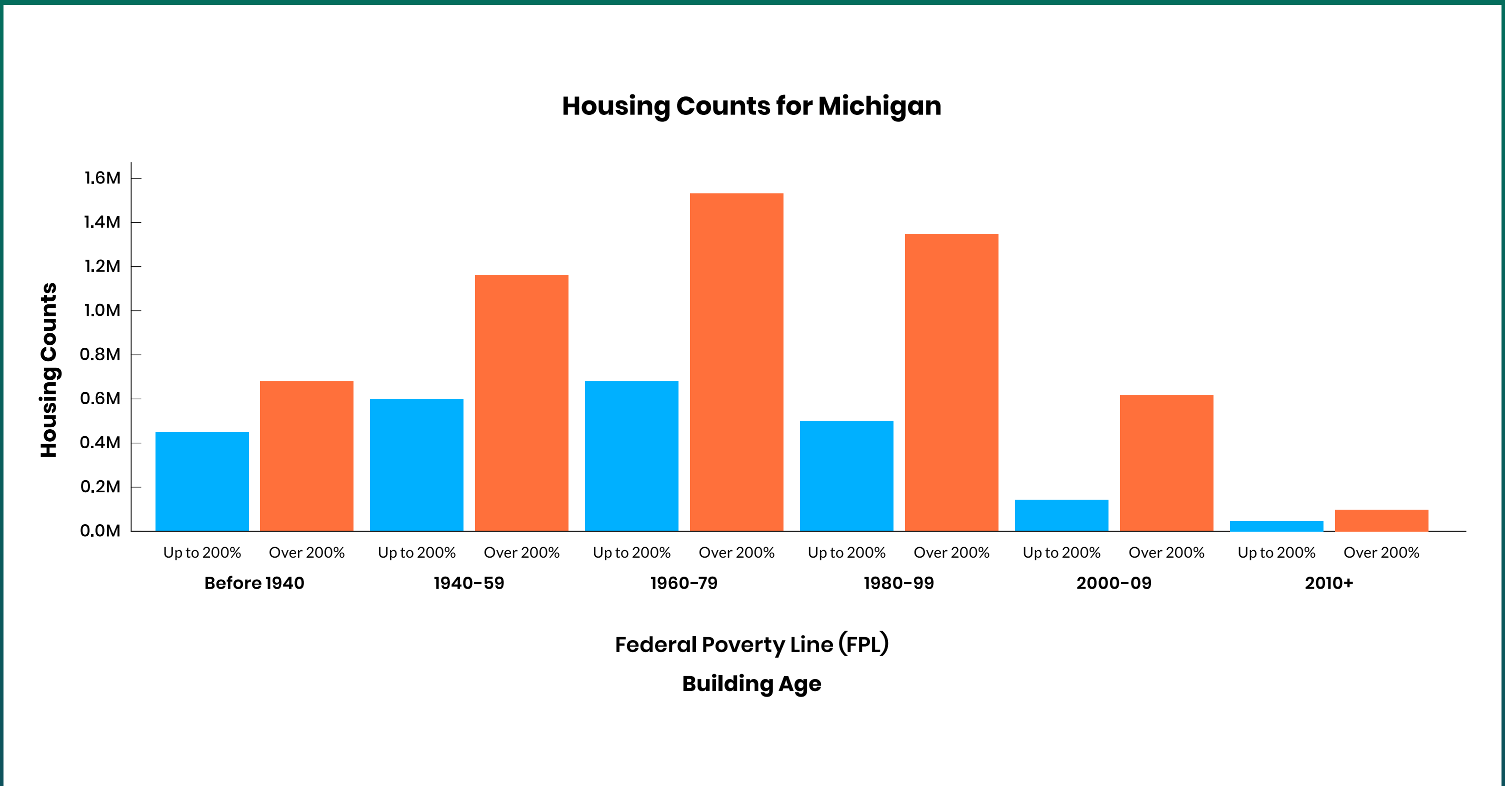
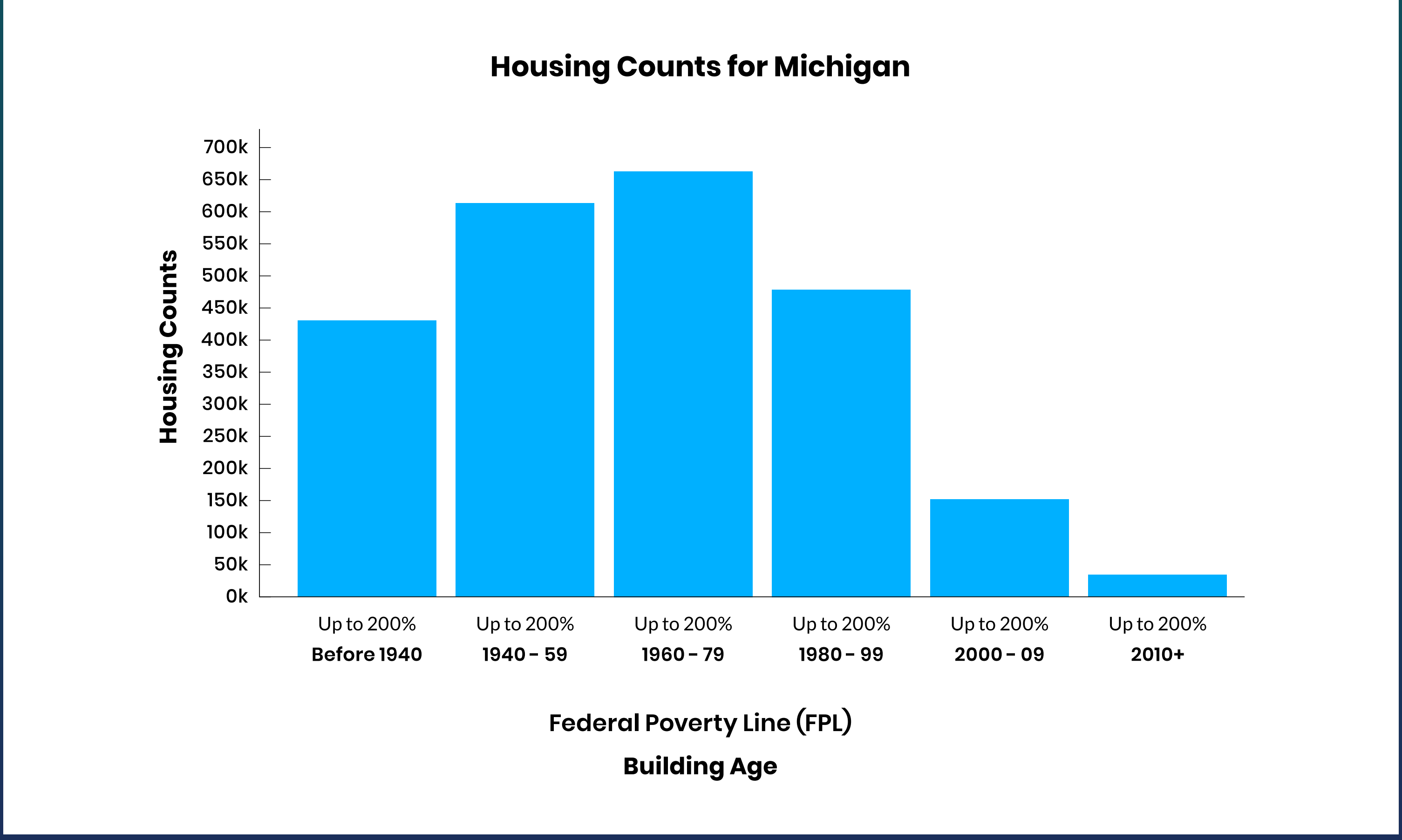


Figure 6. Vintage up to 200% FPL



Appendix

Retrofit Upgrades

Table 3. ResStock Potential Michigan Energy Efficiency Upgrades

TYPE	ENERGY EFFICIENCY UPGRADE	APPLICABILITY TO THIS ANALYSIS FOR SINGLE-FAMILY HOMES
Enclosure	• Air sealing • Drill-and-fill wall cavity insulation • R-60 attic insulation • R-10 basement wall insulation • R-5 insulated wall sheathing (at siding replacement) • Low-E storm windows (DIY install)	According to ResStock, air sealing is applicable to 100% of homes in Michigan; attic insulation to 78% of homes, drill-and-fill cavity insulation to 46% of homes, and basement wall insulation to 35% of homes. Between their applicability and their heating and cooling support, these upgrades were included in this analysis. In contrast, wall sheathing is only applicable to 18% of homes in Michigan, and only cost effective when a home's siding is already being replaced. Similarly, low-E storm windows, while applicable to 34% of homes, are not nearly as helpful for weatherization as installing double-pane windows. However, double-pane windows are some of the most expensive weatherization upgrades and do little for heating and cooling effectiveness relative to other insulating and sealing upgrades. Therefore, wall sheathing and low-e storm windows were excluded from this analysis.
HVAC	• Duct sealing and insulating • High-efficiency heat pump (replace electric furnace at wear out)	According to ResStock, duct sealing is applicable to 42% of homes in Michigan. It is also one of the most important ways of ensuring efficient distribution of conditioned air throughout homes with ductwork, so it was included in this analysis. Heat pumps are the best technology for heating and cooling effectively, so they are included in this analysis. Their applicability to the Michigan housing stock is underrepresented in NREL's calculations in ResStock, since only those homes already outfitted with an electric furnace were included in their analysis.

Gas to Electric:

Equitable Home Electrification Policy in Michigan

MICHIGAN ENVIRONMENTAL JUSTICE COALITION

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