Louisville Communities LEAP Engagement: Improving Energy Efficiency in Affordable Housing

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List of Acronyms

AMI	Area median income
BECP	U.S. Department of Energy Building Energy Codes Program
Buildings UP	Buildings Upgrade Prize
DOE	U.S. Department of Energy
DOEE	Washington D.C. Department of Energy & Environment
EERE	U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy
EPA	U.S. Environmental Protection Agency
ESPM	ENERGY STAR® Portfolio Manager
EUI	Energy Use Intensity
GHG	Greenhouse gas
HUD	U.S. Department of Housing and Urban Development
KFTC	Kentuckians for the Commonwealth
LAHTF	Louisville Affordable Housing Trust Fund
Communities LEAP	Communities Local Energy Action Program
LG&E	Louisville Gas and Electric
LIHEAP	Low Income Home Energy Assistance Program
LMG	Louisville Metro Government
LMHA	Louisville Metro Housing Authority
LMI	Low and Moderate Income
MHC	Metropolitan Housing Coalition
NOAH	Naturally Occurring Affordable Housing
NREL	National Renewable Energy Laboratory
PNNL	Pacific Northwest National Laboratory
SCEP	U.S. Department of Energy's Office of State and Community Energy Programs
TA	Technical Assistance
URLTA	Uniform Residential Landlord Tenant Act
WAP	Weatherization Assistance Program

Executive Summary

In 2022, the U.S. Department of Energy selected Louisville/Jefferson County, Kentucky (City of Louisville), for support through the Communities Local Energy Action Program (Communities LEAP), a pilot technical assistance (TA) program aimed at supporting low-income, energy-burdened households in environmental justice areas. Communities LEAP is managed by the National Renewable Energy Laboratory (NREL), in coordination with subject matter experts.

Over 18 months, NREL researchers worked with the community coalition, including the city's Office of Sustainability, the Metropolitan Housing Coalition, and Kentuckians for the Commonwealth, to address issues of energy affordability in affordable housing. This project resulted in five related workstreams:

- **Energy Efficiency Analysis**: Provide support to prioritize technologies. While many energy efficiency technologies are readily available, Louisville needed to identify those that most directly addressed utility bill costs, were economically feasible, and reduced overall greenhouse gas emissions.
- **Policy Analysis**: Identify policies that Louisville currently has in place and policies implemented in other jurisdictions that may be applicable. Louisville is constrained in the policies it can implement due to state control of the building code. This workstream identified complementary policies from other jurisdictions that could be explored to bolster energy efficiency uptake in Louisville.
- **Community Benchmarking Ordinance**: Explore mechanisms to identify buildings to prioritize for upgrades and monitor progress. While Louisville cannot implement mandatory benchmarking, a voluntary benchmarking program with possible incentives could help residents and business owners establish baseline energy use and incentivize efforts to increase energy efficiency.
- **Workforce Analysis**: Identify existing workforce efforts in the state and models in other jurisdictions to develop a 'right-sized' workforce and ensure the employment benefits of energy efficiency are shared by all. The Louisville coalition sought to ensure that residents of low-income, environmental justice communities were provided opportunities to substantially participate in the workforce required to complete future energy efficiency work. This workstream identified which specific trades would be necessary and how Louisville could establish pathways to provide needed trainings and certifications.
- **Financing Analysis**: Identify obstacles keeping low-income residents from taking advantage of energy efficiency upgrades, and how Louisville can help address these obstacles. With a focus on low-income households (both homeowners and renters), Louisville sought to establish financing mechanisms to cover upfront costs of energy efficiency upgrades.

To inform these workstreams, NREL researchers used the ResStock™ tool, which models the diversity of housing stock in a geographic area along with the impacts of different energy efficiency technologies to estimate potential energy and cost savings and emissions reductions. Additionally, NREL researchers analyzed current and potential policies for energy-benchmarking and building performance standards as well as applicable programs and policies from other municipalities. NREL also conducted a workforce analysis using data from the Bureau of Labor Statistics to identify possible gaps in the existing workforce and workforce development programs.

Project Limitations

Several assumptions and limitations to the data and analysis are discussed throughout this report. This report does not detail actual energy consumption, greenhouse gas emissions, or utility bill data for the City. Instead, NREL used tools to model potential energy consumption patterns. Although the models are highly vetted and the baseline building stock data was cross-checked with city and county assessor data, every model makes specific assumptions and therefore has its uncertainties and limitations. More information about modeling assumptions and limitations can be found in the Modeling Assumptions and Limitations Section.

Summary of Analysis Results

The ResStock modeling of Louisville's housing stock found that single-family detached is the largest category of housing type at 65% of all households, followed by large multifamily (19%), and small multifamily (10%). While low- and moderate-income (LMI) households make up about 50% of all households, they account for only 37% of single-family detached homes and 40% of single-family attached homes. LMI households comprise 74% and 68% of small and large multifamily units, respectively.

For the vintage of housing (year of construction), ResStock aggregates homes into three periods: pre-1940, 1940-1979, and 1980 or after. Based on ResStock data, 65% of homes in Louisville were built before 1980. While LMI and non-LMI households are evenly distributed between pre-1940 and 1940-1979 homes, LMI households account for only 32% of homes built in the 2000s and 26% of homes built in the 2010s.

ResStock modeling of Louisville's housing stock found that nearly 70% of homes suffer from a poor combined envelope rating (compared to modern energy code performance levels), resulting in higher energy consumption, more emissions, higher energy burdens, and higher energy bills. Envelope performance also has potential impacts on occupant comfort. Modeled results show that a basic enclosure upgrade to all homes with a poor rating would result in an estimated $139 million in annual bill savings and reduce emissions by 637 million $kgCO_2e$.[1,2] Enhanced enclosure coupled with whole-home electrification could have the most significant impact on reducing energy burden for Louisville households, particularly for households at 0-80% area median income (AMI).[3]

The research into workforce development included high-level information on clean energy employment in general for all communities supported through Communities LEAP, a focused look at the Louisville workforce ecosystem today, and a curated list of workforce development programs that could serve as an example for Louisville's efforts.

The policy analysis identified the current programs in Louisville that include energy efficiency as well as case studies of programs and policies in other cities that could be adapted for Louisville. NREL researchers also analyzed community benchmarking ordinances, specifically including case studies

[1] The basic enclosure upgrade was the most cost-effective modeled measure for this analysis and includes upgrading attic insulation to modern building codes, reducing air leakage by 30%, sealing ducts to 10% leakage and adding R-8 insulation, and adding cavity wall insulation to R-13.
[2] kgCO2e, or kilograms of carbon dioxide equivalent, represents the combination of pollutants that contribute to climate change adjusted using their global warming potential, measured in kilograms, where carbon dioxide has a global warming potential factor of 1 (see 'Carbon Dioxide Equivalent in the U.S. EPA's Glossary of Climate Change Terms for more information).
[3] The enhanced enclosure package includes everything in the basic enclosure package plus adding R-10 insulation to foundation walls and rim joists, sealing crawlspace vents, and insulating finished attic and cathedral ceilings to R-30.

from peer cities, developed a summary of benchmarking program elements, and highlighted complementary program designs.

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How To Use/Read This Document

This document is a comprehensive summary of the related workstreams pursued through the Communities Local Energy Action Program (Communities LEAP) pilot Technical Assistance (TA) program. It begins with an analysis around energy efficiency technologies, focused on building envelope improvements,[4] that explores the impact to individual residents as well as the impact to the community at-large if the upgrades were adopted city-wide. Community benchmarking ordinances and complementary policies are considered next, including comparisons of programs with peer communities. A workforce development section then covers the state of Louisville's workforce today and identifies programs in peer communities that Louisville could consider emulating to achieve a "right-sized" workforce. The document closes out with an overview of policies around energy efficiency in peer communities that Louisville could explore, with considerations for the City's unique policy context. Throughout the above sections, where possible, considerations and challenges relating to financing energy efficiency technologies are explored. Given their role as a neutral TA provider, National Renewable Energy Laboratory (NREL) researchers do ***not*** make policy recommendations but, instead, try to highlight policies or decisions that Louisville could consider to achieve its clean energy ambitions. Throughout the report, key points have been bolded and included in the Executive Summary.

[4] A similar set of results is explored for a set of whole-home electrification plus building envelope upgrade packages in an appendix.

Introduction

Overview of the Community

Louisville-Jefferson County is a merged city-county government in north-central Kentucky, a state with a long history of coal dependence. Louisville covers almost 400 square miles with a population of 773,399 and is the largest city in the state. Almost a third of the city's households earn less than 200% of the Federal Poverty Level, and 8.51% of the total population spends 6% or more of their gross income on their energy bills, meeting the definition of energy burdened. Louisville's population is 63.4% white, 21.9% Black or African American, 6.9% Hispanic or Latino, and 4.5% reporting two or more races. In Louisville, 63.2% of housing units are owner-occupied with a median home value of $242,900 (U.S. Census Bureau 2023a).

According to reports from the Metropolitan Housing Coalition (MHC), the historic practices of "redlining"[5] continue to impact residents today, particularly in the nine neighborhoods that make up west Louisville (the West End) (MHC 2019; 2023). Census tracts in these neighborhoods often have high rates of foreclosures, high rates of renters, high unemployment, lower median income, lower home values, and higher rates of chronic illness and a life span up to 11 years shorter than Louisville as a whole (Center for Health Equity 2017; Louisville Metro Government 2017; MHC 2019; 2023). West Louisville is also 73% Black or African American with a median home value of $82,000 and household income of $32,659, about half that of the median value for the rest of Louisville ($64,619) (U.S. Census Bureau 2023a). Lower income levels in these neighborhoods have exacerbated energy burden rates for many households.

A 2016 report found that in 2013, the median energy burden in Louisville was 3.57%, but that the median energy burden for low-income households was over twice that at 7.60%. The report also found that the median energy burden in 2013 was 4.66% for African American households, 4.16% for Latino households, and 4.77% for renting households (Drehobl and Ross 2016). Census tract energy burden data from 2017 indicates that 8.51% of the total population of Louisville/Jefferson County experiences an energy burden of 6% or higher (U.S. Census Bureau 2023a).

Clean Energy Ambitions and Emissions Profile

To address the impacts of climate change, the Louisville Metro Council passed a Clean Energy Resolution (R-102-19) in February 2020, setting the following ambitious clean energy goals (Coan et al., 2020):

- 100% clean electricity for government operations by 2030
- 100% clean energy for government operations by 2035
- 100% clean energy community-wide by 2040.

Additionally, in October 2022, Mayor Greg Fischer signed an Executive Order (No. 2022-006) to revise the Emissions Reduction Plan (ERP) reduction targets to net-zero emissions (Scope 1, 2, and 3) by 2040 by incorporating such strategies as carbon sequestration to offset unavoidable emissions, and an interim target of 50% reductions by 2030 (Fischer, 2022).

The 2016 Community Greenhouse Gas Emissions Inventory Report, published by the City of Louisville's Office of Sustainability, found that Louisville's Core greenhouse gas (GHG) emissions

[5] "Redlining refers to lending (or insurance) discrimination that bases credit decisions on the location of a property to the exclusion of characteristics of the borrower or property. Usually, it means that lenders will not make loans to areas with African Americans or other perceived risks to real estate investments." (Hillier 2003)

(building energy use, fugitive, energy industries, transportation, and water) was 14,540,142 tCO2e, or 18.9 tCO2e/person.[6] Of these core emissions, 26.5% were from residential buildings.

Louisville-Jefferson County is served by Louisville Gas & Electric (LG&E), an investor-owned, vertically-integrated utility and subsidiary of PPL Corporation regulated by the Kentucky Public Services Commission. LG&E has served Louisville for over 100 years and has provided predominantly fossil fuel-generated energy. LG&E reports that their current energy mix is 84% coal, 15% natural gas, and 1% renewable energy.[7] Given the fossil fuel-dominated power system, and the limited control Louisville has over the generation mix used to serve its demand, reducing electricity consumption from the grid through energy efficiency investments can have a significant impact on the community's emissions.

Overview of Communities LEAP

The U.S. Department of Energy developed the Communities Local Energy Action Program (Communities LEAP) pilot to facilitate sustained community-wide economic empowerment through clean energy, improve local environmental conditions, and open the way for other benefits through clean energy deployment. This opportunity was specifically for low-income, energy-burdened communities that were also experiencing either direct environmental justice impacts or direct economic impacts from a shift away from historical reliance on fossil fuels.

Through a competitive process, 24 cities were selected for the pilot program in at least one of 7 pathways:

- Clean Energy Planning and Deployment
- Energy Efficient Buildings and Beneficial Electrification Planning and Investment
- Clean Transportation Planning and Investment
- Carbon Capture and Storage
- Energy Site Reclamation and Critical Minerals Processing
- Community Resilience Microgrids
- New or Enhanced Manufacturing.

Communities in the U.S. were eligible to apply if they met the following criteria:

- 30% of the community population classified as low income AND
- High or severe energy burden (median spending of household income on energy bills ≥ 6%).

Community applicants were required to have multi-stakeholder teams, including at least one community-based organization with a demonstrated track record of working with community stakeholders and at least one local, Tribal, territorial, regional, or state government entity.

The National Renewable Energy Laboratory (NREL) is a national laboratory focused on leading research, innovation, and strategic partnerships to deliver solutions for a clean energy economy and was selected as the primary TA provider for Communities LEAP.

Developing the Scope of Work

After selection, Louisville began work with NREL experts to develop a detailed scope of work based on their application and stakeholder input. The workstream was designed to address the following key areas:

[6] tCO2e represents tons of carbon dioxide equivalent; see footnote 2 for a more detailed explanation of carbon dioxide equivalent measurements.
[7] https://lge-ku.com/future.

- **Energy Efficiency Analysis**: Provide support to prioritize technologies. While many energy efficiency technologies are readily available, Louisville needed to identify those that most directly addressed utility bill costs, were economically feasible, and reduced overall greenhouse gas emissions.
- **Policy Analysis**: Identify policies that Louisville currently has in place and policies implemented in other jurisdictions that may be applicable. Louisville is constrained in the policies it can implement due to state control of the building code. This workstream identified complementary policies from other jurisdictions that could be explored to bolster energy efficiency uptake in Louisville.
- **Community Benchmarking Ordinance**: Explore mechanisms to identify buildings to prioritize for upgrades and monitor progress. While Louisville cannot implement mandatory benchmarking, a voluntary benchmarking program with possible incentives could help residents and business owners establish baseline energy use and incentivize efforts to increase energy efficiency.
- **Workforce Analysis**: Identify existing workforce efforts in the state and models in other jurisdictions to develop a 'right-sized' workforce and ensure the employment benefits of energy efficiency are shared by all. The Louisville coalition sought to ensure that residents of low-income environmental justice communities were provided opportunities to substantially participate in the workforce required to complete future energy efficiency work. This workstream identified which specific trades would be necessary and how Louisville could establish pathways to provide needed trainings and certifications.
- **Financing Analysis**: Identify obstacles keeping low-income residents from taking advantage of energy efficiency upgrades, and how Louisville can help address these obstacles. With a focus on low-income households (both homeowners and renters), Louisville sought to establish financing mechanisms to cover upfront costs of energy efficiency upgrades.

For each of the above areas, technical experts at NREL worked with the coalition through four scoping meetings to develop a work plan. Regular coalition meetings helped ensure that the development of deliverables met the needs of the team. Additionally, meetings and interviews were held with stakeholders such as the Louisville Affordable Housing Trust Fund, the Louisville Metro Housing Authority, and Louisville Metro Government's Home Repair program to better understand current issues and initiatives in their development of affordable housing.

Not All Affordable Housing Is the Same

This report addresses potential energy efficiency improvements for affordable housing in Louisville, but the term affordable can encompass a wide range of housing types. Affordable housing in general is defined as housing (rent/mortgage plus utilities) that is no more than 30% of a household's income (Colton 2011). Affordable housing may be developed by local government, nonprofit entities, or for-profit companies.

Louisville Metro Housing Authority (LMHA) owns and operates public housing developments that are income-based. LMHA also offers vouchers to qualified households that can be used to acquire housing from a private owner. The LMHA vouchers offer a fixed amount of money that can be applied toward rent, and the resident is responsible for any difference between the voucher amount and the

rent. LMHA also owns scattered site properties, which include apartments and homes within other developments.[8]

Louisville also provides financial support to the Louisville Affordable Housing Trust Fund (LAHTF), a nonprofit created by Metro Council, as a way to invest local public funds in the development of affordable housing by either nonprofit or for-profit developers.[9] LAHTF makes grants and loans, provides TA, and enables builders and developers to construct affordable housing with less financial risk. The costs of these developments, whether rent in multifamily buildings or cost for homeownership, are typically based on Area Median Income (AMI). Some developments focus on 80-150% AMI, while others are intended for those making <80% AMI.

Louisville also provides funding directly to nonprofit affordable housing developers who commit to providing affordable housing options to low-to-moderate income households. The organizations may also develop housing focused on a specific range of AMI. Properties acquired through Louisville's Land Bank may also have affordable housing provisions for prospective purchasers who acquire vacant property at a lower cost.[10] Naturally occurring affordable housing (NOAH) refers to housing that is affordable to low-to-moderate income households but is unsubsidized by government funding.

In Kentucky, cities cannot adopt a stricter building or energy code than what is required by the state (Stivers et al. 2023). However, when public funding is used to subsidize affordable housing development, the city could potentially include higher efficiency standards. Although constrained by state-level policy decisions, Louisville can work across its own portfolio of affordable housing, as well as partner with affordable housing developers (especially those who receive support from Louisville Metro) to ensure new units are built to a particular energy code.

Beyond Communities LEAP

The Communities LEAP engagement aimed to provide Louisville direction on which technologies and examples from peer communities would be applicable. Addressing the interconnected issues of climate change, energy affordability, and housing is an enormous challenge that will require a concerted effort from the entire community. Communities LEAP did not seek to fully address these issues but rather provide Louisville with the information and analysis it needs to have confidence in taking further action. Beyond Communities LEAP, there are several other initiatives that can build on the work here:

- In 2023, Mayor Craig Greenberg announced the details of a new city initiative, My Louisville Home—A Comprehensive Housing Strategy, aimed at increasing the affordable housing stock in Louisville (Louisville Metro Government 2023). The city announced a goal of creating and preserving 15,000 units of affordable housing in the city by 2027. As a part of the initiative, the city aims to "further Louisville's health and environmental goals by promoting sustainable building technologies," and indicated that "… the [Communities LEAP] plan will be evaluated and integrated into [the housing initiative]." This report can contribute to that effort by helping Louisville weigh the impacts of different technologies and identifying complementary policies, as well as workforce development practices to support maximum impact.
- The U.S. Department of Energy's Office of State and Community Energy Programs (SCEP) offers an opportunity, the Energy Efficiency and Conservation Block Grant Program, that

[8] https://www.lmha1.org/about_lmha/agency_profile.php.
[9] https://loutrustfund.org/about-us/.
[10] https://louisvilleky.gov/government/community-development/purchase-vacant-property-landbank.

allows communities to access federal funding through a simple application to support the deployment of energy efficiency technologies.[11] This report gives Louisville information and analysis as it identifies options for valuable technologies to prioritize when leveraging this funding opportunity.

- The U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) recently announced its Buildings Upgrade Prize (Buildings UP), which offered $22 million to a total of 45 community teams, for up to $400,000 in prizes and TA for each team. Louisville was announced as a Phase 1 winner and aims to use the funding and TA to "to eliminate severe energy burden in low and moderate income (LMI) affordable housing. and provide supplemental support to other focus areas (benchmarking, financing, and workforce)."[12] This Communities LEAP report can support that effort by providing initial analysis, which the Buildings Upgrade team can further develop.

[11] https://www.energy.gov/scep/eecbg-program-formula-grant-application-hub.
[12] https://www.energy.gov/eere/buildings/buildings-upgrade-prize-buildings.

Energy Efficiency Analysis

Approach and Methodology

Louisville's goal for this workflow was to ensure that those most impacted by high energy burdens would see the benefits of energy efficiency investments. Low-income households are likely to suffer higher energy burdens (Drehobl and Ross 2016), but are least able to afford the upfront investment needed for energy efficiency upgrades and technologies that could help them address such burdens (ACEEE 2024). Understanding the most economically feasible interventions for affordable housing allows Louisville to make targeted investments with the most impact and encourage affordable housing developers to do the same.

Determining which technologies will have the highest impact in Louisville as it seeks to meet its clean energy goals required an understanding of the costs of each technology, its impact on carbon emissions, and its impact on customer energy bills. Among other factors, technology costs are a function both of the technology and specific housing characteristics (e.g., the size of the home, the presence of existing ductwork, current insulation, etc.). The impact on emissions is dependent on residential efficiency and electrification upgrades (e.g., replacing a natural gas furnace with an efficient electric heat pump for heating) and the changing demand for electricity generation from the broader power system. For instance, when electrifying natural gas heating end uses there is a *reduction* of emissions from within the house, but a potential *increase* in emissions from the power sector driven by increased electricity demand. The magnitude of these induced grid emissions is driven by characteristics unique to Louisville's power system and to the generator that is providing electricity to meet demand at a given point in time.[13] Finally, the impact on customer energy bills depends on changes to expenditures on electricity and the original heating fuel, like natural gas or propane. These changes are both a function of energy usage as well as the structure of residents' energy tariffs and rates. This analysis seeks to inform discussions around technology prioritization by providing an estimate of potential impacts in the three areas of technology costs, emissions reduction, and impacts on energy bills.

To identify promising energy efficiency technologies, the Communities LEAP team leveraged modeling results from NREL's residential building stock model, ResStock.[14] ResStock is a physics-simulation tool that generates statistically representative households (Wilson et al. 2017). It considers the diversity in the age, size, construction practices, installed equipment, appliances, and resident behavior of the housing stock across U.S. geographic regions. ResStock enables a new approach to large-scale residential energy analysis by combining large public and private data sources, statistical sampling, and detailed subhourly building simulations. The tool generates a group of statistically representative building simulation models from a housing parameter space derived from existing residential stock data (Sandoval et al. 2023).

ResStock generates energy consumption, emissions, and energy bill savings estimates for a representative building stock for a specific geography under multiple technology adoption scenarios. The tool allows users to model how specific energy efficiency upgrades impact energy consumption for the building stock in that location, in this case Louisville. Additional information on the ResStock methodology and data can be found in Liu et al. (2023). Figure 1 provides a high-level illustration of

[13] This analysis evaluated emissions based on long-run marginal emissions factors for the Louisville region from NREL's Cambium model (Liu, Brossman, and Lou 2023; NREL 2022). Cambium provides hourly emissions factors that estimate "the rate of emissions that would be either induced or avoided by a change in electric demand, taking into account how the change could influence both the operation as well as the structure of the grid" (NREL 2023).

[14] https://resstock.nrel.gov/.

the ResStock process to produce estimates for changes in energy bills, energy consumption, and emissions. These estimates were provided for 1,403 "building prototypes," which were designed to represent common housing characteristics present in Louisville (such as floor area, insulation values in the home, etc.). In addition to these housing characteristics, ResStock provides information on the modeled occupant household, such as income (as measured by the AMI).

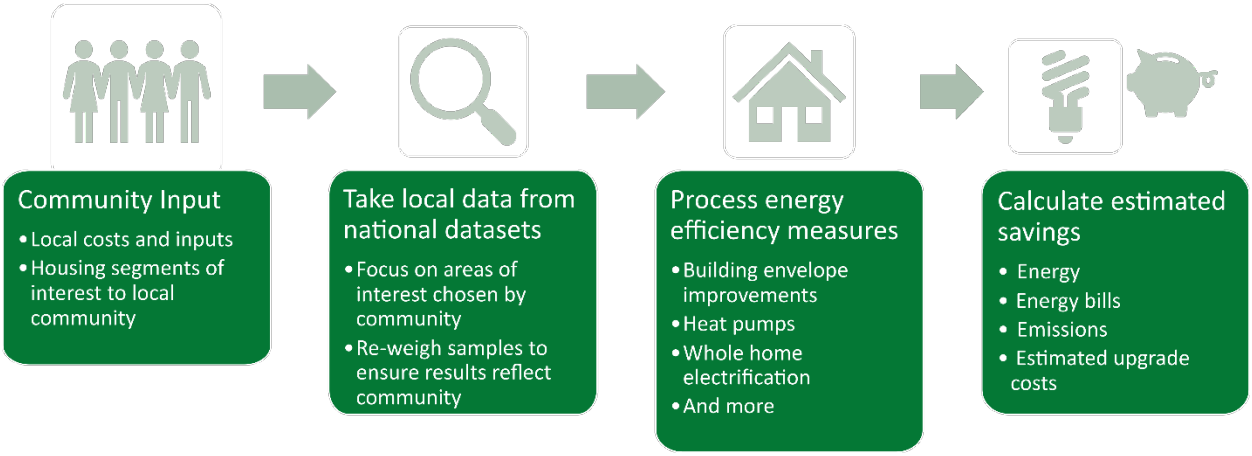

Figure 1. Overview of the ResStock Communities LEAP Approach for Louisville.

Modeling Assumptions and Limitations

ResStock provides a highly granular view of the energy consumption of households under a variety of technology adoption assumptions. However, these are only modeled results; all models have uncertainty. Furthermore, this modeling is based on a set of 'prototypical' housing units, and the results for any individual housing unit within a community can vary substantially based on the unique attributes of the housing in question, or the behavior of its occupants. While useful for evaluating technologies at the community level, the findings from this work are not necessarily applicable to any individual household, and a detailed energy audit can yield information more specific to a particular unit.

Within Louisville, technology cost estimates were derived based on national average costs, scaled with a local cost and inflation adjustment factor. Except where specified, these costs do not include the impact of rebates or other incentives. The costs also do not cover interventions that may be needed to *enable* particular upgrades, such as installing new electrical panels, mold remediation, lead abatement, or repairs to roofs. The costs of installing a particular technology within a specific housing unit can vary substantially based on factors unique to the project. Similarly, this analysis assumed a uniform retail tariff applied to all residential consumption that was used to estimate bill impacts. Customers on low-income bill assistance programs or on different retail tariffs could see different bill savings.

This analysis explored a variety of technology upgrades but did not explore all potential technologies or possible combinations of technologies. Notably, the ResStock EUSS 2022.1 dataset used in this analysis often explored lower and higher energy efficient versions of technologies (i.e., a basic or

high-efficiency version of a particular technology like heat pumps[15]). In actual installations, depending on many factors, residents installing technologies could see a wide range of energy, bill, and emissions savings.

For more information about the modeling methodology, assumptions, and limitations see Liu et al. (2023).

Modeled Scenarios

The rest of this section looks at:

- The "baseline" scenario of the ResStock analysis, which is an estimate of the housing stock and associated energy usage, energy bills, and residential emissions as it stands in an assumed 2018 year.
- A set of "enclosure" upgrade scenarios from ResStock, which look at the potential impacts of improving the building envelope (including walls, windows, doors, floors, foundation, and ceiling) for Louisville's housing stock.
- An additional upgrade scenario for a combined envelope upgrade plus heat pump, which explores the potential impact of improving the building's envelope while electrifying heating can be found in Appendix D. Energy Efficiency Analysis: Whole-Home Electrification and Envelope Upgrade.

A total of 16 technology upgrade packages were explored in the ResStock analysis. The enclosure upgrade scenarios represented the best economics, as measured by simple payback period (see section 'Envelope Improvements'). Envelope upgrades represent long-lasting investments that often provide years of additional savings after being paid back. Envelope upgrades reduce infiltration and increase insulation (see Section 'Description of the Building Envelope'), which can often allow accompanying or future replacement heating and cooling systems to be sized smaller, translating to lower costs. These envelope upgrades can be a first step in Louisville's decarbonization efforts. Furthermore, unlike heating, which has a natural "investment period" at the end of the resident's current heating system's lifetime, residents may not necessarily consider envelope improvements at a specific time, unless their thermal comfort is severely impacted in colder or hotter months. This could make envelope upgrades a good option for heightened support from the local government and other community partners, including education and awareness.[16]

Louisville Building Energy Consumption Baseline Analysis

The following subsections explore the baseline characteristics of Louisville's housing stock and associated energy usage and energy bills, based on data from 2018.

[15] In particular, heat pumps were modeled with existing heating system as backup and also separately modeled with electric backup and sized for cooling loads, which can produce more conservative estimates.
[16] Local governments could also consider encouraging the adoption of efficient heating systems at the end of the resident's current heating system's lifetime, as residents may not necessarily consider technologies like heat pumps. This equipment can have long lifetimes and replacing them represents important opportunities for decarbonization.

Building Stock Characteristics

This section explores some basic characteristics of Louisville's housing stock, such as household income levels, housing types, age of the housing stock, and quality of the building envelope.

AREA MEDIAN INCOME

Within each building prototype modeled, each household is assigned an income and associated AMI level. Houses were assigned to one of 7 AMI bins,[17] and results shown throughout this report are provided at the AMI bin level to show how trends vary between different income levels. The AMI bins and associated income limits are based on U.S. Department of Housing and Urban Development (HUD) income limits for a four-person household at and below the 80% AMI level in 2019 (Liu, Brossman, and Lou 2023). For higher AMI bins, the limits are extrapolated. Table 1 shows the HUD income limits used in this analysis for Louisville's AMI bins.

Table 1. AMI Limits for Louisville.

	Family of four in 2019
80% AMI	$61,100 / year
50% AMI	$38,200 / year
30% AMI	$25,750 / year

Source: (Liu, Brossman, and Lou 2023).

ResStock indicates that there is a substantial level of low- and moderate-income (0-80% AMI) households in Louisville, comprising nearly 50% of the total households (Figure 2). Notably, middle-income households (80-150% AMI) comprise a relatively small proportion of total housing stock (30%), while high-income households (150%+ AMI) comprise just over 20% of the total housing stock. The household income, as measured by AMI level, is a strong indicator of the occupant's ability to afford energy expenditures, in addition to other key non-discretionary spending (such as housing or food).

[17] These bins range from: 0-30%, 30-80%, 60-80%, 80-100%, 100-120%, 120-150%, and above 150% AMI.

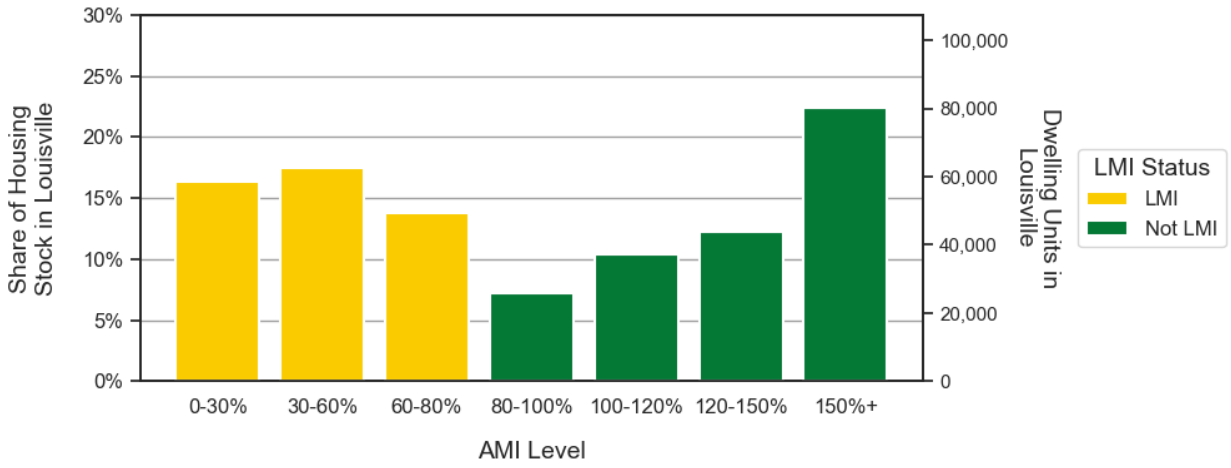

Figure 2: Modeled Breakdown of Louisville Residential Building Stock by Occupant Area Median Income.
LMI: Low- and Moderate Income (Income between 0-80% AMI).

BUILDING GEOMETRY

ResStock divides the housing stock into "geometries": mobile or manufactured homes, multifamily homes (both "small" with 2-4 units, and "large" with 5 units or more), and single-family homes (both attached and detached).[18] Single-family detached is the largest category of housing geometry at 65% of all dwellings, followed by large multifamily (19%), small multifamily (10%), single-family attached (4%), and mobile homes (1%). ResStock indicates that the distribution of LMI households is not equal across all housing geometries. For instance, while LMI households comprise approximately 50% of all households in Louisville, they make up only 37% of single-family detached homes and 40% of single-family attached homes, like a townhome. Conversely, LMI households comprise 95% of mobile homes, and 74% and 68% of small and large multifamily units, respectively (Figure 3). For decarbonization efforts, single-family detached homes will be a primary category to address given their large share of the housing stock, but for efforts to benefit those with high energy burden, multifamily homes will be a primary area to address.

[18] For many results shown in the rest of this report, "single-family attached" and "single-family detached" are combined into a "single-family" category, and large multifamily (5+ units) and small multifamily (2-4 units) are combined into a "multifamily" category.

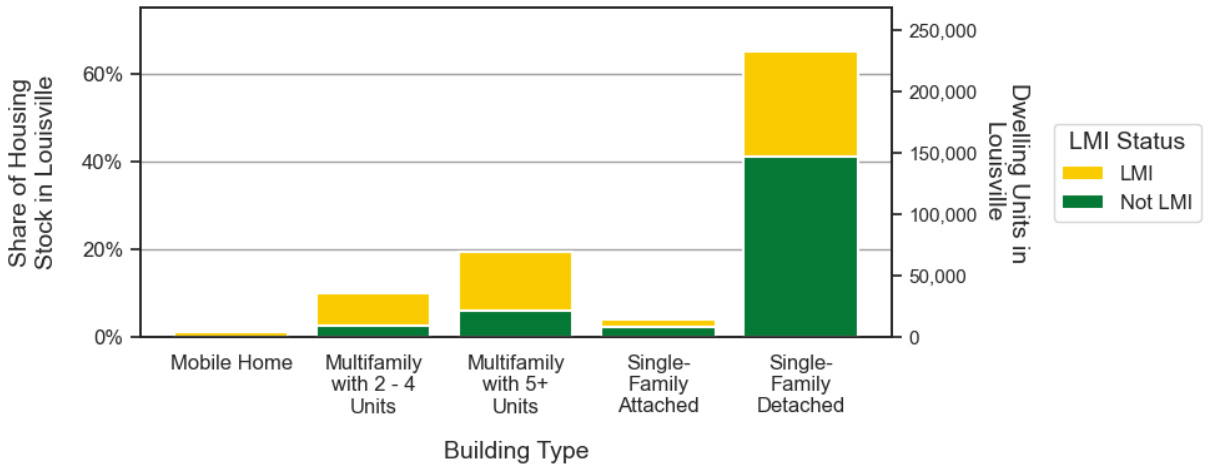

Figure 3: Modeled Breakdown of Louisville Residential Building Stock by Building Geometry.
LMI: Low- and Moderate Income (Income between 0-80% AMI).

BUILDING VINTAGE

ResStock provides a breakdown of building vintages (the time period in which the building was constructed), which can be an important consideration for energy efficiency: on average, older homes typically are 'leakier' (high rates of air infiltration) and less insulated, making them more energy-intensive and costly to heat and cool. Among other factors, this is because older homes had less stringent building codes at the time of construction compared to newer homes. Furthermore, older homes may have hazardous material in place that can complicate efforts to retrofit or provide improvements to the household: lead paint and asbestos, for instance, are much more common in buildings constructed in periods between the advent of their use and their eventual banning. Remediating these hazardous materials and other required housing upgrades at large should be a consideration of a city-wide strategy because they may come up frequently,[19] they can be costly, and must be done before envelope or other home upgrades can take place.

ResStock provides the decade in which a home was constructed, which is then aggregated into three periods: 'pre-1940,' '1940-1979,' and '1980 or after' in Figure 4. ResStock indicates that the majority (65%) of homes in Louisville were built before 1980, making them over 40 years old in 2023. Furthermore, while the distribution of LMI and non-LMI residents is fairly even for 'Pre-1940' (57% LMI, 43% non-LMI) and '1940-1979' (50% LMI, 50% non-LMI) homes, newer homes are predominantly non-LMI (38% LMI, 62% non-LMI). Although not shown Figure 4, this is particularly true for homes built in the 2000s (32% LMI, 67% non-LMI) and 2010s (26% LMI, 74% non-LMI). Retrofitting the existing Louisville building stock will likely be beneficial to LMI households, many of which are older and less energy-efficient homes. Meanwhile, ensuring new construction meets newer

[19] One *national* survey conducted by HUD estimated that 29.4% of all housing units contained some lead paint, but that this was not equally distributed across all households. The vintage of the home was a key predictor for lead: for homes constructed between 1978-2017 the rate of presence of lead was 6.5%, for 1960-1977 the rate was 23.6%, for 1940-1959 the rate was 61.0%, and for homes constructed before 1940 the rate was ***85.4%***. The survey also found for households earning less than $35,000 per year, the rate for the presence of lead was 30.8% (including 39.5% of households below the income threshold with one or more children under the age of 6), while for homes earning more than $30,000 per year, the rate was lower, at 20.6% (including 12.5% of households below the income threshold with one or more children under the age of 6). (Children are among the most vulnerable to the health hazards of lead.) (Office of Lead Hazard Control and Healthy Homes 2021).

energy code requirements can have long-term impacts for the entire city's energy usage, emissions, and energy expenditures. (A more complete discussion on energy codes and the impacts on energy can be found in Section 'Current Building Codes Affecting Envelopes' and 'Appendix C. Comparison of Energy Codes in Kentucky.')

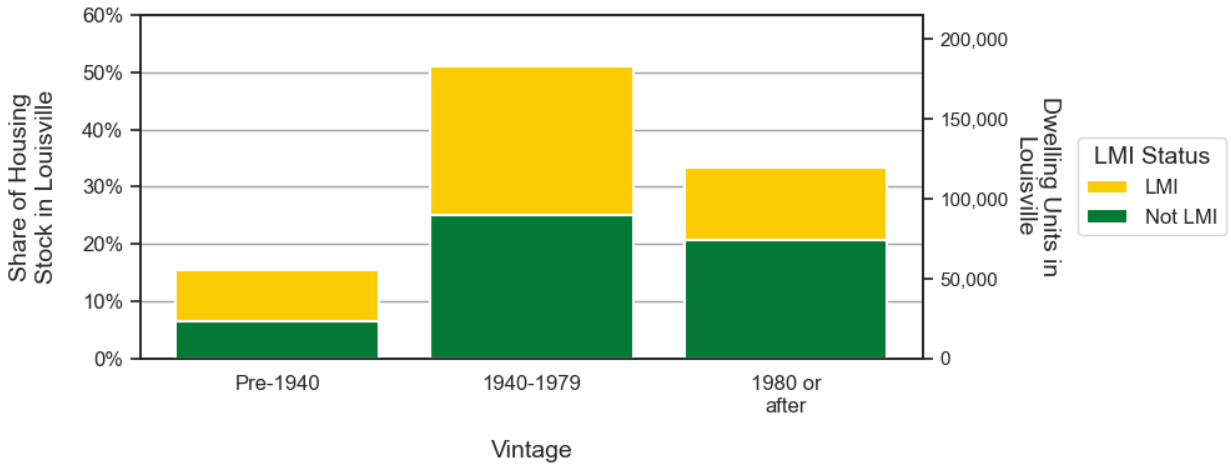

Figure 4: Modeled Breakdown of Louisville Residential Building Stock by Building Vintage.

LMI: Low- and Moderate Income (Income between 0-80% AMI).

ENVELOPE RATING

ResStock also includes the physical attributes of typical buildings to model energy consumption. These include the building envelope as measured by infiltration rate (measured by the number of Air Changes per Hour [ACH]) and the insulation levels (measured by the R-value) at the external walls and attic. For each attribute, ResStock ranked the performance of the building prototype as "Good," "Fair," or "Poor" (Table 2). These individual ratings were aggregated into a "combined envelope rating," which was calculated as the lowest score among the individual insulation and infiltration categories. Overall, the envelope rating provides a simple indication of how airtight and well insulated the building envelope is, which directly correlates to energy consumption. The envelope rating has important implications for the dwelling's heating and cooling energy use, which are some of the largest energy use categories for residential dwellings and a key driver of energy bills (electricity and natural gas). "Good" or modern code performance level was defined by 2023 IECC R402.1.3. "Fair" and "Poor" were defined by finding the mean rating value of each climate zone's respective baseline housing samples, which is at or below the 2023 code performance levels. "Fair" values were defined as those above the average value for that climate zone, but below the modern code performance level. Poor values were defined as those below both the average value for that climate zone and modern code performance levels (Liu, Brossman, and Lou 2023).

Table 2: ResStock Envelope Rating Definitions.

Envelope Metric (unit)	Good	Fair	Poor
Frame wall insulation (R-value)	$x \geq 30$	$7 \leq x < 30$	$x < 7$
Masonry wall insulation (R-value)	$x \geq 8$	$5 \leq x < 8$	$x < 5$
Ceiling or roof insulation (R-value)	$x \geq 60$	$14 \leq x < 60$	$x < 14$
Infiltration (ACH_{50})	≤ 3	$3 < x \leq 20$	$x > 20$

Figure 5 shows the breakdown of the combined modeled envelope rating for the Louisville housing stock, broken down by the occupant income levels. Across all income levels, ***nearly 70%*** **of the homes in Louisville suffer from a poor combined envelope rating**, leading to higher energy consumption, more emissions, and higher energy burdens and bills, as well as reduced occupant comfort. The majority of modeled homes in each AMI bracket showed Poor or Fair ratings, but the trend was not the same across all income levels. While over 70% of households with very-low-, low-, and moderate-incomes also had below-average envelopes, for high-income households (150%+), this share was substantially lower at 54%, a 16% difference. No modeled home in the ResStock sample for Louisville received a "Good" combined envelope rating.

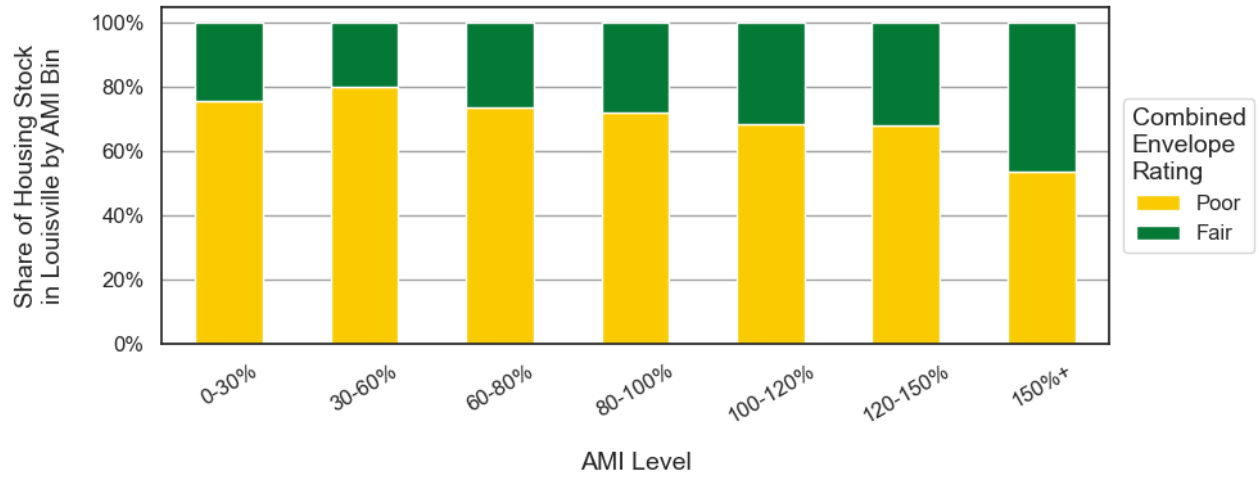

Figure 5: Modeled Breakdown of Louisville Residential Building Stock by Combined Envelope Rating.

HEATING

Heating is a key source of energy usage, given Louisville's climate, and a majority of Louisville's energy usage is devoted to heating end uses (Figure 8).[20] Figure 6 shows the breakdown of housing by the top 5 heating categories split between multifamily and single-family homes. The primary difference between the two housing types is that electric heating comprises over 60% of multifamily heating by dwelling count, whereas only ~24% of single-family homes use electric heating, with the rest dominated by natural gas.

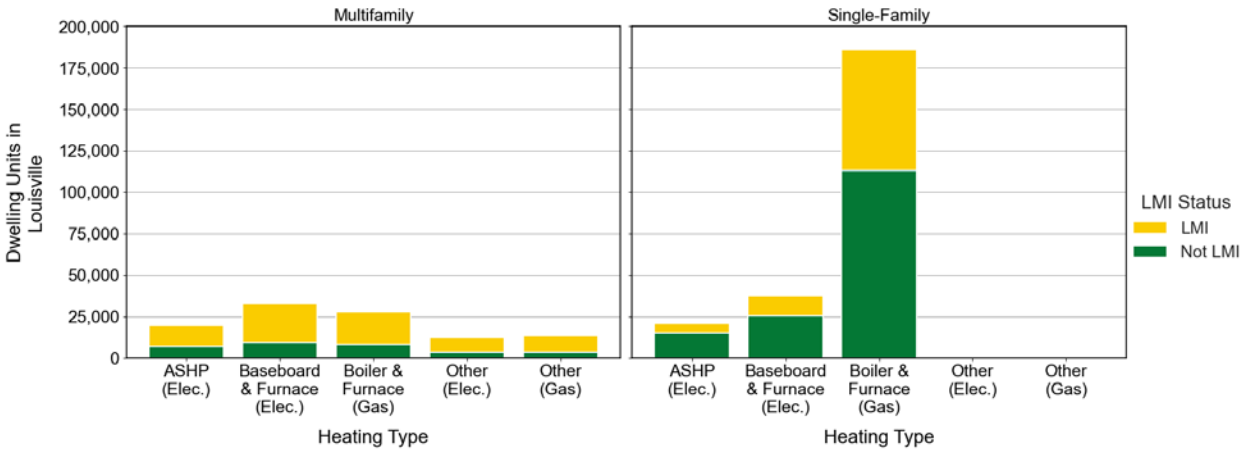

Figure 6: Modeled Breakdown of Louisville Residential Housing Stock by Heating Type.
ASHP: Air-source heat pump. Other (Elec.) includes the following ResStock categories: "Electricity Shared Heating" and "Electricity Electric Boiler". Other (Gas) includes the following ResStock categories: "Natural Gas Shared Heating". Only the top 5 heating categories (as measured by number of modeled buildings) were plotted; this *excluded* propane heating.

Baseline Energy Usage

This section explores energy consumption across some of the characteristics outlined above, as well as by fuel and end use. This can help provide a better understanding of which areas and which housing could be prioritized to make the biggest impact on total energy usage and associated emissions in Louisville.

CONSUMPTION BY FUEL AND END-USE

The ResStock model showed that the majority of Louisville's residential energy consumption is driven by natural gas, at 54% of total consumption, followed by electricity (46%), with a small amount of propane consumption (< 1%) (Figure 7). Of the end-use categories tracked by ResStock, the majority of residential energy consumption is driven by space heating (57%), followed distantly by cooling (13%), water heating (11%), plug loads (9%), and lighting (4%) (Figure 8). Finally, focusing on the top five end uses, natural gas accounts for 80% of modeled space heating and 70% of water heating end uses, with the rest of the heating/water heating and other end uses supplied by electricity (Figure 9). This indicates that **there is a large potential for decarbonization of residential energy use by reducing natural gas consumption associated with heating loads**, through energy efficiency

[20] Unless otherwise indicated, all energy consumption or usage results are reported as *site energy*, as opposed to *source energy*, and only captures the energy usage at the site consumption, rather than the amount of energy that must be produced and delivered to meet site demand. Source energy captures not only site consumption, but also energy lost in the transmission, delivery, or production process. For more information, see (ENERGY STAR n.d.-d)

upgrades like building envelope improvement measures and electrification of heating and hot water heating end uses.

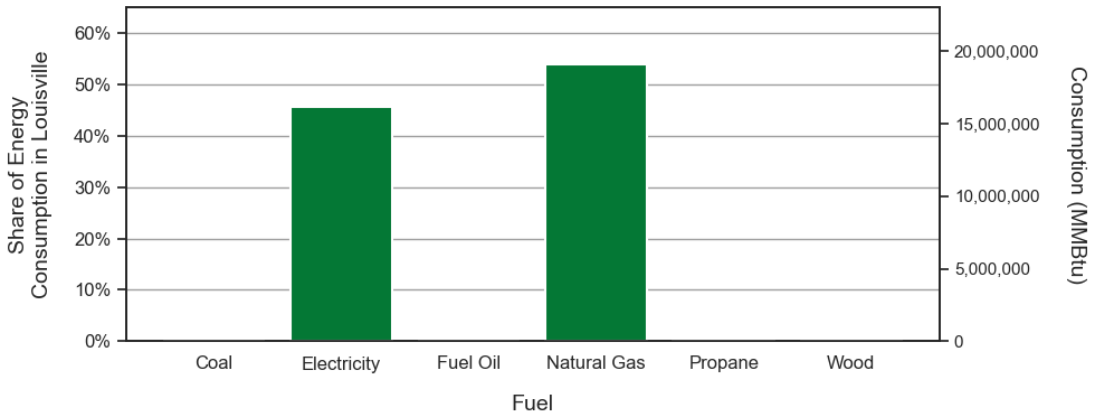

Figure 7: Modeled Louisville Residential Energy Consumption by Fuel Source.

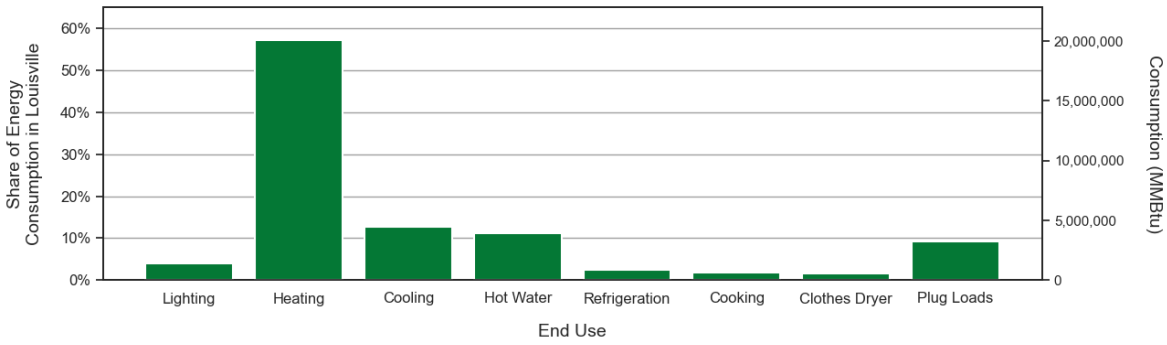

Figure 8: Modeled Louisville Residential Energy Consumption for Eight Highest End Uses.

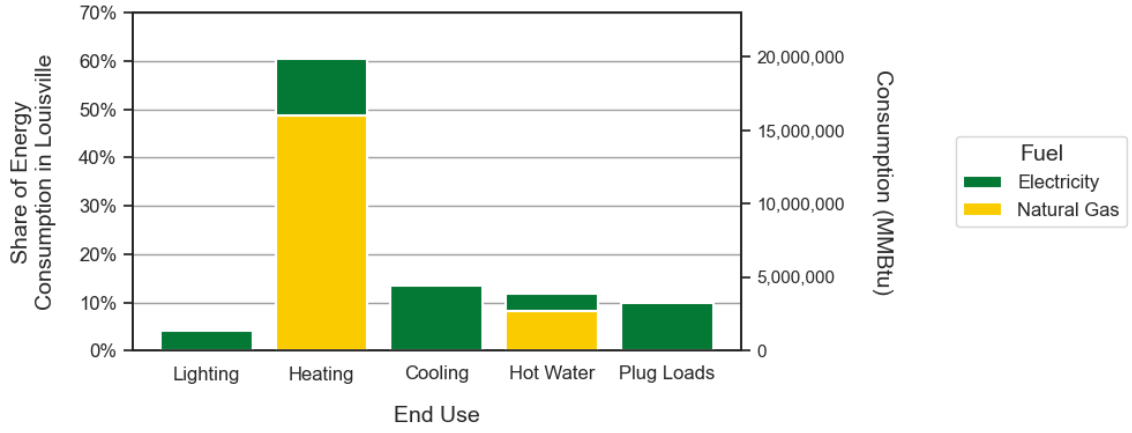

Figure 9: Modeled Louisville Residential Energy Consumption by Fuel Type for Five Highest End Uses.
Propane (not shown) is used in Louisville in small amounts, including ~139,000 MMBtu (0.39%) for space heating, 28,000 MMBtu (0.08%) for hot water heating, and 12,000 MMBtu (0.03%) for cooking.

CONSUMPTION BY HOUSING CHARACTERISTICS

While the above section looked at community-wide energy consumption to reveal patterns in consumption by end use and fuel, this section explores patterns in energy consumption at the individual household level to identify patterns that may help Louisville prioritize its efforts. Figure 10 looks at median annual energy consumption by income (as measured by AMI level). Generally, the trend is for increasing energy consumption with increasing income. Despite overall lower energy usage, low-income residents typically experience higher energy burden rates than higher-income residents.

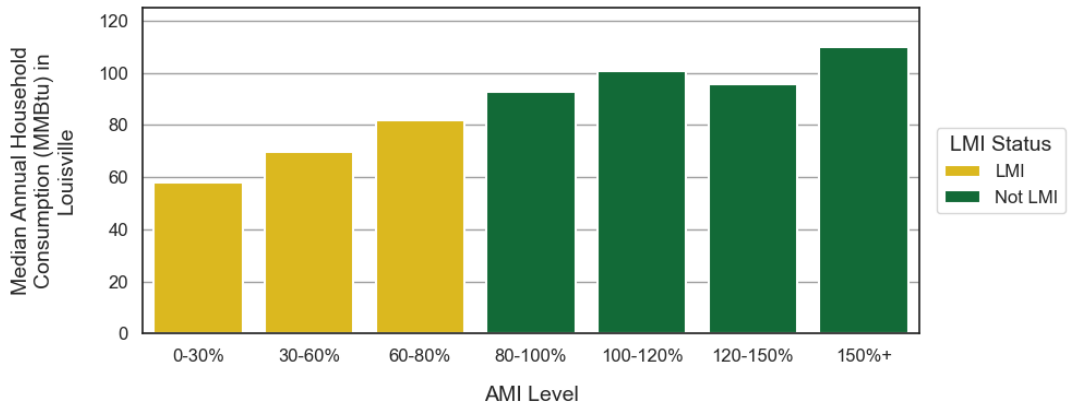

Figure 10: Modeled Louisville Household Median Annual Energy Consumption by AMI Level.

LMI: Low- and Moderate Income (Income between 0-80% AMI).

Figure 11 shows the median annual energy consumption by building vintage. Unsurprisingly, older homes tend toward higher energy consumption, likely due to construction under less stringent building codes (with respect to energy efficiency). As lower-income households are more likely to dwell in older buildings (Figure 4), this could mean that they are subject to higher energy bills relative to the level of comfort they can maintain in their home: older, leakier homes will be more difficult to heat and cool as heat escapes in the winter and infiltrates in the summer.

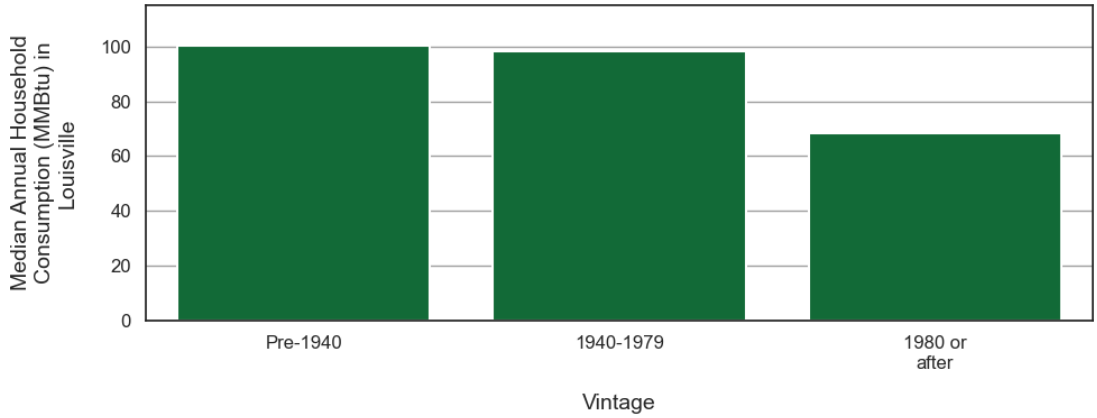

Figure 11: Modeled Louisville Household Median Annual Energy Consumption by Housing Vintage.

Figure 12 shows the median annual energy consumption for most housing types explored in the analysis, excluding mobile homes (which comprise only 1% of Louisville's housing stock), split

between homes with “Poor” and “Fair” envelope grades. Large multifamily housing uses the least amount of energy per housing unit, approximately a third of the amount of energy used by the median single-family detached household. This is likely partly driven by reduced heating and cooling needs due to typically smaller floor areas. Multifamily units in larger buildings can also help to insulate one another, compared to single-family detached building envelopes, which would be exposed to ambient air temperatures on all sides. These two factors could also help explain why single-family attached homes see significantly lower energy usage as well.[21] Additional factors may also be in play, as Figure 3 shows that different household income levels are more likely to dwell in particular housing geometries. Within each housing type, unsurprisingly, better-insulated homes (“Fair”) use less energy than poorly insulated homes (“Poor”), with the most dramatic energy usage reductions in single-family homes. Most housing categories, excluding small multifamily households, see about 25% less median annual energy consumption between the “Poor” and “Fair” envelope grades. Figure 13 provides an estimate of the *energy use intensity* (EUI), or the annual energy consumption divided by the floor area of the housing unit, for Louisville by combined envelope rating and housing geometry. Many of the trends shown in Figure 12 persist when normalizing for floor area size, but the magnitude of differences across geometries is reduced.

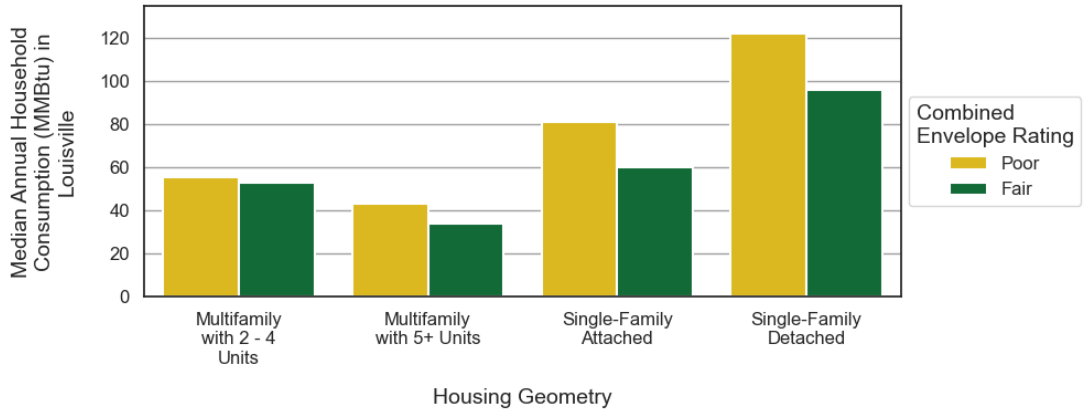

Figure 12: Modeled Louisville Household Median Annual Energy Consumption by Housing Type and Envelope Rating.

[21] For instance, among modeled ResStock households and geometry types, the share of households with floor areas greater than 2,500 ft^2 was 0.0% for mobile homes and small multifamily homes, 0.4% for large multifamily homes, 17.9% for attached single-family homes, and 23.5% for detached single-family homes.

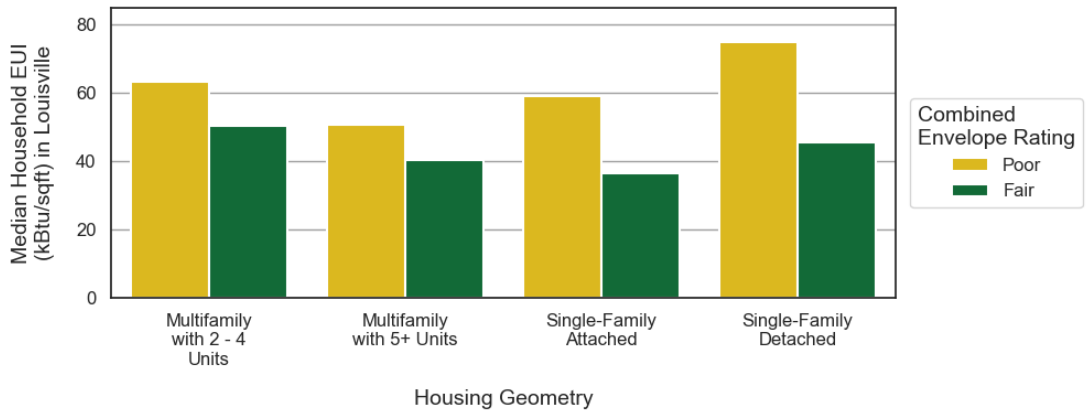

Figure 13: Modeled Louisville Household Median Energy Use Intensity by Housing Type and Envelope Rating.

Baseline Energy Expenditures and Burdens

This section explores how energy consumption impacts residents in the form of spending on energy bills, both in absolute terms and as a share of income. This can provide a better understanding of which residents could be experiencing a higher-than-average energy burden and help Louisville focus its efforts as it seeks an equitable clean energy future. It should be noted that these bill calculations *exclude* any low-income bill assistance from LIHEAP that could reduce energy burdens for those low-income residents who were enrolled to receive support from the federal government program. Additionally, while many residential customers across the country rely on flat volumetric rates for electricity, time-of-use rates are also available in LG&E, and customers on this tariff would see different energy bills and savings.

ENERGY EXPENDITURES

Figure 14 shows the median annual energy expenditures (bills) broken out by AMI level and by housing geometry (excluding mobile homes and combining all single-family housing types and all multifamily housing types). For multifamily housing, natural gas expenditures tend to be a much-smaller fraction of overall spending on energy bills, likely driven by fewer multifamily homes relying on natural gas for heating (Figure 6). Electricity spending in multifamily homes is slightly smaller than in single-family homes, and with the latter, there is a slight trend toward increasing spending with income.

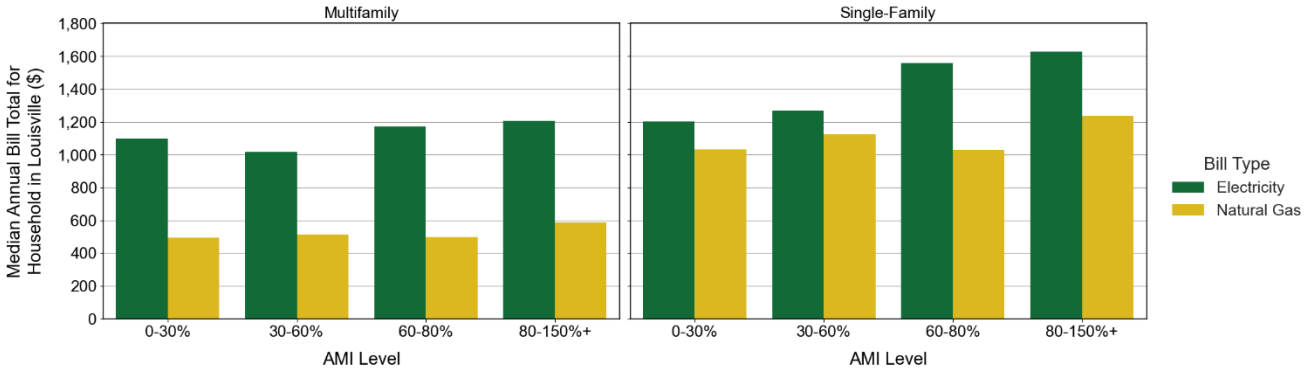

Figure 14: Modeled Per-Unit Median Annual Energy Expenditures in Louisville by AMI Level and Housing Type.

ENERGY BURDEN

Household energy burden—the percentage of household income spent on energy bills—is a common energy affordability metric. An energy burden of 6% or less is a common threshold for affordable utility costs (Colton 2011). Figure 15 shows the modeled median annual energy burdens (both electricity and natural gas) by AMI level for single-family and multifamily households. Although modeled energy expenditures are relatively similar or even increasing by increasing income levels, energy burdens are, unsurprisingly, substantially higher for lower-income households. In the plot, the dashed red line indicates the 6% energy burden threshold, which shows that the median households for most income levels are not energy burdened. However, very-low-income residents (0-30%) are *significantly* burdened, spending ~15-25% of their income on electricity bills alone.

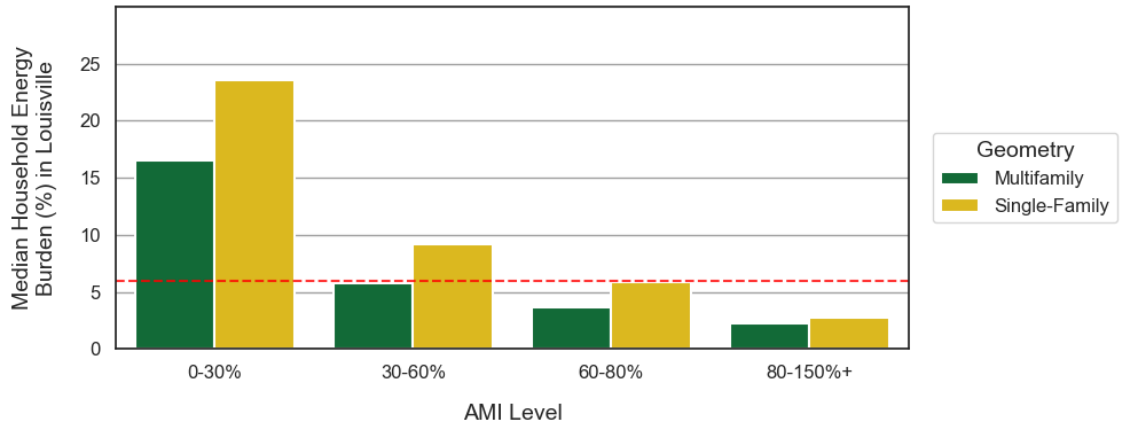

Figure 15: Modeled Per-Unit Median Household Energy Burden Rate in Louisville by AMI Level and Housing Type.

Importantly, the values above are only the *median* energy burden for each AMI level and do not give a complete picture of the number of households that could be experiencing high energy burdens. To better understand how many residents could potentially be experiencing high energy burdens, Table 3 shows the total count of households modeled as spending more than 6% of their estimated annual income on electricity and natural gas, by housing type and AMI level. Beneath each customer count is the share of that household segment (AMI level and housing type) estimated to experience high energy burdens. Unsurprisingly the lower the AMI level, the more residents are estimated to exceed the 6% threshold, but *nearly all* very-low-income (0-30% AMI) residents are estimated to experience high energy burdens. Single-family households see higher total numbers of households with high energy burdens, which is partially driven by the larger number of single-family households (Figure 3), but also likely by the higher energy expenditures (Figure 14), which is reflected in the *share* of energy-burdened residents across the two housing types.

Table 3: Estimated Number and Share of Households Experiencing High Energy Burdens (6%+) by Income Level

Income Level	0-30%	30-60%	60-80%	80-100%	100-120%	120-150%	150%+
Multifamily	29,800 (98%)	12,500 (47%)	800 (4%)	300 (5%)	0 (0%)	0 (0%)	0 (0%)
Single-Family	24,700 (99%)	28,600 (82%)	15,100 (47%)	4,100 (20%)	4,300 (15%)	800 (2%)	0 (0%)

Envelope Improvements

The following subsections explore the impacts of building envelope improvements on Louisville's building stock, both in terms of community-wide reduction in energy usage and emissions, and also reductions to energy bills and burdens for individual households.

Description of the Building Envelope

The building envelope consists of all elements of the house that separate the interior of the home from the exterior environment. This includes walls; windows; attics, ceilings, and roofs; and foundation floors and walls. When estimating the quality of the building envelope, two key elements are the level of insulation and the level of infiltration/exfiltration. *Insulation* is a measure of the thermal resistance of a material (how much a material resists exchanging heat), typically reported by its R-value, where higher R-values correspond to higher thermal resistance. More insulation can help keep the home cooler in the summer by slowing the transmission of ambient heat into the home and warmer in the winter by keeping heat inside.

Infiltration and exfiltration refer to air leaking into and out of the home due to gaps in the building envelope. A home's air "leakiness" is often reported by the number of air changes per hour that a home experiences at a 50-Pascal pressure differential with outdoor air (ACH50), a metric that can be measured through blower door testing.[22] This is different from *managed ventilation,* which refers to the intentional exchange of stale indoor air with fresh outdoor air to keep indoor air quality within tolerances, keep moisture from building up and dilute sources of indoor air pollution like combustion stoves (ENERGY STAR 2006). Figure 16 shows some of the more common air leaks that can impact building envelope performance and lead to higher energy bills and reduced occupant comfort.

[22] https://basc.pnnl.gov/building-science-measures/blower-door-test.

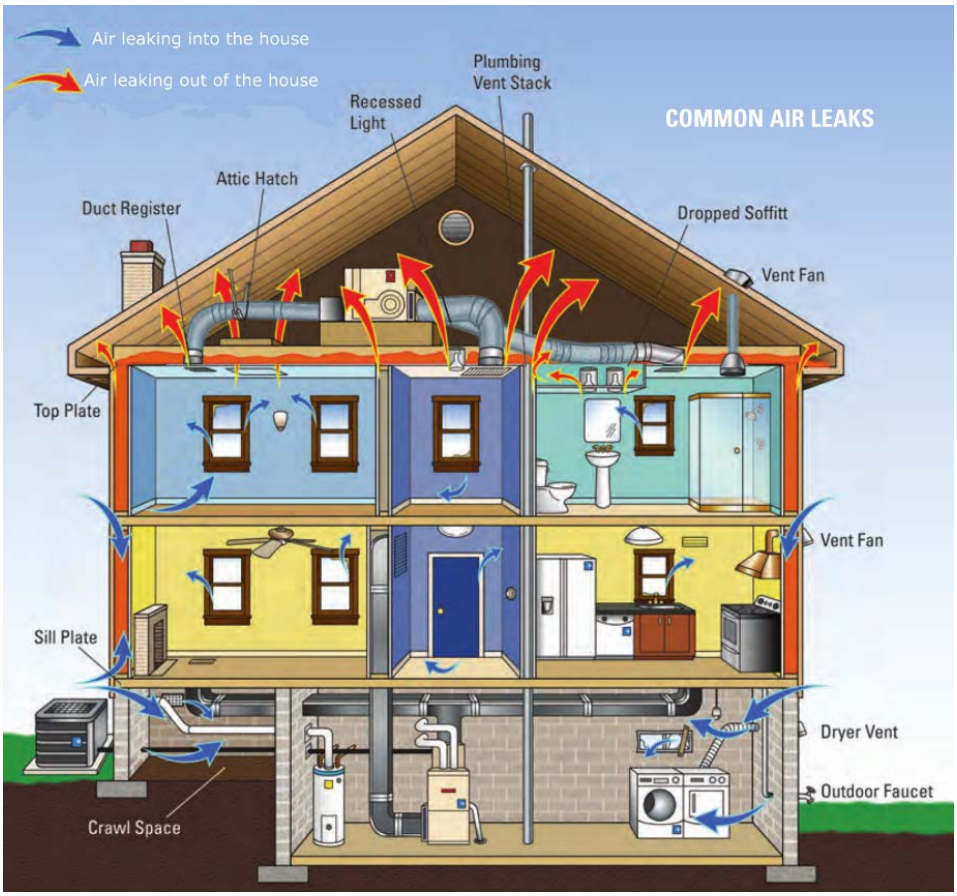

Figure 16: Common Air Leaks within the Home.
Source: (ENERGY STAR 2009)

Current Building Codes Affecting Envelopes

Building codes are laws that set the minimum requirements for how various elements of residential and commercial buildings should be designed and constructed, including HVAC, wiring, and structural elements (NIST 2022). Some jurisdictions also have building *energy* codes that require minimum energy efficiency appliances or design elements in new construction or for certain renovations. These building energy codes can help reduce energy consumption, reducing emissions and saving consumers money (U.S. DOE n.d.-l). In some states, the authority to establish building energy codes is determined at the municipal or county level, with the state providing a minimum threshold for performance. In Kentucky, the state determines all elements of the building codes and communities like Louisville have little authority over establishing more stringent standards on new construction, limiting their ability to improve the housing stock's performance (Stivers et al. 2023). While Louisville could not uniformly enforce stricter energy standards, when the City is contributing funds to affordable housing projects, either new construction or rehabilitation of affordable housing, it could work with its partners to increase energy efficiency performance. This context around energy codes could help inform ongoing discussions around new affordable housing that will be built to meet the Mayor's affordable housing initiative and could be used to evaluate the energy performance of existing affordable housing that receives financial support from the city.

The statewide energy code, a subset of the building code, currently in use in Kentucky for residential dwellings is the 2009 IECC (International Energy Conservation Code) with amendments, and the

statewide building codes are amended versions of the 2015 IECC codes (U.S. DOE n.d.-g).[23] Tables in "Appendix C. Comparison of Energy Codes in Kentucky" show the requirements of energy codes currently in practice in Kentucky, updated versions of the IECC, and ambitious "beyond-code" green building certifications. These tables provide context for how Louisville compares to "best-in-class" standards adopted elsewhere.

The U.S. Department of Energy's (DOE's) Building Energy Codes Program (BECP) led a multi-year series of studies exploring the energy savings potential of increased code compliance in seven states, including Kentucky, before and after efforts to improve code compliance. The initial study found that compliance with Kentucky's *current* 2009 IECC codes varied dramatically by measure across a sample of newly constructed single-family homes (Table 4) (Bartlett et al. 2017; Blanding et al. 2022).

Table 4: Average Measure-Level Compliance Rate With 2009 IECC Codes in Kentucky (%)

State	Envelope Tightness	Duct Tightness	Wall Insulation (U-factor)	Ceiling Insulation (U-factor)	Lighting	Window (U-factor)
Kentucky	70%	77%	28%	41%	31%	98%

Source: Blanding et al. (2022).

Note: These compliance rates are based on the Phase I results prior to education, training, and outreach efforts during Phase II to improve compliance. Phase III measured changes to compliance and found that, within Kentucky, compliance was improved for all categories *except* duct tightness.

The series of studies also estimated the energy savings possible from improving code compliance by modeling the difference in energy consumption between observed levels of envelope tightness and other measures and code-prescribed levels of those measures (Bartlett et al. 2017; Blanding et al. 2022). The studies found that of all measures explored, improving the building envelope air leakage rates, or infiltration rates, provided the most energy savings on a per-home basis, followed by improving ceiling insulation and exterior wall insulation (Table 5).[24]

Table 5: Modeled Statewide Annual Measure-Level Savings for Kentucky.

	Measure Electricity Savings (kWh/ home)	Natural Gas Savings (therms/ home)	Total Savings (kBtu/ home)	Number of homes*	Total Energy Savings (MMBtu)	Total Energy Cost Savings ($)	Total State Emissions Reduction (MTCO2e)
Envelope Air Leakage or Infiltration	442	22	3,701	7,345	27,182	484,314	3,092

[23] Kentucky falls within IECC's climate zone 4A, although as annual temperatures have been increasing due to climate change, these zones have shifted further north, and portions of Kentucky could fall into Zone 3A in future code iterations.

[24] Measure-level savings from improving code compliance for windows were not included in Bartlett et al. (2017); this could be because state-level code compliance for windows is already significant (Table 4).

	Measure Electricity Savings (kWh/ home)	Natural Gas Savings (therms/ home)	Total Savings (kBtu/ home)	Number of homes*	Total Energy Savings (MMBtu)	Total Energy Cost Savings ($)	Total State Emissions Reduction (MTCO2e)
Ceiling Insulation	213	8	1,548	7,345	11,372	215,656	1,080
Exterior Wall Insulation	163	7	1,263	7,345	9,277	171,044	1,102
Lighting**	300	-2	782	7,345	5,742	197,544	1,427
Duct Leakage	46	1	291	7,345	2,135	43,142	284

*: The number of homes indicates the average annual number of homes assumed to be built across the state for estimating the total energy, energy cost, and emissions savings from each measure.

**: Negative values mean that savings or reductions decrease if the measure is brought up to code. For example, for lighting, increasing the amount of high-efficacy lighting reduces electrical usage, but increases natural gas usage for heating, as the heat from less efficient bulbs must be replaced.

Note: values for foundation insulation were originally included in the study but are excluded here, as the results depend on the type of foundation.

Source: Bartlett et al. (2017)

A separate Pacific Northwest National Laboratory (PNNL) analysis looked at the cost-effectiveness of using more updated energy codes (IECC 2021) in Kentucky compared to the current codes (IECC 2009) (Salcido et al. 2021). This study found that using the more recent energy code would result in statewide energy savings of 28.5%, and result in approximately $687 on average per household of annual utility bill savings. **Across the entire state updating to the IECC 2021, over a 30-year period, could result in emissions reductions equivalent to the annual emissions of 3 million cars and result in 4,246 jobs created through reduced utility bills and 3,685 jobs created through construction-related activities.**[25] The study compared estimated incremental construction cost *increases* for prototypical single-family homes and multifamily units by foundation type (summarized in Table 6) against anticipated annual energy cost *savings* (summarized in Table 7).

[25] It should be noted that this is for *new* construction, not retroactively applying IECC 2021 codes to the existing building stock. Job impact estimates include both direct impacts (e.g., incremental cost to build more energy efficient buildings) and indirect impacts (e.g., increased economic activity due to higher household disposable income as a result of bill reductions).

Table 6: Estimated Kentucky Total Single-family and Multifamily Construction Cost Increase for 2021 IECC Compared to 2009 IECC, by Foundation Type.

Foundation Type	Crawlspace	Heated Basement	Slab	Unheated Basement
Single-Family	$6,158	$6,158	$6,635	$6,158
Multifamily	$2,231	$2,231	$2,301	$2,231

Note: Costs based on national estimates and then adjusted to reflect local construction costs.

Source: Salcido et al. (2021)

Table 7: Estimated Annual Per-Dwelling Energy Costs and Savings by End Use Comparing 2009 IECC and 2021 IECC.

	End Use	Heating	Cooling	Water Heating	Lighting	Fans	Vents	Total
Annual Energy Costs	2009 IECC	$898	$196	$291	$158	$105	$37	$2,412
	2021 IECC	$527	$154	$102	$124	$77	$18	$1,725
Net Annual Energy Cost Savings		$371 (41.3%)	$42 (21.4%)	$189 (64.9%)	$34 (21.5%)	$28 (26.7%)	$19 (51.4%)	$687 (28.5%)

Source: Salcido et al. (2021)

Building Envelope Upgrade Packages

The ResStock dataset used for this analysis considers sixteen upgrade packages including “Basic Enclosure” and “Enhanced Enclosure,” which feature improvements to the attic/ceiling insulation, infiltration rates, ductwork leakage and insulation (if present), wall insulation, and foundation insulation. Figure 17 lists the individual measures within each package. These packages were applied to the existing modeled housing stock as retrofits to bring the dwelling to the level described in Figure 17. That is, in the baseline, there is a distribution of different insulation and infiltration values in the modeled housing stock, but in the upgrade packages the dwellings have upgrade measures applied to bring them to the efficiency levels described in Figure 17, such that there is a more uniform level of insulation and infiltration performance values. (Dwellings that exceed the values in Figure 17 were left as is.) The costs of the upgrade were modeled based on national estimates with local cost adjustment factors applied to better estimate regional costs (Liu, Brossman, and Lou 2023). It should be noted that the costs shown in the results below represent the *median* values of *modeled* project costs and real-world project costs can vary substantially based on the specific project context (for additional discussion of limitations, see “Modeling Assumptions and Limitations”).

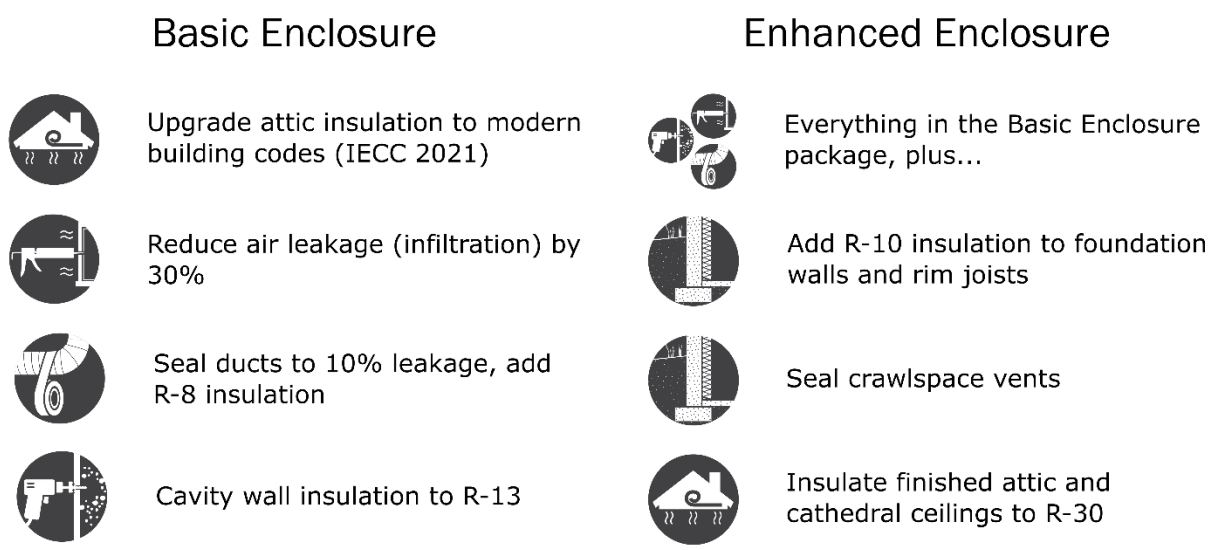

Figure 17: Description of Measures in the Building Envelope Upgrade Packages.

It is important to note that the upgrade costs do not cover all costs associated with a particular project. For example, 'prerequisite' steps may be required before energy-related upgrades can be safely installed, such as repairing roof damage or mold remediation or lead abatement. Both the final upgrade cost and the building energy improvements were, in part, functions of the baseline housing characteristics, such as initial insulation levels and housing size. Additionally, both the estimated savings and the project costs from each upgrade package represent a series of investments (depending on the household) such as duct sealing *and* cavity wall insulation *and* attic insulation. While the following results are specific to the collection of measures shown in Figure 17, Louisville could choose to prioritize a particular subset of the packages instead, e.g. prioritizing attic insulation above cavity wall insulation.

Results

The following results reflect potential savings of various technologies but do not address the issue of split incentives for renters in either multifamily or single-family homes. Split incentives result from the cost of capital investment being borne by the owner while savings accrue to the renter when they are responsible for the utility costs. Because the utility bill savings do not necessarily accrue to the building owner, it can make them less willing to make the initial investments to improve the buildings. An additional complication may arise when owners pay the utility bill and pass these bill costs and efficiency investment costs on to the occupants in the form of rent, but do not pass any savings achieved through energy investments onto the tenants.

Figure 18 shows the median annual energy (electricity and natural gas) expenditures for the baseline and each of the envelope upgrade scenarios, split between single-family and multifamily dwellings, for low- and-moderate income AMI brackets (0-30%, 30-60%, and 60-80%) and all other AMI brackets merged. All dwelling types showed modeled energy savings, although single-family homes saw substantially higher savings than multifamily units, with 15% and 10% median bill reductions for the Basic Enclosure and 19% and 11% median bill reductions for the Enhanced Enclosure, respectively.

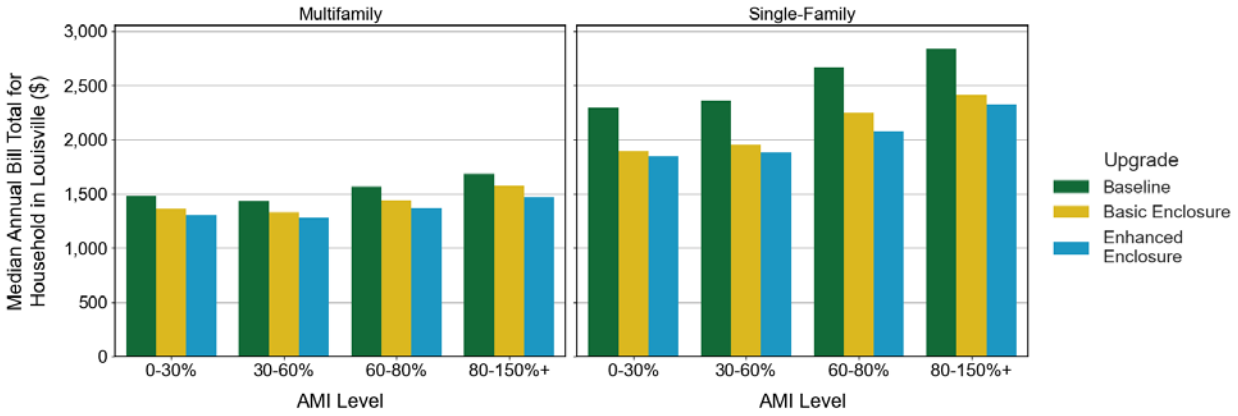

Figure 18: Modeled Median Annual Energy Expenditures in Louisville by Income Level for Envelope Upgrade Scenarios.

Figure 19 shows the modeled change in the median annual energy burden across the same housing types and income levels shown in Figure 18. Energy burdens were calculated solely on estimates for bills and household incomes. They do ***not*** reflect expenditures associated with the upgrade (i.e., the cost to install an upgrade). Payback periods, estimated below, offer a comparison between the cost of the upgrade and the bill savings from the upgrade. While energy expenditures were relatively constant across incomes, changes to median energy burden are much more pronounced for lower-income levels, as the same change in energy bills will have a larger impact for lower income residents. As with expenditures, energy burden tends to be more pronounced for single-family homes compared to multifamily homes, with a median change in household energy burden of 0.45% and 0.6% for the Basic Enclosure and 0.55% and 0.76% for the Enhanced Enclosure, respectively.[26] Table 8 shows the total number of residents with 6% or higher energy burden for the baseline and envelope upgrade packages. Across all income levels, there were approximately 23,000 and 28,000 fewer energy-burdened residents (i.e., residents whose energy expenditures exceeded 6% of their income) for the Basic Enclosure and Enhanced Enclosure packages, respectively. In absolute terms, most of the reductions in energy-burdened residents came from single-family homes. By AMI level, the smallest reductions in the number of energy-burdened residents occurred within the group that most significantly needed support: the very-low-income (0-30%) AMI bracket. This, however, does not indicate that these households did not benefit from the envelope packages. In fact, very-low-income households across single-family and multifamily housing types saw the largest reductions in energy burden, with a median reduction of 2.68%, compared to a 0.95% reduction for 30-60% AMI, 0.68% for 60-80% AMI, and 0.35% for 80-150% AMI. The baseline energy burden for these very-low-income households is so high to begin with that even significant reductions still result in energy-burdened households above the 6% threshold.

[26] It should be noted that for median bill reductions, percentage changes represent the percent reduction from the baseline, while for median energy burden reductions, percentage changes represent the absolute reduction from the baseline. For instance, if the baseline energy *expenditures* were $1,000/year and the post-upgrade expenditures were $800/year, this would be presented as a 20% reduction, while if the baseline energy *burden* was 5% and the upgrade energy burden was 4%, this would be presented as a 1% reduction.

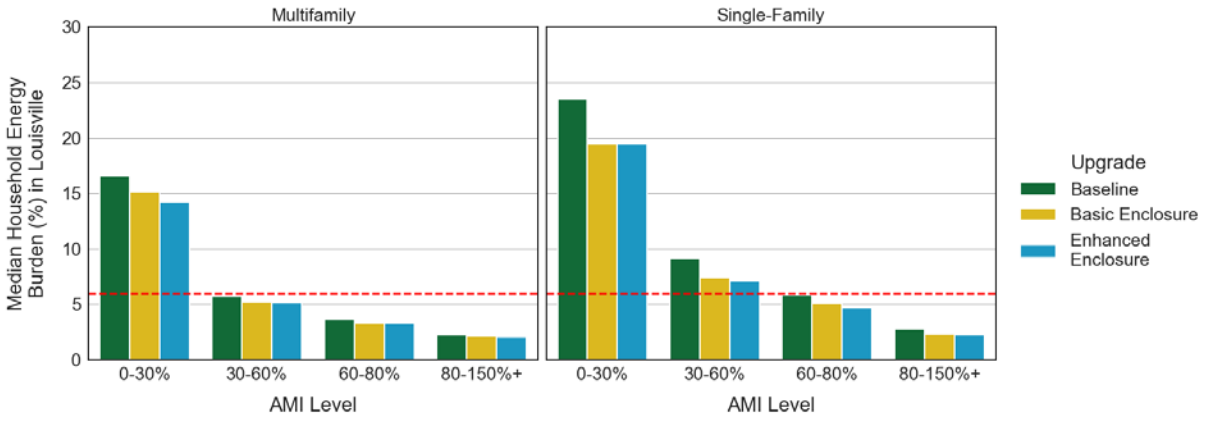

Figure 19: Modeled Impacts of Envelope Upgrades on Per-Household Median Annual Energy Burden Rates by Income Level

Note: Energy burden calculations only consider bill reduction impacts and do not capture the cost of installing the upgrade.

Table 8: Envelope Packages - Estimated Number of Households Experiencing High Energy Burden (6%+) by Income Level.

Upgrade	Housing Type	0-30%	30-60%	60-80%	80%+
Baseline	Multifamily	29,800 (98%)	12,500 (47%)	800 (4%)	300 (1%)
	Single-Family	24,700 (99%)	28,600 (82%)	15,100 (47%)	9,200 (6%)
Basic Enclosure	Multifamily	26,800 (95%)	9,200 (36%)	300 (2%)	300 (1%)
	Single-Family	24,200 (97%)	25,000 (72%)	9,900 (31%)	2,300 (1%)
Enhanced Enclosure	Multifamily	27,600 (96%)	7,900 (30%)	300 (2%)	0 (0%)
	Single-Family	24,200 (97%)	23,200 (66%)	8,200 (26%)	1,500 (1%)

When comparing the effectiveness of different upgrades packages, both the lifetime savings as well as the upfront costs need to be considered. One approach to combine these two factors is with a payback period, which calculates the number of years of annual savings required to recoup the initial investment. A “simple” payback period indicates that the technology cost is divided by the estimated annual savings, without trying to account for the time-value of money (e.g., through a discounted cash flow) or for changes over time to potential savings (e.g., through increased electricity prices). It is possible to estimate with an adjusted (or “discounted”) payback period that accounts for future electricity rates or time value of money. However, the scope of this analysis chose a simple payback

period. Upgrade costs are a core driver of payback periods, with lower costs associated with shorter payback periods. Table 9 shows the median and 25th and 75th percentile of the modeled upgrade costs by envelope upgrade package and housing geometry.

Table 9: Range of Modeled Upgrade Package Costs by Housing Type.

Upgrade Package	Housing Type	25th Percentile	Median	75th Percentile
Basic Enclosure	Single-family	$3,700	$5,900	$8,500
Basic Enclosure	Multifamily	$800	$1,400	$2,200
Enhanced Enclosure	Single-family	$5,400	$8,400	$11,500
Enhanced Enclosure	Multifamily	$900	$2,000	$3,400

The costs in Table 9 do not capture a range of considerations that could impact the economics of investing in building envelope improvements, such as repairs and preparation work (e.g., roof repairs, mold remediation) or local, state and federal incentives. Two sets of incentives are tax credits and point-of-sale rebates, both of which could be made available in Kentucky through the Inflation Reduction Act.[27] Figure 20 shows the median payback periods for low-income households for the envelope packages (a) without any incentives as a solid circle, (b) with "IRA-like" tax credits as a solid 'X', and (c) with "IRA-like" rebates as a solid square. The methodology used to develop these values is in Appendix A. Methodology for IRA-Like Discounts. While for this analysis envelope improvements generally see modeled payback periods in the 9–12-year range for multifamily and 14–17-year range for single-family without any financial support, these drop dramatically with tax credits and rebates, with reductions in median payback periods of ~30% for multifamily homes with tax credits, ~78% for multifamily homes with rebates, 16-20% for single-family homes with credits, and 60-66% for single-family homes with rebates. While many of the envelope improvements are long-lived and would eventually be recouped even under higher payback periods, these incentives clearly make the investments substantially more attractive.

[27] Please note that at the time of writing, the exact rules for how IRA funds could be used within Kentucky are still being determined by the state. While a federally funded opportunity, eligible uses for the IRA funds are determined at the state level based on federal guidelines, and implementation within the state may vary from what is described here. This analysis was only performed as an illustration of how rebates and tax incentives potentially similar to the IRA based on available information at the time could impact payback periods.

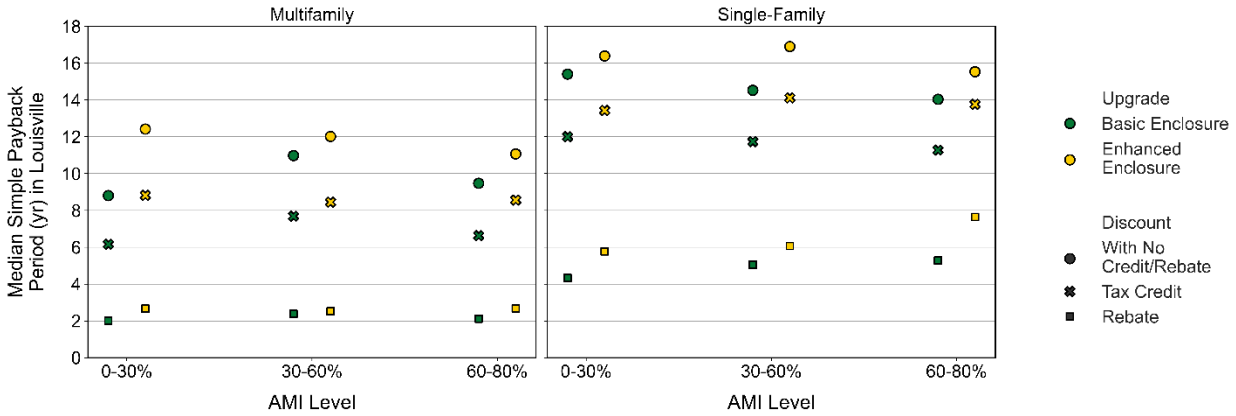

Figure 20: Simple Payback Periods with Discounts for Envelope Packages.

To understand how the widespread adoption of building envelope improvements would impact Louisville's clean energy ambitions, the emissions associated with building energy consumption can be examined. Figure 21 shows the modeled annual emissions from the residential sector (both directly from combustion appliances, such as natural gas heating, as well as 'indirectly' from electricity consumption from the power system), under the baseline and for Basic and Enhanced Enclosure packages. **Even assuming no additional electrification, based on the modeled results, Louisville could see an approximately 21% reduction in its emissions (from the residential building sector) under a community-wide Basic Enclosure adoption, and 25% reduction under a community-wide Enhanced Enclosure adoption scenario.**

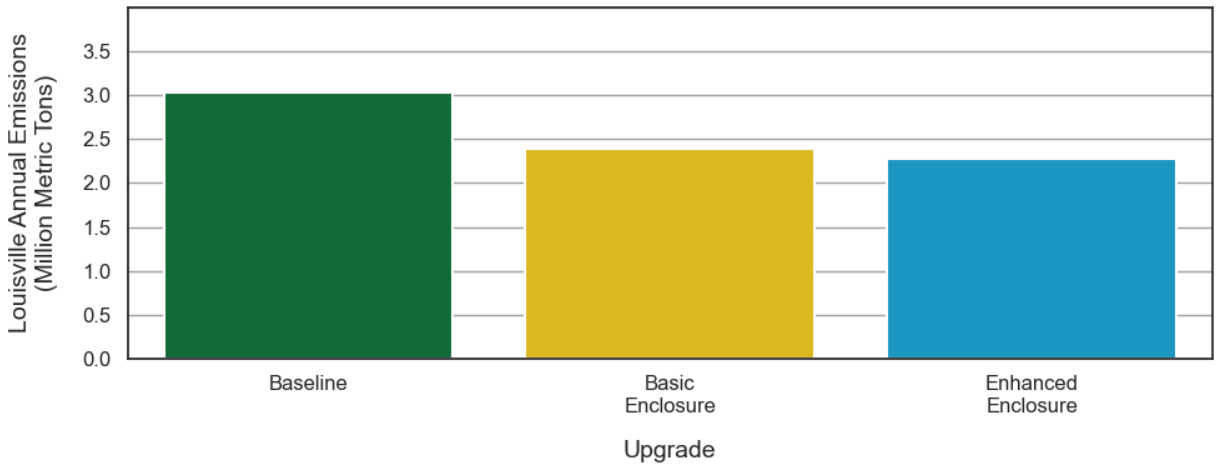

Figure 21: Modeled Impact of Building Envelope Upgrade Packages on Community-Wide Residential Building Emissions.

The Issue of Split Incentives

While the above analysis shows the potential for substantial energy and cost savings, to whom those benefits accrue can be complicated for renters and landlords. Typically, the upfront cost of energy efficiency upgrades would be borne by the property owner. The costs of energy expenditures (i.e., electricity and gas bills) can be either paid directly by the renters (assuming their consumption can be separately metered) or can be paid by the landlord and recovered from the renter through the

rent itself. If the renter pays the utility bills, then the energy savings from efficiency investments will go directly to the renters. If energy costs are included in the rent amount, however, then it is ultimately up to the landlord to determine how energy bill savings created by energy efficiency investments will be passed along to the tenant. This situation is complicated by the fact that tenants often lack the credit, capital, or authority to make energy efficiency investments in properties they rent, as well as not having as clear a motivation to make investments that may not pay themselves back before the tenant moves out. As communities across the country seek to incentivize investments in energy efficiency to benefit low-income residents, this issue has remained paramount.

In one example of a community attempting to address split incentives, New York City developed the Energy Aligned Clause[28], which uses a green lease to align tenant and landlord interest. When a property owner makes energy efficiency capital improvements, predicted savings are determined by an energy specialist agreed upon by both parties. Tenants are then charged for 80% of the expected savings, with 20% as a buffer and to provide savings to both tenant and property owner. Owners are paid back in full, with the simple payback period extended by 25%. In Louisville, the Louisville Metro Government (LMG) Housing Department offers up to $10,000 per unit in funding for landlords in the Russell neighborhood for rehabilitation and in exchange requires that they commit to keeping their properties affordable and in good condition for five years following the rehabilitation.[29] While this is not energy efficiency-specific funding, it does provide a precedent for funding to landlords being contingent on keeping units affordable. For more examples of communities facilitating and encouraging energy efficiency investments in rental properties, see Section “Energy Efficiency Standards for Rentals.”

[28] https://www.nyc.gov/html/gbee/downloads/pdf/eac_overview.pdf.
[29] https://louisvilleky.gov/government/housing/home-repair-programs.

Investigating a Community Benchmarking Ordinance

Introduction

Building benchmarking, in the context of energy, water, and waste, is a systematic process of measuring a building's consumption of resources against a set of standards, similar buildings, past performance, or best practices (U.S. EPA n.d.-a). Benchmarking is integral to understanding and improving the operational performance of buildings. It involves collecting, analyzing, and interpreting data related to energy use, water consumption, and waste generation over time to monitor changes and identify points of improvement (U.S. EPA 2008). The ultimate goal is to identify opportunities for reducing consumption and cost, enhancing efficiency, minimizing environmental impact, and maximizing inhabitant comfort (U.S. EPA 2008).

Different Types of Benchmarking

The three types of benchmarking that municipalities typically pursue are:

- **Energy Benchmarking**: Energy benchmarking focuses on evaluating a building's energy usage, including electricity, natural gas, and other fuel types. This process involves tracking the total energy consumed over a period, usually recorded monthly over a year, and comparing it to the building's past performance, similar buildings, or industry averages. Key metrics used in energy benchmarking include EUI, which is annual energy use per square foot, and the building's operational characteristics like occupancy, usage patterns, existing HVAC and other energy-consuming system efficiency, and existing weatherization (U.S. EPA n.d.-c).
- **Water Benchmarking**: Similar to energy benchmarking, water benchmarking involves measuring a building's water use. It tracks the total water consumed, encompassing both potable and non-potable water. This data is then compared to historical data or benchmarks from similar properties. Water benchmarking helps in identifying leaks, inefficiencies in water-using fixtures, and opportunities for water conservation. The key metric for benchmarking water is water use intensity (WUI), which is calculated by dividing the total water consumed by a building in one year by the total gross floor area (U.S. EPA n.d.-c).
- **Waste Benchmarking**: Waste benchmarking assesses how much waste a building generates and how it is managed. This includes tracking the volume or weight of waste produced, the composition of the waste stream (e.g., recyclables, organic waste, non-recyclable materials), and the building's waste diversion rate (the percentage of waste diverted from landfills through recycling and composting). Waste benchmarking is crucial for identifying opportunities to reduce waste generation and increase recycling and composting rates (U.S. EPA 2016b).

Potential Benefits of Benchmarking

Building benchmarking has a significant number of potential benefits that communities can leverage as they seek to reduce energy and water usage, as well as waste generation, in response to the following policy priorities and community sustainability goals:

- **Performance Assessment**: Benchmarking allows building owners and managers to assess the performance of their properties in energy, water, and waste management. It also provides a baseline from which improvements can be measured.

- **Cost Savings**: By identifying areas of high consumption or inefficiency, benchmarking can lead to significant cost savings (U.S. EPA 2016a). Reduced energy and water use directly translates to lower utility bills. Doing so through upgrading appliances and building retrofits may increase inhabitant comfort and health, while effective waste management can reduce disposal costs and help minimize the effect of improper disposal on the property (U.S. EPA 2016b).
- **Human Health Impact:** Benchmarking energy, water, or waste can inform programs, policies, or targets for improvement, which may positively impact human health related to indoor environmental health variables, such as air quality, relative humidity, mold, and more.
- **Environmental Impact**: Benchmarking plays a critical role in understanding and reducing a building's environmental footprint. Efficient energy and water usage and reduced waste production contribute to lowering greenhouse gas emissions and conserving resources.
- **Regulatory Compliance**: In many regions, benchmarking is not just a best practice but a regulatory requirement. Buildings may need to report their energy and water usage and waste management practices to comply with local regulations (IMT 2020). Benchmarking also offers a clear pathway to measuring the progress of related regulatory efforts (climate action plan, sustainability plans, etc.).
- **Market Competitiveness**: Buildings that perform well in benchmarking assessments may gain a competitive edge in the market (U.S. EPA n.d.-b). High-efficiency buildings are often more attractive to tenants and buyers who are increasingly environmentally and climate conscious (IMT 2011). These tenants are often interested in leveraging higher-efficiency technology in their everyday lives due to lower utility bills and better indoor comfort and air quality (Robinson et al. 2016).

In summary, building benchmarking is a powerful tool that offers numerous potential benefits. As the focus on energy efficiency and reducing emissions grows, benchmarking is becoming an increasingly vital aspect of effective building management.

Local Benchmarking Case Studies

According to the Institute for Market Transformation, 53 building energy benchmarking programs exist in the U.S. across different levels of government and require different levels of reporting and additional elements.[30] These benchmarking programs tend to focus on commercial, public, government, and multifamily buildings, which often count for a small percentage of buildings in a region but make up large percentages of total square footage and energy usage.

In this section, we present three case studies of municipal energy benchmarking programs: Indianapolis, IN, Kansas City, MO, and Washington, D.C. Indianapolis and Kansas City are similar to Louisville in population, climate zone, and the demographic and socioeconomic factors outlined in Table 10. Similar to Louisville, all locations considered operate under Dillon's rule.[31] Washington, D.C. provides a perspective of a larger city with a scaled benchmarking program that has a focus on multifamily affordable housing. The three cities are at different stages of their respective benchmarking programs, and together they provide a good overview of best practices and expectations for potential implementation for Louisville.

[30] Source: IMT (2015).
[31] Dillon's Rule states that local governments only have powers expressly granted by the state. In this context, these municipalities do not have local control of building or energy codes.

Table 10: Comparison of Select Demographics of the Case Study Cities and Louisville Based on 2022 Estimates.

	Louisville, KY[32]	Indianapolis, IN[32]	Kansas City, MO[32]	Washington, D.C.[32]
Population estimates	624,444	880,621	509,297	671,803
Number of households	261,105	356,357	216,513	315,785
Median household income	$63,114	$59,110	$65,256	$101,722
Owner-occupied housing unit rate	60.4%	54.90%	54.0%	41.4%
Percent of population in poverty	15.6%	15.9%	14.9%	15.1%
Dillon's Rule	Yes	Yes	Yes	Yes

Source: U.S. Census Bureau (2023a).

Indianapolis

The Benchmarking and Transparency Ordinance in Indianapolis, named Thriving Buildings, passed in July 2021 and was developed by the Office of Sustainability in collaboration with various stakeholders across the city (Indianapolis and Marion County Government n.d.). The ordinance is part of the city's broader sustainability and resiliency action plan, Thrive Indianapolis, which aims for citywide carbon neutrality by 2050 (City of Indianapolis Office of Sustainability, 2019), specifically targets energy benchmarking and transparency for buildings in Indianapolis and Marion County.

Key aspects of the ordinance include:

- **Administration and Program Structure:** Benchmarking is managed in the Office of Sustainability within the Indianapolis and Marion County municipal government. The larger initiative has its own website, where the community can go to understand the context of benchmarking and check if their property is on the covered buildings list (Indianapolis and Marion County Government n.d.). According to the benchmarking program office, one full-time employee manages the entirety of the program, sometimes with support from interns and fellows. The staff member points out that Indianapolis is of similar size to Louisville, and Indianapolis' program is manageable for one person. The staff member is in charge of the outreach to and training for building owners, answering questions from building owners, managing the data, following up with noncompliant buildings, and other duties as needed.
- **Goal:** To achieve citywide carbon neutrality by 2050, reduce greenhouse gas emissions from buildings, reduce energy expenditure, and increase workforce development.

[32] Actual areas selected were: Louisville, KY: "Louisville/Jefferson County metro government (balance), Kentucky"; Indianapolis, IN: Indianapolis city (balance), Indiana; Kansas City, MO: Kansas City (city), Missouri; Washington, D.C.: Washington city, District of Columbia.

- **Annual Deadline:** Building owners are required to report their utility usage annually by June 1st (Indianapolis and Marion County Government n.d.).
- **Size Requirements:** Initially, benchmarking was only required for city-owned buildings larger than 50,000 square feet and voluntary for other buildings. Subsequently, the requirement expanded to a wider range of buildings. Starting in 2024, all buildings 50,000 square feet or larger located in the City of Indianapolis/Marion County, and city-owned buildings over 25,000 square feet of gross floor space, all are required to comply. The size threshold expands to smaller buildings in future years (Indianapolis and Marion County Government n.d.).
- **Utilities Required for Reporting:** This includes all energy utilities (electricity, natural gas, district energy, and other fuel types), water, and steam (Indianapolis and Marion County Government n.d.).
- **Building Owner Reporting Tool:** ENERGY STAR Portfolio Manager (ESPM) tool (Indianapolis and Marion County Government n.d.).
- **Outreach Process:** Email and postcard reminders sent to building owners, according to program staff.
- **Data Collection Mechanism:** According to program staff, benchmarking data is collected through ESPM property sharing (Byarley 2024). The program started with using a data request link for building owners to follow and upload data each year, but has now switched to property sharing on ESPM, where property owners only need to link their property with the city once, and new data will automatically be shared with the city.
- **Data Management System:** BEAM, which automatically connects to ESPM and allows for tracking compliance and streamlines communications with building owners. BEAM offers email templates for frequently asked questions from building owners; the program staff member points out that this feature allows the program to be managed by one person without third-party support of TA and troubleshooting (Byarley 2024). More information on BEAM (SEED-based Platform) and related tools can be found in the Data Management Solutions section below.
- **Automation in the Reporting Process:** The data upload process is not automated; it requires manually registering properties and uploading all types of consumption and bill data, including electric, natural gas, steam, and water. ESPM allows for spreadsheet uploads that include information for multiple properties and utility meters, but the spreadsheets require manual compilation of the user (Indianapolis and Marion County Government n.d.).
- **Utility Support for Aggregated Data for Multifamily/Tenant Buildings**: Local utilities do not yet automatically provide aggregated data for multifamily building owners (Indianapolis and Marion County Government n.d.), but according to program staff, the local electric utility is planning on providing a solution by the next reporting cycle (Byarley 2024). Currently, landlords can call the electric utility for assistance on obtaining tenant data. For the local gas, water, and steam utility (one utility handles the three), building owners would need to ask each tenant (multifamily and commercial) for each unit's data, compile them manually, then upload everything to ESPM.
- **Enforcement:** As stated in the ordinance (Indianapolis and Marion County Government n.d.), a fine of $100 is assessed for the first offense of failure to make benchmarking submission, and $200 for the second offense.

- **Compliance Assistance:** The City's Office of Sustainability has hosted free workshops and one-on-one sessions to provide TA for building owners/operators ("Data Jams"). Step-by-step on-demand resources are also provided to assist the reporting process, including guides on how to obtain utility data from local utilities. For buildings that participated before June 1, 2023, the city offered eligibility for winning a free energy audit (Indianapolis and Marion County Government n.d.).
- **Program Budget:** According to program staff, the budget includes $63K for one staff's salary (not including benefits), around $40k each year for BEAM (the staff member noted there are subsidies that may be applied in the first year), and around $5K each year for communications and outreach (Byarley 2024).

Kansas City

The Kansas City Energy Benchmarking Program, part of the city's Energy Empowerment Ordinance, aims to reduce energy bills and foster sustainable development.

Key aspects of the ordinance include:

- **Administration and Program Structure**: Administered by the City of Kansas City government, under the Office of Environmental Quality (KCMO n.d.-b). According to the benchmarking program staff member, one full-time employee administers the program with support from the Metropolitan Energy Center to provide help desk services and training to building owners (Tokos 2024).
- **Goal**: a carbon-neutral, equity-focused, and resilient Kansas City by 2040 (KC Green 2022).
- **Annual Deadline**: Building owners are required to report their utility usage annually by May 1st (KCMO n.d.-b).
- **Size Requirements**: Initially, benchmarking was only required for municipal buildings larger than 10,000 square feet. Currently, institutional, commercial, industrial, and multifamily properties above 50,000 square feet are required to comply (KCMO n.d.-b).
- **Utilities Required for Reporting**: This includes all energy utilities (electricity, natural gas, and other fuel types), water, chilled water, and steam (KCMO n.d.-b).
- **Building Owner Reporting Tool**: ESPM tool (KCMO n.d.-b).
- **Outreach Process**: According to program staff, official mail is sent around the end of January each year, followed by several email communications, about one each month as the deadline approaches (Tokos 2024). In June, a reminder/warning letter is sent to those who have not yet reported. Two email reminders/warnings are also sent in the summer. Their partner Metropolitan Energy Center also regularly contacts building owners (both through email and direct "cold" phone calls).
- **Data Collection Mechanism**: According to program staff, benchmarking data is collected through ESPM data calls (Tokos 2024). Building owners submit data through a link provided by the program. The program office reports the mechanism is generally working well, although in some cases troubleshooting is required due to the complicated multistep submission process. In these cases, building owners do not get through to the end of the process, resulting in the city not actually getting access to the data despite it being already entered into the system.

- **Data Management System**: According to program staff, the program does not use a third-party data management system but is exploring options (Tokos 2024). The program exports data from ESPM and performs analysis in spreadsheets.
- **Automation in the Reporting Process**: The building owner reporting process for submitting consumption and bill data is not automated. A building owner must manually upload bill information for types of utilities (could be for multiple properties and/or meters), including electric, natural gas, other energy sources, and water, into ESPM (KCMO n.d.-b). At this point building owners must manually share their profile in ESPM with the city's ESPM account to report building data to the city, leading to potential issues of building owners not following through to the final step and the city not receiving the submission.
- **Utility Support for Aggregated Data for Multifamily/Tenant Buildings**: Local electric and gas utilities offer aggregated data for multifamily and multi-tenant buildings (KCMO n.d.-b).
- **Enforcement**: A written warning is issued to property owners that fail to meet the reporting deadline; failure to comply within 60 days of when the warning is issued will result in a fine of between $50 and $500 (KCMO n.d.-b).
- **Compliance Assistance**: The City of Kansas City provides training and resources for stakeholders involved in the benchmarking process. This includes step-by-step guides, training sessions, and FAQs to assist building owners in complying with the Energy Empowerment Ordinance (KCMO n.d.-b).
- **Program Budget**: According to program staff, the budget includes $70K for one staff's salary (not including benefits), around $500 each year for printing and mailing, and around $100K for Metropolitan Energy Center to manage the "help desk" and provide training sessions in the spring (Tokos 2024).

Washington, D.C.

Washington, D.C.'s (District) energy benchmarking laws require large buildings to annually track their energy and water efficiency and report the results to the Department of Energy & Environment for public disclosure.

- **Administration and Program Structure**: Benchmarking is managed by the D.C. Department of Energy & Environment (DOEE), Energy Administration, Data & Benchmarking Division (DOEE n.d.-b). According to the office, one employee is dedicated to the benchmarking program full time, with support from staff in other roles; the total staff time commitment is about two full-time employees (Saunders 2024).
- **Goal**: 45,000 metric tons CO2(e) reduction from 2019 baseline by 2032.
- **Annual Deadline**: Building owners are required to report their utility usage annually by April 1st (DOEE n.d.-b).
- **Size Requirements**: The District government is required to benchmark and disclose the energy and water efficiency of District government buildings over 10,000 gross sq. ft. As of the 2022 reporting deadline, all privately-owned buildings over 25,000 sq. ft are required to submit annual benchmarking data. Starting with 2024 data (due in 2025), all privately-owned buildings over 10,000 sq. ft will be required to benchmark (DOEE n.d.-b).
- **Utilities Required for Reporting**: This includes all energy utilities (electricity, natural gas, and other fuel types) and water (DOEE n.d.-b).
- **Building Owner Reporting Tool**: ESPM tool (DOEE n.d.-b).

- **Outreach Process**: According to program staff, official mail is sent around February. When there is a change in building size requirements, education and outreach campaigns begin around a year and a half in advance so building owners are not surprised (Saunders 2024).
- **Data Collection Mechanism**: According to program staff, benchmarking data is collected through ESPM property sharing (Saunders 2024). The program reported having much fewer troubleshooting requests after switching from data calls to property sharing, despite this not necessarily being the case for other benchmarking cities.
- **Data Management System**: BEAM, which automatically connects to ESPM and allows for tracking compliance and streamline communications with building owners (DOEE n.d.-b). Program staff mentioned that D.C.'s program started with SEED and switched to BEAM, a third-party platform built on top of SEED (Saunders 2024). (See Data Management Solutions section below for more information on SEED and BEAM.)
- **Automation in the Reporting Process**: The building owner reporting process for submitting consumption and bill data can be automated, although it differs for different utilities and requires the building owners to set up the connection between the utility's data system and ESPM, as it is not automatic for all buildings. Building owners have the option to manually download data from the utility and upload it to ESPM following ESPM formatting. Despite utilities having the capability of connecting with ESPM for automated data inputting, if a building owner chooses the manual route, a spreadsheet of data downloaded from the utility is not in the format required by ESPM for spreadsheet uploads. Hence, the program really encourages building owners to set up connections between the utilities and ESPM (DOEE n.d.-b).
- **Utility Support for Aggregated Data for Multifamily/Tenant Buildings**: Local electric and gas utilities offer aggregated data for multifamily and multi-tenant buildings (DOEE n.d.-b).
- **Enforcement**: Failure to comply can result in fines of up to $100 per day of noncompliance (DOEE n.d.-b).
- **Compliance Assistance**: The DOEE provides detailed instructions and Frequently Asked Questions on the benchmarking process. The D.C. Sustainable Energy Utility (DCSEU) set up a Benchmarking Help Center to provide technical support and guidance on compliance with District regulations. The DCSEU also provides educational opportunities in energy benchmarking to help stakeholders understand and comply with the benchmarking requirements and the Building Energy Performance Standards (BEPS) (DOEE n.d.-b).
- **Program Budget**: According to program staff, the annual budget includes around $250,000 for staffing, around $65,000 for BEAM, and $50,000 for printing, mailing, and collateral (Saunders 2024).

Table 11: Summary of Benchmarking Program Highlights of the Case Study Cities.

	Indianapolis, IN	Kansas City, MO	Washington, D.C.
Year implemented	2021	2015	2008
Administering entity	The City's Office of Sustainability	City of Kansas City, Office of Environmental Quality	D.C. Department of Energy & Environment, Energy Administration, Data & Benchmarking Division
Partners involved in benchmarking policy design	Building Efficiency Advisory Committee	Midwest Energy Efficiency Alliance; Metropolitan Energy Center; Kansas City Power and Light; Laclede Energy; AIA Kansas City; Bridging the Gap; City Energy Project; EPA Region 7; Greenwood Consulting Group, LLC; Kansas City Public Schools; Kansas City Sierra Club; Mid-America Regional Council; and the USGBC Central Plains Chapter.	Could not find information in sources that were reviewed by authors
Annual deadline	June 1	May 1	April 1
Program funding	Continuing, non-reverting designated Energy and Water Efficiency Fund (Indianapolis and Marion County Government n.d.)	Not mentioned on website or in the ordinance document	Not mentioned on website or in the ordinance document
Covered buildings	According to implementation schedule: as of 2024, benchmarking is required for Municipal buildings greater than 25,000 sq. ft; All Marion County buildings greater than 50,000 sq. ft	Institutional, Commercial, Industrial, Multifamily, 50,000 sq. ft and above	According to implementation schedule: as of 2022, benchmarking is required for all privately owned commercial and multifamily buildings over 25,000 gross sq. ft and District government buildings over 10,000 gross sq. ft
Number of buildings impacted	Approximately 2,500 buildings	1,357 buildings	Approximately 3,500 buildings
Building owner reporting Software	Energy Star Portfolio Manager	Energy Star Portfolio Manager	Energy Star Portfolio Manager

	Indianapolis, IN	Kansas City, MO	Washington, D.C.
City data management software	BEAM	Computer spreadsheets	BEAM
Utilities required for reporting	Energy utilities, water, and steam	Energy utilities, water, and steam	Energy utilities and water
Data gathering methods	Upload monthly consumption every year	Upload monthly consumption every year	Upload monthly consumption every year
Data publishing and access	Scores for buildings will be published by benchmarking phases, starting with covered city properties in 2023.	Annual building-level aggregated data publicly available, annual report available[a]	Annual building-level data and map publicly available[b]
Data support and infrastructure	"Data Jams", one-on-one training, and detailed instructions on how to obtain energy data from utilities[c]	Step-by-step detailed instructions and training available[d]	Step-by-step detailed instructions and training available[e]
Help contact	benchmarking@indy.gov	Benchmarking@kcmo.org	building.performance@dc.gov
Affordable multifamily specifics	Could not find information in sources that were reviewed by authors	Could not find information in sources that were reviewed by authors	Affordable Housing Retrofit Accelerator[f]
Incentives	Enter a drawing for a free energy audit with participation before annual deadline in 2023	Could not find information in sources that were reviewed by authors	Could not find information in sources that were reviewed by authors
Enforcement	Violation of code and civil penalty if failed to comply, first offense $100, second offense $250	60 days to comply after written warning, penalty will not be less than $50.00 and not more than $500.00	Failure to comply can result in fines of up to $100 per day of noncompliance.
Beyond benchmarking	Could not find information in sources that were reviewed by authors	Energy audits and energy retrofits are not required	Benchmarking reports are required to be third-party verified every three years, Building Energy Performance Standard in place
Complementary program design	Part of a larger effort, Thrive Indianapolis, the city's first sustainability and resiliency action plan. Indiana Energy	Provide support in measuring progress towards climate action goals, revising current benchmarking program by	Affordable Housing Retrofit Accelerator, Building Energy Performance Standard

	Indianapolis, IN	Kansas City, MO	Washington, D.C.
	Independence Fund is being established[g]	adding building performance standards in underway	
Key implementation partners and programs	AES Indiana, The Industrial Assessment Center at IUPUI, Faith in Place	Could not find information in sources that were reviewed by authors	DC Green Bank, D.C. Sustainable Energy Utility, DOEE's Solar for All, Solar Works D.C.
Projected bill savings	By 2030, building owners see roughly $194 million in bill savings cumulatively[h]	Reduce energy bills in the city's largest buildings by $394 million (no timeframe mentioned)[i]	Could not find information in sources that were reviewed by authors
Projected emissions reduction	8% CO_2 reduction by 2030, a 27% greater impact than is projected if no policies were implemented at all[h]	16% reduction in GHG emissions by 2040[j]	Goal to reduce GHG emissions and energy consumption by 50% by 2032 through the Sustainable D.C. plan[k]
Projected health benefits	$78 million cumulatively by 2030[h]	Could not find information in sources that were reviewed by authors	Could not find information in sources that were reviewed by authors
Projected job creation	Over 1,100 net jobs cumulatively by 2030[h]	Could not find information in sources that were reviewed by authors	Could not find information in sources that were reviewed by authors

a: https://www.kcmo.gov/programs-initiatives/energy-and-water-benchmarking/resources.
b: https://opendata.dc.gov/datasets/building-energy-benchmarking/explore.
c: https://www.indy.gov/activity/benchmarking-and-transparency.
d: https://www.kcmo.gov/programs-initiatives/energy-and-water-benchmarking/training.
e: https://dc.beam-portal.org/helpdesk/kb/benchmarking/.
f: https://www.dcseu.com/retrofitaccelerator.
g: https://energyindependencefund.org/.
h: https://citybase-cms-prod.s3.amazonaws.com/b33767de916d460195a83b40c7b4b395.pdf.
i: https://mosaves.com/missouris-energy-efficiency-laws-policies/missouri-building-benchmarking-policies/.
j: https://www.kcmo.gov/home/showpublisheddocument/9912/638112897582470000.
k: https://sustainable.dc.gov/sdc2.

Data Management Solutions

Multiple options exist for benchmarking data management for the city. The Standard Energy Efficiency Data (SEED) Platform™ is a free and open-source software created by NREL to manage building performance data. SEED can be connected to ESPM to organize, clean, and validate benchmarking data and generate reports and queries. SEED and third-party platforms based on SEED are not replacements for ESPM, as building owners still need to submit their data through ESPM. However, SEED and other platforms (e.g., BEAM, used in Indianapolis and Washington, D.C.) provide centralized and streamlined platforms for the city to visualize data and compliance, send communications to building owners (BEAM), and generate analysis results from benchmarking data (Figure 22 and Figure 23).

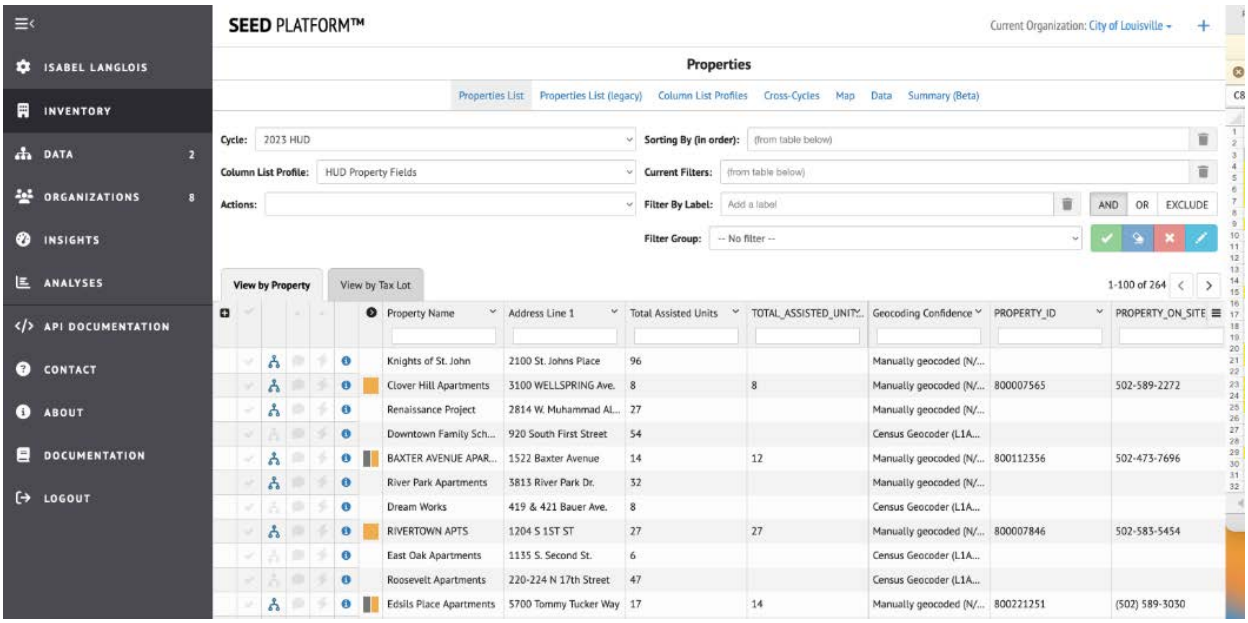

Figure 22: Benchmarking program manager view in SEED.
Image credit: Isabel Langlois-Romero, NREL

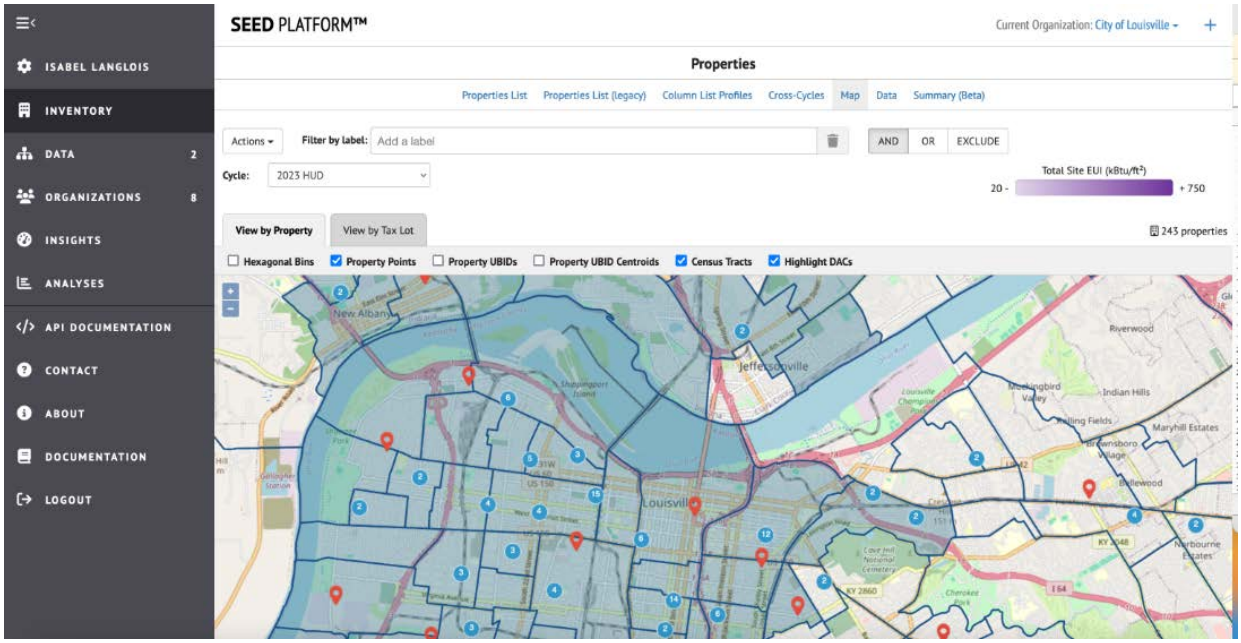

Figure 23: Map view of covered buildings' locations in SEED.
Image credit: Isabel Langlois-Romero, NREL

BEAM is a third-party platform based on SEED. According to program staff from Indianapolis and Washington, D.C., BEAM has provided customer relations-related features that made communicating with building owners and troubleshooting much simpler. BEAM provides email templates for frequently asked questions from building owners and allows the program staff to directly send and receive communications from BEAM's portal.

Case Study Community Engagement Strategies

This section highlights the steps taken by two communities in implementing community engagement strategies for benchmarking ordinances.

In Indianapolis, the City's Office of Sustainability included stakeholders from the beginning of the ordinance's development. The Office of the Mayor, the Department of Business and Neighborhood Services, the Office of Sustainability, and the Building Efficiency Advisory Committee took part in the policy development process. The Committee represented various community members and organizations, including those managing or owning larger buildings, industry groups, local resident groups, local universities, and public schools. The Committee was convened five times in 2020 to develop the draft ordinance, and the members were actively involved in shaping the policy, providing feedback, and helping to refine key aspects of the ordinance, such as the decision to omit third-party data audits due to their cost and complexity. Throughout the five meetings, the advisory group learned about benchmarking basics, best practices from other cities' programs, including positive impacts like emissions reductions, to the types of buildings that were exempt from benchmarking ordinances. The group was able to arrive at key decision points of the program: building types, sizes and implementation timeline, types of data to collect, data verification requirements, sharing of building scores and other select information, important resources, and trainings to provide, ensuring compliance and eligibility for exemption requests. The engagement process ended with a report of projected benefits to the city and an outline of the elements of the Indianapolis benchmarking program.

Kansas City established an approach to engage various stakeholders in its Energy Benchmarking Program. The city contracted with the Metropolitan Energy Center to facilitate stakeholders in the benchmarking process and comply with the city's ordinance. Other stakeholders and partners involved included the Midwest Energy Efficiency Alliance, representatives from Kansas City Power and Light, Laclede Energy, AIA Kansas City, Bridging the Gap, City Energy Project, EPA Region 7, Greenwood Consulting Group, LLC, Kansas City Public Schools, Kansas City Sierra Club, Mid-America Regional Council, and the USGBC Central Plains Chapter. According to meeting minutes of the Environmental Management Commission (KCMO n.d.-c), the first draft of the ordinance was submitted by the City Energy Project Advisory Committee to the City Council in December 2014, after meetings with the Institute of Market Transformation, the Kauffman Foundation, and the City Energy Project. The draft ordinance was initially met with pushback over concerns that: a benchmarking ordinance could eventually lead to an efficiency mandate, foreshadowing costly retrofits to come; a benchmarking ordinance could potentially drive away development in the city to neighboring cities; and the data reported would be proprietary. There was, however, support for benchmarking ordinances from other groups, including residents and large property management firms. Overall, the process led to additional communication and engagement with a broad array of stakeholders and community members. Kansas City published the results from community engagements in service of the 2022 Kansas City Climate Protection and Resiliency Plan (KCMO n.d.-a). The engagement process took place for Northland, Central, and South Kansas City, with separate results published for each region (KC Green 2022). The Plan identifies ongoing efforts to update the existing benchmarking program by adding building performance standards, for the goal of increasing building efficiency and health for commercial and public buildings.

Examples of Complementary Program Design

There are examples of additional policies and/or programs that communities have implemented to enhance the outcomes of benchmarking ordinances. Below are a few such categories of complementary policies and programs, along with specific community examples.

Building Performance Standards

The D.C. Building Energy Performance Standards (BEPS)[33] were established under Title III of the Clean Energy D.C. Omnibus Act of 2018, the first Building Performance Standard in the country. The 2021 Building Energy Performance Standards, which became effective on January 1, 2021, set a minimum threshold for energy performance for existing buildings, based on their demonstrated energy performance as indicated in their benchmarking data. Buildings that fail to meet the standard for their property type are mandated to improve their performance over a compliance cycle.

The BEPS program applies to privately-owned buildings larger than 50,000 sq. ft. and D.C.-owned buildings larger than 10,000 sq. ft (DOEE n.d.-a). The threshold for compliance will expand over time to include smaller buildings, eventually encompassing all buildings 10,000 sq. ft. or larger. Standards are set in the form of ENERGY STAR scores and EUIs. Building owners who meet the standards are encouraged to continue improving their energy efficiency to stay ahead of progressively stringent standards in future periods. For buildings that do not meet the standards, various compliance pathways are available,[34] each with its own set of requirements and deadlines.

Green Financing and Affordable Multifamily Programs

The DC Green Bank, established in 2018, and initially funded by the D.C. government, functions as an innovative financial tool, leveraging public funds to attract private capital investment (DC Green Bank 2024). It aims to expand renewable energy, lower energy costs, reduce greenhouse gas emissions, create green jobs, and enhance resilience in the District. The Bank provides financing through Property Assessed Clean Energy (PACE) and offers pre-development loans for energy-related pre-development costs (including benchmarking and design), with this aspect of financing specifically targeting multifamily residential properties and community-based nonprofit organization buildings. The DC Green Bank has been involved in significant financial support for environmental and affordable housing initiatives. In FY23, $9.6 million in funds was invested in supporting affordable housing (DC Green Bank 2023a). This includes a $3.3 million financial support deal for new construction of affordable housing in Ward 8 and energy efficiency and renewable energy upgrades in Ward 7: a $3 million construction loan from the DC Green Bank, and a $300,000 grant awarded to the developer through Capital Impact Partners' Housing Equity Accelerator Fellowship, funded by Amazon's Housing Equity Fund (DC Green Bank 2023b).[35]

To further support multifamily affordable housing buildings in their path to energy efficiency, lower operational and maintenance burden of landlords, reduced utility costs, and improved living conditions for residents, DOEE, the D.C. Sustainable Energy Utility (DCSEU), and the DC Green Bank launched the Affordable Housing Retrofit Accelerator.[36] The accelerator provides "direct technical and financial assistance to multifamily affordable housing buildings so they can meet the compliance requirements of the nation's first Building Energy Performance Standards (BEPS)" (DOEE 2021). Buildings are eligible for the accelerator by meeting the following requirements: multifamily building over 50,000 square feet, the building meets the definition of affordable housing, and the

[33] https://doee.dc.gov/publication/guide-2021-building-energy-performance-standards.
[34] https://dc.beam-portal.org/helpdesk/kb/BEPS/35/.
[35] https://planning.dc.gov/whatsmyward.
[36] https://doee.dc.gov/release/bowser-administration-launches-program-help-multi-family-affordable-housing-meet-new-energy.

building does not meet the District's 2021 BEPS (ENERGY STAR score lower than 66 in calendar year 2019) (DOEE 2021).

The interaction between these financing mechanisms and the benchmarking and building performance standards is key. The benchmarking program requires large buildings, including multifamily residences, to annually measure and disclose energy and water consumption. The Building Energy Performance Standard sets minimum energy performance thresholds and lays out achievable pathways to compliance. The DC Green Bank's role in financing and supporting energy-efficient projects complements these regulations by providing financial resources for building owners to meet or exceed these standards. The Affordable Housing Retrofit Accelerator provides tailored support for affordable housing buildings to meet energy efficiency goals. These initiatives aim to create and preserve affordable housing units in the District.

Green banks or lenders specifically aligned with public programs will often offer streamlined financing processes with below market interest rates. If Louisville is not willing or able to establish its own financing entity, it may want to consider partnering with specific financial institutions to lend for the program (typically chosen by a bidding process). A key incentive for private lenders to participate is the pipeline of borrowers the program will deliver, along with lower lender risk and entry into the clean energy technology sector (DC Green Bank n.d.).

Additional Energy Benchmarking and Disclosures Examples

Although this section has focused on Indianapolis, Kansas City, and Washington, D.C., many communities across the country have leveraged benchmarking and complementary programs, such as energy disclosures. Energy disclosures help to inform residents about their current energy usage and possible future energy use in a new home. This can help ensure that residents have a complete picture of the costs associated with any purchases they are considering and indirectly drive energy efficiency investments by highlighting the long-term savings associated with energy-efficient homes. Examples of this practice include the following:

- At the time of property transfer, Piedmont, California, requires a Home Energy Score, or an energy assessment/audit from the last five years for all residential buildings over 10 years in vintage (City of Piedmont n.d.). Piedmont also requires audits for certain Design Review permits which have an energy impact.
- Montgomery County, Maryland, requires at the time of sale for single-family homes and condos, that a seller disclose energy information to the buyer - including copies of electric, gas, and home heating oil bills or cost and usage for the prior 12 months the home was occupied (Office of Consumer Protection n.d.). The requirement is intended to ensure that a home buyer is informed about a home's energy performance before a sale and is aware of options to finance energy efficient improvements.
- Bend, Oregon, requires, as of July 1, 2023, all publicly listed homes for sale to include a Home Energy Score report, allowing potential buyers to compare the efficiency of different homes and make informed decisions (City of Bend n.d.). Homes listed for sale before July 1, 2023, and are still active are exempt from this requirement.
- Davis, California's, Resale Program requires at the time of property transfer for residential properties with 1-3 units to undergo a resale inspection no later than fifteen days prior to the close of escrow or other change in ownership (City of Davis n.d.). The inspection results in a report that must be provided to the property buyer, which outlines areas where the property does not meet minimum building codes and health, fire, and safety regulations. Any violations are divided into three tiers – with the first requiring remediation and re-inspection by the city. Tier 2 notes items that need to be remedied, but do not require re-inspections,

and finally Tier 3 are items that do not require action but are called out as informational to the buyer. Multifamily properties with four units or more are eligible for a self-certification rather than a city inspection.

Applications for Louisville

From early conversations with the Louisville Energy Alliance (LEA), NREL researchers learned about Louisville's voluntary benchmarking program and challenges that arose from the program. Kilowatt Crackdown, Louisville's voluntary benchmarking program that launched in 2007, encourages all commercial buildings within the Louisville Metropolitan Statistical Area to participate in an annual competition through submitting annual benchmarking reports. Buildings compete for Best Performer and Most Improved titles in their respective building type categories. This program gives buildings the opportunity to be recognized for their efforts in energy conservation and efficiency, as well as a special recognition if the building earns the ENERGY STAR label through benchmarking.

Kilowatt Crackdown generally targeted commercial and industrial buildings, but the city is interested in expanding the benchmarking efforts to include multifamily and affordable housing in the future. LEA outlined the main challenges of the program: outreach for the program in the community and TA for getting the data into ESPM. For Louisville to continue building its benchmarking program upon Kilowatt Crackdown, it will be crucial to conduct an inventory of affordable housing buildings in the city. A covered buildings list will inform the personnel needs that will fulfill the administrative tasks of consolidating data into ESPM, as the reporting process still largely relies on manual labor, as seen from the case study city with established programs.

As Louisville looks forward to potentially establishing its formal benchmarking ordinance, LEA has been weighing potential considerations and clauses to include in the benchmarking ordinance that serve to alleviate multifamily affordable housing resident concerns. One example would be to include a clause to limit rent increases after energy efficiency upgrades to buildings for a set number of years, as residents would be concerned about higher housing costs after a renovation. Another example would be to include a clause stating personal/tenant-level data that reveals energy usage will not be shared at the individual level with the multifamily building owner, as individual unit-level energy use data can sometimes reveal sensitive personal and behavior data (e.g., what times people are away from home).

The case studies include examples of utilities offering options to aggregate building-level data for multifamily buildings owners to upload. Resources, including a model law, exist to support law makers in mandating local utilities to make aggregated whole-building energy data readily available. Understanding the local building stock inventory will inform the scope of the benchmarking ordinance, which will then inform how these types of clauses could be framed. For example, if Louisville starts with a benchmarking ordinance for the subsidized housing subset of the affordable housing, then rent increases are not as pertinent for LEA. However, if the benchmarking ordinance includes naturally occurring affordable housing, then provisions to protect tenants from rent increase due to increased property value are important considerations for LEA.

Potential Steps for Establishing a Voluntary Benchmarking Program for Multifamily Buildings in Louisville

From the case study examples and conversations with Louisville, three possible high-level actions were identified for Louisville to initiate a voluntary multifamily affordable housing benchmarking program.

- The Kilowatt Crackdown provides an existing benchmarking ordinance structure that has lived among the community for over a decade, with consensus from LEA; it provides a

foundation to build the benchmarking ordinance from. This program could be supported and expanded to include a main landing page for existing resources and can be expanded to include more resources and training from the ESPM and success stories from other cities. Louisville already has established a relationship with the U.S. Environmental Protection Agency (EPA) and HUD to support the establishment of a benchmarking ordinance and provide resources for TA. LEA, as the administrator of Kilowatt Crackdown, is positioned to develop the partnerships necessary to promote and sustain a benchmarking ordinance.

- ☐ Louisville could support affordable housing providers by coordinating TA with HUD. The HUD Green and Resilient Retrofit Program (GRRP) offers free TA for energy and water benchmarking for all buildings that are HUD assisted, covering a significant portion of the building owners in the affordable housing sector. Training tailored to Louisville can then be developed from experience gained through the partnership with HUD.
- ☐ Louisville could work with EPA, HUD, and LG&E to develop the local utility's capacity of data sharing and management. The option to aggregate whole-building data for multifamily building owners can streamline implementation and reduce costs borne by property owners, while minimizing tenant privacy concerns. A longer-term goal could be working with EPA and local utilities to provide direct connections between ESPM and utilities.

In addition to the three above high-level actions, additional program details are provided below for consideration to build on a voluntary benchmarking ordinance.[37]

VOLUNTARY MULTIFAMILY AFFORDABLE HOUSING BENCHMARKING PROGRAM.

Planning time: 1-2 years

Potential tasks towards establishing a voluntary multifamily affordable housing benchmarking program:

- ☐ Compile building stock inventory of local affordable housing, including subsidized housing, privately owned properties, publicly owned properties, and unsubsidized housing, including buildings in Louisville that are already using ESPM to benchmark, to create a covered building list.
- ☐ Identify HUD and EPA personnel dedicated to benchmarking and TA for the program administrators and building owners.
- ☐ Establish working relationships with HUD and EPA to provide long-term support of benchmarking efforts in Louisville.
- ☐ Understand tenancy of covered buildings and estimate potential outcomes of benchmarking, including the state of energy efficiency in affordable housing, funding needs to make improvements, projected bill savings for tenants, projected emissions reductions, and more qualitative benefits of benchmarking and energy efficiency upgrades on resident health and comfort, indoor air quality, etc.
- ☐ Understand the timing needs of property financing agreements for affordable housing properties.

[37] These program details are not exhaustive and are only meant to provide examples of the program steps a community could undertake to establish a benchmarking program.

- □ Determine an implementation schedule (usually by building size) to expand the covered buildings list year by year.
- □ Determine what should be included in floor area in the implementation schedule (gross floor area of the property, residential living space, public or open space, etc.).
- □ Determine whether to include water as part of the benchmarking effort.
- □ Understand data availability for energy utilities providing less common fuel types, determine the extent to which alternative fuel types should or could be included in the benchmarking effort.
- □ Establish incentives for building owners to participate. One case study city offered free energy audits to participating buildings.
- □ Determine the reporting approach, either data request or property sharing through ESPM. Each approach has pros and cons, as detailed in the linked document and experienced by case study programs.
- □ Determine whether to make benchmarking data public as part of the voluntary program, engage the community to understand concerns from stakeholders including residents living in covered buildings, building owners, energy efficiency service providers, policy experts, and be frank about the benefits of a benchmarking program as well as the levels of effort that would be required of participants for a successful program.
- □ If the data will be made publicly available, determine the format it will be published in (spreadsheet, map, interactive portal), level of detail and types of information (e.g., building owner's name, aggregated annual consumption vs. monthly consumption) and timeline from when the benchmarking program begins to start publishing data (e.g., Indianapolis' program started in 2021, but any data have yet to be published).
- □ Compile training resources tailored to the local community, understand the level of technology proficiency of building owners to determine the level of support and TA required, and estimate cost of providing assistance.
- □ Compile resources for multifamily affordable housing building owners to scope, plan, and finance energy efficiency upgrades.

VOLUNTARY BENCHMARKING PROGRAM EXPANDED TO INCLUDE MORE BUILDING TYPES

Planning time: 3-5 years

Potential additional tasks towards a more comprehensive voluntary benchmarking program:

- □ Compile detailed building stock inventory by building and industry type.
- □ Determine implementation schedule to include smaller buildings and more building types.
- □ Determine whether to make multifamily affordable housing benchmarking mandatory as more building types and industries are included as voluntary.
- □ Engage a wider range of stakeholders from different building types to understand the burden and feasibility of a more comprehensive program to different industries.
- □ Determine the reporting requirements for more complicated properties (e.g., should a university report its entire usage as one, or by aggregated dorm building type, teaching building type, or building by building).
- □ Consider seeking additional funding for benchmarking program support and development.
- □ Estimate potential impact of a more comprehensive benchmarking program.

- □ Compile or establish resources for building owners from different sectors to support energy efficiency upgrades.
- □ Identify, recruit, and secure financing partners to support building owners in making efficiency upgrades.

Workforce Development

Workforce development represents both a prerequisite for and opportunity from widespread energy efficiency deployment. Without a "right-sized" workforce that is sufficiently trained to install energy efficiency upgrades, widespread adoption will not be possible. Conversely, an appropriate workforce pipeline to educate and train energy efficiency workers that is accessible to all can bring job opportunities to disadvantaged groups. The workforce development TA pursued through Communities LEAP consisted of 3 distinct areas:

- High-level information on clean energy employment that was applicable to all the communities supported through Communities LEAP.
- A focused look at Louisville's workforce ecosystem today.
- A curated list of workforce development programs that could serve as an example for Louisville's efforts.

According to the ResStock analysis described in this report, there are approximately 250,000 dwellings (split between single-family homes and multifamily units) that have a combined envelope rating of "Poor." Improving these envelopes would consist of tasks that vary by home: some may need better wall insulation, or attic insulation, or ductwork sealing, or general leak repairs around the home. If Louisville sought to improve building envelopes as a core component of its strategy towards meeting its 2040 community energy goals, this would amount to approximately 15,500 units retrofitted per year, in addition to any new construction not considered in the analysis. While Louisville could seek to improve building envelopes as a core strategy towards reaching its energy goals, the actual number of units retrofitted per year could be much less than this.

One method for estimating the number of jobs a particular set of investments could support is to use the total costs of those investments and a state- and industry-specific multiplier. Truitt et al. (2022) provides an estimate of this multiplier by state for direct energy efficiency jobs, based on utility energy efficiency program spending. For Kentucky, this multiplier amounts to 4.87 jobs per $1 million invested. Assuming that the total costs of the upgrades explored in the envelope packages were evenly distributed between now and 2040, this would sustain approximately 550 and 750 jobs per year for the next 16 years for the Basic and Enhanced Envelope upgrade packages, respectively. While this represents a significant investment, it also represents a significant jobs opportunity if the requisite workforce can be deployed to install those upgrades.

Communities LEAP Workforce Development Resources

Communities LEAP TA provided several high-level resources to offer participating communities additional context and information on clean energy technology investments and associated workforce needs and opportunities. These resources were not context-specific to any particular community but were supplemented by analysis of the workforce ecosystem in each community and publicly available information from the Bureau of Labor Statistics. As Louisville begins to chart out its own workforce development program, these resources can help it consider the potential benefits of such programs, how to expand such programs to ensure equitable access to job opportunities from clean energy deployment, and understand where the community sits today with respect to workforce development efforts.

High-Level Resources on Workforce Development and Clean Energy

The first workforce resource for communities is the "Clean Energy Employment Impacts" fact sheet that identifies at a high level the types of employment impacts that can be expected based on the source of the clean energy employment (solar PV, wind, and energy efficiency).[38]

The next resource is the "Clean Energy Employment Impacts and Occupational Analyses: Building Envelope & Electrification Upgrades" report.[39] This report provides additional details on the types of jobs that would be involved in the subcomponents of the upgrade packages explored above (e.g., attic insulation, wall insulation), and which professionals would perform the work in question. For each of these professions, links to official pages with additional information are provided, including to the Green Buildings Career Maps and the U.S. Bureau of Labor Statistics, that provide salary ranges, educational and training requirements, skills, and additional details that can be valuable to consider when developing a workforce development program.

The final resource is the "Community Toolkit for Designing and Implementing a Contractor Accelerator Program," which provides communities with an overview of the methodology and approach to designing, developing, and implementing contractor development programs.[40] These programs support small businesses from historically underrepresented communities so that they can better compete and become leaders in the clean energy marketplace.

Louisville's Workforce Ecosystem Analysis

In order to better understand Louisville's current workforce status, which could impact the city's ability to commence significant electrification or energy efficiency efforts in the near future, NREL researchers analyzed data from the Bureau of Labor Statistics for Jefferson County for 2022. This data looked at employment levels and wages for Jefferson County for building construction and related energy efficiency/electrification jobs (Appendix F. Workforce Development Data). One way to measure the size of the workforce for a particular industry is to compare it against the national average to determine how much employment one would anticipate in a region and industry given the region's total population. The Location Quotient (LQ) represents this as a fraction, where a value of 1.0 means the area has exactly the amount of employment one should expect given national trends and the area's population. Values more than 1.0 indicate employment above national trends and values less than 1.0 indicate employment below national trends.

Figure 24: shows the Location Quotient for select industry groups related to the construction of residential dwellings and for various efficiency and electrification jobs. Notably, nearly all of the industry groups shown have LQ's below 1.0, sometimes significantly below, indicating that Louisville has far fewer people employed in these areas than its population would suggest given national trends. This is despite the fact that across all industries (including those unrelated to efficiency or construction), Louisville has an LQ above 1.0 (indicated by the dashed red line), meaning that Louisville's workforce is larger than its population would indicate given national trends (Appendix F. Workforce Development Data). Among efficiency-related groups, only the plumbing and HVAC category sees higher employment than what national trends would predict. This may indicate that Louisville could struggle to find a sufficient workforce if it decided to incentivize an increase in efficiency investments or new housing construction.

[38] The Clean Energy Employment Impacts factsheet is available for free online here: https://www.nrel.gov/docs/fy23osti/86712.pdf.
[39] The Clean Energy Employment Impacts and Occupational Analyses: Building Envelope & Electrification Upgrades report is available for free online here: https://www.nrel.gov/docs/fy23osti/86711.pdf.
[40] The Community Toolkit for Designing and Implementing a Contractor Accelerator Program is available for free online here: https://www.nrel.gov/docs/fy24osti/87713.pdf.

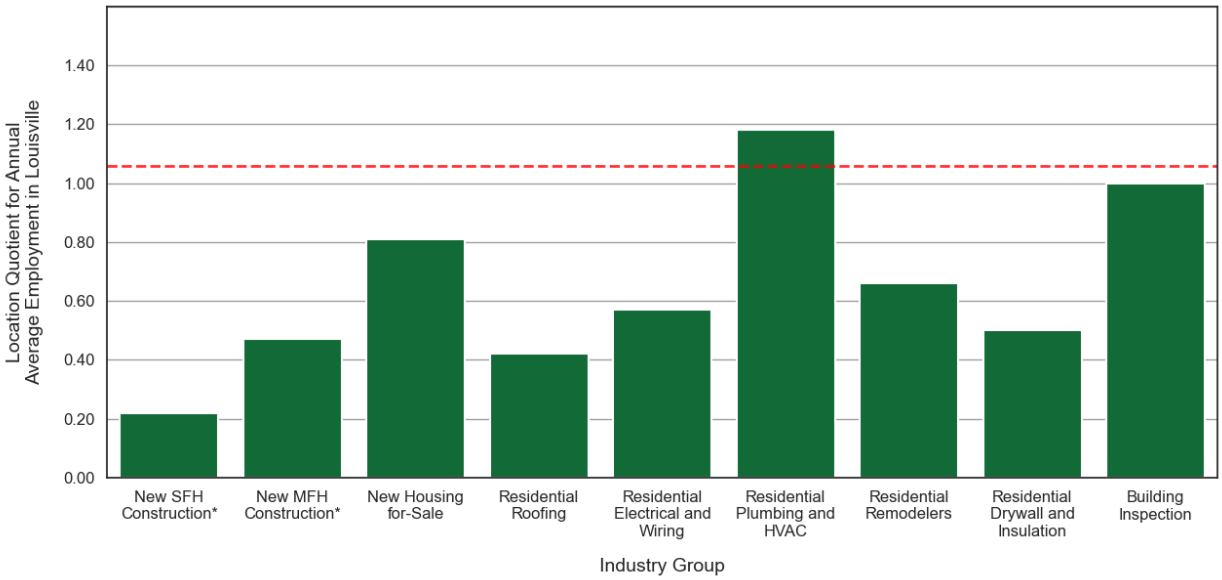

Figure 24: Location Quotient Values for Selected Industry Groups in Jefferson County.

*: SFH = Single-family Home, MFH = Multifamily Home. The red line indicates the location quotient for "Total, All Industries". The following NAICS codes correspond to groups shown above: New SFH Construction: 236115; New MFH Construction: 236116; New Housing for-Sale: 236117; Residential Roofing: 238161; Residential Electrical and Wiring: 238211; Residential Plumbing and HVAC: 238221; Residential Remodelers: 236118; Residential Drywall and Insulation: 238311; Building Inspection: 541350.

In addition to reviewing overall employment data, Communities LEAP also explored the training programs available in Jefferson County to understand what existing programs the community could leverage should it decide to scale up workforce development efforts. The results of that overview are available in Appendix F. Workforce Development Data, and the number of programs based on the technology focus and type of program are summarized in Figure 25. Based on the ecosystem analysis, there were *no* workforce development programs focused explicitly on residential energy efficiency available in Louisville, although there was an energy efficiency program offered by a local union focused on commercial and industrial applications. Louisville has a good mix of programs (based on intended audience and who was hosting the programs) for HVAC and plumbing applications, although these were not necessarily focused on energy efficiency.

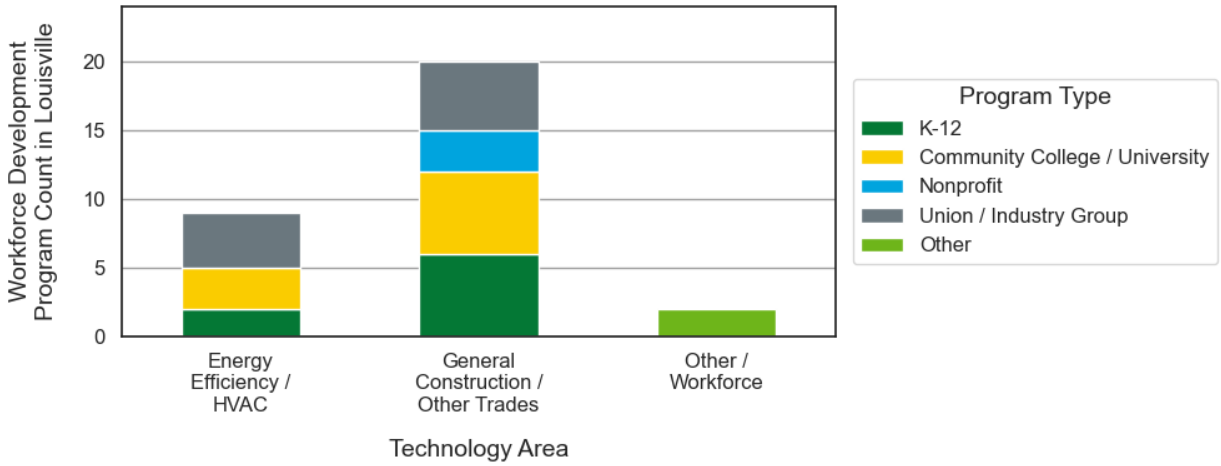

Figure 25: Breakdown of Workforce Development Program in Louisville by Technology area and Program Type.

Louisville could look to take advantage of the various construction-related programs already up and running, and partner with the hosting organizations to incorporate energy efficiency elements from existing curricula, such as through:

- Louisville has existing workforce programs in the community with whom it could partner, such as YouthBuild Louisville, which has a Construction Trades career track that could potentially be expanded to include building science and energy efficiency elements.
- The Building Performance Institute's (BPI) Building Science Principles Certificate, which is a widely recognized general certification program that has been incorporated in high school CTE programs across the country.
- The Residential Energy Efficiency Training program offered by the Kentucky Housing Corporation, which offers BPI certifications and is accredited by the Interstate Renewable Energy Council (IREC) for the U.S. Department of Energy Weatherization Assistance Program.
- The U.S. Green Building's Council, which has resources aimed at CTE programs.

Although the full development of a career technical education (CTE) program would have to be coordinated through the state's CTE program with the Kentucky Department of Education, these conversations could be started with local organizations to gauge interest and identify professionals able to support the process.

Training and Consortia Examples From Other Communities

When looking to establish additional training and workforce development programs, Louisville can look to efforts in other jurisdictions to identify what has worked for similar communities. Although an in-depth case study analysis of workforce programs across the country was beyond the scope of Communities LEAP, this section provides a high-level overview of programs that Louisville could explore under future TA opportunities, such as Buildings UP.[41] In addition to these examples, the Center for Energy Workforce Development provides an overview of state-level consortia focused on supporting careers in energy, including renewable energy: https://cewd.org/state-consortia/. Here, visitors can learn more about what other states are pursuing as they continue to build their clean energy workforces. Although there is no entry for the state of Kentucky, examples from other states could provide an example for Louisville to follow. Finally, SCEP has curated success stories from weatherization programs across the country, including successes communities have had in their weatherization workforce development efforts.[42] Louisville can use this database to see how peer programs have fared and determine if those programs are worth emulating.

[41] Buildings UP encourages teams to build capacity to transform U.S. buildings rapidly and equitably by upgrading existing buildings to efficiently run on clean energy, helping to address climate change. The U.S. Department of Energy Building Technologies Office developed and funded the prize as part of its overall mission to reduce the carbon footprint of the U.S. building stock while maintaining or improving affordability, comfort, and performance. Buildings UP is administered by the National Renewable Energy Laboratory and is part of the American-Made program, which fast-tracks innovation through prizes, training, teaming, and mentoring.

[42] https://www.energy.gov/scep/wap/successes-solutions-center.

Training Examples

BRIGHT SOLAR FUTURES

The Philadelphia Energy Authority, a municipal organization focused on energy affordability and sustainability, runs the Bright Solar Futures Curriculum, a 3-year Career and Technical Education (CTE) vocational program focused on solar energy. The program trains participants in areas such as electrical basics, rooftop solar PV installations, solar PV sales and permitting issues, building science, and energy efficiency and weatherization. The program is funded through grants from the U.S. Department of Energy's Solar Energy Technologies Office and the local utility, PECO. The curriculum materials are available for free online to allow organizations to start their own training programs at high schools, community colleges, and other venues. The first vocational solar PV program for high schoolers opened in 2020 at Frankford High School, and the Philadelphia Energy Authority sponsors fellowship opportunities through Bright Solar Futures PowerCorpsPHL that offers 680 hours of training and feeds into a 10-week internship and other job opportunities.

BUILDING GREEN FUTURES, PENNSYLVANIA COLLEGE OF TECHNOLOGY

The Pennsylvania College of Technology's Clean Energy Center offers training in a host of areas, including in residential and commercial energy efficiency and solar PV. The center serves as a Weatherization Training Center that has launched a three-week collaborative training program, certified through IREC. Participants can train and receive accreditation towards becoming a Home Energy Professional (HEP), including as HEP retrofit installers, HEP Crew Leaders, HEP Energy Auditors, and HEP Quality Control Inspectors. The training includes Building Science Principles education and certification, OSHA 10 certification, as well as career coaching and wrap-around services such as childcare, safety clothing, and travel reimbursement. Community partners help recruit diverse participants, and employer partners offer job shadowing, field visits, and networking opportunities.

CENTER FOR ENERGY AND ENVIRONMENT MINNESOTA HOME ENERGY CAREER TRAINING

The Center for Energy and Environment in Minneapolis, Minnesota, worked with Xcel Energy, an investor-owned utility serving their area, to develop their Home Energy Career Training and Green Construction Training, geared towards enrolling underrepresented groups, with priority given to those living in "Green Zones" (see Policy Context section below). The Home Energy Career Training is a five-week paid training program that includes building science education that prepares students for the Building Science Principles credential, hands-on installation training from industry/employer partners, and job site safety training. There are two tracks that prepare the trainee for a career as an Energy Auditor or as an Insulation Contractor. At the end of the training, graduates can be placed in a four-month paid internship that includes health insurance with either their utility partner or the local weatherization agency. The Green Construction Training offers 45-hours of paid hands-on training funded by Ramsey County and St. Paul College, a local institution of higher learning, in the areas of insulation and HVAC. After the 45-hour course is complete, there is an additional 2-week intensive training, after which the trainees can directly seek employment or participate in a 4-6 month paid internship with industry partners. Trainees are also eligible for transportation assistance through their community partners.

GREEN GENERATION WORKFORCE DEVELOPMENT INITIATIVE

In Illinois, the Community and Economic Development Association of Cook County (CEDA) partnered with the University of Illinois and the Urban Efficiency Group to create an energy efficiency training program for local high schools (with a focus on students of color not in STEM schools). The program is multiyear and includes career introduction/exploration, as well as training and certification. (Students can earn BPI Air Leakage Control Installer and Infiltration and Duct Leakage certifications.) Students participate 1-2 times per month during school year, as well as in the summer, and have paid internships with local employers.

Policy Context and Peer Community Analysis

The following is an overview of existing federal, state, and local energy policies and programs available to the Louisville metro area, and a summary of clean energy strategies deployed by other communities that could further support the Louisville Community Coalition's goals in advancing local clean energy. This report focuses on strategies for existing buildings with particular focus on low-income single-family and multifamily residential units.[43]

Federal Funding

In 2021, Congress passed the Infrastructure Investment and Jobs Act (IIJA), sometimes also referred to as the Bipartisan Infrastructure Law (BIL). The IIJA included historic investments in energy efficiency for buildings ($6.5 billion). The following year, Congress passed the Inflation Reduction Act (IRA), which also includes investments in clean energy, residential energy efficiency and electrification, and resilient and healthy communities. Much of this funding will flow through state energy offices, local governments, or weatherization and housing agencies who will develop and implement programs to allocate those funds within their given state (The White House 2022).

The IRA created new programs and augmented existing programs already administered through state energy offices, resulting in a larger overall investment in efficiency measures by the federal government and an increased focus on directing program benefits to low- and moderate-income households and disadvantaged communities. Programs of particular interest are the Home Energy Rebates, Weatherization Assistance Program (WAP), the Energy Efficiency and Conservation Block Grant Program and programs administered by the federal U.S. Department of Housing and Urban Development (HUD), and the Environmental Protection Agency (EPA) (The White House 2023).

Kentucky Weatherization Assistance Program (WAP) and Low Income Home Energy Assistance Program (LIHEAP)

The U.S. Department of Energy (DOE) Weatherization Assistance Program (WAP) and the U.S. Department of Health and Human Services (HHS) Low-Income Home Energy Assistance Program (LIHEAP) are federal programs that help low-income households reduce their energy costs through local service providers. WAP provides no-cost energy efficiency measures to reduce energy use and energy bills while ensuring health and safety for income-qualified households (U.S. DOE n.d.-b).

LIHEAP provides direct assistance to help households cover energy costs and stay connected to utility services, as well as weatherization and minor energy-related repairs (U.S. Department of Health and Human Services 2024). The Louisville Metro Office of Resilience and Community Services (RCS) is the local provider of the Low-Income Home Energy Assistance Program (LIHEAP) for Jefferson County residents.

Both programs have received an influx of additional funding through the IIJA, compared to prior funding years. In 2023, Kentucky received in $5,833,014 in WAP annual formula funds and $51,942,185 in IIJA funds, available until expended.[44] In Fiscal Year 24, Kentucky will receive

[43] The following program descriptions are offered as high-level summaries and are subject to change. Please refer to specific programs for official details and latest requirements.

[44] Weatherization Assistance Program Allocations: https://www.energy.gov/sites/default/files/2023-02/WPN_23-2_Program_Year_2023_Grantee_Allocations.pdf. Infrastructure Investment and Jobs Act Allocations: https://www.energy.gov/sites/default/files/2023-12/wpn-bil-2_122223.pdf.

$54,146,588 in LIHEAP funds.[45] Although LIHEAP is primarily a utility bill assistance program, up to 25% of a state's LIHEAP funds can be allocated to weatherization with a waiver (Administration for Children and Families - Office of Community Services n.d.). Kentucky currently allocates 15% of its LIHEAP funds to weatherization. A portion of WAP and LIHEAP funds are reserved for workforce training.

A maximum of $8,250 in WAP funds can be spent on upgrades (excluding health and safety measures) for each dwelling unit. Health and safety costs, including labor and materials, are limited to an average of 15% of the final costs per unit, not to exceed a maximum of $4,000 per unit. Households that fall at or below 200% of the 2023-24 Federal Poverty Guidelines, can receive cash assistance payments under Temporary Assistance for Needy Families (TANF) or Kentucky Transitional Assistance Program (K-TAP), and are eligible for LIHEAP and WAP. Both owner-occupied and rental units are eligible (U.S. DOE 2024). Income eligibility for LIHEAP is based on annual household income with a household of one at a maximum of $21,870 per year (Benefits.gov n.d.). Renters are eligible for the LIHEAP subsidy with a letter from their landlord confirming that utilities are tenant's responsibility.

State Energy Office-Administered Programs

With the passing of the IRA, two new home energy efficiency and electrification programs were authorized, collectively known as the Home Energy Rebates. The goal of the program is to accelerate the transition to more affordable, efficient, resilient, and low-carbon homes with objectives to lower the energy burden for low-income households and disadvantaged communities; continue the market transformation; and reduce pollution from buildings to support the clean energy economy (U.S. DOE 2023).

To participate, states must submit applications by January 31, 2025, which describe their state plans for proposed rebate programs and demonstrate compliance with federal programmatic requirements. As part of the application, states must include a Community Benefits Plan that addresses the following federal priorities – a) support community and labor engagement; b) support and engagement of a skilled and qualified workforce; c) promote diversity, equity, inclusion, and accessibility; and d) contribute to the Justice40 Initiative with the goal of at least 40% of benefits flowing to disadvantaged communities (U.S. DOE 2023).

States that do not meet the program requirements will forfeit their allocation formula grant, and any funds will be distributed to other state energy offices. The table below indicates the allocation to Kentucky under the two new programs according to DOE's Home Energy Rebates Program Requirements and includes specific allocations for single-family and multifamily low-income homes. It should be noted that the state government has the final decision on the allocations that households in Louisville will be able to access (U.S. DOE 2023).

Table 12: Homes Energy Rebates, Kentucky State Allocation Amounts.

Program	Total Rebate Allocation Amount	Minimum for Low-Income	Minimum 10% Low-Income Multifamily	Maximum Open Electrification Rebate
Home Energy Performance-Based,	$67,319,140	$21,852,975	$5,385,531	$26,616,806

[45] LIHEAP 2024 Allocations: https://www.acf.hhs.gov/sites/default/files/documents/ocs/CORR_LIHEAP_1stFundingReleaseAtt1_StatesTerrs_FY2024_2.pdf.

Program	Total Rebate Allocation Amount	Minimum for Low-Income	Minimum 10% Low-Income Multifamily	Maximum Open Electrification Rebate
Whole-House Rebates				
High-Efficiency Home Rebate Program	$66,927,750	$21,725,923	$5,354,220	$26,462,057

Additional information on the rebate programs is available in Appendix B. Federal Rebates and Tax Credits Available through the IRA.

Tax Credits and Deductions

Please note: this section is designed to be an overview of tax credits for energy efficiency-related investments. It is not intended to serve as a recommendation to the City of Louisville and should not be construed as professional tax advice or other professional financial guidance. This section should not be used as the only source of information when making purchasing decisions, investment decisions, or tax decisions, or when executing other binding agreements. Please refer to IRS guidance or state guidance for relevant tax laws and requirements for tax credits.

In addition to the state energy office-administered programs, the following federal tax programs are not considered rebate programs and may be able to be combined or braided (not duplicating federal rebates for the same measure) with WAP, LIHEAP, HUD Community Development Block Grants, HOME assistance funds or loans, EPA's Greenhouse Gas Reduction Fund (GGRF), and other utility rebates, state, and local incentives to bring low- and moderate-income residences up to current building code standards and achieve deeper energy efficiency (IRS 2022).

Tax credits may be able to be stacked with the Home Electrification and Appliance Rebates discussed above. Rebate amounts are used to reduce the total cost of the improvement, and the tax credit can be applied to the remaining amount (IRS 2022). Dwelling units that further qualify for ENERGY STAR New Homes could earn an additional tax credit of $2,500 per home or unit and up to $5,000 if certified as a DOE Zero Energy Ready Home (U.S. DOE n.d.-k). Table 16 in Appendix B.3. Tax Credits provides additional information on the tax credits available to *homeowners* under the IRA.

Worth noting is that the tax credit benefit is applied at the time of a tax return, and households would need to pay upfront for the cost of improvements and be eligible for a tax return from the Internal Revenue Service. Also, there is a $3,200 limit on the total tax credits claimed in a given tax year for any combination of envelope improvements plus furnaces, boilers, and central air conditioning (IRS 2022).

Other tax programs provide a reduction in business tax liability for home builders. The 179D Commercial Buildings Energy Efficient Tax Deduction applies to commercial buildings, including multifamily units, that are retrofitted to reduce energy usage by at least 25%. Building owners may be able to reduce their overall tax liability with a deduction of $0.50-$5.00 per square foot based on energy savings. To qualify, commercial property owners must comply with the prevailing wage stipulations (U.S. DOE n.d.-a).

New energy-efficient homes, including multifamily rentals, may be able to take advantage of the 45L New Energy Efficient Homes Tax Credit that provides incentives of $2,500 for homes certified under the ENERGY STAR Single-Family New Home (SFHNH) or Manufactured Home (MH) programs.

Multifamily homes certified to ENERGY STAR Multifamily New Construction (MFNC) standards may be eligible for $500, with a larger tax credit of $2.500 available when prevailing wage requirements are met (ENERGY STAR n.d.-a). Homes that are certified to DOE's Zero Energy Ready Home Program may be eligible for even higher incentives (U.S. DOE n.d.-k). Given the abundance of energy efficiency rebates, tax credits, and other incentives, Louisville will want to determine which align best with its desired strategy and will likely want to clearly communicate the program to participants when it is rolled out.

The Green and Resilient Retrofit Program (GRPP)

The Green and Resilient Retrofit Program is a new federal program focused on apartments to improve energy and water efficiency, indoor air quality, and sustainability. Grants and loans will be made available directly by HUD to multifamily building owners and will include funds for energy benchmarking and TA (U.S. HUD n.d.).

Eligibility is focused on buildings that are Section 202, 811, or Project Based Section 8 and Section 236 properties. The program requires five years of extended affordability after the retrofits and a minimum of 15 years of affordability (U.S. HUD n.d.). HUD offers three different program paths to property owners with capital resources to make energy-efficient, carbon-reduction, renewable energy, or climate-resilient improvements:

- Elements – provides funding of up to $40,000 per unit or $750,000 per property for building owners who have secured recapitalization financing.
- Leading Edge – provides funding of up to $60,000 per unit or $10 million per property for those seeking a green certification.
- Comprehensive – provides funding up to $80,000 per unit or $20 million per property.

Round one awards were announced in September 2023 and include one multifamily property in Louisville – the Chenoweth Apartments. HUD expects to announce additional awards throughout 2024 (U.S. HUD 2023).

EPA Programs

Administered by the U.S. Environmental Protection Agency (EPA), the Greenhouse Gas Reduction Fund (GGRF) program will provide competitive grants to states, Tribes, cities, and nonprofit organizations who in turn provide financial and TA for projects to reduce or avoid GHG emissions and other forms of air pollution in low-income and disadvantaged communities. A total of $27 billion investment will be made available through three competitive grant opportunities - National Clean Investment Fund, Clean Communities Accelerator, and Solar for All (U.S. EPA 2024b).

The program is similar to green banks that finance a wide variety of projects in some states and cities. EPA also administers formula funding through the Climate Pollution Reduction Grants (CPRG) to states or municipal governments for providing flexible funding for climate planning, implementation, and for training, tools, and TA (U.S. EPA 2024a). The Environmental and Climate Justice Block Grants support community-based organizations, Tribes, and local governments that are addressing communities adversely impacted by climate change, historic disinvestment, and legacy environmental pollutions (U.S. EPA 2023).

State Programs

In addition to the federally funded programs administered by state energy offices, the Kentucky Office of Energy Policy started a Kentucky Energy Affordability Workgroup, kicking off in June 2023. The workgroup aims to facilitate data sharing and education and identify policy and resource gaps - resulting in the creation of an Energy Affordability Guide that will be made available through the State Office of Energy Policy (Kentucky Energy and Environment Cabinet 2021).

Furthermore, the State of Kentucky offers property assessed clean energy financing for energy efficiency, water conservation, and on-site renewable energy systems. Local governments are authorized to establish an Energy Project Assessment District (EPAD), where multifamily property owners with five units or more can finance a project over a longer period and with lower interest rates than traditional financing. Projects must cost a minimum of $20,000, be permanently affixed to the building, and have a life of at least 5 years.[46] Louisville currently has an active EPAD program, focused on larger commercial and multifamily buildings (Louisville Metro Government 2020a).

Regional Programs

WeCare Program

The Weatherization, Conservation Advice and Recycling Energy (WeCare) Program is a utility administered program that offers income-qualified residents served by LG&E a walk-through home energy assessment that includes a safety inspection of water heating and furnaces, and energy-efficient LED lightbulbs, aerators, and shower heads. Some residents may receive air and duct sealing, attic/wall insulation, HVAC tune-ups, programmable thermostats, energy-efficient refrigerators, and window air conditioner replacements (LG&E 2024c).

Customer eligibility includes income at 200% of the federal poverty level, at least 9 months of continuous utility service, and must not have received WeCare services within the past three years. Rental properties are eligible with the landlord's consent (LG&E 2024c).

Residential Demand Conservation

LG&E's Demand Conservation is a voluntary program which provides a bill credit to residential customers in exchange for allowing the utility to remotely control central air conditioners, heat pumps, and pool pumps to conserve energy and help alleviate critical loads on the electrical grid during peak demand summer events. Renters may participate in the program with their landlord's consent (LG&E 2024b).

LG&E has proposed 14 new demand-side management/energy efficiency programs that would go into effect in 2025. These proposed programs include income-qualified solutions, such as Low-Income Weatherization (formerly known as We Care) and Whole-Building Multifamily (LG&E 2024a).

The We Care program would provide energy audits, energy education, and installation of energy conservation measures in qualified single-family homes. Whole-Building Multifamily is a new education and weatherization program that provides installation of energy-saving devices to help reduce energy use in residents' living units and in common areas. Incentives would be provided to property managers and owners that purchase high-efficiency equipment to retrofit the property as a whole.

Repair Affair

New Directions Housing Corporation, a nonprofit community development organization serving Louisville/Jefferson County offers Repair Affair program which provides free home repair via

[46] https://louisvilleky.gov/government/sustainability/epad-program.

volunteers for owner-occupied single-family homes for seniors 60 years or older and for those with permanent disabilities. Individuals must also be income-eligible by making less than 50% of the Area Median Income (New Directions Housing Corporation n.d.).

An assessment of applicant homes is made to identify repairs that improve the safety, security, and weatherization of selected homes. Weatherization improvements could include door and window repair, weather stripping doors, caulking, sealing windows, programmable thermostats, and LED or CFL lightbulbs (New Directions Housing Corporation n.d.).

Project Warm

Funded jointly by LG&E and LMG, Project Warm is a nonprofit organization that provides year-round weatherization repairs and energy management workshops free of charge to income-eligible homeowners and renters, including the elderly, veterans, and those with disabilities. Weatherization services include door and window repair, caulking, weather-stripping, air sealing, minor drywall and floor repairs, and self-weatherization kits. Income eligibility is based on the Federal Poverty Guidelines at median income up to 200% of the federal poverty level and determined at the time of application (Energy Conservation Associates 2018).

Project Warm holds an annual event called the Project Warm Blitz and additional "Mini-Blitzes" through the year, which are large-scale volunteer events to weatherize homes of seniors (aged 60 or older) and those with disabilities and who are unable to attend an energy management workshop. The Blitz is open to homeowners, renters, and single-family and multifamily apartments (Energy Conservation Associates 2018).

Solar Over Louisville Program

This bulk-purchasing program is run by the Louisville Sustainability Council in partnership with LMG. The program offers a 15-23% discounted, wholesale rate for residents to install solar photovoltaics on their rooftops within the Kentucky counties of Jefferson, Oldham, Spencer, Shelby, and Bullitt (Louisville Metro Government 2024a).

The Louisville Sustainability Council has also partnered with other community organizations to build program awareness and solar uptake within West Louisville, including with area churches and neighborhood associations, Center for Neighborhoods, Southwest Dream Team, Russell: Place of Promise, and the Kentucky NAACP (Louisville Metro Government 2024a).

LMG is currently offering limited Solar Grants, funded by Community Development Block Grants funds, to assist income-qualified property owners in Louisville by covering the cost of solar installation (Louisville Metro Government 2024a).

City of Louisville

Codes and Standards

In February 2020, the Louisville Metro Council passed a Clean Energy Resolution (R-102-19), committing the city to three goals (Coan et al., 2020):

- 100% clean electricity by 2030 for municipal operations,
- 100% clean energy by 2035 for municipal operations, and
- 100% clean energy community-wide by 2040.

Furthermore, the Clean Energy Resolution committed LMG to the revision of all building codes for new construction to require energy efficiency, conservation, and renewable energy applications toward an eventual goal of net zero or net positive energy, water, and waste for LMG. The resolution

also included support for the opening of free market pricing for electrical generation and guarantee of total cost access to the electrical grid in order to provide the public with cleaner and cheaper electricity. This resolution, although passed, may not be entirely actionable given that the authority to establish building code requirements is decided at the state level (Stivers et al. 2023).

In April 2020, the Louisville Metro Government's Office of Advance Planning and Sustainability published a Greenhouse Gas Emission Reduction Plan (ERP) and draft Climate Adaptation Plan, establishing an 80% greenhouse gas reduction target by 2050 and an updated inventory of GHG Scope 1 and Scope 2 emissions. Under the 80% reduction goal, the city is seeking to achieve a reduction of 3,383,063 carbon dioxide tonnes equivalent (tCO_2e) per year, down from 18,766,066 tCO_2e forecasted in a "Business as Usual" community-wide carbon scenario if no actions are taken (Louisville Metro Government 2020b; Stantec 2020).

The ERP further identifies key strategies and actions for GHG reductions within six sectors – residential buildings, commercial and industrial buildings, manufacturing industries and construction, energy industry, transportation, and waste treatment. In October 2022, Mayor Greg Fischer signed an Executive Order (No. 2022-006) to revise the ERP reduction targets, to net-zero emissions (Scope 1, 2, and 3) by 2040, incorporating such strategies as carbon sequestration to offset unavoidable emissions, and an interim target of 50% reductions by 2030 (Fischer 2022).

Since the adoption of the Clean Energy Resolution, ERP, and Executive Order, the Office of Sustainability, the Office responsible for these goals, has prioritized underserved communities during implementation and sought resources and programs options which promote greater energy equity for low-income residents.

Programs

Through the REVERT Program, the Louisville Affordable Housing Trust Fund will provide funding to 216 families who have been generationally affected by discriminatory redlining mortgage loan practices by offering up to $50,000 in rehabilitation funds towards home purchase and renovation, including code compliance and energy efficiency upgrades within historically redlined neighborhoods (Louisville Metro Government 2017).

HOME Program

LMG's Office of Housing offers an annual program leveraging federal dollars[47] to create new affordable housing developments for a variety of homebuyers and renters and for rehabilitation and preservation of existing affordable single-family and multifamily dwelling units.

In early 2021, LMG announced a set-aside of $80,000 per project to facilitate energy efficiency improvements such as tankless water heaters, solar panels, and other upgrades. Projects that incorporate energy-efficient, renewable, and sustainable building standards, practices, and appliances and/or achieve ENERGY STAR, LEED, Enterprise Green Community, or similar nationally

[47] Federal funds include set-asides from the U.S. Department of Housing and Urban Development (HUD) HOME Investment Partnerships Program (HOME), and Community Development Block Grant (CDBG), and from the U.S. Department of the Treasury Emergency Rental Assistance 2 Program (ERA2).

recognized certifications are given priority for funding consideration (Louisville Metro Government 2021).

Home Repair Program

Administered by the Department of Community Development, elderly and disabled single-family homeowners are eligible for repairs, including furnace, HVAC, electrical, plumbing, roof and gutter, and other repairs deemed necessary. To be eligible, households must be at or below 80% of area median income. Funding is allocated through federal HUD funds (Louisville Metro Government 2024c).

Under the Home Repair Neighborhood Specific program, elderly and disabled homeowners currently residing in certain neighborhoods–Algonquin, California, Chickasaw, Hallmark, Park DuValle, Parkland, Park Hill, Portland, Shawnee, Shelby Park, and Smoketown neighborhoods–may apply for separate Home Repair assistance (Louisville Metro Government 2024c).

Similarly, the City offers a neighborhood specific grant program to eligible affordable housing property owners to rehab units within the Russell neighborhood (Russell Rental Rehab). Property owners may apply for up to $10,000 per unit (two units or more within the same building) or up to $20,000 for a single-family unit. Property owners must adhere to keeping the improved property affordable and in good condition for at least five years following the renovation (Louisville Metro Government 2024c).

Cool Roof Incentive Program

The Office of Sustainability offers incentives to residential and commercial property owners who install a cool roof on their building. Residential buildings, including multifamily, may earn $1 per square foot for new or retrofit steep-slope and flat cool roofs (as certified by ENERGY STAR or by the Cool Roof Rating Council), up to a maximum of $2,000 per building. Multifamily buildings with 20 units or more can receive up to $5,000 maximum. LMG has identified the following Council Districts (1, 3-6, 12, 14-15) as priorities due to higher heat impacts and lower residential incomes. Because one of the most popular cool roof shingle products has been discontinued, LMG expects to see a slowdown in program participation. If this happens, the Cool Roof Incentive funds could be redirected to other energy efficiency measures (Louisville Metro Government 2024b).

Property Assessment and Reassessment Moratorium Program

This local program offers a tax moratorium for properties that make repairs and energy efficiency upgrades to their properties, including LEED certification. Under the program, qualified commercial and residential property owners, with existing buildings at least 25 years in age, may be able to freeze a portion of their local tax obligation for a period of up to five years to offset property reassessments made by the Jefferson County Property Valuation Administrator resulting in higher valuation due to upgrades and improvements (Louisville Metro Government 2024d).

The conditions for qualifying properties include a range of improvement cost thresholds, with lower thresholds for properties located in historically disinvested neighborhoods and owner-occupied homes. To qualify, a property owner must meet one of the following criteria (Louisville Metro Government 2024d):

- Cost of improvements is equal to at least 25% of the value of the property improvements based on the latest property assessment; or
- Cost of improvements is equal to at least 10% of the value of the property improvements based on the latest property assessment and the property is located within a Qualified

Census Tract, designated by HUD, where at least 50% of households have an income less than 60% of the area median gross income in Jefferson County; or

- Cost of improvements is equal to at least 5% of the value of the property improvements based on the latest property assessment and is located within one of the following Louisville neighborhoods: Algonquin, California, Chickasaw, Park Duvalle, Park Hill, Parkland, Portland, Russell, Shawnee, Shelby Park, or Smoketown Jackson; or
- The improvements to the property will result in a Leadership in Energy and Environmental Design certification.

The program was funded through $9.1 million in private equity (Louisville Metro Government 2024d).

Case Studies From Other Cities

Throughout the engagement with Louisville, the community expressed an interest in exploring examples of successful programs and policies from similar peer communities in driving energy efficiency in affordable housing. These examples can help provide a blueprint for policies and programs Louisville could consider as it seeks to achieve its clean energy goals. Successfully driving energy efficiency in affordable housing means tackling several challenges simultaneously (e.g., split incentives, lack of access to capital or affordable financing, the need for preliminary building repairs), and communities across the country have adapted various approaches to achieve an equitable energy transition. Where possible, the examples try to outline where Louisville may have difficulty in implementing a similar program, given its unique policy context. Additional example programs and policies in other contexts can be found in Moe (2024).

Neighborhood Approach (Green Zones, Eco Districts, Overlay Zones)

In many communities, local government has supported the creation of special zones which receive additional funding and support to drive energy efficiency evaluations and investments. These zones are typically created in areas with a disproportionate presence of disadvantaged residents to ensure equitable outcomes. The limited geographic focus can help the community: (a) counteract historic disinvestment in particular regions, (b) make the most of limited bandwidth and resources when rolling out energy efficiency programs, and (c) serve as a pilot program for rolling out larger, community-wide programs at a later date.

- In 2016, Minneapolis, Minnesota, adopted a Green Zone Initiative as an extension of their Climate Action Plan. The Green Zone designation was applied to two city neighborhoods found to be disproportionately impacted by environmental, social, political, and economic vulnerabilities. By creating the designation, city and community partners were able to devise a cross-cutting community plan for targeting sustainability, greenhouse gas reductions, and equity goals within the neighborhoods, including connecting residents with workforce training to help deliver energy efficiency retrofit programs. Residents with incomes below $100,000 or living in a city Green Zone can receive a free audit through the city's Home Energy Squad program (City of Minneapolis 2024c). Under the Green Cost Share program, the City of Minneapolis will match 30% of energy efficiency project costs (up to $30,000) for properties within the Green Zone and 40% (up to $40,000) for income-qualified housing projects (City of Minneapolis 2024b).
- Northampton, Massachusetts, created a Smart Growth overlay district, requiring new buildings 1,200 square feet or less to have a RESNET HERS Index of 47 or lower. Buildings larger than 1,200 square feet must have a Home Energy Rating Score (HERS) Index of 41 or

lower. Alternatively, buildings must be certified as LEED New Construction Gold or LEED Neighborhood Development Gold. At least 20% of housing units constructed must be affordable housing. For an affordable rental unit, the monthly rent including utilities and parking cannot exceed 30% of the maximum monthly income permissible for an eligible household (City of Northampton 2024). Louisville could consider applying a similar policy to those affordable housing units that receive funding from the local government.

- The City of Ithaca, New York, has a goal of electrifying 6,000 properties. To accomplish this goal, the city has partnered with BlocPower and a private equity group (Alturus) to create low-cost loans for low- and moderate-income residents and businesses to install heat pumps (Walton 2022). The loans are a lease-to-own model with zero capital required as a down payment. Before heat pumps are installed, the program includes weatherization assessment and strategies. The project has established a Community Advisory Board which meets quarterly and guides the city on equity and accessibility issues related to the city's goal of electrification (City of Ithaca n.d.).

Although not a part of a "neighborhood approach," other communities have distinguished between buildings by disadvantaged status and allocated additional funding and support to those buildings:

- The City of Denver, Colorado, offers additional funding and facilitation services to "Equity Priority Buildings," which include affordable housing (deed-restricted and naturally occurring), and nonprofit human service providers (City of Denver 2024).

City-Sponsored Incentives

While energy efficiency incentives and rebate program are typically administered by utilities or state energy offices, some communities have implemented their own local programs to fill gaps and to meet community carbon reduction goals faster. The following are a handful of examples where communities have leverage creative partnerships or funding to directly incentivize weatherization and energy efficiency upgrades at the local level.

- Milwaukee, Wisconsin's Energy Efficiency (ME2) program offers a fixed rate loan, up to $15,000 for attic and wall insulation, air sealing, space and water heating, air conditioners, and ENERGY STAR windows. No down payment, home equity, or minimum credit score is required to qualify. Income-eligible households can qualify for a higher incentive amount upon income verification. Funding of the fixed rate loan is through a local credit union (City of Milwaukee n.d.).
- Nashville, Tennessee's Summer Cooling program offers free fans and/or air conditioning units to the elderly, families with children under six years old, and disabled residents with medical conditions in the months of May to August. The program is largely supported by the public with donations of financial support and new air conditioning units. This program is similar to Louisville's existing Fan Fair program, and Louisville could look to expand the program to include other energy-efficient investments that can help protect residents from extreme heat (City of Nashville 2024).
- Holland, Michigan, started a nonprofit called the Holland Energy Fund to support the city's Community Energy Plan. The fund supports two programs – Holland Energy Fund Rebates and Home Energy 101. Home Energy 101 provides residents with a free 60–90-minute

session with an energy educator to assess in-home areas for energy savings and efficiency upgrades for single-family homes, condos, and apartments. The energy educator reviews utility bills with the customer, creates an energy savings plan, and provides up to $300 worth of weatherization and efficiency supplies such as caulk, door seals, and water-saving shower heads. The Home Energy 101 assessment is a prerequisite for Home Energy Rebates, which include 20% of home air sealing, insulation, up to 10% of audit costs, up to $300 for heat pump water heaters, and up to $4,000 for HVAC heat pumps (City of Holland 2024).

- ☐ St. Helena, California's Energy-Friendly Permit Sale was a time-limited incentive program (from April 1 to September 30, 2023) that encouraged property owners to reduce their carbon pollution through reduced building permit fees of up to 75% for water heater/heat pump replacement, HVAC replacement, window/door replacement, electric vehicle charging stations, or solar photovoltaics and battery storage systems (City of St. Helena 2023).

Energy Efficiency Standards for Rentals

Energy efficiency standards can be incorporated into long-term and short-term rental licensing as a condition of approval. Rocky Mountain Institute's Better Rentals, Better City Report provides examples of energy efficiency programs focused on rental properties in various cities (Petersen and Lalit 2018).

LMG currently requires registration of long-term and short-term rental properties. Failure of a property owner to register their rental will result in an inspection by the Department of Codes & Standards. On an annual basis, 10% of registrants within the Renter Tenure Areas (Housing market areas with high renter rates as defined by Metro's Office of Housing and Louisville Affordable Housing Trust Fund's Housing Needs Assessment, updated every five years) will be inspected for compliance with the Property Maintenance Code (*Louisville-Jefferson County Metro Government Code § 156*) to ensure a minimum level of public health and safety. New units built within the last ten years and units renovated within the last five years are exempt from inspection. (*Louisville-Jefferson County Metro Government Code* § 119.03**).** In addition to registering and annual fee, a Conditional Use Permit is required to establish a short-term rental in certain neighborhoods, e.g., Old Louisville or Limerick, and in properties where the rental is not the owner's primary residence (Louisville Metro Government n.d.).[48]

Currently, no requirements exist in the Conditional Use Permit that such units meet minimum energy efficiency standards. The Property Maintenance Code also does not contain energy efficiency measures. Although Louisville could consider the following examples in efforts to meet its clean energy goals, it may be limited in the conditions it can apply to rental properties by the Uniform Residential Landlord Tenant Act (URLTA) (Kentucky General Assembly 2024). URLTA provides a standardized template for lease agreements that communities in the state of Kentucky can adopt wholesale. Where adopted, URLTA helps ensure residents are aware of their rights and provides a uniform agreement between landlords and tenants. Despite these benefits, URLTA may also limit the ability of localities to apply additional requirements on rental agreements, including those related to energy efficiency.[49] An analysis of the potential restrictions imposed by URLTA, the trade-offs

[48] For additional information on Conditional Use Permits and short-term rentals see: https://louisvilleky.gov/government/office-planning/short-term-rental-information.

[49] This occurs in Section 383.500 which clarifies "If adopted, these provisions shall be adopted in their entirety and without amendment. No other ordinance shall be enacted by a city, county or urban-county government which relates to the subjects embraced in KRS 383.505 to 383.705."

between benefits and potential restrictions, or a pathway to enable layering on energy requirements onto URLTA was beyond the scope of this analysis.

Rental programs from other cities include:

- Boulder County, Colorado's SmartRegs policy requires all rentals to meet or exceed a certain level of energy efficiency - either a through prescriptive path (achieving a score of 100) or a performance path, which requires a HERS Index of 120 or below. Rentals within the city must apply for a business license for their rental properties. Rental owners that are noncompliant with the energy efficiency standards risk losing their rental licenses. The program has measured and provided upgrades to rental units, promoted affordable housing through stabilizing utility costs, and educated both landlords and tenants (City of Boulder 2024). The program aids rental owners through Boulder County's EnergySmart advisory program by funding incentives above those offered by the utility and in helping to fund and schedule contractors to make energy efficiency upgrades. The program is funded through a Climate Action Plan (CAP) tax, fines collected from noncompliant rentals, and funding from DOE (Boulder County 2024; U.S. DOE n.d.-c).
- Minneapolis, Minnesota, runs a 4d Affordable Housing Incentive program, which offers state tax incentives for rental property owners if they agree to keep 20% or more of their rental units affordable. The program also provides cost sharing for energy efficiency improvements or solar PV investments. Tax savings need to be applied to property maintenance, property security, property improvements, or rent stabilization or the property's replacement reserve account (money set aside to replace building components that reach the end of their useful lifetime during the building's economic life). This benefit is in addition to the energy efficiency incentives offered by the city. New construction with at least 20% of units that are ENERGY STAR, Zero Energy Ready, or Passive House Institute US (PHIUS) certified are eligible for an incentive of up to $100,000 (City of Minneapolis 2024a).
- Cincinnati, Ohio's WarmUp Cincy Initiative launched three pilots in 2020 aimed at addressing energy efficiency in multifamily apartment buildings and for renters. The Whole Building Retrofit Pilot included community partner Over-the-Rhine Community Housing, utility bill assistance through the Tenant Energy Efficiency Program, and the Matching Grants for Building Owners program. The city also created a toolkit which includes energy-aligned lease language and other tenant resources that promotes energy education for property managers, tenant engagement plans, and a checklist for making efficiency improvements during unit turnovers (IMT and City of Cincinnati 2021).
- The public housing authority in Rockford, Illinois, implemented a $7.5 million, 15-year energy performance contract to reduce energy use across nine of its 11 housing developments. Rockford Housing Authority (RHA) started by utilizing a HUD-provided template to create a request for proposals to find a contractor to conduct energy audits and estimate project costs. RHA finalized the plan and submitted it to HUD for approval. RHA also provided training to local lenders to encourage their participation in financing the project (U.S. DOE n.d.-e).

Green Banks and Energy Efficiency Financing

- Indianapolis, Indiana recently formed a nonprofit green bank, known as the Indiana Energy Independence Fund (IEFF), which will establish low-interest loans for energy efficiency and

renewable energy improvement for new and existing buildings within the state. Funds from the McKinney Family Foundation, the Energy Foundation, the City of Indianapolis Office of Sustainability, Elevate Energy, and the Natural Resource Defense Council will seed the revolving loan fund. The establishment of the fund is a direct outcome of a built environment goal set by Indianapolis's Plan for Community Resilience and Sustainability (City of Indianapolis 2019).

- Nashville Electric Service (NES) Power of Change program rounds up customer utility bills with funds going towards NES's Home Uplift program, which provides an average of $10,000 in weatherization and energy efficiency services to low-income residents. Residents are automatically enrolled in the Power of Change program and must opt-out if they do not wish to participate. The program started on January 1, 2022, and finds an average of $6 per customer is generated annually for the Home Uplift program (Nashville Electric Service 2024).

Conclusion

The City of Louisville has committed to addressing climate change and greenhouse gas emissions through Metro Council Resolutions and Mayoral executive order. The Mayor's Office of Sustainability, the office responsible for achieving these goals, recognizes that reducing energy consumption would be a critical step in meeting climate and emissions commitments. Through Communities LEAP, the City sought to identify and prioritize energy efficiency investments that would be most likely to reduce emissions, lower energy burdens for LMI households, and be cost-effective.

Energy Efficiency

This report highlights the opportunity for significant reductions in energy consumption through improvements to residential building envelopes. Across all income levels, *nearly 70%* of the homes in Louisville suffer from a poor combined envelope rating, leading to higher energy consumption, more emissions, higher energy burdens and bills, as well as reduced occupant comfort. Even assuming no additional electrification, based on the modeled results Louisville could see an approximately 21% reduction in its emissions (from the residential building sector) under a community-wide Basic Enclosure adoption scenario, and 25% reduction under a community-wide Enhanced Enclosure adoption scenario. The envelope upgrade packages explored also offered substantial energy utility bill savings potential, with median annual savings in the range of 15%-19% possible for single-family homes and 10%-11% possible for multifamily homes. The analysis found that Louisville's modeled residential energy consumption is driven in large part by natural gas, at 54% of total energy consumption. This indicates a large potential for decarbonization of residential energy use by reducing natural gas consumption associated with heating loads, through energy efficiency upgrades like building envelope improvement measures. While electrification of heating and hot water heating end uses were not explored in-depth in favor of envelope improvements, combined envelope and electrification results are available in Appendix D. Energy Efficiency Analysis: Whole-Home Electrification and Envelope Upgrade Appendix D. Energy Efficiency Analysis: Whole-Home Electrification and Envelope Upgrade

Benchmarking

Several of Louisville's peer cities have successfully implemented benchmarking programs. These programs reflect local priorities and offer examples of how municipalities are designing complementary programs to advance energy efficiency and clean energy goals. In evaluating appropriate programs for Louisville, the city can consider if these example programs are scalable, how effective they have been in other cities, and how they might be adapted to the unique context of Louisville. The report has identified core components from case study city programs for Louisville to consider, summarized tools and funding opportunities that the City could leverage if it considers developing its own program, and discussed examples of complementary policies that these cities have implemented.

Workforce Development

While there are several mature workforce development efforts focused on the construction trades, there is still a lack of skilled workers to install the potential energy efficiency upgrades that could help achieve the City's goals. BLS data indicate that in Louisville nearly all of the industry groups related to construction of residential dwellings and energy efficiency and electrification have fewer people employed than its population would suggest based on national trends. This may indicate that without additional efforts, Louisville could struggle to find a sufficient workforce if it decided to

incentivize an increase in efficiency investments or new housing construction. While constituting an upfront effort, these workforce development efforts could yield significant employment opportunities to local residents, while also driving energy savings.

While Louisville has several successful job training programs, there are none that focus specifically on energy efficiency and electrification. Example programs from other cities could be used to develop a model that would increase workforce readiness and provide job opportunities to the un- and under-employed, particularly those in disadvantaged neighborhoods.

Funding Opportunities

There is currently an unprecedented amount of federal funding for the clean energy transition at both the state and federal level. Louisville has already been accepted into the Buildings Upgrade Prize (Buildings UP) program and has applied for EECBG formula funds.[50] This report provides useful data to help inform future decisions on which energy efficiency technologies to potentially fund or incentivize, should the City choose to use the funding for this purpose.

[50] See an overview of the program and the Phase 1 winners here: https://www.energy.gov/eere/buildings/buildings-upgrade-prize-buildings.

References

ACEEE. 2024. “Low-Income Energy Efficiency Programs Reduce Barriers to Affordable Energy, Improve Health and Comfort, Create Local Jobs, and Keep Money in Communities.” Low-Income Energy Efficiency Programs. 2024. https://www.aceee.org/topic/low-income.

Administration for Children and Families - Office of Community Services. n.d. “Low Income Home Energy Assistance Program.” Washington, DC: U.S. Department of Health and Human Services. Accessed May 6, 2024. https://www.acf.hhs.gov/sites/default/files/documents/ocs/COMM_OCS_LIHEAP%20FactSheet.pdf.

Bartlett, R., M. Halverson, V. Mendon, J. Hathaway, Y. Xie, and M. Zhao. 2017. “Kentucky Residential Energy Code Field Study: Baseline Report.” Technical Report PNNL-26727. Richland, WA: PNNL. https://www.energycodes.gov/sites/default/files/2019-09/Kentucky_Residential_Field_Study.pdf.

Benefits.gov. n.d. “Kentucky Low Income Home Energy Assistance Program.” Government Website. Benefit Categories - Housing and Public Utilities. Accessed May 6, 2024. https://www.benefits.gov/benefit/1539.

Blanding, I., R. Bartlett, M. Halverson, Y. Xie, and J. Williams. 2022. “Residential Energy Code Field Studies: Assessing Implementation in Seven States.” Technical Report PNNL-31216. Richland, WA: PNNL. https://www.energycodes.gov/sites/default/files/2022-11/Combined_Residential_Energy_Code_Field_Study_Report_Final%20v3.pdf.

Boulder County. 2024. “Energy Smart YES.” *EnergySmart Your Efficiency Solutions* (blog). 2024. https://energysmartyes.com/.

Building America Solution Center. 2018. “Whole House Ventilation Strategies for Existing Homes.” Government Website. Guides A-Z. March 6, 2018. https://basc.pnnl.gov/resource-guides/whole-house-ventilation-strategies-existing-homes#edit-group-description.

———. 2022a. “Air Sealed, Insulated Basements.” Government Website. Guides A-Z. October 24, 2022. https://basc.pnnl.gov/resource-guides/air-sealed-insulated-basements#edit-group-description.

———. 2022b. “Continuous Rigid Insulation Sheathing: More Information.” Government Website. Guides A-Z. September 16, 2022. https://basc.pnnl.gov/resource-guides/continuous-rigid-insulation-sheathing#edit-group-more-info.

———. 2022c. “Enclosure Leakage Test.” Government Website. Guides A-Z. December 3, 2022. https://basc.pnnl.gov/resource-guides/enclosure-leakage-test#edit-group-scope.

———. 2022d. “Spray Foam Insulation Applied to Existing Attic Floor.” Government Website. Office of Energy Efficiency and Renewable Energy. November 2022. https://basc.pnnl.gov/resource-guides/spray-foam-insulation-applied-existing-attic-floor#edit-group-description.

Building Science Corporation. 2007. “Guide to Insulating Sheathing.” Building America. Westford MA: Building Science Corporation. https://buildingscience.com/sites/default/files/migrate/pdf/GM_Guide_Insulating_Sheathing.pdf.

Byarley, Madison. 2024. Interview with Indianpolis Thriving Buildings.

Center for Health Equity. 2017. "2017 Health Equity Report: Uncovering the Root Causes of Health." Louisville, KY: Louisville Metro Department of Public Health and Wellness. https://louisvilleky.gov/ government/center-health-equity/health-equity-report.

City of Bend. n.d. "Home Energy Score Program." Government Website. Energy. Accessed April 20, 2024. https://www.bendoregon.gov/city-projects/community-priorities/sustainability/energy/home-energy-score.

City of Boulder. 2024. "SmartRegs Compliance." Government Website. SmartRegs Guide. 2024. https://bouldercolorado.gov/smartregs-guide.

City of Davis. n.d. "Resale Program." Government Website. Community Development and Sustainability - Building. Accessed April 20, 2024. https://www.cityofdavis.org/city-hall/community-development-and-sustainability/building/resale-program.

City of Denver. 2024. "Building Electrification Rebates." Government Website. Rebates and Incentives for Electrification. 2024. https://denvergov.org/Government/Agencies-Departments-Offices/Agencies-Departments-Offices-Directory/Climate-Action-Sustainability-Resiliency/Cutting-Denvers-Carbon-Pollution/High-Performance-Buildings-and-Homes/Denver-Electrification-Program/Rebates-and-Incentives-for-Electrification/Building-Electrification-Rebates.

City of Holland. 2024. "Holland Energy Fund." Government Website. Holland Board of Public Works. 2024. https://hollandenergyfund.com/.

City of Indianapolis. 2019. "Thrive Indianapolis." 2019-CPS-R-001. Indianapolis, IN: Metropolitan Development Commission. https://www.thriveindianapolis.com/home.

City of Ithaca. n.d. "Green New Deal." Government Website. Community. Accessed May 28, 2024. http://www.cityofithaca.org/642/Green-New-Deal.

City of Milwaukee. n.d. "Milwaukee Energy Efficiency Program." Government Website. Residential Energy Efficiency. Accessed May 28, 2024. https://city.milwaukee.gov/eco/Buildings-Energy/Homeowners.

City of Minneapolis. 2024a. "4d Affordable Housing Incentive." Government Website. Rental Property Ownership. April 29, 2024. https://www2.minneapolismn.gov/government/programs-initiatives/housing-development-assistance/rental-property/4d/.

———. 2024b. "Green Cost Share." Government Website. Environmental Programs. January 26, 2024. https://www.minneapolismn.gov/government/programs-initiatives/environmental-programs/green-cost-share/.

———. 2024c. "Green Zones." Government Website. Sustainability. March 19, 2024. https://www.minneapolismn.gov/government/departments/health/sustainability-homes-environment/sustainability/green-zones/.

City of Nashville. 2024. "Energy Assistance Programs." Government Website. Community Programs. 2024. https://www.nashville.gov/departments/metro-action/community-programs/utility-assistance-program.

City of Northampton. 2024. "Section 20 Sustainable Growth Overlay District (SG)." Government Website. Code of Ordinances. 2024. https://ecode360.com/39475327.

City of Piedmont. n.d. "Home Energy Assessments." Government Website. About Building. Accessed April 20, 2024. https://piedmont.ca.gov/services___departments/planning___building/about_building_/home_energy_assessments.

City of St. Helena. 2023. “St. Helena Announces Permit Fee Reductions for Energy Friendly Projects.” Press Release 2023–12. St. Helena, CA. https://www.cityofsthelena.org/DocumentCenter/View/1321/2023-12-02152023-St-Helena-Announces-Permit-Fee-Reductions-for-Energy-Friendly-Projects-PDF?bidId=.

Coan, Brandon, Nicole George, and Bill Hollander. 2020. *A Resolution for 100% Clean Renewable Electricity for Metro Government Operations by 2030, 100% Clean Energy for Metro Government Operations by 2035 and 100% Clean Energy Community-Wide by 2040 (As Amended)*. https://louisville.legistar.com/LegislationDetail.aspx?ID=4324981&GUID=F850C816-ED26-46C5-B313-4107CF4C18B3&FullText-1.

Colton, Roger D. 2011. “Home Energy Affordability in New York: The Affordability Gap (2008-2010).” Prepared for: New York State Energy Research Development Authority (NYSERDA). Belmont, MA: Fisher, Sheehan & Colton. https://www-nyserda- ny-gov.webpkgcache.com/doc/-/s/www.nyserda.ny.gov/- /media/Project/Nyserda/Files/EDPPP/LIFE/Resources/2008-2010-affordability-gap.pdf.

DC Green Bank. 2023a. “Annual Report & Audited Financial Statements.” Press statement. DC Green Bank. December 2023. https://dcgreenbank.com/press/annual-reports-audited-financial-statements/.

———. 2023b. “DC Green Bank, Capital Impact Partners, and Amazon Deliver $3.3 Million to Bolster Affordable Housing in the District – DC Green Bank.” Press statement. DC Green Bank. July 2023. https://dcgreenbank.com/press/dc-green-bank-capital-impact-partners-and-amazon-deliver-3-3-million-to-bolster-affordable-housing-in-the-district/.

———. 2024. “Supporting a Thriving Clean Economy for All DC.” DC Green Bank. 2024. https://dcgreenbank.com/.

———. n.d. “Capital Providers.” DC Green Bank. Accessed April 20, 2024. https://forms.monday.com/forms/embed/8554ec3f9f2df4c88c97575edd3207cb?r=use1.

DOEE. 2021. “Bowser Administration Launches Program to Help Multi-Family Affordable Housing Meet New Energy Performance Standards | Doee.” 2021. https://doee.dc.gov/release/bowser-administration-launches-program-help-multi-family-affordable-housing-meet-new-energy.

———. n.d.-a. “Building Energy Performance Standard.” Government Website. Building Performance Helpdesk. Accessed April 20, 2024. https://dc.beam-portal.org/helpdesk/kb/BEPS/.

———. n.d.-b. “Knowledgebase.” Government Website. Building Performance Helpdesk. Accessed April 20, 2024. https://dc.beam-portal.org/helpdesk/.

Drehobl, Ariel, and Lauren Ross. 2016. “Lifting the High Energy Burden in America’s Largest Cities: How Energy Efficiency Can Improve Low Income and Underserved Communities.” Technical Report. Energy Efficiency for All. Washington, DC: ACEEE. https://www.aceee.org/research-report/u1602.

Energy Conservation Associates. 2018. “Project Warm.” Project Warm. 2018. https://www.projectwarm.org.

ENERGY STAR. 2006. “Mechanical Ventilation.” Fact Sheet. Washington, DC: Energy Star. https://www.energystar.gov/ia/new_homes/features/MechVent_062906.pdf.

———. 2009. “A Guide to Energy-Efficient Heating and Cooling.” Environmental Protection Agency. https://www.energystar.gov/sites/default/files/asset/document/HeatingCoolingGuide%20FINAL_9-4-09_0.pdf.

———. n.d.-a. “45L Tax Credits for Home Builders.” Government Website. Federal Tax Credits for Energy Efficiency. Accessed May 6, 2024. https://www.energystar.gov/about/federal-tax-credits/ss-45l-tax-credits-home-builders.

———. n.d.-b. “Choosing the Appropriate Insulation Type.” Government Website. Seal and Insulate with ENERGY STAR. Accessed May 6, 2024. https://www.energystar.gov/saveathome/seal_insulate/certified_insulation.

———. n.d.-c. “Federal Tax Credits for Energy Efficiency.” Government Website. About ENERGY STAR. Accessed May 28, 2024. https://www.energystar.gov/about/federal-tax-credits.

———. n.d.-d. “The Difference Between Source and Site Energy.” Commercial Buildings. Accessed April 9, 2024. https://www.energystar.gov/buildings/benchmark/understand-metrics/source-site-difference.

Fischer, Greg. 2022. *An Executive Order Establishing a Science-Based Target of Net Zero Greenhouse Gas Emissions Community-Wide by 2040 in Louisville-Jefferson County*. *Exective Order*. https://louisvilleky.gov/sites/default/files/2022-10/EO%202022-006.pdf.

Hillier, Amy E. 2003. “Redlining and the Home Owners’ Loan Corporation.” *Journal of Urban History* 29 (4): 394–420. https://doi.org/10.1177/0096144203029004002.

IMT. 2011. “Rental Premiums of Green Commercial Buildings in the U.S.” January 1, 2011. https://imt.org/resources/rental-premiums-of-green-commercial-buildings-in-the-u-s/.

———. 2015. “Comparison of U.S. Commercial Building Energy Benchmarking and Transparency Policies.” September 18, 2015. https://imt.org/resources/comparison-of-commercial-building-benchmarking-policies/.

———. 2020. “Building Performance Standards.” March 6, 2020. https://imt.org/public-policy/building-performance-standards/.

IMT and City of Cincinnati. 2021. “WarmUp CINCY: Affordable Housing Energy Efficiency Toolkit.” Cincinnati Toolkit. Cincinnati, OH: Institute for Market Transformation. https://www.cincinnati-oh.gov/sites/oes/assets/Cincinnati%20Affordable%20Housing%20Energy%20Efficiency%20Toolkit%20FINAL%20122021.pdf.

Indianapolis and Marion County Government. n.d. “Thriving Buildings.” Government Website. Benchmarking and Transparency. Accessed April 19, 2024. https://www.indy.gov/activity/benchmarking-and-transparency.

IRS. 2022. “Frequently Asked Questions about Energy Efficient Home Improvements and Residential Clean Energy Property Credits.” Fact Sheet FS-2022-40. Washington, DC: Internal Revenue Service. https://www.irs.gov/pub/taxpros/fs-2022-40.pdf.

———. 2023. “Credit for Builders of Energy-Efficient Homes.” Government Website. Clean Energy and Vehicle Credits. December 2023. https://www.irs.gov/credits-deductions/credit-for-builders-of-energy-efficient-homes.

KC Green. 2022. “Climate Protection and Resiliency Plan.” Kansas City, MO: KCMO. https://www.kcmo.gov/home/showpublisheddocument/9912/638112897582470000.

KCMO. n.d.-a. “Climate Action.” Government Website. Office of Environmental Quality. Accessed April 18, 2024. https://www.kcmo.gov/city-hall/departments/city-manager-s-office/office-of-environmental-quality/climate-action.

——. n.d.-b. “Energy and Benchmarking Compliance.” Government Website. Programs and Initiatives. Accessed April 19, 2024. https://www.kcmo.gov/programs-initiatives/energy-and-water-benchmarking.

——. n.d.-c. “Environmental Management Commission.” Government Website. Office of Environmental Quality. Accessed April 20, 2024. https://www.kcmo.gov/city-hall/departments/city-manager-s-office/office-of-environmental-quality/environmental-management-commission.

Kentucky Energy and Environment Cabinet. 2021. “Energy Affordability Workgroup.” Government Website. Energy Affordability. June 2021. https://eec.ky.gov/Energy/Programs/EnergyAffordability/Pages/affordabilityworkgroup.aspx.

Kentucky General Assembly. 2024. “KRS Chapter 383.” Government Website. Kentucky Revised Statutes. May 28, 2024. https://apps.legislature.ky.gov/law/statutes/chapter.aspx?id=39159.

Krigger, John, and Chris Dorsi. 2009a. “Chapter 4: Insulation.” In *Residential Energy: Cost Savings and Comfort for Existing Buildings*, 5th ed. Helena MT: Saturn REsource Management. https://srmi.biz/product/residential-energy/.

——. 2009b. “Chapter 5: Windows & Doors.” In *Residential Energy: Cost Savings and Comfort for Existing Buildings*, 5th ed. Helena MT: Saturn REsource Management. https://srmi.biz/product/residential-energy/.

LG&E. 2021a. “Rates, Terms, and Conditions for Furnishing Electric Service.” Tariff Book. Louisville, KY: Louisville Gas and Electric Company. https://lge-ku.com/sites/default/files/media/files/downloads/LGE-Electric-Rates-040123.pdf.

——. 2021b. “Rates, Terms, and Conditions for Furnishing Natural Gas Service.” Tariff Book. Louisville, KY: Louisville Gas and Electric Company. https://lge-ku.com/sites/default/files/media/files/downloads/LGE-Gas-Rates-040123.pdf.

——. 2023a. “Monthly Billing Adjustments - Electricity.” Tariff Book. Louisville, KY: Louisville Gas and Electric Company. https://lge-ku.com/sites/default/files/media/files/downloads/LGE-Billing-Adjustments-Electric-April-2023.pdf.

——. 2023b. “Monthly Billing Adjustments - Natural Gas.” Tariff Book. Louisville, KY: Louisville Gas and Electric Company. https://lge-ku.com/sites/default/files/media/files/downloads/LGE-Billing-Adjustments-Gas-April-2023.pdf.

——. 2024a. “A Sustainable Energy Future with the Right Mix.” Utility. LG&E | KU. 2024. https://lge-ku.com/future.

——. 2024b. “Demand Conservation.” Utility Programs. Energy Efficiency Programs. 2024. https://lge-ku.com/demand-conservation.

——. 2024c. “WeCare Program.” Utility Programs. Energy Efficiency Programs. 2024. https://lge-ku.com/wecare.

Liu, Lixi, Jes Brossman, and Yingli Lou. 2023. “ResStock Communities LEAP Pilot Residential Housing Analysis - Detailed Methodology.” Technical Report NREL/TP-5500-88058. Golden, CO: NREL. https://data.nrel.gov/submissions/224.

Louisville Metro Government. 2017. “Redlining Louisville: Racial Capitalism and Real Estate.” Redlining Community Dialogue. 2017. https://louisvilleky.gov/government/redevelopment-strategies/redlining-community-dialogue.

——. 2020a. “Energy Project Assessment District.” Program Manual Version 1.0. Louisville, KY. https://louisvilleky.gov/sustainability/document/louisvilleepadprogrammanualrev032020pdf.

——. 2020b. “Prepare Louisville: Building a Climate Resilient City for All.” Draft. Louisville, KY: Office of Advanced Planning and Sustainability. https://louisvilleky.gov/sustainability/document/preparelouisvilleadaptationplandraftforpubliccommentpdf.

——. 2021. “Notice of Funding Availability for Louisville Metro Government’s Affordable Development Projects.” Affordable Housing Development Program HOME NOFAs. Louisville, KY: Develop Louisville Office of Housing. https://louisvilleky.gov/government/housing/affordable-housing-development-program.

——. 2023. “My Louisville Home: A Comprehensive Housing Strategy For a Connected, Healthy, Authentic, Sustainable, Equitable and Safe City.” Draft Government Policy. Louisville, KY: LMG. https://louisvilleky.gov/housing/document/my-louisville-home-final-draft.

——. 2024a. “100% Clean Energy Community-Wide by 2040.” Government Website. 100 Percent Louisville. 2024. https://www.100percentlou.com/2040.

——. 2024b. “Cool Roof Incentive Program.” Government Website. Office of Sustainability. 2024. https://louisvilleky.gov/government/sustainability/cool-roof-incentive-program.

——. 2024c. “Home Repair Programs.” Government Website. Office of Housing and Community Development. 2024. https://louisvilleky.gov/government/housing/home-repair-programs.

——. 2024d. “Tax Moratorium.” Government Website. Construction Review. 2024. https://louisvilleky.gov/government/construction-review/tax-moratorium.

——. n.d. “Chapter 156: Property Maintenance Code.” Municipal Code. American Legal Publishing. Accessed May 29, 2024. https://codelibrary.amlegal.com/codes/louisvillemetro/latest/loukymetro/0-0-0-16549.

MHC. 2019. “22,000 Equities: Addressing Racial Gaps in Homeownership and Wealth.” The State of Metropolitan Housing. Louisville, KY: Metropolitan Housing Coalition. https://metropolitanhousing.org/wp-content/uploads/2020/10/2019-State-of-Metropolitan-Housing-Report_LR.pdf.

——. 2023. “The State of Housing in a Changing Climate.” The State of Metropolitan Housing. Louisville, KY: Metropolitan Housing Coalition. https://metropolitanhousing.org/report/2023-state-of-metropolitan-housing-report/.

Moe, Allison. 2024. “Introduction to Local Policy and Program Approaches for Electrifying and Decarbonizing Existing Buildings.” Golden, CO: NREL. https://www.osti.gov/biblio/2310350.

Nashville Electric Service. 2024. “Power of Change.” Utility. 2024. https://www.nespower.comhttps://www.nespower.com/power-of-change/.

Natarajan, H, S Klocke, and S Puttagunta. 2012. “Measure Guideline: Installing Rigid Foam Insulation on the Interior of Existing Brick Walls.” Technical Report. Building America. Norwalk CT: Consortium for Advanced Residential Buildings. https://www1.eere.energy.gov/buildings/publications/pdfs/building_america/measure_guide_rigid_foam.pdf.

New Directions Housing Corporation. n.d. “Apply for Repair Affair.” Housing & Services. Accessed May 29, 2024. https://www.ndhc.org/apply-for-repair-affair/.

NIST. 2022. “Understanding Building Codes.” Government Website. Buildings and Construction. June 21, 2022. https://www.nist.gov/buildings-construction/understanding-building-codes.

NREL. 2022. “End-Use Load Profiles for U.S. Building Stock: Technical Documentation.” Technical Documentation. Golden, CO: NREL. https://oedi-data-lake.s3.amazonaws.com/nrel-pds-building-stock/end-use-load-profiles-for-us-building-stock/2022/EUSS_ResRound1_Technical_Documentation.pdf.

———. 2023. “Cambium.” Energy Analysis. 2023. https://www.nrel.gov/analysis/cambium.html.

Office of Consumer Protection. n.d. “Utility Bill Disclosure.” Government Website. Energy and Environmental Advocacy - Montgomery County. Accessed April 20, 2024. https://www.montgomerycountymd.gov/OCP/energy/utility.html.

Office of Lead Hazard Control and Healthy Homes. 2021. “American Healthy Homes Survey II: Lead Findings.” Washington, DC: Department of Housing and Urban Development. https://www.hud.gov/sites/dfiles/HH/documents/AHHS%20II_Lead_Findings_Report_Final_29oct21.pdf.

Petersen, Alisa, and Radhika Lalit. 2018. “Better Rentals, Better City.” Technical Report. Basalt, CO: Rocky Mountain Institute. https://rmi.org/wp-content/uploads/2018/05/Better-Rentals-Better-City_Final3.pdf.

Robinson, Spenser J., Robert Simons, Eunkyu Lee, and Andrew Kern. 2016. “Demand for Green Buildings: Office Tenants’ Stated Willingness-to-Pay for Green Features.” *Journal of Real Estate Research* 38 (3). https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3186724#.

Salcido, Victor R, Yan Chen, YuLong Xie, and Zachary T Taylor. 2021. “Cost-Effectiveness of the 2021 IECC for Residential Buildings in Kentucky.” Technical Report PNNL-31599. Richland, WA: PNNL. https://www.energycodes.gov/sites/default/files/2021-07/KentuckyResidentialCostEffectiveness_2021_0.pdf.

Sandoval, Noah, Katelyn Stenger, Anthony Fontanini, Lixi Liu, Janet Reyna, Philip White, Ry Horsey, Patricia Romero-Lankao, and Nicole Rosner. 2023. “LA100 Equity Strategies. Chapter 6: Universal Access to Safe and Comfortable Home Temperatures.” NREL/TP-5500-85953. National Renewable Energy Laboratory (NREL), Golden, CO (United States). https://doi.org/10.2172/2221833.

Saunders, JoAnna. 2024. Interview with DOEE Data & Benchmarking Division.

Sommeiller, Estelle, and Mark Price. 2018. “The New Gilded Age: Income Inequality in the U.S. by State, Metropolitan Area, and County.” Washington, DC: Economic Policy Institute. https://www.epi.org/publication/the-new-gilded-age-income-inequality-in-the-u-s-by-state-metropolitan-area-and-county/.

Stantec. 2020. “Louisville Greenhouse Gas Emissions Reduction Plan.” Louisville, KY: Louisville Metro Government, Office of Advanced Planning and Sustainability. https://louisvilleky.gov/sustainability/document/ghgerpfinaldraft202004220pdf.

Stivers, Robert, David P Givens, Damon Thayer, Gerald A Neal, Julie Raque Adams, Reginald Thomas, Mike Wilson, et al. 2023. *Informational Bulletin No. 145*. *Kentucky Municipal Statutory Law*. https://legislature.ky.gov/LRC/Publications/Informational%20Bulletins/ib145.pdf.

The White House. 2022. “Building A Better America: A Guidebook To The Bipartisan Infrastructure Law For State, Local, Tribal, And Territorial Governments, and Other Partners.” Washington, DC: The White House. https://www.whitehouse.gov/wp-content/uploads/2022/05/BUILDING-A-BETTER-AMERICA-V2.pdf.

——. 2023. “Building A Clean Energy Economy: A Guidebook To The Inflation Reduction Act’s Investments In Clean Energy And Climate Action.” Washington, DC: The White House. https://www.whitehouse.gov/cleanenergy/inflation-reduction-act-guidebook/.

Tokos, Regan. 2024. Interview with KCMO Energy Benchmarking Program.

U.S. Census Bureau. 2022. “Gini Index of Income Inequality.” Data Portal. American Community Survey - 1-Year Estimates Detailed Tables -- B19083. 2022. https://data.census.gov/table/ACSDT1Y2022.B19083?q=B19083:%20Gini%20Index%20of%20Income%20Inequality%20by%20county&tp=true.

——. 2023a. “American Community Survey 1-Year Data (2005-2022).” Data Portal. Census.Gov. September 14, 2023. https://www.census.gov/data/developers/data-sets/acs-1year.html.

——. 2023b. “QuickFacts.” Data Portal. QuickFacts. 2023. https://www.census.gov/quickfacts/fact/table/US/PST045223.

U.S. Department of Health and Human Services. 2024. “Low Income Home Energy Assistance Program (LIHEAP).” Government Website. Office of Community Services. April 24, 2024. https://www.acf.hhs.gov/ocs/programs/liheap.

U.S. DOE. 2023. “Inflation Reduction Act: Home Energy Rebates.” Program Requirements & Application Instructions Version 1.1. Washington, DC: Office of State and Community Energy Programs. https://www.energy.gov/sites/default/files/2023-10/home-energy-rebate-programs-requirements-and-application-instructions_10-13-2023.pdf.

——. 2024. “Weatherization Assistance Program: State Plan / Master File Worksheet.” Grant Application Grant Number: EE0009904. Washington, DC: U.S. DOE. https://www.kyhousing.org/Partners/Developers/Single-Family/Weatherization-Assistance/Documents/KY_WAP_Master%20File_Draft.pdf.

——. n.d.-a. “179D Commercial Buildings Energy-Efficiency Tax Deduction.” Government Website. Office of Energy Efficiency and Renewable Energy. Accessed May 6, 2024. https://www.energy.gov/eere/buildings/179d-commercial-buildings-energy-efficiency-tax-deduction.

——. n.d.-b. “About the Weatherization Assistance Program.” Government Website. Office of State and Community Energy Programs - Weatherization Assistance Program. Accessed May 6, 2024. https://www.energy.gov/scep/wap/about-weatherization-assistance-program.

——. n.d.-c. “Boulder County Customers Get EnergySmart and Save.” Government Website. Better Buildings Neighborhood Program. Accessed May 30, 2024. https://www.energy.gov/eere/better-buildings-neighborhood-program/boulder-county-customers-get-energysmart-and-save.

——. n.d.-d. “Insulation Materials.” Government Website. Energy Saver. Accessed May 6, 2024. https://www.energy.gov/energysaver/insulation-materials.

——. n.d.-e. “Rockford Housing Authority’s Use of Energy Performance Contracting for Quality Affordable Housing.” Government Website. Better Buildings. Accessed May 29, 2024. https://betterbuildingssolutioncenter.energy.gov/implementation-models/rockford-housing-authoritys-use-energy-performance-contracting-quality.

——. n.d.-f. “Section 45L Tax Credits for Zero Energy Ready Homes.” Government Website. Residential Buildings. Accessed May 29, 2024. https://www.energy.gov/eere/buildings/section-45l-tax-credits-zero-energy-ready-homes.

——. n.d.-g. “Status of State Energy Code Adoption: Kentucky.” Building Energy Codes Program. Accessed April 9, 2024. https://www.energycodes.gov/status/states/kentucky.

——. n.d.-h. “Types of Insulation.” Government Website. Energy Saver. Accessed May 6, 2024. https://www.energy.gov/energysaver/types-insulation.

——. n.d.-i. “Where to Insulate in a Home.” Government Website. Home Comfort. Accessed May 29, 2024. https://www.energy.gov/energysaver/where-insulate-home.

——. n.d.-j. “Whole-House Ventilation.” Government Website. Energy Saver. Accessed May 29, 2024. https://www.energy.gov/energysaver/whole-house-ventilation.

——. n.d.-k. “Zero Energy Ready Home Program.” Government Website. Office of Energy Efficiency and Renewable Energy. Accessed May 6, 2024. https://www.energy.gov/eere/buildings/zero-energy-ready-home-program.

——. n.d.-l. “Codes 101.” Government Website. Building Energy Codes Program. Accessed May 3, 2024. https://www.energycodes.gov/codes-101.

U.S. EPA. 2008. “ENERGY STAR Building Upgrade Manual.” Documentation 2008 Edition. Washington D.C.: U.S. Environmental Protection Agency Office of Air and Radiation. https://www.energystar.gov/sites/default/files/buildings/tools/EPA_BUM_Full.pdf.

——. 2016a. “Benchmarking to Save Energy.” Brochure 430-K-07–003. Washington D.C.: U.S. Environmental Protection Agency. https://www.energystar.gov/buildings/tools-and-resources/benchmarking-save-energy.

——. 2016b. “Managing and Reducing Wastes: A Guide for Commercial Buildings.” Government Website. Sustainable Materials Management. August 4, 2016. https://www.epa.gov/smm/managing-and-reducing-wastes-guide-commercial-buildings.

——. 2023. “Inflation Reduction Act Environmental and Climate Justice Program.” Government Website. Inflation Reduction Act. November 21, 2023. https://www.epa.gov/inflation-reduction-act/inflation-reduction-act-environmental-and-climate-justice-program.

——. 2024a. “Climate Pollution Reduction Grants.” Government Website. Inflation Reduction Act. May 29, 2024. https://www.epa.gov/inflation-reduction-act/climate-pollution-reduction-grants.

——. 2024b. “Greenhouse Gas Reduction Fund.” Collections and Lists. April 22, 2024. https://www.epa.gov/greenhouse-gas-reduction-fund.

——. n.d.-a. “Benchmark Your Building With Portfolio Manager.” Government Website. ENERGY STAR. Accessed April 18, 2024. https://www.energystar.gov/buildings/benchmark.

——. n.d.-b. “ENERGY STAR Certification for Buildings.” Government Website. ENERGY STAR. Accessed April 19, 2024. https://www.energystar.gov/buildings/building-recognition/building-certification.

——. n.d.-c. “Understand Portfolio Manager Metrics.” Government Website. ENERGY STAR. Accessed April 19, 2024. https://www.energystar.gov/buildings/benchmark/understand-metrics.

U.S. HUD. 2023. “HUD Announces Funding to Support Energy Efficiency and Climate Resilience in Multifamily Assisted Housing Properties As Part of President Biden’s Investing in America Agenda.” Press Release. Press Room. September 13, 2023. https://www.hud.gov/press/press_releases_media_advisories/hud_no_23_195.

——. n.d. “Green and Resilient Retrofit Program (GRRP).” Government Website. Accessed May 29, 2024. https://www.hud.gov/GRRP.

Walton, Robert. 2022. “Inside Ithaca’s Plan to Electrify 6,000 Buildings and Grow a Regional Green Workforce Using Private Equity Funds.” News Blog. Utility Dive. June 2, 2022.

https://www.utilitydive.com/news/inside-ithacas-plan-to-electrify-6000-buildings-and-grow-a-regional-green/623126/.

Wilson, Eric J., Craig B. Christensen, Scott G. Horowitz, Joseph J. Robertson, and Jeffrey B. Maguire. 2017. "Energy Efficiency Potential in the U.S. Single-Family Housing Stock." NREL/TP-5500-68670. National Renewable Energy Lab. (NREL), Golden, CO (United States). https://doi.org/10.2172/1414819.

Appendix A. Methodology for IRA-Like Discounts for the Simple Payback Period Analysis

For envelope packages, the upgrades were considered eligible for two types of discounts, tax credits and rebates, with the latter split between the "Homes Energy Performance Based, Whole House Rebates" (HOMES) and "Home Electrification and Appliance Rebates (HEAR – formerly HEEHR)" rebates. For the tax credits, a discount of 30% of the project's cost up to a maximum of $1,200 was applied for each of the upgrade packages. This critically assumes that the household would have sufficient tax burden to fully take advantage of the tax credit, which may not be the case, especially for lower-income households. For the rebates, the higher of the HOMES or HEAR rebate was applied to the project cost. For the HOMES rebate, the number of eligible rebates depends on both the AMI level of the household and the anticipated or measured energy savings (although in the case of low-income envelope improvements this did not make a difference in the number of available rebates). The HOMES rebate was assumed to apply to the overall project cost (both labor and material). The HEAR rebate was based solely on the AMI level, and was assumed to apply only to material costs, which were assumed to be a flat 75% of the total project costs, across all projects, as a simplification.

Table 13: Upgrade Rebates Used for Simple Payback Period Calculation.

Upgrade Package	AMI Level	Rebate*	Modeled Energy Savings	Project Rebate Maximum	Project Percent of Costs Covered
Insulation / Weatherization	0-80% AMI	HOMES	35% +	$8,000	80%
		HOMES	20 - 35 %	$4,000	80%
		HOMES	15-20% measured	$4,000	80%
		HEAR	N/A	$1,600	100%

*IRA-like rebates assumed for the purposes of this analysis of Louisville housing stock, with simplifying assumptions. Consult HOMES and HEAR program information for official program requirements.

Appendix B. Federal Rebates and Tax Credits Available through the IRA

Appendix B.1. Home Energy Performance-Based, Whole-House Rebates

The Home Energy Performance-Based, Whole-House Rebates are administered through the state energy offices and will include two approaches – Modeled and Measured Energy Savings. Modeled savings includes an energy assessment, a customized retrofit package, and modeled energy savings prior to improvements being made (U.S. DOE 2023). While this section provides an overview of the programs as established by DOE, the ultimate form that the program will take will be determined by state governments and state energy offices, including the eligible measures and rebate amounts offered.[51]

Requirements laid out by DOE state that all income levels may be eligible for the program, as are apartments. Single-family incentives start at $2,000 for 20-34% energy savings. An achievement of 35% or greater energy savings may be eligible for a $4,000 rebate. Households with a single-family income below 80% of the AMI may be eligible for double the incentive levels, with a range of $4,000 to $8,000 (U.S. DOE 2023).

Multifamily properties must have at least 50% of households with incomes less than 80% AMI to qualify for a rebate of $4,000 per dwelling unit or 80% of project costs for 20-34% energy savings. Multifamily with 50% of households over 80% AMI may be eligible for $2,000 rebate per unit (up to $200,000 per building). Projects achieving higher energy savings may be eligible for higher incentives. Table 14 below provides an overview of the rebate tiers under the Modeled Savings approach. DOE has provided guidance for the low-income rebate program that states include conditions for property owners leveraging these funds for rental properties (U.S. DOE 2023).[52]

Table 14: Home Energy Performance, Whole-House Rebates Modeled Savings.

Housing Type	Modeled Savings	Income Level	Rebate Amount
Single-Family	20-34%	Less than 80% AMI	Lesser of $4,000 or 80% of project costs
		80% AMI or greater	Lesser of $2,000 or 50% of project costs
	35% or greater	Less than 80% AMI	Lesser of $8,000 or 80% of project costs
		80% AMI or greater	Lesser of $4,000 or 50% of project costs

[51] See more detailed program requirements here: https://www.energy.gov/sites/default/files/2023-10/home-energy-rebate-programs-requirements-and-application-instructions_10-13-2023.pdf.

[52] Such conditions could require that property owners agree to certain tenant protections such as keeping the improved unit affordable for at least two years after improvements and to not evict current tenants nor raise rents due to building enhancements, in exchange for access to the rebates.

Housing Type	Modeled Savings	Income Level	Rebate Amount
Multifamily	20-34%	A building with at least 50% of households with income less than 80% AMI	Lesser of $4,000 per dwelling unit or 80% of project costs
		A building with at least 50% of households with income at 80% AMI or greater	$2,000 per dwelling unit, up to $200,000 per building
	35% or greater	A building with at least 50% of households with income less than 80% AMI	Lesser of $8,000 per dwelling unit or 80% of project costs
		A building with at least 50% of households with income at 80% AMI or greater	$4,000 per dwelling unit, up to $400,000 per building

Note: Table for summary purposes only. Consult program information for official program requirements. Table for summary purposes only. Consult program information for official program requirements. Summary information based on U.S. DOE (2023), n. Table 22.

Based on DOE requirements, the second approach, Measured Energy Savings, includes a prorated per kilowatt-hour saved rebate based on 20% energy savings amount for the average single-family or multifamily home. This approach may be suited best for programs that are retrofitting a large number of properties in a given neighborhood. Households with less than 80% of the AMI may receive the largest rebate at $4,000 (or 80% of project costs). Single-family households or multifamily buildings with at least 50% of households with income at 80% AMI or greater may be eligible for a $2,000 rebate (or 50% of project costs). Contractors performing energy-efficient retrofits within a disadvantaged community may be eligible for an additional $200 rebate for each dwelling unit (U.S. DOE 2023).

Appendix B.2. Home Electrification and Appliance Rebate Program

This program provides rebates to low- and moderate-income households for the installation of new energy-efficient building materials, electric appliances that are replacing an existing non-electric appliance , or if a first-time purchase of a heat pump for the primary space heating and cooling within an existing home (U.S. DOE 2023). These materials and appliances can either be part of a new construction or part of a gas-to-electric retrofit within existing dwelling units. Rebate categories include heat pumps, insulation, air sealing, and electrical service/wire upgrades. Both single-family and multifamily units are eligible (U.S. DOE 2023). While this section provides an overview of the programs as established by DOE, the ultimate form that the program will take will be determined by state governments and state energy offices, including the eligible measures and rebate amounts offered.[53]

[53] See more detailed program requirements here: https://www.energy.gov/sites/default/files/2023-10/home-energy-rebate-programs-requirements-and-application-instructions_10-13-2023.pdf.

DOE requirements include rebates of up to 50% of the qualified project costs for households with 80-150% of AMI and up to 100% of qualified project costs for those with an income below 80% of AMI. There are maximum incentives for each type of equipment and a $14,000 total rebate per household limit. Table 15 below is a list of specific rebates limits for each equipment type (U.S. DOE 2023). Additional incentives, not to exceed $500, are also being made available to eligible government, commercial, or nonprofit entities that perform the installation of the qualified measures listed (U.S. DOE 2023, 73).

Table 15: Home Electrification and Appliance Rebate Limits.

Qualified Product	Rebate Amount Not to Exceed
Heat Pump Water Heater	$1,750
Heat Pump for Space Heating or Cooling	$8,000
Electric Stove, Cooktop, Range, Oven Or Heat Pump Clothes Dryer	$840
Electric Service Load Center	$4,000
Insulation, Air Sealing, and Ventilation	$1,600
Electric Wiring	$2,500

Table for summary purposes only. Consult program information for official program requirements. Summary information based on U.S. DOE (2023).

Appendix B.3. Tax Credits

*Please note: this section is designed to be an overview of tax credits for energy efficiency-related investments. It is **not** intended to serve as a recommendation to the City of Louisville and should **not** be construed as professional tax advice or other professional financial guidance. This section should not be used as the only source of information when making purchasing decisions, investment decisions, or tax decisions, or when executing other binding agreements. Please refer to IRS guidance or state guidance for relevant tax laws and requirements for tax credits.*

The table below lists federal tax credits that have been expanded under the IRA. This list includes both eligible equipment and building envelope improvements through the 25C Energy-Efficient Home Improvement Credit Program and the Residential Clean Energy Property Credits. These programs offer residential tax credits beginning January 1, 2023, until December 31, 2032, for low- to moderate-income households completing energy efficiency, electrification, and clean energy upgrades to owner-occupied homes and by renters (as indicated in Table 16) if a tenant makes improvements to the principal home they are renting. A home is defined as the main place of residence, whether a single-family house, houseboat, mobile home, cooperative apartment, condominium, or a manufactured home (ENERGY STAR n.d.-c).

Table 16: Energy-Efficient Federal Tax Credits for Homeowners.

Improvement	Eligibility	Tax Credit
General		
Home Energy Audit	A home inspection must be conducted by a certified auditor and result in a written report that identifies the most significant and cost-effective energy efficiency improvements. Existing homes (owner-occupied and renters).	30% of costs, up to $150.
Electrical Panel Upgrade	Load capacity of not less than 200 amps for any improvement associated with qualified electrical equipment, or replacement of, a panelboard, sub-panelboard, branch circuits, or feeders. Existing homes (owner-occupied).	30% of project costs or $600 maximum amount credited.
Building Envelope		
Insulation	Typical bulk insulation products such as batts, rolls, blow-in fibers, rigid boards, expanding spray, and pour-in-place. Products that reduce air leaks through air sealing (with a Manufacturers Certification Statement), including: • Weather stripping • Spray foam in a can • Caulk designed to air seal • House wrap • Existing homes (owner-occupied and renters).	30% of project costs or $1,200 maximum amount credited.
Exterior doors	ENERGY STAR-certified doors. Glazing level: (a) opaque with ≤ 0.17 U-Factor, or (b) ≤ 1/2-Lite with ≤ 0.25 and ≤ 0.25 SHGC, or (c) > 1/2-Lite, ≤ 0.30 U-Factor and ≤ 0.25 SHGC. Existing homes (owner-occupied and renters).	30% of project costs or $500 ($250 per door) maximum amounts credited.
Windows and Skylights	Exterior windows or skylights must meet the ENERGY STAR Most Efficient criteria. Existing homes (owner-occupied and renters).	30% of project costs or $600 maximum amount credited.

Improvement	Eligibility	Tax Credit
Furnaces (Natural Gas, Oil)	ENERGY STAR-certified gas furnaces with AFUE > 97% are eligible. ENERGY STAR-certified oil furnaces that are rated by the manufacturer for use with fuel blends at least 20% of the volume of which consists of biodiesel, renewable diesel, or second-generation biofuel. Existing homes (owner-occupied and renters).	30% of project costs or $600 maximum amount credited.
Hot Water Boilers (Natural Gas, Propane, Oil)	ENERGY STAR-certified gas boilers with AFUE > 95% are eligible. ENERGY STAR certified oil boilers that are rated by the manufacturer for use with fuel blends at least 20% of the volume of which consists of biodiesel, renewable diesel, or second-generation biofuel. Existing homes (owner-occupied and renters).	30% of project costs or $600 maximum amount credited.
Central air conditioners	For split systems, ENERGY STAR-certified equipment with SEER2 > 16 is eligible. All ENERGY STAR-certified packaged systems are eligible. Existing homes (owner-occupied and renters).	30% of project costs or $600 maximum amount credited.
		TOTAL LIMIT CREDIT $3,200
Heat Pumps and Biomass		
Heat pumps*	Either ducted with the ENERGY STAR label or non-ducted (minisplits) with ENERGY STAR certification of SEER2 > 16, EER2 > 12, HSPF2 > 9 Existing homes (owner-occupied and renters).	30% of project costs or $2,000 maximum amount credited.
Heat Pump Water Heaters*	Heat pump water heaters that have earned the ENERGY STAR label are eligible for this credit. Existing homes (owner-occupied and renters).	30% of project costs or $2,000 maximum amount credited.
Biomass Stoves/Boilers*	Must have a thermal efficiency rating of at least 75% (measured by the higher heating value of the fuel).	30% of project costs or $2,000 maximum amount credited.

Improvement	Eligibility	Tax Credit
	Existing homes (owner-occupied and renters).	
		TOTAL CREDIT LIMIT $2,000
Clean Energy Credits		
Solar electric PV or PV cells (used to power attic fans),	Includes panels, inverters, wiring, mounting equipment, and associated labor for electrical generation. New and existing homes (owner-occupied and renters).	30% for property placed in service after December 31, 2021, and before January 1, 2033.
Solar Water Heating	Equipment must be certified by the Solar Rating Certification Corporation, or a comparable entity endorsed by the State of Kentucky. New and existing homes (owner-occupied and renters).	
Battery Storage Technology	Battery must have a capacity of at least 3 kilowatt hours. New and existing homes (owner-occupied and renters).	
Geothermal Heat Pumps	Equipment which: (1) uses the ground or ground water as a thermal energy source (to heat), or as a thermal energy sink (to cool) a home, and (2) is ENERGY STAR-certified. New and existing homes (owner-occupied and renters).	
Small Wind Turbine	Qualified small wind energy property costs are costs for property that uses a wind turbine to generate electricity for use in connection with your home located in the United States. The home does not have to be your main home. New and existing homes (owner-occupied and renters).	
Fuel Cell (Residential Fuel Cell and Microturbine System)	The fuel cell equipment must have a nameplate capacity of at least one-half kilowatt of electricity using an electrochemical process and an electricity-only generation efficiency greater than 30%. New and existing homes (owner-occupied and renters).	30% of project costs for installations between 2022 and 2032. Limited to $500 for each half kilowatt of capacity, not to exceed $1,667 for all combined persons in household that share

Improvement	Eligibility	Tax Credit
		joint ownership but are not married.

Table for summary purposes only. Consult program information for official program requirements. Summary information based on Energy Star (n.d.-c).

*: Any combination of heat pumps, heat pump water heaters, and biomass stoves/boilers are subject to an annual total limit of $2,000. Measures under the Clean Energy Credits do not count towards the limitations under the Home Efficiency Credits (ENERGY STAR n.d.-c).

Appendix C. Comparison of Energy Codes in Kentucky

The following tables compare the energy codes currently in practice in Kentucky against more updated versions of the IECC, as well as more ambitious "beyond-code" green building certifications, which in some jurisdictions are paired with incentives if adopted in new construction or renovation projects (ENERGY STAR n.d.-c; IRS 2023; U.S. DOE n.d.-f). These tables are meant to provide a better understanding of where Louisville sits today, compared to "best in class" standards adopted elsewhere.

WINDOWS AND SKYLIGHTS

Window and skylight performance is specified through their insulation value (U-factor or the inverse of R-value) and through their Solar Heat Gain Coefficient (SHGC), which defines how much solar heat is allowed through the window. Less solar heat gain is helpful in southern climates with long cooling seasons, while higher solar heat gain glazing is preferred in northern climates dominated by heating loads (Krigger and Dorsi 2009b). For both metrics, lower values correspond to less heat allowed into the envelope and therefore higher performance. Table 17 shows the required performance for windows for a range of codes, including Kentucky's code today (2012 Kentucky Residential Energy Code),[54] while Table 18 shows the equivalent requirements for skylights.

Table 17: Windows (Fenestration) Performance - Maximum U-Factor and SHGC by Code Version.

	2012 Kentucky Residential Energy Code R402.1.1	Model 2015 IECC R402.1.1	Model 2018 IECC R402.1.1	Model 2021 IECC R402.1.1	ENERGY STAR 3.1*	Zero Energy Ready Homes v2.1
U-Factor	0.35	0.35	0.32	0.30	0.30	0.30
SHGC	Not required	0.40	0.40	0.40	0.40	0.40

*: For ENERGY STAR's North-Central climate zone.

[54] https://www.energycodes.gov/status/states/kentucky.

Table 18: Skylight Performance - Maximum U-Factor and SHGC by Code Version for New Construction.

	2012 Kentucky Residential Energy Code R402.1.1	Model 2015 IECC R402.1.1	Model 2018 IECC R402.1.1	Model 2021 IECC R402.1.1	ENERGY STAR 3.1*	Zero Energy Ready Homes v2.1
U-Factor	0.60	0.55	0.55	0.55	0.53	0.53
SHGC	Not required	0.40	0.40	0.40	0.35	0.35

*: For ENERGY STAR's North-Central climate zone.

CEILING AND ATTIC

Ceiling and attic insulation can be applied in two locations, and the prescriptions for the required level of insulation vary depending on where it is applied. Insulation can be applied at the ceiling or attic line, leaving the attic unconditioned and out of the building envelope, or at the roofline, bringing the attic into the building envelope.[55] Table 19 shows the required performance of attics and ceilings for new construction for both insulation at the ceiling line (first row) in R-values and at the roofline (second row) in U-factors and their corresponding R-value.[56] Insulating at the ceiling line (leaving attic out of building envelope) is often done with blow-in or batt insulation installed above the top floor ceiling, between and sometimes over the ceiling joists, with vents at the sides and ridgeline to keep the air moving. The prescriptive minimums listed in Table 19 are the baseline when installing insulation at the ceiling line, unless a trade-off calculation is completed that demonstrates the total insulation values in the home surpass the code minimums.[57]

[55] For additional information on where to apply insulation within the home, see (U.S. DOE n.d.-i).
[56] When installing insulation at the roofline instead of at the ceiling line, the minimum amount of insulation that can be installed and meet code must meet or exceed the applicable code u-factor. For instance, when installing insulation at the roofline to meet the 2015 IECC, a minimum of R-38 must be installed at the roofline to meet the requirement.
[57] While a full comparison of the many types of available insulating materials applicable to attic and ceiling insulation is beyond the scope of this report, there are many existing resources that cover this topic in detail. For high-level descriptions of insulating materials and their relative advantages and disadvantages, please see: (ENERGY STAR n.d.-b; U.S. DOE n.d.-h; n.d.-d). For additional detail on the application of various insulation types in attics and elsewhere in the home, the Building America Solution Center also provides useful case studies and guides (see for example this guide on applying spray foam insulation to an attic floor in an existing home: (Building America Solution Center 2022d)).

Table 19: Ceiling/Attic Performance –– Minimum R-value and Maximum U-Factor by Code Version for New Construction.

	2012 Kentucky Residential Energy Code R402.1.1	Model 2015 IECC R402.1.1	Model 2018 IECC R402.1.1	Model 2021 IECC R402.1.1	ENERGY STAR 3.1*	Zero Energy Ready Homes v2.1
Insulation installed at the ceiling line (R-value)	R-38	R-49	R-49	R-60	R-49	R-60
Insulation installed at the roofline (U-factor)	0.030 (R-33)	0.026 (R-38)	0.026 (R-38)	0.026 (R-38)	0.026 (R-38)	0.026 (R-38)

*: For ENERGY STAR's North-Central climate zone.

WALLS

When insulating walls, two key sets of considerations are: (1) whether the wall is wood frame, or mass (typically masonry, or concrete structural wall); and (2) whether insulation will be applied to a cavity or in a continuous fashion. (Based on ResStock modeled data, approximately 93% of all residential housing stock in Louisville is estimated to be wood-framed, with the rest as brick or concrete masonry.)

Cavity insulation is installed inside the wall, in between the wall framing, while continuous insulation is installed at the exterior of the wall framing/sheathing in a continuous plane. When referring to the code table, there are often multiple options to meet the prescriptive code, with cavity only, cavity and continuous, and within the 2021 IECC, continuous-only options to meet the prescriptive code. Wood frame wall insulation is described in the code by both cavity and continuous insulation values. Mass walls (typically masonry or concrete structural walls), can, due to their heavy mass, be insulated on the inside or outside, with continuous or cavity insulation.[58] Continuous insulation, when installed properly, greatly reduces thermal bridging, or the interruption of an insulated plane by a material with a lower insulation value. Because of the reduced thermal bridging, continuous insulation's effective R-value is essentially its rated R-value, while a wall insulated with cavity insulation has a lower effective R-value than the insulation's R-value (Krigger and Dorsi 2009a).[59]

When retrofitting insulation in the wall cavities, the most cost-effective way to add insulation to uninsulated cavities is typically from the exterior, with drill-and-fill approaches with blow-in or spray-foam insulation. If removing the interior wall finishes, rigid insulation, when installed tight to the

[58] Depending on the details of the application, specific approaches may be needed to ensure proper moisture management and durability. For more discussion on moisture management in different contexts, see Building America Solution Center (2022a, 2022b); Building Science Corporation (2007).

[59] For instance, a 2x4 wood stud wall with wood siding and ½" drywall interior insulated only with R-13 batts in the cavity has an effective R-value of R-12, while the same wall with R-13 continuous insulation and no cavity insulation has an effective R-value of almost R-17. For more information, see additional resources at the Building America Solution Center (Building America Solution Center 2022b), and in particular Building Science Corporation (2007).

interior face of the stud cavities and sealed at the top and sides, can provide a high degree of air-sealing and insulation to an existing wall. Batts can also be installed if removing the interior wall finishes, but an air barrier should be included at the interior face of the sheathing if the sheathing is not in continuous sheets, or if air leaks are present (Building Science Corporation 2007).

The most energy-efficient method of insulating mass walls is with exterior continuous insulation, but the most common method is to build an interior wood-framed furring wall at the interior of the masonry wall and install batt insulation into the cavities of the wall. A slightly more expensive, but preferred way of installing insulation at masonry walls, is to install continuous insulation at the interior of the masonry walls, and then add furring strips to install interior finishes; this reduces the risk of condensation at the masonry wall interior when cold outside (Building Science Corporation 2007; Natarajan, Klocke, and Puttagunta 2012). Table 20 shows the minimum R-values for framed and masonry (mass) walls across a variety of codes for new construction.

Table 20: Wall Performance - Minimum R-Value by Code Version for New Construction.

	2012 Kentucky Residential Energy Code R402.1.1	Model 2015 IECC R402.1.1	Model 2018 IECC R402.1.1	Model 2021 IECC R402.1.1	ENERGY STAR 3.1*	Zero Energy Ready Homes v2.1
Wood Frame Wall	R-13	R-20 or R-13+R-5ci	R-20 or R-13+R-5ci	R-30 or R-20+R-5ci or R-13+R-10ci or R-0+R-20ci	R-20 or R-13+R-5ci	R-30 or R-20+R-5ci or R-13+R-10ci or R-0+R-20ci
Mass Wall	R-5ci/R-10	R-8ci/R-13	R-8ci/R-13	R-8ci/R-13	R-8ci/R-13	R-8ci/R-13

*: For ENERGY STAR's North-Central climate zone.

FLOORS, CRAWLSPACES, BASEMENTS, AND SLAB FOUNDATIONS

Floors that are exposed to exterior air or that overhang exterior areas, either over a crawlspace, building bumpouts, or carports/garages, must be insulated per the energy code. These areas must also be air-sealed at the underside of the floor. In lieu of insulating the floor of an occupied space over a crawlspace, it is typically more cost- and time-efficient to insulate the crawlspace walls, seal the crawlspace vents, install an effective vapor barrier, and provide dehumidification to the basement. This reduces moisture in the living space, helps improve indoor air quality, and reduces infiltration into the house, while also lowering utility bills for heating and cooling.

Crawlspace walls can be insulated with either continuous or cavity insulation. Typically, sealed crawlspaces, as described in the floor section, are one of the most cost-effective home energy improvements (Building America Solution Center 2022a). Basements, like crawlspaces, can be insulated with either continuous insulation, or batts, per code.[60] Continuous, rigid insulation is typically the preferred choice, as it can also be air-sealed (Building America Solution Center 2022a).

[60] In areas with significant termite activity, a 3" clear inspection strip is required at the top of the basement wall, below the sill plate; rigid insulation can meet this requirement by making a 3" folding strip at the top of the wall to allow the wall to be fully insulated and easily inspected.

When insulating a slab on grade, the code requires insulation to be installed at the slab edge, meeting a minimum of R-10 and going at least 2' below the top of slab.[61] Table 21 shows the new construction minimum insulation values for various floors and foundation types for a variety of building codes and standards.

Table 21: Foundation Performance – Minimum R-Value by Code Version for New Construction.

	2012 Kentucky Residential Energy Code R402.1.1	Model 2015 IECC R402.1.1	Model 2018 IECC R402.1.1	Model 2021 IECC R402.1.1	ENERGY STAR 3.1*	Zero Energy Ready Homes v2.1
Cantilevered /Elevated Floor	R-19	R-19	R-19	R-19	R-19	R-19
Basement Wall	R-10ci/R-13	R-10ci/R-13	R-10ci/R-13	R-10ci/R-13	R-10ci/R-13	R-10ci/R-13
Slab (R-value and depth)	R-10ci, 2 ft	R-10ci, 2 ft	R-10ci, 2 ft	R-10ci, 4 ft	R-10ci, 2 ft	R-10ci, 2 ft
Crawlspace	R-10ci/R-13	R-10ci/R-13	R-10ci/R-13	R-10ci/R-13	R-10ci/R-13	R-10ci/R-13

*: For ENERGY STAR's North-Central climate zone.

INFILTRATION

Building infiltration is measured through a blower door test; this test uses a calibrated fan to pressurize or depressurize the home to determine the rate of air leakage. Air leakage is measured in terms of "air changes per hour" (ACH), typically at a negative pressure of 50 pascals (Pa) indicated by ACH50. Lower air leakage is correlated with lower energy usage for heating and cooling. 3 ACH50 is considered a "tight" house, while existing housing often has ACH50 rates of 10 or higher (Building America Solution Center 2022c). Table 22 shows the maximum infiltration rates allowed under various codes and standards for new construction.

[61] See the 2012 Kentucky Residential Energy Code table 402.1.1 note "d" for specific slab edge clarifications (https://www.energycodes.gov/status/states/kentucky).

Table 22: Infiltration - Maximum ACH50 Values by Code Version for New Construction.

	2012 Kentucky Residential Energy Code R402.1.1	Model 2015 IECC R402.1.1	Model 2018 IECC R402.1.1	Model 2021 IECC R402.1.1	ENERGY STAR 3.1*	Zero Energy Ready Homes v2.1
Infiltration	7 ACH50	3 ACH50	3 ACH50	3 ACH50	3 ACH50	2.25 ACH50

*: For ENERGY STAR's North-Central climate zone.

Separate from infiltration, the 2018 Kentucky Residential Building Code requires mechanical ventilation meeting rates, as described in Table M1507.3.3(1). The code does not require a particular means of ventilation, however. Ventilation systems with a central fan integrated supply or a balanced system with heat recovery ventilation (also known as energy recovery ventilation) can allow the outside air to be filtered and conditioned before entering occupied spaces, whereas exhaust-only systems do not filter or condition outside air. Appropriate ventilation is very important for a tight house in providing healthy air for breathing, and also allows for the outside air introduced to the house to be filtered and conditioned before entering the occupied area of the house (Building America Solution Center 2018; U.S. DOE n.d.-j).

Appendix D. Energy Efficiency Analysis: Whole-Home Electrification and Envelope Upgrade

This section explores the impacts of a combined envelope and whole-home electrification upgrade on energy usage, energy expenditures and burdens, and community-wide emissions within Louisville. This is meant to serve as a comparison with the results shown in the Energy Efficiency Analysis section. The same limitations shown in the Energy Efficiency Analysis section are relevant here, and these results should be taken to be *indicative* of the impacts Louisville could potentially see. Notably, this section does not attempt to model the costs of these upgrade packages or their simple payback periods, as was done with the envelope upgrade packages.

Whole-Home Electrification and Envelope Upgrade Packages

In addition to the "Basic Enclosure" and "Enhanced Enclosure" upgrade packages shown above, the ResStock dataset used for this analysis also considered "Basic enclosure and high-efficiency whole-home electrification" and "Enhanced enclosure and high-efficiency whole-home electrification" upgrade packages. These packages included all of the upgrades modeled in the "Basic Enclosure" and "Enhanced Enclosure" upgrade packages, plus (NREL 2022):

- High-efficiency heat pump for all dwelling units with non-electric heating or less-efficient electric heating.
- Heat pump water heater for all dwelling units with non-electric heating or less-efficient electric water heating.
- Ventless heat pump dryer (CEF=5.2) for all dwelling units with non-electric dryers or less-efficient electric dryers.
- Electric oven and induction range for all dwelling units.

Results

Figure 26 shows the median annual energy (electricity and natural gas) expenditures for the baseline and each of the combined whole-home electrification and envelope upgrade scenarios, split between single-family and multifamily dwellings, for low- and moderate-income AMI brackets (0-30%, 30-60%, and 60-80%) and all other AMI brackets merged. All dwelling types showed substantial modeled energy savings, although unlike with the envelope upgrades (Figure 18), there is a smaller difference in the savings observed between single-family and multifamily homes. Single-family homes saw median bill reductions of 47% and 49%, and multifamily homes saw median bill reductions of 43% and 43%, for the Basic Enclosure with High-Efficiency Whole-Home Electrification and the Enhanced Enclosure with High-Efficiency Whole-Home Electrification upgrade packages, respectively.

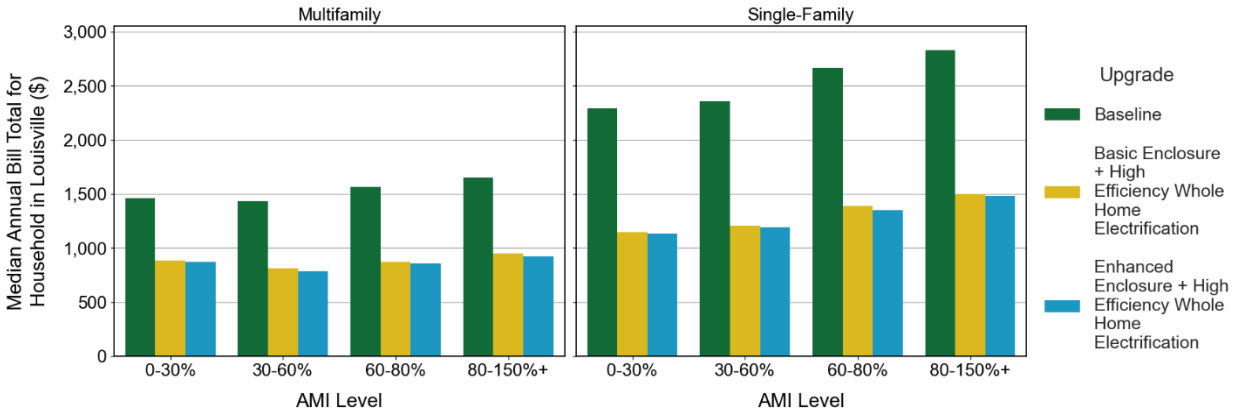

Figure 26: Modeled Median Annual Energy Expenditures in Louisville by Income Level for Combined Whole-Home Electrification and Envelope Upgrade Scenarios.

Figure 27 shows the modeled change in the median annual energy burden across the same housing types and income levels as shown in Figure 26. Energy burdens were calculated solely on estimates for bills and household incomes. They do ***not*** reflect expenditures associated with the upgrade (i.e., the cost to install an upgrade). While energy expenditures were relatively constant across incomes (by housing geometry type), changes to median energy burden are much more pronounced for lower income levels, as the same change in energy bills will have a larger impact for lower-income residents. As a comparison, for the Basic Enclosure with High-Efficiency Whole-Home Electrification upgrade package, the median reduction in energy burden was 9.3%, 3.4%, 2.3%, and 1.2% for the 0-30%, 30-60%, 60-80%, and 80-150%+ AMI brackets, respectively. The reductions were similar for the same AMI brackets for the Enhanced Enclosure with High-Efficiency Whole-Home Electrification upgrade package: 9.52%, 3.48%, 2.31%, and 1.21%. Energy burden reductions tend to be similar for single-family homes compared to multifamily homes, with a median reduction in household energy burden of 1.86% and 1.90% for single-family units and 2.09% and 2.09% for multifamily units for the Basic Enclosure with High-Efficiency Whole-Home Electrification and Enhanced Enclosure with High-Efficiency Whole-Home Electrification upgrade packages, respectively.[62]

Table 23 shows the total number of residents with 6% or higher energy burden for the baseline and envelope upgrade packages. Across all income levels and housing geometries, there were approximately 66,000 fewer energy-burdened residents (i.e., residents whose energy expenditures exceeded 6% of their income) for both combined electrification and envelope upgrade packages. As with the envelope only packages described in the Energy Efficiency Analysis section above, the smallest reductions in the number of energy-burdened residents occurred within the group that most significantly needed support: the very-low-income (0-30%) AMI bracket. This, however, does not indicate that these households did not benefit from the envelope packages, as the reduction in energy burdens outlined above show. The baseline energy burden for these very-low-income households is so high to begin with that even significant reductions still result in energy-burdened households above the 6% threshold.

[62] It should be noted that for median bill reductions, percentage changes represent the percent reduction from the baseline, while for median energy burden reductions, percentage changes represent the absolute reduction from the baseline. For instance, if the baseline energy *expenditures* were $1,000/year and the post-upgrade expenditures were $800/year, this would be presented as a 20% reduction, while if the baseline energy *burden* was 5% and the upgrade energy burden was 4%, this would be presented as a 1% reduction.

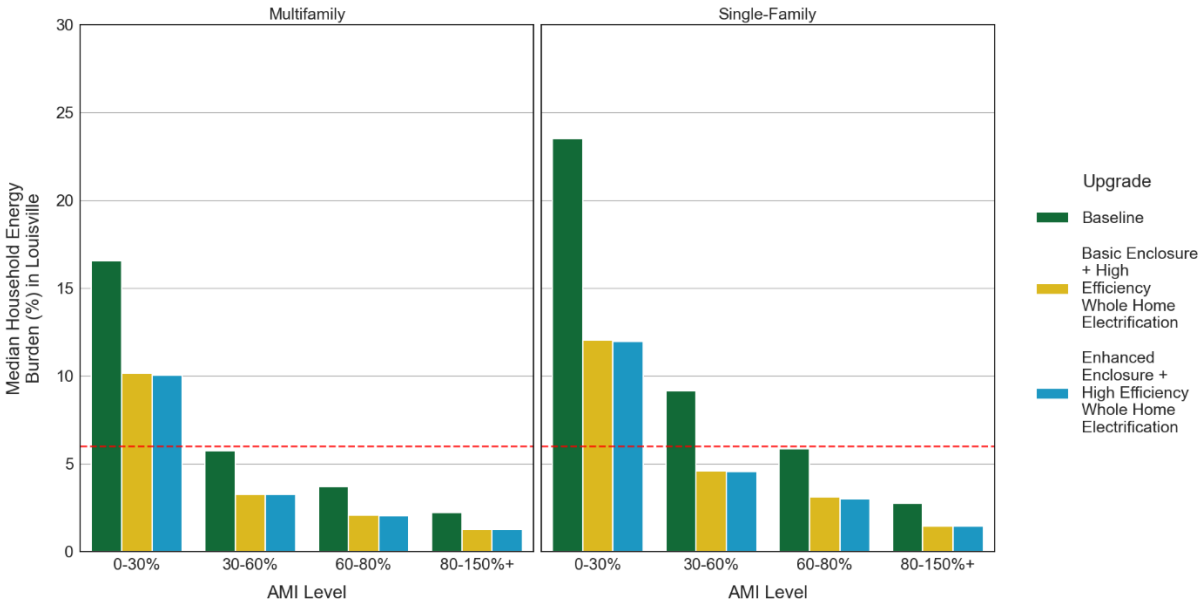

Figure 27: Modeled Impacts of Combined Whole-Home Electrification and Envelope Upgrades on Per Household Median Annual Energy Burden Rates by Income Level.

Note: Energy burden calculations only consider bill reduction impacts and do not capture the cost of installing the upgrade.

Table 23: Combined Electrification and Envelope Packages - Estimated Number of Households Experiencing High Energy Burden (6%+) by Income Level.

Upgrade	Housing Type	0-30%	30-60%	60-80%	80%+
Baseline	Multifamily	29,800 (98%)	12,500 (47%)	800 (4%)	300 (1%)
	Single-Family	24,700 (99%)	28,600 (82%)	15,100 (47%)	9,200 (6%)
Basic Enclosure with High-Efficiency Whole-Home Electrification	Multifamily	22,200 (73%)	1,000 (4%)	0 (0%)	0 (0%)
	Single-Family	21,900 (88%)	8,200 (23%)	800 (2%)	300 (1%)
Enhanced Enclosure with High-Efficiency Whole-Home Electrification	Multifamily	22,200 (73%)	1,000 (4%)	0 (0%)	0 (0%)
	Single-Family	21,900 (88%)	7,700 (22%)	800 (2%)	300 (1%)

To understand how the widespread adoption of combined electrification and building envelope improvements would impact Louisville's energy usage and clean energy ambitions, the total energy

consumption by end use and fuel type and the associated emissions associated with building energy consumption can be examined. Figure 28 shows the modeled energy usage for Louisville's residential building stock, broken down by fuel type and end use, for the five largest end uses. While some end uses do not see any changes (lighting, plug loads), substantial reductions are modeled for heating, cooling, and hot water heating, in particular heating. In both combined electrification and envelope upgrade packages, natural gas usage is almost completely eliminated (99% reduction). Notably, even electricity consumption is reduced under the combined electrification and envelope upgrade packages, due to reduced cooling (57% and 58%, for whole-home electrification with basic and enhanced envelopes, respectively), reduced hot water heating (33% for both upgrade packages) and reduced heating (30% and 35%, respectively). These reductions, despite the electrification of some of these end uses, are driven by the envelope improvements that reduce the absolute need for heating and cooling and increased efficiencies of space heating, space cooling, and water heating equipment.

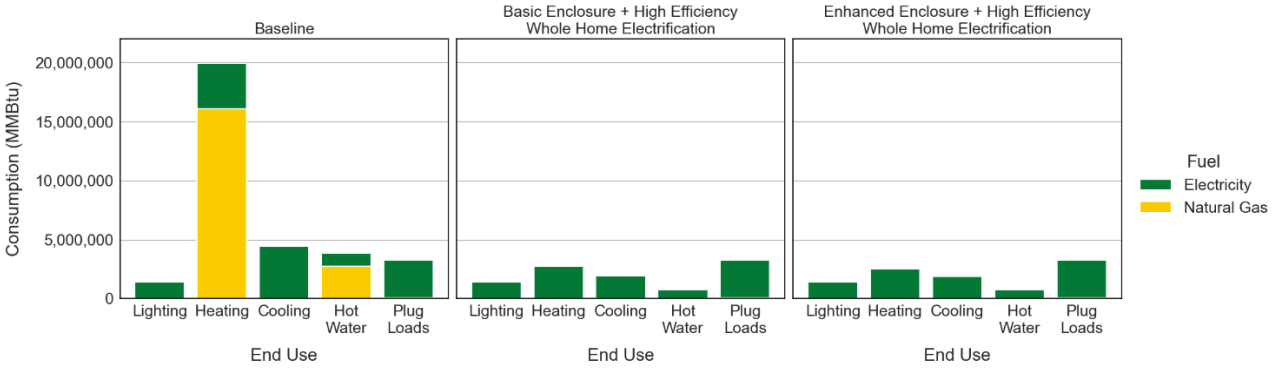

Figure 28: Comparison of Modeled Energy Usage for Louisville Residential Buildings by Fuel and End Use for Combined Electrification and Envelope Upgrades.

Figure 29 shows the modeled annual greenhouse gas emissions (in million metric tons of CO_2 equivalent) from the residential sector (both directly from combustion appliances, such as natural gas heating, as well as 'indirectly' from electricity consumption from the power system), under the baseline and for Basic Enclosure with High-Efficiency Whole-Home Electrification and Enhanced Enclosure with High-Efficiency Whole-Home Electrification upgrade packages, **Based on the modeled results, Louisville could see an approximately 57% reduction in its [kgC02e] emissions (from the residential building sector) under a community-wide Whole-Home Electrification plus Basic Enclosure adoption, and 58% reduction under a community-wide Whole-Home Electrification plus Enhanced Enclosure adoption scenario.**

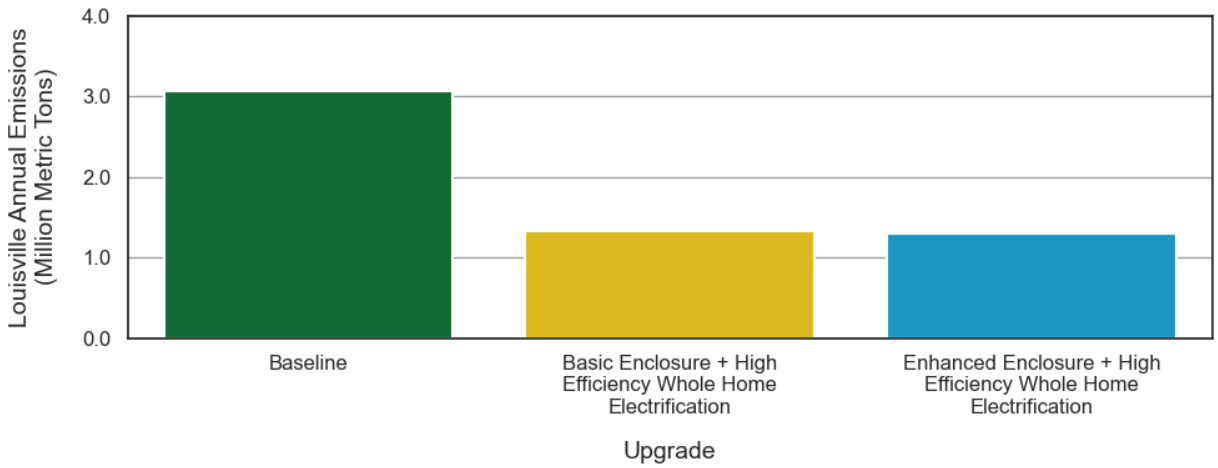

Figure 29: Modeled Impact of Combined Building Whole-Home Electrification and Envelope Upgrade Packages on Community-Wide Residential Building Emissions.

Appendix E. Overview of Tariffs Used for Bill Calculations

Electricity bills were calculated assuming a volumetric energy charge of $0.11366 / kWh across all hours and seasons (i.e., a flat volumetric energy charge as opposed to a time-of-use rate) and a monthly fixed charge of $13.9875 / month, based on information from LG&E (2021) for the Residential Service tariff. The monthly fixed charge was taken to be the "Basic Service Charge per Day" charge ($0.45 per day) plus the "Home Energy Assistance Program" charge ($0.30 per month). The Basic Service Charge and the Home Energy Assistance charge were converted to a single monthly charge: $0.45 per day * 365 days per year / 12 month per day = $13.6875 per month + $0.30 per month = $13.9875 per month. The energy charge was taken to be the combination of the following charges and adjustments:

- Infrastructure charge ($0.06927 / kWh) (LG&E 2021a)
- Variable charge ($0.03165 / kWh) (LG&E 2021a)
- Billed Fuel Adjustment Clause (Apr 2023: $0.00585 / kWh) (LG&E 2023a)
- Fuel Adjustment Clause (Apr 2023: $0.00639 / kWh)
- Off-System Sales Adjustment Clause (Apr 2023: - $0.00054 / kWh)
- DSM Rate for Residential Service (Apr 2023: $0.00104 / kWh).

Natural gas bills were calculated using the Residential Gas Service tariff from LG&E (2021) and billing adjustments from LG&E (2023b). The fixed charge component was taken to be the "Basic Service Charge," which was $0.65 per day, plus the Home Energy Assistance charge ($0.30 per month) plus the Gas Line Tracker Charges ($1.39 per month per meter for Residential Gas Service) = $0.65 per day * 365 days per year / 12 months per year =$19.7708 per month + $0.30 per month + $1.39 per month = $21.4608 / month. The volumetric charge was the combination of the Distribution Charge ($0.51809 / ccf) plus the Gas Supply Cost Component ($0.67619 / ccf) plus the DSM billing adjustment factor ($0.00337 / ccf) plus the Gas Line Tracker Charges ($0.00256 / ccf) = $1.20 / ccf or $1.157 per therm.

It should be noted that the electricity bill calculations *excluded* an "Environmental Cost Recovery Surcharge" which for the Residential Service would amount to an additional charge equal to 2.29% of the rest of the bill.[63]

[63] That is, if this analysis shows an electric bill of $100 for a given month, the customer's 'actual' electric bill would be $100 * 1.0229 = $102.29 for that month.

Appendix F. Workforce Development Data

Table 24 provides additional information on the number of establishments, employment levels, wages, and comparisons to national averages for select industries that are associated with residential construction and energy efficiency-related investments. Table 25 provides similar data for a different set of industry codes (as established by the North American Industry Classification System [NAICS]) that combines residential and commercial values for related industries. Table 26 provides an overview of the various workforce development programs currently in Louisville, which the community could attempt to leverage when establishing a program for residential energy efficiency training and employment.

Table 24: BLS NAICS Results for Residential Employment and Wages for Jefferson County in 2022 for Select Industry Groups.

NAICS Industry Group (NAICS Code)	Annual Establishments	Annual Average Employment	Total Annual Wages	Annual Wages per Employee	Annual Average Employment Location Quotient	Total Annual Wages Location Quotient
Total, all industries	30,344	429,732	$28,284,275,031	$65,818	1.06	1.05
Residential remodelers (236118)	287	897	$52,711,424	$58,759	0.66	0.72
Residential masonry contractors (238141)	24	54	$2,018,391	$37,668	0.24	0.19
Residential Building Construction (23611)	415	1,371	$86,869,122	$63,343	0.48	0.46
New single-family housing construction (except for-sale builders) (236115)	105	274	$18,356,095	$67,013	0.22	0.21
New multifamily housing construction (except for-sale builders) (236116)	12	62	$5,515,027	$89,192	0.47	0.45
New housing for-sale builders (236117)	11	139	$10,286,576	$74,227	0.81	0.54
Residential Glass and glazing contractors (238151)	12	114	$6,543,734	$57,192	1.39	1.48
Residential roofing contractors (238161)	48	159	$10,566,784	$66,388	0.42	0.51
Residential electrical contractors (238211)	101	615	$35,551,680	$57,768	0.57	0.56
Residential plumbing and HVAC contractors (238221)	194	2,367	$149,591,299	$63,212	1.18	1.28
Residential drywall contractors (238311)	32	183	$10,081,338	$55,215	0.5	0.51
Residential painting contractors (238321)	89	243	$10,674,778	$43,869	0.6	0.6
Residential flooring contractors (238331)	41	175	$9,208,485	$52,495	1.03	1.08
Residential finishing carpentry contractors (238351)	54	292	$19,351,576	$66,291	0.74	0.93
Other residential finishing contractors (238391)	20	127	$7,023,699	$55,523	1.1	1.09
Residential site preparation contractors (238911)	27	68	$3,857,275	$56,655	0.15	0.16

NAICS Industry Group (NAICS Code)	Annual Establishments	Annual Average Employment	Total Annual Wages	Annual Wages per Employee	Annual Average Employment Location Quotient	Total Annual Wages Location Quotient
All other residential trade contractors (238991)	58	364	$21,470,210	$59,025	0.63	0.68

Table 25: BLS NAICS Results for Combined Residential and Commercial Employment and Wages for Jefferson County in 2022 for Select Industry Groups.

NAICS Industry Group (NAICS Code)	Annual Establishments	Annual Average Employment	Total Annual Wages	Annual Wages per Employee	Annual Average Employment Location Quotient	Total Annual Wages Location Quotient
Commercial and institutional building construction (236220)	156	1,967	$164,599,211	$83,666	0.91	0.88
Building Foundation and Exterior Contractors (2381)	233	2,243	$142,203,839	$63,413	0.75	0.79
Power and communication line and related structures construction (23713)	31	676	$50,345,677	$74,439	0.93	0.79
Poured concrete structure contractors (23811)	49	598	$35,277,324	$59,025	0.77	0.74
Steel and precast concrete contractors (23812)	18	273	$20,176,793	$74,043	1	1.06
Framing contractors (23813)	19	59	$3,046,644	$51,711	0.27	0.29
Siding contractors (23817)	16	83	$5,234,069	$62,746	0.63	0.75
Building equipment contractors (2382)	549	8,584	$615,278,044	$71,677	1.15	1.19
Electrical and wiring contractors (23821)	201	2,925	$188,210,125	$64,344	0.92	0.85
Plumbing and HVAC contractors (23822)	292	4,875	$358,762,340	$73,595	1.28	1.41
Other building equipment contractors (23829)	57	784	$68,305,579	$87,106	1.65	1.71

NAICS Industry Group (NAICS Code)	Annual Establishments	Annual Average Employment	Total Annual Wages	Annual Wages per Employee	Annual Average Employment Location Quotient	Total Annual Wages Location Quotient
Building finishing contractors (2383)	351	1,908	106,991,046	56,065	0.73	0.72
Drywall and insulation contractors (23831)	50	419	23,751,294	56,686	0.55	0.5
Painting and wall covering contractors (23832)	112	412	$20,104,944	$48,848	0.64	0.62
Flooring contractors (23833)	52	260	$13,266,213	$51,106	1.02	0.91
Finishing carpentry contractors (23835)	69	382	$24,924,199	$65,247	0.76	0.89
Other building finishing contractors (23839)	40	290	$17,633,299	$60,909	1.09	1.12
Other specialty trade contractors (2389)	143	1,049	$64,540,979	$61,512	0.45	0.44
Site preparation contractors (23891)	52	505	$32,640,072	$64,634	0.42	0.43
All other specialty trade contractors (23899)	91	544	$31,900,907	$58,614	0.47	0.44
Building material and garden equipment and supplies dealers (444)	186	3,961	$169,576,653	$42,813	0.88	0.95
Real estate and rental and leasing (53)	1,459	6,546	$425,583,662	$65,016	0.89	0.83
Building inspection services (541350)	22	85	$3,206,983	$37,952	1	0.64
Engineering services (541330)	254	2,486	$235,952,421	$94,916	0.73	0.65
Architectural, engineering, and related services (5413)	427	3,944	335,082,319	84,969	0.78	0.67
Architectural services (541310)	67	387	$36,237,273	$93,636	0.62	0.61
Labor unions and similar labor organizations (813930)	60	573	$25,339,666	$44,255	1.74	1.5

Table 26: Ecosystem of Workforce Development Programs in Louisville.

Name	Overview	Details	Audience Type	Training Offered	Degrees/Certifications Offered
Iroquois High School - Plumber Assistant	This pathway prepares individuals to practice as licensed plumbers by applying technical knowledge and skills to layout, assemble, install, and maintain piping fixtures and systems for steam, natural gas, oil, hot water, heating, cooling, drainage, lubricating, sprinkling, and industrial processing systems in home and business environments. It includes instruction in source determination, water distribution, waste removal, pressure adjustment, basic physics, technical mathematics, blueprint reading, pipe installation, pumps, welding and soldering, plumbing inspection, and applicable codes and standards.	Plumbers and Electricians	K-12/CTE	In-person training; Apprenticeship	HS Diploma/GED
Iroquois High School - Skilled Trades Commercial Carpentry Track	The Carpentry TRACK pre-apprenticeship program creates streamlined postsecondary opportunities with Registered Apprenticeship training providers. After successfully completing a four-course sequence, safety modules or OSHA 10, and an end-of-program assessment, students will receive a pre-apprenticeship industry certification. Credit for prior learning is at the discretion of the training provider upon acceptance into a Registered Apprenticeship program.	General Construction	K-12/CTE	In-person training; Apprenticeship	HS Diploma/GED; Certification
Iroquois High School - Skilled Trades Construction Electrical Track	The Electrical TRACK pre-apprenticeship program creates streamlined postsecondary opportunities with Registered Apprenticeship training providers. After successfully completing a four-course sequence, safety modules or OSHA 10, and an end-of-program assessment, students will receive a pre-apprenticeship industry certification. Credit for prior learning is at the discretion of the training provider upon acceptance into a Registered Apprenticeship program.	Plumbers and Electricians	K-12/CTE	In-person training; Apprenticeship	HS Diploma/GED; Certification
Iroquois High School -	**No longer offered.** This pathway prepared individuals to apply	HVAC/R	K-12/CTE	In-person training	HS Diploma/GED

Name	Overview	Details	Audience Type	Training Offered	Degrees/Certifications Offered
Environmental Control System Technician	technical knowledge and skills to repair, install, service and maintain the operating condition of heating, air conditioning, and refrigeration systems. The pathway included instruction in diagnostic techniques, the use of testing equipment and the principles of mechanics, electricity, and electronics as they relate to the repair of heating, air conditioning, and refrigeration systems.				
Marion C. Moore School - Skilled Trades Construction Electrical Track	The Electrical TRACK pre-apprenticeship program creates streamlined postsecondary opportunities with Registered Apprenticeship training providers. After successfully completing a four-course sequence, safety modules or OSHA 10, and an end-of-program assessment, students will receive a pre-apprenticeship industry certification. Credit for prior learning is at the discretion of the training provider upon acceptance into a Registered Apprenticeship program.	Plumbers and Electricians	K-12/CTE	In-person training; Apprenticeship	HS Diploma/GED; Certification
Western High School - Residential Carpenter Assistant	**This school is transitioning OUT OF this CTE offering.** This pathway prepares individuals to apply technical knowledge and skills to layout, cut, fabricate, erect, install, and repair wooden structures and fixtures, using hand and power tools. The pathway includes instruction in technical mathematics, framing, construction materials and selection, job estimating, blueprint reading, foundations and roughing-in, finishing carpentry techniques, and applicable codes and standards.	General Construction	K-12/CTE	In-person training	HS Diploma/GED
Valley High School - Environmental Control System Technician (HVAC)	HVAC (Heating, Ventilation and Air Conditioning) equipment needs a control system to regulate the operation of a heating and/or air conditioning system. Students learn how to operate HVAC, including installing, troubleshooting, and repairs.	HVAC/R	K-12/CTE	In-person training	HS Diploma/GED

Name	Overview	Details	Audience Type	Training Offered	Degrees/Certifications Offered
Valley High School - Industrial Electrical Technician	In Valley's electrical technician pathway, students perform machine setup, troubleshooting, repairs, and preventive maintenance service. These students will learn how to read and interpret equipment manuals and work orders to perform maintenance and service. Maintenance mechanic students learn how to analyze and inspect equipment, structures, and materials to identify errors, problems, and /or defects.	Plumbers and Electricians	K-12/CTE	In-person training	HS Diploma/GED
Jefferson Community & Technical College - Construction Technology	The Construction Technology program is designed to prepare students for entry-level positions in the construction industry. Residential and light commercial construction applications are taught. This program includes instructional units in blueprint reading, building site layout procedures, foundation systems, light framing construction methods, exterior and interior finish systems, concrete forming systems, and construction safety. The community college also offers carpentry apprenticeships.	General Construction	Community College	In-person training; Apprenticeship	Diploma Available + Certificates available in: Basic Carpenter, Carpenter Helper, Construction Forms Helper, Residential Carpenter, Residential Roofer, Residential Site Layout Assistance, Rough Carpenter.
Jefferson Community & Technical College - Engineering and Electronics Technology Diploma	This program gives individuals the background to work as assistants to engineers or as liaisons between engineers and skilled craftsmen, and as plant maintenance specialists. The Engineering Technology degree allows students to tailor their degrees to their own interests while providing them with a broad understanding of technologies commonly used in industry. Degree + Mechanical Diploma and Certificates include basic electrical education and training.	Plumbers and Electricians	Community College	In-person training	AA/AS; Certification
Jefferson Community & Technical College - Heating & Air Conditioning Technology	Installing and servicing heating, air conditioning, and refrigeration equipment is the focus of this program. Academic courses, theory courses, and laboratory experiences are designed to promote success for students entering the heating and air-conditioning field. One required course is on Heat Pumps.	HVAC/R	Community College	Online training; In-person training	Certificates available in: Environmental Control System Service, Environmental System Repair Helper, Domestic Air Conditioner and Furnace Installer, Refrigeration Mechanic.

Name	Overview	Details	Audience Type	Training Offered	Degrees/Certifications Offered
Jefferson Community & Technical College - Plumbing Technology	Installing water supply and waste disposal systems in residential, commercial, and highly complex industrial sites is the focus of the plumbing program. In addition to practical experiences, instruction is given in laws and codes, blueprint reading, drawing, special equipment, and other related areas.	Plumbers and Electricians	Community College	In-person training	AA/AS; Certification. AS earns trainees 1 year towards 2 years of experience needed to become a Journeyman Plumber.
University of Louisville - Mechanical Engineering	Not specific to only HVAC.	Plumbers and Electricians	College/University	In-person training	BA/BS
University of Louisville - Electrical Engineering		HVAC/R	College/University	In-person training	BA/BS
University of Louisville - MS in Materials and Energy Science & Engineering	UofL's online M.S. in Materials and Energy Science & Engineering is a multidisciplinary program, designed to help professionals advance their careers, support the implementation of new energy technologies, and influence the quality of life worldwide. Topics include advanced energy materials, biofuels, biomass conversion, energy storage, solar energy conversion, solar fuels, and more.	Plumbers and Electricians	College/University	Online training	MA/MS
University of Louisville - Conn Center for Renewable Energy Research	The center advances the goal of renewable energy and promotes technologies, practices, and programs that increase efficiency for energy utilization. To accomplish these objectives, the Conn Center conducts and facilitates R&D on potentially commercializable renewable energy and energy efficiency technologies. The center promotes partnerships among colleges and universities, private industries, and nonprofit organizations to actively pursue federally and privately funded research and development resources that are dedicated to renewable energy solutions in 7 themes. Includes participation in Solar Decathlon.	Solar	College/University	Other	Other

Name	Overview	Details	Audience Type	Training Offered	Degrees/Certifications Offered
University of Louisville - Construction Operations	The certificate in Construction Operations within the Civil Engineering Dept. is designed to provide students with training in skill sets needed for construction-related duties, such as land survey, material testing, construction equipment, and construction management. The certificate will provide professional engineering career paths for civil engineering students and provide more opportunities for leadership roles in construction companies.	Solar; Energy Efficiency/Green Building (includes insulation)	College/University	In-person training	Certificate in Construction Operations
YouthBuild Louisville (Construction Trades Track)	GED & Pre-Apprenticeship program. YouthBuild Louisville students have the opportunity to build housing for low-income families and individuals in the community while getting career counseling and leadership training that will lead to college or employment. YouthBuild is completely different than a regular high school shop class. Training starts in the classroom, but then quickly moves off campus to a local job site. Students will learn about all aspects of residential construction on a real job site, gaining hands-on experience with power tools, deconstruction, foundations, framing walls and roofs, installing doors and windows and interior finishes, siding, and painting.	General Construction	Corps	In-person training; Work-based Learning; Apprenticeship	HS Diploma/GED; Certification; Job / Work Experience. Certifications provided: PACT, First Aid/CPR, HAZMAT, OSHA 10
Louisville Urban League - Kentuckiana Builds	Offers participants the opportunity to learn basic skills to equip them to start working immediately or go on to develop more specialized skills through apprenticeships and advanced training in fields like electrical, heavy machinery operation, fiber optic installation, among other options.	General Construction	Nonprofit	In-person training; Work-based Learning	Job / Work Experience
Whitney Young Job Corps Center - Building Construction Technology	HS Diploma + Pre-apprenticeship in Building Construction Technology. Experience includes maintaining and repairing machines, mechanical equipment, flooring, plumbing, electrical and HVAC systems, typically in large buildings. Also train to read blueprints.	General Construction	Corps	In-person training; Work-based Learning; Apprenticeship	HS Diploma/GED; Job / Work Experience
HVAC Associates	Technical training and continuing education for HVAC, plumbing, and electrical trades. Includes	General Construction	Industry Group/Company	In-person training;	

Name	Overview	Details	Audience Type	Training Offered	Degrees/Certifications Offered
	courses on indoor air quality, codes, combustion and venting, and heat pumps.			Professional Development	
Habegger Corporation Louisville	HVAC NATE Accreditation training, including continuing education	HVAC/R; Plumbers and Electricians	Industry Group/Company	In-person training; Professional Development	
Sheet Metal Workers Local #110	Apprenticeship program, covering sheet metal fabrication, welding, blueprint reading, and HVAC fabrication and installation	HVAC/R	Union/Skilled Trades	In-person training; Work-based Learning; Apprenticeship; Professional Development	Certification; Provides continuing education credits for journeymen; Job / Work Experience
United Association of Plumbers & Pipefitters, Local #502	Plumbing Apprenticeship	HVAC/R	Union/Skilled Trades	In-person training; Work-based Learning; Apprenticeship; Professional Development	Certification; Provides continuing education credits for journeymen; Job / Work Experience
Insulators Union - Local 51	Local 51 provides training programs and apprenticeships to ensure that its members are skilled and up-to-date with the latest insulation techniques and safety practices. **Industrial and commercial** insulation services covering 34 counties in Kentucky and 12 counties in Southern Indiana.	Plumbers and Electricians	Union/Skilled Trades	In-person training; Work-based Learning; Apprenticeship; Professional Development	Certification; Provides continuing education credits for journeymen; Job / Work Experience
IBEW Local 369 - Louisville Office	Electrical apprenticeship, training, and continuing education	Energy Efficiency/Green Building (includes insulation)	Union/Skilled Trades	In-person training; Work-based Learning; Apprenticeship; Professional Development	AA/AS (Associates Degree in Applied Science); Certification; Continuing Education Credits; Job / Work Experience;
LIUNA - Local 576	Training, apprenticeship, and continuing education for construction workers, including some energy projects	Plumbers and Electricians	Union/Skilled Trades	Online training; In-person training; Work-based Learning; Apprenticeship	Certification; Continuing Education Credits; Job / Work Experience

Name	Overview	Details	Audience Type	Training Offered	Degrees/Certifications Offered
Indiana Kentucky Ohio Regional Council of Carpenters (IKORCC) - Louisville Hub	Construction classes available for carpenters, millwrights, and floor coverers	General Construction	Union/Skilled Trades	Online training; In-person training; Work-based Learning; Apprenticeship	Certification; Continuing Education Credits; Job / Work Experience
Kentucky Career Center	Offers support to job seekers in Bullitt, Henry, Jefferson, Oldham, Shelby, Spencer, and Trimble counties in finding jobs, education, and training, and connects employers with skilled, qualified workers.	General Construction	General Job Seekers	In-person training; Support/Wrap-Around Services	Support with career counseling, creating resumes, interview skills, and employer connections
Small Business Association - Kentucky District Office	Offers support for small businesses and provides help with SBA services, including funding programs, counseling, federal contracting certifications, and disaster recovery. SBA also connects small businesses to partner organizations, lenders, and other community groups that can help them succeed.	General Workforce/Other	Economic/ Business Services	Professional Development; Other	

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