Final Report for RK Mellon Foundation

Residential 2030 District Pilot

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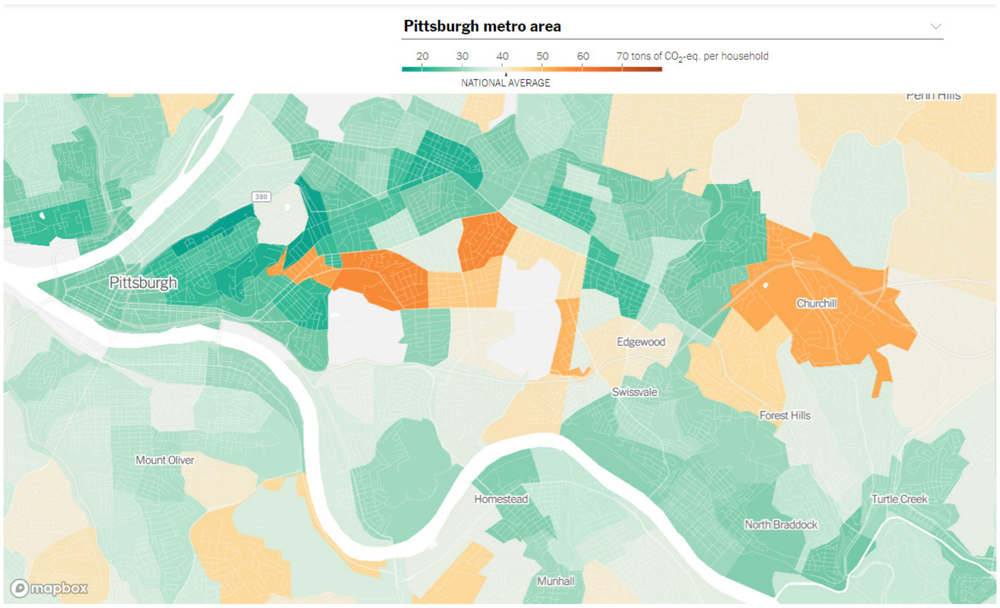
EXECUTIVE SUMMARY

Decarbonizing the built environment presents a tremendous opportunity and priority due to its significant impacts on climate change, human health, social equity, and economic vitality. Architecture 2030 states, "the built environment accounts for 50% of global CO2 emissions." This decade is critical if we are going to stem the impacts of climate change in an equitable way that leaves no one behind. Our region has not fully evaluated the residential sector on how best to scale energy efficiency to reduce energy burden, improve indoor air quality, and spur more economic development. Thanks to the support of the Richard King Mellon Foundation, Tri-COG Land Bank (TCLB) has partnered with Green Building Alliance (GBA) and Rebuilding Together Pittsburgh (RTP) to build upon each organization's expertise to develop a strategy to create a Residential 2030 District Pilot program within Woodland Hills School District. This collaboration builds off the success of the Pittsburgh 2030 District which focuses on community anchors such as commercial properties, cultural institutions, K-12 schools, and multi-family buildings to reduce their energy, water, and carbon emissions while improving indoor air quality. While the ethos of the Pittsburgh 2030 District program for non-residential sector remains the same, the barriers and implementation strategies within the residential sector vary significantly based on ownership, income, and motivation.

"While the ethos of the Pittsburgh 2030 District program remains the same, the barriers and implementation strategies within the residential sector vary significantly based on ownership, income, and motivation."

In the Fall of 2021, GBA approached TCLB about expanding the 2030 program to the residential sector, particularly in low-income and minority neighborhoods in the inner ring suburbs of Allegheny County. In its unique position as a land bank, TCLB has special legal abilities that make it easier to recover abandoned properties and steward them back to productive use. TCLB's inventory of vacant properties offers the opportunity to act as a testing ground to measure the impact of green building interventions and share best practices with homebuyers, contractors, elected officials, and nonprofit developers.

While many of the successes from the Pittsburgh 2030 District informed the initial approach to this project, we quickly learned that catalyzing energy efficiency updates in the residential sector is quite different. The residential sector has a wider variety of homeowner characteristics and concerns. While the tactical construction interventions themselves do not necessarily vary by demographic, the barriers to making those repairs and the incentives needed to motivate action do. As shown in the map below, wealthier neighborhoods tend to have larger houses and consume more energy, while lower-income communities use less energy because they have smaller homes and fewer resources to consume. The challenge in lower-income communities is the preservation of existing housing to ensure affordability and safety thus energy efficiency is not prioritized. Expanding the Pittsburgh 2030 District to a residential context offers a meaningful opportunity to move the needle on equity. In lower income communities, savings on energy bills can offset a significant portion of household expenses and also overlap with repairs that increase home health, safety and comfort.



This map shows average household emissions from transportation, housing, food, goods, and services, with the dark green having the least emissions and the dark red having the most emissions.[1]

Recognizing the need for a targeted implementation approach for different demographic groups, the addition of RTP to the core project team was an essential component of this planning endeavor. RTP's long standing expertise working in the lower-income context was crucial to developing a fuller strategy for the residential sector. Additionally, we leveraged the RTP energy sector staff expertise gained from the recent merger with Conservation Consultants, Inc. (CCI) which brought vast experience overseeing energy efficiency upgrades for low income homeowners. In this pilot, GBA serves as the primary clearinghouse of resources to serve homeowners and provide contractor education and training. For project implementation, GBA will be the primary entry point for middle- and upper-income homeowners and RTP will serve as the primary entry point implementation entity for low-income homeowners. TCLB will support the 2030 District

1. *https://www.nytimes.com/interactive/2022/12/13/climate/climate-footprint-map-neighborhood.html*

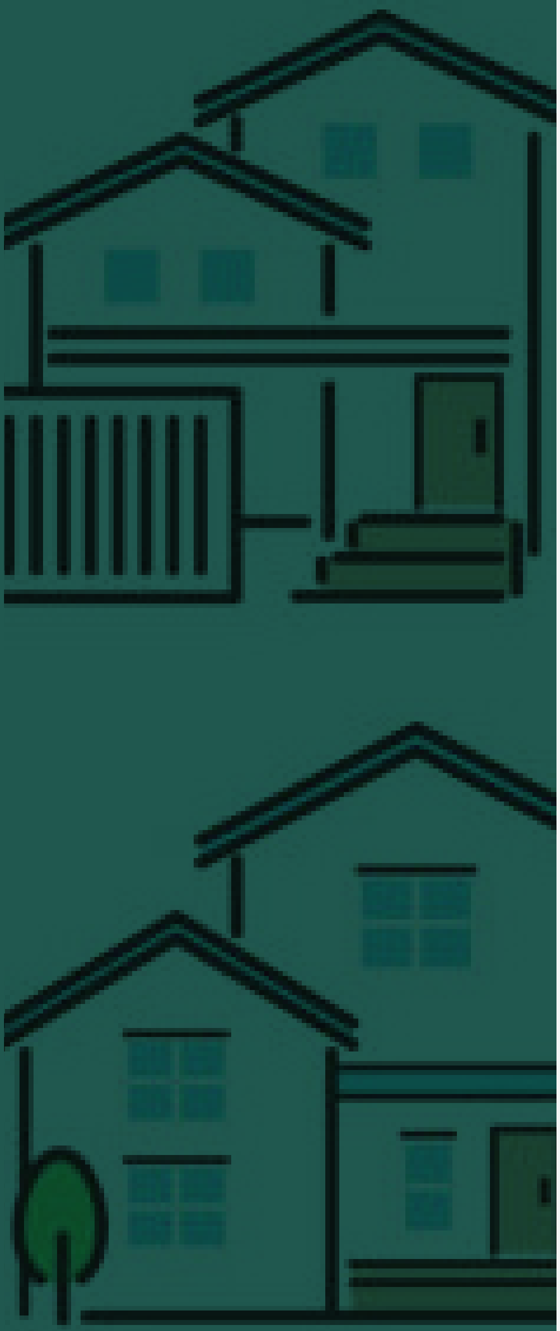
> "We may not understand the science, but we know how to fix just about anything. If you tell us what to do - insulation, windows, whatever - we have the skills to make it happen. We just need to be given better instructions."
>
> **Contractor Focus Group 2022**

by creating a pool of incentives for its property buyers to make energy efficiency upgrades and by launching a new initiative to do more of its renovations in-house to incorporate more green building techniques.

A key deliverable uniting all three organizations in the 2030 District is the Energy Efficiency Contractor Playbook, which outlines in detail the actions that will most improve building performance. This Playbook outlines a proven, prescriptive approach to residential renovations to improve energy efficiency no matter the housing characteristics. All three organizations will draw upon the Energy Efficiency Contractor Playbook, included in full in Appendix A, to define the interventions recommended to homeowners and contractors. The Playbook also divides recommendations into three "tiers" based on expected impact and estimated cost with renovations striving to achieve Tier 1 at a minimum. Tier 2 and 3 acknowledges which interventions may be more aspirational versus essential. These tiers allow TCLB to determine incentive amounts and how best to help homeowners and contractors to set priorities and implementation strategies.

By working together, all three organizations grew stronger through their involvement in this planning process. RTP's energy efficiency expert trained TCLB's property development manager to complete energy audits, building internal capacity as this project moves from the planning phase into implementation. The pilot projects between RTP and TCLB were a fertile testing ground for the interventions outlined in the Playbook, and the results underscored the impact of these techniques on improving building performance and helping low-income homeowners become more financially stable. GBA's experience with the Pittsburgh 2030 District and data modeling laid the groundwork for pushing the boundary of its existing program to bring best practices of green building design, energy efficiency, sustainability, and equity to the residential sector.

This report envisions a multi-layered approach to motivating homeowners to take action, building on existing research and best practices to connect nonprofits, developers, contractors, and community members with resources and technical assistance to bring a Residential 2030 District to fruition.



Part 1: A Conceptual Design for the

Residential 2030 District Pilot

BACKGROUND AND OVERVIEW

Tri-COG Land Bank revitalizes neighborhoods by transitioning abandoned properties to beneficial reuse.

TCLB is committed to a transparent and community-driven process that benefits both neighborhoods and their residents.

Green Building Alliance (GBA) positively transforms the world through the built environment to create a healthy, sustainable, and just future for everyone.

We envision a world where every building and community is sustainable so that every person can thrive.

Rebuilding Together Pittsburgh (RTP) has spent the last 28 years working to transform the lives of homeowners in need and the communities they call home.

A Residential 2030 District aims to improve energy efficiency by addressing user comfort, affordability, and equity issues associated with our region's aging housing stock. Historically, residential energy efficiency programs have been designed to address individual homes or dwelling units in any given community. While this "one-house-at-a-time" approach certainly does benefit individual homeowners and households, it does not achieve impact at the scale that is necessary to realize systemic change in residential energy use. The intent of the proposed Residential 2030 District is to realize energy efficiency at the scale of neighborhoods, communities, and municipalities. No single organization will have the capacity to achieve this goal so we must design and build a structural network of organizations which fill complementary roles.

This approach builds upon existing organizational strengths and established processes and the unique role each could play within the residential sector and a commitment to organizational collaboration and partnerships. Tri-COG Land Bank (TCLB) has the ability to acquire vacant properties within their service area and incentivize future homeowners on how and why energy efficiency is in their best interest. Rebuilding Together Pittsburgh (RTP)'s organizational charter states they support households at 80% Average Median Income (AMI) or below but in reality, they work in households 50% AMI and below. Their work is primarily subsidy-based and focuses on addressing home stabilization strategies. RTP has a strong network of contractors and a pipeline of work but additional proven interventions, funding, and training are needed to fully embed energy efficiency more holistically into their projects. Green Building Alliance (GBA) manages the Pittsburgh 2030 District, the largest district in North America. GBA focuses on commercial and community anchor institutions as well as multi-family housing properties. The program uses data, education, and technical expertise as its approach to scaling and showcasing continued progress.

In the Pittsburgh 2030 District, early adopters of the program became leaders that helped to motivate others to greater action. The majority of the target population could be persuaded to participate, but there will always be a group of stragglers who require mandates and/or heavy subsidies in order to make the desired changes. While the residential sector is more complex than the commercial sector for encouraging behavior change, the team expects that this overall trend will hold: there will be early adopters which will help to motivate the larger majority, and there will be a group that require subsidies to make these repairs possible.

All Residential 2030 District Pilot implementation partners share a commitment to sustainable development across multiple dimensions, including equity and neighborhood opportunity. We know that sustainable development IS equitable development, and we cannot leave behind predominantly low-income or non-white neighborhoods. This commitment guided our choice of the Woodland Hills School District as an initial pilot community.

A Residential 2030 District would accomplish its goals by grouping many single-family and multi-family buildings together into "district-sized" areas. Once assembled, these districts would be studied as a whole, and comprehensive energy efficiency (EE) plans would be developed accordingly.

Residential 2030 District Pilot is limited to the property types listed below:

- **Single-Families—occupied by Owner or Tenant**
- **Duplexes—occupied by Owner and/or Tenants**
- **Triplexes—occupied by Owner and/or Tenants**
- **Quadplexes—occupied by Owner and/or Tenants**

Multi-Family properties that are 5-units and above are invited to join the Pittsburgh 2030 District. The Pittsburgh 2030 District is open to all building owners in Western PA through a District Affiliate designation.

"All Residential 2030 District partners share a commitment to sustainable development across multiple dimensions, including equity and neighborhood opportunity.

We know that sustainable development IS equitable development, and we cannot leave behind predominantly low-income or non-white neighborhoods."

ADDRESSING EQUITY

With a growing body of research showing correlation between home zip code, life expectancy, and quality of life, the team understands that the health, success, and quality of life of residents relies upon a web of dependencies centered around the communities that have experienced direct environmental impacts from our industrial past as well as the loss of investment when those industries left. Allegheny County ranks in the top 2 percent in the US for cancer risk from air pollution which leads to higher asthma, cancer, respiratory, and other health risks. Not only does the built environment contribute to more than 50% of all global greenhouse gas emissions, it is also one of the strongest social determinants of health and well being. While energy efficiency and decarbonization of the region's commercial and industrial sectors will have significant impacts on the air quality and environment, it is imperative to highlight the equity and public health impacts of working to make the residential sector a critical priority.

In the Pittsburgh region, 61% of the housing stock is over 100 years old.

In the Pittsburgh region, 61 percent of the housing stock is over 100 years old; the majority of which are energy inefficient, with high maintenance costs due to aging systems. The age and quality of our city's housing stock leads to higher year-round energy bills, with 40% of Woodland Hill School District residents living under the poverty line, this inevitably causes a disproportionate energy burden. The lack of investment in area houses means lead, mold, and radon concerns may go unaddressed which may contribute to ongoing health issues as well. The challenge in lower-income communities is the preservation of existing housing to ensure affordability and safety thus energy efficiency is not prioritized. Expanding the Pittsburgh 2030 District to a residential context offers a meaningful opportunity to move the needle on equity. In lower income communities, savings on energy bills can offset a significant portion of household expenses and also overlap with repairs that increase home health, safety and comfort.

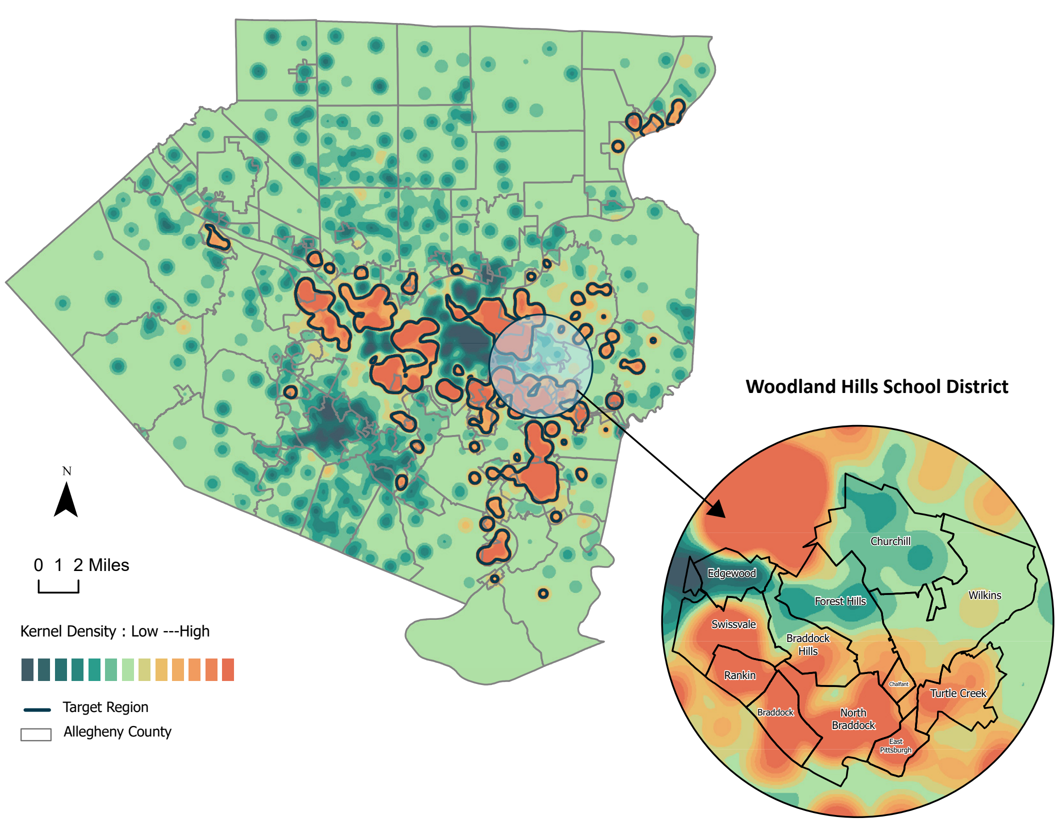
40% of Woodland Hill School District residents live under the poverty line.

Expanding the 2030 District to these residential contexts offers a meaningful opportunity to move the needle on equity. In lower income communities, savings on energy bills can offset a significant portion of household expenses and also overlap with repairs that increase home health, safety and comfort.

ESTABLISHING COMMUNITY BASELINES:
SOCIAL VULNERABILITY

As part of this planning process, we established community baselines for each municipality within the Woodland Hills School District (WHSD). WHSD is an ideal pilot location because it contains a mix of economic classes and neighborhood market conditions. The map below illustrates the racial and socioeconomic diversity within WHSD (additional demographic maps are available in Appendix B.) This Social Vulnerability Index was calculated using five indicators: race, poverty, vacancy, real estate market strength (based on the Allegheny County Market Value Analysis), and property condition. The map illustrates a contrast between middle- and upper-middle class communities like Forest Hills and Churchill and historically redlined communities like the Boroughs of East Pittsburgh, North Braddock, Rankin, and Swissvale. By piloting the Residential 2030 District in an area of Allegheny County with a variety of neighborhood conditions and demographic makeups, we will ensure that we are developing an approach that is adaptable enough to scale and ultimately expand across the region beyond WHSD alone.

Allegheny County Social Vulnerability Index Map



Social Vulnerability Index Indicators:

1. **Black Population**
2. **Household Poverty**
3. **Vacancy**
4. **Market Value Analysis (MVA)**
5. **House units with Poor Physical Conditions.**

All indicators have been standardized with equal weighting for each indicator (20%).

The color ranges from dark blue to red based on the density of each indicator.

The higher density areas (red areas) indicate that the number of each indicator is relatively high demonstrating the regions in the most need.

Data Sources:

1. Black Population:2020 Census data, B02009, https://data.census.gov
2. Poverty:2020 Census data, B17017, https://data.census.gov
3. Poor Physical Condition: No fuel house unit B25040 + No Internet house unit B28002 + No completely plumbing facilities house unit B25047, 2020 Census data, https:// data.census.gov
4. Vacancy: 2020 Census data B25002, https:// data.census.gov
5. MVA 2021: Economic Development Allegheny County, https://www.alleghenycounty.us/economic-development/mva.aspx

ESTABLISHING COMMUNITY BASELINES:
Approach

Determining a community's progress towards reducing energy use and carbon emissions requires an initial point of comparison, or baseline. Baselines can be an agreed-upon national average from a specific point in time, or they can be established with the earliest collected actual data. GBA set out to determine both a widely accepted national average AND the actual earliest collected data (local baseline). Both baselines take into account climate zone and building use type and are normalized for weather and building size.

National baseline for a single family home is 46-51 kbtu.

We began by identifying the predominant residential building types (Single Family, 2-, 3-, 4-Family, Townhouse, Apartment, Condominium) and quantities of each type using the Allegheny County Real Estate Assessment data. We cross-referenced the quantities against municipal utility use data from Duquesne Light which provided the number of residential accounts. We divided the residential building types into two categories: Multi-Family or Single-Family and estimated the average living area for each type.

Woodland Hills School District single family homes ranged between 95-108 kbtu.

Because this study is an outgrowth of Architecture 2030's mission to "rapidly transform the built environment from the major emitter of greenhouse gasses to a central solution to the climate crisis," we relied upon the baselines established by Architecture 2030 using Zero Tool (www.zerotool.org). Architecture 2030 developed the Zero Tool to compare a building's energy use intensity (EUI) with similar building types and set EUI targets.

The Zero Tool sets baselines using the EPA's Energy Star Portfolio Manager Commercial Building Energy Consumption Survey (CBECS) 2003 dataset, an industry baseline which has been agreed upon by most building sector organizations including Architecture 2030, American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE), American Institute of Architects (AIA), and US Green Building Council (USGBC). GBA identified Zero Tool baselines for Multi-Family (81.45 kbtu/SF/year) and Single-Family (46 to 51 kbtu/SF/year) building types and pro-rated the baselines in each WHSD community to account for the relative living area of each building type.

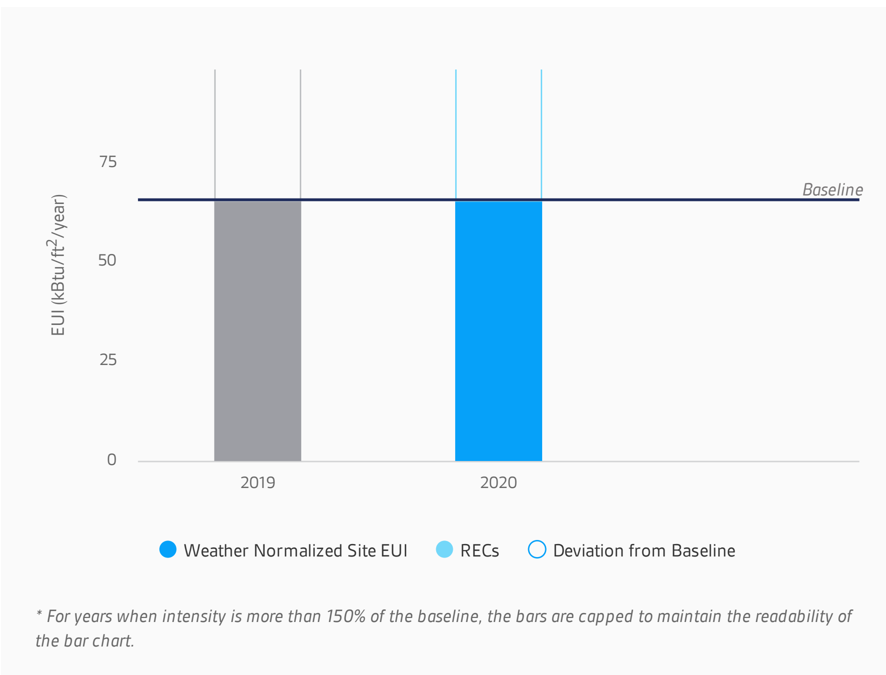
GBA then set out to understand the actual energy performance of each community. GBA obtained aggregate residential electricity use by each community from Duquesne Light for 2019-2020. GBA was unable to obtain aggregate gas use from the local gas utility (Peoples Gas, an Essential Utilities

Company) due to its refusal to provide data. To work around this lack of data, GBA used 2018 gas data from Sharpsburg and Millvale to estimate an average gas use in each municipality. GBA's calculation of the average energy use intensity ranged from 95 kbtu/sf/year to 108 kbtu/sf/year; well above the national average baseline from Zero Tool. An example for the Borough of Braddock is shown below, and the full report for all municipalities in WHSD is available in Appendix C.

Braddock Municipal Energy Baseline

Energy Report: ENERGY STAR® Portfolio Manager® Report

The graph below summarizes annual energy performance over time relative to building intensity baselines and targets.



Baseline

65.4 EUI

kBtu/ft²

2020 Performance

104.4 EUI

↑ 59.65% above the baseline (with RECs)

2019 Performance

99.8 EUI

↑ 52.61% above the baseline (with RECs)

This calculation will set the stage to evaluate future progress, both in the changes to energy use (kbtu/sf/year) as well as changes to emissions (kg CO2e/sf/year). Because the local baseline accounts for the local climate zone and local weather, we recommend tracking future progress against the local baseline. The biggest limitation that this study has revealed is the lack of cooperation by the gas utility company to provide aggregated municipal usage. This lack of data will hamper the ability to assess community-wide progress on energy and emissions reductions.

ENERGY EFFICIENCY CONTRACTOR PLAYBOOK

Through our research and discovery process, it quickly became clear that building characteristics and type do not dramatically impact recommendations for what should be done to increase energy efficiency. This realization enabled the team to focus on the known barriers to energy efficiency and how best to address them. One solution was creating the Energy Efficiency Contractor Playbook that establishes core prescriptive interventions that should occur in residential buildings regardless of income level or demographics.

While all three "arms" of the Residential 2030 District will operate independently, they are united through shared standards set by the Energy Efficiency Contractor Playbook, shared branding, and shared commitment to the best practices and core values of the work. This approach allows each organization to execute the principles of the Residential 2030 District in the way that best aligns with its mission while still contributing to the momentum created by a larger joint initiative.

The Playbook is organized by parts of the house, building envelope, heating systems, etc. The Playbook focuses primarily on recommendations for whole house rehabilitations, since those are the renovations that offer the greatest opportunity to dramatically decrease a property's energy footprint. For example, some of the highest impact interventions, such as air sealing, are most effective when done at the time of whole home renovation but acknowledge that is not always an option when most homeowners renovate one room at a time.

The Playbook is comprehensive and outlines strategies that are applicable to occupied homes. All three partners in this initiative will draw upon the Playbook when creating programming, offering incentives, and, in conjunction with a home energy audit, advising homeowners on repairs that will have the biggest impact on their home's energy performance. Recognizing that not every property owner has the same capacity to make repairs, the Playbook also groups interventions into multiple "tiers" based on their estimated cost and their expected impact on the home's energy efficiency. This helps to set strategy for which repairs the Residential 2030 District should emphasize the most and how to match groups of repairs with other cash and behavior-based incentives to compel homeowners to take action.

A 2022 Rebuilding Together Pittsburgh report found homes rehabilitated by Pittsburgh nonprofits averaged a Home Energy Score (HES) of 2.9 on the scale of 1 to 10, with 10 being most efficient.

The Pennsylvania average score is 4 and indicates major missed energy efficiency opportunities, such as air sealing and hot water heat pump upgrades.

Furthermore, the Contractor Playbook provides in-depth explanations on best practices for contractors to achieve the performance needed to meet Residential 2030 District goals. This high level of detail was found to be necessary in response to a study conducted by Rebuilding Together Pittsburgh in 2022 that found homes rehabilitated by nonprofits in Pittsburgh averaged a Home Energy Score of 2.9 on the scale of 1 to 10, with 10 being most efficient. This falls below the Pennsylvania average score of 4 and indicates major missed energy efficiency opportunities, especially in air sealing and including an upgrade to a hot water heat pump for water heating.

These findings were echoed and expanded when the team held a focus group with local contractors. At this focus group, contractors expressed an interest in attending training on whole house renovations and a desire for a standardized set of instructions with specific guidance on proper techniques. The barriers to energy efficiency are not only the cost of the interventions, but also a lack of widespread contractor education on how to execute the interventions in a way that will effectively maximize their impact. In the focus group, the contractors expressed a desire for very direct, specific instructions that are organized and consistent across project sites. Thus, the Contractor Playbook was designed to serve multiple purposes: to set standards for the partner organizations of the Residential 2030 District to uphold, while providing the education needed for contractors to effectively implement those standards and achieve performance goals. A few examples of the tiered recommendations are outlined below:

TIER 1 (Most Important Specifications) Examples

- Air Seal both conditioned and unconditioned space in attic
- If windows are replaced, install 3-pane U value 0.2 or less
- All HVAC ducts should be air sealed and located in the thermal envelope
- All bathrooms should have an Energy Star exhaust fan vented outdoors

TIER 2 (Desirable Specifications) Examples

- Air Seal and Insulate porch roof connections to interior walls
- Upgrade appliances to energy star certified and low-energy use
- Install induction cook stoves
- Install airtight outlet boxes when electric system is redone

TIER 3 (Advanced Specifications) Examples

- When replacing a roof with a finished attic, install rigid exterior insulation
- During siding replacement, walls shall be insulated with spray foam
- Home shall be equipped with heat recovery ventilation
- If hot water heat pump is not feasible, install tankless gas hot water heater

IDENTIFYING AND REMOVING BARRIERS:
Brand Recognition

One of the most impactful elements of the Pittsburgh 2030 District is the strength of its brand, and how that brand was leveraged to create a sense of shared purpose, motivation, and community amongst participants. While "branding" is itself a more "corporate" term, for homeowners the same sense of group belonging and pride can be fostered with yard signs for participating households and regular convenings, led by GBA, where homeowners will share best practices and success stories. This process provides a forum for the early adopters to motivate later adopters to sign on and deepen their commitment, and for everyone in the group to share resources and celebrate their accomplishments.

The community baseline establishes a starting point for the community to collectively establish energy efficiency goals while simultaneously helping to break down their known barriers together. This allows for community-wide organization with a series of monthly education sessions that can introduce the Residential 2030 District concept, methodologies, and performance goals. It is important to work within areas with established Pittsburgh 2030 Partners, especially community anchors, places of worship, and schools as it provides direct connection to parents, employees, and daily building users. Additional outreach via direct fliers to property owners within the community by attending local community meetings will serve as the primary recruitment strategy.

Overcoming Energy Efficiency Barriers

The Residential version of the 2030 District will share some similarities with GBA's Pittsburgh 2030 District, including the provision of technical assistance to property owners, the 2030 District branding, collecting and tracking data to demonstrate progress, and shared education and celebration of successes. However, as the team reviewed the latest research on what motivates homeowners to undergo energy efficiency upgrades, it became clear that additional thought and consideration would be needed to make this approach work in the Residential sector. The team reviewed common barriers preventing homeowners from making energy efficiency upgrades and developed an approach from a shared understanding of best practices in the field. A full summary of these barriers is available in Appendix D, and the chart on the next page summarizes how the Residential 2030 District will begin to address them.

KNOWN BARRIER	RESIDENTIAL 2030 DISTRICT SOLUTION APPROACH
Homeowners lack understanding and are unsure how to prioritize improvements.	• GBA will provide technical assistance to interested homeowners, ensuring that the planned renovations have an energy savings impact.
Efficiency information is not catching the homeowner's attention.	• Residential 2030 District will employ strategies to tie affordable energy efficiency with social belonging and identity, building a community around energy efficiency that will help to motivate homeowners to take action.
Complexity of interdependent property components and finding contractors to deliver optimal solutions.	• GBA's technical assistance will help homeowners navigate the complexity of whole home repairs and maximize the impact of upgrades. • GBA will match homeowners with vetted contractors, eliminating the need for the homeowners to collect multiple bids and attempt to identify quality contractors on their own. • The Contractor Playbook sets renovation standards for the contractors to follow and outline best practices.
Lack of an easy, affordable way to pay for upgrades and to address any structural barriers to energy efficiency renovation (ie, knob and tube wiring).	• GBA serves as resource and financial clearinghouse for energy upgrades and home repairs. They will directly assist homeowners in accessing tax credits, grants, and loans to finance needed upgrades.

IDENTIFYING AND REMOVING BARRIERS:
Low-Income Homeowners

The barriers previously outlined assume that the homeowner has the resources needed to make upgrades and motivation is the sole challenge. Low-income homeowners face additional barriers as well. To serve low-income homeowners, an entity is needed to leverage and unlock funding to make these repairs possible.

Additionally, in many cases, low-income homeowners have multiple repair needs, making it difficult to prioritize energy efficiency without other trade-offs. The chart below pulls from a data sample of applications received from RTP for repairs within the WHSD. As shown, the majority of applicants needed to have many repairs addressed at once in addition to energy efficiency:

Data Group	Number	Classification	Roof	Gutter/ Downspout	Exterior	Water in Basement	Heating	Electrical	Interior	Tripping Hazards
Need based on WHSD Homeowners assessment	66	In need of repair	55%	45%	70%	53%	24%	30%	76%	24%
		No need for repair	45%	55%	30%	47%	76%	70%	24%	76%
Need based on RTP assessment	20	In need of repair	45%	70%	90%	90%	30%	35%	75%	25%
		No need for repair	55%	30%	10%	10%	70%	65%	25%	75%

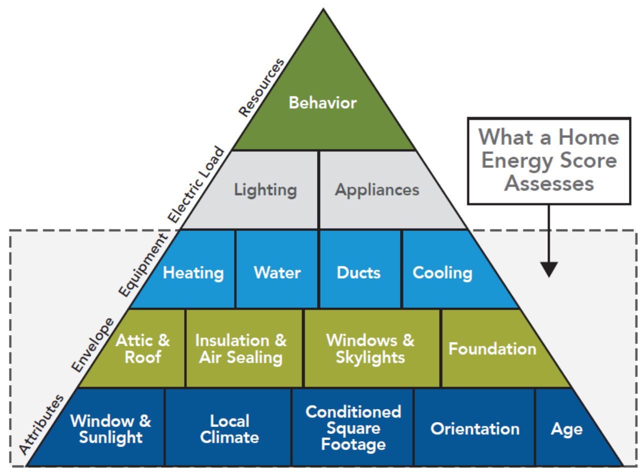
In an area with aging housing stock that has often gone years without maintenance, the need for multiple repairs at once is underscored further. While TCLB's properties are not occupied by anyone, they are often located in low-income neighborhoods and thus may be representative of some of the challenges low-income communities face when undertaking sustainable revitalization initiatives.

To evaluate the potential impact of energy efficiency upgrades on TCLB's properties, we used an unbiased professional software modeling tool developed by the Department of Energy called Home Energy ScoreTM (HES). Like a miles-per-gallon rating for a car, the Home Energy Score is based on a standard assessment of energy-related assets in each home to easily compare energy use across different homes, with a Score of 1 indicating least efficient, and a Score of 10, most efficient homes.

The actual energy used by the house was not available (these are abandoned properties) and was not factored into the Score, whereas the fixed assets of the home (such as the square footage, building materials, insulation levels, and major fixed equipment like furnaces and water heaters) were modeled through building energy software to estimate home energy performance. See Figure below for further details on what is included in the Score. This helps to set strategy for which repairs the 2030 District should emphasize the most and how to match groups of repairs with other cash and behavior-based incentives to compel homeowners to take action.

The Home Energy Score tool also generates automatic recommendations if they meet an estimated simple payback of 10 years or less to implement. The energy saving potential is estimated at 42% annually, which could save the future homeowner $589 per year in energy costs.

In low income neighborhoods, these cost savings are even more impactful because utilities make up a larger portion of the household budget and there is usually no room to spare for unnecessary spending.



House Address	Home Energy Score	Predicted Annual Energy Cost (pre-inflation)	Energy Saving Potential	Annual Energy Cost Savings Potential	Recommended Improvements
2342 Buena Vista St. Swissvale	2	$1814	46%	$566	Attic Insulation, Air tightness, Ducts, Better water heater, furnace, AC, insulation w/roof replacement
1172 Grandview Ave, Braddock	5	$1331	35%	$253	Air tightness, Attic and roof insulation, new water heater
650 Mortimer Ave, Turtle Creek	2	$1713	53%	$630	Attic insulation, Air tightness, Ducts, Better water heater, furnace, Wall insulation, Low-e Storm Windows
34 Chartiers Ave, Rankin	1	$2561	44%	$841	Attic insulation, Air tightness, Ducts, Better water heater, furnace, AC
609 Sunnyside Ave, East Pittsburgh	1	$2960	45%	$1008	Attic insulation, Air tightness, Ducts, Better water heater, Wall insulation
113 Center St., East Pittsburgh	4	$1607	27%	$238	Attic insulation, Air tightness, Better water heater
Averages:	**2.5**	**$1998**	**42%**	**$589**	

The table above outlines the results obtained for six TCLB properties analyzed using the HES tool.

1.Expressed in terms of so-called "source energy" savings. Source energy is energy needed to generate energy used at a "site", that is, in a home, and accounts for energy losses in the generation and transport.

Part 2: Implementation Strategies

Residential 2030 District Pilot

RESIDENTIAL 2030 DISTRICT IMPLEMENTATION:
Overview

While the building interventions do not vary significantly based upon on the region's housing stock, the implementation and engagement strategies will. This section of the document builds upon each organization's charters, leverages current execution strengths while acknowledging known gaps within the residential sector. Green Building Alliance (GBA) will serve as the main point of intervention for occupied middle-income homeowners, Rebuilding Together Pittsburgh (RTP) will focus on occupied low-income homeowners, and Tri-COG Land Bank (TCLB) demonstrates implementation strategies for vacant properties.

Occupied Middle-Income Homeowners

Many middle-income households (60 AMI – 120 AMI) often either lack access to capital or are reserving these funds for emergencies. Families within this income bracket are focused on paying down debt and increasing savings and are not prioritizing non-emergency energy efficiency improvements. Often, these homeowners are risk adverse and cautious depending on their personal upbringing and relationships with money. Eighty-three percent of middle-income families own or rent single-family units. This presents a unique opportunity to scale impact by increasing energy efficiency, decreasing energy burden, and improving air quality. Current incentives and rebates are helpful in aiding homeowners that have been debating when to move forward on their energy efficiency improvements.

Currently, there is not a consistent technical advisor for the residential sector to provide resources, materiality sourcing, and recommended contractors with verified energy efficiency skills and green building experience. GBA would like to use the Residential 2030 District to establish a process and the engagement tools to assist homeowners. In this capacity, GBA would serve as the primary resource and expert for energy efficiency communications, energy use and metric tracking, renovation strategies, construction financing and tax credits/rebates utilization.

Through this project, GBA would be responsible for:

- **Community outreach, education, and organizing**
- **Data collection and data analysis**
- **Project planning and management**
- **Coordination with program contractors**

Specifically, GBA will conduct the following activities to assist middle class households:

Project Assessment and Planning

Once homeowners are identified and fully committed, they would sign a non-binding agreement (District Partner Pledge) and share two years of utility bills with GBA so an individual property baseline can be created. Once the baseline is established, the property owner will complete an energy audit by a certified professional who will provide a detailed report and projected cost analysis. This individualized energy efficiency roadmap identifies the highest impact renovations for reducing their energy burden.

Next, GBA staff will review the energy audit and work alongside the property owner to further assess and document any additional needed improvements and develop renovation plans that align with their identified priorities and funding. It is important to note that addressing moisture, mold, lead, and radon or other environmental factors should be addressed prior to or in conjunction of any energy efficiency improvements.

All property owners will be equipped with the Contractor Playbook to outline the appropriate prescriptive solutions they should be following as they start to make improvements within their houses. It is our recommendation that middle-income properties should ensure that Tier 1 (Most Important) improvements are completed as a baseline while adhering to Tier 2 (Desirable) Specs and Tier 3 (Advanced) where feasible based on the property's building characteristics.

As multiple property owners participating in Residential 2030 District cohort complete their energy audits and establish renovation plans, GBA will develop a community-scale renovation plan in which the individual home renovations are coordinated with each other (to the greatest extent possible) in relation to project scope and timing. This will maximize effective cost-sharing for property owners as contractors will have a higher amount of confirmed work with less mobilization costs. A final community-scale renovation plan—which includes all project sites, a renovation and construction management schedule, insurance policy revisions, and financing models will help keep property owners accountable and supported as they move towards implementation.

Implementation and Evaluation

In accordance with the community-scale renovation plan, GBA staff will collaborate with the individual property owners to carry out the energy efficiency renovation projects and conduct a post-renovation evaluation to document work completed. During this evaluation, property owners will be advised on how to properly operate and maintain their systems to maximize energy efficiency benefits.

GBA has strong data and tracking mechanisms established for all programming, and for the Residential 2030 District, staff would evaluate impact both on the individual and community-scale. Each year, the property owner would continue to share their utility data with GBA, to calculate dollars saved which demonstrates a reduction in energy burden per household. Staff can examine the renovations that have occurred and evaluate the respective impact and further evaluate which solutions are best suited for our region's housing stock.

An aggregate of the individual renovation projects can be further analyzed to measure the impact on the community-scale on overall energy and carbon reductions against our established baseline. These tangible results, backed by data, will spur more investment and energy efficiency improvements within the community. This ongoing analysis will allow GBA to critique, revise, and improve the Residential 2030 District program for middle- and upper-class homeowners.

Occupied Low-Income Homeowners

Rebuilding Together Pittsburgh's extensive experience serving homeowners with incomes at or below 200% Federal Poverty Guidelines (or, roughly at or below 50% of Area Median Income) informs this proposal. The homeowners may be elderly, residing in their homes for a long time but unable to keep up with maintenance, or family members who inherited or bought a home in some level of disrepair. RTP uses state and local funding to stabilize and repair these homes, within allotted budgets. Funding comes from the Federal Home Loan Bank, McAuley Ministries, PA Department of Community and Economic Development, PHARE, and other sources. However, while the programs provide for protection from moisture, system and equipment upgrades, kitchen and bath renovations, and addressing health, safety, and accessibility, energy efficiency and climate resilience are not frequently addressed as other needs are more pressing. RTP proposes to turn every opportunity to serve low-income homeowners into an opportunity to also include energy reduction measures in order to meet the Residential 2030 District goals.

Each project will seek the low hanging fruit of upgrading lights to LEDs, installing programmable thermostats, executing air sealing and/or higher performance door and windows, etc., which, if already being replaced for the homeowner, only incrementally increases the cost of home repair. For example, a 50% more efficient 3-pane window costs ~$250, compared to a basic window cost of ~$200, and installation cost is the same. Air sealing may require an additional blower door evaluation and identifying the biggest leaky areas in the house, but it is also relatively low cost. We propose to create an "air sealing specialist" position at RTP to train and dedicate one project coordinator staff for this task. Twenty percent of finished projects could be re-measured to estimate energy efficiency gain. Implementing these energy efficiency focused steps and process changes could also spur the adoption of the same approach in regions beyond WHSD and motivate other funders to embark on similar attention to energy efficiency.

The Inflation Reduction Act (IRA provides $4.5 billion for its High-Efficiency Home Rebate Program.

To achieve higher than "low hanging fruit" efficiency, RTP also proposes to leverage available funding to:

Maximize Available Rebates

Low-income homeowners have less tax liability wherein tax breaks are not going to have as much of a financial impact the way current available rebates may. RTP recommends developing a strategy for an administrative effort to coordinate and help low-income homeowners take advantage of the generous rebates available for electric system/appliance purchases and energy efficiency upgrades. The recently passed U.S. Inflation Reduction Act provides $4.5 billion for its High-Efficiency Electric Home Rebate Program. The maximum rebate is $14,000 per household, and individual rebates are as follows:

- Heat pump water heaters: $1,750
- Electric stoves: $840 (LdB: induction stoves)
- Heat pump clothes dryers: $840
- Electrical panel upgrades: $4,000
- Insulation, air sealing, and ventilation: $1,600
- Electric wiring: $2,500

It is critical to maximize IRA's and Infrastructure Investment and Jobs Act funding for contractor and project managers training on energy efficiency and indoor air quality, and home renovation projects.

These rebates cannot be combined with other federal grants but there is no prohibition on combining these rebates with the state or other types of funding. While these rebates do not cover the full cost nor the installation cost of the appliance or system, they go a long way in reducing the overall cost of these measures and would result in markedly better efficiency outcomes per home. Utilizing these rebates for electrical system upgrades would also free some funding that is currently dedicated to these repairs within RTP projects.

Increase Home Performance

Some homes could be better served by utilizing the HOMES portion of the IRA funding instead of rebates. For example, if the home requires a furnace upgrade, and that is funded through a state grant and provides for 10-15% improvement in the efficiency, the HOMES program would deliver $8,000 per household if the efficiency gain can be increased to 30% or more. That level of extra funding could be utilized to air seal and add insulation in the attic and/or walls, and the 30% gain would be more or less assured. To pursue this goal would require funding of a program manager and energy auditor (either part time or two functions combined into one) position at RTP to provide necessary software modeling predictions required in HOMES and to administer the program.

Remove the Structural Barriers to Energy Efficiency

Some households who might otherwise qualify for the state or federally funded weatherization services are unable to be served because their homes do not meet safety or prerequisite infrastructure requirements. Services are also typically restricted to meet the program sponsor's cost-effectiveness requirements, limiting the spending to those measures that directly produce the energy efficiency gain. Utilities tasked with implementing these programs and weatherization agencies report that they are unable to serve around 25% of households (so called "deferred" households) for these reasons.

Potential structural barriers that may exist in homes include:

- **Knob & tube.** Updating electrical to remove knob & tube in just the attic may cost $2K-$5K per home. For removal in the whole home, the cost may range from $10K-$20K. There are no energy savings associated with this removal, and its presence prevents air sealing and attic insulation without additional expense.
- **Sewer or foundation drainage issues.** Not addressing water and sewer issues can result in wet basements and addressing these issues may take $5K-$20K. New downspouts and gutters may run $2K-$4K. There are no energy savings associated with these improvements, but their presence prevents basement-level improvements like an upgrade of old heating equipment or air sealing.
- **Leaky roofs**. Similar to basement issues, water damage in the attic prevent installation of weatherization measures and can cost roughly $12K-$17K to replace.
- **Mold.** Mold remediation may roughly cost $5K-$10K. Mold is typically due to not addressing water issues within the structure.
- **Asbestos** (including vermiculite insulation in the attic). While the insulation level is too low for today's energy standard, a highly specialized removal would be required, and most programs never address it.

Investing in removal of these barriers could potentially unlock utility and state weatherization services while substantially improving household residents' health and comfort. These programs are more likely to serve high energy users. It would therefore be more effective to partner with utilities and directly focus on users they select. Homeowners would need to commit to accepting weatherization in order to receive these other services, like new roofs. The goal would be to remove the backlog of deferred homes and unlock multiple funding sources per home.

Among the utility companies, currently only Columbia Gas funds removal of these structural barriers in order to enable weatherization services. The recently adopted Whole Homes Repair Program in PA, with up to a $50K grant per household, may be able to provide funding to remove barriers. Additionally, some funds through the American Rescue Plan or other less structured programs and block grants may permit the removal of the barriers outlined above.

Typically, the Weatherization Assistance Programs (WAP) and Low-Income Usage Reduction Program (LIURP) spend on the order of $7K-$12K (pre-inflation) per household to achieve the program's 15-20% weatherization goals. As can be seen from these quoted approximate costs, home repairs and removal of structural barriers do cost much more than energy efficiency expenditures.

"the Weatherization Assistance Programs and Low-Income Usage Reduction Program spend on the order of $7K-$12K (pre-inflation) per household to achieve the program's 15-20% weatherization goals"

Expand Solar Utilization

RTP recommends diversifying its energy reduction approach by including solar installations in Environmental Justice communities. The IRA provides tax credits that are now directly payable to nonprofit organizations that don't owe federal taxes, with cost discounts for solar that can amount to up to 60% of the total solar project cost for domestic hardware and "low-income economic benefit projects." This will spur more investment in affordable energy solutions once a homeowners has addressed their home's energy efficiency needs.

Vacant Property Strategies

Tri-COG Land Bank (TCLB) has special powers enabled by state legislation to recover abandoned properties, clear their title, and return them back to productive tax paying status. In 2012, the Steel Rivers Council of Governments and Turtle Creek Valley Council of Governments produced a Cost of Blight Study that found that vacant, abandoned, and deteriorating properties cost our communities a total of $19.3 million in direct costs per year, with an additional $218 – 247 million lost to surrounding property values, eroding a powerful source of wealth for local residents[1]. These properties are the most highly concentrated in non-white communities, exacerbating wealth gaps among groups that have historically faced systemic barriers to homeownership and economic mobility. Additionally, a growing body of research shows that living in proximity of blighted and deteriorating properties increases a person's risk of being a victim of violent crime[2] and developing chronic illnesses like diabetes, hypertension, heart disease, and depression[3].

Many of the properties TCLB acquires require full rehabilitations. This presents a key leverage point to optimize the energy efficiency of the properties at the time of renovation, when multiple repairs already need to be made and the incremental cost of layering energy efficiency improvements on top of those repairs is lower than it otherwise would be in an occupied house.

At this time, TCLB does not do most of the renovations on its properties itself. Instead, it sells the properties "as is" and requires all applicants for the property to submit a Renovation Plan detailing the repairs they will make and approximate costs. TCLB also provides a Property Assessment Report with each property that lists repairs needed to bring the property up to code. This report is created by TCLB's Property Development Manager, a former Code Enforcement Officer. Applicants can reference the Property Assessment Report as they develop their Renovation Plan.

1 *Delta Development Group, 2013, https://www.tricoglandbank.org/resources.*
2 *Branas et. al., 2016, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5104992/.*
3 *de Leon and Shilling, 2017, https://www.urban.org/sites/default/files/publication/89491/2017.04.03_urban_blight_and_public_health_vprn_report_finalized.pdf*

TCLB proposes the following methods to integrate the Residential 2030 District into its property application process:

Buyer Incentive Fund Creation

These incentives will encourage property applicants to rehab their property to standards set by the Contractor Playbook in exchange for a discount on the property's purchase price. These buyers will still pay the full purchase price up front, but the incentives will be released from escrow when the interventions are completed.

TCLB will set the incentive amounts in advance based on the estimated cost of the interventions and the "tier" each intervention is assigned in the Contractor Playbook. The value of the incentives will be proportionate to, but may not cover fully, the intervention costs.

If a buyer is interested in participating in the program, TCLB will perform a Home Energy Score assessment on their property to help the homeowner identify high impact interventions specific to their property. However, all of the interventions in the Contractor Playbook will be eligible.

The buyer will be required to provide proof that the intervention was completed in the form of invoices or receipts from the contractor who performed the work. To claim credit for the Playbook items that are performance standards (ie, "whole house air sealing shall improve air leakage by at least 25%"), the buyer must procure an evaluation showing that those standards were met.

Creating Opportunities for Homeownership

Creating homeownership opportunities specifically for populations most impacted by disinvestment is a top priority for land banks across the country. This work, however, is situated in neighborhoods facing decades of disinvestment. Decisions to invest in costly repairs are made more difficult by appraisal gaps between repairs needed and value of the property. Often, TCLB is forced to cobble together funds on a house-by-house basis, hindering its ability to positively affect the trajectory of a neighborhood. In 2023, TCLB will pilot an effort to catalyze the repair and revitalization of its properties by providing basic renovations in-house.

While full "flips" are too resource intensive to be scalable, TCLB will hire skilled contractors to complete system improvements (envelope, electrical, plumbing, heating) and address any code deficiencies. The product will be a safe home that can be sold to and occupied by a homeowner while they finish more cursory renovations such as adding more modern appliances, new carpets or cabinets.

This "renovation-lite" phase is also an ideal time to provide insulation and other energy-saving modifications to the shell of a vacant home. Coupled with the incentive programs (above), TCLB can deliberately influence the adoption of the concepts in the Contractor Playbook and steer working-class homeowners towards more climate-friendly homes than their budget may typically allow.

Leveraging Partnerships

To achieve specific community goals such as affordable housing development, partnerships have become a part of TCLB's DNA as an organization. In 2021, it executed Memorandum of Understandings with both Rebuilding Together Pittsburgh (RTP) and the City of Bridges Community Land Trust (CBCLT) for pilot projects that will result in income qualified homeownership opportunities. TCLB continued to deepen its relationships with both organizations and the Turtle Creek Valley COG in 2022 through participation in a structured planning process to outline a holistic, equitable model for neighborhood revitalization and stabilization. Called the Equitable Communities Collaborative (ECC), the partnership seeks to address neighborhood revitalization from multiple angles, recognizing that many different factors influence community stability, and no single organization can solve the problem alone.

Through this collaboration, TCLB will act as an "acquisition arm" for City of Bridges and Rebuilding Together Pittsburgh, increasing the pipeline of affordable housing for local residents and preserving the quality and safety of "naturally occurring" affordable housing as well. Additionally, the ECC seeks to move beyond a "property by property" approach to catalyze community change at the block or even neighborhood level through a coordinated set of interventions. These interventions will include new, creative uses for abandoned, vacant land, including green infrastructure installations that will help to absorb stormwater runoff and increase community resiliency as more severe weather patterns occur due to climate change.

As the Residential 2030 District continues to evolve, TCLB will be equipped to seamlessly integrate new program offerings into these collaborations. It already used some standards from the Contractor Playbook in the pilot properties in its partnership with RTP. Using funds from the Federal Home Loan Bank of Pittsburgh and First Commonwealth Bank, RTP purchased and renovated a house in the Borough of Rankin to be sold to an income qualified homeowner. The property renovation included a new roof and siding, wall, and attic insulation, rewiring and replumbing the entire house, installation of a high efficiency heat pump for zone heating and cooling, new low-e insulating windows, a new kitchen and remodeled bathroom, new flooring throughout the house, French drain in the basement, and a new parking pad and landscaping beds.

The table below shows the pre- and post-construction results for this property, resulting in a final Home Energy Score of 9 on a scale from 1 to 10:

	Home Energy Score	Predicted Annual Energy Cost (pre-inflation)	Energy Saving Potential	Annual Energy Cost Savings Potential	Recommended Improvements
Pre-Construction	2	$2140	62%	$975	Exterior walls, attic insulation, air tightness, roof insulation, furnace, water heater, ducts
Post-Construction	9	$1179	33%	$220	Air tightness, basement insulation, heat pump water heater

This property, and others like it, will demonstrate and inspire other nonprofits and homeowners to use a similar approach in their property renovations. The intent of the ECC is to expand over time to include more organizations, offering more opportunities to bring new partners into the 2030 District conversation.

Before

After

Part 3: Future Directions

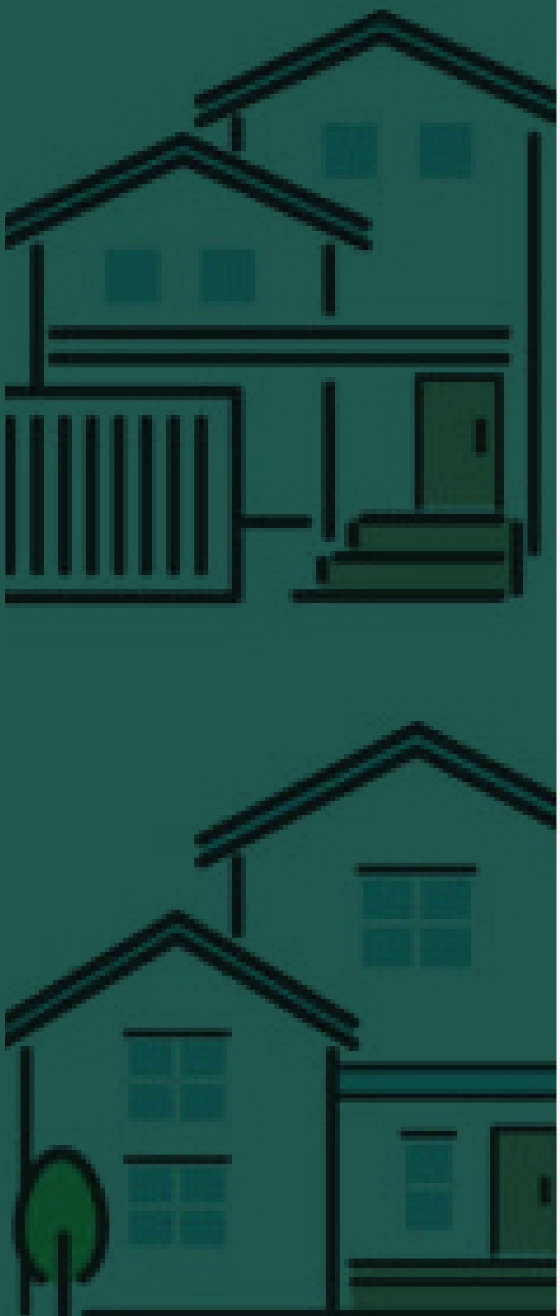
Residential 2030 District Pilot

CONCLUSION AND FUTURE DIRECTIONS:

To begin to design a Residential 2030 District, this planning grant largely focused on the **"what"** - what interventions are most important to recommend, what organizations should play what roles, what research has been done by others in this space, what is the baseline energy usage for our target community currently, and what are the resources potentially available to help support this work. However, as we move toward implementation, the most challenging question to answer is the **"how"**- how do we successfully compel homeowners and contractors to take the actions necessary to achieve meaningful increases in energy efficiency at the home and community scale?

While this report lays the foundation to begin to answer this question, planning on its own can only accomplish so much. To test our plans and assumptions, more pilot projects are needed. As we implement the recommendations from the Contractor Playbook and test their impact on the performance of different properties in varying conditions, we will begin to gather more precise data on the costs and benefits of each intervention. We will also gain a better market sense of which interventions are most appealing to homeowners and developers, and perhaps more importantly, which approaches and incentives are the most effective vehicles to motivate action.

In a region with aging housing stock and longstanding racial and economic disparities, leaving energy efficiency out of the conversation about revitalization would be a huge missed opportunity and an injustice to the people bearing the brunt of climate change, systemic racism, and historic disinvestment. New legislation like the U.S. Infrastructure Investment and Jobs Act and Pennsylvania's Whole Homes Repair Program spur new opportunities to integrate sustainability into property renovation plans and programming. As neighborhoods revitalize and homeowners upgrade, the Residential 2030 District offers a hub of resources, assistance, incentives and community building to ensure that these new developments are built to last in our rapidly changing climate. Together, we can accomplish much more than anyone could on their own, with the banner of the 2030 District tying us together, building momentum to create a more equitable and resilient Greater Pittsburgh region. We appreciate the RK Mellon Foundation for this opportunity and look forward to partnering in improving the quality of life for our region.



Part 4: Appendices

Residential 2030 District Pilot

Energy Efficiency Contractor Playbook

Intervention Specifications for Home Energy Reductions

Table of Contents

Tier 1 (Most Important) Specs

Air Sealing

1. **All areas between conditioned and unconditioned space in the attic shall be air sealed and inspected prior to adding insulation.**
2. **Whole house air sealing shall address major bypasses and improve air leakage by at least 25%.**
3. **If siding is replaced, the house shall be air sealed from the exterior using vapor open weather barrier taped at all seams and integrated into window and door openings.**
4. **Home shall be tested for air leakage at the conclusion of rehab.**

Insulation

5. **Unfinished attic shall be insulated to R-49 level, or R-30 if space does not permit it.**
6. **Finished attic slopes, flats and any vaulted ceiling in the home shall be insulated with dense-packed cellulose, and attic knee walls insulated to R-19.**
7. **Special case of PA flat roof brick row house.**
8. **All framed exterior walls without insulation shall be insulated to class I or II level.**
9. **Home shall have a pre-drywall inspection of air leakage and insulation.**

Windows and Doors

10. **If windows are replaced, the windows upgrade will be to 3-pane U-value of 0.2 or less.**
11. **If doors are replaced, insulated steel doors with U-value of 0.17 or less will be used (for ½ lite doors, U-value less than 0.25).**

HVAC

12. **All accessible HVAC ducts in unconditioned areas (vented attics, crawlspaces, and garages) shall be sealed and insulated.**
13. **All new HVAC ducts shall be located within the thermal envelope and be air sealed.**
14. **All bathrooms with bathtub or shower shall have an Energy Star exhaust fan installed and vented to outdoors.**

Water diversion and basement

15. **If gutters are replaced, new gutters and downspouts shall be 1'' bigger, with an added leaf guard when leaf accumulation is likely.**

16. **Bulk water issues shall be preferentially resolved using passive techniques in order to save energy.**

17. **Vapor and air barrier shall be installed in crawl space to reduce moisture entering home.**

18. **For basements where moisture issues can be well addressed, rim joists shall be insulated and air sealed.**

19. **If homes exhibit unsafe radon levels on completion of the renovation, the radon mitigation system shall be installed.**

Tier 2 (Desirable) Specs

Use these specs in addition to Tier 1 Specs to increase energy efficiency and energy reductions.

1. **Porch roof connection to interior wall shall be insulated and air sealed.**

2. **Cantilevered and closed floor cavities adjacent to unconditioned spaces shall be insulated.**

3. **Exterior walls behind tub or shower shall have an air barrier and insulation or the tub or shower shall be relocated away from the exterior wall.**

4. **Dropped ceilings and soffits shall have an air barrier installed.**

5. **HVAC ducts shall be relocated to the interior of the house.**

6. **HVAC ducts in the exterior walls shall be insulated and tested for air leakage.**

7. **Air-tight outlet boxes shall be installed when the electrical system is redone.**

8. **Hot water heat pump with Energy Factor of 3.5 shall be installed for domestic hot water heating.**

9. **Furnace upgrade shall be to Energy Star, min 95% AFUE, sealed combustion, direct vent with ECM motor furnace.**

10. **Boiler upgrade shall be to Energy Star, min 90% AFUE, sealed combustion, direct vent boiler**.

11. **Air Conditioner upgrade shall be to SEER-16 unit**.

12. **Kitchen exhaust fan vented to outdoors shall be installed.**

13. **Vented crawl space shall be converted to unvented crawl space insulated at the perimeter.**

14. **Unused chimneys and all fireplaces shall be either removed or closed off.**

15. **Low-flow water fixtures and 0.8 gallon/flush toilets shall be installed.**

16. **All newly installed appliances shall be Energy Star certified and low-energy use.**

17. **Induction cookstove shall be installed.**

18. **Recessed lighting shall use air sealed cans.**

Tier 3 (Advanced) Specs

Tier 3 specs are for more advanced projects that receive substantive dedicated funding for efficiency.

1. **When the roof of a home with finished attic is replaced, an additional rigid exterior insulation shall be added on top of the roof decking to increase the insulation value of attic slopes.**

2. **Rigid foam insulation shall be added to flat roofs when the roof is being replaced.**

3. **Exterior framed walls shall be insulated with spray foam or by flash-and-batt insulation (flash is a 1.5-2'' application of spray foam to help air seal the building).**

4. **During siding replacement, 1.5-2'' of rigid foam or mineral wool insulation shall be added on the exterior.**

5. **Heating system in a home with well-insulated and air sealed exterior walls and attic shall be upgraded to air-source heat pump.**

6. **When hot water heat pump installation is not feasible, tankless gas hot water heater shall be installed.**

7. **Home shall be equipped with heat recovery ventilation.**

Resources and Disclaimer

This Playbook was conceived upon encountering many missed energy efficiency opportunities in fully rehabbed properties intended for the affordable housing market. These deficiencies stemmed roughly from 3 things: 1) lack of awareness of which things matter for efficiency, 2) lack of attention to detail and haphazard installations of, e.g., insulation that is then hidden behind the drywall, 3) lack of expectations or higher efficiency goals. And while this Playbook attempts to address items 1 and 2 by explicitly calling out various procedures, methods and measures that are known to reduce energy use in homes, the success of the project will be incomplete without setting the high expectations, and then verifying the results with the energy audit and measurement.

Except for the occasional mention of risks related to moisture, mold, asbestos, electrical hazards, indoor air quality issues, fire, or combustion safety, etc., this document does not contain sufficient details or instructions on how to identify such risks and how to address them. It is explicitly assumed that these risks and hazards are being taken care of elsewhere, as part of the building rehabilitation.

The following resources were used in preparing this document:
Pennsylvania Weatherization Field Guide (WAP)
Home Improvement Expert Checklists from the U.S. Department of Energy's Building America research program
Air Sealing and Insulating Attic from EPA's Energy Star Program
Mass Save Deep Energy Retrofit Builder's Guide
Green Building Advisor https://www.greenbuildingadvisor.com/ resources
Residential Energy. Cost Savings and Comfort for Existing Buildings, 6th Edition by John Krigger and Chris Dorsi, and our own experience with Building Performance Institute-certified auditing & home improvements, running of Home Performance with Energy Star program, and quality assurance of contractor's work.

Energy-efficiency related building code references:
https://www.dli.pa.gov/ucc/Pages/UCC-Codes.aspx
https://codes.iccsafe.org/content/IECC2018/chapter-5-re-existing-buildings and
https://codes.iccsafe.org/content/IECC2018/chapter-4-re-residential-energy-efficiency

Disclaimer

Approach to Energy Efficiency, Including Prerequisites and Sequencing

Residential energy efficiency is achieved through three different pursuits: a) air leakage reduction, b) improving insulation, or an overall R-value of the building envelope, and c) an upgrade of equipment, lighting, and appliances to energy efficient ones. While the equipment upgrades can happen anytime and in any order, improvements to the building's air leakage and insulation need to be considered in proper sequence in relation to other improvements in the home to assure the value of these upgrades while minimizing potential harm from safety, indoor air quality and moisture issues. When correctly implemented, energy efficiency saves homeowners money for many years to come and makes the home more durable, comfortable, and healthier by minimizing moisture, pests, dusts, and allergens. Attention to detail and quality assurance are very important parts of achieving these goals.

STEP 1: ENSURE SAFE AND DURABLE

Identify and improve water management, structural issues, health hazards, and safety issues.

Inspect home for water leaks and moisture. Repair roof, flashing, any other water intrusion, or broken pipes. Examine structural issues in home. Check for pests and pests' damage. Review electrical, gas, and plumbing and any other building issues, such as railing, etc., for any code violation and immediate hazards. Upgrade knob and tube. **Insulation cannot be added to active knob & tube areas.** Install CO and fire detectors. Address mold if present. Examine radon at the conclusion of home improvements.

STEP 2: ENSURE FRESH AIR

Measure air leakage and determine recommended ventilation rate. Ensure effective ventilation before increasing air tightness.

Measure air leakage and determine recommended ventilation rate. Mechanical ventilation is required at or below 5 ACH@50, which is 5 air changes of the house air volume, per hour, under the pressure of 50 Pascals. Otherwise, assure that some operable windows exist on each floor. Add 70 cfm bathroom vents and vent them outdoors, not to the attic.

STEP 3: ENSURE MOISTURE CONTROL

Ensure adequate water protection before reducing the ability of walls to dry by adding air sealing and insulation.

Ensure shedding of rain water from walls and leaks-free exterior. Add well-functioning gutters and downspouts and direct water away from home to protect the basement and foundation from moisture. When replacing any windows or doors follow manufacturer instructions on flashing and integration with existing weather barriers to ensure water cannot penetrate the wall. **Basement air sealing or insulation should not proceed if water/moisture issues cannot be adequately addressed.**

STEP 4: ENSURE DRAFT-FREE

Capture air sealing opportunities not accessible after insulation is installed.

Reduce the air leakage by at least 25%, to be verified with pre- and post-retrofit blower door testing. Air seal in all known areas where the air leakage occurs, especially focusing on bypasses. Address areas of air leakage like top plate to roof connection, porch roof connection, dropped soffits, and all vent and electrical penetrations. Weather-strip and caulk doors and windows and close off fireplaces. Air seal and insulate rim joists and seal all penetrations between basement and the floor above and basement and outdoors.

STEP 5: ENSURE THERMAL COMFORT

Insulate at least to the latest national code recommendations for your location after addressing related safety, indoor air quality, and moisture management issues.

Add insulation to the attic to R-49 level, or as space permits. Add R-19 batt for the knee-walls and cover them with an air barrier. Dense pack attic slopes and/or vaults with cellulose. Insulate framed walls and cantilevers. Upgrade windows and doors or add storms. Convert vented crawl space to unvented crawl. Add an air barrier & exterior insulation when replacing siding or roof. **Improvements in envelope last long and are best done during whole house renovation.**

Roofs

Roofs can be ventilated or not ventilated. Sometimes complexity of dormers and valleys prevents any possibility of correctly ventilating roofs or adding ventilation channels is not practical in cathedral ceiling configuration. Some roof shingle manufacturers, like CertainTeed, warranty their shingles for unvented roof applications. When adding insulation to roofs, it is very important to create an air barrier and sometimes also a vapor barrier between the interior moisture laden air and the cold roof decking. (Roof decking becomes cold when the insulation is added to the roof, creating an added risk of condensation.)

Flat Roof Replacement

Flat roof ceilings often limit the amount or possibility to add insulation from the interior side. Examine the possibility to air seal and insulate as in the Special Case of Flat Roof in PA Row Houses. Otherwise, add rigid board insulation to the roof, from the exterior, when the flat roof is being replaced. This solution requires 3 components:

1) An air barrier layer that is created by either taping the existing wood roof decking with Zip flashing tape or by installing a fully adhered vapor and air membrane.
2) Built-out fascia board with rigid foam installed horizontally on the inside of fascia and air sealed to the existing structure to create an air-tight assembly (there should be no venting or gaps through which warm air escapes from below the roof).
3) Either a 6'' of roofing glass-faced insulation suitable for matching EPDM systems and installed per manufacturer's specification or layered insulation sheets with seams staggered and a new roof decking on top of that insulation. Link to detailed specs / steps with pictures and sample products

Roof Insulation for Finished Attics

The ceilings of finished attics can be insulated in two different ways:

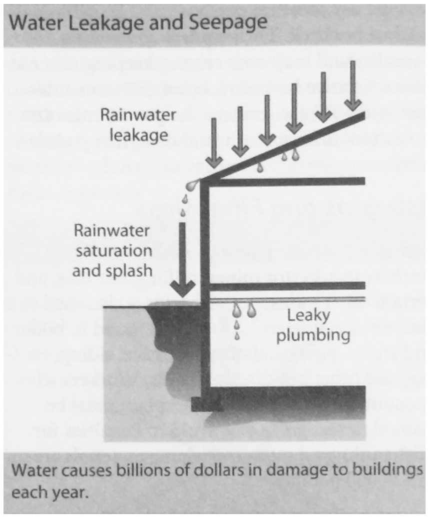
1) Insulation is added in between the roof rafters, through the entire length of the roof rafters, from eave to ridge. This entails closing any roof vents including gabble and soffit vents or otherwise isolating ventilation paths from the thermal and air boundary of the attic. All of the attic becomes part of the conditioned space.
   Details at this link.
2) Insulation follows the outline of the knee wall and is also added to the attic floor behind the knee wall and to the flat section of the attic ceiling. Here also parts of the attic can be ventilated, and care needs to be taken to create an air-tight air barrier to separate ventilated and unventilated parts of the attic. Details here.

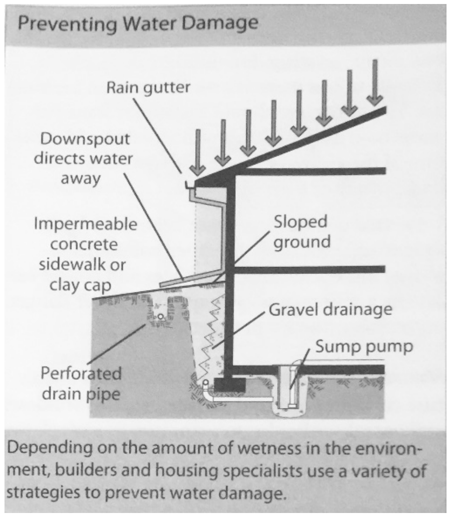
Sloped Roof Replacement with Exterior Insulation

Nailbase manufacturers make it relatively easy to add insulation on top of existing roof decks for uncomplicated sloped roofs. Their composite board typically consists of a 4'x8' panel of closed cell rigid foam board, a middle layer of solid wood spacers creating 1'' ventilating air space, and top layer of OSB or plywood. These are fastened to the existing roof deck. Detailing and installation instructions are provided by the manufacturers, e.g., Hunter Panels Cool Vent https://www.hunterpanels.com/polyiso-roof-products-2/engineered-roof-products/cool-vent.

Care needs to be taken to assure venting path from eaves to the ridge vent, but to air seal any other pathways that would allow air to escape this unvented attic (this solution is only applicable to unvented attics). For detailed specifications, see Link.

Preventing Water Damage





Protecting home from rain and weather and draining rain water away is one of the most important ways to assure home's durability and health. **Ensure this adequate water protection for the building before reducing the ability of walls to dry by adding air sealing and insulation.**

Gutters and Downspouts

Due to increasing rainfall in Western PA, as well as increasing intensity of rains and storms, gutters of higher capacity are needed to protect homes from wetness. Replace all gutters with 1'' bigger gutters, like 6'' gutters. Replace downspouts with similarly bigger downspouts, and/or increase number of downspouts and install new ones where currently missing to ensure that water is moved away from the foundation by at least 5 feet. The gutters need to be pitched 1/2'' for every 10' to move water. Some municipalities permit disconnecting downspouts from underground storm water lines.

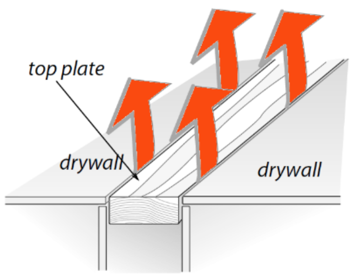
Install gutter covers for homes with high likelihood of leaf accumulation in gutters. Example of an effective leaf protection product https://www.raytecllc.com/division/seamless-gutter-accessories/real-gutter-cover.

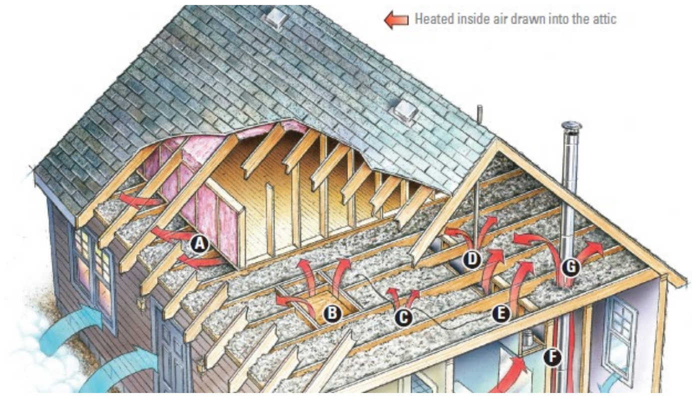
Attics

Attic Air Sealing

Insulation needs an air barrier adjacent to it to be effective. If the air barrier is missing, air moving through insulation reduces its R-value and can deposit moisture in the attic, leading to condensation and mold. Drywall or sheathing make up the majority of the typical home's air barrier. The air sealing work in the attic, to seal the gaps in the air barrier, is near the top plates, around lights protruding to attic, below the knee walls, around chimney chute, open soffits, and soil and plumbing vents. Attic access points also need to be weather-stripped, insulated, and get locks or latches to be closed tight. Allow for air sealing inspection by project manager or energy expert.

Any leaks, moisture, or electrical safety issues (like knob-and-tube or other unsafe wiring for contact with insulation) need to be resolved first.





Finished and Unfinished Attics

Attic insulation shall not be installed unless attic bypasses have been sealed. An attic bypass is any air passageway between a conditioned space and an unconditioned attic. Finished attic air sealing and insulation details can be found in two alternative scopes for finished attics: adding insulation to roof rafters or insulating behind the knee walls, slopes and flats, also linked to their respective details in the Roofs section.

For unfinished attics:

1) Take care to provide and/or preserve attic ventilation pathways through soffit or gable vents and through ridge vent.
2) Air seal all areas of air leakage, as illustrated above, using different techniques for different areas. More details here.
3) Add insulation to building code level, R-49, or to R-30 when space does not permit it. Blown-in cellulose is preferred.

Special Case of PA Flat Roof Brick Row House

The attic in a typical flat roof brick house in PA is about 2-3 feet high at the front wall, down to 1 foot height in the rear. Blowing in insulation into these attic spaces has produced disappointing results in energy savings. The air moves up through passages formed by many construction features common to brick row houses such as furring strip spaces on exterior walls, duct chases, chimneys, and plumbing stacks. These leakage paths allow warm house air to go through or around the insulation and cause the energy loss.

To address this, three special steps are needed:

1) cutting a hole in the roof big enough for a person to enter
2) crawling in the attic to cover and seal as many bypasses and holes as possible
3) dense-packing cellulose insulation into inaccessible areas to restrict the air flow and to insulate

For illustrations and further details see link.

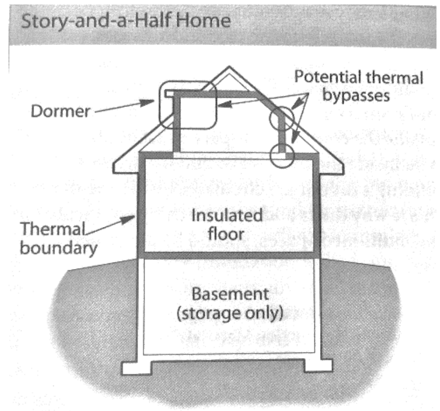
Whole House Air Sealing

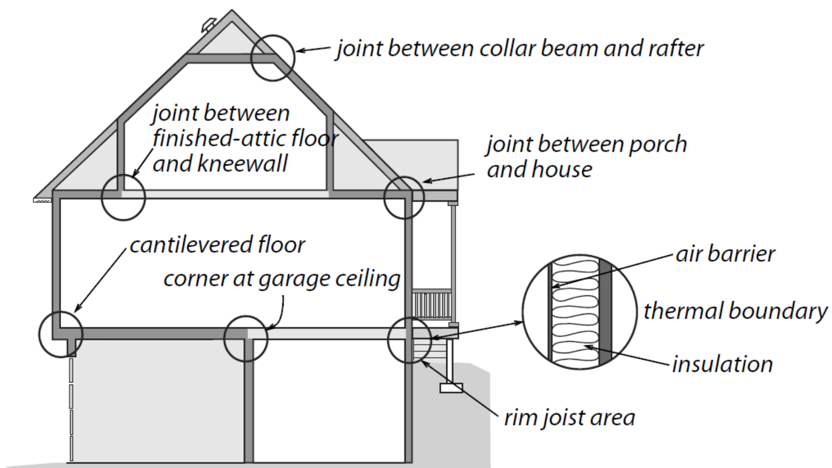
Home's thermal boundary consists of an air barrier and insulation. Air travels into and out of the building by three main pathways:

1. Bypasses, which are significant flaws in the home's air barrier.
2. Seams between building materials and vent, gas, & electrical penetrations.
3. The building materials themselves.

Air leakage in homes accounts for up to 40% of annual heating costs. Air-leakage reduction is one of weatherization's most important functions, and often the most difficult. The air-leakage reduction also helps to avoid moisture migration into building cavities. Major air sealing includes sealing bypasses and other relatively large openings between the conditioned and unconditioned space. Minor air sealing involves sealing cracks and gaps around windows, doors, cracks in masonry, etc.

Before air sealing, be aware of all indoor air-quality and water issues, which should be resolved before the air sealing can proceed.





Bypasses

Bypasses are areas particularly prone to large air-leakage, allowing an unconditioned air to pass through the thermal boundary. When they are not easily accessible, contractors sometimes blow densely packed cellulose (it should be firm like a mattress to be considered "densely packed") into surrounding cavities, hoping that the cellulose will resist airflow and plug spaces between building materials. Here are the most typical bypasses, and how to fix them:

Joist spaces under knee-walls

in finished attic areas: Connect knee-wall with the plaster or drywall ceiling of the floor below by creating a rigid seal under the knee-wall. See link for specific techniques.

Porch roof connections to framed buildings:
Porch roofs often create a substantial air leak because of numerous joints and because there may not be any sheathing or siding behind the porch. To reach this area, remove the porch ceiling, inspect for signs of water leakage; repair as needed. Install sheathing between the house and the porch attic to close off this open area which creates an air bypass. Add rigid foam board insulation from the exterior.

Kitchen or bathroom interior soffits:
Framing flaws leave soffits open to both the wall cavity and ventilated attic. Correctly framed interior soffits or bulkhead would be isolated from other floor and wall assemblies by finished drywall, as seen on the picture. To repair, from the attic, plug any open stud cavities with insulation stuffed into plastic bags to prevent air movement. Seal the top of the soffit with fire-rated foil faced foam board, plywood, or drywall, fastened, and sealed to ceiling joists and soffit framing. See the [link for more details].

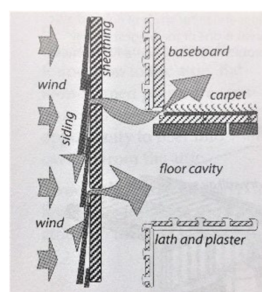
Two-level attics in split-level houses:
Split-level homes create wall cavities connected to the ventilated attic. Seal the wall cavity with a rigid material fastened to studs and wall material.

Duct chases:
If the chase opening is large (in the attic), seal with a rigid barrier such as fire-rated foam board, plywood, or drywall, and seal the new barrier to ducts with caulk or foam. Smaller cracks between the barrier and surrounding materials may be foamed or caulked.

Tops and bottoms of balloon-framed wall cavities, missing top plates:
Seal at the attic level and/or basement with a fiberglass insulation plug, covered with a 2-part foam air-seal, or a plug made from insulation stuffed into plastic bags. Alternatively seal with a rigid barrier, like 1/4-inch plywood or 1-inch foam board sealed to surrounding materials with caulk or spray foam.

Other air leakage locations

Soil stacks, plumbing vents, open plumbing walls: Seal joints with expanding foam or caulk. If the joint is too large, stuff with fiberglass insulation, and spray foam over the top to seal the surface of the plug or fit a rigid foam board to the opening and seal into place with spray foam. Attend to these penetrations at all levels in the house, that is, in the attic, at floors, and in the basement.



Floor-Wall Junction in balloon-framed homes: Wall cavities and floor cavities are connected together in balloon-framed homes. Loose exterior siding and/or attic connects these cavities to the outdoors. Seal wall to floor gaps before installing baseboards and flooring. Plug at top and bottom (see above).

Chimney, fireplace: Seal chimney and fireplace bypasses with sheet metal (minimum 28-gauge thickness). Seal to chimney or flue and ceiling structure with a high temperature sealant or chimney cement.

Wiring and conduit penetrations to the exterior or between the basement and the 1st floor: Tradesmen often knock large holes in the walls or basement ceiling without patching them. These can create air leaks. Seal penetration with caulk or foam.

Housings of exhaust fans and recessed lights: Caulk joints where housing comes in contact with the ceiling with high-temperature silicone sealant.

Rim joists in basements: Air seal penetrations through the rim before insulating. Two-part spray foam is the most versatile method for basement rim joists because it can reach, and cover areas filled with cables, piping, and other obstructions. It is also best suited for masonry basement wall sealing. If foam boards are used to insulate the rim, spray foam or caulk sealant should be used to seal around the foam board. See here for more details.

Windows and Doors

High-performance windows are now manufactured for the mass market, not just the high-end market. Vinyl 3-pane windows with insulated frames and U-value of 0.2 or better are available for about 20% cost premium, compared to basic American Craftsman standard that offers 50% lower efficiency (U-0.3). For example, Edison & Radiance-style windows from Vinylmax, a company in OH, meet these requirements and sell for about $250/window for typical size or when width plus height<101''. Similarly, well-known companies like JELD-WEN or Masonite mass produce insulated and low air leakage steel doors. Installed correctly, energy efficient windows and doors can reduce utility bills while improving comfort and durability.

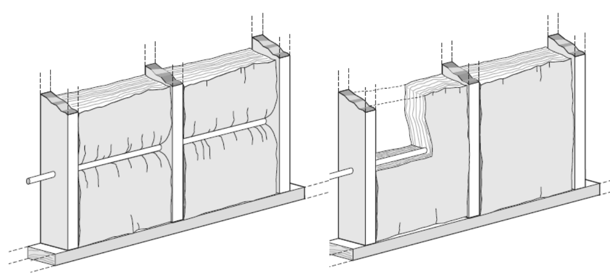
Windows and doors should be sealed to the rough opening from both the exterior and interior. Use low expansion foam on the inside. Seal gaps between framing and the masonry or brick wall as well. If the window framing is to be reduced in size, the resulting space needs to be insulated. **Allow for inspection of window and door installation by project manager or energy expert prior to interior trim being installed.**

Walls

Before insulating walls, all penetrations, and holes through the walls and in the top and bottom horizontal framing (if framed) at each floor need to be sealed. All bypasses listed in the Air Sealing section need an air barrier. **Allow for insulation inspection by project manager or energy expert before the drywall is installed.**

Framed walls insulation with batt

Install batts in full contact on all 6 sides with sheathing, framing and future drywall. Insulation needs to be correctly sized for wall width and height. Cut insulation to fit around electrical boxes, blocking and piping. Split the batt such that it fills the cavity behind the electrical wires and in front of the electrical wires, as shown on the right picture. Leave no gaps anywhere and do not compress it. These techniques will result in a Class I or II level of quality of installation. Poor installation quality, with 5+% gaps and voids (insulation not in contact with surrounding materials) results in as much as 70% reduction of its nominal R-value.
Mineral wool batts perform better than fiberglass batts and are the preferred material.



Fiberglass batts, compressed by a cable: This reduces the wall's R-value by creating a void between the wire and interior wallboard.

Batt, split around a cable: The void is avoided, and the batt achieves its rated R-value.

Framed walls insulation with blown-in cellulose

In the blown-in, or "drill and fill" method, holes are drilled in either from the exterior or in the interior drywall/plaster, insulation is blown-in through a tube inserted into the hole, and then the holes are patched and finished. **Preferred material is cellulose. Only the dense-packing method of installing blown-in cellulose assures that the insulation material does not shift down** leaving uninsulated gaps through which the heat can escape. This is accomplished by inserting an insulation tube deep into the stud cavity and packing the insulation as the filling progresses. Learn more how to achieve the desired 3.5 lbs per square foot density of installation at [this link].

Exterior insulation added during siding replacement

Weather and air barrier

Replacing siding offers an opportunity to install a new weather barrier and reinforce the air barrier, which is typically the sheathing. An air barrier is any material that resists the flow of air through the construction assembly. Tyvek, Grace, or other weather barrier materials used to protect the sheathing from weather becomes an air barrier also, if the membrane sections are all taped. Some, like Grace Vycor are self-adhered, increasing the effectiveness of air flow resistance. Typically, rough opening flashing is applied first, followed by a weather barrier with top layer overlapping bottom membrane layer for proper shedding of water. It is recommended that the weather barrier be vapor permeable to allow drying of the wall to the outside.

Rigid foam board or mineral wool installed with rainscreen

Insulation and air barriers are most effective if they can be as continuous as possible around the entire building, and from all sides. Therefore, exterior insulation which covers corners, floor to wall junctures, and studs (if the wall is framed), reduces heat loss through the building in a way that no other insulation (just in between the studs) can do.

Add a minimum of 1.5'' [1]of rigid foam board or mineral wool insulation and hold it in place by vertical furring strips. The vertical furring strips also provide the means of attachment for the exterior siding. In the case of vinyl siding, the foam board can be tacked to the wall without the furring strips.

If rigid foam board is used for the exterior siding, care needs to be taken to avoid a second vapor-barrier or too much retarding of vapor on the interior side of the wall. Otherwise, any water that may get into the wall through any flaw in the exterior weather barrier would have no way to dry out. Follow foam manufacturer installation instructions to avoid flaws and this possibility. Mineral wool is vapor-permeable and a safer alternative from this perspective.

Flash and batt method

Use this method for particularly leaky walls, where the wall integrity as an air barrier is under question. Examples of that: very old wood, brick with worn out mortar, walls, which when taken to the studs one can see exterior through various gaps. Flash refers to adding a 1.5''-2'' of closed-cell spray foam insulation within each wall cavity followed by installing batt insulation. This combination provides air tightness at the reduced cost, compared to filling the whole cavity with closed-cell spray foam.

Fireplaces & chimneys

Unfortunately, fireplaces are big "holes to the outdoors" and can increase the heat load for the furnace or boiler due to the strong draft that pulls the air out while the fire is going. They can also create indoor air quality issues when improperly operated. It is therefore best to completely seal off all fireplaces and build out the closure with bricks or similar. If the chimney is no longer used by any combustion system in the house (and only the sealed combustion HVAC systems are used) it can be closed off and dismantled.

Wall behind bathtub and shower

In the retrofit process for the bathroom, tub and showers are typically installed first and before insulation is installed. As a result, it is almost impossible to properly install insulation and complete air barriers at exterior walls adjoining tubs and showers. This can lead to convective air flow that circumvents insulation. The installation of air barriers and insulation behind tubs and showers at exterior walls can be achieved with proper planning: drywall and insulation material delivered to site prior to bathtub, and a tradesman, e.g., framer, assigned to installing them.

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[1] The minimum is determined for our climate zone and a typical wall size. Rule of thumb to approximate the dew-point location in the wall sets the exterior portion of the insulation at 1.5'' thickness.

Properly installed and sealed walls prior to bathtub or shower install

Cantilevered or closed floor cavities adjacent to unconditioned spaces

It is typical to find cantilevered floors suffering from both the air leakage and lack of insulation. The best solution is to dense pack them with cellulose using drill and fill method. Dense packing restricts air movement. Insulation should be packed to all corners of the cavity and achieve the 3.5 lbs./cubic foot density; the detail how to assure such density are provided at link.

Electrical

Attic box-covers for light fixtures

Inefficient incandescent light bulbs and mercury tainted CFL light bulbs (that is, all incandescent and all CFLs) should be replaced with LED alternatives. CFLs need to be properly disposed of. All non-ICAT (not rated for contact with insulation) light fixtures protruding to the attic should be boxed with a solid material such as fire-rated 5/8'' drywall that is sealed at all seams with caulk or mastic and sealed to the attic floor around the light fixture. Example of store-available light cover: https://www.tenmatusa.com/wp-content/uploads/Tenmat-FF130E-Installation.pdf

Air-tight outlet boxes

When replacing all of the electrical wiring, install air-tight outlet boxes to reduce the amount of air that can move in and out of the wall. Example product: https://www.homedepot.com/p/Carlon-1-Gang-18-cu-in-Old-Work-Draft-Tight-Electrical-Box-FN-18-OWV/204984795

Recessed lights

Retrofit recessed lights with air-sealed LED light kits as in http://cdnassets.hw.net/a7/02/52c31dd640cf9b64b7627bb17b6d/adv101614-all-pro-rl7-led-brochure.pdf

Electrical prep for hot water heat pump

While the product lines are fast evolving, most of the currently available electric heat pump water heaters require a 220V line. Hence, they need a room for 2 breakers and 30 Amps breaker protection in the electrical panel. If the panel does not have room to add 2 breakers, provide a sub-panel extension. Consult manufacturer's spec for further details.

Electrical prep for tankless gas hot water heater

Determine whether the water heater model to be installed requires an outlet or a hard-wired power supply, confirm or install the power supply near the location for the water heater, and install an outlet if necessary.

Electrical prep for air-source heat pump

While the product lines are fast evolving, most of the currently available electric heat pumps require a dedicated circuit. Consult manufacturer's spec for details related to the selected product. If the panel does not have room to add new breakers, provide a sub-panel extension or plan for a higher capacity electrical service.

Electrical prep for induction stove

Determine whether the induction stove model to be installed requires an outlet or a hard-wired power supply, confirm or install the power supply near the location for the induction stove, and install an outlet if necessary. Typically, induction stove requires a 220 V outlet and 40-50 Amps breaker protection at the electrical panel.

Mechanical Systems and Ducts

Using sealed combustion mechanical systems in place of naturally drafted combustion systems provides not only more efficient but also much safer and healthier conditions, with reduced risk of carbon monoxide pollution and backdrafting.

Furnace Upgrade

Furnace should be upgraded when the existing furnace's Annual Fuel Utilization Efficiency (AFUE) is at or below 0.8, or for reasons related to age and poor functioning of the furnace.

1) Install Energy Star, min. 95% efficient furnace with sealed combustion and with ECM motor.
2) Size the furnace according to Manual J and S calculations and install it in accordance with ANSI/ACCA Standard 5 HVAC Quality Installation Specifications.
3) The ducts system shall be evaluated to determine if the supply and return air flows are balanced and if ducts are properly sized, and if not, corrections shall be made.
4) Correct air flow through the furnace, firing rate, and temperature rise shall all be verified. If the air filter is installed in a filter box attached to the air handler, the filter access panel shall be fitted with a flexible, air-tight gasket.
5) If installation of a new direct-vent sealed-combustion furnace results in a vacated entry point in the chimney, the hole in the chimney wall shall be sealed. Chimney liner will be installed if DHW uses draft venting.

Boiler Upgrade

Boilers should be upgraded when the existing gas boiler efficiency is below 65%, or for other reasons related to age and poor functioning of the boiler.

1) Install min. 90% efficient, sealed combustion, direct vent boiler.
2) Size the boiler according to Manual J and S calculations and install in accordance with ANSI/ACCA Standard 5 HVAC Quality Installation Specifications.
3) Settings for the boiler reset curve and flow rates shall be selected to optimize the performance of the system and to ensure that the return temperatures are low enough to promote condensing.
4) If installation of a new direct-vent sealed-combustion boiler results in a vacated entry point in the chimney, the hole in the chimney wall shall be sealed. Chimney liner will be installed if DHW uses draft venting.
5) When DHW needs replacement at the same time as a boiler, a combi-boiler for both heating and hot water could be an efficient and cost-effective combination.

Install insulating heat reflectors behind radiators to reduce energy losses through the wall, regardless of boiler upgrade status, if the radiators are present, as a low-cost efficiency measure. Example product: https://www.lowes.com/pd/Reflectix-R-21-50-sq-ft-Unfaced-Reflective-Roll-Insulation-24-in-W-x-25-ft-L/3011904

Heat Pump for Water Heating

Water heating can consume as much as 18% of the total home's energy use. To improve the energy efficiency, two lines of approach can be taken: installing boiler-combi, a combination system of a boiler with hot water heating or an electric heat pump water heating. The electric heat pump water heaters are most efficient among all hot water heating systems; 2-4 times as efficient as electric storage water heaters. The installation requires:

1) Electrical panel capacity to add an appliance which requires 220 V

2) Space from which the heat pump can draw heat. Basement and utility rooms are good locations, but a small closet would not be. See more at link.

Tankless Gas Hot Water Heater

Tankless gas hot water heaters save 20-30% of energy compared to traditional gas hot water heaters with storage tanks. Given that they are sealed combustion, with intake and output PVC pipes to the outdoors, they also avoid the risk of combustion gases in the home. See details for this option at https://basc.pnnl.gov/home-improvement-expert/checklists/gas-tankless-water-heater.

Tankless system can have a one gallon "tank" inside, speeding the delivery of warm water; this option is recommended.

Heat Pump for Space Heating

Heat pumps are the most efficient type of heating, surpassing the resistive electric heat efficiency by a factor of 200-400%. However, heat pumps installed in an older home that is not brought up to the building code thermal performance of a newly constructed home could cause very high energy bills. When the heat pump cannot maintain desired indoor temperatures due to heat loss through air leakage and through the building envelope, resistive backup heating fires up and such an electric heating is very costly. Therefore, the heat pumps for space heating are only recommended for well insulated and air sealed homes. To further save costs, one could use an older existing furnace as a backup for the coldest time of the year.

Like air conditioners, air-source heat pumps are available as centralized units with ducts or as room units (mini-splits, ductless, etc.).

1) The heat pump should be sized according to Manual J and S calculations and installed in accordance with ANSI/ACCA Standard 5 HVAC Quality Installation Specifications.
2) For ducted systems, the ducts should be evaluated to determine if the supply and return air flows are balanced and if ducts are properly sized, (and sealed), and if not, corrections should be made.
3) Correct refrigerant charge, proper room-to-room air flow and pressure balance shall all be verified. If the air filter is installed in a filter box attached to the air handler, the filter access panel shall be fitted with a flexible, air-tight gasket.

Ducts Placement

1) Always place new duct runs within the thermal boundary of the building, by using dropped soffits and chases that are well sealed and separated from unconditioned areas with drywall installed and finished prior to adding the duct soffit.
2) To further improve the efficiency, consider relocating ducts from exterior walls to the interior, as they prevent proper insulation of the exterior walls and contribute to even greater heat losses due to proximity to the outdoors.

Ducts Air Sealing and Insulation

1) Air sealing of newly added HVAC ducts is mandatory per building code. Seal collars and stackheads, elbows, joints, and all connections. Seal plenum. Seal all duct boots and registers to finished surfaces, like floor, wall, or ceiling. Use caulk or UL 181 tape or mastic.
2) Seal all penetrations in the building thermal envelope where ductwork transitions from conditioned to unconditioned space.
3) Insulate supply ducts to R-8, and return ducts to R-6, if they are located in garages, crawl spaces, or unconditioned attics (per code). Cover all exposed portions of ducts, tape insulation seams and fasten insulation with plastic straps or UL-rated metal tape.
4) If the ducts are located in the exterior walls, use 2-part spray foam along the full length behind the ducts to maximize the R-value of the exterior wall, and to separate the ducts from unconditioned space.
5) When ducts and air handlers are not located fully within the thermal envelope, duct air leakage must be tested and comply with the code requirements.

AC Upgrade

When the existing AC unit SEER value is 10 or below, or the unit is 15 years or older, replace the unit with a SEER-16 unit. The AC shall be sized according to Manual J and S calculations. All equipment shall be installed in accordance with ANSI/ACCA Standard 5 HVAC Quality Installation Specifications. The ducts system shall be evaluated to determine if the supply and return air flows are balanced and if ducts are properly sized, and if not, corrections shall be made.

Energy Recovery Ventilation

One can ventilate the house with air leakage or using mechanical ventilation. Ventilation helps to prevent moisture condensation (see section below) and helps with the removal of CO_2 that we breathe out. Other indoor air contaminants are best controlled by reducing their source, or using exhaust fans, like for the cooking fumes. Mechanical ventilation is required by the building code for homes where the air leakage is below 5 ACH@50 Pascals. In our region, old housing stock rarely reaches this target; the average air leakage is around 19 ACH@50. If air leakage is reduced and ventilation is desired, conserve energy while ventilating by using products like Panasonic's Whisper Comfort ERV for living area or bedroom.

Kitchen and Bath

Kitchen and bath are major sources of water vapor, from showers, cooking, laundry, wet clothes, etc. When the outdoor temperatures fall, this vapor can condensate on cold surfaces. Insulation keeps the surfaces warmer, reducing condensation. Air sealing reduces air transport of moisture into building cavities. Reduce the sources of water vapor by installing exhaust ventilation, as specified below. Additional strategies to reduce moisture condensation include air conditioning, dehumidification, and energy recovery ventilation. Preventing moisture problems is the best way to guarantee a building's durability and health.

Exhaust Vents

Energy Star exhaust vents with backdraft dampers and preferably with motion detection sensors are needed for each bathroom with a shower or a tub. See more on installation and product info at link.

Kitchen exhaust fan needs to vent to the outdoors through a smooth, galvanized steel or stainless-steel pipe with the functioning backdraft damper. Install Energy Star exhaust fans with minimum air flow of 100 cubic feet per minute. Seal wall or roof penetration with spray foam with exterior surfaces flashed as needed for full weather protection. Cover the outside termination of the exhaust duct with louvers, a screen, or a grille.

Energy Efficient Appliances

Pay close attention to energy consumption of the appliance, and select those that use less energy, especially for frequently running appliances, like refrigerators. Energy Star has a new website https://www.energystar.gov/products/most_efficient.

Water Saving Measures

Replace shower head with low-flow and hand-held shower head meeting 1.5 gallon/min. Example product: https://www.conservationwarehouse.com/low-flow-shower-heads.html or any marked with EPA's WaterSense logo at Home Depot, etc. Install low-flow aerators on all faucets, e.g., https://www.conservationwarehouse.com/faucet-aerators-and-accessories.html. New 0.8 gallon per flush toilets use as much as 40% less water compared to standard toilets. Example product comfort-height 0.8 gallon/flush Niagara Shadow with Stealth Technology https://niagaracorp.com/ toilets available from Famous Supply.

Basements

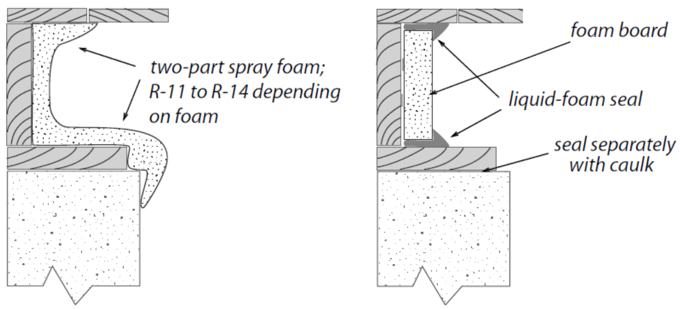
Bulk water issues

Consider using passive techniques, that is techniques that do not require energy to operate, to address bulk water issues. Examples of these are grading slope away from home, improved waterproofing, exterior French drain/ curtain drain / gravel.

These can be contrasted with techniques that rely on energy to remove water, like sump pumps, dehumidifiers, etc. There are two benefits of passive techniques: overall smaller energy use, but also more resilience in case of power loss.

Basement air sealing, insulation and Indoor Air Quality

Bilco door insulation and air sealing is very well represented in this short video, quoted with permission from Efficiency Vermont. https://www.efficiencyvermont.com/blog/how-to/how-to-air-seal-and-insulate-your-basement-video.
Rim joists are best sealed and insulated using one of the two methods illustrated here:



Foam-insulated rim joists: Installing foam insulation is the best way to insulate and air-seal the rim joist. The R-value of the foam should be between 11 - 14, depending on the foam.

Additional considerations for basements:

1) Radon gas may leak through cracks in the foundation, and it is recommended to test for radon after the completion of rehab work. Elevated level of radon requires radon remediation.
2) Cellar door and basement section below the porch are notorious for losing heat. Close off any gaps and insulate the cellar door with 2'' of rigid foam board.
3) To avoid bringing outdoor moisture-laden air into the basement it is best not to provide louvers or openings in the block glass windows.
4) It is sometimes necessary to dehumidify basements in the non-heating parts of the year. Select an Energy Star and efficient air conditioner sized for the space of the basement.
5) Seal HVAC ductwork with mastic to prevent basement air from being distributed all around the house.

Crawl Spaces

The ground under a crawl space or basement can be the major source of water vapor from air migration through the ground and also evaporation from damp ground. To protect homes from this moisture, ground-moisture barriers should be installed over dirt floors of crawl spaces and under concrete slabs (if new concrete is poured). Reinforced polyethylene plastic makes a good ground moisture barrier. If the seams of the barrier are sealed with a durable tape and/or sealant, this ground covering can also be an air barrier.

Two more points about crawl spaces:

1) It is preferable to convert vented crawl spaces to unvented to conserve energy. This process includes adding ground moisture barrier, sealing its seams, and sealing it to the perimeter of the crawl space. In such case, the insulation would be added to the walls of the crawl space and not the ceiling/floor above it. Rigid insulation with sealed seams, installed along the perimeter would complete the air barrier.
2) Since crawl space is not intentionally conditioned, any ducts present in the crawl space should be air sealed and insulated.

Inspections

The inspections can be done by a project manager, designated energy efficiency expert, or a hired 3rd party able to provide expertise and blower door and/or duct testing.

Pre-insulation air sealing inspection

It can take two forms: either a visual inspection, prior to the installation of insulation and going over all possible bypass and air leakage areas to verify that they have been sealed and addressed, or a blower-door assisted inspection where the blower door can help to identify the location that are still contributing too much to the overall air leakage. This inspection allows us to discover and fix problems before everything is enclosed in the drywall and hidden out of view with, e.g., windows and doors trim. Final air leakage test is performed at the end of construction.

Pre-drywall inspection

Pre-drywall inspection is used to verify level I or II quality of insulation installation. For batts, there can be no voids, compressions, gaps, etc. and insulation needs to be in contact with building components on all 6 sides. For blown-in cellulose, the full coverage, and the target density of 3.5 lbs./cubic foot are checked.

HVAC duct air leakage test

PA building code requires testing of air leakage and compliance with air leakage limits on all new HVAC ducts installed in retrofitted homes, unless they are located completely within the thermal envelope. Ducts located in the exterior walls of the building displacing insulation or other parts of the wall structure that would otherwise provide insulating value (e.g., an air gap between wall components) are not located “within the thermal envelope”.

Final air leakage test

Final air leakage test is performed at the end of construction. The goal is to achieve at least 25% reduction in the air leakage compared to pre-retrofit measurement. If the pre-retrofit air leakage is not known, the goal is to reach 15 ACH@50 Pascals or less for the air leakage, at a minimum, and to reach 10 ACH@50 Pascals as a desired goal.

Appendix (Detailed Steps and Specs)

Details for flat roof with adding insulation from exterior

Use this scope for homes with flat or almost flat roofs which do not have attic or sufficient space to add insulation in the attic.

Remove *all existing roofing material, unless specified otherwise.* ***Remove*** *existing soffit vents, gutters, and fascia.*

Repair rafters *and decking as required. If the existing roof sheathing is wood (plywood or OSB), tape all joints with Zip flashing tape to create an air-tight air control layer. If all insulation will be on top of the roof deck, a vapor barrier is needed for both the vapor and air control.*

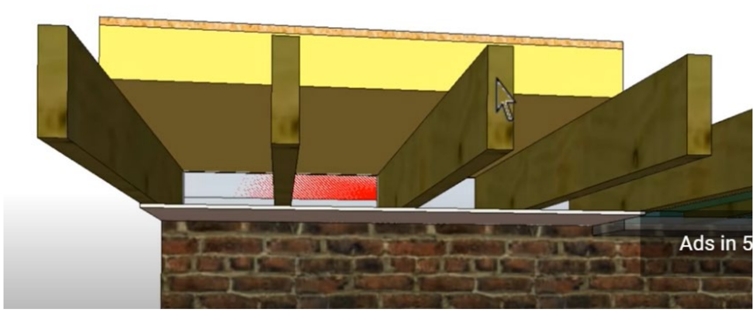
Install 2'' rigid foam insulation, XPS or Polyisocyanurate, horizontally, on the inside of fascia board *and seal it to the existing structure with a compatible caulk or spray foam, to create an air-tight assembly between the roofing insulation board and the walls behind the facia. (If bricks fill the openings between roof rafters, air-seal between the brick and the rafters). There is to be no venting in this roof.*

Install 6'' of Polyiso rigid foam on top of the existing decking*, in 2, 3'' thick sheets, with seams staggered, and new decking. Any type of Polyiso board is acceptable if new decking is added. Nailbase systems like Hunter Panels H-Shield NB combine insulation and new decking. Alternatively, use a total of 6'' of roofing glass-faced insulation suitable for adhered matching EPDM systems and install per manufacturer's specification without adding a new deck on top of insulation. Example products: SecurShield Polyiso from Versico or Isogard from Firestone. Fasten to joist using recommended size/type fasteners or adhesives, as suitable for the solution selected.*

Extend fascia *to account for a higher roof.*

Install fully adhered new EPDM roofing *according to manufacturer instructions. Replace all flashing and accessories.*

Replace all gutters *with 1'' bigger gutters.* ***Replace downspouts*** *with 3''x5'' and install new ones where currently missing to ensure that water is moved away from the foundation. Use downspout extensions of 5', unless underground pipes are available.*

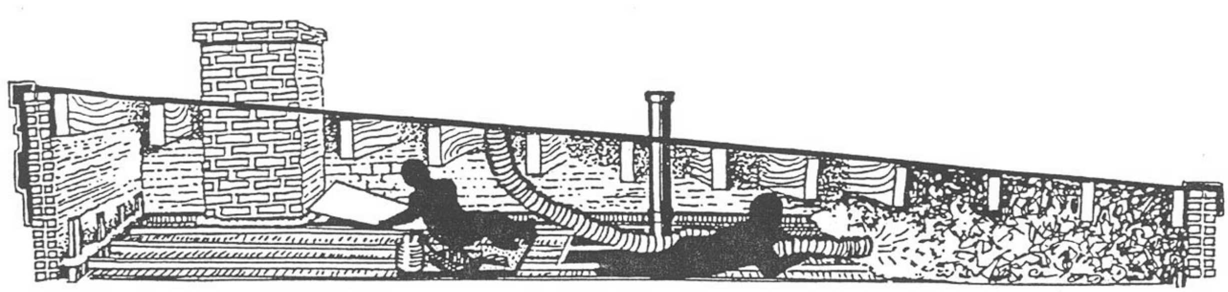


Red area marks the location that needs to be insulated and air sealed in between each roof joist, with 2'' foam board installed horizontally, perpendicular to the joists. Similarly, air seal and insulate along the last roof joist that lines up with the edge of the roof/wall. (Original roof decking is not shown here).

Details for special case of PA flat roof brick row house

Use this scope for flat roof brick row houses with space of about 3' to 1' between the ceiling and roof.

Cut access hole in the roof *near the front wall or where the attic height is the greatest. When entering this cavity distribute weight on the ceiling joists and not on plaster.*



Crawl as far to the rear as possible and directly seal all accessible bypasses*.*
Spray foam the tops of the channels between the furring strips around the perimeter of the attic. Cap the duct chase with rigid board, fasten securely with heavy duty staples and seal with durable caulk or foam. If a wall of the duct chase is made of brick, then thicker rigid board works better for making a tight friction-fit seal against the bricks. Close all noticeable gaps, e.g., open tops of partition walls, etc.

Dense pack the rear wall perimeter and the tops of any inaccessible rear chases with cellulose *at 3.5 lbs per cubic food density. (It should feel like a mattress to touch). The entire unreachable rear section should be filled to the roof deck with insulation.*

Blow insulation *to the required depth of 16'' for the areas that were directly air sealed.*

Repair the roof *using standard procedures.*

Details for adding rigid insulation to sloped roof of finished attic

This scope is applicable when the roof is replaced. It is not applicable to homes with unfinished vented attics. This scope assumes that the roof is also insulated below the roof deck. To do that one can use the opportunity of opened roof decking to blow-in insulation in between roof rafters, from the exterior.

Remove *all existing roofing material, unless specified otherwise.* ***Remove*** *gutters and existing fascia.*

Repair *rafters and decking as required. Re-nail the sheeting to the rafters, using 2-2 1/2" ring shank galvanized nails. If the existing roof sheathing is wood (plywood or OSB), tape all joints with Zip flashing tape to create air control layer. Otherwise install a fully adhered membrane to create air control layer.*

Install 2'' rigid foam insulation, XPS or Polyisocyanurate, horizontally, on the inside of fascia board *and seal it to the existing structure with a compatible caulk or spray foam, to create an air-tight assembly between the roofing insulation/sheathing and the walls behind the facia. Install two layers of 2x4 wood support along the eave's edge and later attach fascia boards to both rafter/joists and this blocking using 2-2 1/2" ring shank galvanized nails.*

Install 3'' of Polyiso rigid foam, in 2, 1.5'' thick foil-faced sheets, with seams staggered covering the entirety of the sloped roof. *Attach first layer with nail caps. Tape second layer seams.*

Add new 5/8'' Zip roof decking *over Polyiso and attach it through the insulation with appropriate 6'' long screws to roof rafters. Use 1 screw every 24'' along the roof rafters. Bring the roof sheathing all the way up so it meets on both sides of the ridge beam without any spaces. Tape all joints with the ZIP tape and roll for proper adhesion.*

Alternatively, use nail board panels *(e.g., https://www.hunterpanels.com/product-documents/hpanels/speciality-products/103-cool-vent/file or https://www.buildsite.com/pdf/johnsmanville/Nailboard-Summary-Brochure-153217.pdf) with 5/8'' OSB or plywood) to provide both rigid insulation and new decking. Install per manufacturer's instruction.*

Install ice and water shield along eaves, valleys and any place flashing is required. *Install alum. drip edge along all eaves and rakes.*

Re-roof the house *according to manufacturer specifications, using vapor-permeable underlayment like GAF's Deck Armor, VaproShield or SlopeShield. Asphalt felt should not be used.*

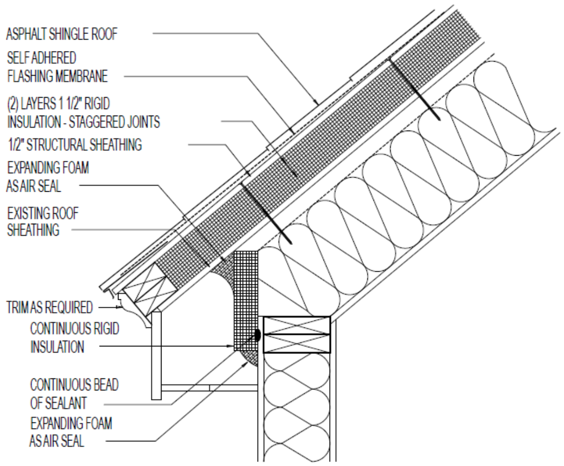
Replace fascia *and add any trim necessary to finish.*

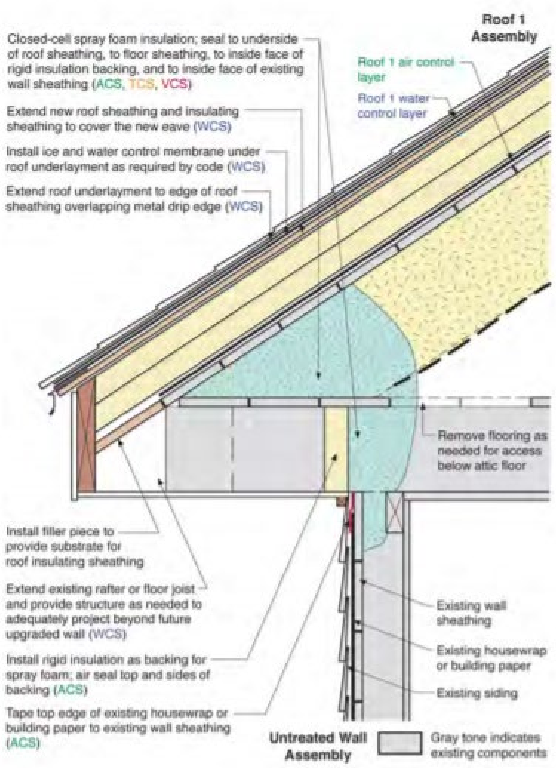
Replace all gutters *with 1'' bigger gutters.* ***Replace downspouts*** *with 3''x5'' and install new ones where currently missing to ensure that water is moved away from the foundation by at least 5'.*

Haul away job debris *and clean affected areas after work is complete.*

Sources: https://basc.pnnl.gov/resource-guides/water-managed-roof-re-roofing-and-adding-insulation-over-sloped-roof#edit-group-scope

https://www.greenbuildingadvisor.com/article/how-to-build-an-insulated-cathedral-ceiling
https://www.buildingscience.com/sites/default/files/migrate/pdf/GM_DER_Guide_2013-01-18.pdf page 89, or see below



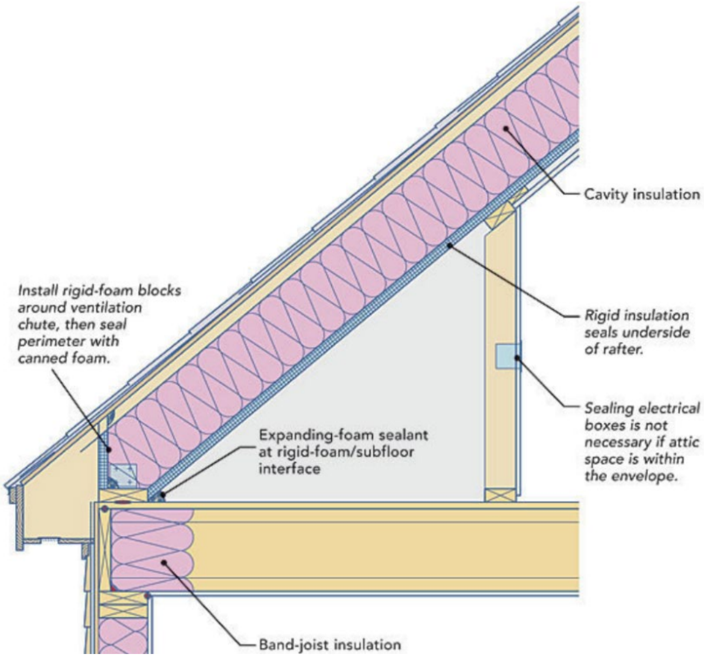


Roof 1 to Untreated Wall (Non-Chainsaw)—Eave

- This transition is to be used if roof framing structure cantilevers beyond the walls.

Details for insulating sloped roof of finished attic

Typical for 1.5 story homes built in 1950-ties. Half-story is in the attic. Knee walls are set back from the house footprint, or there may not be any knee walls.



<u>Create access points</u> *(small doors) to reach behind the knee walls in the attic, unless already present.*

<u>Insulate the underside of roof rafters</u> *using fire-resistant 1.5'' thick rigid Polyiso insulation boards (example: Dow Thermax Polyiso). Attach with plastic or metal insulation washers and 3'' drywall screws and tape seams between boards with Zip tape. Cover the entirety of accessible roof underside.*

<u>Create a dam in each roof rafter at the perimeter of the house.</u> *Push existing floor insulation back or add rolled up 24'' insulation batts stuffed in plastic bags (air tight plugs) to prevent air leakage.*

<u>Insulate gable walls when present.</u> *If gable walls are unfinished, install rigid foam cut to fit exactly and with seams taped, otherwise, insulate finished gable walls with blown-in, dense packed cellulose insulation. Seal any gaps with gun foam to make an airtight seal around the envelope.*

<u>Open up the top of the roof</u> *along the ridge to access both sides of roof rafters.*

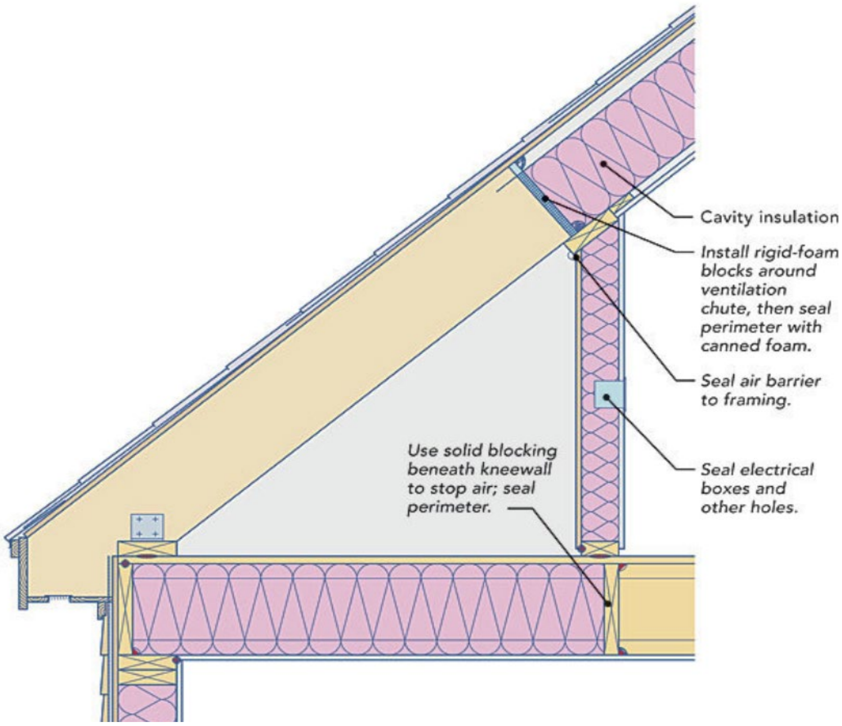
<u>Dense pack cellulose insulation into the roof rafters</u>*, extending the fill tube down as far as possible and filling from the bottom. From the same roof opening, blow-in cellulose on top of any flat area, up to R-49 level where it fits.*

<u>Install a continuous ridge vent</u> *(*http://www.airvent.com/products/exhaust-vents/ridge-vents/continuous-ridge-vent*) in the roof per manufacturer instructions and restore the roof.*

Alternatively, blow in dense-packed cellulose insulation into the slopes and flats of the finished attic from the inside. Patch and repair blowing holes.

Details for insulating finished attic behind knee walls and at slopes and flats

This scope can be used interchangeably with [this scope](). Decision which scope to execute may depend on ease of access to the space behind the knee walls. This scope does not require large sheets of rigid foam. All work could be done from the interior.



<u>Create access points</u> *<u>(small doors)</u> to reach behind the knee walls in the attic, unless already present.*

<u>Air seal knee walls</u> *using electrical caulk for electrical penetrations through the knee wall.*

<u>Install solid blocking under the bottom plate of the knee wall and in between the rafters above the top plate of the knee wall.</u> *If the roof is vented, the rafter blocking should extend to the ventilation baffles; if the roof is not vented, this blocking should extend all the way to the roof sheathing. Use rigid foam or OSB as blocking and seal the perimeter of the blocking with caulk or canned foam. Alternatively, 24'' rolled up fiberglass batt inside a plastic bag can be stuffed underneath the knee wall for the blocking beneath knee wall.*

Insulate the knee wall and cover it. *Insulate with fiberglass or mineral wool batts and cover it with Tyvek or another house wrap on the back side of the knee wall. Seal house wrap seams with compatible tape and staple it to framing to form a complete air barrier.*

Air seal and insulate the attic floor behind the knee *walls that separates conditioned and unconditioned spaces. Any light fixtures protruding to that area of the attic should be boxed with a solid material such as drywall or rigid foam that is sealed at all seams with a sealant such as caulk or spray foam. Similarly seal any plumbing and other penetrations in that space. Insulate to min level of R-30.* ***If vents are present, install insulation vent baffles to prevent covering them with insulation.***

Dense pack blown in cellulose insulation into attic slopes and flats at the ceiling of the finished attic. *The insulation blown either from interior or exterior. If insulating from the interior, patch and finish blowing holes. If insulating from the exterior, open up the top of the roof along the ridge in order to access both sides of roof rafters and dense pack cellulose insulation into the roof rafters and on top of any flat area, up to R-49 level where it fits. Install a continuous ridge vent* (http://www.airvent.com/products/exhaust-vents/ridge-vents/continuous-ridge-vent) *in the roof per manufacturer instructions and restore the roof.*

Install 4'' thick insulation on knee wall access doors *(for example, layers of rigid foam glued to the back of the door), install a tight threshold, good weatherstripping, and a latch that pulls the door tightly shut.*

In the event when the space behind the knee walls is too small for a person to enter, the entire "triangle" can be dense packed with cellulose instead.

Sources: https://www.finehomebuilding.com/2012/09/06/two-ways-to-insulate-attic-kneewalls
https://basc.pnnl.gov/resource-guides/attic-knee-walls#edit-group-scope
https://www.greenbuildingadvisor.com/detail-library

Details for air sealing and insulating unfinished attic in sloped roof home

This scope is for unfinished attics that are not intended to be conditioned. Attics and top of houses are very important to improve due to the stack effect (warm air rising), and the resulting loss of energy.

Attic Preparation

Remove *or shift objects stored in attic to allow for necessary access. If storage space is needed, a small storage floor can be constructed on top of insulation.*

Address any roofing leaks and moisture.

Add ridge vent *(e.g., http://www.airvent.com/products/exhaust-vents/ridge-vents/continuous-ridge-vent) following the rule to provide ~1 sf of vent/300 sf of attic.*

Address knob and tube wiring or any unsafe wiring if present in the attic. *Also confirm all electrical junction boxes have an intact cover plate. Insulation cannot be installed if this step is not done.*

If soffits vents are present, install ventilation baffles for each soffit vent *to protect the ventilation path from being covered by insulation. Baffles need to extend at least 6'' above the final insulation level.*

If a bathroom exhaust vent fan is to be added, or vent rerouted (it must be vented outdoors), follow that scope before adding insulation.

If there are any HVAC ducts in the attic, air seal and insulate them.

Attic Air Sealing

Air seal all gaps, cracks, seams, and penetrations between conditioned and unconditioned space.

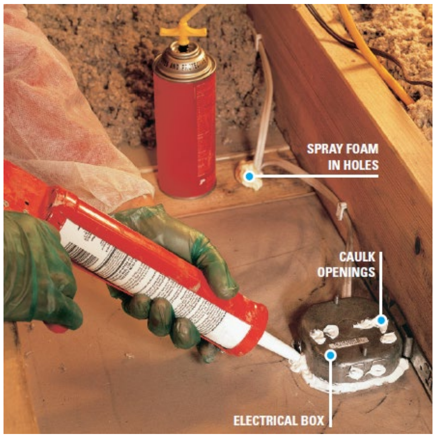
Plug open stud cavities, if present, with insulation stuffed into plastic bags to prevent air movement. *Dropped soffits studs and tops of balloon-framed walls or gable walls are often completely open to the ventilated attic.*

Cover dropped soffits with reflective foil, plywood or rigid foam and seal it in place with adhesive. Similarly ***cover and seal duct chases terminating in the attic. These are the most important bypasses to address*** *as they are often large and contain heating ducts, which increases heat losses.*

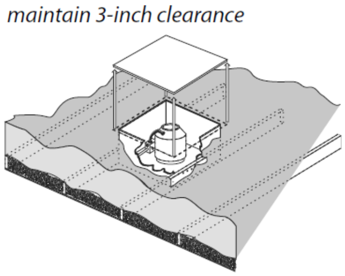
Close furring strip spaces on exterior walls in brick houses, around the perimeter of the attic. *Brick house exterior walls were built with furring strips attached to brick and lath and plaster. These furring strips create an open channel from basement to attic, and house air leaks through any electrical outlets, baseboards, etc. directly to attic. Foam the top of channels between the furring strips. Also seal along the top plates of interior walls with caulk or spray foam.*

Seal bypasses and gaps around active masonry chimneys and potentially hot gas appliance vents using aluminum flashing, high-temperature-rated caulk or foam *and separate from insulation by at least 1'' with a metal dam. However, if all combustion equipment in the house is getting converted to high efficiency condensing units, and fireplaces are permanently closed, the gaps around old chimney and vents can be sealed with just regular caulk or spray foam.*

Gaps around lighting fixtures, electric wiring and plumbing pipes: *Clean the areas to be sealed with vacuum and damp cloth to remove dust. Use caulk or fire-rated foam if the gaps are narrow enough or use rigid blocking material sealed in place with sealants.*



Box all non-ICAT recessed light fixtures *protruding to attic with a solid material such as drywall sealed at all seams with a sealant such as caulk, mastic, or spray foam, or cover the lights with https://www.homedepot.com/p/Tenmat-Recessed-Light-Cover-FF130E/204286308*



Covering recessed light fixtures: Covering recessed light fixtures with fire-rated 5/8″ drywall or sheet-metal enclosures reduces air leakage and allows insulation to be blown around the box.

Make attic air sealing available for inspection before adding insulation.

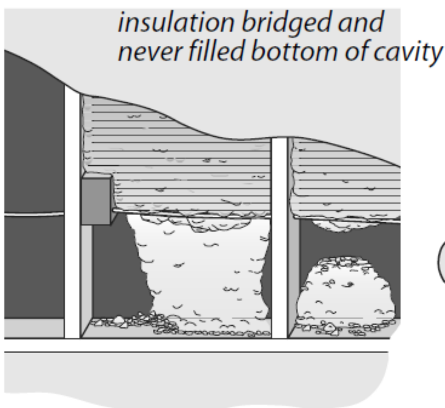
Attic Insulation

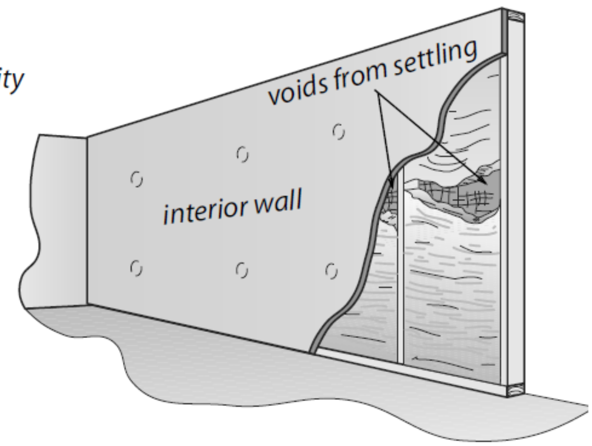
Insulate attic access panels, doors, and drop-down stairs *with R-15 rigid foam insulation and gasket them to provide a continuous air seal when closed. Insulate drop-down stairs by creating a rigid foam box with seams sealed, to be positioned over the stairs from above. Construct OSB or plywood insulation dams around attic access points.*

Insulate attic floor to R-49 level (R-30 minimum, where space does not permit). *If blown-in cellulose (preferred) or blown-in fiberglass insulation is installed, attach paper rulers in several locations in the attic. If batts are used, install with less than 2% gaps, voids, and compressions. In case a floor is present over attic floor joists insulate below this floor using blown-in dense packed cellulose, in addition to insulating above to reach the R-49 level.*

Details for framed walls insulation with blown-in cellulose

Densely packed cellulose wall insulation reduces air leakage through cracks inside walls and other closed building cavities because the fibers are driven into the cracks by the blowing machine. Where possible, insulate at a density of 3.5 lbs./cu.ft. Use a 1-hole tube-fill method to install dense packed insulation. In this method, the insulation is delivered through the tube inserted deep into the wall cavity. 1 or 2 hole method where insulation is blown through the hole(s) results in voids, as illustrated below.





<u>Inspect walls for evidence of moisture</u> *damage and correct problems before proceeding. Seal gaps in external window trim and other areas that may admit rain water into the wall.*

<u>Inspect</u> *indoor surfaces of exterior walls to assure that they are strong enough to withstand the force of insulation blowing. Also inspect for interior openings from which insulation may escape, such as pocket doors, balloon framing, un-backed cabinets, interior soffits, and closets. Seal openings as necessary.*

<u>Probe all wall cavities through holes, as you drill them</u>*, to identify fire blocking, diagonal bracing, and other obstacles. Drill whatever additional holes are necessary to ensure complete coverage. If the wall cavity has some existing batt insulation, cut out a 1-foot strip along the wall near the floor to remove it.*

<u>Here are the tips to achieve the 3.5 lbs density of cellulose installation:</u>

1) *Dense-packed wall insulation is best installed using blower equipped with separate controls for air and material feed*
2) *Drill 2-3'' diameter hole to access stud cavity*
3) *Use fill tube marked with 1' intervals to know the correct tube penetration into the wall*
4) *A typical 2x4, 16'' on center wall cavity needs 1.2 lbs of insulation per square foot. An 8-foot cavity should consume a minimum of 10 pounds of cellulose insulation. Start with an empty hopper and verify that this amount is delivered to the cavity.*
5) *With balloon-framed walls, try to blow an insulation plug into each floor cavity. Using a plastic bag which is inserted and filled with blown insulation while in the floor/wall cavity area will limit the amount of insulation needed to create a plug.*

Details for installing bathroom exhaust fan

Exhaust fans are required for all bathrooms with bath or shower.

Install an Energy Star retrofit exhaust fan with motion sensor, like Panasonic FV-08-11VFM5 *(https://shop.panasonic.com/support-only/FV-08-11VFM5.html)*

Vent to the outside *using 6" where possible rigid galvanized metal or Sewer & Drain PVC vent with a smooth surface with the most direct route to the outside, and with no bends for the first foot from the fan. Do not use flexible plastic ducting. Exit roof with a 6" roof vent (regardless of vent size) with* ***a backdraft damper*** *that closes when the fan is not operating and a bird screen, e.g., https://www.broan-nutone.com/en-us/accessory/634m or through a wall penetration, e.g., https://www.broan-nutone.com/en-us/accessory/843bl .*

Seal all exhaust duct seams and connections *with UL-approved mastic or UL 181 tape. Seal fan to ceiling using foam gun when the housing is in a vented attic.* ***Long vent runs above insulation level should be sealed and insulated to prevent moisture condensation.***

Details for installing electric heat pump for hot water heating

Hot water heat pumps can be installed in place of electric or gas-powered hot water heaters provided that the space allows drawing heat from surrounding air. Basement and utility rooms are good locations, but a small closet would not be.

When replacing a domestic hot water heater due to its deterioration, malfunction, or age (older than 10 years) install a hot water heat pump *with minimum Uniform Energy Factor of 3.0.*
Example models: https://www.homedepot.com/p/Rheem-Performance-Platinum-40-Gal-10-Year-Hybrid-High-Efficiency-Smart-Tank-Electric-Water-Heater-XE40T10H45U0/312742067 or https://www.hotwater.com/Water-Heaters/Residential/Electric/ProLine/XE/Voltex-Hybrid-Electric/Voltex-Hybrid-Electric-Heat-Pump-Water-Heater-HPTU-50N/.

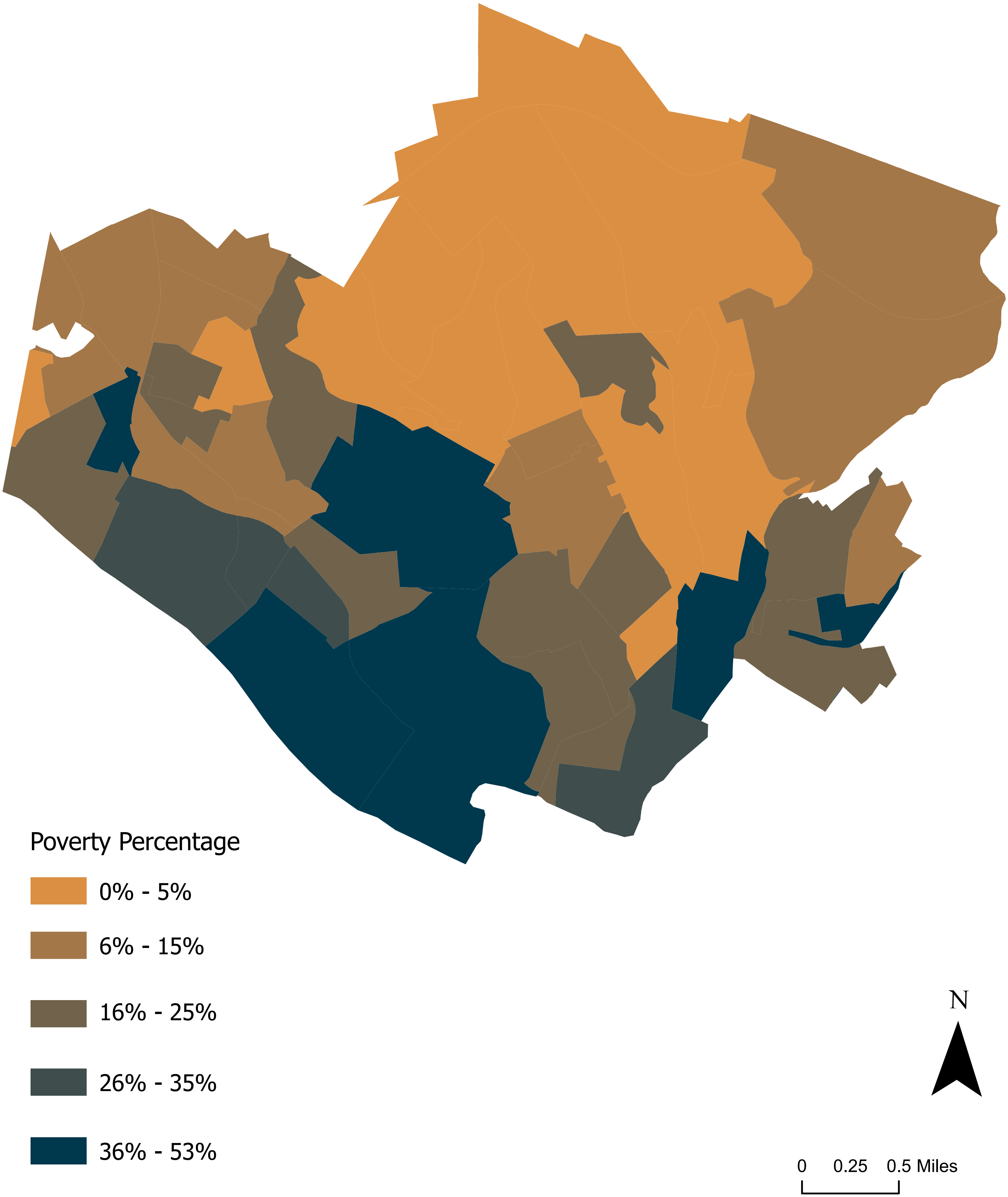
Seal the vacated entry point in the chimney.

Provide for condensate water discharge *to the floor drain.*

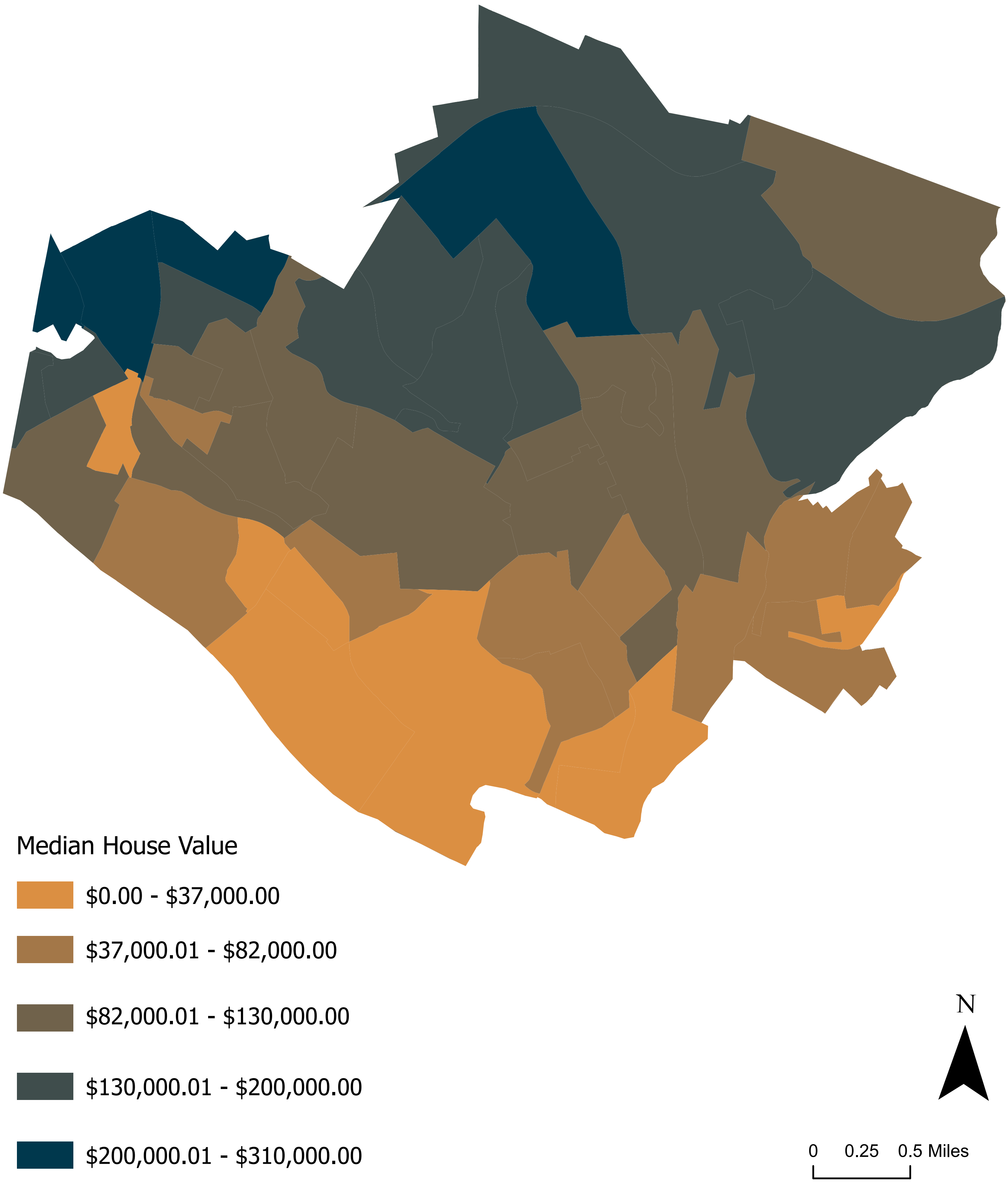
Provide 2-gallon expansion tank*. Provide vacuum break for bottom fed units.*

Provide necessary electrical upgrade. *Heat pumps require 220 V line, therefore need a room for 2 breakers and 30 Amps fuse protection in the electrical panel. If the panel does not have room to add 2 breakers, provide a sub-panel extension.*

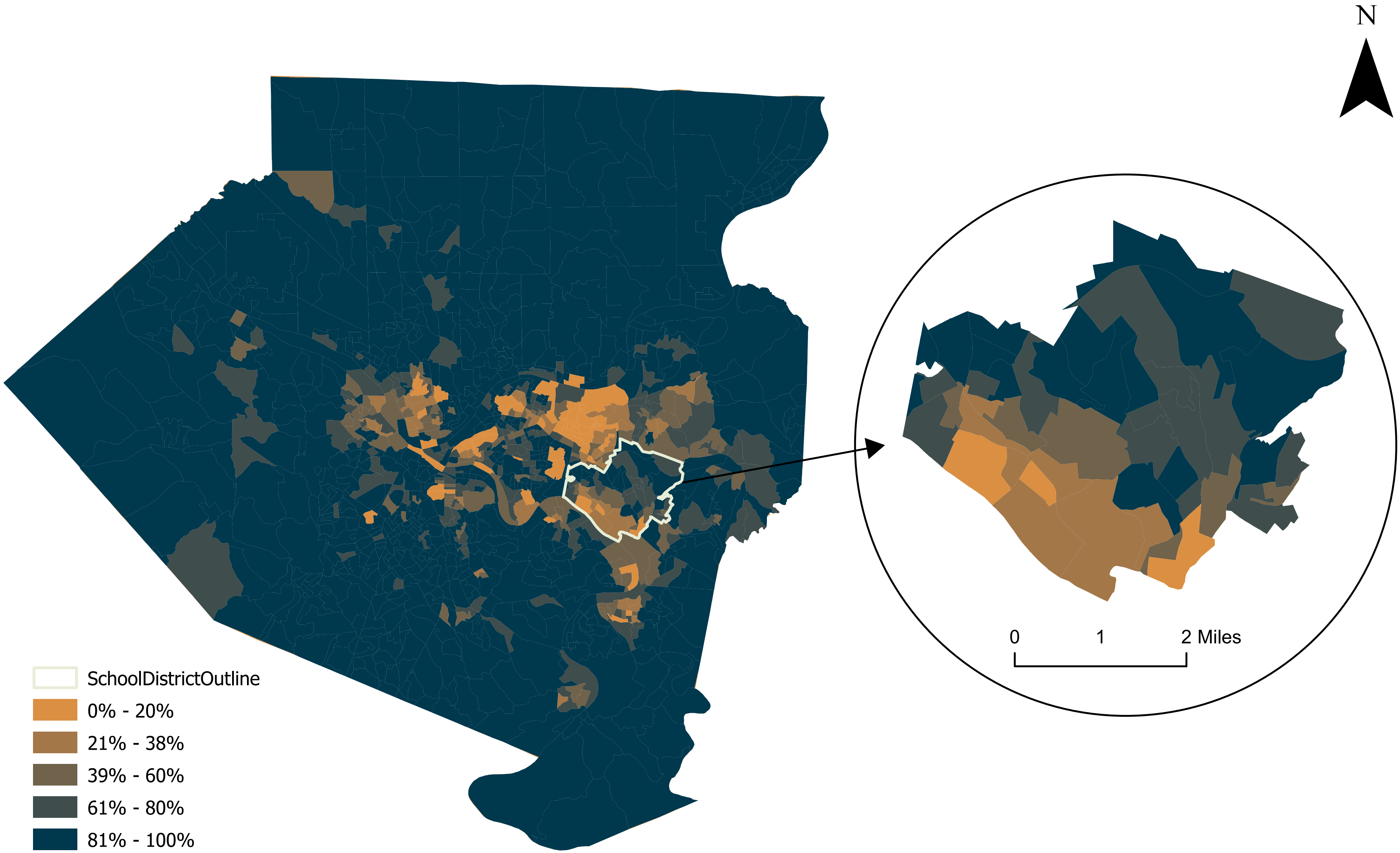
Estimated Percent of Poverty House Unit in Woodland Hills School District from 2016-2020



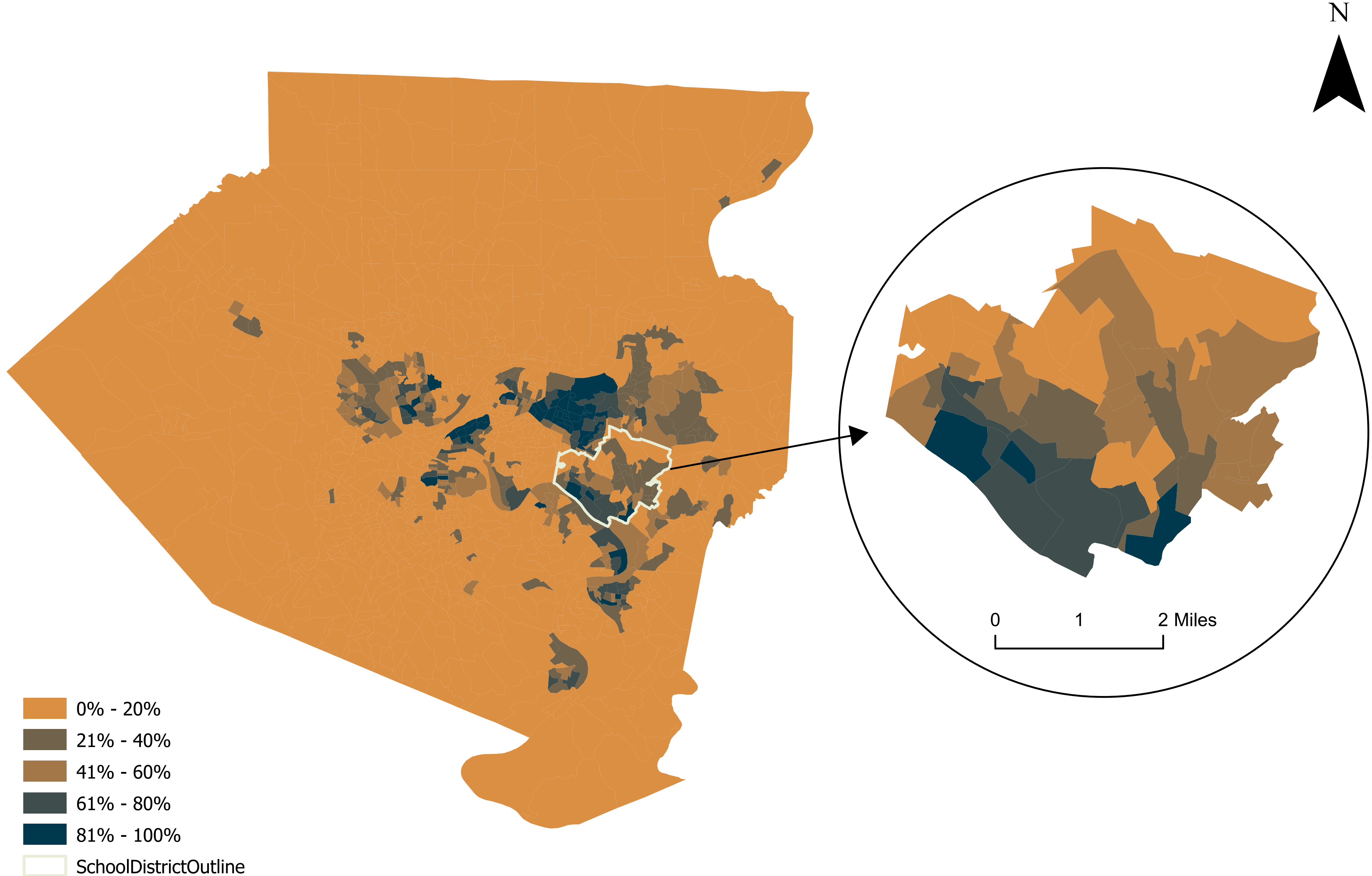
Estimated Median House Value
in Woodland Hills School District from 2016-2020



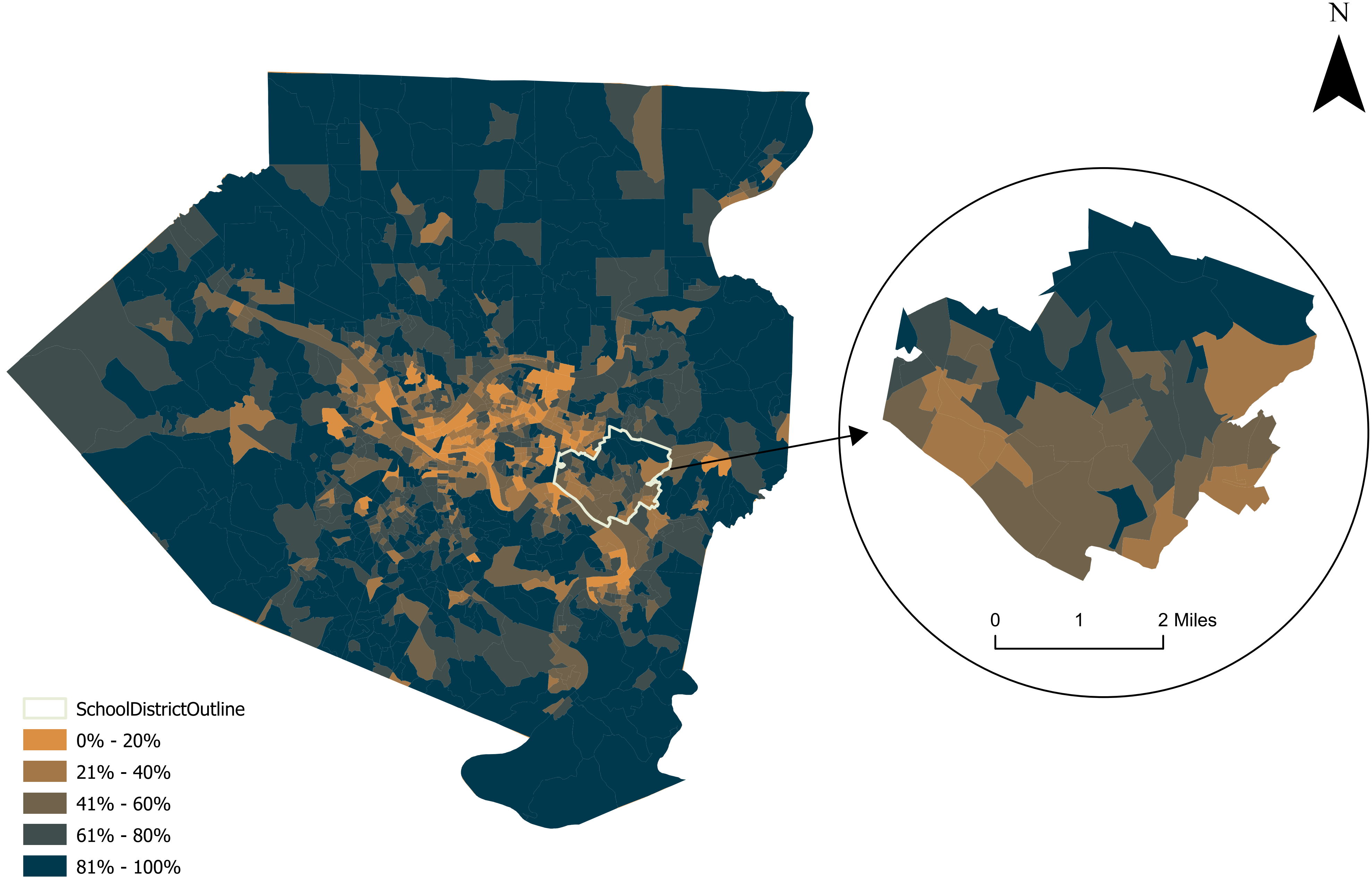
Estimated Percent of White Population in Allegheny County from 2016-2020



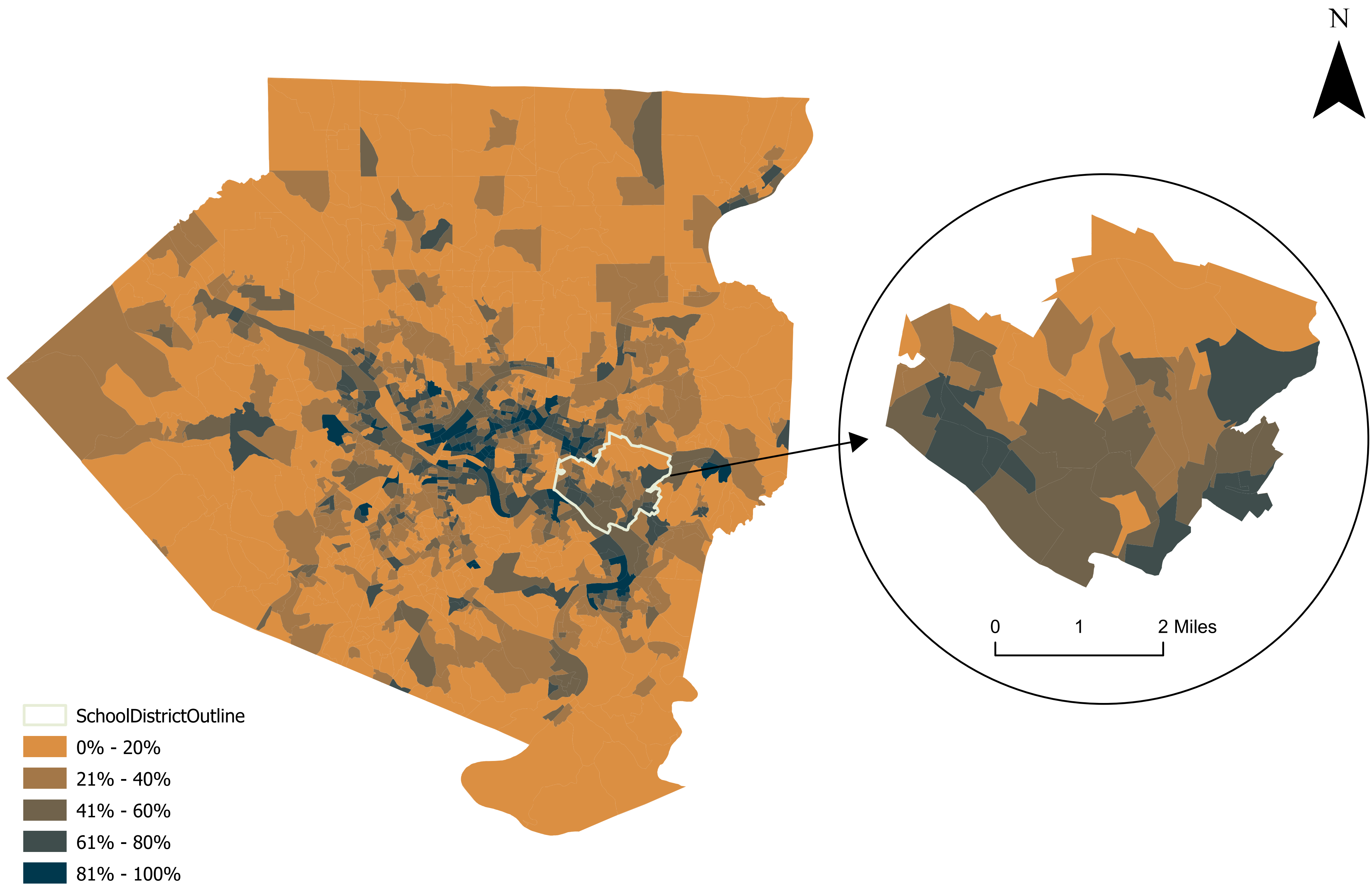
Estimated Percent of Black Population in Allegheny County from 2016-2020



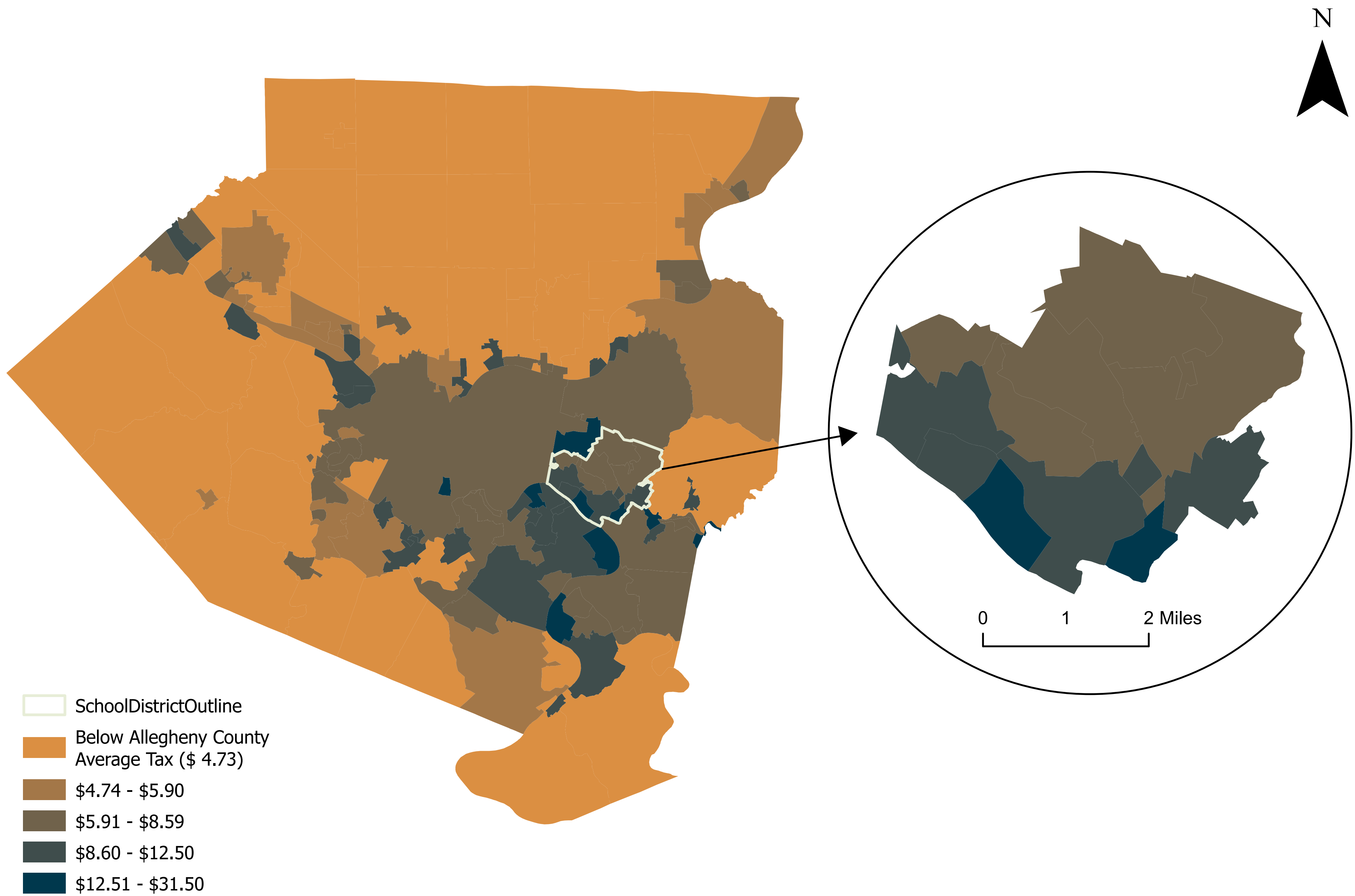
Estimated Percent of Owner Population in Allegheny County from 2016-2020



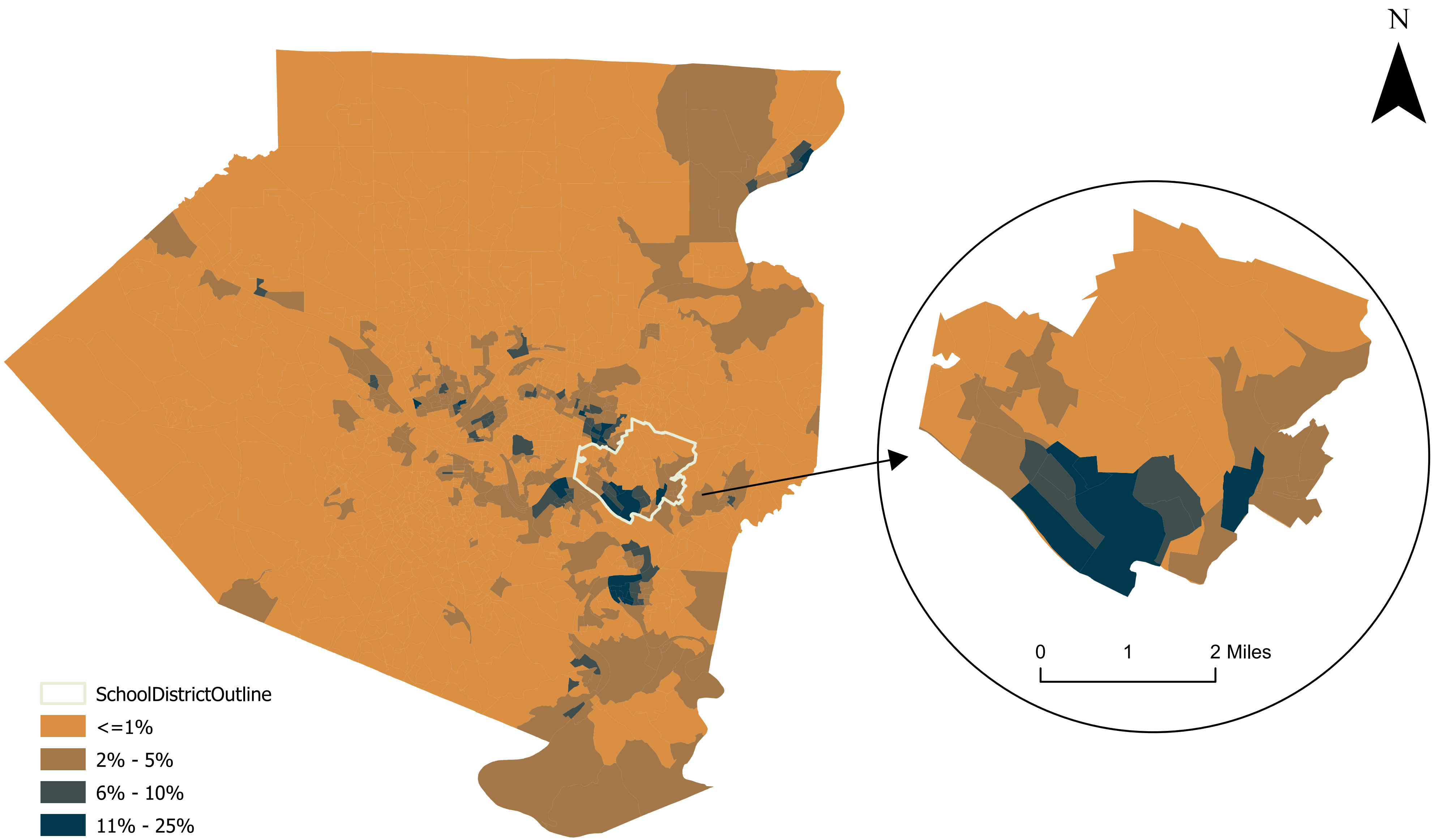
Estimated Percent of Renter Population in Allegheny County from 2016-2020



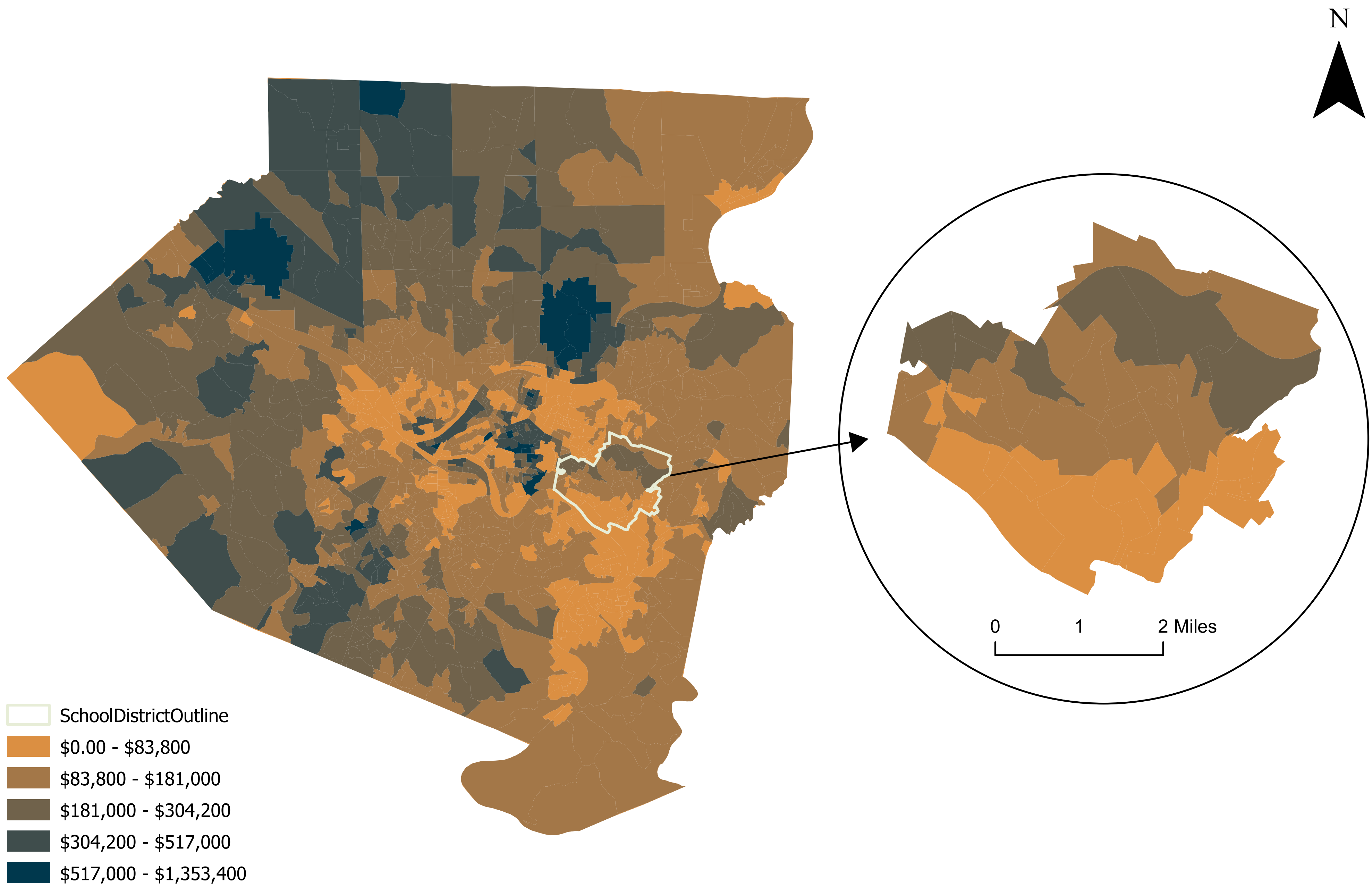
Property Tax (Millage Rate) in Allegheny County from 2022



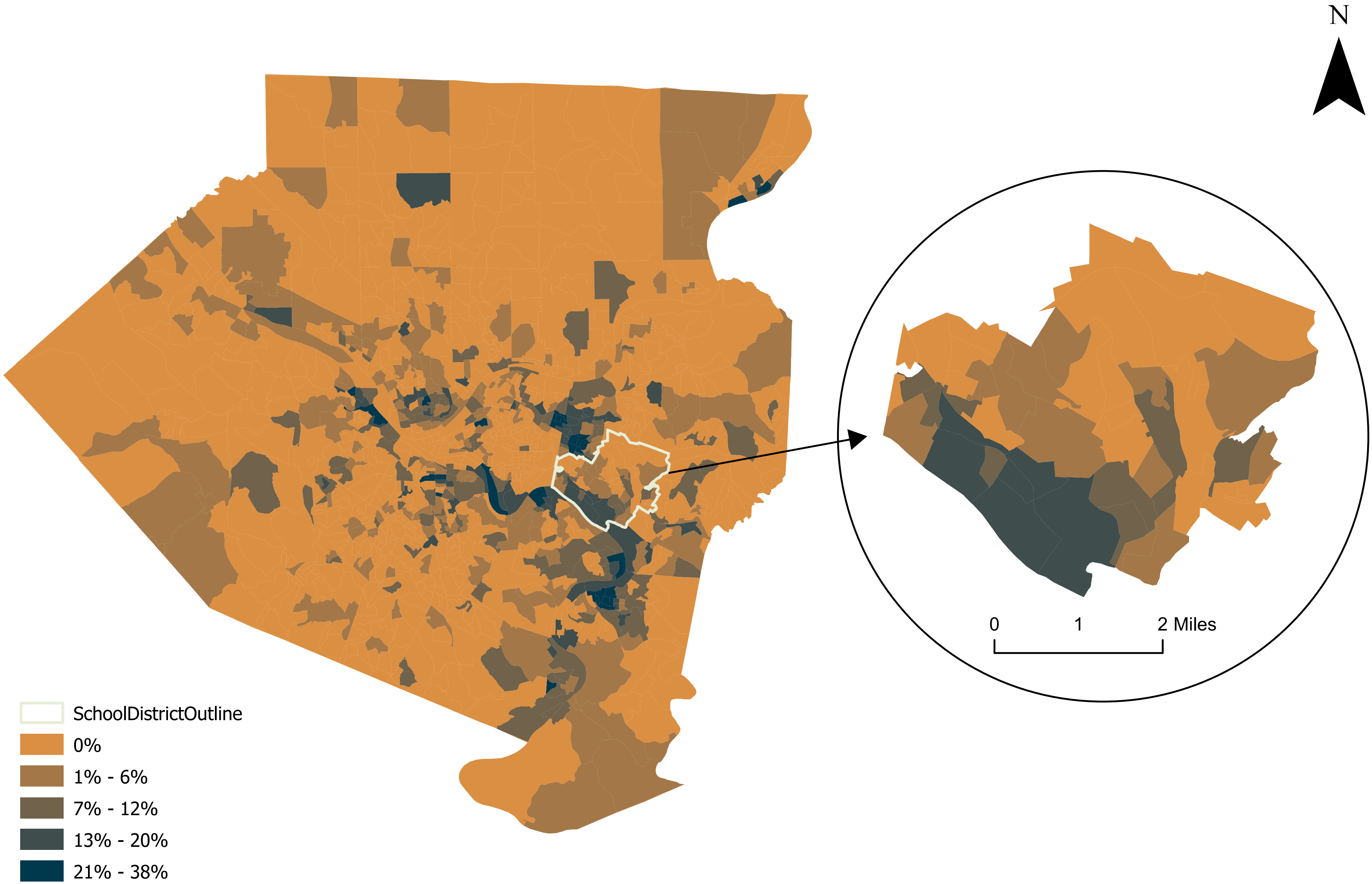
Percent of Parcels in Poor or Worse Condition in Allegheny County



Estimated Median House Value in Allegheny County from 2016-2020

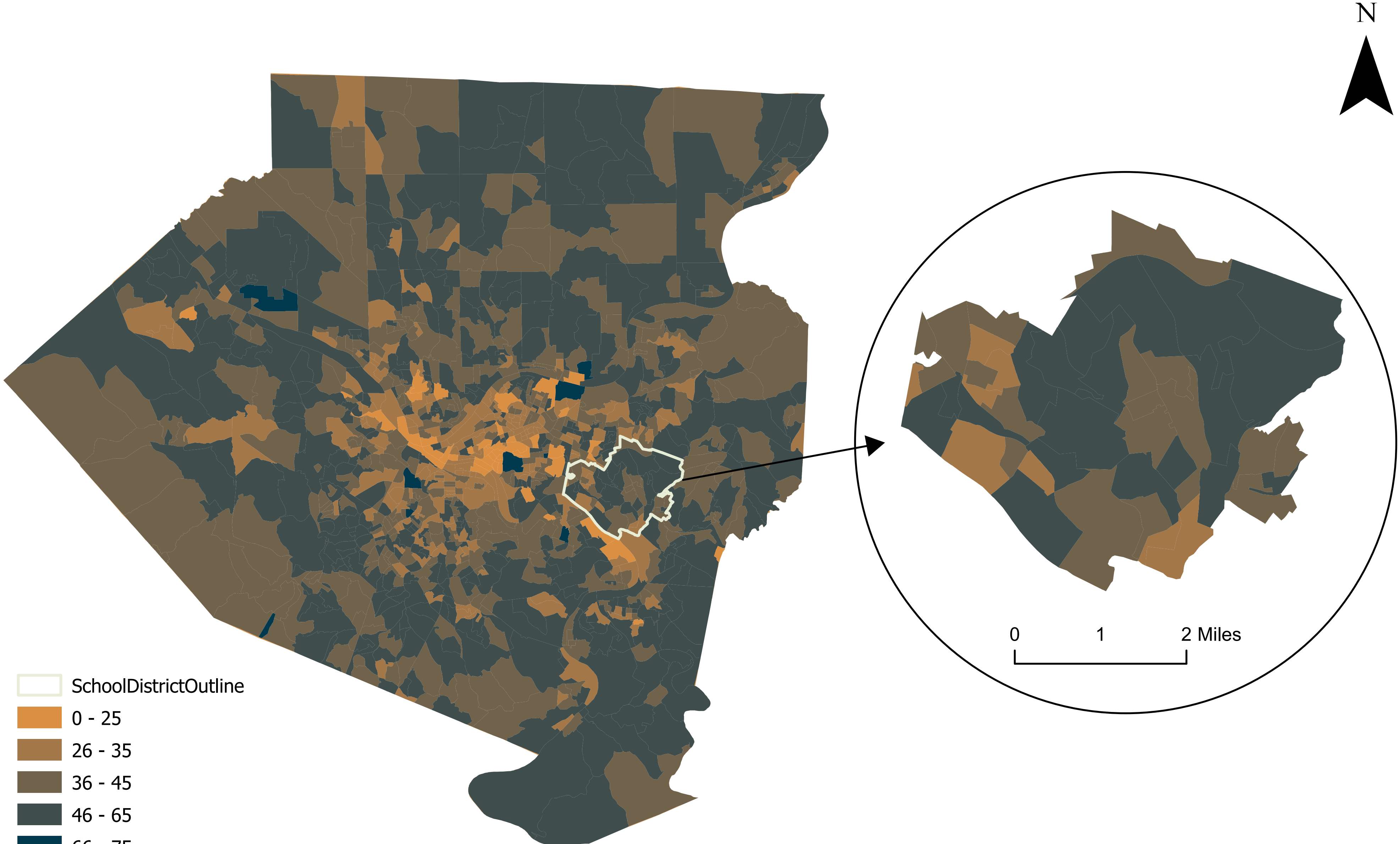


Estimated Percent of Housing Units Lacking Complete Plumbing Facilities in Allegheny County from 2016-2020

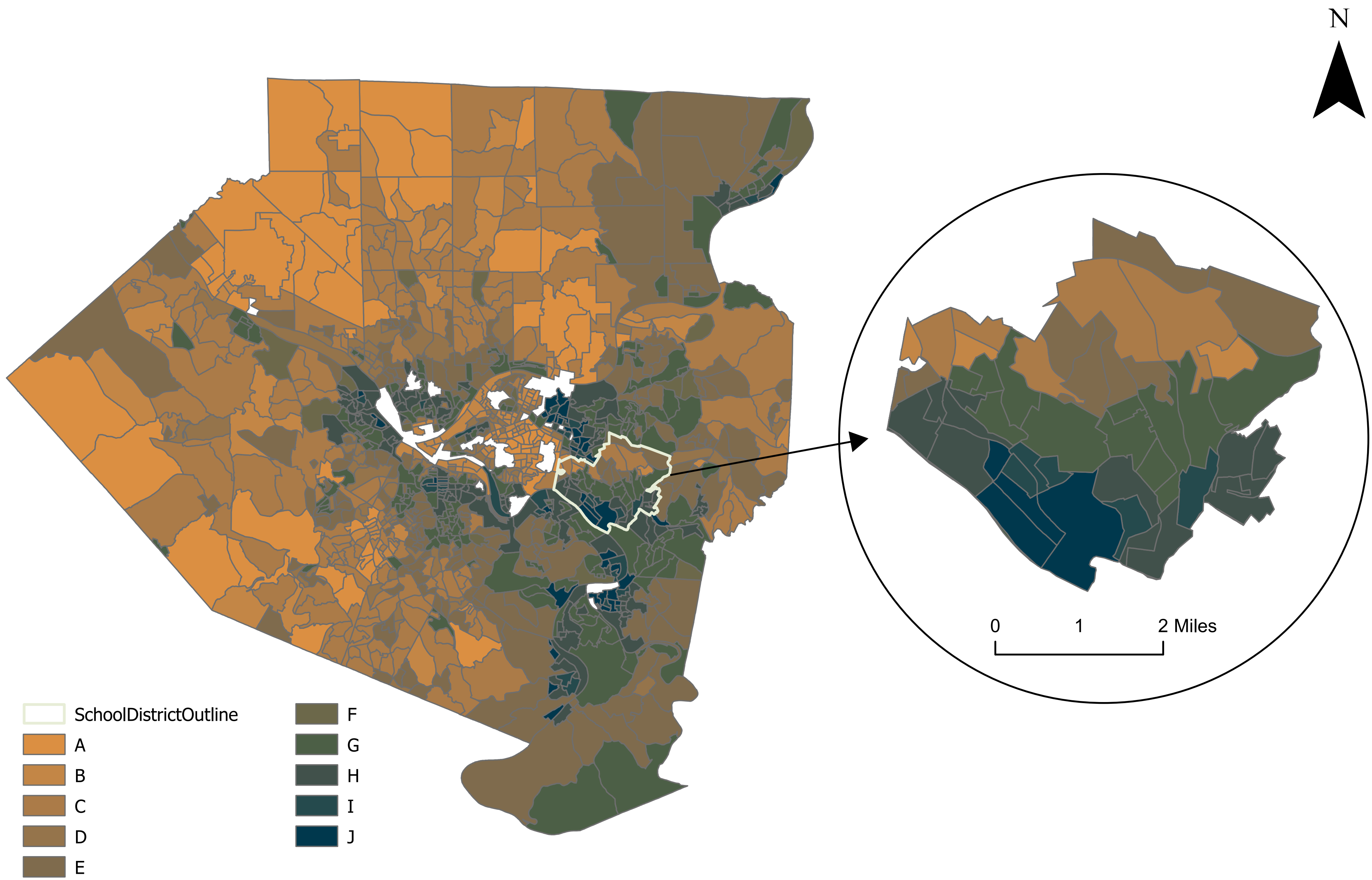


TCLB
Tri-COG Land Bank

Estimated Median Age in Allegheny County from 2016-2020

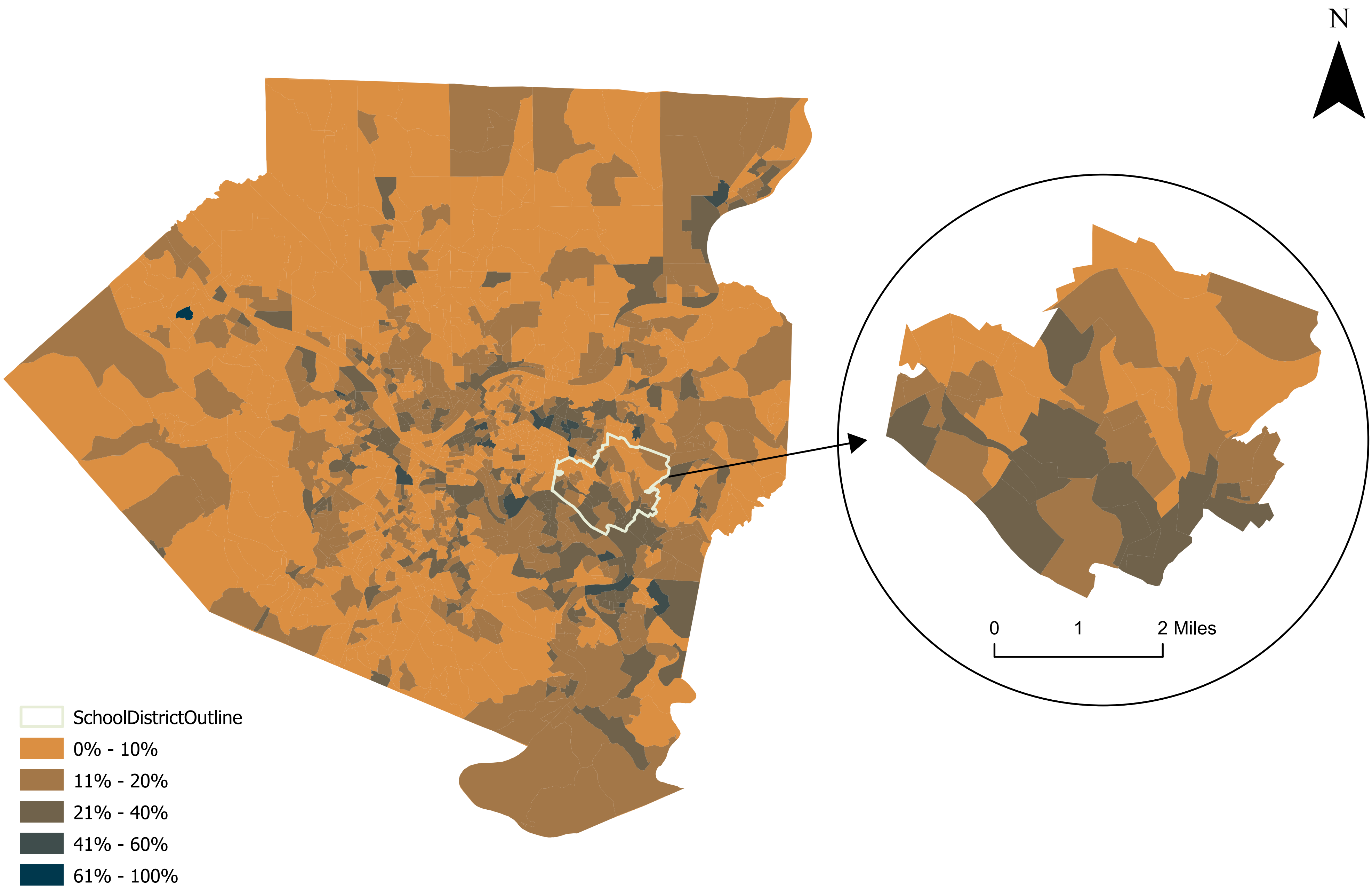


Market Value Analysis in Allegheny County from 2021



TCLB
Tri-COG Land Bank

Estimated Percent of Housing Units without Internet Access in Allegheny County from 2016-2020



Green Building Alliance

PERFORMANCE TARGETS REPORT

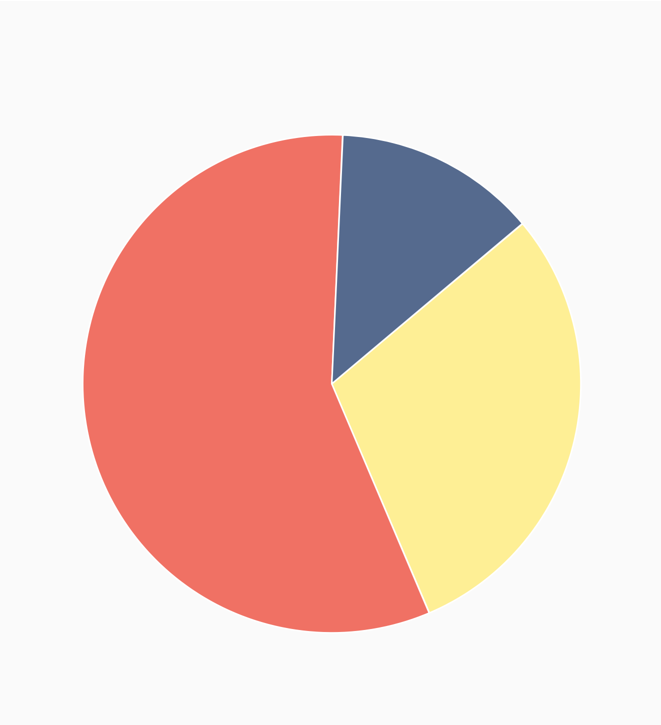
Residential-all types Performance Report

Created: 9/30/2022

ENERGY

Site Energy Breakdown by Type: ENERGY STAR® Portfolio Manager® Source Report – 2021

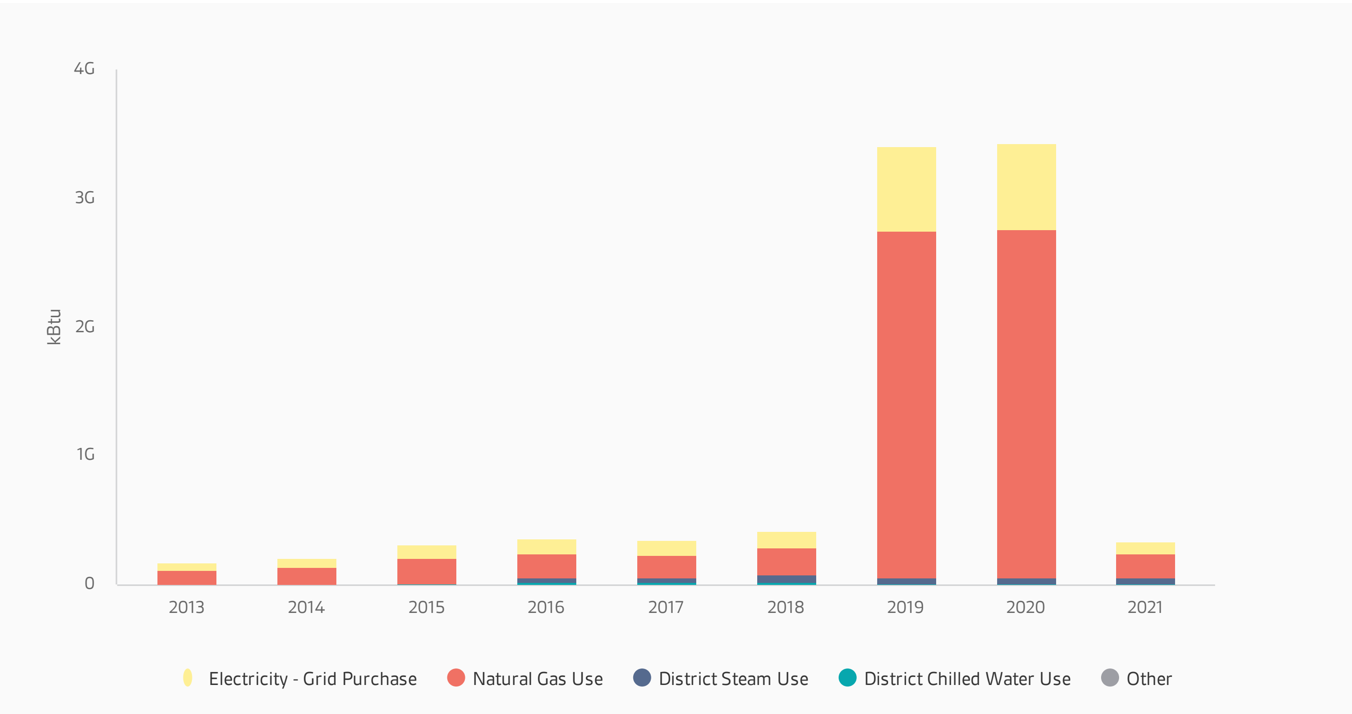
The following section displays a breakdown of energy by type consumed in the portfolio. 61 buildings have reported Weather Normalized Site Energy Use data for the selected year.



Energy Type	kBtu
Natural Gas Use	184,906,098.5
Electricity - Grid Purchase	96,220,762.0
District Steam Use	42,664,915.0
On Site Renewable Electricity	0.0
District Hot Water Use	0.0
Diesel #2 Use	0.0
Fuel Oil #4 Use	0.0
Other	0.0
Total Site Energy Use	337,334,485.9

Total Portfolio Site Energy Consumption: ENERGY STAR® Portfolio Manager® Report - Last 9 Years

Annual Consumption for all Site Energy Types



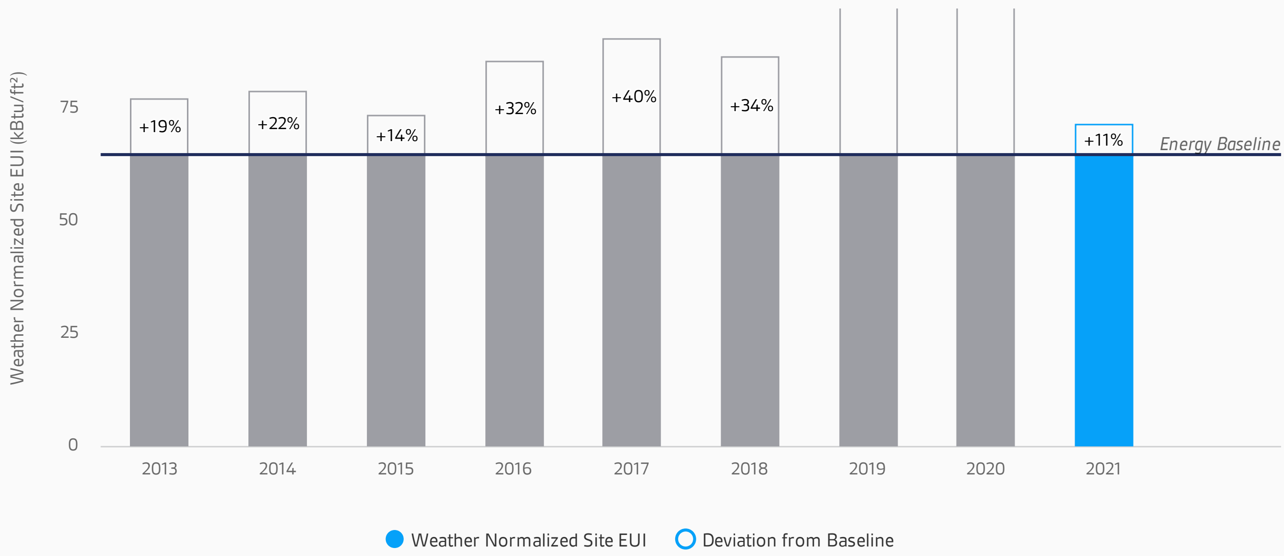
Performance by Energy Usage: ENERGY STAR® Portfolio Manager® Report – All Years

Each year in the table presents the annual total energy use for buildings that have reported energy data for that year. Buildings that do not have energy data for a given year are excluded for that year.

	Number of Buildings	Total Floor Area (ft²)	Weather Normalized Site Electricity Use (Grid and Onsite Renewables) (kBtu)	Weather Normalized Site Natural Gas Use (kBtu)	Weather Normalized Other (kBtu)	Weather Normalized Site Energy Use (kBtu)
2013	29	2,279,696.0	57,042,656.9	117,222,785.8	1,865,904.7	176,131,347.3
2014	29	2,576,969.0	68,665,438.0	129,132,510.1	5,651,128.0	203,449,076.1
2015	32	4,368,902.0	106,705,291.6	201,877,829.7	12,944,665.7	321,527,787.0
2016	41	4,407,157.0	113,429,372.9	201,740,654.0	62,493,615.8	377,663,642.7
2017	42	4,052,228.0	111,019,453.3	195,538,946.5	61,107,845.7	367,666,245.6
2018	59	4,731,345.0	123,145,322.7	206,754,762.1	80,717,956.6	410,618,041.4
2019	69	34,488,166.0	630,601,034.7	2,808,931,644.8	56,325,491.1	3,495,858,170.6
2020	75	35,110,460.0	619,677,019.6	2,937,958,790.5	89,735,163.5	3,647,370,973.6
2021	61	4,981,699.0	66,447,424.1	201,750,324.4	88,276,944.5	356,474,693.0
Changes ?	↓ 18.67%	↓ 85.81%	↓ 89.28%	↓ 93.13%	↓ 1.63%	↓ 90.23%

Year to Year Trends: ENERGY STAR® Portfolio Manager® Report

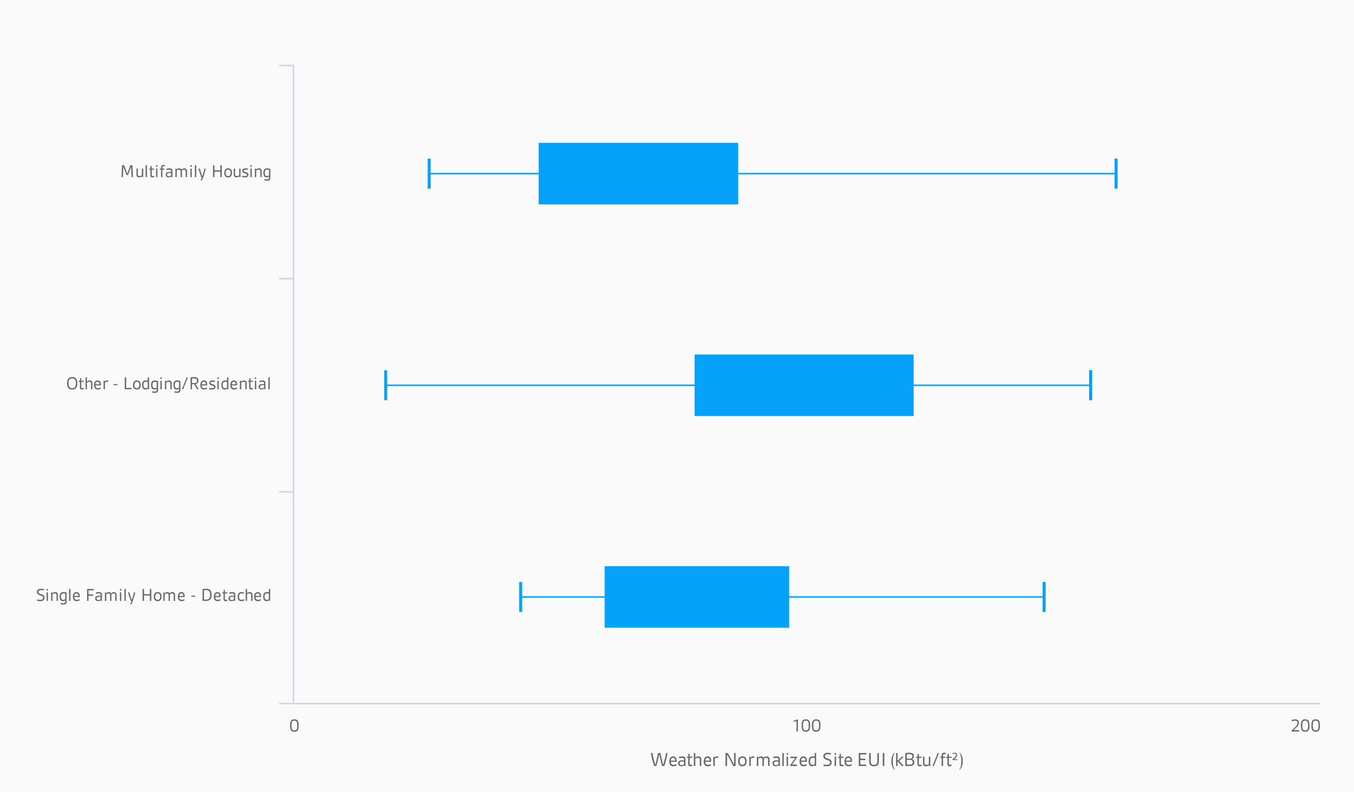
The following plot shows the weighted average Energy Use Intensity of buildings across the portfolio. Only buildings with reported energy use data for a given year are included in the intensity calculation for that year.



** For years when intensity is more than 150% of the baseline, the bars are capped to maintain the readability of the bar chart.*

EUI by Building Type: ENERGY STAR® Portfolio Manager® Report – 2021

The following plot shows the distribution of EUI for each building type in the portfolio.



Energy Use Intensity by Building Type: ENERGY STAR® Portfolio Manager® Report – 2021

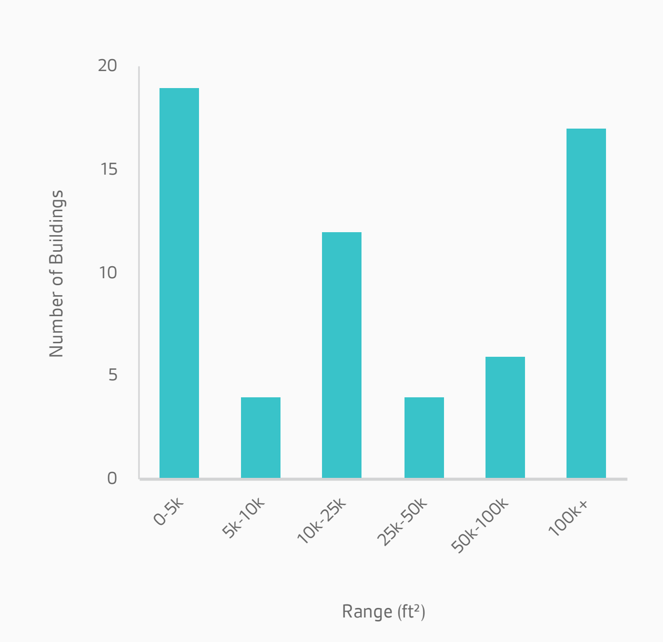
The following table summarizes the number of buildings and their energy use intensity by building type.

Building Type	Number of Buildings	Min Weather Normalized Site EUI (kBtu/ft²)	Max Weather Normalized Site EUI (kBtu/ft²)	Median Weather Normalized Site EUI (kBtu/ft²)
Multifamily Housing	31	26.1	160.2	76.3
Other - Lodging/Residential	20	17.6	155.1	102.9
Single Family Home - Detached	10	43.9	146.1	71.6
Office	0	–	–	–
Non-Refrigerated Warehouse	0	–	–	–
Refrigerated Warehouse	0	–	–	–
Retail Store	0	–	–	–
Retail, High Street	0	–	–	–
Retail, Shopping Center	0	–	–	–

BUILDINGS

Building Size by Floor Area – 2021

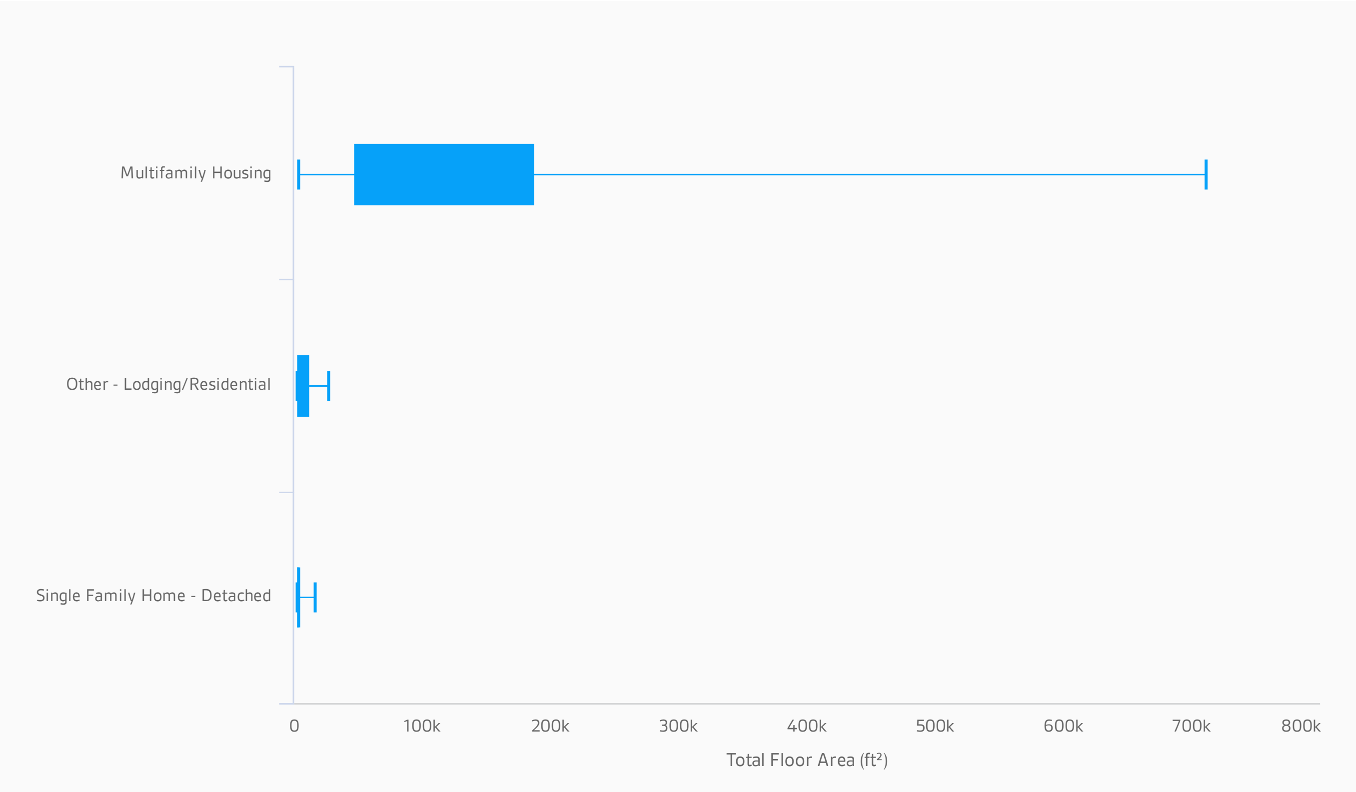
The following section displays the distribution of building sizes in the portfolio.



Range (ft²)	# of Buildings	Total Floor Area (ft²)
0-5k	19	52,372.0
5k-10k	4	26,291.0
10k-25k	12	154,703.0
25k-50k	4	144,693.0
50k-100k	6	382,763.0
100k+	17	4,252,204.0

Floor Area by Building Type – 2021

The following plot shows the distribution of floor area for each building type in the portfolio.



Floor Area Breakdown by Building Type – 2021

The following table summarizes the number of buildings and their floor area by building type.

Building Type	Number of Buildings	Total Floor Area (ft²)	Min Floor Area (ft²)	Max Floor Area (ft²)	Average Floor Area (ft²)
Multifamily Housing	31	4,800,917.0	2,516.0	710,350.0	154,868.3
Other - Lodging/Residential	21	169,725.0	1,280.0	26,359.0	8,082.1
Single Family Home - Detached	10	42,384.0	1,850.0	16,000.0	4,238.4
Office	0	–	–	–	–
Non-Refrigerated Warehouse	0	–	–	–	–
Refrigerated Warehouse	0	–	–	–	–
Retail Store	0	–	–	–	–
Retail, High Street	0	–	–	–	–
Retail, Shopping Center	0	–	–	–	–

PERFORMANCE TARGETS REPORT

Braddock Hills Residential Test

2019 – 2020

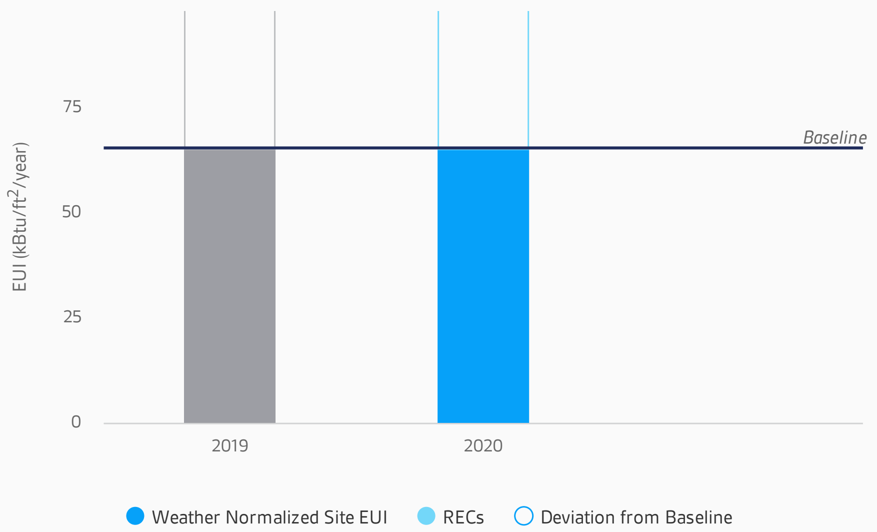
Created: 9/30/2022

Main St
Braddock Hills, PA
15104 United States

ENERGY

Energy Report: ENERGY STAR® Portfolio Manager® Report

The graph below summarizes annual energy performance over time relative to building intensity baselines and targets.



** For years when intensity is more than 150% of the baseline, the bars are capped to maintain the readability of the bar chart.*

Baseline

65.3 EUI

kBtu/ft²

2020 Performance

115.6 EUI

77.11% above the baseline (with RECs)

2019 Performance

111.5 EUI

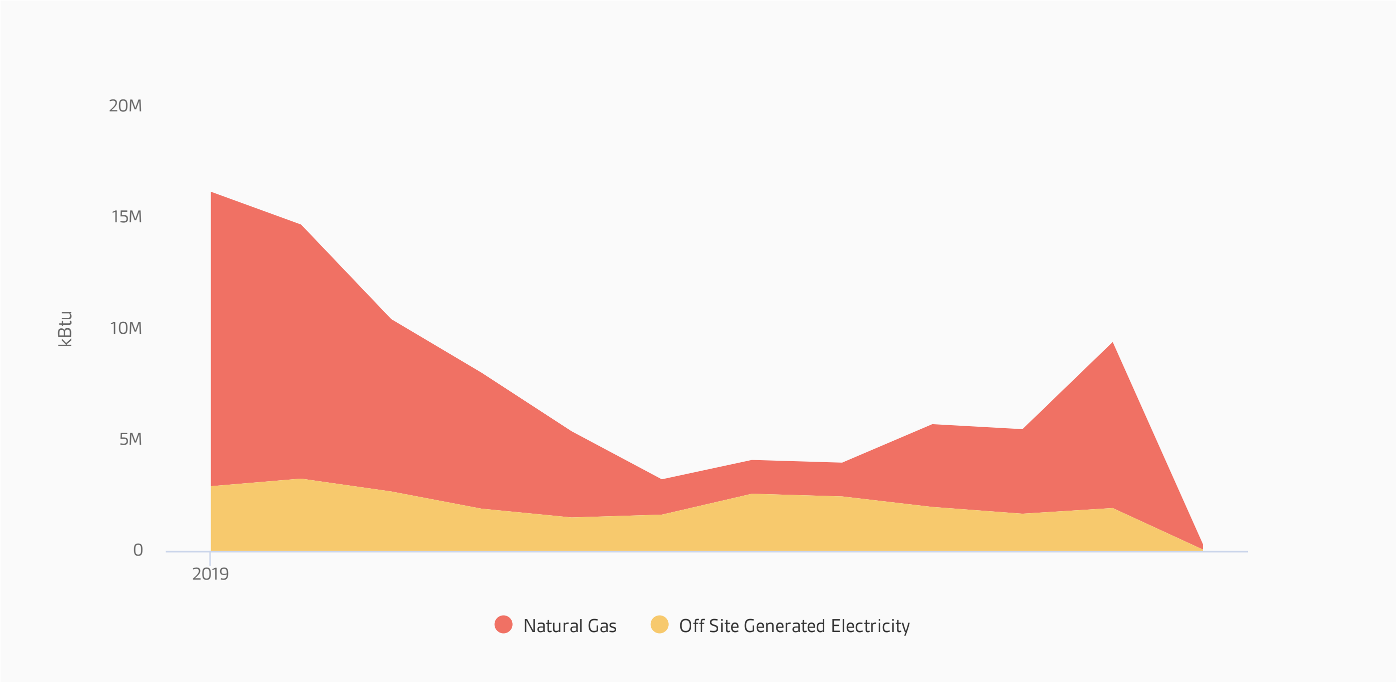
70.83% above the baseline (with RECs)

Single Family Home - Detached Energy Performance Savings: 2021

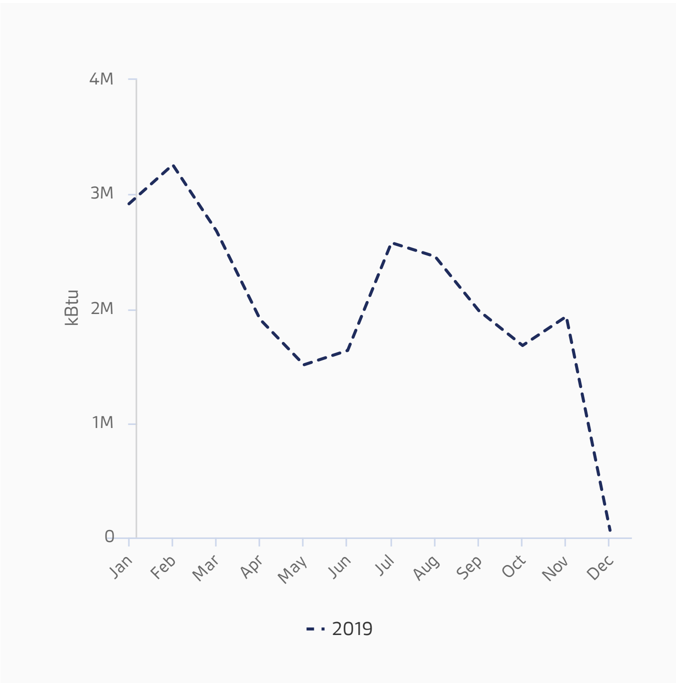
The chart below compares the energy performance of all sites of similar type relative to their individual baselines. Note: For sites using more than 20% energy above their baseline, the bars are capped to maintain chart readability.

There is currently no data to display.

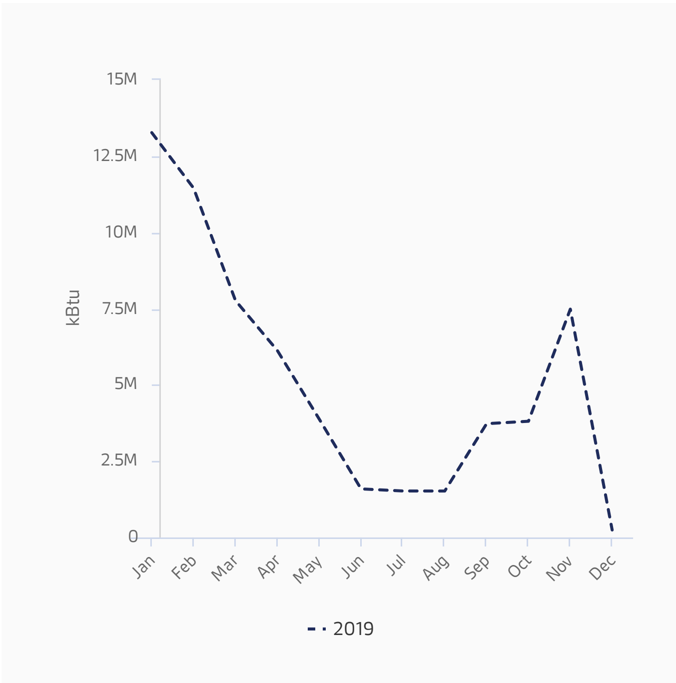
Total Energy Use by Calendar Month – Stacked Area Chart



Total Off Site Generated Electricity

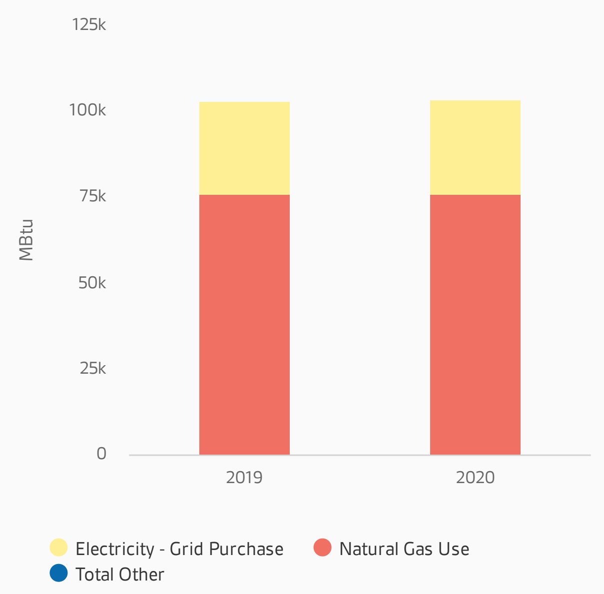


Total Natural Gas



Calendar Year Total Energy Consumption: ENERGY STAR® Portfolio Manager® Report

Annual Consumption for All Energy Types



Calendar Year Total Energy Spend: ENERGY STAR® Portfolio Manager® Report

Annual Spend for All Energy Types

There is currently no data to display.

Performance by Energy Type Usage: ENERGY STAR® Portfolio Manager® Report

All data displayed in the following table is weather normalized

	Weather Normalized Site Electricity Use (Grid and Onsite Renewables) (kBtu)	Weather Normalized Site Natural Gas Use (kBtu)	Total Other (kBtu)	Weather Normalized Site Energy Use (kBtu)
2019	26,867,595	79,246,439.0	N/A	106,109,633.0
2020	27,539,625	82,470,253.0	N/A	110,005,319.0
Changes	↑ 2.5%	↑ 4.07%	↓ 0%	↑ 3.67%

SITE USE INFORMATION

Other – Single Family Home

Gross Floor Area	*761,531 ft²*

Multifamily Housing – Multifamily Housing

Gross Floor Area	*189,774 ft²*
Number of Residential Living Units	*228*
Number of Bedrooms	*266*
Resident Population Type	
Is Government Subsidized Housing	*No*
Percent That Can Be Heated	*All of it - 100%*
Percent That Can Be Cooled	*All of it - 100%*

Green Building Alliance

PERFORMANCE TARGETS REPORT

Braddock Residential Test

2019 – 2020

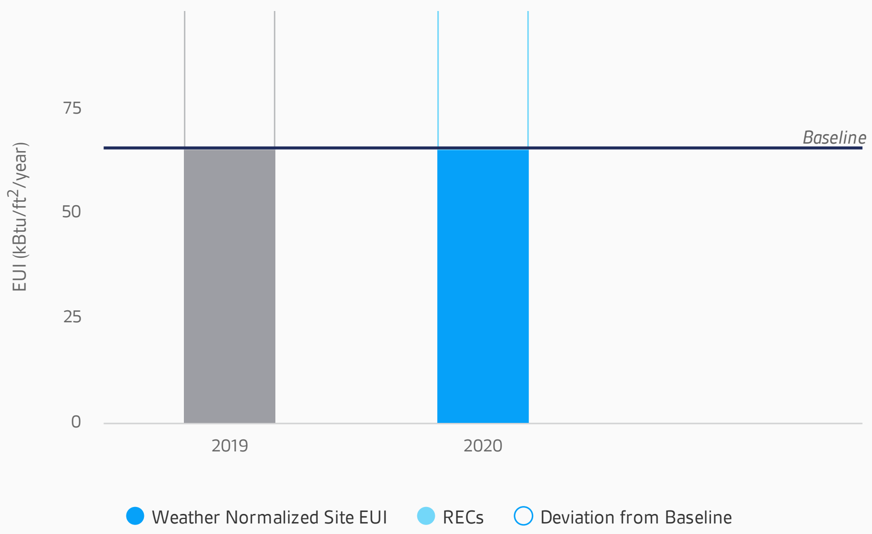
Created: 9/30/2022

Main St
Braddock, PA
15104 United States

ENERGY

Energy Report: ENERGY STAR® Portfolio Manager® Report

The graph below summarizes annual energy performance over time relative to building intensity baselines and targets.



** For years when intensity is more than 150% of the baseline, the bars are capped to maintain the readability of the bar chart.*

Baseline

65.4 EUI

kBtu/ft²

2020 Performance

104.4 EUI

↑ 59.65% above the baseline (with RECs)

2019 Performance

99.8 EUI

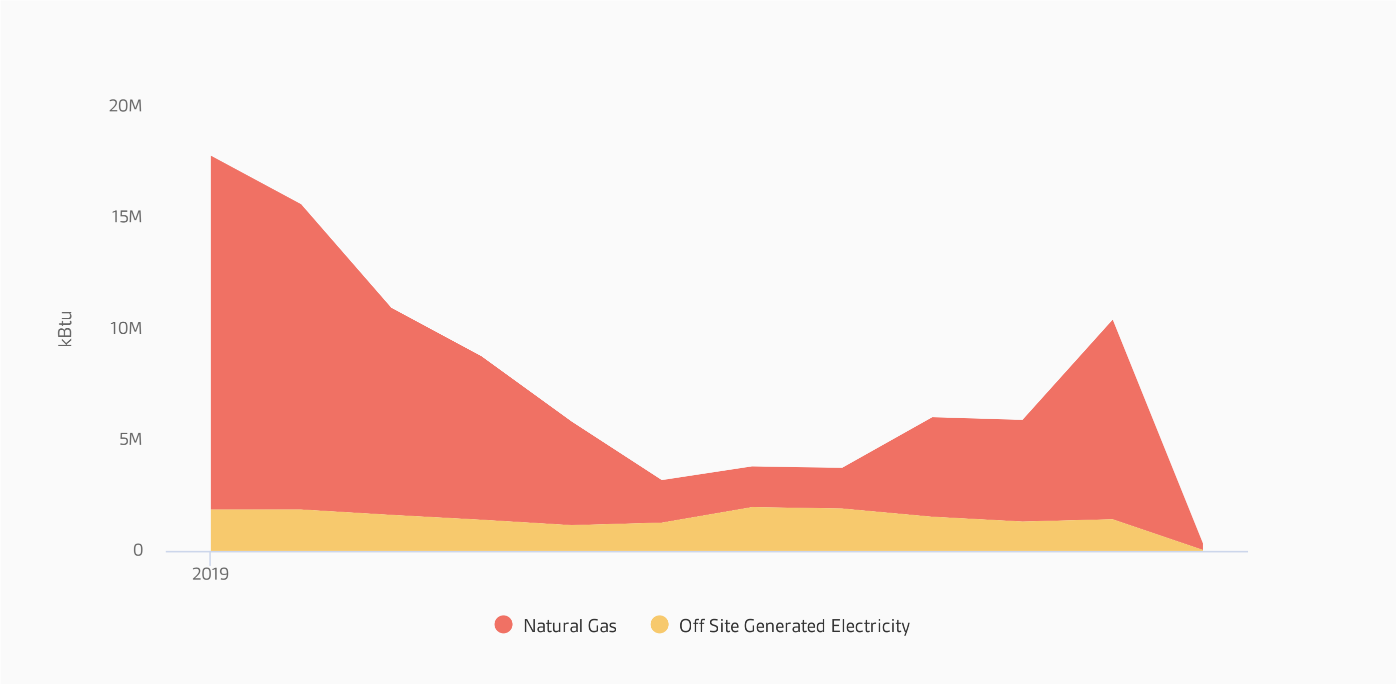
↑ 52.61% above the baseline (with RECs)

Single Family Home - Detached Energy Performance Savings: 2021

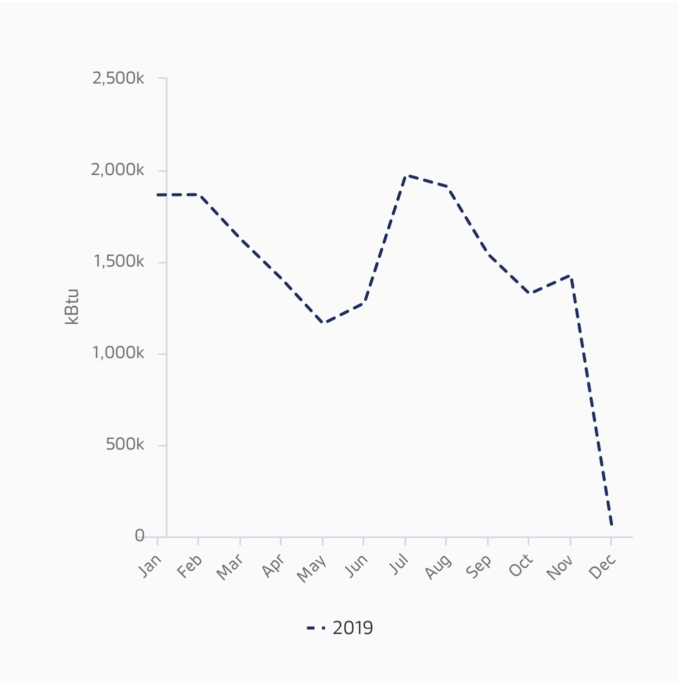
The chart below compares the energy performance of all sites of similar type relative to their individual baselines. Note: For sites using more than 20% energy above their baseline, the bars are capped to maintain chart readability.

There is currently no data to display.

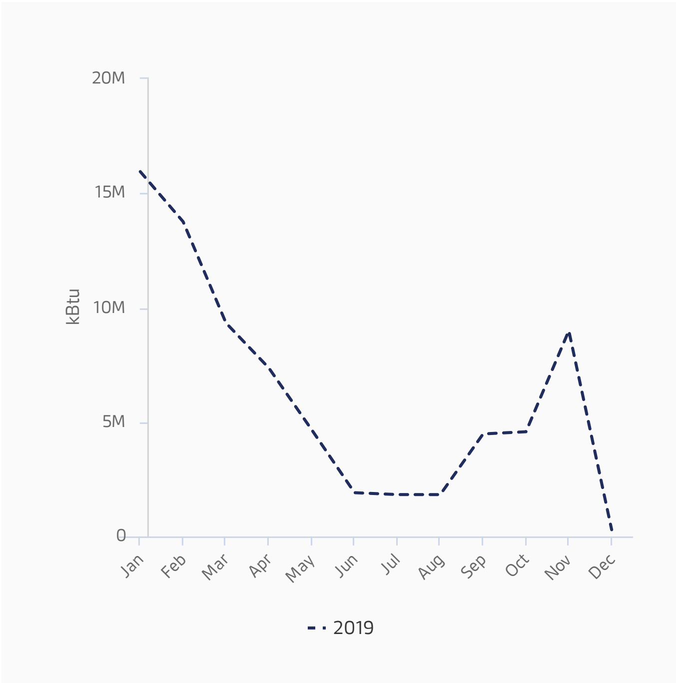
Total Energy Use by Calendar Month – Stacked Area Chart



Total Off Site Generated Electricity

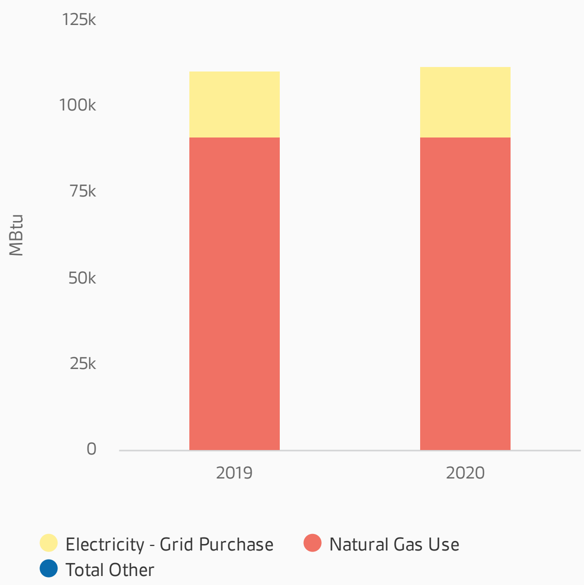


Total Natural Gas



Calendar Year Total Energy Consumption: ENERGY STAR® Portfolio Manager® Report

Annual Consumption for All Energy Types



Calendar Year Total Energy Spend: ENERGY STAR® Portfolio Manager® Report

Annual Spend for All Energy Types

There is currently no data to display.

Performance by Energy Type Usage: ENERGY STAR® Portfolio Manager® Report

All data displayed in the following table is weather normalized

	Weather Normalized Site Electricity Use (Grid and Onsite Renewables) (kBtu)	Weather Normalized Site Natural Gas Use (kBtu)	Total Other (kBtu)	Weather Normalized Site Energy Use (kBtu)
2019	18,843,229	95,221,973.0	N/A	114,060,464.0
2020	20,227,277	99,095,683.0	N/A	119,318,010.0
Changes	↑ 7.35%	↑ 4.07%	↓ 0%	↑ 4.61%

Green Building Alliance *Braddock Residential Test*

SITE USE INFORMATION

Other – Building Use

Gross Floor Area	*897,349 ft²*

Multifamily Housing – Multifamily Housing Use

Gross Floor Area	*245,733 ft²*
Number of Residential Living Units	*303*
Number of Bedrooms	*344*
Resident Population Type	
Is Government Subsidized Housing	*No*
Percent That Can Be Heated	*All of it - 100%*
Percent That Can Be Cooled	*All of it - 100%*

PERFORMANCE TARGETS REPORT

Chalfant Residential Test

2019 – 2020

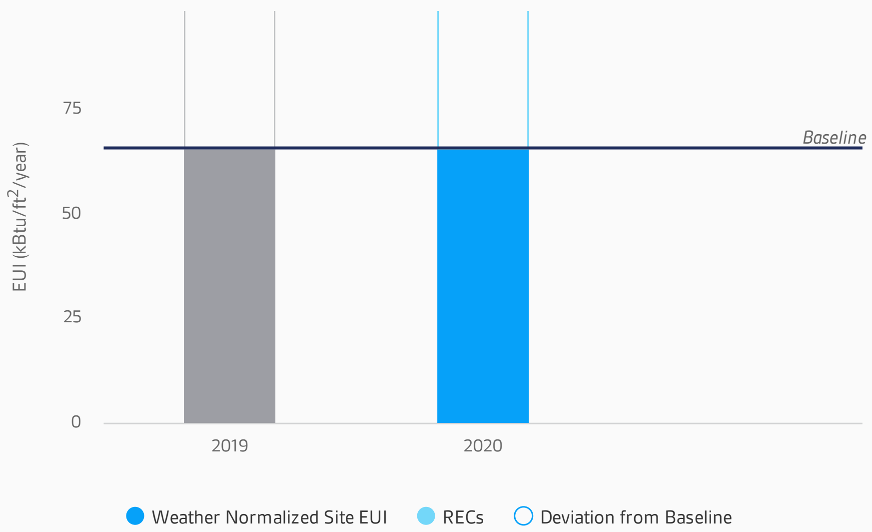
Created: 9/30/2022

Main St
Chalfant, PA
15104 United States

ENERGY

Energy Report: ENERGY STAR® Portfolio Manager® Report

The graph below summarizes annual energy performance over time relative to building intensity baselines and targets.



** For years when intensity is more than 150% of the baseline, the bars are capped to maintain the readability of the bar chart.*

Baseline
65.6 EUI
kBtu/ft²

2020 Performance
105.2 EUI
↑ 60.32% above the baseline (with RECs)

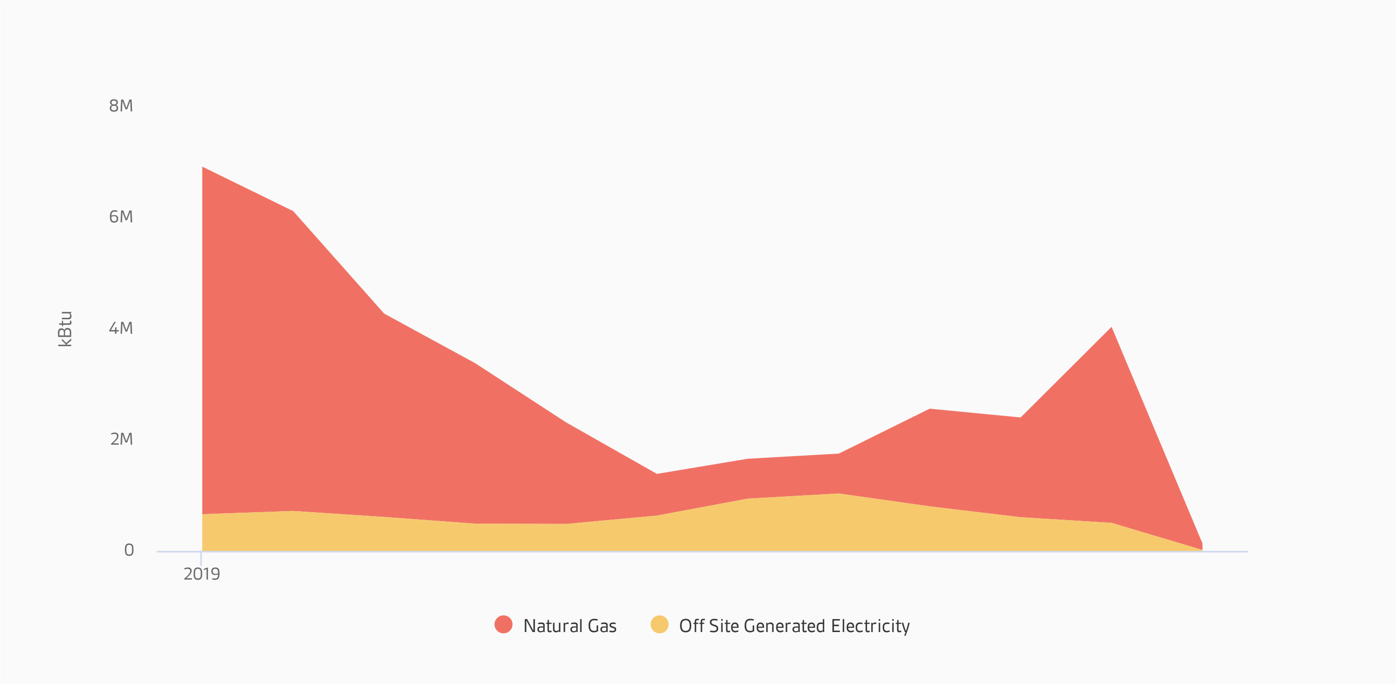
2019 Performance
100.8 EUI
↑ 53.61% above the baseline (with RECs)

Single Family Home - Detached Energy Performance Savings: 2021

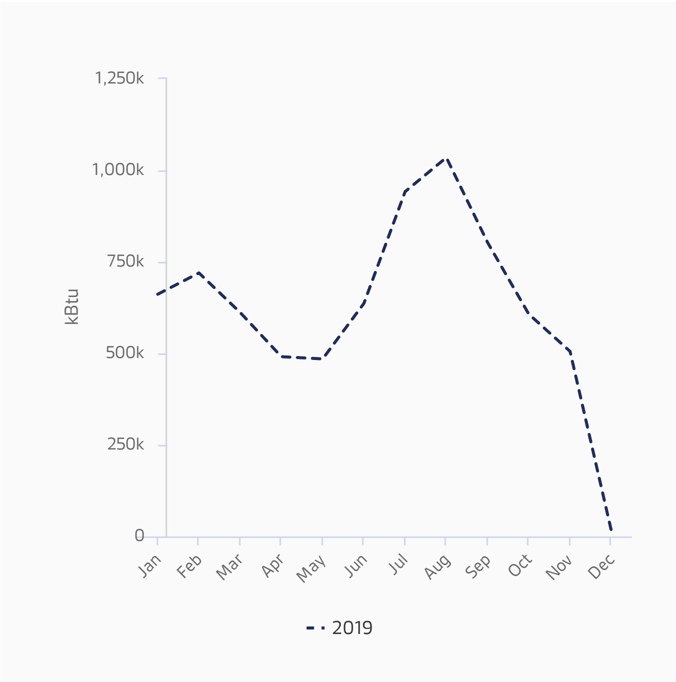
The chart below compares the energy performance of all sites of similar type relative to their individual baselines. Note: For sites using more than 20% energy above their baseline, the bars are capped to maintain chart readability.

There is currently no data to display.

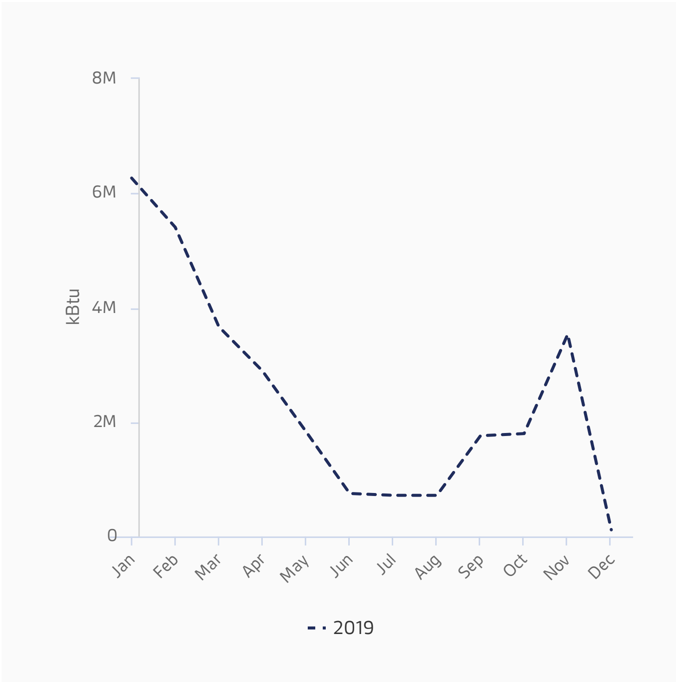
Total Energy Use by Calendar Month – Stacked Area Chart



Total Off Site Generated Electricity

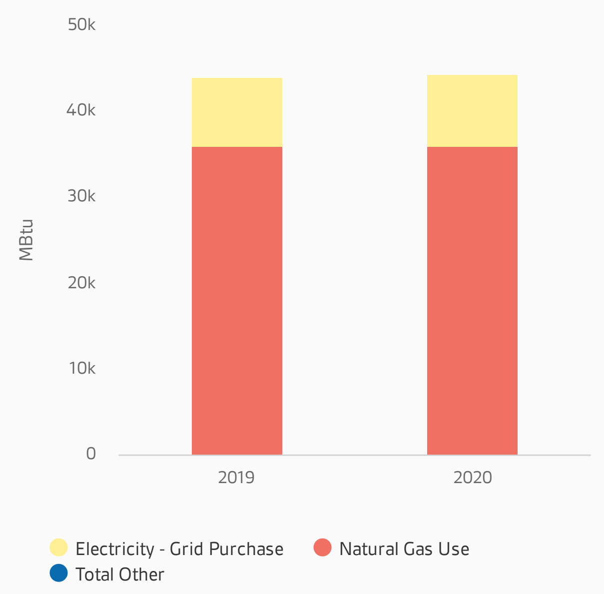


Total Natural Gas



Calendar Year Total Energy Consumption: ENERGY STAR® Portfolio Manager® Report

Annual Consumption for All Energy Types



Calendar Year Total Energy Spend: ENERGY STAR® Portfolio Manager® Report

Annual Spend for All Energy Types

There is currently no data to display.

Performance by Energy Type Usage: ENERGY STAR® Portfolio Manager® Report

All data displayed in the following table is weather normalized

	Weather Normalized Site Electricity Use (Grid and Onsite Renewables) (kBtu)	Weather Normalized Site Natural Gas Use (kBtu)	Total Other (kBtu)	Weather Normalized Site Energy Use (kBtu)
2019	7,874,586	37,416,043.0	N/A	45,288,754.0
2020	8,317,059	38,938,166.0	N/A	47,253,266.0
Changes	↑ 5.62%	↑ 4.07%	↓ 0%	↑ 4.34%

SITE USE INFORMATION

Multifamily Housing — Multifamily Housing

Gross Floor Area	*2,433 ft²*
Number of Residential Living Units	*3*
Number of Bedrooms	*3*
Resident Population Type	
Is Government Subsidized Housing	*No*
Percent That Can Be Heated	*All of it - 100%*
Percent That Can Be Cooled	*All of it - 100%*

Other — Single Family Home

Gross Floor Area	*446,724 ft²*

Green Building Alliance

PERFORMANCE TARGETS REPORT

Churchill Residential Test

2019 – 2020

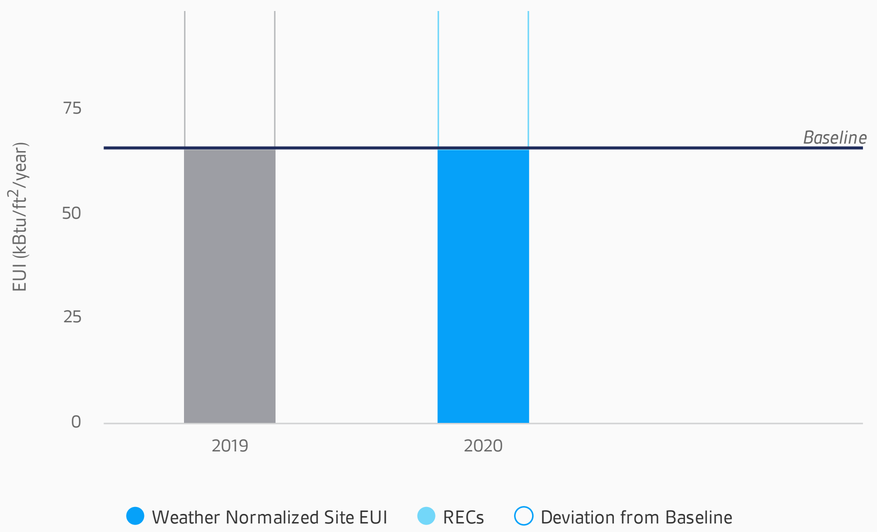
Created: 9/30/2022

Main St
Churchill, PA
15104 United States

ENERGY

Energy Report: ENERGY STAR® Portfolio Manager® Report

The graph below summarizes annual energy performance over time relative to building intensity baselines and targets.



** For years when intensity is more than 150% of the baseline, the bars are capped to maintain the readability of the bar chart.*

Baseline

65.6 EUI

kBtu/ft²

2020 Performance

111.4 EUI

69.83% above the baseline (with RECs)

2019 Performance

106.9 EUI

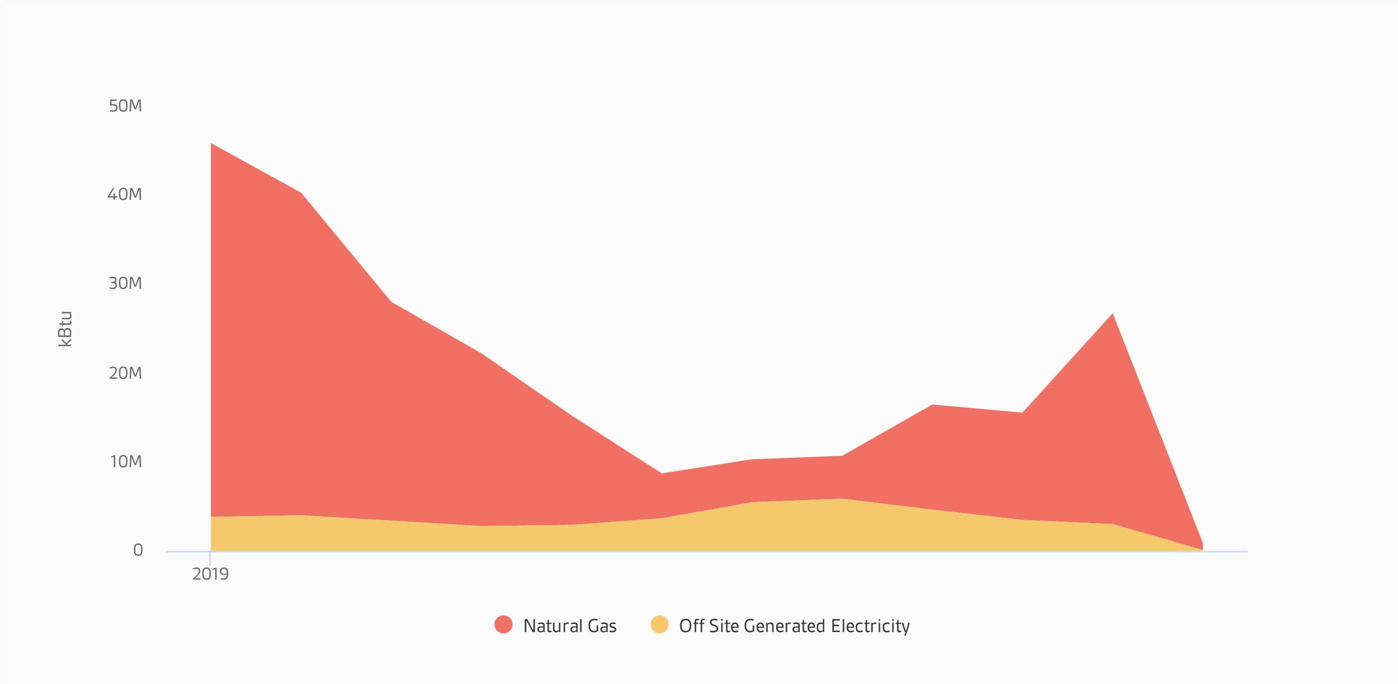
62.97% above the baseline (with RECs)

Single Family Home - Detached Energy Performance Savings: 2021

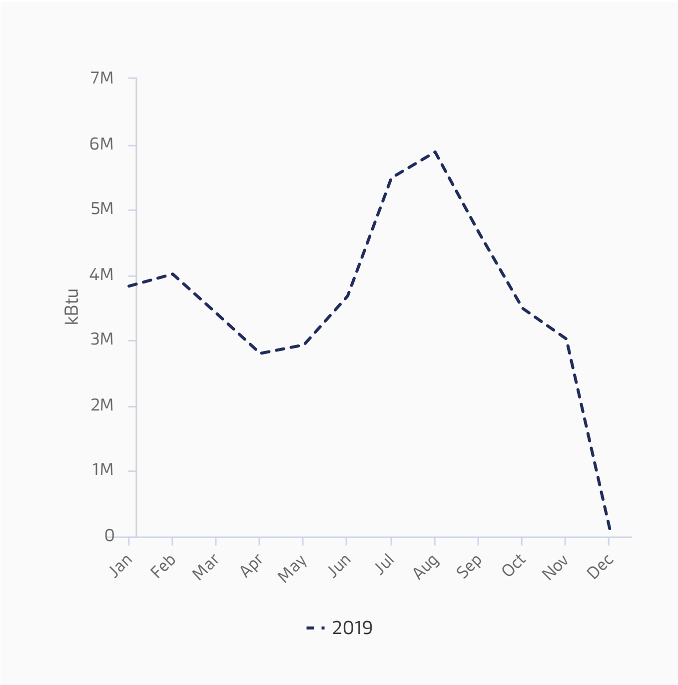
The chart below compares the energy performance of all sites of similar type relative to their individual baselines. Note: For sites using more than 20% energy above their baseline, the bars are capped to maintain chart readability.

There is currently no data to display.

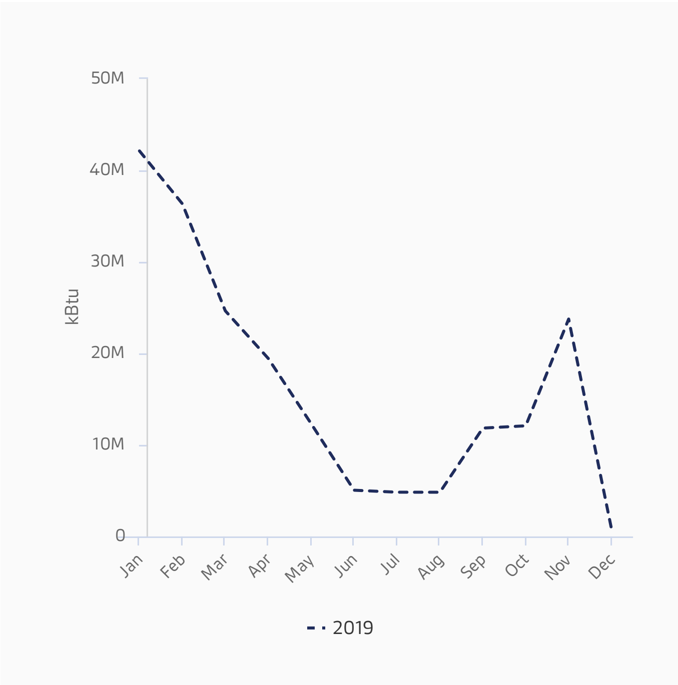
Total Energy Use by Calendar Month – Stacked Area Chart



Total Off Site Generated Electricity

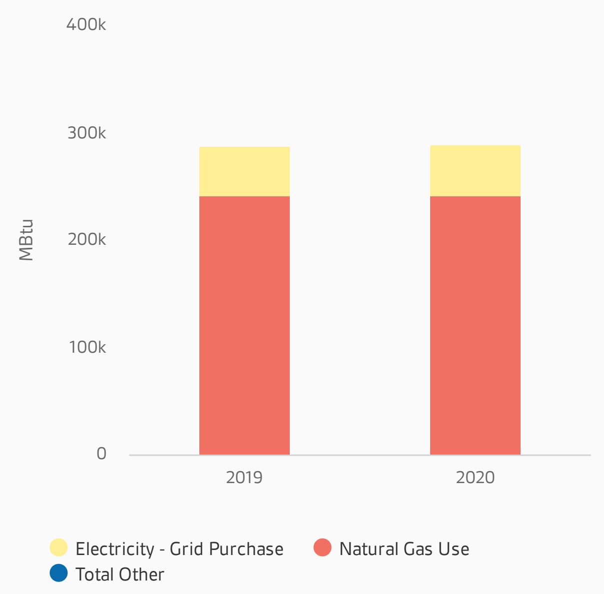


Total Natural Gas



Calendar Year Total Energy Consumption: ENERGY STAR® Portfolio Manager® Report

Annual Consumption for All Energy Types



Calendar Year Total Energy Spend: ENERGY STAR® Portfolio Manager® Report

Annual Spend for All Energy Types

There is currently no data to display.

Performance by Energy Type Usage: ENERGY STAR® Portfolio Manager® Report

All data displayed in the following table is weather normalized

	Weather Normalized Site Electricity Use (Grid and Onsite Renewables) (kBtu)	Weather Normalized Site Natural Gas Use (kBtu)	Total Other (kBtu)	Weather Normalized Site Energy Use (kBtu)
2019	45,478,042	251,552,642.0	N/A	297,018,358.0
2020	47,529,251	261,786,016.0	N/A	309,302,432.0
Changes	↑ 4.51%	↑ 4.07%	↓ 0%	↑ 4.14%

SITE USE INFORMATION

Multifamily Housing – Multifamily Housing

Gross Floor Area	*56,096 ft²*
Number of Residential Living Units	*67*
Number of Bedrooms	*79*
Resident Population Type	
Is Government Subsidized Housing	*No*
Percent That Can Be Heated	*All of it - 100%*
Percent That Can Be Cooled	*All of it - 100%*

Other – Single Family Home

Gross Floor Area	*2,721,623 ft²*

PERFORMANCE TARGETS REPORT

East Pittsburgh Residential Test

2019 – 2020

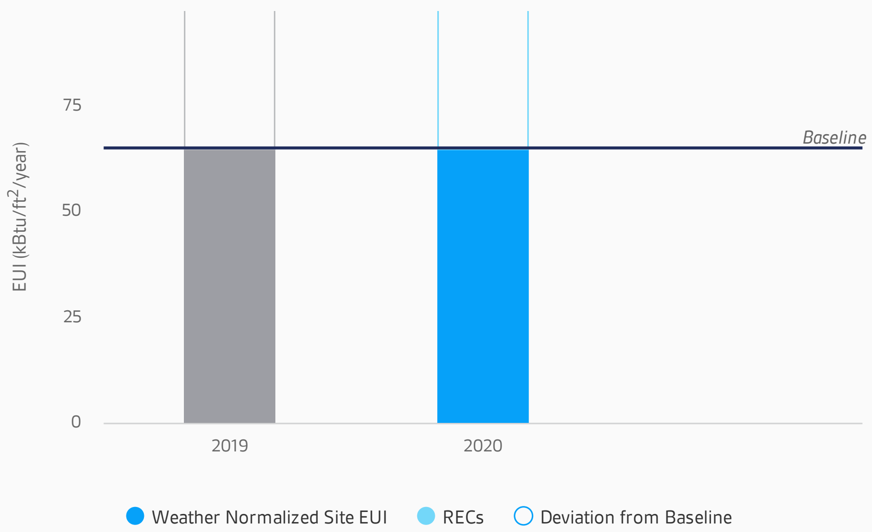
Created: 9/30/2022

East Pittsburgh total municipality
East Pittsburgh, PA
15112 United States

ENERGY

Energy Report: ENERGY STAR® Portfolio Manager® Report

The graph below summarizes annual energy performance over time relative to building intensity baselines and targets.



** For years when intensity is more than 150% of the baseline, the bars are capped to maintain the readability of the bar chart.*

Baseline

64.9 EUI

kBtu/ft²

2020 Performance

105.7 EUI

62.78% above the baseline (with RECs)

2019 Performance

101.1 EUI

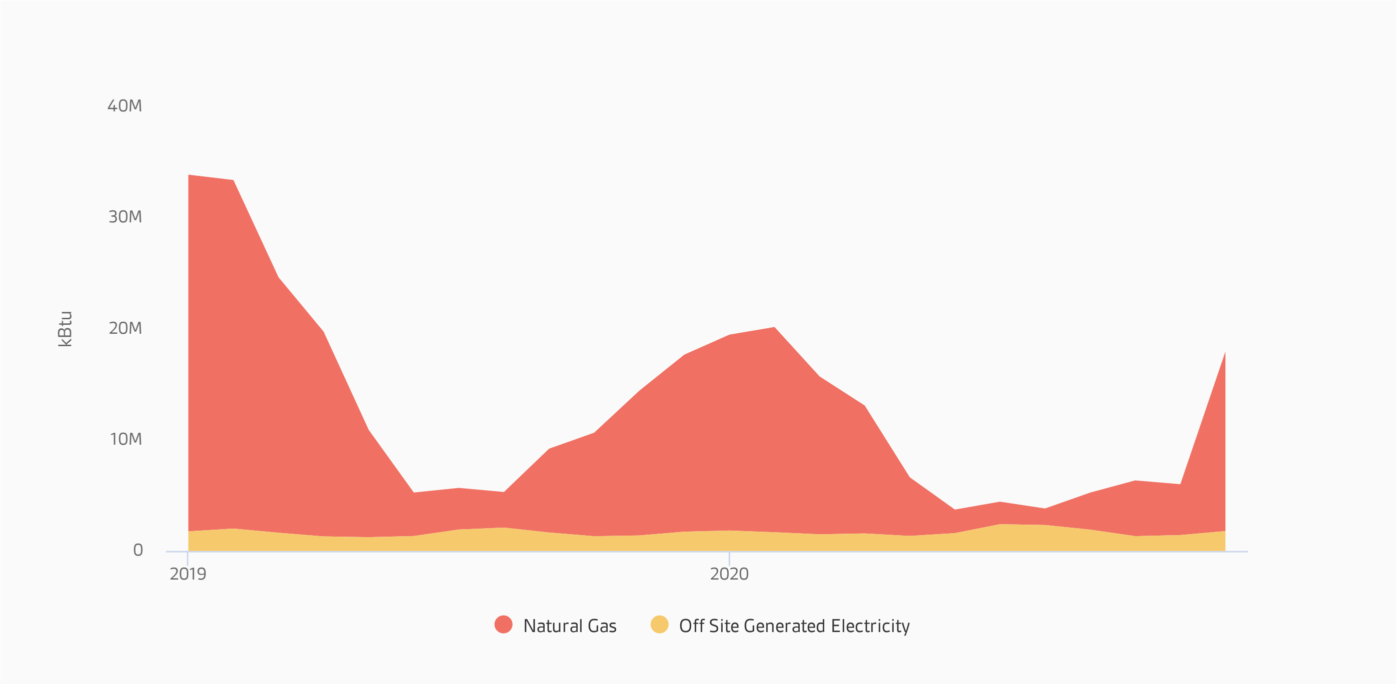
55.69% above the baseline (with RECs)

Single Family Home - Detached Energy Performance Savings: 2021

The chart below compares the energy performance of all sites of similar type relative to their individual baselines. Note: For sites using more than 20% energy above their baseline, the bars are capped to maintain chart readability.

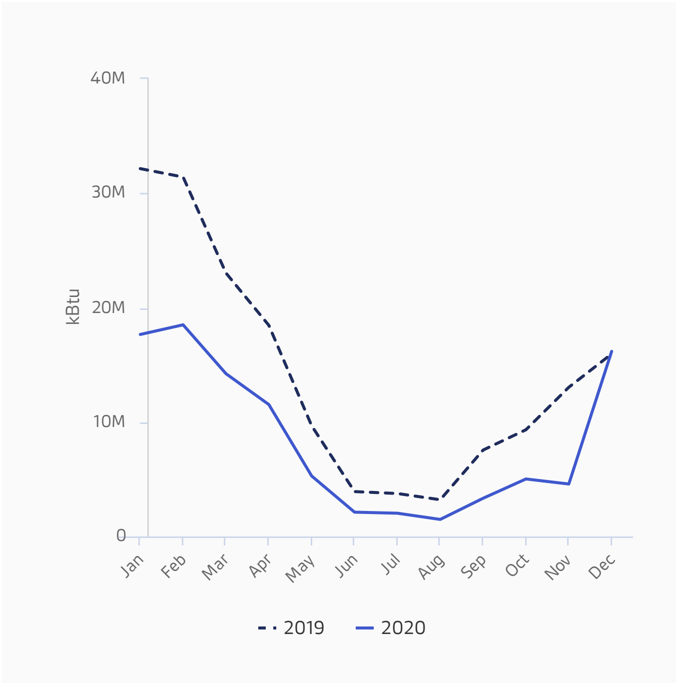
There is currently no data to display.

Total Energy Use by Calendar Month — Stacked Area Chart



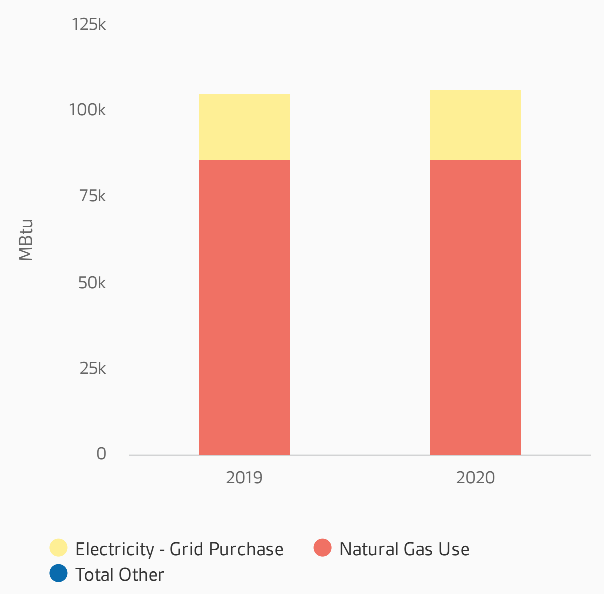
Total Off Site Generated Electricity

Total Natural Gas



Calendar Year Total Energy Consumption: ENERGY STAR® Portfolio Manager® Report

Annual Consumption for All Energy Types



Calendar Year Total Energy Spend: ENERGY STAR® Portfolio Manager® Report

Annual Spend for All Energy Types

There is currently no data to display.

Performance by Energy Type Usage: ENERGY STAR® Portfolio Manager® Report

All data displayed in the following table is weather normalized

	Weather Normalized Site Electricity Use (Grid and Onsite Renewables) (kBtu)	Weather Normalized Site Natural Gas Use (kBtu)	Total Other (kBtu)	Weather Normalized Site Energy Use (kBtu)
2019	19,085,769	89,557,067.0	N/A	108,638,327.0
2020	20,473,089	93,200,329.0	N/A	113,668,704.0
Changes	↑ 7.27%	↑ 4.07%	↓ 0%	↑ 4.63%

SITE USE INFORMATION

Other — Building Use

Gross Floor Area	*802,582 ft²*

Multifamily Housing — Multifamily Housing Use

Gross Floor Area	*272,496 ft²*
Number of Residential Living Units	*336*
Number of Bedrooms	*611*
Resident Population Type	*No specific resident population*
Is Government Subsidized Housing	*No*
Number of Laundry Hookups in All Units	*515*
Percent That Can Be Heated	*All of it - 100%*
Percent That Can Be Cooled	*All of it - 100%*

PERFORMANCE TARGETS REPORT

Edgewood Residential Test

2019 – 2020

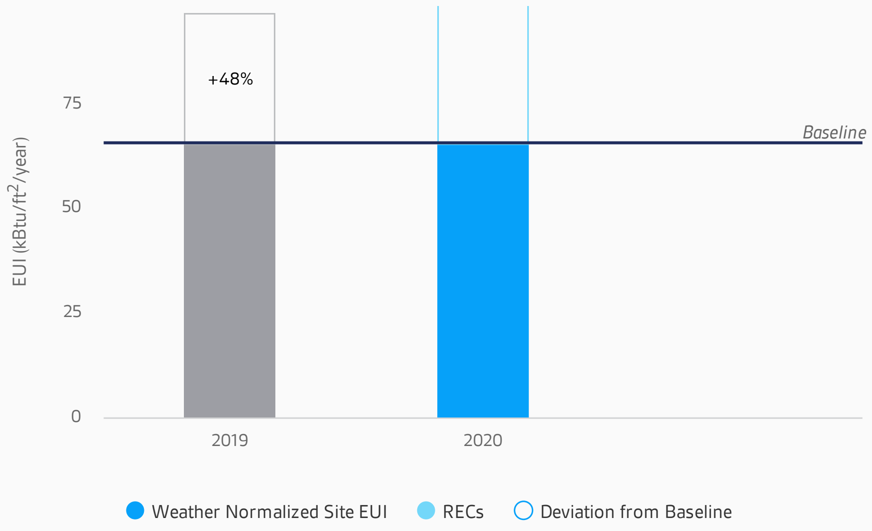
Created: 9/30/2022

Main St
Edgewood, PA
15104 United States

ENERGY

Energy Report: ENERGY STAR® Portfolio Manager® Report

The graph below summarizes annual energy performance over time relative to building intensity baselines and targets.



** For years when intensity is more than 150% of the baseline, the bars are capped to maintain the readability of the bar chart.*

Baseline
65.4 EUI
kBtu/ft²

2020 Performance
101.1 EUI
54.47% above the baseline (with RECs)

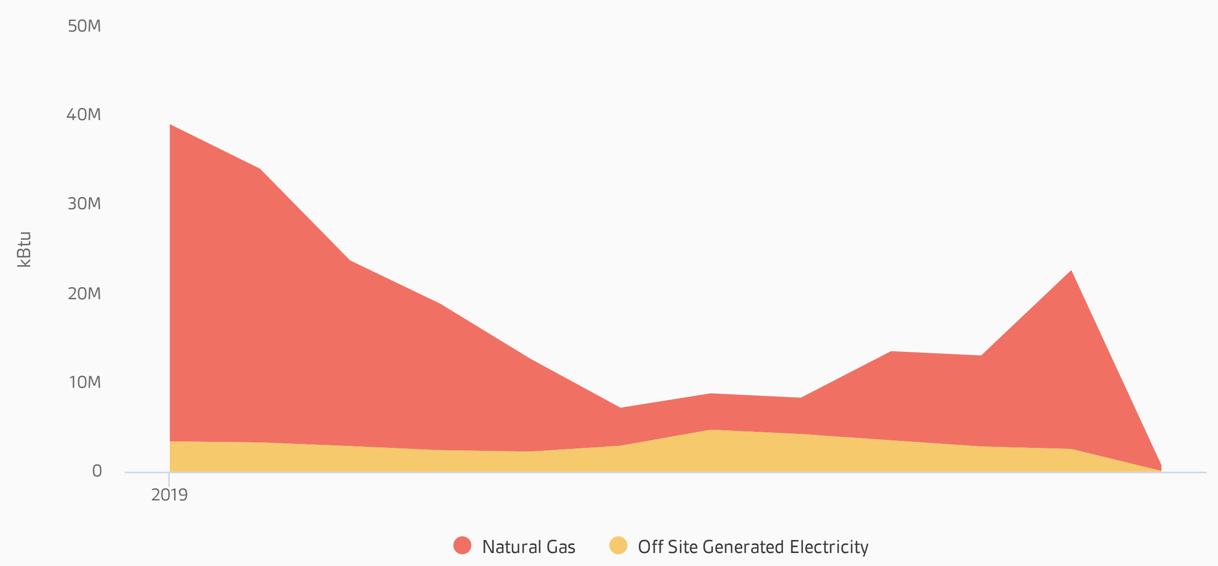
2019 Performance
96.7 EUI
47.75% above the baseline (with RECs)

Single Family Home - Detached Energy Performance Savings: 2021

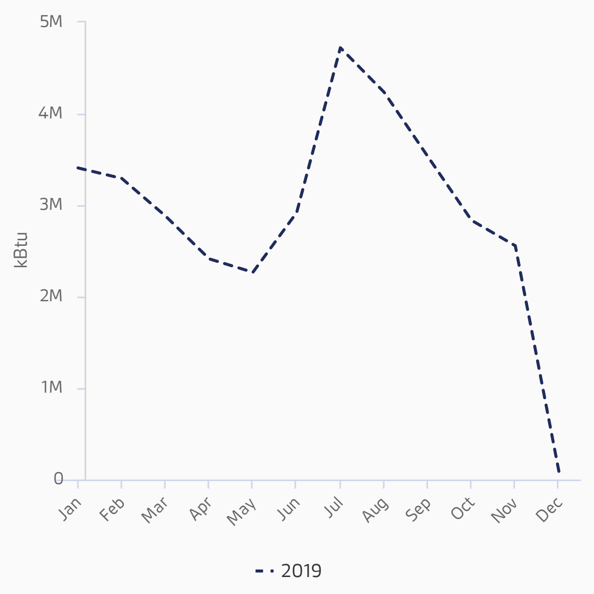
The chart below compares the energy performance of all sites of similar type relative to their individual baselines. Note: For sites using more than 20% energy above their baseline, the bars are capped to maintain chart readability.

There is currently no data to display.

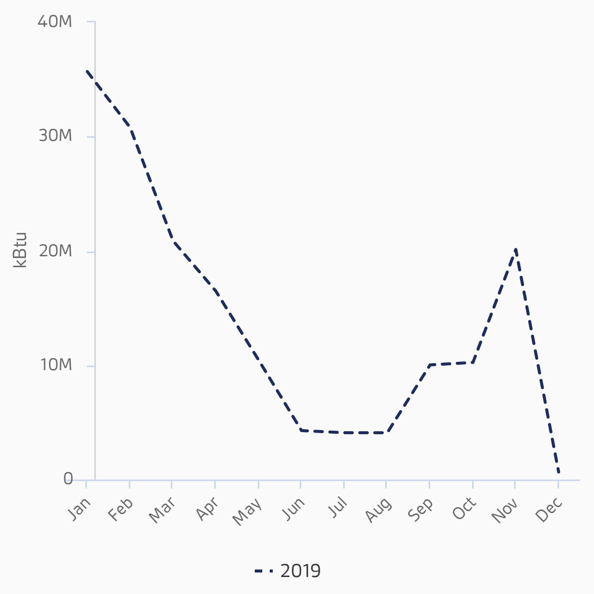
Total Energy Use by Calendar Month – Stacked Area Chart



Total Off Site Generated Electricity

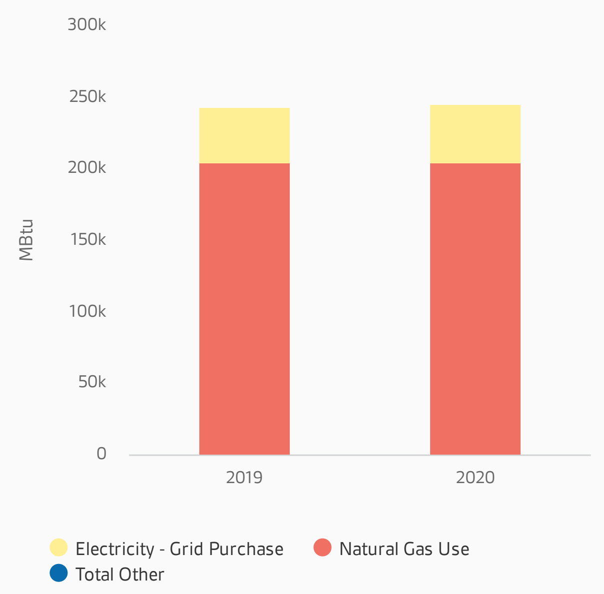


Total Natural Gas



Calendar Year Total Energy Consumption: ENERGY STAR® Portfolio Manager® Report

Annual Consumption for All Energy Types



Calendar Year Total Energy Spend: ENERGY STAR® Portfolio Manager® Report

Annual Spend for All Energy Types

There is currently no data to display.

Performance by Energy Type Usage: ENERGY STAR® Portfolio Manager® Report

All data displayed in the following table is weather normalized

	Weather Normalized Site Electricity Use (Grid and Onsite Renewables) (kBtu)	Weather Normalized Site Natural Gas Use (kBtu)	Total Other (kBtu)	Weather Normalized Site Energy Use (kBtu)
2019	37,164,957	213,156,788.0	N/A	250,311,355.0
2020	39,983,187	221,828,188.0	N/A	261,800,512.0
Changes	↑ 7.58%	↑ 4.07%	↓ 0%	↑ 4.59%

Green Building Alliance *Edgewood Residential Test*

SITE USE INFORMATION

Other – Single Family Home

Gross Floor Area	*2,340,073 ft²*

Multifamily Housing – Multifamily Housing

Gross Floor Area	*249,475 ft²*
Number of Residential Living Units	*299*
Number of Bedrooms	*349*
Resident Population Type	
Is Government Subsidized Housing	*No*
Percent That Can Be Heated	*All of it - 100%*
Percent That Can Be Cooled	*All of it - 100%*

Green Building Alliance

PERFORMANCE TARGETS REPORT

Forest Hills Residential Test

2019 – 2020

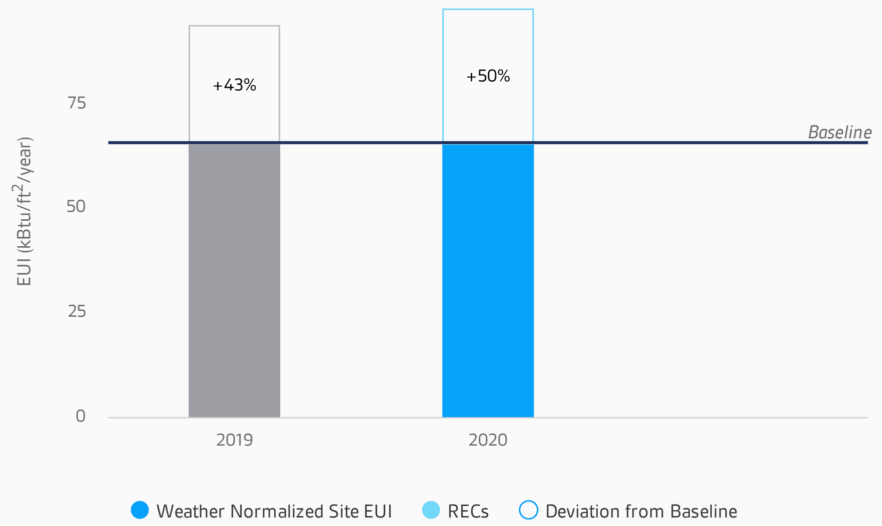
Created: 9/30/2022

Main St
Forest Hills, PA
15104 United States

ENERGY

Energy Report: ENERGY STAR® Portfolio Manager® Report

The graph below summarizes annual energy performance over time relative to building intensity baselines and targets.



** For years when intensity is more than 150% of the baseline, the bars are capped to maintain the readability of the bar chart.*

Baseline
65.4 EUI
kBtu/ft²

2020 Performance
97.9 EUI
49.6% above the baseline (with RECs)

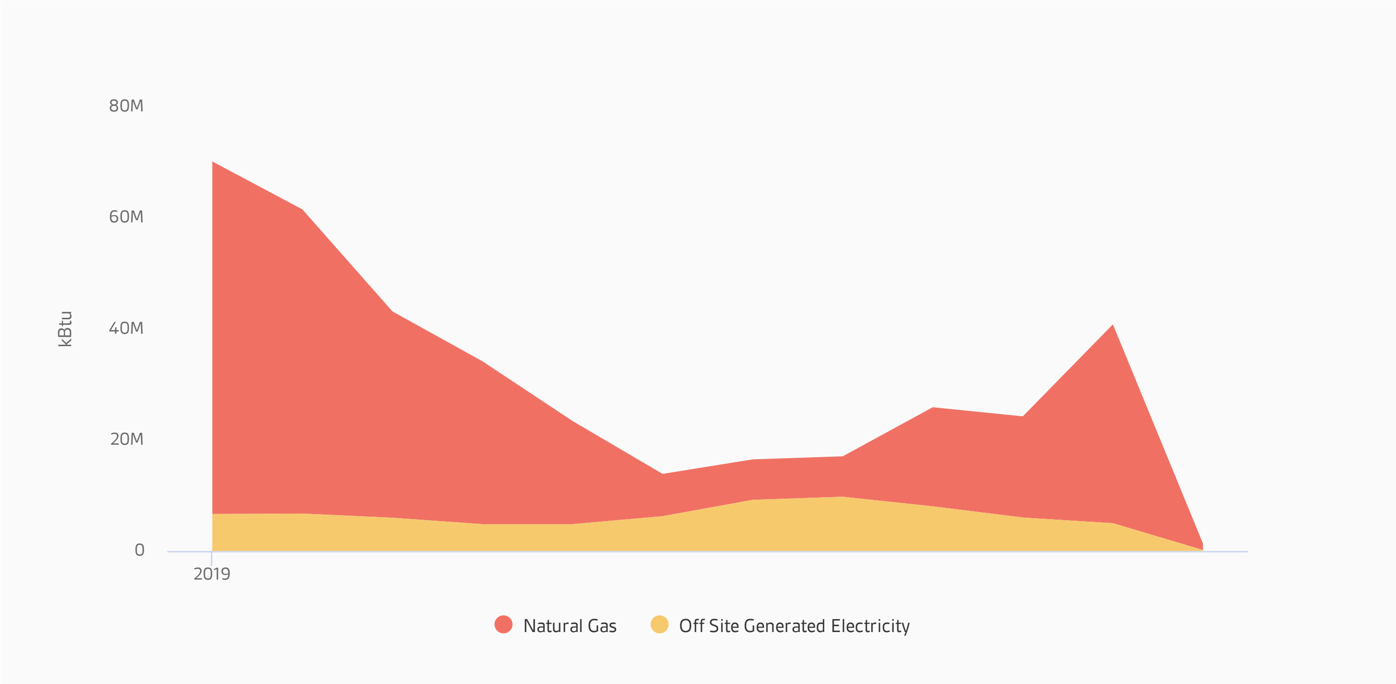
2019 Performance
93.7 EUI
43.18% above the baseline (with RECs)

Single Family Home - Detached Energy Performance Savings: 2021

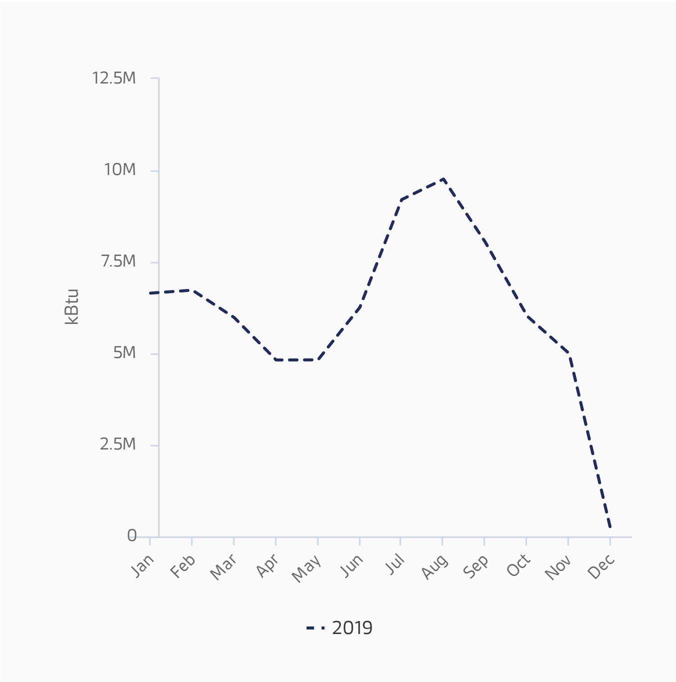
The chart below compares the energy performance of all sites of similar type relative to their individual baselines. Note: For sites using more than 20% energy above their baseline, the bars are capped to maintain chart readability.

There is currently no data to display.

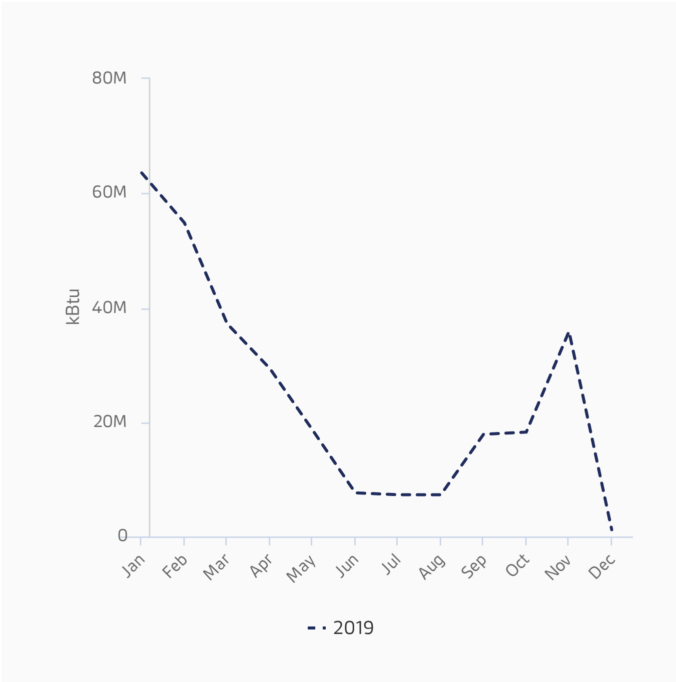
Total Energy Use by Calendar Month – Stacked Area Chart



Total Off Site Generated Electricity

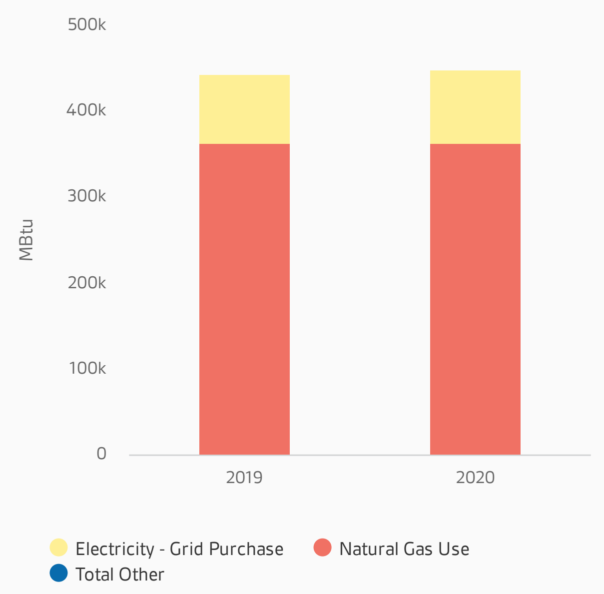


Total Natural Gas



Calendar Year Total Energy Consumption: ENERGY STAR® Portfolio Manager® Report

Annual Consumption for All Energy Types



Calendar Year Total Energy Spend: ENERGY STAR® Portfolio Manager® Report

Annual Spend for All Energy Types

There is currently no data to display.

Performance by Energy Type Usage: ENERGY STAR® Portfolio Manager® Report

All data displayed in the following table is weather normalized

	Weather Normalized Site Electricity Use (Grid and Onsite Renewables) (kBtu)	Weather Normalized Site Natural Gas Use (kBtu)	Total Other (kBtu)	Weather Normalized Site Energy Use (kBtu)
2019	77,150,216	379,543,074.0	N/A	456,674,344.0
2020	82,389,924	394,983,225.0	N/A	477,353,344.0
Changes	↑ 6.79%	↑ 4.07%	↓ 0%	↑ 4.53%

SITE USE INFORMATION

Other – Single Family Home

Gross Floor Area	*4,371,137 ft²*

Multifamily Housing – Multifamily Housing

Gross Floor Area	*504,004 ft²*
Number of Residential Living Units	*605*
Number of Bedrooms	*706*
Resident Population Type	
Is Government Subsidized Housing	*No*
Percent That Can Be Heated	*All of it - 100%*
Percent That Can Be Cooled	*All of it - 100%*

Green Building Alliance

PERFORMANCE TARGETS REPORT

North Braddock Residential test

2019 – 2020

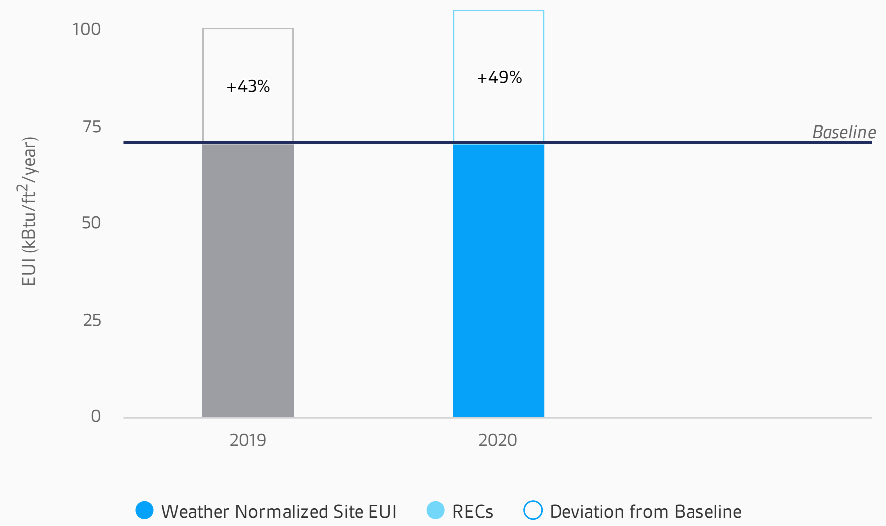
Created: 9/30/2022

North Braddock total municipality
North Braddock, PA
15112 United States

ENERGY

Energy Report: ENERGY STAR® Portfolio Manager® Report

The graph below summarizes annual energy performance over time relative to building intensity baselines and targets.



** For years when intensity is more than 150% of the baseline, the bars are capped to maintain the readability of the bar chart.*

Baseline

70.8 EUI

kBtu/ft²

2020 Performance

105.5 EUI

↑ 48.96% above the baseline (with RECs)

2019 Performance

101 EUI

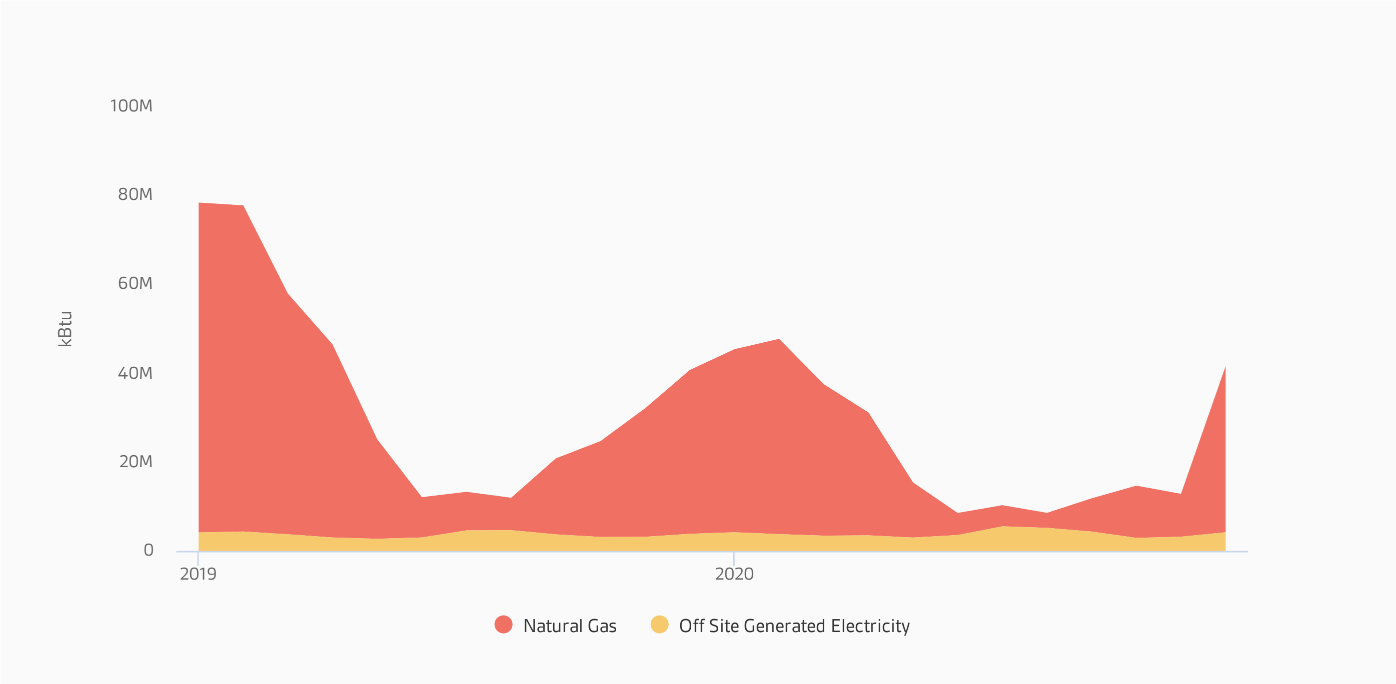
↑ 42.61% above the baseline (with RECs)

Single Family Home - Detached Energy Performance Savings: 2021

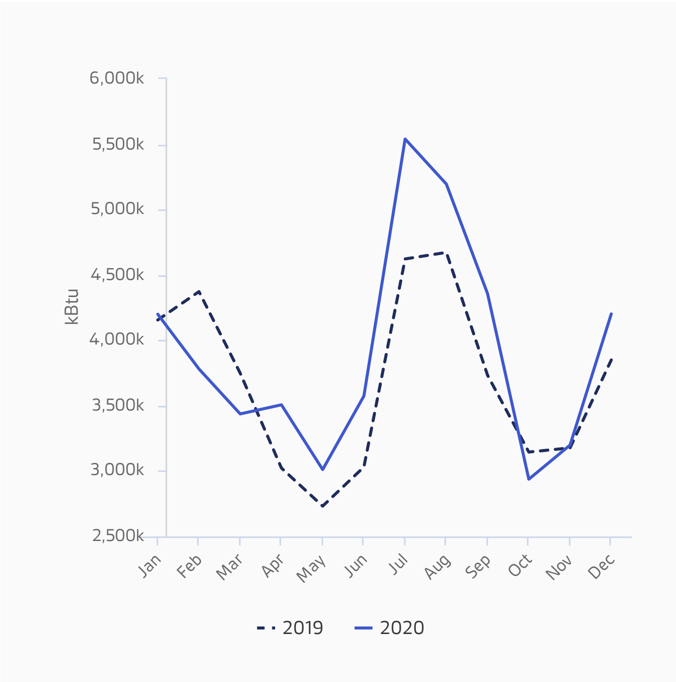
The chart below compares the energy performance of all sites of similar type relative to their individual baselines. Note: For sites using more than 20% energy above their baseline, the bars are capped to maintain chart readability.

There is currently no data to display.

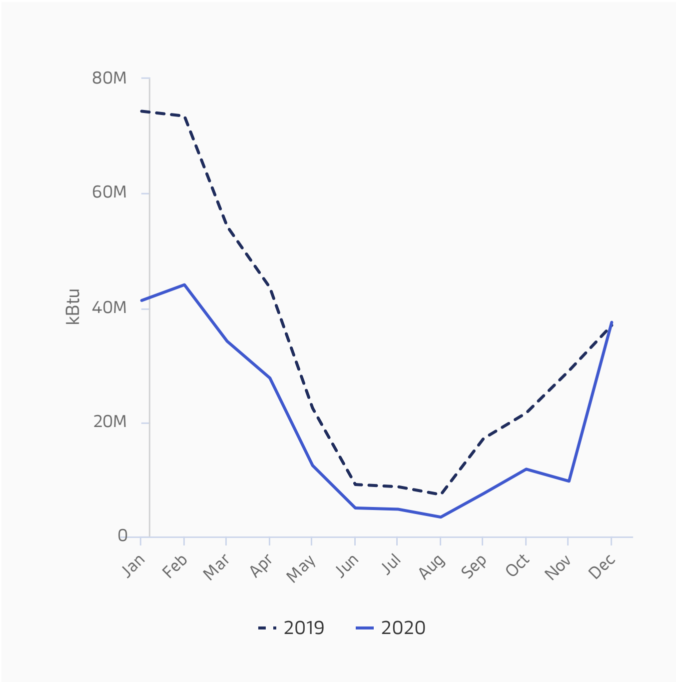
Total Energy Use by Calendar Month — Stacked Area Chart



Total Off Site Generated Electricity

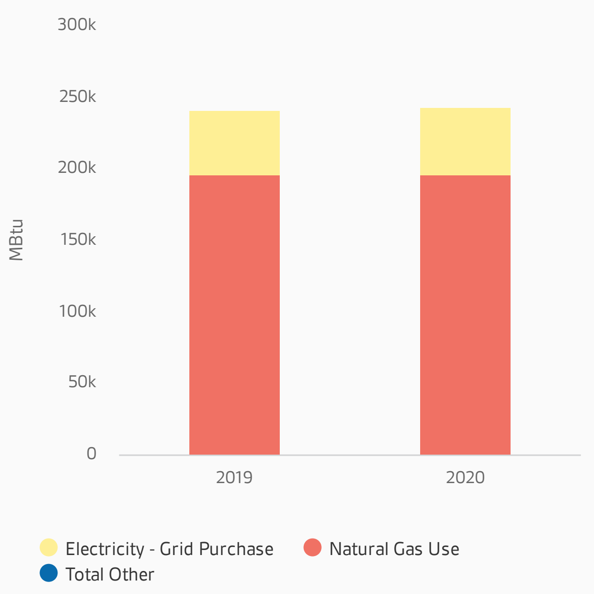


Total Natural Gas



Calendar Year Total Energy Consumption: ENERGY STAR® Portfolio Manager® Report

Annual Consumption for All Energy Types



Calendar Year Total Energy Spend: ENERGY STAR® Portfolio Manager® Report

Annual Spend for All Energy Types

There is currently no data to display.

Performance by Energy Type Usage: ENERGY STAR® Portfolio Manager® Report

All data displayed in the following table is weather normalized

	Weather Normalized Site Electricity Use (Grid and Onsite Renewables) (kBtu)	Weather Normalized Site Natural Gas Use (kBtu)	Total Other (kBtu)	Weather Normalized Site Energy Use (kBtu)
2019	43,541,061	204,490,898.0	N/A	248,021,672.0
2020	46,110,915	212,809,813.0	N/A	258,909,990.0
Changes	↑ 5.9%	↑ 4.07%	↓ 0%	↑ 4.39%

Green Building Alliance

North Braddock Residential test

SITE USE INFORMATION

Multifamily Housing – Multifamily Housing Use

Gross Floor Area	*347,919 ft²*
Number of Residential Living Units	*429*
Number of Bedrooms	*1,200*
Resident Population Type	*No specific resident population*
Is Government Subsidized Housing	*No*
Number of Laundry Hookups in All Units	*1,286*
Percent That Can Be Heated	*All of it - 100%*
Percent That Can Be Cooled	*All of it - 100%*

Other – Building Use

Gross Floor Area	*2,106,870 ft²*

PERFORMANCE TARGETS REPORT

Rankin Residential Test

2019 – 2020

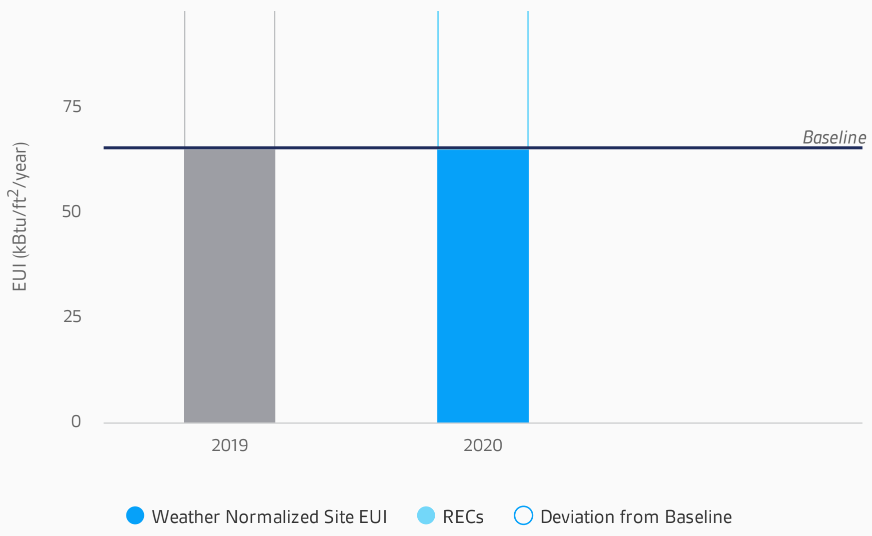
Created: 9/30/2022

Main St
Rankin, PA
15104 United States

ENERGY

Energy Report: ENERGY STAR® Portfolio Manager® Report

The graph below summarizes annual energy performance over time relative to building intensity baselines and targets.



** For years when intensity is more than 150% of the baseline, the bars are capped to maintain the readability of the bar chart.*

Baseline

65.2 EUI

kBtu/ft²

2020 Performance

104.3 EUI

↑ 59.91% above the baseline (with RECs)

2019 Performance

99.7 EUI

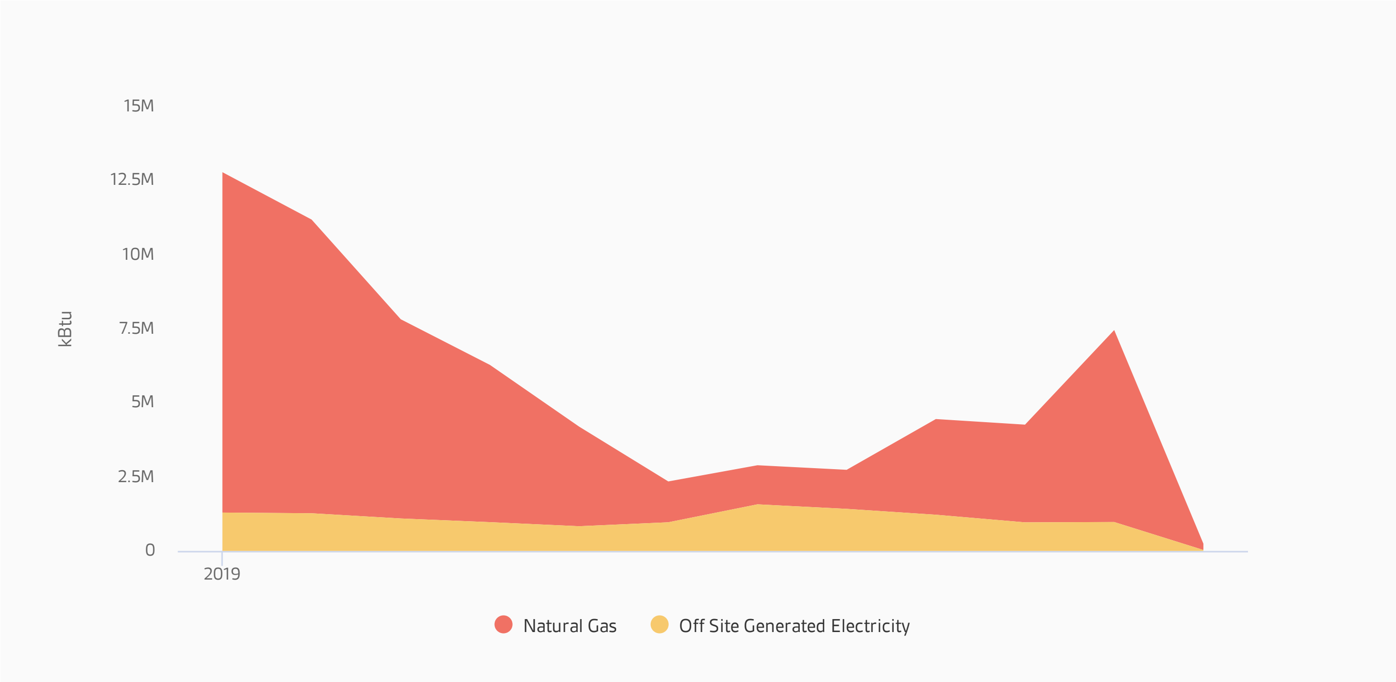
↑ 52.86% above the baseline (with RECs)

Single Family Home - Detached Energy Performance Savings: 2021

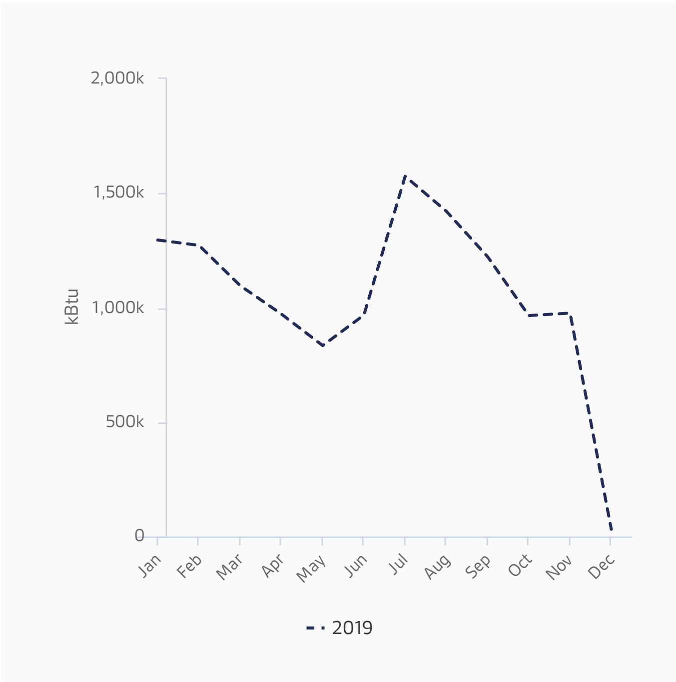
The chart below compares the energy performance of all sites of similar type relative to their individual baselines. Note: For sites using more than 20% energy above their baseline, the bars are capped to maintain chart readability.

There is currently no data to display.

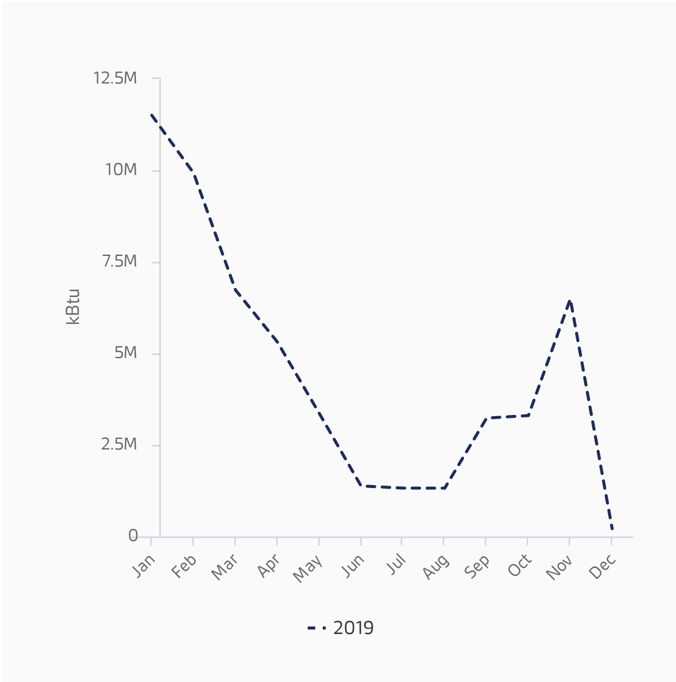
Total Energy Use by Calendar Month – Stacked Area Chart



Total Off Site Generated Electricity

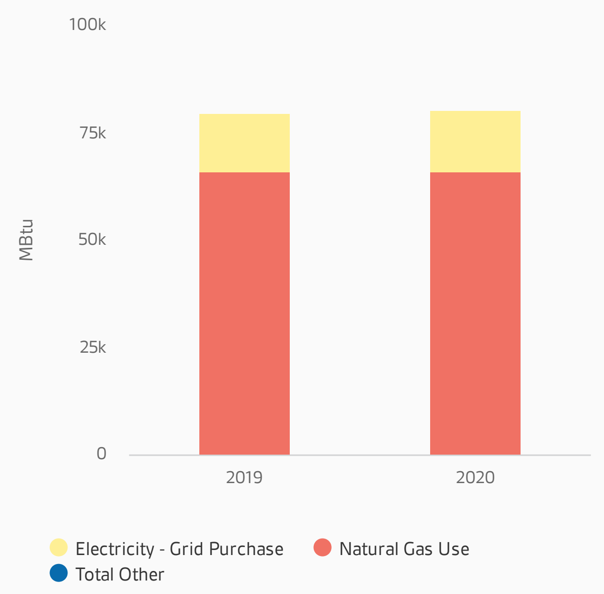


Total Natural Gas



Calendar Year Total Energy Consumption: ENERGY STAR® Portfolio Manager® Report

Annual Consumption for All Energy Types



Calendar Year Total Energy Spend: ENERGY STAR® Portfolio Manager® Report

Annual Spend for All Energy Types

There is currently no data to display.

Performance by Energy Type Usage: ENERGY STAR® Portfolio Manager® Report

All data displayed in the following table is weather normalized

	Weather Normalized Site Electricity Use (Grid and Onsite Renewables) (kBtu)	Weather Normalized Site Natural Gas Use (kBtu)	Total Other (kBtu)	Weather Normalized Site Energy Use (kBtu)
2019	13,526,796	68,708,382.0	N/A	82,231,769.0
2020	14,487,254	71,503,508.0	N/A	85,987,191.0
Changes	↑ 7.1%	↑ 4.07%	↓ 0%	↑ 4.57%

Green Building Alliance *Rankin Residential Test*

SITE USE INFORMATION

Other – Single Family Home

Gross Floor Area	*648,815 ft²*

Multifamily Housing – Multifamily Housing

Gross Floor Area	*175,987 ft²*
Number of Residential Living Units	*211*
Number of Bedrooms	*246*
Resident Population Type	
Is Government Subsidized Housing	*No*
Percent That Can Be Heated	*All of it - 100%*
Percent That Can Be Cooled	*All of it - 100%*

Green Building Alliance

PERFORMANCE TARGETS REPORT

Swissvale Residential Test

2019 – 2020

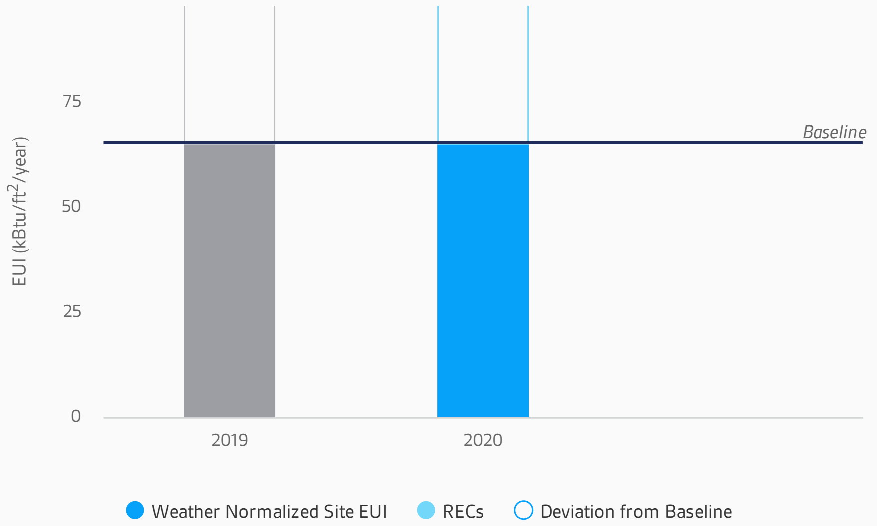
Created: 9/30/2022

Main St
Swissvale, PA
15104 United States

ENERGY

Energy Report: ENERGY STAR® Portfolio Manager® Report

The graph below summarizes annual energy performance over time relative to building intensity baselines and targets.



** For years when intensity is more than 150% of the baseline, the bars are capped to maintain the readability of the bar chart.*

Baseline

65.2 EUI

kBtu/ft²

2020 Performance

104.6 EUI

↑ 60.36% above the baseline (with RECs)

2019 Performance

100.4 EUI

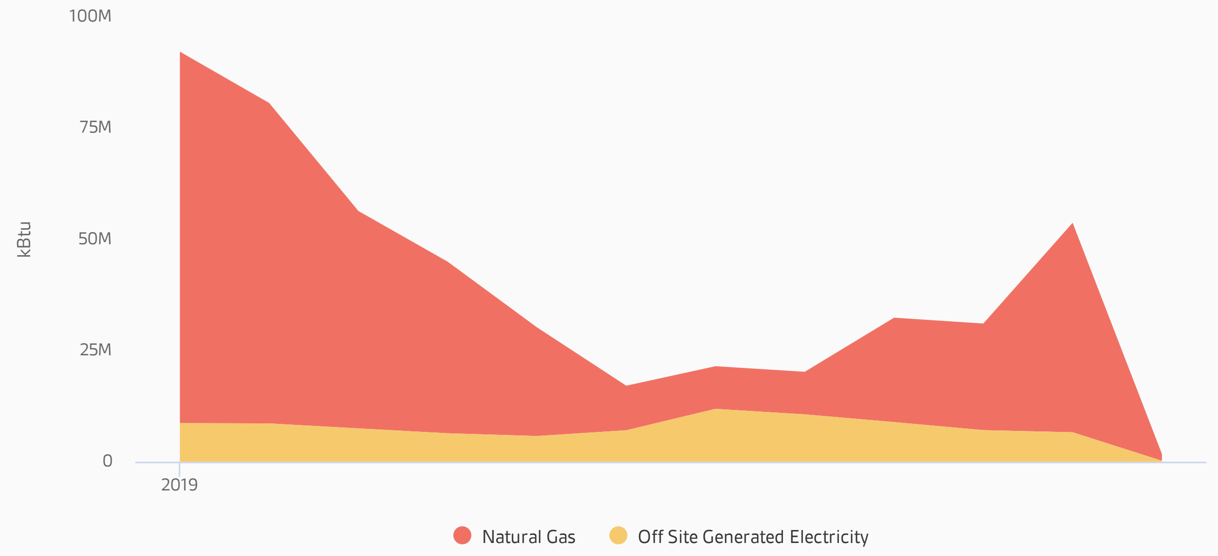
↑ 53.92% above the baseline (with RECs)

Single Family Home - Detached Energy Performance Savings: 2021

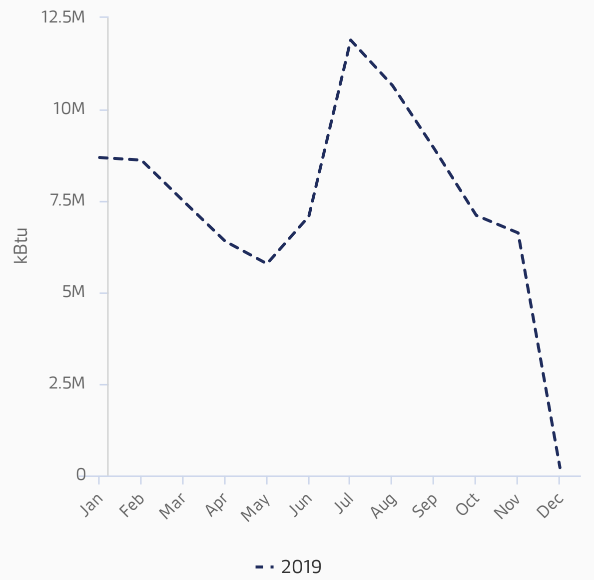
The chart below compares the energy performance of all sites of similar type relative to their individual baselines. Note: For sites using more than 20% energy above their baseline, the bars are capped to maintain chart readability.

There is currently no data to display.

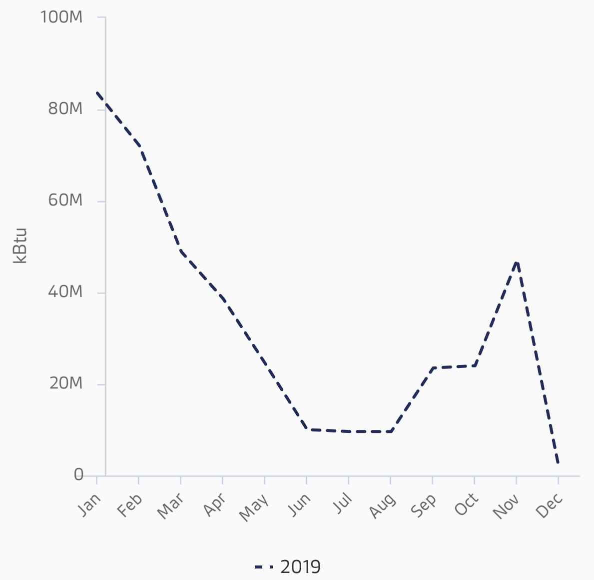
Total Energy Use by Calendar Month — Stacked Area Chart



Total Off Site Generated Electricity

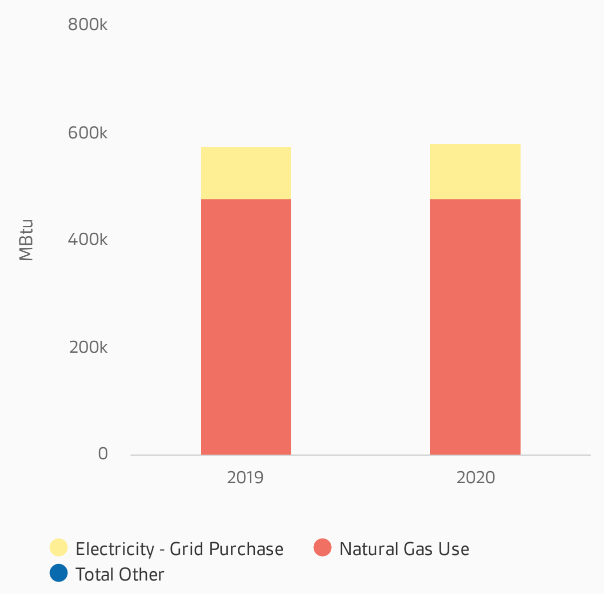


Total Natural Gas



Calendar Year Total Energy Consumption: ENERGY STAR® Portfolio Manager® Report

Annual Consumption for All Energy Types



Calendar Year Total Energy Spend: ENERGY STAR® Portfolio Manager® Report

Annual Spend for All Energy Types

There is currently no data to display.

Performance by Energy Type Usage: ENERGY STAR® Portfolio Manager® Report

All data displayed in the following table is weather normalized

	Weather Normalized Site Electricity Use (Grid and Onsite Renewables) (kBtu)	Weather Normalized Site Natural Gas Use (kBtu)	Total Other (kBtu)	Weather Normalized Site Energy Use (kBtu)
2019	95,160,538	499,016,983.0	N/A	594,152,872.0
2020	100,069,904	519,317,476.0	N/A	619,361,683.0
Changes	↑ 5.16%	↑ 4.07%	↓ 0%	↑ 4.24%

Green Building Alliance

Swissvale Residential Test

SITE USE INFORMATION

Multifamily Housing — Multifamily Housing

Gross Floor Area	*1,276,404 ft²*
Number of Residential Living Units	*1,532*
Number of Bedrooms	*1,787*
Resident Population Type	
Is Government Subsidized Housing	*No*
Percent That Can Be Heated	*All of it - 100%*
Percent That Can Be Cooled	*All of it - 100%*

Other — Single Family Home

Gross Floor Area	*4,643,039 ft²*

Green Building Alliance

PERFORMANCE TARGETS REPORT

Turtle Creek Residential Test

2019 – 2020

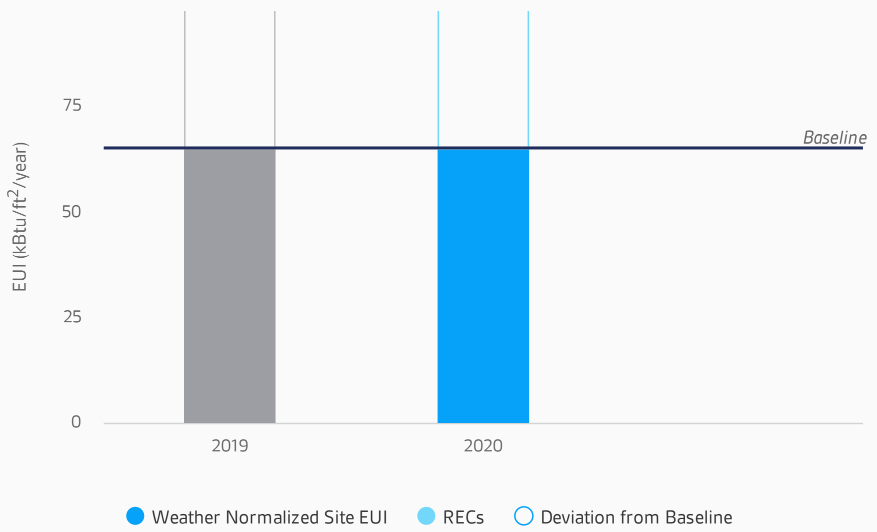
Created: 9/30/2022

Main St
Turtle Creek, PA
15104 United States

ENERGY

Energy Report: ENERGY STAR® Portfolio Manager® Report

The graph below summarizes annual energy performance over time relative to building intensity baselines and targets.



** For years when intensity is more than 150% of the baseline, the bars are capped to maintain the readability of the bar chart.*

Baseline

65.1 EUI

kBtu/ft²

2020 Performance

129.8 EUI

↑ 99.44% above the baseline (with RECs)

2019 Performance

124.6 EUI

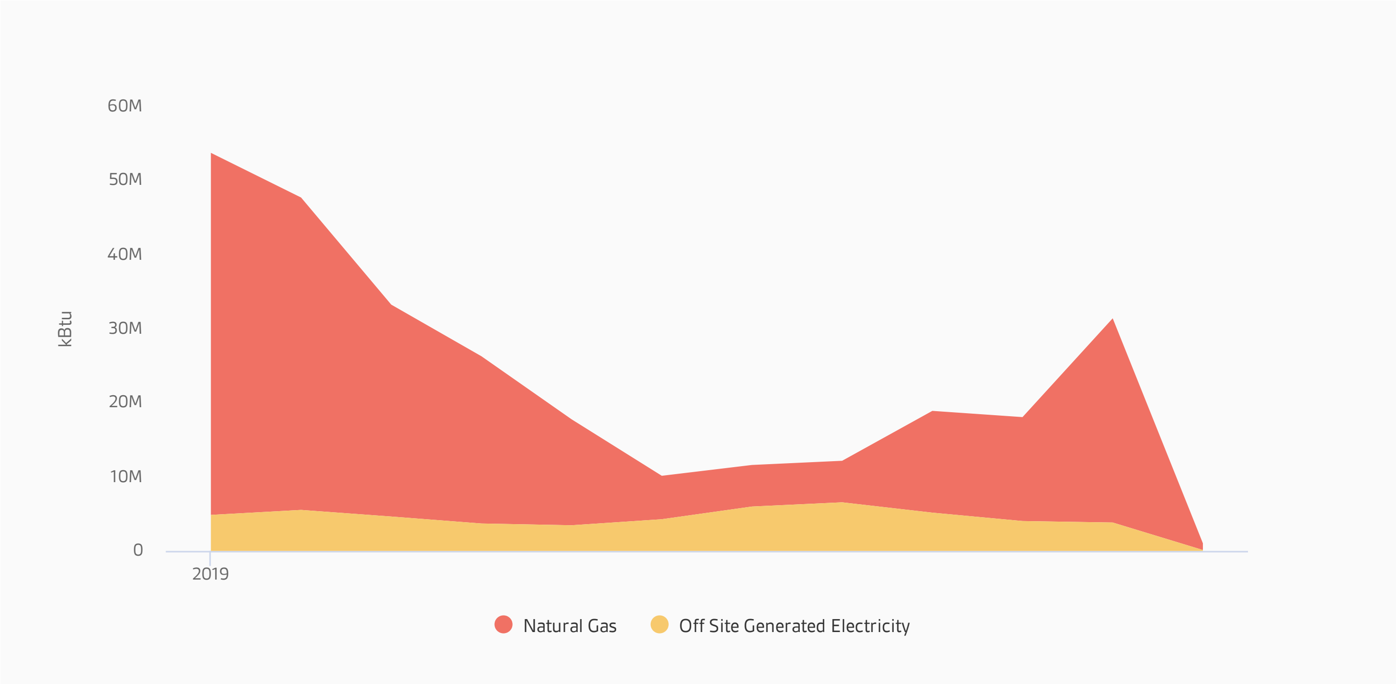
↑ 91.45% above the baseline (with RECs)

Single Family Home - Detached Energy Performance Savings: 2021

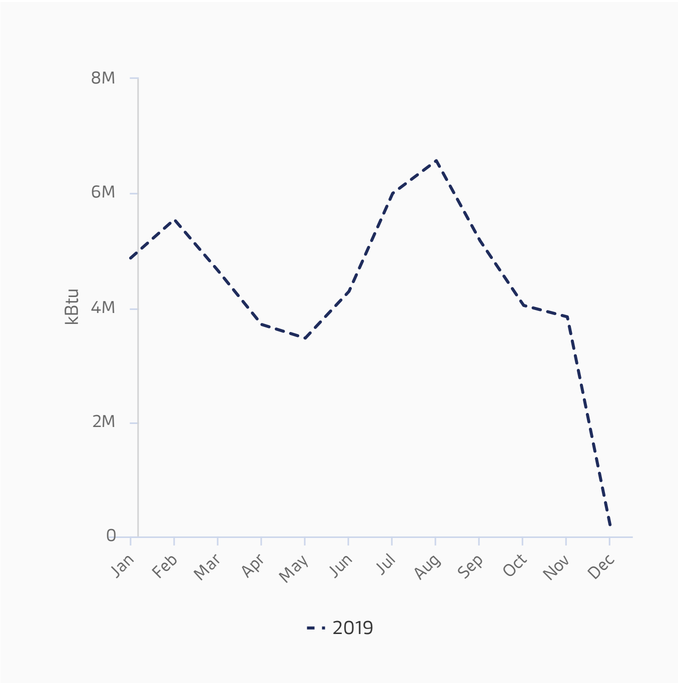
The chart below compares the energy performance of all sites of similar type relative to their individual baselines. Note: For sites using more than 20% energy above their baseline, the bars are capped to maintain chart readability.

There is currently no data to display.

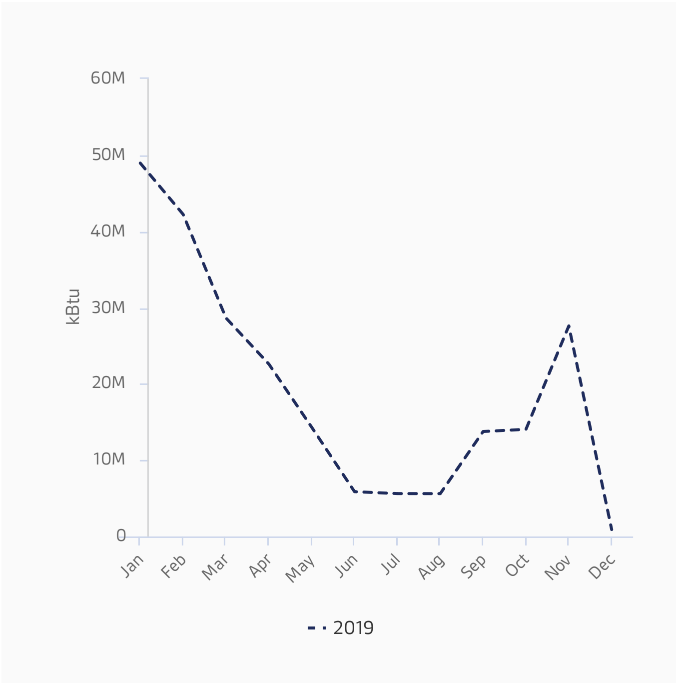
Total Energy Use by Calendar Month – Stacked Area Chart



Total Off Site Generated Electricity

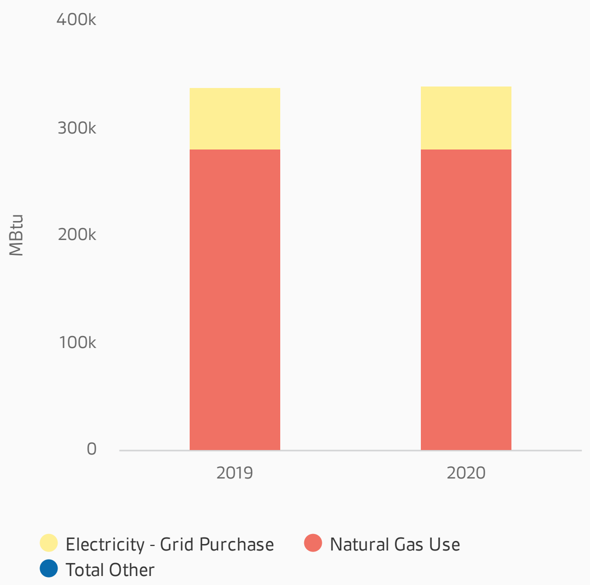


Total Natural Gas



Calendar Year Total Energy Consumption: ENERGY STAR® Portfolio Manager® Report

Annual Consumption for All Energy Types



Calendar Year Total Energy Spend: ENERGY STAR® Portfolio Manager® Report

Annual Spend for All Energy Types

There is currently no data to display.

Performance by Energy Type Usage: ENERGY STAR® Portfolio Manager® Report

All data displayed in the following table is weather normalized

	Weather Normalized Site Electricity Use (Grid and Onsite Renewables) (kBtu)	Weather Normalized Site Natural Gas Use (kBtu)	Total Other (kBtu)	Weather Normalized Site Energy Use (kBtu)
2019	55,703,754	292,329,274.0	N/A	348,018,588.0
2020	58,449,251	304,221,498.0	N/A	362,655,707.0
Changes	↑ 4.93%	↑ 4.07%	↓ 0%	↑ 4.21%

Green Building Alliance

Turtle Creek Residential Test

SITE USE INFORMATION

Multifamily Housing — Multifamily Housing

Gross Floor Area	*822,354 ft²*
Number of Residential Living Units	*987*
Number of Bedrooms	*1,151*
Resident Population Type	
Is Government Subsidized Housing	*No*
Percent That Can Be Heated	*All of it - 100%*
Percent That Can Be Cooled	*All of it - 100%*

Other — Single Family Home

Gross Floor Area	*1,971,312 ft²*

Green Building Alliance

PERFORMANCE TARGETS REPORT

Wilkins Residential Test

2019 – 2020

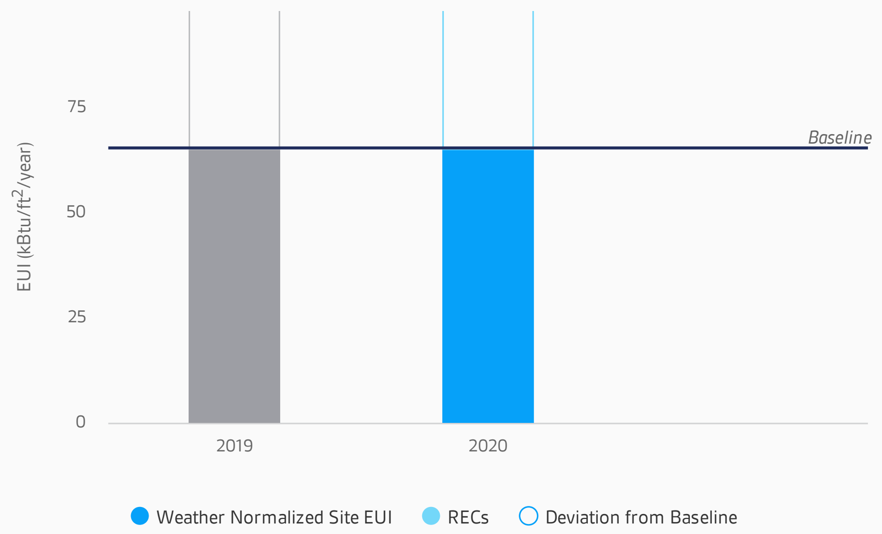
Created: 9/30/2022

Main St
Wilkins, PA
15104 United States

ENERGY

Energy Report: ENERGY STAR® Portfolio Manager® Report

The graph below summarizes annual energy performance over time relative to building intensity baselines and targets.



** For years when intensity is more than 150% of the baseline, the bars are capped to maintain the readability of the bar chart.*

Baseline

65.3 EUI

kBtu/ft²

2020 Performance

122.5 EUI

↑ 87.46% above the baseline (with RECs)

2019 Performance

117.5 EUI

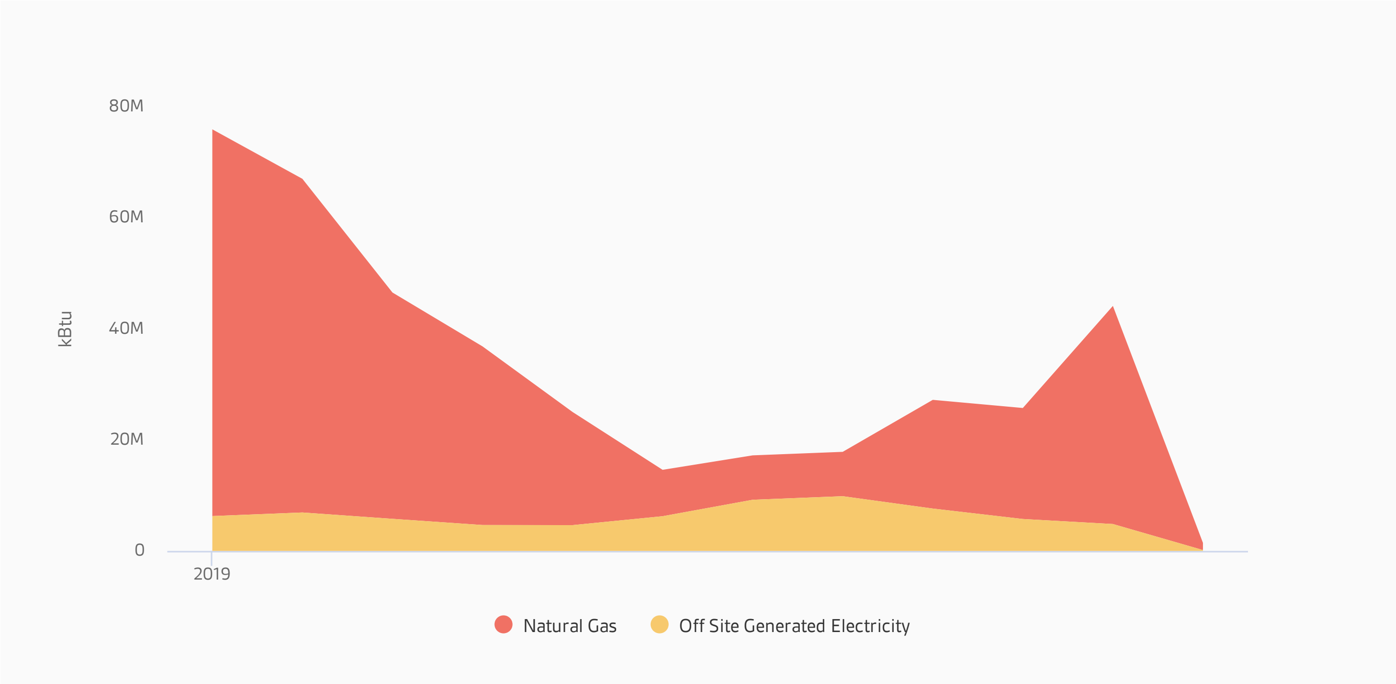
↑ 79.81% above the baseline (with RECs)

Single Family Home - Detached Energy Performance Savings: 2021

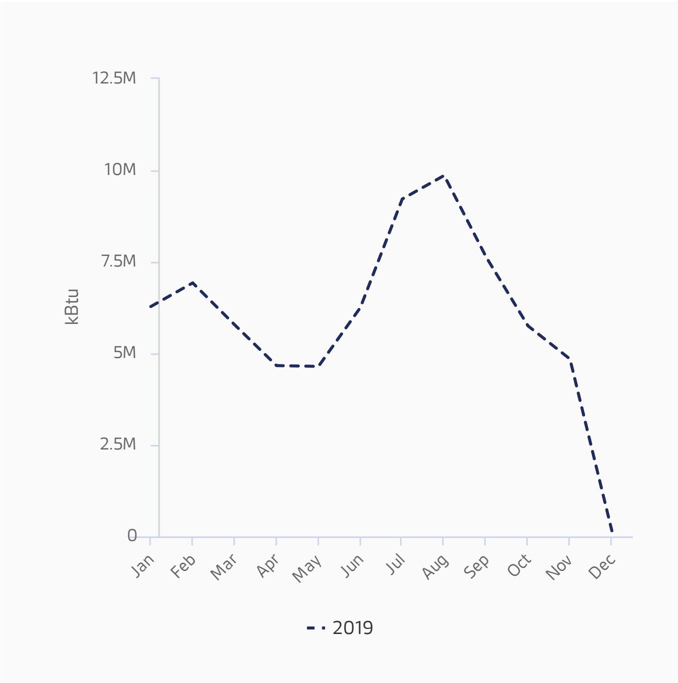
The chart below compares the energy performance of all sites of similar type relative to their individual baselines. Note: For sites using more than 20% energy above their baseline, the bars are capped to maintain chart readability.

There is currently no data to display.

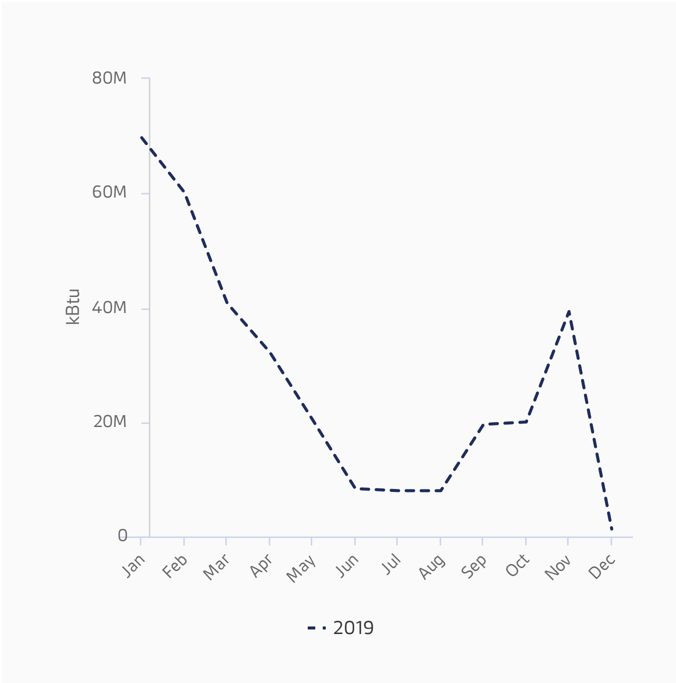
Total Energy Use by Calendar Month – Stacked Area Chart



Total Off Site Generated Electricity

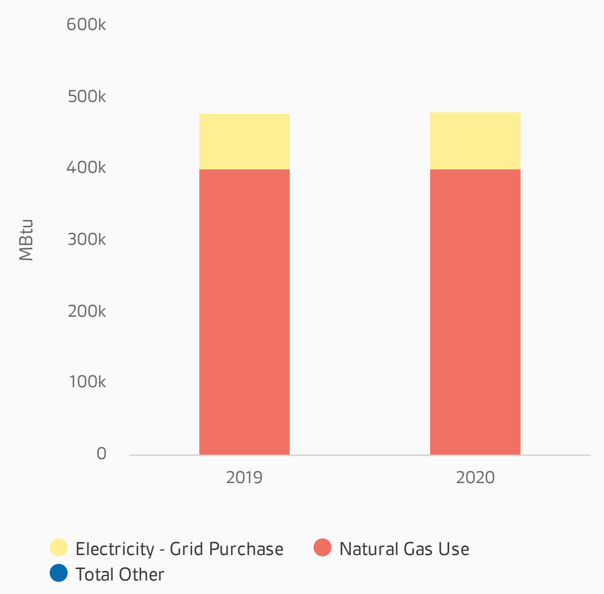


Total Natural Gas



Calendar Year Total Energy Consumption: ENERGY STAR® Portfolio Manager® Report

Annual Consumption for All Energy Types



Calendar Year Total Energy Spend: ENERGY STAR® Portfolio Manager® Report

Annual Spend for All Energy Types

There is currently no data to display.

Performance by Energy Type Usage: ENERGY STAR® Portfolio Manager® Report

All data displayed in the following table is weather normalized

	Weather Normalized Site Electricity Use (Grid and Onsite Renewables) (kBtu)	Weather Normalized Site Natural Gas Use (kBtu)	Total Other (kBtu)	Weather Normalized Site Energy Use (kBtu)
2019	75,456,516	416,315,481.0	N/A	491,751,593.0
2020	79,341,287	433,251,604.0	N/A	512,571,622.0
Changes	↑ 5.15%	↑ 4.07%	↓ 0%	↑ 4.23%

Wilkins Residential Test

SITE USE INFORMATION

Multifamily Housing — Multifamily Housing

Gross Floor Area	*639,068 ft²*
Number of Residential Living Units	*767*
Number of Bedrooms	*895*
Resident Population Type	
Is Government Subsidized Housing	*No*
Percent That Can Be Heated	*All of it - 100%*
Percent That Can Be Cooled	*All of it - 100%*

Other — Single Family Home

Gross Floor Area	*3,546,604 ft²*

Barriers to Middle-Class Homeowners Taking Action on Energy Efficiency (EE) in a Single Family/Townhome/Rowhouse configs and typical ways in which the home performance industry and EE programs have tried to address it

This overview[1] applies to homeowners with some disposable income and/or some ability to borrow funds, (therefore in principle able to improve inefficient homes), based on CCI/RTP's experience in the middle-class market and from home performance literature review.

Homeowners lack interest. Energy efficiency (or saving on energy bills) is not an important goal to them. Households can afford the energy costs, and preferences like lots of lighting, or a comfortable temperature when entering home are important; homeowners will not sacrifice these to save a few dollars. Other home improvements related to space configuration or aesthetics have higher priority. Similarly, other pursuits, not related to home, take precedence. *Appealing to improving comfort, when colds or drafts exist, and appealing to increasing home's resilience and health are often used to spark interest in efficiency. Additionally, appealing to social consciousness and climate mitigation, for those who are concerned with the climate crisis.*

There is a lack of understanding of energy and how homes operate. Surprising number of homeowners do not know how much they pay for energy, what are the units of energy, how do their homes compare to other homes in energy use, what is the R-value, or efficiency measure of an appliance, etc. Operationally, they may not understand how a window opened in a basement works against their home's cooling or heating, or what is the operational cost of an inefficient mechanical system. *Creating outreach to educate homeowners on energy and energy efficiency through workshops and presentations has been tried in the past. Programs combine it with some incentives to get people in the door. Also, working with contractor estimators or energy auditors to provide education and engage homeowners during home visits is also a known strategy. Home maintenance and energy efficiency guides and manuals have been developed but their efficacy is not well established.*

Homeowners don't know where to begin. Homeowners may know that they have an old furnace, but have no idea how effective their insulation is, or, if they have it, or which improvements are likely to pay off for their home. Substantial number of them have never heard of an energy audit and would not know what to expect. *Good energy audits conduct blower door tests, use infrared imaging, analyze past energy bills, provide pictures of the problem spots, provide total cost estimates and energy savings estimates. These good audits also identify health and safety issues in the home and conditions*

[1] Prepared by Lucy de Barbaro, RTP, July 2022.

that may need resolving before the energy upgrades can be undertaken. Good energy audits typically cost ~$500.

Information on efficiency does not catch the homeowner's attention. It is well established that even among those homeowners who receive energy audits, either free or for a fee, (which is better than handing them a booklet) a large proportion do not take further steps or make the recommended improvements. Forgetfulness, busyness, inertia, and habit dampen likelihood of action, even if it would be in the homeowner's self-interest to act on these recommendations. *It turns out that when the auditors are trained to be good communicators, and a) engage homeowner in the audit tasks, present memorable experience and communicate vividly (e.g., all holes in your home add up to a size of 3 pages of paper), b) personalize their recommendations and make it very specific to the issues uncovered in the home c) induce commitment by specific asks and phone call follow ups, and d) frame recommendations in terms of "loss" instead of "gain", the likelihood of homeowners' investment and action is roughly doubled. Training contractors to be effective program ambassadors is an important part of motivating the homeowners.*

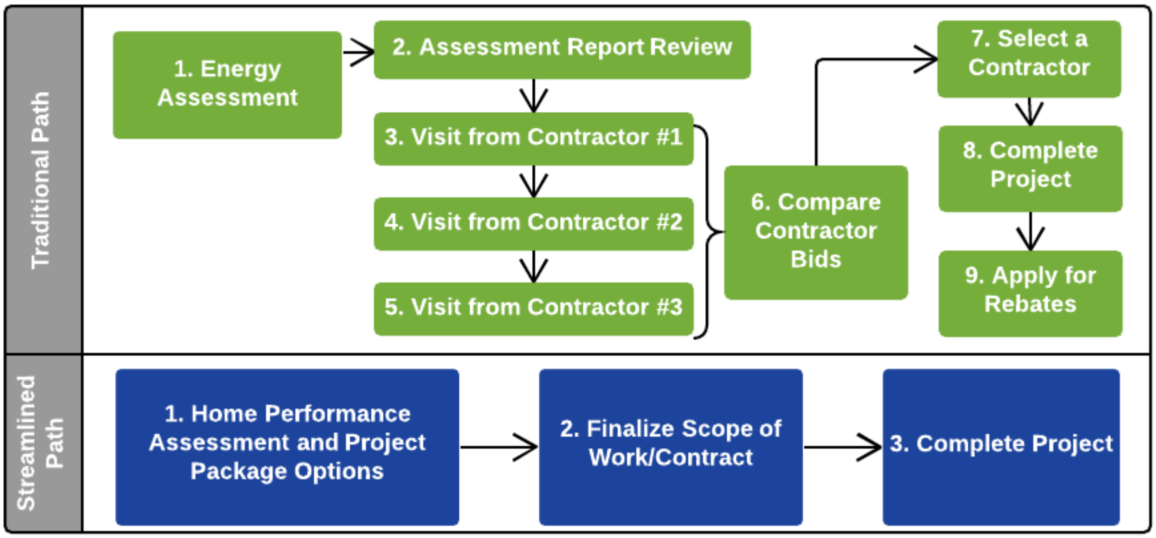
Some utility programs have successfully used home-specific energy information and a vivid presentation of this information, for example by comparing one customer's energy use to those in their street or presenting an infrared photo of the energy waste through the home's roof and a score on how it compares to other homes, to stimulate energy upgrades.

Complexity. Complexity exists on multiple planes in the home efficiency upgrade process:

1) Homes have interdependent components and changing one may impact other aspects. For example, switching from a natural draft furnace to a much more efficient sealed-combustion furnace may result in insufficient draft flow for other gas-powered equipment, like a hot water heater. Or, insulating and air sealing a basement which is sometimes prone to water, without addressing water issues, may result in unhealthy indoor air quality. Selecting the right solution for a specific home usually requires a good understanding of building science principles and a whole-house evaluation. Multiple aspects may need to be sequentially addressed when improving energy efficiency, for example: air sealing of cracks and gaps should be paired with targeted ventilation that removes moisture from bathroom and cooking and then with insulation. ***To achieve energy reductions on the order of 30% per home would require addressing this technical complexity and specificity of each home.*** *Simpler, singular actions like installing insulation in the attic or swapping hot water heater with the heat pump, while achieving much smaller energy reduction, would avoid this part of the complexity.*

2) There are multiple products and technological solutions for each component of the home, each with differing cost, quality, and sometimes differing functionality. Even a relatively inexpensive and simple component like a thermostat requires understanding and non-trivial decision making. Different contractors will usually present different products/solutions to homeowners. Sorting out which solutions are good and suitable for the home and who to trust to deliver unbiased information is a challenging task. Predictions of energy savings can often be wildly exaggerated by contractors to obtain customers. But even programs that run energy efficiency services may also overestimate energy saving potential, and different modeling tools differ in predictions.

3) Typical bidding process involves getting 2-3 bids with differing prices and products and is prolonged, especially when it is hard to find the contractors to do the work. Which contractors will perform the work well, and within the price range affordable to the homeowner?



Programs that offer streamlined path and a more-limited set of technological solutions, plus manage contractor price expectations and are able to present one unified contractor bid that is acceptable to a number of contractors interested in performing this work, as well as integrate any available rebates or financing options into the proposal, help homeowners avoid a lot of this complexity.

As a third-party overseeing quality assurance on contractor work in the utility programs or, formerly, as a Home Performance with Energy Star provider, CCI/RTP has also learned that there is a lot of weatherization and HVAC work out there done in a sub-standard fashion and without proper attention to detail or the industry standards, undercutting the resulting efficiency improvement. *Requiring building science credentials, pre-qualifying contractors, and conducting quality assurance on the percentage of their work is rather important to achieve energy reduction goals.*

Cost effectiveness. High project costs are the most important deterrent based on homeowners' surveys. The cost of achieving a 20% reduction averaged roughly $10,000 in the past 2017-2019 CCI/RTP projects, assuming that no additional structural barriers like knob & tube were present. Cost of borrowing the money would need to be added on top. 20% reduction in energy bills (average: $2657/y) equates to about $500/year in energy savings. Cost to achieve 30% improvement would still be much higher, and not proportionally equal to $15,000, due to increase in complexity and no low-hanging fruit which is assumed in the first $10,000 expenditure. ***Programs that offer substantial rebates/incentives to homeowners, to the tune of $800-$3000 of the upgrade costs, which might also be doubled for income-qualified homeowners, successfully stimulate efficiency uptake (examples in References).*** *Recent energy cost increases may also prompt some folks to consider making efficiency upgrades. For this purpose, an effective illustration of possible payback periods accounting for energy cost increases could help motivate some homeowners. The cost effectiveness does increase when the selection of more efficient options occurs at the* *time of end of life of equipment or at any other trigger time / change (e.g., home purchase is the time when the new homeowners may elect to install new windows, or before remodeling, etc. Some programs target new home buyers for that reason.).*

Structural barriers to energy efficiency. A subset of homes in our region have health and safety issues and conditions that prevent energy efficiency upgrades until removed. The knob and tube, an outdated electrical system, prevents installation of insulation anywhere where knob and tube is present. The cost of removal, (~$5,000-$20,000) depends on difficulty of snaking new wires through the walls, and the extent of active knob and tube. It usually also requires a costly upgrade of an electrical panel. Asbestos can be present in the form of attic insulation, or heating pipe wrap, or other. Moisture in the basement or leaky roof, also implicated as barriers to efficiency, are a very costly set of repairs for the homeowners, typically $10,000-$20,000 each. *PA Home Finance Agency offers a $10,000 1% interest loan for homeowners up to 80% AMI (or up to 150% in some circumstances) to help repair these deficiencies. A recent passage of the Whole Home Repairs bill by the PA legislature could also help to remove these structural barriers for homeowners who are otherwise prevented from installing energy efficiency and who's homes suffer unhealthy conditions and disrepair.*

Lack of an easy, affordable way to pay for improvements. Program participation is shown to depend on how easy it is for the homeowners to obtain financing if they cannot pay for the upgrade up-front. *Connecting homeowners with low-cost loans, setting up programs that streamline the application process, buying down interest rates to make borrowing for energy efficiency more affordable are all examples of strategies to reduce this barrier for homeowners.*

To summarize, achieving high participation rates in energy efficiency programs and high audit-to-project completion rates are driven largely by shrewd marketing and outreach efforts, multiple touch points with the target audience, contractor engagement and training, and generous financial incentives.

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