# INVESTING IN VIRGINIA THROUGH ENERGY EFFICIENCY: AN ANALYSIS OF THE IMPACTS OF RGGI AND THE HIEE PROGRAM

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# Investing in Virginia through Energy Efficiency:
# An Analysis of the Impacts of RGGI and the HIEE Program


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## Frequently Used Acronyms

ACEEE: American Council for an Energy Efficient Economy

AMI: Area Median Income

APCO: Appalachian Power Company

ASNH: Affordable and Special Needs Housing

BIL: Bipartisan Infrastructure Law (i.e., the federal Infrastructure Investment and Jobs Act)

BTU: British Thermal Units

DHCD: Virginia Department of Housing and Community Development

DOE: U.S. Department of Energy

EERE: Office of Energy Efficiency & Renewable Energy (part of U.S. Department of Energy)

EIA: U.S. Energy Information Administration (part of U.S. Department of Energy)

FPL: Federal Poverty Level

GTSA: Grid Transformation and Security Act

HIEE: Housing Innovations in Energy Efficiency

IRA: Inflation Reduction Act

KWH: Kilowatt-hours

LEAD: Low-Income Energy Affordability Data tool

LIHEAP: Low-Income Home Energy Assistance Program

LIHTC: Low-Income Housing Tax Credit

MWH: Megawatt-hours

NREL: National Renewable Energy Laboratory

RECS: Residential Energy Consumption Survey (U.S. Department of Energy)

RGGI: Regional Greenhouse Gas Initiative

SCC: State Corporation Commission

VCEA: Virginia Clean Economy Act

VHDA: Virginia Housing Development Authority (aka Virginia Housing)

WAP: Weatherization Assistance Program

## Executive Summary

This study examines the low-income energy efficiency programs funded by Virginia's participation in the Regional Greenhouse Gas Initiative (RGGI). Its goal is to understand the extent to which those programs can address the problem of high energy burdens among Virginia's low-income residents, and to estimate the impacts that those energy efficiency investments could have on the broader Virginia economy.

Our report begins with a review of existing research on "energy burdens," or the concept that some residents, particularly those in lower income brackets, spend a disproportionate percentage of their incomes on home energy costs (heating, cooling, etc.). We then discuss the potential to relieve those burdens through investments in energy efficiency, and summarize some of the federal and state-level policies and programs that support energy efficiency and "weatherization" for low-income households.

We then present our original analysis for this study, which includes the following components:

- A series of maps that evaluate the spatial distribution of low-income energy burdens in Virginia
- A projection of potential future RGGI revenue for Virginia (high and low scenarios) through 2030
- An analysis of the potential energy efficiency benefits from the two RGGI revenue scenarios, including the number of housing units that could be upgraded and the resulting energy consumption reductions and customer bill savings
- An analysis of the broader economic impacts that would result from these RGGI-funded energy efficiency investments, including total economic impact, value added, and jobs created

Some of the more notable findings from our analysis are as follows:

- Average energy burdens for low-income households are at or above the 10% threshold for "Severe" energy burden across much of Virginia, particularly in rural areas.
- Virginia's metro regions have lower low-income energy burdens on average, with some exceptions in in parts of Hampton, Newport News, Norfolk, Portsmouth, and Richmond
- Virginia has approximately 579,000 low-income households located in Census tracts with a High average low-income energy burden (above 6%), and about 154,000 low-income housing households in Census tracts with a Severe average low-income energy burden (above 10%).
- If Virginia continues to participate in the RGGI program through 2030, the estimated total revenue over the decade (2021-2030) will be in the range of $2.5 - $3.3 Billion, resulting in between $125 - $165 million per year for low-income energy efficiency programs.
- This estimated revenue from the RGGI program far exceeds the total funding otherwise available for low-income energy efficiency via existing state and federal programs.
- These RGGI funds could provide energy efficiency upgrades to up to 130,000 homes in the High revenue scenario, leading to over 590,000 MWh in annual electricity reductions and $89 million in annual customer bill savings, for an average of $676 in annual energy savings per household.
- The expenditure of these RGGI energy efficiency funds would have a statewide economic impact of between $2.03 billion and $2.67 billion over the course of the decade (2021-2030), including up to $1.75 billion in Value Added, and would create and sustain up to 2,115 new jobs.

Virginia's participation in the Regional Greenhouse Gas Initiative (RGGI) program has generated over $250 million for low-income energy efficiency programs over the past two years (2021-2022). These funds, passed through the Department of Housing and Community Development's (DHCD) Housing Innovations in Energy Efficiency (HIEE) program, support energy-efficiency upgrades in two ways:

- Provide funding to include highly energy-efficient features in new and rehabilitated affordable multi-family housing developments, via the DHCD's existing Affordable and Special Needs Housing Program (ASNH-EE)
- Fund repairs to homes that have been deemed unsuitable for weatherization, via the DHCD's new Weatherization Deferral Repair (WDR) program, thus allowing those homes to gain access to federal Weatherization Assistance Program (WAP) dollars

The $125 million per year that Virginia's participation in RGGI has provided for the HIEE program thus far dwarfs all other low-income energy efficiency programs operating in the state, which are anticipated to provide less than $55 million per year combined over the next few years. This includes about $17.25 million from the federal Low-Income Home Energy Assistance Program (LIHEAP), which primarily provides bill relief but also supports low-income weatherization, and about $13 million a year in WAP funding. Both of these totals include recent short-term funding increases resulting from the 2021 passage of the federal Infrastructure Investment and Jobs Act. The $55 million total also includes the $15 million a year that Dominion Energy and Appalachian Power (APC) are required to spend on low and moderate income (LMI) energy efficiency programs under the provisions of the Grid Transformation and Security Act (GTSA) and the Virginia Clean Economy Act (VCEA). Finally, this total includes an additional $6 million per year from Dominion's Energy Share program, plus low-income energy efficiency investments from Virginia's natural gas utilities, which are believed to total less than $4 million.

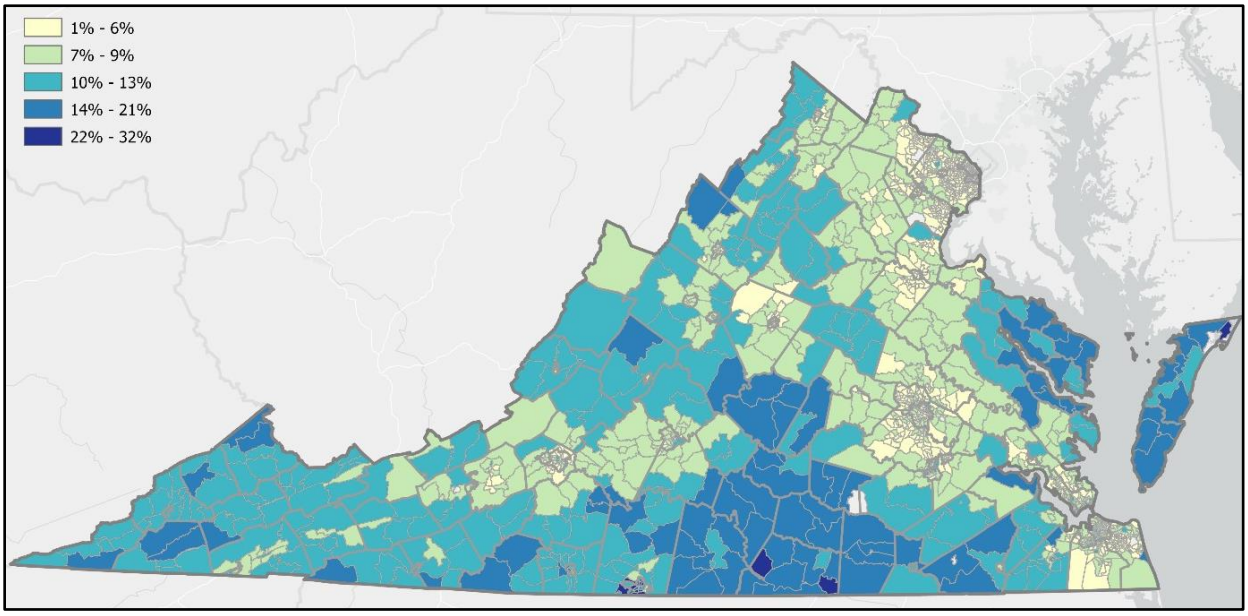
## The Challenge of Low-Income Energy Burdens in Virginia

This substantial increase in low-income energy-efficiency funding will go a long way towards addressing the significant "energy burden" problems facing many of Virginia's low-income residents. According to data from the U.S. Department of Energy (DOE), low-income households in Virginia – defined as those earning less than 80% of the Area Median Income (AMI) – spend about 7% of their income on home energy costs (heating, cooling, etc.). This exceeds the 6% threshold that constitutes "High" energy burden. Extremely-low-income households in Virginia (incomes of 0-30% AMI) have an average energy burden of 17%, which is well above the 10% threshold for "Severe" energy burden and more than eight times the 2% average for households with incomes above 80% AMI.

Energy burden is not only a function of income. Low-income households tend to live in less-efficient housing units, have less-efficient appliances, etc., which leads them to spend more on household energy costs (per square foot) compared to non-low-income households. This leads to higher rates of "energy insecurity," in which households react to high energy burdens by reducing their food and/or medical expenditures and/or resort to dangerous coping mechanisms, such as leaving their homes at unhealthy temperatures or using ovens and space heaters to heat their homes.

While low-income energy burdens are a challenge throughout Virginia, they are particularly acute in certain regions. We evaluated these regional disparities, using data from the Census Bureau and the DOE's Low-Income Energy Affordability Data (LEAD) Tool, to produce a series of maps found in Section 3. The first of these maps, shown here as Figure ES-2, demonstrates the average energy burden by Census tract for households with incomes below 80% AMI.

**Figure ES-1. Map of Average Energy Burden of Low-Income Households by Census Tract**




*Source: Low-Income Energy Affordability Data (LEAD), US Department of Energy*

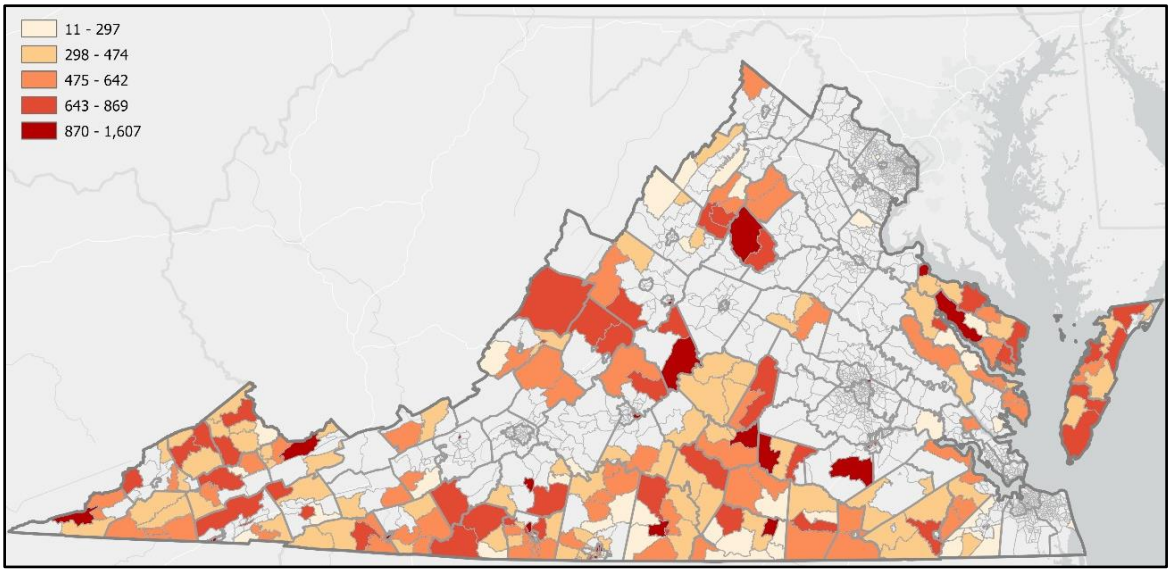
The map above shows that average energy burdens for low-income households are at or above the 10% threshold for Severe energy burden across much of Virginia's rural areas. This is particularly the case in Southwest Virginia, Southside Virginia, the Northern Neck, and the Eastern Shore.

Average low-income energy burdens are generally lower in the state's metro regions. However, Map 1.A. in Section 3.1 shows that concentrations of High to Severe low-income energy burden are found in some urban areas, particularly in parts of Hampton, Newport News, Norfolk, Portsmouth, and Richmond.

Our research also identified some pockets of extreme low-income energy burden. There are 76 Census tracts in Virginia where the average energy burden for low-income households is at or above 15%, or more than twice the national average for households in the 0-80% AMI range. Twelve of those tracts are in the Danville area. There are also 15 Census Tracts in Virginia where the average low-income energy burden is at least 22%, or more than double the threshold for Severe energy burden.

We then mapped the number of housing units within each of the Census Tracts that have average low-income energy burdens exceeding the High and Severe energy burden thresholds, with the latter shown in Figure ES-2 below. Additional housing unit maps are found in Section 3.1 and Appendix C.

**Figure ES-2. Housing Units in Census Tracts with Severe Low-Income Energy Burden**




*Source: Low-Income Energy Affordability Data (LEAD), US Department of Energy*

The map above demonstrates the total housing units in each of Virginia's Census Tracts where the average energy burden for low-income households exceeds the 10% threshold for Severe energy burden. Like the map shown in Figure ES-1 above, this map demonstrates that many of the low-income households facing Severe energy burdens are found in the state's rural areas, particularly in Southwest Virginia, Southside Virginia, the Northern Neck, and the Eastern Shore.

Section 3.1 includes zoomed in maps of the state's metropolitan regions, which demonstrate some concentrations of High average energy burden for low-income households in urban areas, but very few Census Tracts in which low-income households have a Severe average energy burden.

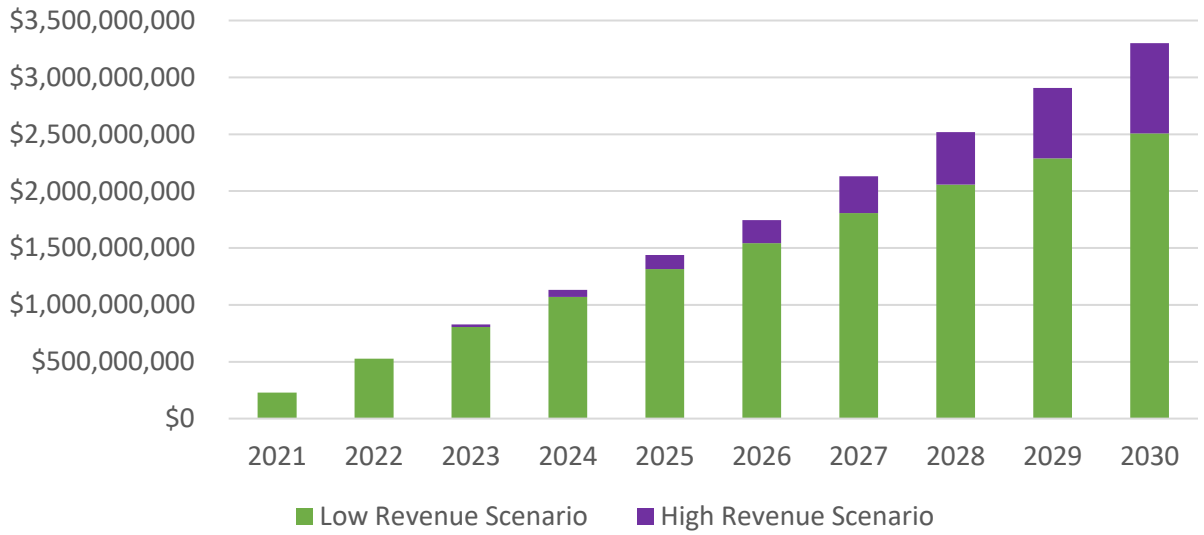
## Addressing Virginia's Energy Burden Challenge via RGGI-Funded Energy Efficiency Programs

Energy efficiency is a powerful tool for reducing energy burdens and energy insecurity. Data from the National Renewable Energy Laboratory (NREL) shows that energy efficiency improvements could reduce low-income household electricity use in Virginia by roughly 30%, which is a higher rate than all but five other states. Numerous other studies, from NREL and other sources, have demonstrated the vast potential for reducing low-income energy consumption and energy burdens via cost-effective energy efficiency solutions, as discussed further in Section 1.2 of this report.

However, low-income households face a variety of challenges when it comes to actually realizing these benefits, most significantly the upfront costs of investing in energy efficiency upgrades. Additionally, while a variety of tax credits and other financial incentives are available from the federal, state, and some local governments, utilizing these programs still requires some element of up-front investment. This is why programs that directly provide energy efficiency upgrades to qualifying homes, such as those under Virginia's HIEE program, are particularly important for addressing low-income energy burdens.

If Virginia continues to participate in the RGGI program through 2030, we estimate that the combined total revenue over the decade (2021-2030) will be in the range of $2.5 - $3.3 Billion, as shown in Figure ES-3 below. (A detailed discussion of the RGGI program, the mechanisms by which it raises revenue for Virginia, and our projections of future RGGI revenue is provided in Section 4 of this report).

**Figure ES-3. Projected Virginia RGGI Revenue, Low vs. High Scenarios, 2021-2030**




*Source: VCU analysis of RGGI auction revenue trends and policies*

As the Clean Energy and Community Flood Preparedness Act requires 50% of the state's RGGI revenue to be spent on low-income energy efficiency improvements, the total funding to HIEE or other similar programs would be about $1.25 - $1.65 Billion, or about $125 - $165 Million per year on average.

The DHCD created the Housing Innovations in Energy Efficiency (HIEE) program as the entity to manage and distribute these RGGI energy efficiency funds, according to the following objectives:

- Deep energy retrofits (exceeding energy code requirements) that complement existing affordable housing construction and rehabilitation incentives, to ensure lowest income population benefits from long-term cost savings;
- Incorporate innovative approaches that will overcome traditional barriers to building and retrofitting affordable housing at scale;
- Prioritize long-term sustainability/durability and occupant health (e.g. preventing moisture issues, improving ventilation) along with energy efficiency upgrades

The DHCD has approved about $37 million in ASNH-EE and WDR expenditures thus far, leading to weatherization and energy efficiency improvements for nearly 4,000 Virginia homes since July 2021. The DHCD has also announced the release of an additional $80 million in ASNH-EE funds, which could support up to 6,500 more highly energy-efficient multi-family units.

One of the goals of this research project was to estimate the potential number of housing units that could receive energy efficiency upgrades via these HIEE programs, assuming that Virginia remains in RGGI and continues to distribute the funding in a manner similar to the first two years. We then sought to estimate the amount of reduced energy consumption and resulting customer bill savings that would result from those energy efficiency investments.

To create these estimates, we relied on publicly available data from DHCD to estimate the average cost per housing unit for the WDR and ASNH-EE programs, which we then used to calculate the estimated number of units that could be upgraded via each program with continued RGGI / HIEE funding. For the WDR program this included separate average costs for single-family homes (SFH) and multi-family housing units (MFH). The results of this analysis are shown in Table ES-1 below.

**Table ES-1. Estimated Units Upgraded via HIEE Programs, per 2021-2030 Revenue Scenario**

| Revenue Scenario | ASNH - EE | WDR - SFH | WDR - MFH | Total Units |
|---|---|---|---|---|
| Low ($1.24 billion) | 78,373 | 10,806 | 11,653 | 100,832 |
| High ($1.64 billion) | 101,833 | 14,041 | 15,141 | 131,015 |

*Source: Calculations by authors*

Next, we estimated the total annual energy savings from the housing units receiving energy efficiency upgrades in each RGGI revenue scenario. For this step we used data from the Virginia Center for Housing Research at Virginia Tech, which completed a study of the HIEE program for DHCD in the fall of 2022. The Virginia Tech researchers calculated the average annual energy savings per unit for each of the three types of energy-efficiency upgrades funded by the HIEE program: WDR – single-family; WDR – multi-family, and ASNH-EE. We then multiplied those averages times the housing unit totals shown in Table ES-1, to get the total estimated annual energy and customer bill savings shown in Table ES-2.

**Table ES-2. Total Units Upgraded (2021-2030) and Annual (Year 2030) Energy and Bill Savings**

| RGGI / HIEE Revenue Scenario | Units Upgraded | Total Energy Savings (MMBTU) | Total Energy Savings (MWH) | Total Bill Savings ($Millions) | Bill Savings / Unit ($) |
|---|---|---|---|---|---|
| Low ($1.24 billion) | 100,832 | 1,551,322 | 454,666 | $68.20 | $676 |
| High ($1.64 billion) | 131,015 | 2,015,703 | 590,769 | $88.62 | $676 |

*Source: Calculations by authors, using energy savings data from Virginia Center for Housing Research*

To clarify, the energy and customer bill savings shown in Table ES-2 are based on the total number of housing units that could receive energy efficiency upgrades via our estimated HIEE revenue scenarios. These are annual values, representing the projected energy and customer bill savings benefits in the year 2030, based on a projected electricity rate of $0.15 / kWh in the year 2030, as a result of the energy efficiency investments funded by HIEE from 2021-2030. These annual energy savings would continue beyond 2030, with corresponding customer bill savings. Annual energy and customer bill savings realized in the preceding years of the HIEE program (i.e., 2021-2029) would be proportional to the number of energy efficiency projects completed by that time.

## Analyzing the Economic Impacts of Virginia's RGGI-Funded Energy Efficiency Programs

In the final stage of this project we created an economic impact model to evaluate how the change in economic activity from Virginia's RGGI-funded energy efficiency investments would impact the broader regional economy. We used IMPLAN, an industry standard for this type of input-output modeling.

The primary result of this analysis is that the expenditure of HIEE funds – $1.24 to $1.64 billion from 2021 through 2030 – would have a statewide impact of between $2.03 and $2.67 billion.

In other words, every dollar spent by the HIEE program generates a total impact of $1.66 – the original $1.00 ("direct impact"), plus another $0.66 generated through indirect and induced impacts. "Indirect impacts" are the dollars from the original expenditures that go to suppliers inside Virginia, while "induced impacts" occur when workers receive income from this new economic activity and subsequently spend those dollars in their communities.

The estimated total impact includes $1.32 to $1.75 billion in Value Added across the 10-year period, which would represent an increase of 0.02% to 0.03% to the state's GDP. We estimate that the Labor Income component of that Value Added ($0.83 to $1.11 billion) would create and sustain 1,552 to 2,115 jobs, at approximately $52,500 to $53,500 per job. These findings are summarized in Table ES-3.

**Table ES-3. Summary of HIEE Impact Components, 2021 - 2030 (Low vs. High Scenarios)**

| Impact | Employment | Labor Income ($Millions) | Value Added ($Millions) |
|---|---|---|---|
| Direct | 1,069 - 1,457 | $581 - $774 | $849 - $1,128 |
| Indirect | 217 - 233 | $102 - $133 | $186 - $240 |
| Induced | 311 - 424 | $150 - $199 | $288 - $382 |
| **Total** | **1,598 - 2,115** | **$834 - $1,106** | **$1,323 - $1,750** |

Unlike the dollar-based impact figures, the job creation figures do not stack cumulatively from year-to-year. Figure 6 shows the number of jobs that the HIEE program would support over the 10-year period, as a function of the amount of revenue generated that year.

**Figure ES-4. Annual Employment Supported by HIEE Expenditures, 2021 – 2030**

*Sources: VCU model of estimated annual RGGI revenue for Virginia (see Section 4)*

# 1. Energy Efficiency as a Solution to Low-Income Energy Burdens

Energy burden and energy insecurity are growing issues for Virginians, particularly among low-income households. The average American household spends $2,177 per year on home energy costs (heating, cooling, lighting, etc.), representing about 3% of their household income.[1] Households that spend more than 6% of their total income on these home energy costs are considered to have "High" energy burden, while those who spend more than 10% are categorized as facing "Severe" energy burden.[2] Households with High or Severe energy burdens often experience "energy insecurity," which refers to an inability to afford basic household heating, cooling, and energy needs, leading to poor health and safety outcomes.

Low-income households are disproportionately more energy burdened, compared to non-low-income households. The concept of a "low-income" household can be defined in different ways, which can sometimes produce seemingly conflicting results when comparing data sources or research studies. Some of the sources cited in this section define "low-income" based on the Federal Poverty Line (FPL), while others are based on percentages of Area Median Income (AMI).[3] Generally speaking, households with incomes of up to 200% of the FPL are considered low-income, as are households with incomes of less than 80% AMI. Households with incomes less than 30% AMI are considered extremely-low-income.[4]

High energy costs are another driver of energy burden and energy insecurity. Virginia's average residential electricity bill of $130.92 per month was 13th highest in the nation as of 2021, but was just 0.33% from the top 10 and 4% away from the top five.[5] The average Dominion Energy customer's bills jumped 30% from 2006-2016,[6] and Appalachian Power bills increased 73% over a similar period.[7]

Energy efficiency is a key strategy to address these challenges, as well-designed energy-efficiency upgrades can substantially reduce household energy costs (i.e., customer bills). Energy efficiency is often cost-effective, according to conventional economic metrics, as an up-front investment in efficiency upgrades can "pay for itself" via reduced energy bills over a reasonable number of years. However, the low-income households that could most benefit from energy-efficiency investments are often unable to do so. First, the majority of low-income households are renters, which means they may not stay in a given housing unit long enough to pay off an energy-efficiency investment, if they are even authorized to make such physical changes to the structure. Low-income homeowners also face barriers, as they often lack the capital or access to financing to make up-front energy efficiency investments.

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[1] U.S. Department of Energy (DOE), Office of Energy Efficiency & Renewable Energy (EERE), 2018. Low-Income Energy Affordability Data (LEAD) Tool. Analysis by authors.

[2] Drehobl, et al., 2020. How High Are Household Energy Burdens? An Assessment of National and Metropolitan Energy Burden across the United States.

[3] U.S. DOE, EERE, 2018. *Low-Income Household Energy Burden Varies Among States -- Efficiency Can Help in All of Them*.

[4] U.S. Department of Housing and Urban Development (HUD), 2022. Methodology for Determining Section 8 Income Limits.

[5] U.S. DOE, Energy Information Administration (EIA), 2022. Electric Sales, Revenue, and Average Price. (Table T5a.)

[6] Virginia Poverty Law Center, 2017. *The Myth of Virginia's Rate Utopia: A Comparison of Rates, Riders, and Bills*.

[7] Pate, 2017. *SCC Presentation to the Commission on Electric Utility Regulation*.

A variety of federal, state, and local policies exist to support residential energy efficiency investments, including a number of tax credits and rebates available as a result of the recent federal Inflation Reduction Act. However, these types of incentive-based energy-efficiency programs are generally not accessible for low-income households, as they still require some element of up-front investment. For this study, the more relevant government policies or programs are those that directly support energy-efficiency improvements to low-income households, such as the federal Weatherization Assistance Program (WAP) and the energy efficiency requirements that Virginia and other states place on housing developers who receive the federal Low-Income Housing Tax Credit (LIHTC). Other programs, such as the federal Low-Income Home Energy Assistance Program (LIHEAP) can help reduce low-income energy burdens by providing direct financial assistance to reduce energy bills, but those bill-assistance programs do not provide the same long-lasting benefits that households receive from energy efficiency improvements (some states, including Virginia, use a portion of their LIHEAP funds for weatherization). Finally, electric and natural gas utilities offer a variety of energy efficiency and bill assistance programs for low-income customers, often according to parameters set by state law.

In Virginia, participation in the Regional Greenhouse Gas Initiative (RGGI) has generated over $250 million in low-income energy efficiency funding since 2021, an amount that far exceeds the annual funding provided via the types of programs described above.

## 1.1. Energy Burden and Energy Insecurity

According to the U.S. Department of Energy (DOE) Office of Energy Efficiency & Renewable Energy's (EERE) Low-Income Energy Affordability Data (LEAD) tool, the average energy burden of low-income households in the U.S. (i.e., those with incomes of 0-80% of AMI) is 7%, compared to 2% for households with incomes above 80% AMI. Broken down into more detail, extremely-low-income households (0-30% AMI) have an average energy burden of 16%, compared to 6% for those in the 30-60% AMI range and 5% in the 60-80% range. In other words, average energy burdens are eight times higher for extremely-low-income households (0-30% AMI), compared to non-low-income households (80% AMI or above).[8]

The average energy burdens across these various income categories are nearly identical for Virginia households, albeit slightly higher (17%) for those in the lowest (0-30% AMI) income bracket. Defining income in a different way, the average energy burden for Virginia households with incomes below the federal poverty level (FPL) is 21%, compared to 18% nationwide. Virginia's average energy burdens are slightly above the national average (8% vs. 7%) for households with incomes between 100-200% of FPL.[9]

However, while low-income energy burdens in Virginia are comparable to the national average, more detailed analysis reveals substantial disparities within the state, with many areas experiencing average energy burdens that far exceed state or national rates. For example, a 2020 study by the American Council for an Energy Efficient Economy (ACEEE) found that 25% of low-income households in the Richmond metro region (defined as less than 200% of the FPL) have an energy burden greater than 15.6%.[10] Energy burden is even more prevalent in some rural parts of the state, as an analysis of LEAD data shows that average energy burdens for low-income households exceed 10% in much of Southwest

[8] U.S. DOE, EERE, 2022. Low-Income Energy Affordability Data Tool. Analysis by authors.

[9] U.S. DOE, EERE, 2022. Low-Income Energy Affordability Data Tool. Analysis by authors.

[10] Drehobl, et al., 2020. How High Are Household Energy Burdens? An Assessment of National and Metropolitan Energy Burden across the United States.

and Southside Virginia, reaching as high as 32% in some Census tracts.[11] These local energy burden trends within Virginia are examined in more detail in Section 3 of this report.

These discrepancies are not merely a function of income. According to data from the U.S. Energy Information Administration (EIA), low-income households spend an average of $1.23 per square foot for utilities, while non-low-income households spend $0.98 per square foot.[12] This can be attributed to housing discrimination and market pressures that push low-income people into older, less efficient housing.[13] In particular, older housing, especially in neighborhoods that have experienced historical disinvestment, tend to have poor insulation, an inefficient building envelope, outdated heating and/or cooling systems, and inefficient appliances, all leading to higher energy use.[14]

The disparity in housing conditions leads to higher rates of energy insecurity for low-income households. The characteristics of an energy insecure household can be divided into three categories - physical, economic, and "coping" or behavioral outcomes. Beyond the immediate economic barriers these trends create for vulnerable households, energy insecurity is also an important social determinant of health, as it can eventually lead to significant health issues and dangerous coping strategies.

For example, a low-income household is more likely to live in low-quality housing with older, energy inefficient appliances, which in turn have a higher energy consumption, higher maintenance costs, and increased risk of failure. In response, the household observes certain practices to reduce their use of energy – such as not using air conditioning, or using ovens and space heaters to heat their homes – leading to uncomfortable and potentially unsafe conditions. Besides the acute risks of fire, these strategies have been proven to disrupt sleep, cause stress, anxiety, and depression, increase risks of respiratory illness, and even increase the risk of death due to extreme heat, extreme cold, or carbon monoxide exposure. The elderly and children are most vulnerable to these impacts.[15, 16]

The U.S. Department of Energy's Residential Energy Consumption Survey (RECS) provides data on energy insecurity across different housing types and population demographics. The 2020 RECS data indicates that 27% of U.S. households reported having experienced at least one form of energy insecurity at some point, such as reducing food and/or medical expenditures in order to pay for energy costs, or leaving their homes at an unhealthy temperature. This includes 23% of households living in single-family homes, and 35% of those living in apartments, as well as 40% of renters and 37% of households with children under 18. The prevalence of these forms of energy insecurity varies greatly by income level and racial demographics, as indicated in Figure 1.[17]

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[11] U.S. DOE, EERE, 2022. Low-Income Energy Affordability Data (LEAD) Tool. Analysis by authors.

[12] Virginia Poverty Law Center, 2018. *Electricity Burden and the Myth of Virginia's Rate Utopia*.

[13] Graff, et al., 2021. *Which Households Are Energy Insecure? An Empirical Analysis of Race, Housing Conditions, and Energy Burdens in the United States*. Energy Research & Social Science. 79.

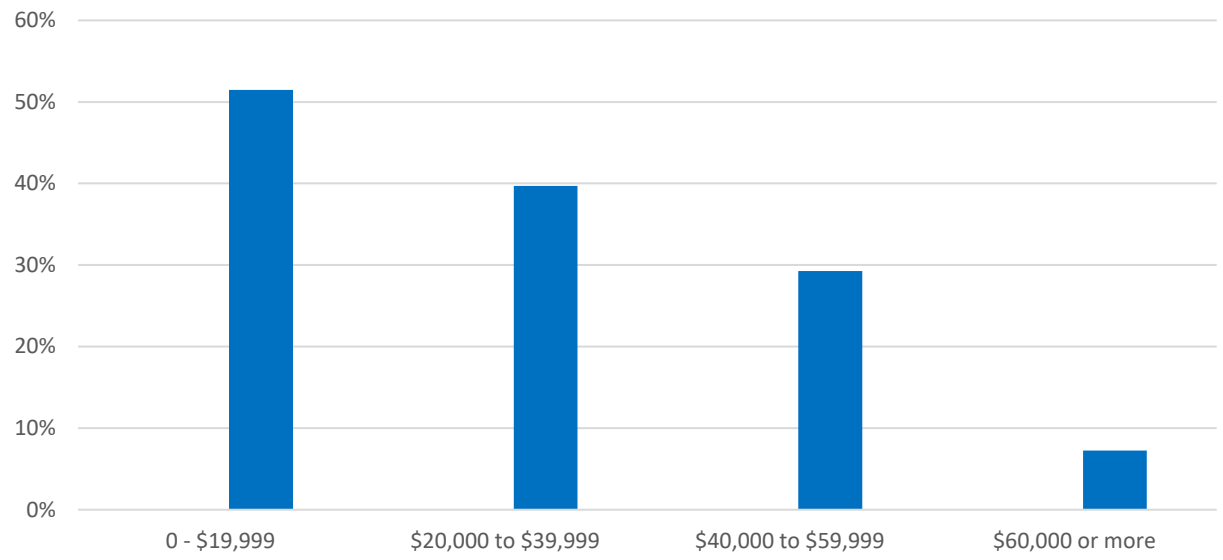
[14] Lewis, et al., 2019. Energy Efficiency as Energy Justice: Addressing Racial Inequities Through Investments in People and Places. Energy Efficiency.

[15] Hernández, et al., 2014. Energy Insecurity among Families with Children.

[16] Graff, et al., 2021. *Which Households Are Energy Insecure? An Empirical Analysis of Race, Housing Conditions, and Energy Burdens in the United States*. Energy Research & Social Science. 79.

[17] U.S. DOE, Energy Information Administration, 2020. Residential Energy Consumption Survey (RECS).

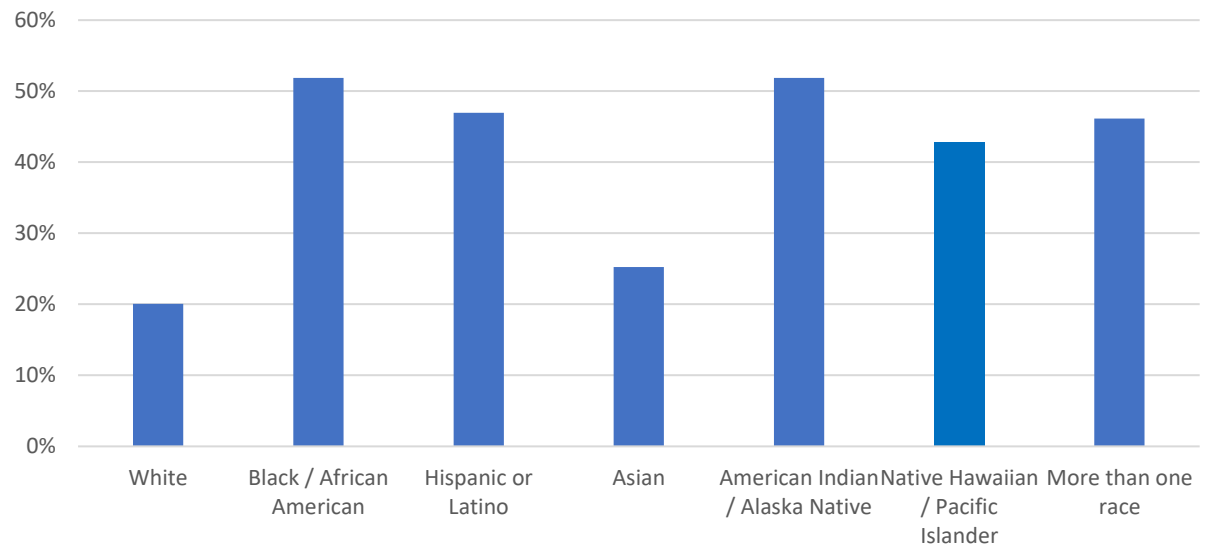
**Figure 1. Percentage of Households Experiencing Energy Insecurity, by Household Income**




*Source: U.S. DOE, 2020. Residential Energy Consumption Survey. Table HC11.1. Additional analysis by authors.*

Energy insecurity also varies greatly by race, with about 20-25% of White and Asian households experiencing these impacts, versus 43-52% in all other racial categories, according to the RECS data.

**Figure 2. Percentage of Households Experiencing Energy Insecurity, by Racial Category**




*Source: U.S. DOE, 2020. Residential Energy Consumption Survey. Table HC11.1. Additional analysis by authors.*

## 1.2. Energy Efficiency Opportunities and Policies

An analysis of U.S. Department of Energy data by the American Council for an Energy Efficient Economy (ACEEE) suggests that energy efficiency can reduce residential energy consumption by 25-35% for all income groups. For low-income households, these energy consumption savings could reduce energy burdens by 25%.[18] Potential savings for Virginia households are even higher, as data from the National Renewable Energy Laboratory (NREL) shows that Virginia is one of six states in the highest range of potential low-income household electricity savings, at 29-32%.[19]

Energy efficiency is also a cost-effective option for reducing energy burdens. Cost-effectiveness can be understood as an investment in energy efficiency that produces cost savings – via lower energy bills – that offset the initial investment. Cost effectiveness can be measured in a variety of ways, most commonly through the Simple Payback Period (SPP), or the number of years it takes for energy bill savings to catch up with the initial up-front cost of the energy-efficiency investment. Another method is to calculate the Net Present Value (NPV) of an energy-efficiency investment, or the difference between the initial cost of an upgrade and the energy bill savings over a given period of time. For an energy-efficiency investment to be considered cost-effective, one would look for the SPP to be fewer years than the "life" of the efficiency upgrades, or an NPV greater than zero over that product lifespan.[20]

However, it must be noted that these traditional cost effectiveness metrics do not consider a variety of other important factors. Most notably, basic SPP and NPV calculations typically do not account for future price increases for the energy that is being saved (e.g., electricity is highly likely to cost more per kilowatt-hour in five or ten years than it does today). These metrics also do not recognize important co-benefits that come with an energy-efficiency investment. For example, reducing energy insecurity through energy efficiency can improve residents' health, as detailed in section 1.1. In addition to reducing medical bills, this can lead to fewer medical absences from work and/or school.[21]

Researchers from the National Renewable Energy Laboratory (NREL) have completed numerous studies on residential energy efficiency opportunities in the United States. One study from 2017 estimated that cost-effective energy efficiency retrofits (NPV > 0) to single-family detached homes in the U.S. could produce 4.2 quadrillion British Thermal Units (BTUs) of annual energy savings, equal to 24.4% of all primary energy consumption in those types of homes and 4.2% of all primary energy consumption nationwide.[22] State-level analysis found the potential energy savings in Virginia to be even greater, at approximately 30% of total primary energy consumption in single-family detached homes.[23]

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[18] Drehobl, et al., 2020. *How High Are Household Energy Burdens?: An Assessment of National and Metropolitan Energy Burden across the United States*

[19] U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, 2018. *Low-Income Household Energy Burden Varies Among States -- Efficiency Can Help in All of Them*.

[20] Wilson, et. al., 2019. Evaluating energy efficiency potential in low-income households: A flexible and granular approach. Energy Policy vol. 129, p. 710-737.

[21] Wilson, et. al., 2019. Evaluating energy efficiency potential in low-income households: A flexible and granular approach. Energy Policy vol. 129, p. 710-737.

[22] Wilson, et al., 2017. Energy Efficiency Potential in the U.S. Single-Family Housing Stock.

[23] Wilson, et al., 2017. Energy Efficiency Potential in the U.S. Single-Family Housing Stock. See Table A-1, Figure A-2.

The economic benefits and potential savings are especially important for low-income households. In one study, researchers estimated that cost-effective energy efficiency upgrades (defined as an SPP of 13-19 years and NPV > 0) could result in a total potential energy cost savings of $13 billion per year for low-income households across the U.S., or $726 per year per household.[24]

A subsequent NREL study found that economically viable energy-efficiency upgrades to single-family detached homes in Virginia with incomes of less than 200% of the federal poverty level could reduce those customers' bills by $356 million. Among those with incomes of less than 80% of AMI, the total increases to $514 million in potential cost-effective energy efficiency savings.[25] Per the LEAD dataset, there are 375,604 single-family detached homes in Virginia with incomes below 200% of the federal poverty level, and 569,559 below 80% AMI.[26] Cross-referencing these figures generates a potential cost-effective per-household energy savings of $902.45 per year for households below 80% AMI, and $947.48 per year for households below 200% of the federal poverty level.

For multi-family housing, a 2016 study by Optimal Energy found that electricity savings of over 20% could be cost-effectively achieved for affordable multi-family housing units in Virginia, resulting in over $227 million in electricity cost savings, or $354 million after including natural gas and other fuels.[27]

However, while low-income energy efficiency has great technical potential, there are many barriers to low-income residents actually realizing those opportunities, most significantly the upfront cost of investing in energy-efficiency upgrades. One barrier is that many existing energy-efficiency programs are not specifically designed for low-income households. These "market-rate" programs, i.e. programs that provide a tax credit, rebate, or other economic incentive to offset the up-front cost of an energy efficiency upgrade, are generally inaccessible to non-low-income households, due to an inability to meet even those reduced upfront costs, and/or a lack of qualifying credit.[28]

These challenges are compounded for renter-occupied households, which represent an estimated 59% of all low-income households across the country. Owners and landlords do not have a financial incentive to pay for energy-efficiency improvements, which leaves the energy burden on the tenants.[29] This is known as the "split-incentive" problem, in that the residents of multifamily buildings or other rental housing units can benefit from energy-efficiency improvements to reduce their energy bills, but the owners of those units would not realize any economic benefit and therefore have no direct financial incentive to pay for those efficiency improvements.[30]

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[24] Wilson, et. al., 2019. Evaluating energy efficiency potential in low-income households: A flexible and granular approach. Energy Policy vol. 129, p. 710-737.

[25] Wilson, et. al., 2019. Evaluating energy efficiency potential in low-income households: A flexible and granular approach. Energy Policy vol. 129, p. 710-737.

[26] U.S. DOE, EERE, 2022. Low-Income Energy Affordability Data Tool. Analysis by authors.

[27] Optimal Energy, 2015. Potential for Energy Savings in Affordable Multifamily Housing.

[28] American Council for an Energy-Efficient Economy, 2022. Low-Income Energy Efficiency Programs.

[29] U.S. DOE, State and Local Solution Center, 2021. Low-Income Community Energy Solutions.

[30] Samarripas, York, 2019. Closing the Gap in Energy Efficiency Programs for Affordable Multifamily Housing.

### *1.2.1 Federal Programs to Address Energy Burden and Increase Energy Efficiency*

This section discusses the primary federal programs that support residential energy efficiency or can help to reduce energy burdens for low-income households. While a variety of tax credits and other programs exist to support market-rate energy-efficiency investments for the broader population, those are generally not accessible to low-income households for the reasons stated earlier in section 1.2.

One of the most significant sources of support for low-income residential energy efficiency is the U.S. Department of Energy's Weatherization Assistance Program (WAP). The WAP program was created in 1976 to provide upgrades to "weatherize" homes for households with incomes less than 200% of the federal poverty level.[31] These improvements, such as insulation and air sealing as well as updated appliances, also contribute to improving health and safety standards by reducing energy related hazards. The WAP program supports 8,500 jobs and provides weatherization services to approximately 35,000 homes across the U.S. yearly, with an average annual savings of $372 per household.[32]

The Low-Income Home Energy Assistance Program (LIHEAP) was formed in 1981 and provides federal assistance – passed through state, territorial, and tribal agencies – to reduce energy costs for low-income households.[33] This program primarily provides monetary relief to low-income households, in the form of heating, cooling, and emergency bill assistance, but states also have the flexibility to allocate up to 15% of their LIHEAP funds to energy conservation measures (often via the same agency that manages the WAP program).[34] From 2018-2022 Virginia received roughly $85-$95 million per year in LIHEAP funds, but this number is increasing to over $115 million in FY 2023 due to additional funding from the Infrastructure Investment and Jobs Act.[35] In FY 2022 Virginia spent 42% of its LIHEAP funds on heating assistance, 20% on cooling and crisis assistance, and 15% on weatherization. (Federal law allows states to spend up to 10% of LIHEAP funds on administration, and carry up to 10% to the next fiscal year).[36]

The Low-Income Housing Tax Credit (LIHTC) program was created by the Tax Reform Act of 1986, and allows state and local agencies to issue approximately $8 billion in tax credits for the acquisition, rehabilitation, or new construction of rental housing targeted to lower-income households.[37] State agencies receive a set amount of tax credits, based on population, which are then distributed according to the state's qualified allocation plan. These plans typically include criteria for energy efficiency and green building, to support sustainability and resilience for low-income families.[38] The Virginia Housing Development Authority (aka Virginia Housing) requires projects that receive LIHTC credits to achieve certain energy efficiency benchmarks,[39] as discussed in Section 1.4.1 of this report.

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[31] U.S. DOE, EERE, 2022. Weatherization Assistance Program.

[32] U.S. DOE, EERE, 2022. Weatherization Assistance Program Factsheet.

[33] U.S. Department of Health and Human Services (DHHS), Office of Community Services, 2022. Low Income Home Energy Assistance Program.

[34] U.S. DHHS, LIHEAP Clearinghouse, 2022. LIHEAP Program Components.

[35] U.S. DHHS, Office of Community Services, 2022. LIHEAP Fact Sheet FY2022.

[36] U.S. DHHS, LIHEAP Clearinghouse, 2022. LIHEAP Funds by Program Component.

[37] U.S. HUD, Office of Policy Development and Research, 2022. Low-Income Housing Tax Credit (LIHTC).

[38] Wasser, 2021. *Deep Dive: How State LIHTC Programs Reference Third-Party Green Building Programs*.

[39] Virginia Center for Housing Research, 2017. Sustaining Energy Efficiency: Longitudinal Evidence of Virginia's Low-Income Housing Tax Credit Properties.

In 2021 the U.S. Congress passed the Infrastructure Investment and Jobs Act, also known as the "Bipartisan Infrastructure Law" (BIL). The BIL is intended to support various aspects of American infrastructure, such as rebuilding roads, bridges, and rails, expanding access to clean drinking water, ensuring high-speed internet access, tackling the climate crisis, advancing environmental justice, and investing in communities.[40] The BIL also supports low-income residential energy efficiency by including $3.5 billion in additional WAP funds.[41] This will provide a one-time investment of $65.59 million for Virginia, on top of the state's regularly allocated WAP funding.[42] The BIL makes another $550 million available for energy efficiency and clean energy projects through the Energy Efficiency and Conservation Block Grant Program.[43] In recent years Virginia has used these block grant funds for projects such as audits and improvements to public buildings, energy efficiency training for localities,[44] and building energy code trainings,[45] none of which is specifically targeted to low-income households.

In 2022, Congress passed the Inflation Reduction Act (IRA),[46] which included billions of dollars in grant and loan programs, as well as a variety of new and modified tax incentives, to support investments in clean energy technology and address the climate change crisis. The IRA extends tax credits for residential energy efficiency projects with a total of $8.6 billion split between the Home Energy Performance-Based Whole-House Rebate program and the High-Efficiency Electricity Home Rebate Program.[47] However, these programs are generally not applicable to low-income households, as they still require some up-front investment in order to receive the applicable tax credits and rebates. Furthermore, low-income homeowners that do not have an income tax liability cannot access these credits.[48] There is a provision that allows local governments and non-profits to receive these tax credits in rebate form, but this option cannot be used by individual households.[49]

### *1.2.2 Virginia Energy Efficiency Programs*

A variety of state, local and utility-sponsored energy-efficiency programs are available in Virginia, offering customers tax credits, subsidies, and rebates for installing and using energy-efficient appliances and products. These programs are available to the general public, and help to reduce energy use and carbon emissions, but without addressing energy burdens for low-income households. For example, the Virginia Department of Taxation created a financial incentive program for residential properties called

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[40] The White House, Briefing Room Statement, 2021. Fact Sheet: The Bipartisan Infrastructure Deal.

[41] Bertrand, Environmental and Energy Study Institute, 2022. How the Inflation Reduction Act and the Bipartisan Infrastructure Law Work Together to Advance Climate Action.

[42] Warner, M. 2022. Warner & Kaine Announce More than $65 Million in Federal Funding to Make Virginia Homes More Energy Efficient and Lower Utility Costs.

[43] Bertrand, Environmental and Energy Study Institute, 2022. How the Inflation Reduction Act and the Bipartisan Infrastructure Law Work Together to Advance Climate Action.

[44] Central Shenandoah Planning District Commission. Energy.

[45] Southeast Energy Efficiency Alliance. Regional Investments: Southeast Energy Efficiency Fund.

[46] Committee for a Responsible Federal Budget, 2022. *What is the Inflation Reduction Act*.

[47] The White House, 2022. Clean Energy Innovation and Implementation. Building A Clean Energy Economy: A Guidebook to the Inflation Reduction Act's Investment in Clean Energy and Climate Action.

[48] Utility Dive, 2022. *The Inflation Reduction Act leaves low-income homeowners out of the clean energy transition. Or does it?*

[49] Clean Energy Group, 2022. *CEG Comments on Direct Pay Option within the Inflation Reduction Act*.

the Income Tax Reduction for Energy-Efficient Products program.[50] Taxpayers may deduct from their taxable personal income an amount equal to 20% of the sales taxes paid for certain equipment, capped at $500. Another state financial incentive is the Property Tax Assessment for Energy Efficient Buildings. This program allows local jurisdictions to assess the property taxes of energy efficient buildings at a reduced rate, by considering them as a separate class of property for local taxation purposes. Localities that have enacted this ordinance include Charlottesville and Virginia Beach.[51]

Another existing program is the State Energy Program (SEP). The SEP is a federal program that provides funding and technical assistance for states to administer energy efficiency and renewable energy programs.[52] From 2015 to the present, Virginia has received $9.4 million from SEP, for an average of $1.34 million/ year. Virginia uses these funds for a few programs, only one of which, the Commercial-Property Assessed Clean Energy (C-PACE) programs, can be accessed by residential property owners.[53] Virginia's C-PACE program can be used by owners of commercial and 5+-unit multi-family buildings to cover the up-front cost of energy efficiency and clean energy projects. The cost is then paid back through annual property tax increases. These programs are not currently available for homeowners, and there are no income eligibility requirements.[54] While C-PACE programs have been enabled in 18 Virginia localities,[55] it has not been widely used, and has mostly remained within the commercial sector.[56]

Before the Virginia Clean Economy Act (VCEA) was passed in 2020, utility companies had some limited energy efficiency programs for low-income customers. For example, Dominion Energy has run its EnergyShare program for 40 years, which currently provides about $6.5 million per year in bill assistance and $6 million in weatherization for vulnerable customers.[57] Appalachian Power Company (APCO) launched a low-income weatherization program in 2014 that supplemented existing state and federal weatherization programs,[58] for which they were able to recover the costs through their base rate.[59]

Some of Virginia's natural gas utilities also offer small low-income energy efficiency programs. For example, Washington Gas and Columbia Gas of Virginia both operate programs in partnership with Community Housing Partners, which together offer about $1.5 million in upgrades per year.[60]

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[50] Database of State Incentives for Renewables and Efficiency, 2020. Income Tax Deduction for Energy-Efficiency Products, North Carolina Clean Energy Technology Center and North Carolina State University

[51] Database of State Incentives for Renewables and Efficiency, 2020. Local Option – Property Tax Assessment for Energy Efficient Buildings, North Carolina Clean Energy Technology Center and North Carolina State University.

[52] U.S. DOE, EERE, 2020. State Energy Program National Evaluation

[53] U.S. DOE, EERE, 2022. Weatherization and Intergovernmental Programs Office Project Map-Virginia

[54] Virginia Energy. PACE

[55] Virginia Energy Efficiency Council, 2022. C-PACE.

[56] Energy News Network, 2021. Virginia finally has its first C-PACE success story, a decade after initial law.

[57] Dominion Energy, 2021-22. EnergyShare Annual Report.

[58] Appalachian Power, 2015. Appalachian Power Launches Two Programs to Help Virginia residential customers use energy more efficiently.

[59] Virginia State Corporation Commission, 2018. Petition of Appalachian Power Company for approval to extend two existing demand-side management programs; Final Order.

[60] Community Housing Partners, 2023. Personal communication from Chase Counts, Senior Director of Operations, Energy Solutions. (January 12, 2023).

In 2018, the passage of the Grid Transformation and Security Act (GTSA) required the state's two primary investor-owned electric utilities propose just over $1 billion in customer energy efficiency programs over the next decade – $870 million for Dominion and $140 million for APCO – including any previously approved energy efficiency programs existing at the time. It did not include specific energy savings goals or require the State Corporation Commission (SCC) to approve the proposed programs.[61]

In 2020, the Virginia Clean Economy Act (VCEA) was signed into law. This legislation is designed to create a 100% carbon-free electricity grid and end in-state fossil fuel generation in Virginia by the year 2050, in addition to creating thousands of new instate jobs in renewable energy and keeping bills low with ratepayer protections and energy efficiency investments.[62] The VCEA includes a specific program that caps monthly bills for low-income Virginians to help alleviate the energy burden of rising costs.[63]

The passage of the VCEA also set mandatory Energy Efficiency Resource Standards for investor-owned electric utilities, which must be met through energy efficiency programs for customers. These standards set a mandatory target of 5% energy reduction for Dominion by 2025, while APCO's reduction target is 2%. After 2025, the SCC is directed to set these targets every three years. They are enforceable because approval of new fossil fuel plants is contingent on evidence of reaching these targets. Dominion and APCO are able to recover the cost of energy efficiency programs though their customers.

The VCEA also increased the percentage of the utilities required energy efficiency spending that must go to LMI households from 5 to 15%.[64] As noted above, the GTSA required the state's investor-owned utilities to spend a combined $1.01 Billion over 10 years, thus about $15 million per year must go to LMI programs. According to the SCC's annual report on energy efficiency programs pursuant to the VCEA, Dominion's Income and Age Qualifying Home Improvement program will spend around $27 million over seven years. They report that this will result in 9,588 Megawatt-hours (MWh) of annual electricity savings. This same report indicates that APCo's low-income single and multi-family programs will result in a net electricity savings of 1,460 MWh per year.[65]

In 2020, the Virginia General Assembly passed the Clean Energy and Community Flood Preparedness Act (HB 981 / SB 1027), which directed the Department of Environmental Quality to develop regulations for entering Virginia into the Regional Greenhouse Gas Initiative (RGGI). The legislation requires that 50% of Virginia's revenue from RGGI "shall be credited to an account administered by [the Department of Housing and Community Development (DHCD)] to support low-income energy efficiency programs," while 45% shall be used for "assisting localities and their residents affected by recurrent flooding, sea level rise, and flooding from severe weather events," with the last 5% going to administrative costs.[66]

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[61] Virginia Legislative Information System, 2018. VIRGINIA ACTS OF ASSEMBLY -- 2018 SESSION.

[62] Chesapeake Climate Action Network, 2020. The Virginia Clean Economy Act (HB1526 and SB851): Putting Virginia on the Path to 100% Clean Electricity.

[63] Chesapeake Climate Action Network, 2020. The Virginia Clean Economy Act SB 851.

[64] American Council for an Energy-Efficient Economy, 2022. State and Local Policy Database: Virginia.

[65] Virginia State Corporation Commission, 2022. Combined Report on Energy Efficiency Programs and Feasibility of Achieving Energy Efficiency Goals.

[66] Virginia Legislative Information System, 2020. HB 981 Clean Energy and Community Flood Preparedness Act.

## 2. The Regional Greenhouse Gas Initiative (RGGI) and Energy Efficiency for Virginia

The Regional Greenhouse Gas Initiative (RGGI) is an agreement between eleven eastern U.S. states to lower greenhouse gas emissions from power plants by establishing a regional cap on carbon dioxide ($CO_2$) emissions. To enforce the cap, power plants in participating states must purchase allowances to cover their carbon emissions. Each allowance permits the emission of 1 short ton of $CO_2$. Participating states receive a set number of allowances based on their share of regional emissions, with the total cap going down each year. Participating states sell $CO_2$ allowances quarterly at auctions, organized and regulated by RGGI member states and an independent market monitor. To ensure stability in the market for allowances, there is a minimum reserve price, as well as minimum and maximum prices that will trigger either the removal of allowances or the release of reserve allowances.[67]

So far, Virginia has brought in $524 million in revenue from eight quarterly RGGI auctions, which would have translated into $262 million in low-income energy-efficiency funding via the DHCD's Housing Innovations in Energy Efficiency program (HIEE).[68] However, in 2022 the General Assembly diverted $11.4 million from HIEE to support the town of Hurley, VA, which had experienced a major flooding event in 2021.[69] This results in a final total of $252 million allocated to the HIEE program thus far, as shown in Table 1 and Figure 3 below.

**Table 1. RGGI Revenue and HIEE Allocations for FYs '21-23**

| Fiscal Year | Auctions | RGGI Revenue ($Millions) | HIEE Allocation ($Millions) [a] |
|---|---|---|---|
| 2021 | 51 | $43.59 | $21.79 |
| 2022[b] | 52, 53, 54, 55 | $258.27 | $117.73[c] |
| 2023 | 56, 57, 58 | $224.6 | $112.3 |
| Totals | | $526.5 | $251.8 |

*Source: RGGI, 2022. Cumulative Allowances and Proceeds-Virginia. Additional calculations by authors.*

a. HIEE *revenue is equal to half of the total RGGI auction results for Virginia for each fiscal year*

b. *While Auction 52 took place in June 2021 (i.e., FY '21) and Auction 56 occurred June 2022 (FY '22), the resulting funds were allocated to the DHCD FY '22 and FY '23 budgets, respectively.*[70, 71]

c. *The total shown here for the FY 2022 HIEE allocation includes 50% of that year's RGGI revenue ($129.1 million), minus the $11.4 million diverted to the Hurley Flood Relief fund.*

[67] The Regional Greenhouse Gas Initiative, 2021. RGGI 101 Fact Sheet.

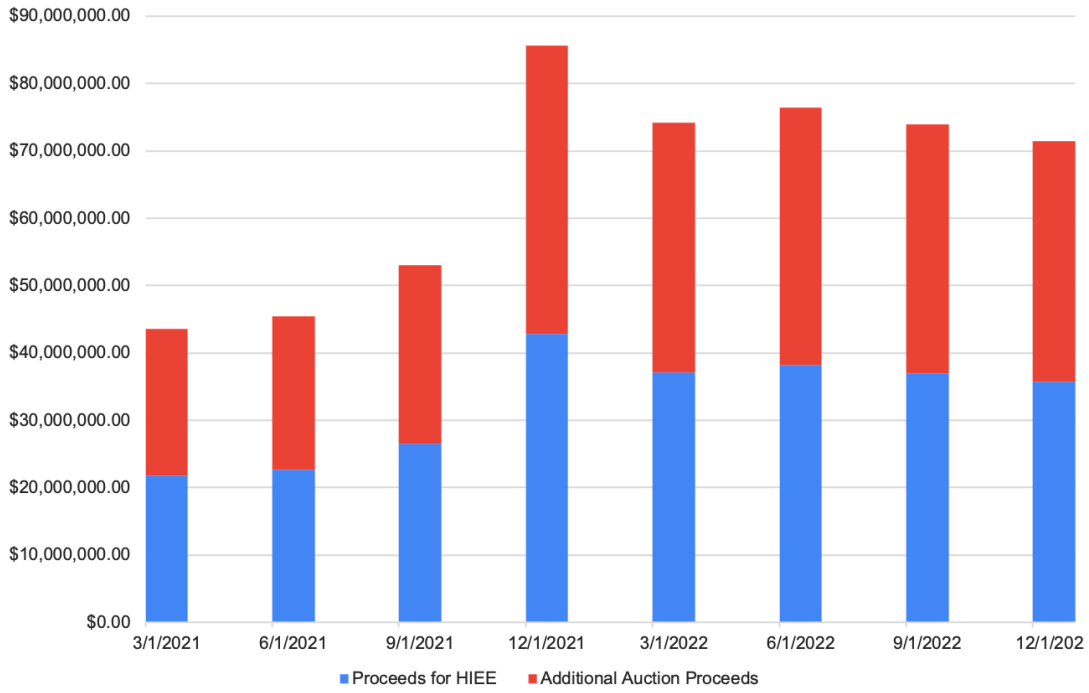
[68] The Regional Greenhouse Gas Initiative, 2022. *Cumulative Allowances and Proceeds-Virginia*.

[69] Moomaw, G. and Vogelsong, S., 2022. *After months of wrangling, Virginia has a budget deal. What's in it?*

[70] Virginia Department of Housing and Community Development (DHCD), 2021. Housing Innovations in Energy Efficiency (HIEE) Program: Fifth Stakeholder Advisory Group and Public Meeting (presentation slides).

[71] Virginia DHCD, 2021. *Housing Innovations in Energy Efficiency (HIEE) Program: Ninth Stakeholder Advisory Group and Public Meeting* (presentation slides).

**Figure 3. Quarterly RGGI Auction Revenue for Virginia, March 2021 – December 2022**




*Source: RGGI, 2022. Cumulative Allowances and Proceeds-Virginia. Additional calculations by authors.*

## 2.1. The Housing Innovations in Energy Efficiency (HIEE) Program

Upon passage of the Clean Energy and Community Flood Preparedness Act, the DHCD formed the HIEE program as the entity to manage and distribute the low-income energy efficiency funds generated by Virginia's participation in the RGGI program. The DHCD formed a 15-member Stakeholder Advisory Group, comprised of "advocacy groups, affordable housing developers, housing development authorities, weatherization agencies and building energy consultants" to provide expertise on the affordable housing market, "achieve broad agreement on key program components," and help the agency "connect with community and thought leaders on strategic investments of Regional Greenhouse Gas Initiative (RGGI) funds.[72]

A presentation from the first stakeholder meeting listed the following objectives for the RGGI funds:

- Deep energy retrofits (exceeding energy code requirements) that complement existing affordable housing construction and rehabilitation incentives, to ensure lowest income population benefits from long-term cost savings;
- Incorporate innovative approaches that will overcome traditional barriers to building and retrofitting affordable housing at scale;

[72] Virginia DHCD, 2020. Housing Innovations in Energy Efficiency (HIEE) Program: First Stakeholder Advisory Group and Public Meeting (presentation slides).

- Prioritize long-term sustainability / durability and occupant health (e.g. preventing moisture issues, improving ventilation) along with energy efficiency upgrades[73]

The HIEE Stakeholder Advisory Group met at least nine times between Dec. 2020 and Dec. 2021. By the fourth meeting, in Feb. 2021, the DHCD had decided to divide the HIEE funds across the Affordable and Special Needs Housing (ASNH), Weatherization Deferral Repair (WDR), and Housing Innovations Partnership (HIP) grants programs, according to the percentages indicated in Table 2.

**Table 2. RGGI Revenue and HIEE Allocations for FYs '21-23**

| Fiscal Year | ASNH | WDR | HIP |
|---|---|---|---|
| FY '21 | 40% | 60% | 0% |
| FY '22 | 60% | 30% | 10% |

*Source: Virginia Department of Housing and Community Development, 2021. Housing Innovations in Energy Efficiency (HIEE) Program: Fourth Stakeholder Advisory Group and Public Meeting (presentation slides).*

The RGGI auctions have generated over $250 million in funding for HIEE, as shown in Table 1, approximately $117 million of which has been spent or committed to energy efficiency projects thus far:

- In July, 2021, the DHCD announced the release of over $21 million in ASNH funds (from various sources) to support 24 low-income multi-family housing projects across Virginia. This included $6.2 million in HIEE funds, which was divided among 11 projects with a total of 707 units.[74]
- In January, 2022, the DHCD announced the release of an additional $60 million in ASNH funds. This included $22.96 million from HIEE, divided among 25 projects with a total of 1,682 units.[75]
- In an October 2022 webinar, DHCD staff stated that approximately $80 million in HIEE funding would be available for Affordable and Special Needs Housing projects (ASNH) during FY '23.[76]
- According to a December, 2022 update from DHCD, the WDR program has committed $7.92 million thus-far, including funds spent and the estimated costs of pre-approved projects. The current total of 558 projects (306 completed, and 252 pre-approved) includes 544 single family projects and 507 multi-family units across 14 projects, for a total of 1,051 units.[77]
- No HIEE funds appear have been spent to-date via the HIP program.

[73] Virginia DHCD, 2020. Housing Innovations in Energy Efficiency (HIEE) Program: First Stakeholder Advisory Group and Public Meeting (presentation slides).

[74] Virginia DHCD, 2022. *Governor Northam Announces Over $21 Million in Affordable and Special Needs Housing Loans*.

[75] Virginia DHCD, 2022. *Governor Northam Announces Over $60 Million in Affordable and Special Needs Housing Loans*.

[76] Virginia DHCD, 2022. *Affordable and Special Needs Housing-ASHN-How to Apply*. Minute 20:00. [Webinar].

[77] Virginia DHCD, 2022. Personal communication from Aaron Shoemaker, Program Administrator, Energy Efficiency Office. (December 8, 2022).

## 2.2. The Affordable and Special Needs Housing (ASNH) Program

The ASNH program combines funds from a variety of sources, including HIEE, to "expand the supply of decent, safe, sanitary, and affordable housing available to low-income, very low-income, and extremely-low income Virginians." Eligible projects fall into one of three categories – new construction, substantial rehabilitation, or adaptive reuse – and must include a minimum of five units of housing. The HIEE funding dedicated to the ASNH program is intended to "assist affordable housing project development teams in completing energy efficiency upgrades that would not have been feasible otherwise," and which meet certain energy performance requirements indicated in Table 3 below. Additional HIEE energy efficiency requirements include green building certification, fresh air ventilation, dehumidification, and duct leakage testing and sealing, among others stipulations.[78]

**Table 3. Energy Efficiency Requirements for HIEE Funds Included in ASNH Program**

| Project Type | VA Housing LIHTC Requirement | HIEE Requirement |
|---|---|---|
| New Construction | ENERGY STAR v3.0 | Zero Energy Ready Homes (ZERH) |
| Substantial Rehab | 30% improvement in HERS index [a] or HERS index 80 (or below) | 40% improvement in HERS index or avg. of HERS 70 (or below) across all units |
| Adaptive Reuse | HERS index 95 (or below) | Average HERS index of 80 or below across all units |

*Source: Virginia Department of Housing and Community Development, 2021. Housing Innovations in Energy Efficiency (HIEE) Program: Seventh Stakeholder Advisory Group and Public Meeting (presentation slides.*

*a. The Home Energy Rating System (HERS) Index is a standard metric for home energy efficiency. A score of 100 represents baseline standard energy efficiency for a given unit type, and lower scores represent increasing efficiency. A HERS index 80 indicates that a housing unit is 20% more efficient than the baseline reference unit.*[79]

Individual ANSH projects that meet the HIEE performance requirements are eligible for HIEE awards of up to $2 million, or 10% of the total project construction costs, whichever is less.[80] To avoid confusion, the HIEE funds dedicated to the ASNH program are hereafter referred to as "ASNH-Energy Efficiency" funds (ASNH-EE) in this report. As indicated above, the DHCD has announced over $29 million in ASNH-EE funds, supporting 2,389 total units,[81, 82] with an additional $80 million available for FY '23.[83]

[78] Virginia DHCD, 2022. Affordable and Special Needs Housing Competitive Application Program Guidelines FY 2023 (presentation slides).

[79] RESNET, 2022. What is the HERS Index?

[80] Virginia DHCD, 2022. Affordable and Special Needs Housing Competitive Application Program Guidelines FY 2023 (presentation slides).

[81] Virginia DHCD, 2022. *Governor Northam Announces Over $21 Million in Affordable and Special Needs Housing Loans.*

[82] Virginia DHCD, 2022. *Governor Northam Announces Over $60 Million in Affordable and Special Needs Housing Loans.*

[83] Virginia DHCD, 2022. Affordable and Special Needs Housing Competitive Application Program Guidelines FY 2023 (presentation slides).

## 2.3. The Weatherization Assistance (WAP) and Weatherization Deferral Repair (WDR) Programs

The WDR program is funded exclusively by HIEE, and supports repairs to housing units (single-family homes or multi-family buildings) that are in such poor condition as to have been deemed unsuitable for weatherization, and have thus been "deferred" from the U.S. federal government's Weatherization Assistance Program (WAP).[84] In Virginia, DHCD administers this program in partnership with WAP providers throughout the state. Virginia receives funds from WAP each year to realize specific weatherization projects through the state's weatherization providers.

Nationally, about 1 in 5 households that apply for the WAP program have to be rejected because the homes are in such poor condition that they are not deemed eligible for weatherization. In Virginia, weatherization providers had to defer services to 525 out of 2,901 applicants (25%) in 2018. As the weatherization program grows, the anticipated number of deferrals in Virginia increases to 1,500 per year.[85] The WDR program bridges this gap by investing in repairs needed to bring otherwise ineligible households out of deferral.[86]

A review of the annual "State Plans" that DHCD submits to the U.S. Department of Energy indicates that Virginia received approximately $22.62 million in WAP funding from 20018-2022, of which $15.61 million was spent on program operations (i.e., spent directly on weatherization projects). This resulted in the weatherization of over 2,300 homes (average of around $6,700 per unit), as shown in Table 4 (note that these plans do not distinguish between single-family and multi-family units).[87]

A report from the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy provides slightly different numbers for weatherization in Virginia. According to that data, the state received $36.4 million in WAP funding from 2015-2022, and has weatherized 6,628 homes in that time period (an average of 828.5 homes per year at less than $5,500 per unit). The same source also indicates that Virginia weatherized an average of 707 homes per year from 2010-2021.[88]

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[84] Virginia DHCD, 2022. Affordable and Special Needs Housing Competitive Application Program Guidelines FY 2023 (presentation slides).

[85] Counts, C., 2020. Utilizing Virginia RGGI Revenue to Support Existing Low-Income Energy Efficiency Programs.

[86] Virginia DHCD, 2021. *Virginia Weatherization Deferral Repair Program Guidelines: 2021-2022.*

[87] Virginia DHCD, 2022. Weatherization Assistance Program (WAP). Data pulled from links for DOE State Plans, 2018-2022.

[88] U.S. DOE, EERE, 2022. Weatherization and Intergovernmental Programs Office Project Map – Virginia.

**Table 4. Annual WAP Allocations for Virginia Weatherization Projects**

| Calendar Year | Total WAP Funding ($Millions) | Program Operations ($Millions) | Total Dwelling Units Weatherized | Average Cost per Dwelling Unit [a] |
|---|---|---|---|---|
| 2018 | $3.14 [b] | $2.34 | 325 | $7,212 |
| 2019 | $4.74 | $2.84 | 377 | $7,526 |
| 2020 | $6.28 | $3.69 | 490 | $7,531 |
| 2021 | $6.44 | $3.85 | 649 | $5,938 |
| 2022[c] | $5.16 | $2.89 | 488 | $5,932 |
| Totals | $22.62 | $15.61 | 2,329 | $6,702 |

*Source: Virginia Department of Housing and Community Development, 2022. Weatherization Assistance Program (WAP). Data pulled from links for DOE State Plans, 2018-2022.*

[a] *Totals in this column do not exactly match results from dividing Program Operations / Total Dwelling Units Weatherized columns, due to rounding of Program Operations totals.*

[b] *The 2018 plan only included funding totals for subgrantee awards. All other years also included overhead totals.*

[c] *The 2022 DOE State Plan is still listed as a "draft" on DHCD's website as of 12/12/22.*

The passage of the federal Infrastructure Investment and Jobs Act (H.R.3684) in November 2021, commonly known as the Bipartisan Infrastructure Law (BIL), includes $3.5 billion for the WAP program. This will provide $65.59 million for Virginia WAP,[89] which is in addition to the regular WAP annual grants and is available until expended.[90] The DHCD's draft application for these funds indicates that $38.5 million of those funds would go to program operations, resulting in the weatherization of 4,808 units of housing at an average of around $8,000 per unit weatherized.[91]

Assuming that Virginia's regular annual WAP awards continue to fund about 465 units per year (the average from 2018-2022 per Table 4), that would add up to about 3,720 units weatherized from 2023 through 2030. If the additional BIL funds were distributed over that same period of time, those projected additional 4,808 units would bring the total to over 8,500 units, or about 1,065 per year.

[89] Warner, M. 2022. Warner & Kaine Announce More than $65 Million in Federal Funding to Make Virginia Homes More Energy Efficient and Lower Utility Costs.

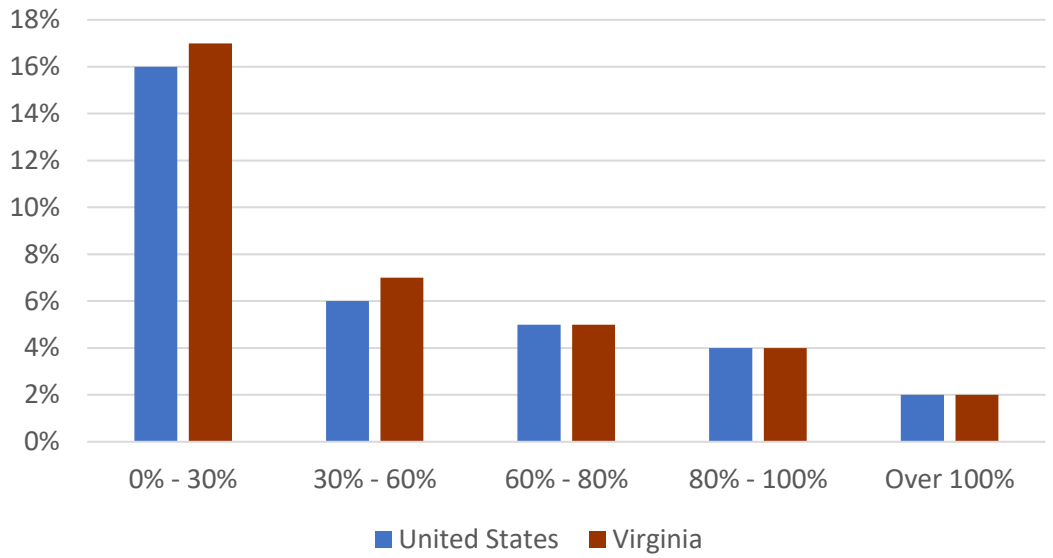
[90] U.S. DOE, 2022. Weatherization Program Notice BIL 22-1.

[91] Virginia DHCD, 2022. Weatherization Assistance Program (WAP). DRAFT BIL WAP 2022-2027 State Plan.

## 3. Analysis of Energy Burden in Virginia

As discussed earlier in this report, the U.S. Department of Energy's (DOE) Low-Income Energy Affordability Data (LEAD) Tool demonstrates how low-income households spend significantly greater percentages of their income on household energy costs (heating, cooling, etc.). This is particularly true of extremely-low-income households, i.e., those household incomes between 0-30% of the Area Median Income (AMI), whose average energy burden of 16% is eight times higher than that of households with an income above 80% AMI. Average energy burdens for Virginia households generally match those national averages across AMI income groups, as shown in Figure 4 below.[92]

**Figure 4. Average Energy Burden by Household Income, Virginia vs. United States**




*Source: U.S. DOE, EERE, 2022. Low-Income Energy Affordability Data Tool. Analysis by authors.*

Using the Federal Poverty Level (FPL) as the income metric, rather than AMI, produces somewhat different results. The FPL is a standardized metric that applies equally across the contiguous United States, based on family size (e.g., $27,750 for a family of four).[93] The AMI is calculated at the regional level, and can vary widely. In Virginia, the 30% AMI threshold for a family of 4 is $42,700 in the Washington-Arlington-Alexandria region, but is less than half of that amount in many other regions of the state (e.g., $21,350 in King and Queen County).[94]

The average energy burden for Virginia households with incomes below the FPL is 21%, compared to 18% nationwide. Virginia's average energy burdens are also slightly above the national average (8% vs. 7%) for households with incomes between 100-200% of FPL.[95]

[92] U.S. DOE, EERE, 2022. Low-Income Energy Affordability Data Tool. Analysis by authors.

[93] U.S. DHHS, 2022. Poverty Guidelines.

[94] U.S. HUD, 2022. 2022 Adjusted Home Income Limits: Virginia.

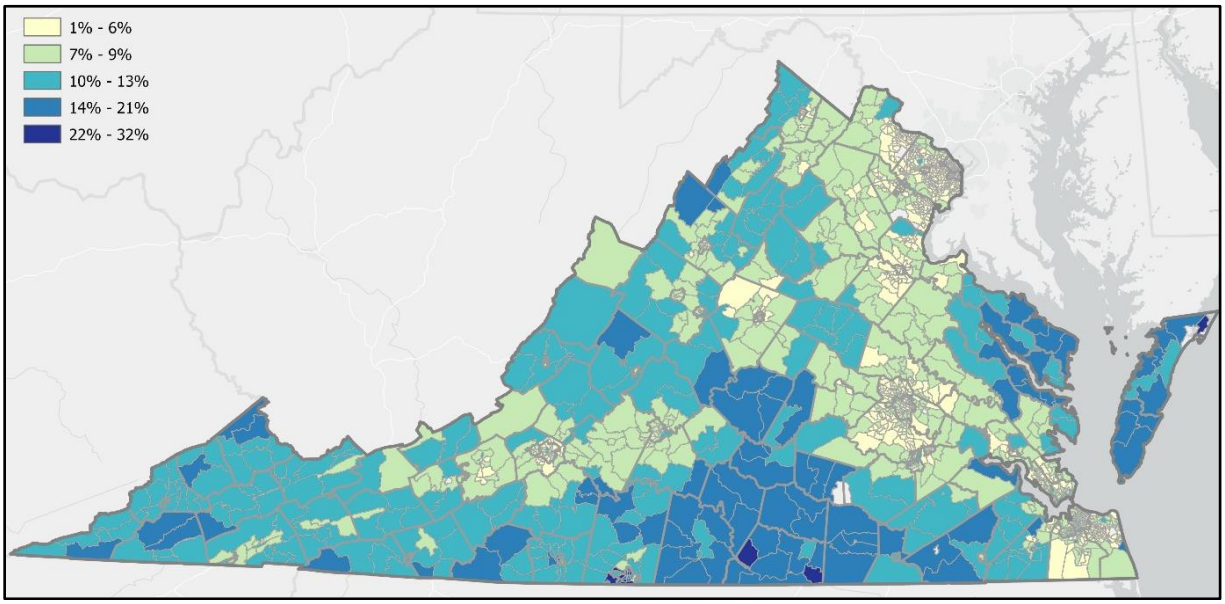
[95] U.S. DOE, EERE, 2022. Low-Income Energy Affordability Data Tool. Analysis by authors.

## 3.1. Regional Comparison of Average Low-Income Energy Burdens Across Virginia

Comparing Virginia's energy burdens to the national average obscures the substantial disparities that exist within the state. To evaluate these regional disparities, we conducted additional analysis using raw data from the LEAD tool, which incorporates the US Census Bureau's 2018 American Community Survey (ACS) Public Use Microdata Samples (PUMS),[96] and the US Census TIGER/Line Geodatabases.[97] More details on these data sources and our methodology can be found in Appendix A.

Through this process we calculated the average energy burden for low-income households (incomes below 80% AMI), for every Census tract in Virginia, as shown in Map 1 below. Hereafter we refer to the average energy burden for low-income households in a given Census tract using the acronym AEB-LI.

**Map 1. Average Energy Burden of Low-Income Households by Census Tract (2018)**




*Source: Low-Income Energy Affordability Data (LEAD), US Department of Energy*

Map 1 demonstrates that low-income households face High (above 6%) to Severe (above 10%) average energy burdens throughout much of the state. Every Census Tract shaded in any color but light yellow has an AEB-LI of at least 7%. Much of the state's rural areas have an AEB-LI of 10% and above, including nearly all of Southwest Virginia, Southside Virginia, the Northern Neck, and the Eastern Shore.

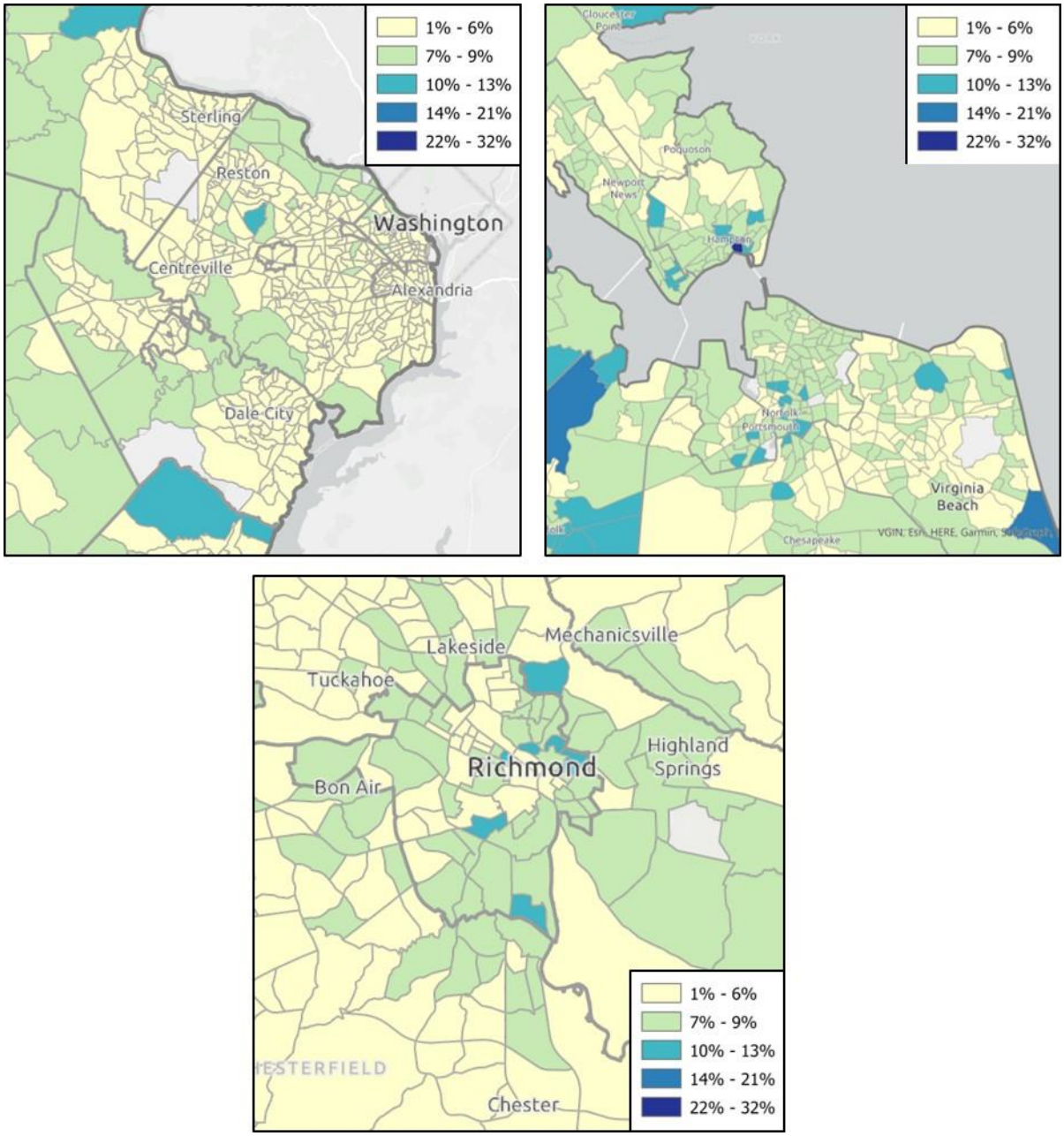
A detailed look at the LEAD data demonstrates that there are 76 Census Tracts in Virginia with an AEB-LI of at least 15%, more than twice the national average of 7% for households in that same income bracket. Of those, twelve are located in the Danville area. The other localities with at least six such Census Tracts are Mecklenburg County (8), Halifax County (7), and Accomack County (6). There are also 15 Census Tracts in Virginia that have an AEB-LI above 22%. This is over three times the national average energy burden for households in that same income bracket. (See detailed list in Appendix B).

[96] U.S. Census Bureau, 2022. Public Use Microdata Sample (PUMS).

[97] U.S. Census Bureau, 2022. TIGER/Line Geodatabases.

Map 1 suggests that AEB-LI percentages are relatively low in the state's metropolitan regions, compared to many rural areas. While this is generally accurate, Map 1.A shows that zooming into those regions reveals pockets of higher AEB-LI throughout each of those regions, particularly in parts of Hampton, Newport News, Norfolk, Portsmouth, and Richmond.

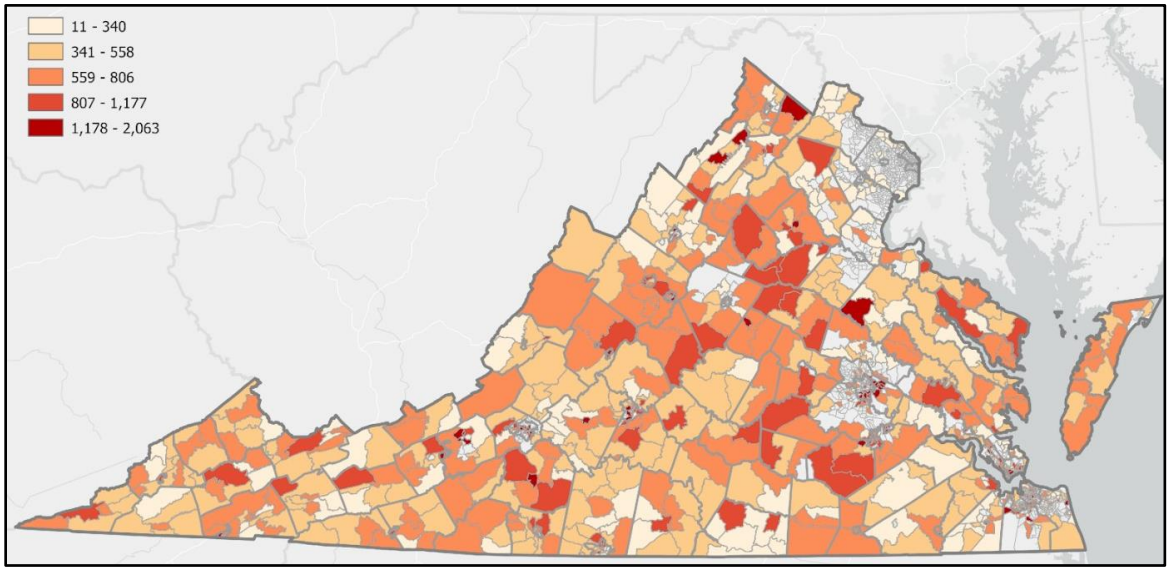
**Map 1.A. Average Energy Burden of Low-Income Households (2018) – Metro Regions**



We then identified the Census tracts in which the AEB-LI is above 6%, and those above 10%, to reflect the standard definitions of "High" energy burden and "Severe" energy burden, respectively. Within these AEB-LI High energy burden and AEB-LI Severe energy burden Census tracts we then calculated the total housing units, single-family homes (SFH) and multi-family housing units (MFH).

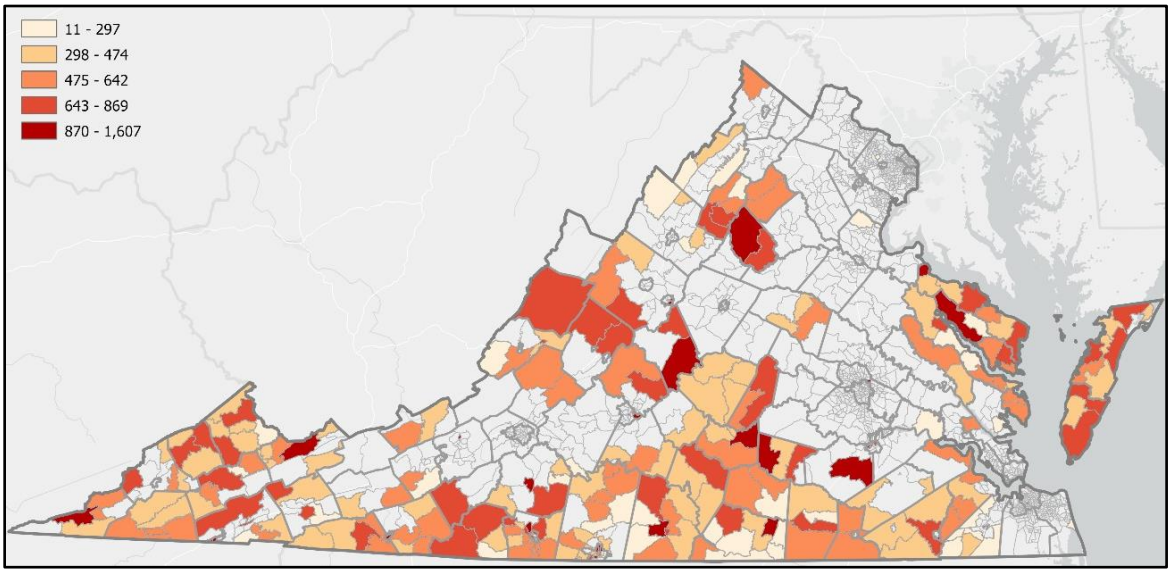
Maps 2 and 3 below show the number of housing units within Virginia Census tracts that have High or Severe average energy burdens, respectively, among their low-income households (0 - 80% AMI). Similar maps focused on single-family homes and multi-family units can be found in Appendix C.

**Map 2. Housing Units in Census Tracts with High Low-Income Energy Burden (2018)**




*Source: Low-Income Energy Affordability Data (LEAD), US Department of Energy*

**Map 3. Housing Units in Census Tracts with Severe Low-Income Energy Burden (2018)**

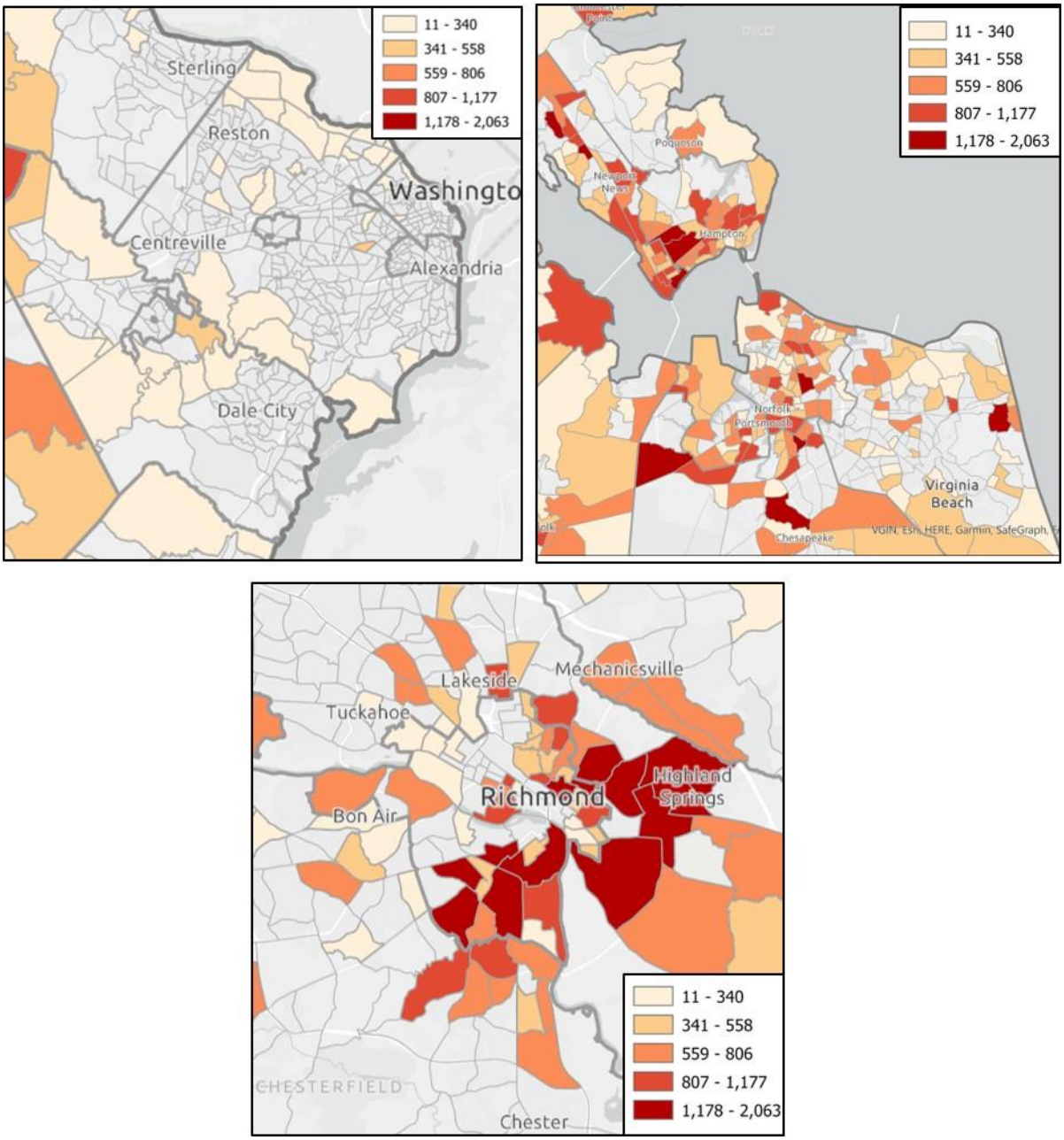



*Source: Low-Income Energy Affordability Data (LEAD), US Department of Energy*

Maps 2 and 3 demonstrate concentrations of High AEB-LI housing units in many rural areas of Virginia, similar to Map 1, along with pockets of Severe AEB-LI throughout much of the state. Many of these Severe AEB-LI tracts are found in SW Virginia, Southside Virginia, the Northern Neck, and the Eastern Shore, again consistent with Map 1. Map 2 also shows concentrations of households in High AEB-LI Census Tracts in some exurban areas outside of the Northern Virginia and Richmond metro regions.

Maps 2.A and 3.A identify housing units in High and Severe AEB-LI areas of the state's metro regions.

**Map 2.A. Housing Units in Tracts with High Low-Income Energy Burden – Urban Regions**

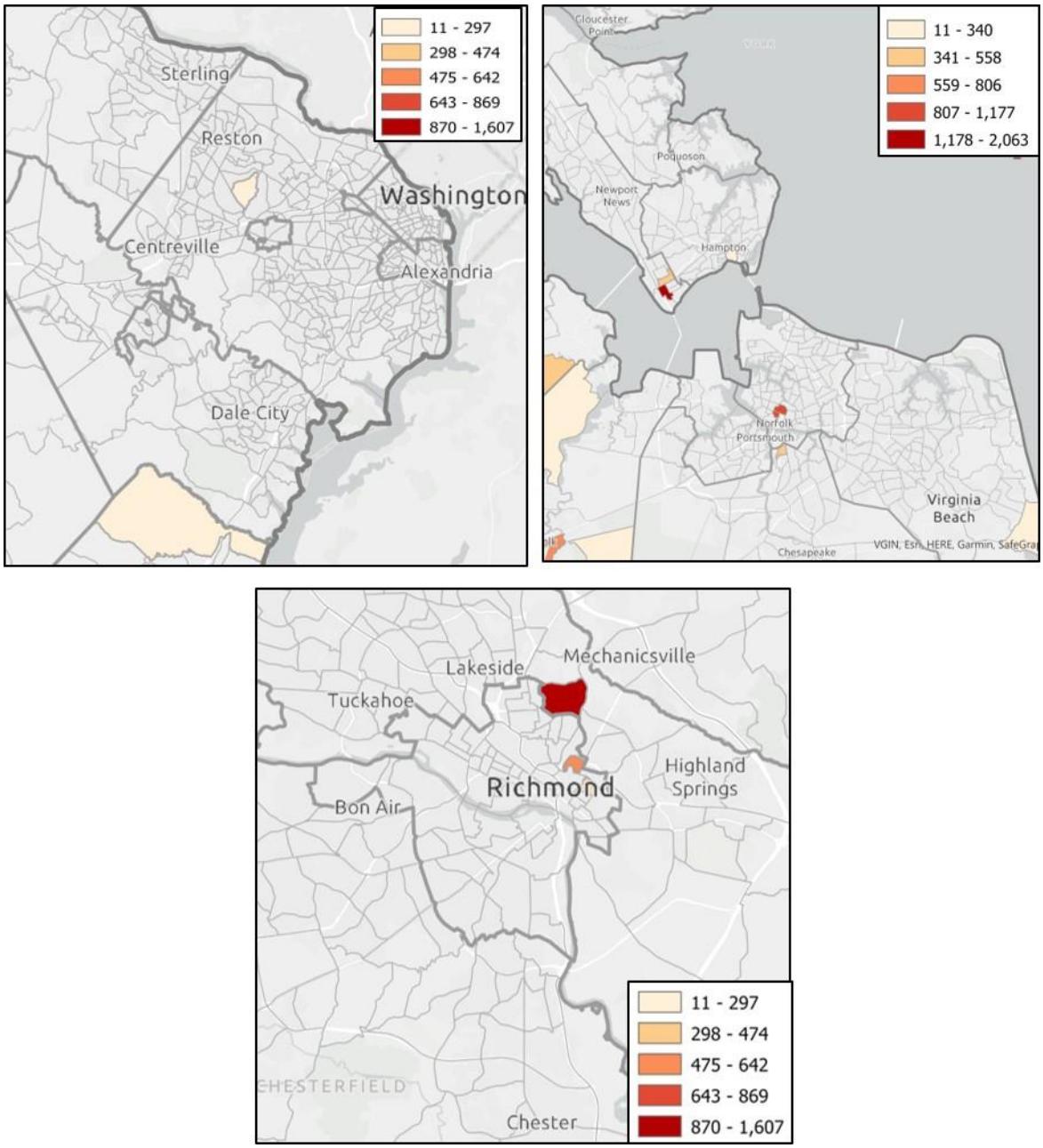



Map 2.A. shows significant concentrations of housing units in High AEB-LI Census Tracts in both the Hampton Roads and Richmond regions, but very little in the Northern Virginia region. In Hampton Roads

this includes large parts of the cities of Hampton, Newport News, Norfolk, and Portsmouth, among other parts of the region. In the Richmond area this includes much of the city's Southside, Northside, and East End areas, as well as portions of eastern Henrico County and northern Chesterfield County.

While the urbanized portions of the Hampton Roads and Richmond regions have large areas with High AEB-LI, Map 3.A. shows that very few of the Census Tracts in those regions have Severe AEB-LI.

**Map 3.A. Housing Units in Tracts with Severe Low-Income Energy Burden (2018)**



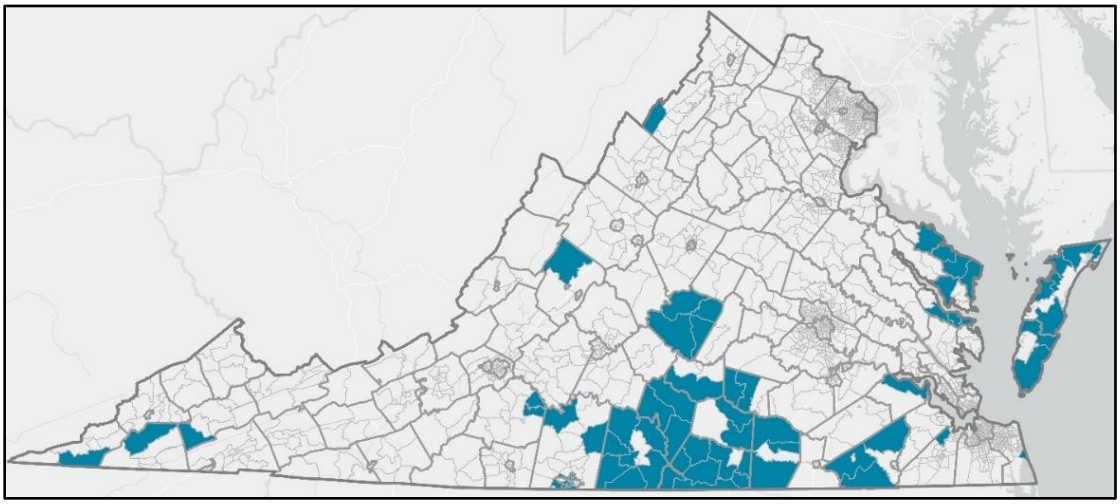
## 3.2. Discussion of Low-Income Energy Burden Findings

The housing data represented in Maps 2 and 3 shows that there are approximately 579,000 households in Virginia that have low-incomes (below 80% AMI) and are located in Census tracts with a High average low-income energy burden (above 6%). This includes roughly 436,000 single-family units and 143,000 multi-family units. Of these, about 154,000 total low-income housing households are located in Census tracts with a Severe average low-income energy burden (above 10%). This includes about 129,000 single-family units and 25,000 multi-family units. (Please note that the single-family plus multi-family units do not add up to the exact total units, due to rounding within the underlying data). For comparison, Census data estimates that there are about 3.25 million households in Virginia as of 2019.[98]

It is important to clarify that the household totals in the preceding paragraph do not represent an estimate of the total households that are actually both low-income and High or Severe energy burdened. Rather, they are low-income households located in Census tracts for which the average low-income energy burden is High or Severe. There are certainly some low-income households in those High or Severe AEB-LI tracts that do not have high energy burdens, just as there are likely many low-income households that do have High energy burdens but are located in tracts where the AEB-LI is not so high.

A closer examination of the 76 tracts with an AEB-LI of at least 15%, shown below in Map 4, indicates that about 10 of them have extreme concentrations of poverty, with anywhere from 48% to 94% of households below 80% AMI. However, the majority do not have extraordinary concentrations of low-income households. In fact, the average percent of households with incomes below 80% AMI in these 76 Census Tracts, 34.2%, is just a shade above the average of 32.9% for all Census Tracts in Virginia. Rather, the common thread among these Census Tracts with an AEB-LI of at least 15% is that almost all of them have an average annual energy cost (AAEC) that is much higher than the statewide average of $2,343. In fact, the average AAEC for those tracts ($3,717) is nearly 60% higher than the statewide average. In 14 of those Census Tracts the AAEC is more than double the statewide average, and in most of those the average energy burden is above 10% for all households. This suggests the opportunity to significantly reduce energy burdens in those areas through investments in low-income energy efficiency.

**Map 4. Census Tracts with Average Low-Income Energy Burden above 15%**



[98] U.S. Census Bureau. American Community Survey Data. 5-Year Estimates, 2017-2021.

# 4. Modeling Virginia's Future RGGI Income and Energy Efficiency Benefits

## 4.1. Understanding RGGI Policies and Trends

This section describes our methodology and assumptions for predicting future RGGI revenue for Virginia. As discussed in Section 1.3, participating states receive a set number of "allowances" based on their share of a regional emissions cap that goes down each year. Power plants in participating states must purchase these allowances at quarterly auctions, with each allowance permitting the emission of one short ton of $CO_2$.

The program includes three "auction mechanisms" that collectively ensure stability in the allowance market. The Minimum Reserve Price is the minimum price that allowances can be sold for at a RGGI auction. The Cost Containment Reserve (CCR) and Emissions Containment Reserve (ECR) are reserves of allowances that help provide market stability if the cost of reducing emissions is higher or lower than expected. The CCR allowances are made available for sale at an auction if the allowance price would otherwise exceed a set trigger price. Conversely, ECR allowances are withheld from sale at an auction, if the price would otherwise fall below a set trigger price.[99]

Virginia's base budget allowance began at 27,160,000 in 2021 and reduces by 840,000 per year, down to 19,600,000 in 2021.[100] However, RGGI announced in 2021 that there would be an "adjustment for banked allowances," which would adjust each state's allowances over the coming five years in order to account for an excess of allowances that had been privately banked from 2009-2020. The effect of this adjustment is a reduction of Virginia's allowances by 4,329,155 per year from 2021-2025.[101]

The ECR trigger prices, set by RGGI program operators, began at $6.00 when Virginia entered the market in 2021. They will increase by 7% per year, reaching $11.02 in 2030.[102] The CCR trigger prices began at $13.00 and will also increase by 7% per year, to $23.89 in 2030.[103] Over the eight auctions since Virginia joined RGGI, the auction clearing price has remained between the ECR and CCR trigger prices, with one exception. In late 2021, the auction price surged from $9.30 in the September auction to the CCR trigger price of $13.00 in the December auction, resulting in the release of 3.9 million allowances from the Cost Containment Reserve, including 888,829 for Virginia. Subsequent prices have remained close, but have not met, the 2022 CCR trigger price of $13.91, closing at $12.99 in the December 2022 auction.[104]

This information is summarized in Table 5, which identifies Virginia's base budget allowances, adjustments, resulting actual allowances, and the identified ECR and CCR trigger prices for each year from 2021-2030. The "net adjustments" column includes the aforementioned adjustment for banked allowances, which reduces Virginia's total by 4,329,155 per year from 2021-2025, as well as the additional 888,829 in allowances added to Virginia's total from the Cost Containment Reserve in 2021.

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[99] The Regional Greenhouse Gas Initiative, 2021. RGGI 101 Fact Sheet.

[100] Virginia Legislative Information System, 2020. 9VAC5-140, Table 140-5A. CO2 allowance allocations.

[101] The Regional Greenhouse Gas Initiative, 2021. Third Adjustment for Banked Allowances Announcement.

[102] Virginia Legislative Information System, 2020. 9VAC5-140, Table 140-1B. $CO_2$ ECR Trigger Price.

[103] Virginia Legislative Information System, 2020. 9VAC5-140, Table 140-1A. $CO_2$ CCR Trigger Price.

[104] The Regional Greenhouse Gas Initiative, 2022. Allowance Prices and Volumes.

**Table 5. Adjusted Virginia RGGI Allowance Totals and Price Trigger Points, 2021-2030**

| Year | Base Budget Allowances | Net Adjustments | Actual Allowances | ECR Trigger Price | CCR Trigger Price |
|---|---|---|---|---|---|
| 2021 | 27,160,000 | -3,440,326 | 23,719,674 | $6.00 | $13.00 |
| 2022 | 26,320,000 | -4,329,155 | 21,990,845 | $6.42 | $13.91 |
| 2023 | 25,480,000 | -4,329,155 | 21,150,845 | $6.87 | $14.88 |
| 2024 | 24,640,000 | -4,329,155 | 20,310,845 | $7.35 | $15.92 |
| 2025 | 23,800,000 | -4,329,155 | 19,470,845 | $7.86 | $17.03 |
| 2026 | 22,960,000 | -4,329,155 | 18,630,845 | $8.41 | $18.22 |
| 2027 | 22,120,000 | 0 | 22,120,000 | $9.00 | $19.50 |
| 2028 | 21,280,000 | 0 | 21,280,000 | $9.63 | $20.87 |
| 2029 | 20,440,000 | 0 | 20,440,000 | $10.30 | $22.33 |
| 2030 | 19,600,000 | 0 | 19,600,000 | $11.02 | $23.89 |

*Sources identified in preceding text and footnotes.*

In order to model future RGGI revenue for Virginia, one must start with estimates for the future clearing prices. If those estimates at any point reach the ECR or CCR trigger prices shown above, then the total number of allowances sold would have to decrease or increase accordingly.

To date there have been very few attempts to model future RGGI clearing prices. The most notable attempt comes from a study prepared by ICF International, as part of RGGI's "second program review," which led to the development of RGGIs 2017 Model Rule.[105] This study modeled a lower projected RGGI allowance price curve that would rise from about $8 in 2023 to roughly $13 in 2030, and a higher projected curve starting at around $14 in 2023 and reaching $23 in 2030 (all prices in nominal dollars for those future years). This lower projected price curve remains above the ECR trigger price from 2021-2030, and the higher price curve remains below the CCR price.[106] While the actual RGGI auction prices were lower than ICF's modeled lower price curve through mid-2020, auction prices have been closer to ICF's modeled higher price curve since September 2021.

## 4.2. Modeling Future RGGI Clearance Prices and Virginia Revenue Scenarios

Given the recent clearing price trends, relative to the ICF's modeled price curves, it is reasonable to assume that RGGI clearance prices are likely to remain above the ECR trigger price, and below the CCR trigger price, from 2023 through 2030.[107] The CCR trigger has only been reached once since late 2015, as a result of the significant clearance price surge in the December 2021 auction. The ECR trigger price has

[105] The Regional Greenhouse Gas Initiative, 2022. Program Review.

[106] ICF International, 2017. DRAFT 2017 Model Rule Policy Scenario Overview.

[107] Shobe, W., 2022. University of Virginia. Personal communication. (December 8, 2022).

not been reached since it came into effect in January 2021. The modeled RGGI clearance prices from ICF do not reach the trigger prices, in either their low price or high price scenarios, from 2023 through 2030.

Given these assumptions, our Low-end and High-end Virginia RGGI revenue scenarios are as shown in Table 6. Both scenarios include the actual Virginia allowances sold, average clearing prices, and actual resulting RGGI revenue for 2021 and 2022. The Low-end, conservative scenario assumes that the average annual clearing price drops by 2.5% per year from the actual average of $13.59 in 2021 to $11.10 in 2030. This is the steepest possible average annual drop in prices without triggering the ECR at any point. The High-end, more aggressive scenario assumes that the average annual clearing price will increase by 5% a year, to $20.07 in 2030, which would not exceed the CCR at any point. All prices are listed in nominal dollars for their respective years.

With the assumption that neither the ECR or CCR price is reached, the allowances sold each year equal the "Actual Allowances" shown in Table 5. The minimum revenue is then calculated as the allowances sold times the Low average clearing price, while the maximum revenue is the allowances sold times the High clearing prices. (Again, actual values are shown for 2021 and 2022, while 2023-2030 are modeled).

**Table 6. Modeled Allowances, Clearing Prices, and Virginia Revenue, Low and High Scenarios**

| Year | Allowances Sold | Average Clearing Price (Low) | Average Clearing Price (High) | Estimated Revenue – Low ($Millions) | Estimated Revenue – High ($Millions) |
|---|---|---|---|---|---|
| 2021 | 23,719,674 | $9.47 | $9.47 | $227.64 | $227.64 |
| 2022 | 21,990,845 | $13.59 | $13.59 | $298.80 | $298.80 |
| 2023 | 21,150,845 | $13.25 | $14.27 | $280.59 | $302.17 |
| 2024 | 20,310,845 | $12.92 | $14.98 | $262.72 | $304.70 |
| 2025 | 19,470,845 | $12.59 | $15.73 | $245.58 | $306.72 |
| 2026 | 18,630,845 | $12.28 | $16.52 | $229.12 | $308.18 |
| 2027 | 22,120,000 | $11.97 | $17.34 | $264.82 | $383.59 |
| 2028 | 21,280,000 | $11.67 | $18.21 | $248.39 | $387.48 |
| 2029 | 20,440,000 | $11.38 | $19.12 | $232.62 | $390.79 |
| 2030 | 19,600,000 | $11.10 | $20.07 | $217.49 | $393.47 |
| **Totals** | **208,713,899** | | | **$2,507.77** | **$3,303.54** |

*Source: RGGI data and analysis by authors*

As a result of the methods outlined above, the estimated total RGGI revenue for Virginia from 2021-2030 is $2.5 billion in the Low scenario, and $3.3 billion in the High scenario. The resulting HIEE funding, 50% of the total, is therefore $1.25 billion (Low scenario) to $1.65 billion (High scenario).

## 4.3. Modeling Household Energy Savings from HIEE Energy Efficiency Investments

In this section we analyze available data on the performance of the HIEE energy efficiency programs to-date, and estimate the projected energy and customer bill savings that the programs could produce through the year 2030. These estimates are presented in two scenarios – Low revenue and High revenue – based on the potential range of RGGI-generated HIEE revenue from the year 2021-2030. As the revenue projections in the prior section are in real, nominal dollars for the years 2021-2030, all cost estimates in this section incorporate reasonable assumptions for inflation over that same period. The initial steps in this modeling process, conducted separately for both revenue scenarios, are as follows:

- Identify a reasonable assumption for how future HIEE revenue would be distributed across the Weatherization Deferral Repair (WDR) and Affordable and Special Needs Housing energy efficiency (ASNH-EE) funds, as well as the distribution of WDR funding across single-family (WDR-SFH) versus multi-family (WDR-MFH) housing projects.
- Identify the average cost per unit upgraded via the ASNH-EE, WDR-SFH, and WDR-MFH projects completed to-date, and project those costs forward through 2030 at a reasonable inflation rate.
- Divide the annual funding estimates for each project type – ASNH-EE, WDR-SFH, and WDR-MFH – by their respective projected costs per unit, producing an estimated number of units receiving energy efficiency or weatherization deferral upgrades, per year (2021-2030), via each program.

Here one must note that there is a natural lag time between when the state receives RGGI funding and when the subsequent HIEE funds result in completed energy efficiency projects. As previously discussed, the revenue generated for the HIEE program since Virginia joined RGGI equals nearly $252 million ($526.5 in RGGI auction revenue times 50%, minus the $11.4 million diverted to the Hurley flood relief fund). But as of December, 2022, DHCD had spent or committed only $37.08 million of those funds (29.16 to ASNH-EE and $7.92 to WDR), with another $80 million in ASNH-EE funds to be released in FY '23. Therefore, in our analysis, the number of units identified for each year corresponds to the estimated number of units that could be upgraded with the revenue generated that year, with an understanding that the actual energy efficiency projects would take place within the subsequent couple of years.

Once the projected number of units upgraded per year has been calculated, the next steps are to estimate the resulting energy efficiency and customer savings benefits. These savings are calculated in the aggregate, based on the total number of housing units that could receive energy efficiency upgrades via the projected HIEE revenue through 2030, and represent the annual energy and customer bill savings benefits resulting from those energy efficiency investments. This is calculated as follows:

- Multiply the number of housing units that could be upgraded, per project type (ASNH-EE, WDR-SFH, and WDR-MFH), by their corresponding estimated annual energy savings per housing unit, in millions of British thermal units (MMBTUs).
- Convert the estimated total annual energy savings from MMBTU to kilowatt-hours (kWh), and multiply the resulting estimated electricity savings times an estimated electricity rate ($ / kWh) for the year 2030, projected forward based on past electricity rate trends.

A key assumption, discussed further below, is that all of the energy savings from the HIEE programs are in the form of reduced electricity consumption. Another key assumption of this analysis is that every WDR project results in a subsequent WAP project, as is the intent of the WDR program, with ensuing energy efficiency benefits. These steps are discussed in more detail in the following sections.

### *4.3.1. Estimating Total Units to be Upgraded with Future HIEE Program Funds*

As noted in Section 1, Table 2, the initial distribution of HIEE funds for FY 2021 was 60% to WDR and 40% to ASNH-EE. In FY 2022 these percentages were essentially reversed, with 60% of funds going to ASNH-EE, 30% to WDR, and 10% to a proposed "Housing Innovations Partnerships" grant program.

Of the HIEE funds spent or committed to-date, roughly 80% has gone to ASNH-EE, versus 20% to WDR. This does not include the additional $80 million in ASNH-EE funds announced in late 2022, which will skew the percentage even higher towards that program. Projecting forward, the amount of weatherization deferral repair work that can be completed is constrained by both the capacity of the state's weatherization provider network as well as the availability of federal WAP funds. While Virginia has experienced a substantial increase in WAP funding from the Bipartisan Infrastructure Law, that is a one-time source of additional funds that is currently only available until expended.

Considering these factors, our model assumes that 85% of HIEE funds generated from 2021-2030 will be dedicated to the ASNH-EE program, and 15% to the WDR program. This amount of funding would still support substantial ongoing weatherization deferral support, as indicated in the final modeling results.

The next critical assumption is the distribution of WDR funds between single-family and multi-family projects. The aforementioned total of $7.92 million in WDR expenditures thus far includes both funds already spent and the estimated costs of projects currently approved and in-progress, including both single-family and multi-family projects. However, detailed cost data is only available for the $4.60 million that has actually been spent thus far. Of those funds, 86.5% ($4.02 million) has been spent on single-family WDR projects, and 13.5% ($627,000) on multi-family projects.[108]

Moving forward, we assume that WDR funding will be split 85% to single-family projects and 15% to multi-family. This results in an overall HIEE funding distribution of 85% to ASNH-EE, 12.75% to WDR-SFH, and 2.25% to WDR-MFH.

Data on the estimated cost per unit for the three HIEE program types is based on information released by DHCD. For ASNH-EE, a July 2021 announcement indicated that $6.2 million in ASNH-EE funds would be spent across 11 projects, supporting a total of 707 units.[109] A subsequent announcement in January 2022 included $22.96 million in ASNH-EE funds, supporting 1,682 units across 25 projects.[110] Combining the numbers from these two announcements results in an average cost per unit of $12,190. For WDR, the aforementioned totals provided by DHCD indicate an average cost per unit of $13,260 for WDR-SFH and $2,170 for WDR-MFH.

Our model uses these totals as the average cost per unit for the respective programs in 2021 and 2022. For future years we apply a 3% average annual increase to each of these costs. This assumption is based on analysis from CBRE, one of the country's leading real estate services and investment firms, which

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[108] Virginia DHCD, 2022. Personal communication from Aaron Shoemaker, Program Administrator, Energy Efficiency Office. (December 8, 2022).

[109] Virginia DHCD, 2021. Governor Northam Announces Over $21 Million in Affordable and Special Needs Housing Loans.

[110] Virginia DHCD, 2022. Governor Northam Announces Over $60 Million in Affordable and Special Needs Housing Loans.

indicates a 14% increase in construction costs from 2021-2022 and anticipates that price escalation "should stabilize to the 2% - 4% range in 2023 and 2024, on par with historical averages."[111] Projecting the per-unit project costs forward at 3% per year, beginning in 2023, results in averages of $15,442 for ASNH-EE, $16,797 for WDR-SFH, and $2,749 for WDR-MFH in the year 2030.

With these assumptions in place for the annual HIEE revenue scenarios, distribution of revenue across project type, and average costs per unit, we can then calculate an estimated number of units across each program that could be upgraded with anticipated funding through the year 2030. While the more detailed calculation tables can be seen in Appendix D, the final results are summarized in Table 7 below.

**Table 7. Estimated Units Upgraded via HIEE Programs, per 2021-2030 RGGI Revenue Scenario**

| Revenue Scenario | ASNH - EE | WDR - SFH | WDR - MFH | Total Units |
|---|---|---|---|---|
| Low ($1.24 billion) | 78,373 | 10,806 | 11,653 | 100,832 |
| High ($1.64 billion) | 101,833 | 14,041 | 15,141 | 131,015 |

As discussed above, there is a natural lag time between when the state receives RGGI funding and when the subsequent HIEE funds result in completed energy efficiency projects. Therefore, the totals shown above correspond to the estimated number of units that could be upgraded with the total revenue generated from 2021-2030, with an assumption that the actual energy efficiency projects would take place within the subsequent couple of years.

### *4.3.2. Estimating Energy Consumption and Bill Savings from HIEE Energy Efficiency Investments*

Having determined the estimated number of units to be upgraded under each funding scenario, we can now project the resulting energy efficiency and customer savings benefits.

First, we used data from the Virginia Center for Housing Research at Virginia Tech, which completed a study of the HIEE program for DHCD in the fall of 2022. The Virginia Tech study found that the WDR-SFH projects that had been completed by that time had generated an average energy savings of 37.1 MMBTU per year, versus 4.8 MMBTU per year for multi-family units in WDR-MFH projects.[112]

As noted above, these modeled savings incorporate the resulting energy efficiency upgrades that would occur as the completed WDR project is further weatherized, with federal funds, via the WAP program. The additional costs of those WAP projects are not incorporated here, as the intent of this study is to evaluate the benefits of the RGGI funding that Virginia routes through HIEE, and the capacity of the WDR program to unlock federal WAP dollars for low-income Virginia residents is one such benefit.

The Virginia Tech study also modeled the energy savings resulting from the various types of ASNH-EE projects. As discussed in Section 1.4.1, any project receiving ASNH funds can be assumed to also be receiving the Low-Income Housing Tax Credit (LIHTC), administered through Virginia Housing. Projects receiving the LIHTC tax credit in Virginia are required to achieve a certain level of energy efficiency performance, based on their project type (new construction, substantial rehabilitation, or adaptive

[111] CBRE, Inc. 2022. 2022 U.S. Construction Cost Trends.

[112] Virginia Center for Housing Research, Virginia Tech, 2022. *Housing Innovations in Energy Efficiency Report*.

reuse), and projects that receive ASNH-EE funds via the HIEE program are expected to reach even more rigorous energy efficiency benchmarks (see details in Table 3).

Therefore, the energy savings from a given ASNH-EE project can be calculated based on that margin between the LIHTC requirements and the ASNH-EE requirements. The Virginia Tech study found those marginal savings to be 29% for New Construction projects, 20% for Substantial Rehabilitation, and 14% for Adaptive Reuse. The Virginia Tech study also calculated an estimated average per-unit energy consumption, in energy use intensity (EUI), customer bill amounts (dollars per year) and greenhouse gas emissions ($CO_2$-equivalent, or $CO_2$-e) for each ASNH-EE project type.

**Table 8. Annual per Unit Energy Performance of ASNH-EE Projects vs. LIHTC Requirements**

| Project Type | Energy Savings (EUI) | Energy Savings (%) | Bill Savings ($) | GHG Savings (tons $CO_2$-e) |
|---|---|---|---|---|
| New Construction | 6.97 | 29% | $200 | 1.6 |
| Substantial Rehab | 7.94 | 20% | $103 | 0.8 |
| Adaptive Reuse | 6.90 | 14% | $154 | 1.3 |

*Source: Virginia Center for Housing Research, Virginia Tech, 2022. Housing Innovations in Energy Efficiency Report.*

Based on the results from Table 8, and employing the current carbon coefficient for electricity in Virginia (626.3 lbs / MWh),[113] we were able to calculate the average annual energy savings for housing units upgraded via each ASNH-EE program. For example, according to the Virginia Tech study, an ASNH-EE new construction project emits 1.6 tons $CO_2$-e / year less than an equivalent project meeting only the LIHTC energy efficiency requirements. The aforementioned carbon coefficient rate for Virginia electricity of 626 lbs / MWh translates to 3193 kWh / ton. Multiplying this carbon ratio times the 1.6 ton difference in emissions results in an annual energy savings of 5,110 kWh from the ANSH-EE new construction unit. At a conversion rate of 3,412 Btu / kWh, this equals 17.43 MMBTU.

Replicating this same process for substantial rehabilitation and adaptive reuse projects resulted in estimated annual energy savings per housing unit of 8.72 MMBTU and 14.16 MMBTU respectively. Using the detailed data on units per ASNH-EE housing type from the DHCD's July 2021 and January 2022 press releases, we then calculated a weighted average of 13.97 MMBTU savings from all ASNH-EE units, relative to equivalent low-income housing units that meet the LIHTC performance standards only.

With the average annual energy savings calculated for ASNH-EE, WDR-SFH, and WDR-MFH projects, we were then able to calculate the total energy savings (MMBTU) and electricity savings (kWh) for the year 2030, for both revenue scenarios. To convert electricity savings to customer bill savings required an estimated cost of electricity in the year 2030. We calculated this estimate based on data from the U.S. Energy Information Administration, which shows that the average retail price of electricity in Virginia has increased from 7.79 cents / kWh in 2002 to 11.96 cents / kWh in 2021, for an average annual growth rate of 2.17%. Extrapolating that same growth rate out produces an estimated average price of 15 cents per kWh in 2030. Multiplying that projected price times the estimated electricity savings produced the estimated total and average per unit customer bill savings shown in Table 9.

[113] U.S. Environmental Protection Agency, 2022. eGrid 2020. See data for SRVC sub-region.

**Table 9. Total Units Upgraded (2021-2030) and Annual (Year 2030) Energy and Bill Savings**

| RGGI / HIEE Revenue Scenario | Units Upgraded | Total Energy Savings (MMBTU) | Total Energy Savings (MWH) | Total Bill Savings ($Millions) | Bill Savings / Unit ($) |
|---|---|---|---|---|---|
| Low ($1.24 billion) | 100,832 | 1,551,322 | 454,666 | $68.20 | $676 |
| High ($1.64 billion) | 131,015 | 2,015,703 | 590,769 | $88.62 | $676 |

*Source: Calculations by authors, using energy savings data from Virginia Center for Housing Research, Virginia Tech, 2022. Housing Innovations in Energy Efficiency Report.*

To reiterate, the energy and customer bill savings shown above are based on the total number of housing units that could receive energy efficiency upgrades via the projected HIEE revenue from 2021 through 2030. These are annual values, representing the projected energy and customer bill savings benefits in the year 2030, as a result of the energy efficiency investments funded by HIEE. These annual energy savings would continue in subsequent years (i.e., beyond 2030), with resulting customer bill savings increasing along with the average price of electricity. Annual energy and customer bill savings realized in the earlier years (i.e., 2021-2029) would be proportional to the number of HIEE energy efficiency projects completed by a given year, and the average electricity price at that time.

A key assumption of this analysis is that virtually all residential energy use in the year 2030 comes in the form of electricity, with direct consumption of natural gas or other fossil fuels for heating, water heating, etc. having been largely phased out in the residential sector. This assumption is in part for simplicity's sake. To include an estimated percentage of energy savings that would come from direct fossil fuel use, rather than electricity, would introduce significant additional complexity to the analysis, without substantively impacting the final results. This assumption is also reflective of a trend towards electrification in new and renovated housing, particularly for subsidized housing units.

## 5. Economic Impact Analysis of Virginia's HIEE Program

An economic impact model describes how a change in economic activity in one or more industries can influence a broader regional economy. The model developed for this analysis utilizes IMPLAN, an input-output modeling system. An input-output model traces a change in spending from the source backwards through the supply chain, identifying how much of the spending is likely to remain inside the region with suppliers and workers, and how it will be spent in turn. The resulting dollar figures describe how the original change in economic activity reverberates through a regional economy, making an impact greater than the initial dollar figure.

The total economic impact of a given economic activity is comprised of several dimensions, as each stage of that activity is comprised of resources that go towards supplies, labor, profit, and taxes. The components of the total impact are divided into Employment, Labor Income, and Value Added. Value Added refers to the amount that a good increases in value at each step of the production process, after subtracting the cost of materials. More broadly, the value added of an industry is the difference between its gross sales and the cost of its supplies (including raw materials, energy, and services).[114]

Each component of economic impact flows from one of three possible stages in the economic process.

1. Direct impacts: Direct impacts are dollars that come from the initial source or change. In this case, the direct impacts are those that flow directly from HIEE funds.
2. Indirect impacts: These impacts flow from an industry's "backward linkages," or the relationship an industry has to its supply chain. For example, a bakery relies on supplies and materials produced by grain farmers, flour producers, and packaging manufacturers. An increase in demand at the bakery will influence purchases from those suppliers.
3. Induced impacts: Labor income changes allow households that receive that labor income to spend additional money on wants and needs. Induced impacts refer to the new spending that happens as a result of income changes spurred by direct and indirect impacts.

The direct impact constitutes the largest component of economic impact. However, indirect and induced impacts represent an essential component of a market economy, as they demonstrate the effects of backwards linkages, supply chains, and household spending that occur in response to direct impacts.

Economic impact analyses should not be considered a cost-benefit analysis. The impacts described may be considered benefits to one industry and costs to another. Impact analysis describes economic activity flowing from a change in production. The input-output modeling used in economic impact analysis is not able to trace the path of each dollar after it leaves the region. Inter-regional economic activity, where spending happens between economic regions, is not captured. Further, input-output models are static. They model changes in demand using existing knowledge of supply chains, but they do not model how those changes may increase or decrease the availability and cost of supplies and labor.

[114] U.S. Bureau of Economic Analysis, 2006. What Is Industry Value Added?

## 5.1. Model Inputs and Outputs

An economic impact begins with a change in economic activity. In this case, we are modeling the spending associated with HIEE revenue generated between 2021 and 2030. After identifying the total HIEE funding for each year, we can divide that funding by program (WDR and ASNH-EE) and, ultimately, categorize each program's dollars by industry equivalent IMPLAN category (e.g., construction of new multifamily residential structures). Similar efforts have classified RGGI-related energy efficiency spending by states in IMPLAN's construction and maintenance categories.[115] Those dollars are entered into the model using the relevant industry code and dollar year.

The model uses a combination of industry and employment multipliers, household spending estimates, and regional purchasing coefficients, or estimates of the percentage of a region's demand for a good met by production within that region. Together, these tools are used to estimate how the inputs – $1.24 billion to $1.64 billion in total – will change demand for suppliers, change demand for labor, and change household spending patterns. The results are expressed in 2022 dollars.

## 5.2. Economic Impact Analysis Results

The anticipated output of HIEE funding from 2021 through 2030—between $1.24 billion and $1.64 billion – would have a statewide impact between $2.03 and $2.67 billion (see Table 10).

Each dollar dedicated to the HIEE program flows through a chain of workers, manufacturers, and suppliers inside and outside of Virginia. Each dollar that leaves the state is considered economic leakage. The dollars that remain inside Virginia, passing from contractor to supplier to manufacturer to worker, constitute what we describe as the economic impact of the original event or spending.

For every $1.00 of HIEE funds spent, the total impact is between $1.656 and $1.658—the original $1.00 plus another $0.66 generated through indirect and induced effects (see Table 11). This means that HIEE program spending has a "multiplier effect" of 1.66, which is comparable to those of the following industries in Virginia:[116]

- Air transportation 1.666
- Wood windows and door manufacturing 1.661
- Glass container manufacturing 1.659
- Paper mills 1.654
- Electric power generation - Solar 1.651
- Electric power generation - Hydroelectric 1.634
- Electric power generation - Fossil fuel 1.619

These multipliers do not indicate that the industries have a net benefit or cost. They describe the ways that dollars flow backwards through the supply chain and worker households inside the region.

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[115] Hibbard, P., et al., 2018. The Economic Impacts of the Regional Greenhouse Gas Initiative on Nine Northeast and Mid-Atlantic States.

[116] IMPLAN, 2021. Estimates of Industry Multipliers in Virginia.

The HIEE program's total economic impact is summarized in Table 10. Please note that the table does not include every element of economic impact, and some elements are subcategories of others. For example, Labor Income is a component of Value Added.

**Table 10. Estimated Economic Impacts of the HIEE Program in Virginia, 2021 through 2030**

| Revenue Scenario | Output | Value Added | Labor Income | Employment [a] |
|---|---|---|---|---|
| Low | $2.03 Billion | $1.32 Billion | $834 Million | 1,552 |
| High | $2.67 Billion | $1.75 Billion | $1.11 Billion | 2,115 |

*Sources: CURA modeling and analysis of VCU projections of HIEE program spending*

[a] *Figure represents new jobs across 10-year study period.*

The impact of HIEE-related spending from 2021 to 2030 will be a function of how much money is spent, and when. In Section 4 we modeled the estimated Low and High ranges of annual RGGI revenue, 50% of which will go to the HIEE program, based on the amount of $CO_2$ allowances available each year and a reasonable estimate of the potential range of allowance prices. As discussed in that section, the HIEE revenue generated from a given year's RGGI auction allowances will fund a certain amount of energy efficiency upgrades via the WDR and ASNH-EE programs over the subsequent years. This allows for an estimation of the economic impacts of that spending on a year-by-year basis.

The estimated annual economic impacts range between $200 million and $300 million each year, resulting in the aforementioned cumulative effect of between $2.0 billion (Low scenario) and $2.7 billion (High scenario), as shown in Figure 5.

**Figure 5. Cumulative Economic Impact of HIEE Expenditures, 2021 – 2030**

*Sources: VCU model of estimated annual RGGI revenue for Virginia (see Section 4)*

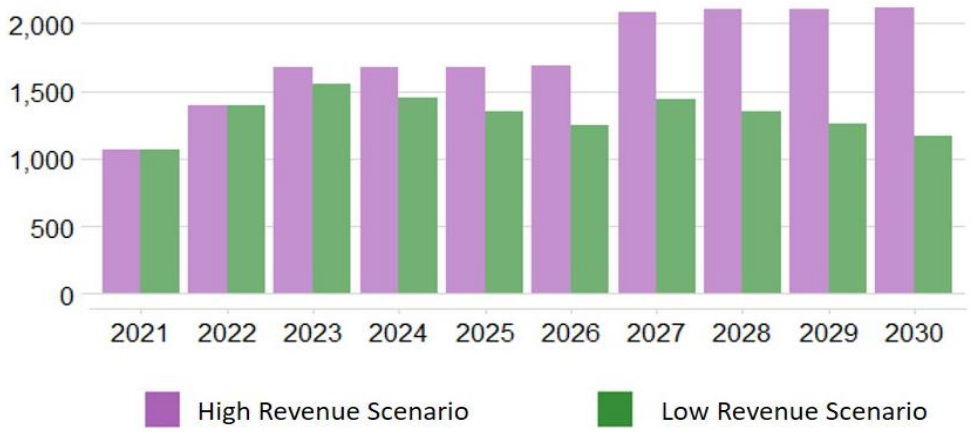
The total impact includes $1.32 (Low RGGI revenue scenario) to $1.75 billion (High revenue scenario) in Value Added across the 10-year period. Value added can be considered a measure of contribution to Virginia's GDP. The Value Added impact of the HIEE program generates an average annual contribution of $132 to $175 million to the state GDP, or around 0.02% to 0.03% of the 2021 GDP.[117]

[117] U.S. Bureau of Economic Analysis, 2022. What Is Industry Value Added?

We estimate that $0.83 to $1.11 billion of the value added would go towards Labor Income, which includes all employee compensation (salaries, benefits, payroll taxes) and "proprietor income" (i.e., payments received by self-employed individuals and unincorporated business owners).[118] This labor income across 10 years would create and sustain 1,552 to 2,115 jobs, at approximately $52,500 to $53,500 per job. The remainder of the value added would go towards corporate profits, capital depreciation, and taxes, and is treated as leakage.

Unlike the dollar-based impact figures, employment is not able to be stacked year-over-year in a cumulative manner. After the change in economic activity supports the job, adding it to the total year-after-year would misrepresent the impact. Figure 6 shows the number of jobs that the HIEE program would support over the 10-year period, as a function of the amount of revenue generated that year.

**Figure 6. Annual Employment Supported by HIEE Expenditures, 2021 – 2030**




*Sources: VCU model of estimated annual RGGI revenue for Virginia (see Section 4)*

Table 11 breaks down the direct, indirect, and induced impacts of projected HIEE funding through 2030. Indirect and induced impacts total $806 million to $1.06 billion over 10 years, roughly 40% of the aforementioned total economic impacts under the Low and High revenue scenarios. Those impact phases represent dollars that have moved through the initial round of business spending to other suppliers in Virginia (indirect) and spending by workers shopping in Virginia (induced).

**Table 11. Summary of HIEE Direct, Indirect, and Induced Impacts, 2021 through 2030**

| Revenue Scenario | Direct | Indirect | Induced | Total |
|---|---|---|---|---|
| Low | $1.22 Billion | $326 Million | $480 Million | $2.03 Billion |
| High | $1.61 Billion | $422 Million | $636 Million | $2.67 Billion |

*Sources: CURA modeling and analysis of VCU projections of HIEE program spending*

[118] Clouse, C., 2020. IMPLAN – Support. Understanding Labor Income (LI), Employee Compensation (EC), and Proprietor Income (PI).

The direct impact constitutes the largest component of economic impact. However, the indirect and induced impacts together account for about 40% of the total impact in each scenario, demonstrating the effects of backwards linkages, supply chains, and household spending that are essential components of a market economy. The induced impact outpaces the indirect impact, highlighting the importance of household spending in the Virginia's economy. Consumer spending often occurs close to home, and the dollars continue to ripple through the economy.

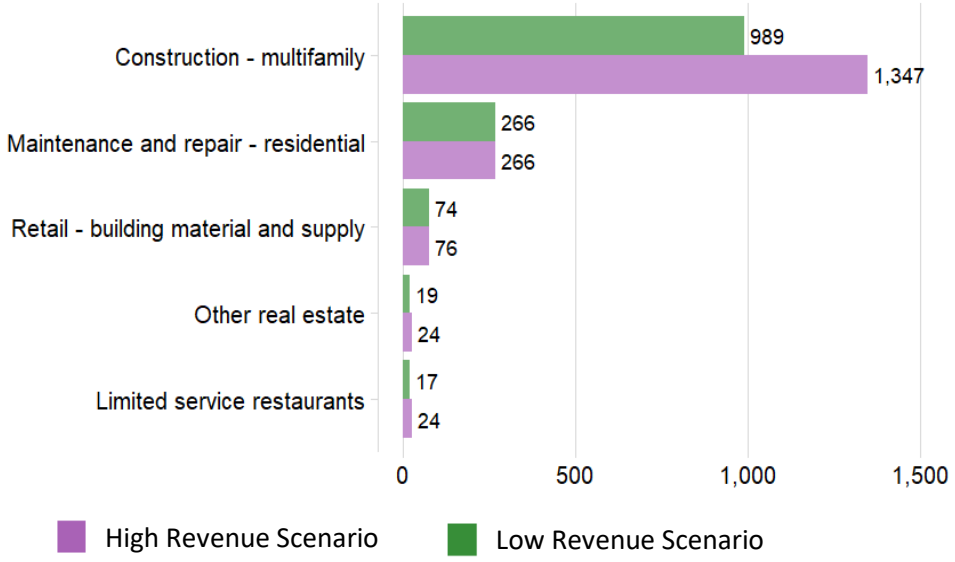
Table 12 merges the information in the previous two tables, demonstrating in greater detail how the various elements of economic impact (employment, labor income, and value added) are distributed across the direct, indirect, and induced components of that impact, per the HIEE revenue scenarios.

**Table 12. Summary of HIEE Impact Components, 2021 - 2030 (Low vs. High Scenarios)**

| Impact | Employment | Labor Income ($Millions) | Value Added ($Millions) |
|---|---|---|---|
| Direct | 1,069 - 1,457 | $581 - $774 | $849 - $1,128 |
| Indirect | 217 - 233 | $102 - $133 | $186 - $240 |
| Induced | 311 - 424 | $150 - $199 | $288 - $382 |
| Total | 1,552 - 2,115 | $834 - $1,106 | $1,323 - $1,750 |

The indirect effects of HIEE funding would create and support 217 to 233 jobs through 2030. The induced effects – those generated by the new household spending that accompanies increases in labor income – would support 311 to 424 jobs through 2030. The influence of those effects is visible in the industries the model estimates will see the greatest increase in employment, such as the increases in retail and restaurant employment shown in Figure 7 below.

**Figure 7. Industries with Largest Employment Impact**




*Sources: VCU model of estimated annual RGGI revenue for Virginia (see Section 4)*

## 6. Summary and Conclusions

The research presented here has demonstrated the vast scope of the low-income energy burden challenge in Virginia, as well as the potential to significantly mitigate those energy burdens through continued participation in the energy efficiency programs funded by Virginia's participation in RGGI.

Hundreds of thousands of low-income households in Virginia experience "High" or "Severe" energy burdens, based on the percent of their incomes that are spent on home energy costs. This energy burden challenge does not sort out along geographic, demographic, or political lines. Concentrations of severe energy burden can be found throughout much of Virginia's rural areas, from the farthest corner of Southwest Virginia to the Eastern Shore, as well as in some of the state's most urban neighborhoods. This includes pockets of extreme energy burden, where low-income households are spending over 20% of their incomes on home energy costs. At these high levels, energy burden is not merely a financial challenge, but brings with it a degree of energy insecurity that threatens residents' health and safety.

Existing federal, state, and utility-sponsored energy efficiency programs – without RGGI – are insufficient to address the vast scope of the energy burden problem in Virginia. The variety of tax credits and financial incentives available to support residential energy efficiency, including the recently adopted or expanded tax credits under the federal Inflation Reduction Act, are largely inaccessible to low-income Virginians who live in rental housing and/or cannot afford even the subsidized up-front costs of energy-efficiency investments. The long-standing federal WAP and LIHEAP programs provide meaningful weatherization services for low-income residents, but even with increased funding under the Bipartisan Infrastructure Law they only address a tiny portion of the problem. While recent Virginia laws direct investor-owned utilities to invest significant funding into achieving ambitious energy-efficiency targets, only 15% of those funds are required to support Low- and Moderate-Income households.

The energy efficiency funding generated through Virginia's participation in RGGI vastly exceeds that of these other existing programs. While the aforementioned federal and state / utility programs will provide less than $55 million per year over the coming years, Virginia's RGGI revenue has already generated $250 million for low-income energy efficiency programs in just two years (2021-2022). If Virginia remains in the RGGI program through 2030, then we project the total funds raised for low-income energy efficiency to be between $1.24 and $1.64 billion over the course of the decade.

Using available data from the state, and a recent analysis from Virginia Tech, we were able to estimate the reduced energy consumption and customer bill savings that these future RGGI energy efficiency funds could provide. According to our calculations, Virginia's projected RGGI revenue through 2030 could eventually lead to energy efficiency improvements for anywhere from 100,000 to 130,000 low-income homes. The resulting energy savings would be between 1.56 and 2.01 trillion Btu per year, or 455,000 to 591,000 MWh of electricity. This would result in $68 to $89 million in customer bill savings per year, at an average of $676 per year per household.

Finally, we estimate that spending the projected RGGI funds through 2030 would have a statewide economic impact of between $2.03 and $2.67 billion. These findings indicate a "multiplier effect" of 1.66, meaning that every dollar invested in low-income energy efficiency generates an additional $0.66 in indirect and induced impacts. The estimated total impact includes $1.32 to $1.75 billion in Value Added across the 10-year period, which would represent an increase of 0.02% to 0.03% to the state's GDP. We estimate that the Labor Income component of that Value Added ($0.83 to $1.11 billion) would create and sustain 1,552 to 2,115 jobs, at approximately $52,500 to $53,500 per job.

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# Appendix A. Energy Burden Mapping Methodology

## Low-Income Energy Affordability Data (LEAD)

The US Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) developed the Low-Income Energy Affordability Data (LEAD) Tool, to help users examine household energy characteristics in relation to household income levels. The LEAD Tool provides three income models to depict income levels: Area Median Income (AMI), Federal Poverty Level (FPL), and State Median Income (SMI). For mapping purposes of this study, AMI was chosen to account for income variations across Virginia, and to establish the threshold of "low-income" defined as income below 80% AMI.

At the time of the study, the LEAD Tool provides estimates derived from the US Census Bureau's 2018 American Community Survey (ACS) Public Use Microdata Samples (PUMS). In specific, LEAD includes estimated household energy cost, energy burden, and housing count according to the following criteria:

- Geographic levels – this study obtained and mapped LEAD at the Census Tract level
- AMI levels – income below 80% AMI was defined as "low-income" in this study
- Building age (construction year of housing unit)
- Heating fuel types
- Building types – this study excluded boat/RV/van and mobile/trailer from single- and multi-family units counts
- Tenure status (homeowner or renter)

A notable limitation of the LEAD data is that it always reports average energy burdens as whole numbers, without a clear indication of how those numbers are rounded. Therefore, we identified Census tracts with a LEAD-reported Average Energy Bruden of seven or more as High Energy Burden, and eleven or more as Severe Energy Burden. It is possible that this method excludes some Census tracts with an actual, un-rounded Average Energy Burden above 6.0 from the High Energy Burden category, or some above 10.0 from the Severe Energy Burden category. However, we chose to err on the side of caution, and avoid inadvertently including Census tracts in which the actual Average Energy Burden is less than 6.0 or 10.0 from those categories.

## Census Geography

Given that the LEAD Tool provides estimates based on 2018 Census data, this study obtained 2018 Virginia Census Tracts from the US Census TIGER/Line Geodatabases page. This study also obtained the 2018 ACS Table B01003 which contains tract-level geography names and population estimates.

## Geodatabase Creation and Mapping

The LEAD Tool allows users to specify their own criteria and download the respective data sets in CSV (comma-separated values) format. A number of CSV files about household energy cost, energy burden, and housing count were downloaded according to the criteria stated earlier. The CSV files were further prepared in Excel before they were joined to the 2018 Virginia Census Tracts in ArcGIS Pro. The resulting geodatabase contains attributes listed in the table below.

| Attribute | Description |
|---|---|
| GEO_ID | Unique Identifier |
| County | Jurisdiction Name (County or City) |
| Tract | Census Tract Number |
| Pop_2018 | Population (2018 ACS 5-year estimate) |
| Total_HU | Total - Housing Counts (Single- and Multi-Family combined) |
| Total_AAEC | Total - Average Annual Energy Cost ($) |
| Total_AEB_pct | Total - Average Energy Burden (% income) |
| Single_HU | Single-Family - Housing Counts |
| Single_AAEC | Single-Family - Average Annual Energy Cost ($) |
| Single_AEB_pct | Single-Family - Average Energy Burden (% income) |
| Multi_HU | Multi-Family - Housing Counts |
| Multi_AAEC | Multi-Family - Average Annual Energy Cost ($) |
| Multi_AEB_pct | Multi-Family - Average Energy Burden (% income) |
| AMI_below80_AEB | Low-Income (below 80% AMI) - Average Energy Burden (% income) |
| AMI_below80_HU | Low-Income (below 80% AMI) - Housing Counts (Single- and Multi-Family combined) |
| AMI_below80_AEB_single | Low-Income (below 80% AMI) - Single-Family Average Energy Burden (% income) |
| AMI_below80_HU_single | Low-Income (below 80% AMI) - Single-Family Housing Counts |
| AMI_below80_AEB_multi | Low-Income (below 80% AMI) - Multi-Family Average Energy Burden (% income) |
| AMI_below80_HU_multi | Low-Income (below 80% AMI) - Multi-Family Housing Counts |

Three sets of maps were created to illustrate the spatial distribution and variation of average energy burden, high energy burden (above 6%), and severe energy burden (above 10%) low-income households at the Census Tract level. Virginia Census Tracts were classified into five groups using the Natural Breaks method which optimizes classification by minimizing the within-group difference while maximizing the between-group difference. These maps and their associated attributes are listed below.

<u>Average Energy Burden</u>

- Average Energy Burden of Low-Income (below 80% AMI) Households
  Attribute: AMI_below80_AEB
- Average Energy Burden of Single-Family Low-Income (below 80% AMI) Households
  Attribute: AMI_below80_AEB_single
- Average Energy Burden of Multi-Family Low-Income (below 80% AMI) Households
  Attribute: AMI_below80_AEB_multi

High Energy Burden (above 6%) Housing Units

- Housing Units of High Energy Burden and Low-Income (below 80% AMI)
  Attribute: AMI_below80_HU, where AMI_below80_AEB > 6
- Single-Family Housing Units of High Energy Burden and Low-Income (below 80% AMI)
  Attribute: AMI_below80_HU_single, where AMI_below80_AEB_single > 6
- Multi-Family Housing Units of High Energy Burden and Low-Income (below 80% AMI)
  Attribute: AMI_below80_HU_multi, where AMI_below80_AEB_multi > 6

Severe Energy Burden (above 10%) Housing Units

- Housing Units of Severe Energy Burden and Low-Income (below 80% AMI)
  Attribute: AMI_below80_HU, where AMI_below80_AEB > 10
- Single-Family Housing Units of Severe Energy Burden and Low-Income (below 80% AMI)
  Attribute: AMI_below80_HU_single, where AMI_below80_AEB_single > 10
- Multi-Family Housing Units of Severe Energy Burden and Low-Income (below 80% AMI)
  Attribute: AMI_below80_HU_multi, where AMI_below80_AEB_multi > 10

## Appendix B. Census Tracts in Virginia with Extreme Low-Income Energy Burden

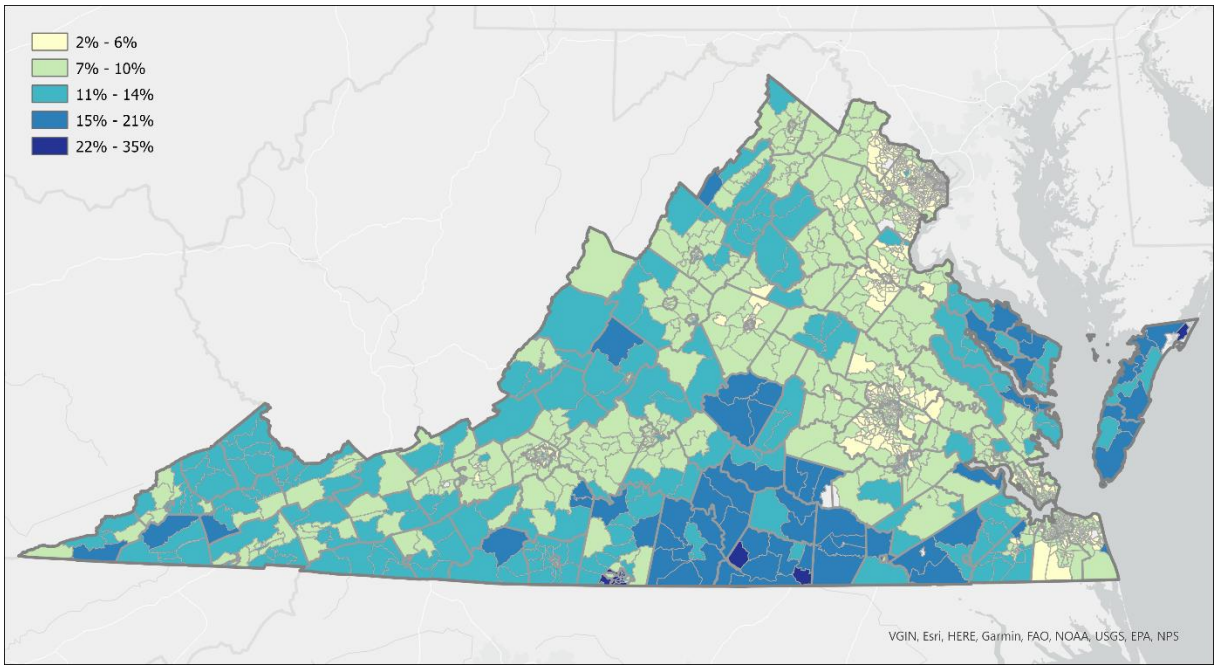
The following table lists all 76 Virginia Census Tracts in which the average energy burden (AEB) for all low-income households (AEB-LI) is 15% or above (i.e., twice the U.S. national average). These tracts are listed in descending order based on their AEB-LI. The table also lists the percent of all households in each tract that are low-income (PCT HU < 80 AMI), the Average Annual Energy Costs (AAEC) for all households in that Census Tract, and the average annual energy burden (AEB) for all households in the Tract.

| County | Census Tract | Pop. (2018) | Housing Units | PCT HU < 80 AMI | AAEC | AEB (All Households | AEB (AMI < 80) |
|---|---|---|---|---|---|---|---|
| Danville city | 4 | 3300 | 1389 | 72.1% | $5,117 | 18 | 32 |
| Danville city | 11 | 1387 | 596 | 58.6% | $5,283 | 12 | 29 |
| Danville city | 6 | 1945 | 919 | 48.5% | $5,250 | 11 | 29 |
| Albemarle County | 109.03 | 3159 | 98 | 93.9% | $1,538 | 20 | 29 |
| Danville city | 10 | 3944 | 1548 | 63.8% | $4,903 | 12 | 27 |
| Danville city | 3 | 2840 | 1461 | 57.2% | $5,237 | 15 | 26 |
| Danville city | 8 | 2676 | 1214 | 38.2% | $4,702 | 8 | 26 |
| Mecklenburg County | 9301.02 | 2872 | 1207 | 17.1% | $5,754 | 10 | 25 |
| Accomack County | 901 | 2899 | 1523 | 26.3% | $4,941 | 7 | 25 |
| Danville city | 12 | 1866 | 759 | 33.9% | $4,805 | 8 | 24 |
| Pittsylvania County | 112 | 2254 | 1075 | 44.1% | $4,693 | 10 | 24 |
| Mecklenburg County | 9305 | 1616 | 706 | 25.5% | $3,972 | 6 | 23 |
| Hampton city | 114 | 2744 | 250 | 90.0% | $2,031 | 10 | 22 |
| Danville city | 9 | 3323 | 1567 | 50.5% | $4,784 | 10 | 21 |
| Mecklenburg County | 9307 | 2096 | 1095 | 22.6% | $4,496 | 8 | 21 |
| Northumberland County | 202 | 2906 | 1394 | 29.1% | $4,049 | 6 | 20 |
| Mecklenburg County | 9306 | 2819 | 991 | 25.7% | $4,002 | 6 | 20 |
| Lunenburg County | 9303 | 2357 | 872 | 28.4% | $3,835 | 7 | 20 |
| Danville city | 5 | 1931 | 910 | 65.4% | $3,658 | 11 | 20 |
| Nottoway County | 2 | 2809 | 1169 | 29.9% | $3,381 | 6 | 20 |
| Brunswick County | 9301 | 3195 | 1445 | 26.6% | $3,341 | 6 | 20 |
| Danville city | 7 | 3346 | 1340 | 31.9% | $5,122 | 6 | 19 |
| Middlesex County | 9512 | 2720 | 1134 | 35.9% | $4,606 | 7 | 19 |
| Danville city | 2 | 4100 | 1846 | 50.1% | $4,177 | 9 | 19 |
| Buckingham County | 9301.01 | 4240 | 1674 | 21.2% | $3,399 | 6 | 19 |
| Virginia Beach city | 454.12 | 1591 | 590 | 21.5% | $5,211 | 4 | 18 |
| Shenandoah County | 402.01 | 2362 | 1015 | 22.8% | $5,040 | 6 | 18 |
| Accomack County | 905 | 2310 | 1015 | 39.8% | $3,243 | 6 | 18 |
| Danville city | 1 | 5543 | 2545 | 35.4% | $4,487 | 8 | 17 |
| Franklin County | 201.01 | 5026 | 2274 | 20.5% | $3,734 | 4 | 17 |
| Brunswick County | 9303 | 5168 | 2134 | 26.9% | $3,570 | 6 | 17 |
| Halifax County | 9303.01 | 2521 | 1019 | 24.5% | $3,544 | 6 | 17 |
| Halifax County | 9302.01 | 4560 | 1802 | 39.4% | $3,430 | 7 | 17 |
| Halifax County | 9301 | 3116 | 1131 | 31.2% | $3,402 | 7 | 17 |
| Charlotte County | 9303 | 3782 | 1350 | 25.4% | $3,370 | 6 | 17 |

| County | Census Tract | Pop. (2018) | Housing Units | PCT HU < 80 AMI | AAEC | AEB (All Households | AEB (AMI < 80) |
|---|---|---|---|---|---|---|---|
| Rockbridge County | 9302 | 4045 | 1682 | 44.3% | $3,280 | 5 | 17 |
| Mecklenburg County | 9303 | 3487 | 1104 | 30.0% | $3,262 | 5 | 17 |
| Westmoreland County | 101 | 4729 | 2079 | 32.0% | $4,051 | 5 | 16 |
| Lancaster County | 301 | 3230 | 1454 | 41.9% | $3,900 | 6 | 16 |
| Northumberland County | 201 | 3672 | 1636 | 34.1% | $3,713 | 6 | 16 |
| Accomack County | 902 | 5960 | 2563 | 25.8% | $3,702 | 7 | 16 |
| Lunenburg County | 9301 | 5602 | 1726 | 35.1% | $3,481 | 7 | 16 |
| Mecklenburg County | 9308 | 4032 | 1458 | 34.2% | $3,461 | 6 | 16 |
| Buckingham County | 9302.01 | 5412 | 1247 | 28.6% | $3,451 | 6 | 16 |
| Middlesex County | 9511 | 2589 | 1163 | 42.4% | $3,385 | 6 | 16 |
| Mecklenburg County | 9301.01 | 3063 | 1114 | 25.0% | $3,356 | 6 | 16 |
| Northampton County | 9303 | 4093 | 1830 | 38.0% | $3,171 | 5 | 16 |
| Charlotte County | 9301 | 5322 | 2058 | 37.4% | $3,154 | 6 | 16 |
| Accomack County | 908 | 3609 | 1348 | 30.1% | $3,141 | 6 | 16 |
| Brunswick County | 9302.01 | 2126 | 742 | 37.7% | $3,126 | 7 | 16 |
| Halifax County | 9302.02 | 2293 | 970 | 30.1% | $3,109 | 6 | 16 |
| Mecklenburg County | 9304 | 5248 | 2000 | 43.0% | $3,098 | 7 | 16 |
| Scott County | 303 | 3104 | 1271 | 24.7% | $3,069 | 7 | 16 |
| Lee County | 9504 | 2616 | 1050 | 35.9% | $2,710 | 7 | 16 |
| Franklin County | 201.02 | 2691 | 1193 | 16.8% | $4,294 | 4 | 15 |
| Northumberland County | 203 | 5645 | 2656 | 31.9% | $3,910 | 4 | 15 |
| Surry County | 8601 | 2779 | 1233 | 42.0% | $3,769 | 6 | 15 |
| Southampton County | 2005 | 3704 | 1494 | 27.4% | $3,651 | 5 | 15 |
| Southampton County | 2001 | 4110 | 1650 | 28.5% | $3,502 | 6 | 15 |
| Prince Edward County | 9303 | 7124 | 2089 | 27.3% | $3,486 | 5 | 15 |
| Southampton County | 2002 | 2613 | 1007 | 31.5% | $3,480 | 5 | 15 |
| Suffolk city | 753.02 | 2402 | 973 | 28.7% | $3,441 | 4 | 15 |
| Middlesex County | 9510 | 3601 | 1511 | 34.9% | $3,408 | 5 | 15 |
| Pittsylvania County | 103 | 3964 | 1777 | 23.9% | $3,298 | 6 | 15 |
| Halifax County | 9304 | 3854 | 1469 | 24.4% | $3,296 | 5 | 15 |
| Buckingham County | 9302.02 | 4425 | 1689 | 21.4% | $3,264 | 5 | 15 |
| Buckingham County | 9301.02 | 2927 | 1217 | 27.9% | $3,256 | 7 | 15 |
| Accomack County | 903 | 2527 | 1021 | 36.9% | $3,208 | 5 | 15 |
| Nottoway County | 3 | 7300 | 2471 | 36.0% | $3,198 | 6 | 15 |
| Pittsylvania County | 107 | 1603 | 685 | 24.5% | $3,163 | 6 | 15 |
| Charlotte County | 9302 | 2991 | 1135 | 35.3% | $2,977 | 6 | 15 |
| Halifax County | 9303.02 | 4231 | 1974 | 28.3% | $2,935 | 5 | 15 |
| Accomack County | 906 | 3693 | 1875 | 35.1% | $2,896 | 5 | 15 |
| Northampton County | 9301 | 4386 | 1833 | 38.8% | $2,893 | 5 | 15 |
| Halifax County | 9306 | 5071 | 2076 | 45.5% | $2,882 | 6 | 15 |
| Russell County | 303 | 3778 | 1535 | 29.8% | $2,584 | 6 | 15 |

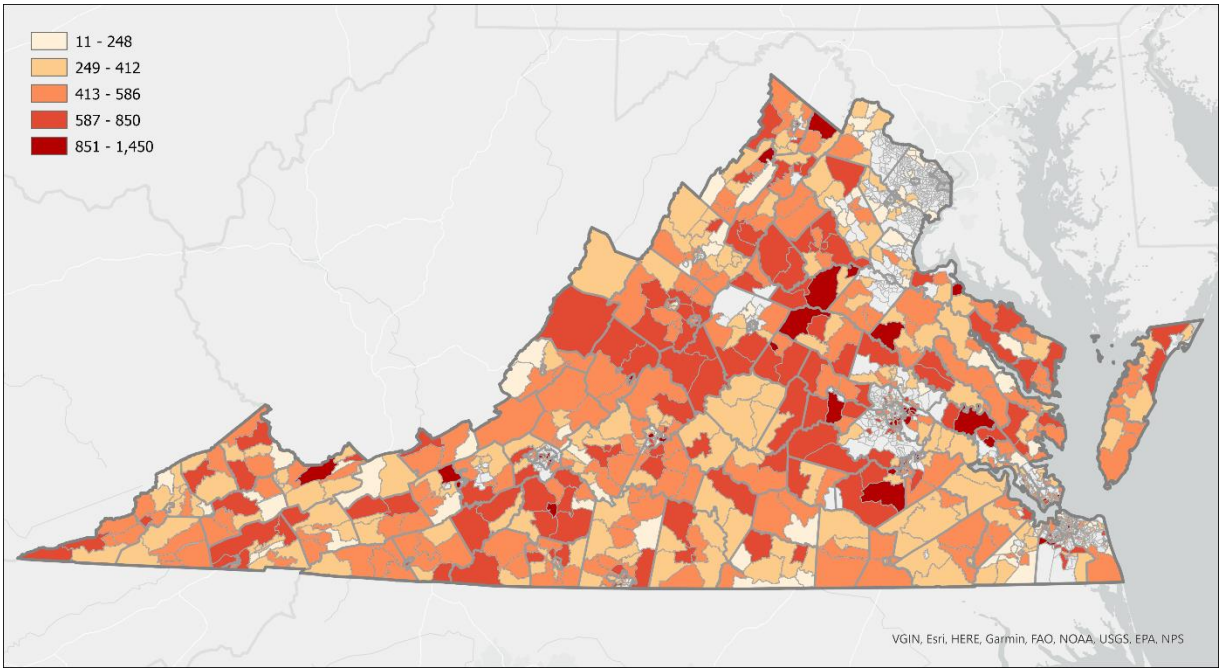
# Appendix C. Energy Burden Maps – Single and Multi-Family Homes

**Map A-1. Average Energy Burden of Single-Family Low Income (below 80% AMI) Households by Census Tract in 2018**



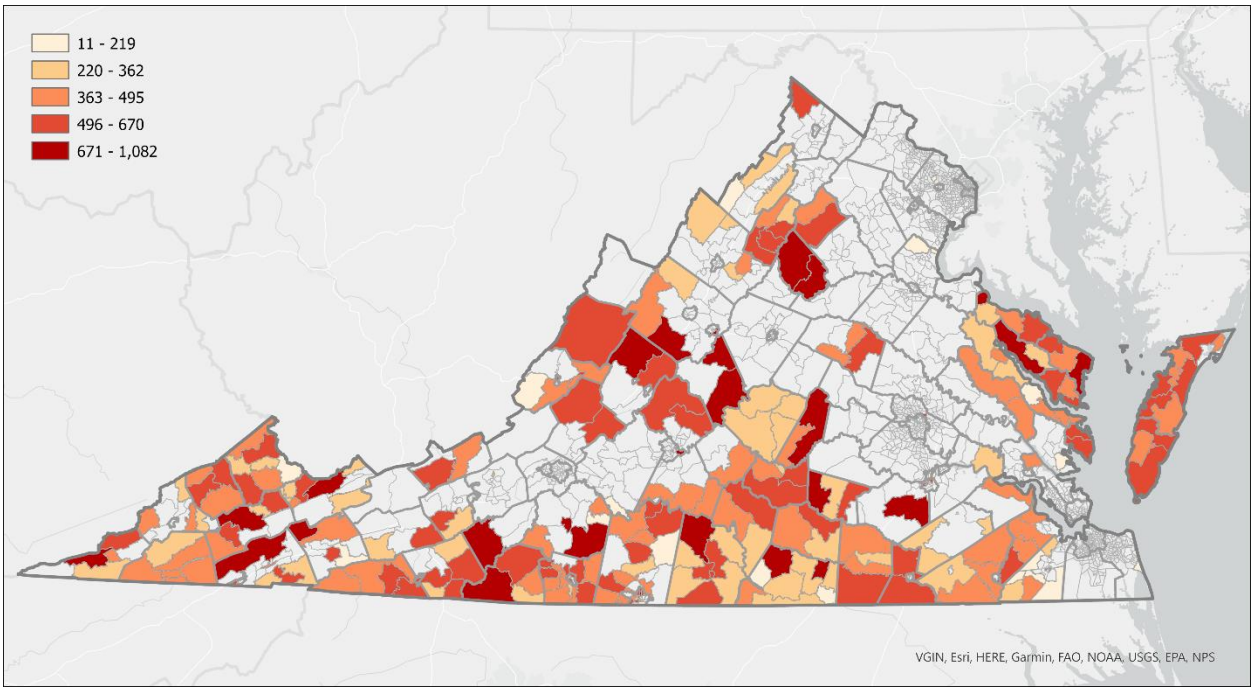

*Source: Low-Income Energy Affordability Data (LEAD), US Department of Energy*

**Map A2. Single-Family Housing Units (435,796) of High Energy Burden (above 6%) and Low Income (below 80% AMI) by Census Tract in 2018**



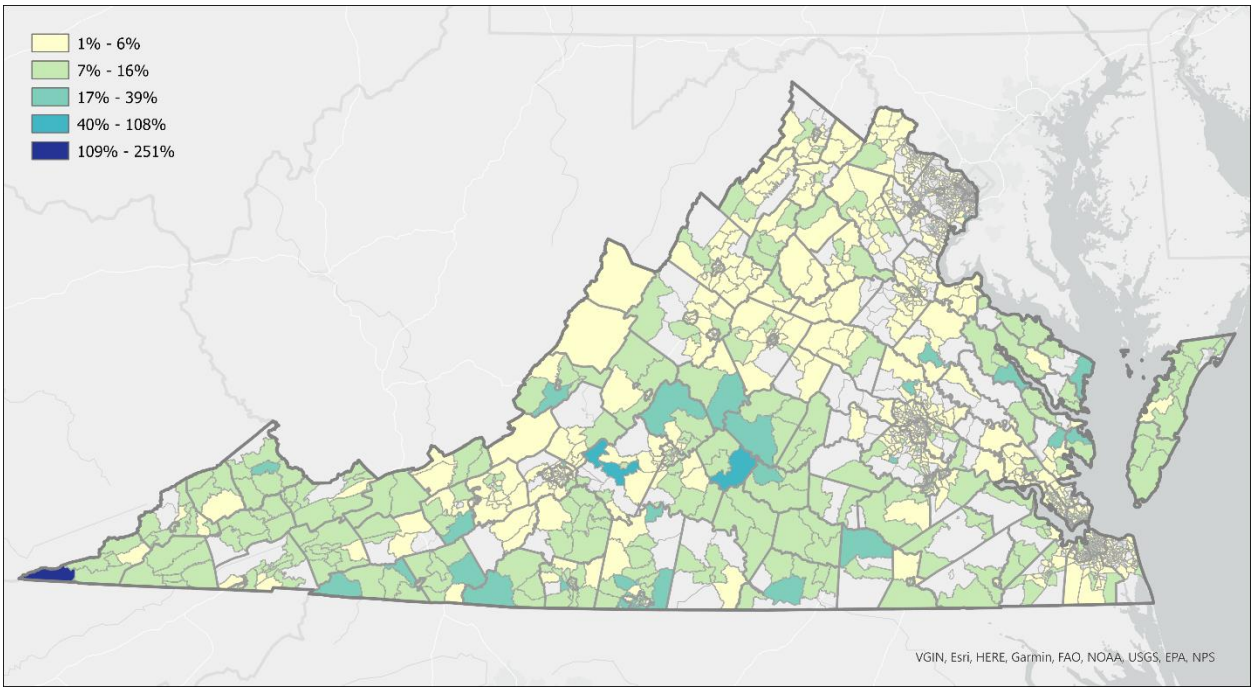

*Source: Low-Income Energy Affordability Data (LEAD), US Department of Energy*

**Map A3. Single-Family Housing Units (128,979) of Severe Energy Burden (above 10%) and Low Income (below 80% AMI) by Census Tract in 2018**



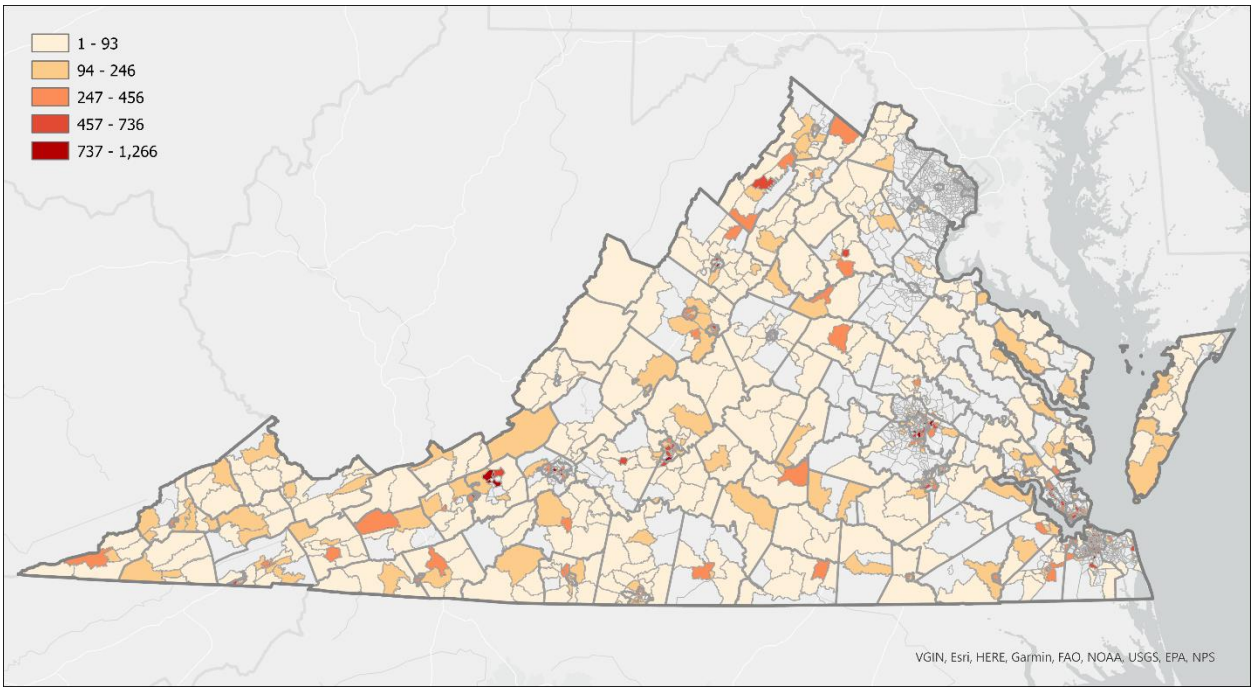

*Source: Low-Income Energy Affordability Data (LEAD), US Department of Energy*

**Map A4. Average Energy Burden of Multi-Family Low Income (below 80% AMI) Households by Census Tract in 2018**



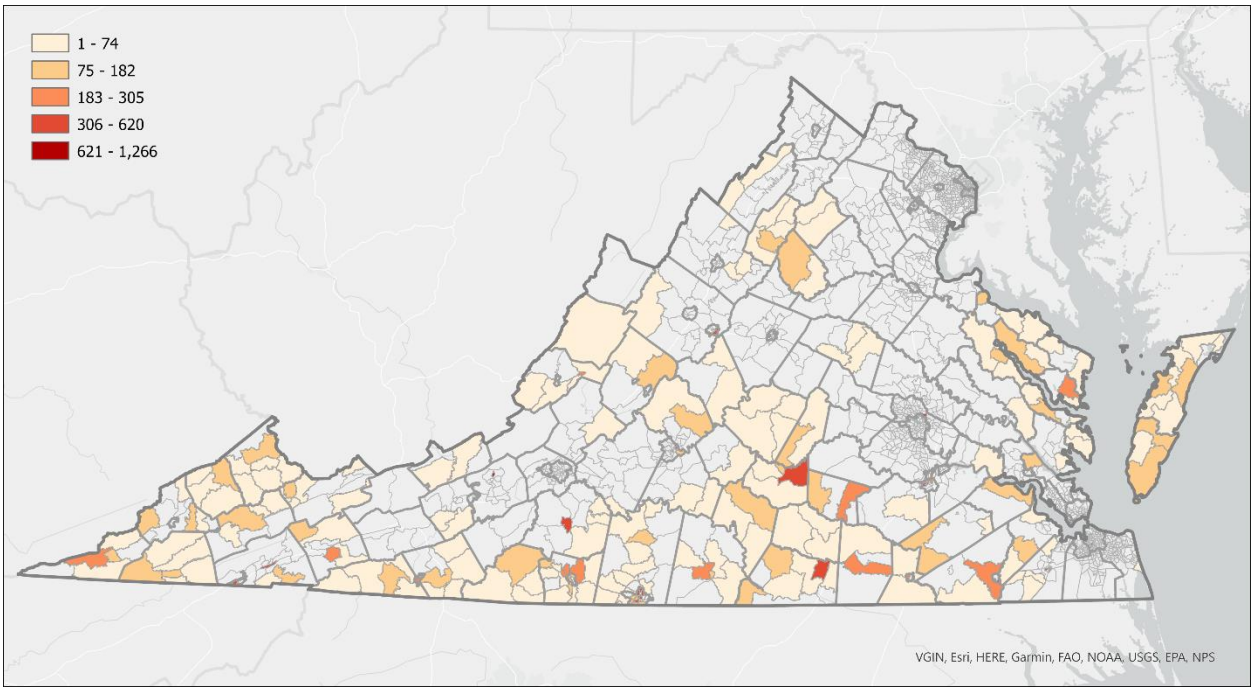

*Source: Low-Income Energy Affordability Data (LEAD), US Department of Energy*

**Map A5. Multi-Family Housing Units (143,195) of High Energy Burden (above 6%) and Low Income (below 80% AMI) by Census Tract in 2018**




*Source: Low-Income Energy Affordability Data (LEAD), US Department of Energy*

**Map A6. Multi-Family Housing Units (25,160) of Severe Energy Burden (above 10%) and Low Income (below 80% AMI) by Census Tract in 2018**




*Source: Low-Income Energy Affordability Data (LEAD), US Department of Energy*

## Appendix D. Data Tables for HIEE Program Modeling

Tables A.2 and A.3 below demonstrate the detailed calculations for the total number of low-income housing units, listed in Table 7, that could receive energy efficiency upgrades under our Low and High RGGI / HIEE revenue scenarios, respectively. The Total HIEE Revenue column is equal to half of Virginia's actual RGGI revenue in 2021-2022, and projected revenue for 2023-2030 (Low and High scenarios), per the process outlined in Section 4.2 and summarized in Table 6. The HIEE revenue totals for 2022 include the $11.4 million deduction from that year's HIEE budget and transferred to the Hurley flood relief fund.

As described in Section 4.2.1, we assume an overall HIEE funding distribution of 85% to ASNH-EE projects, 12.75% to WDR-Single-Family projects, and 2.25% to WDR-Multi-Family projects, which is consistent with the actual HIEE funding distributions to-date. The Total HIEE Revenue values, multiplied by those percentages, produce the values listed in the respective "Budget by Project Types" columns.

The average costs per unit for 2021-2022 are based on our calculations of the actual costs per unit for each HIEE project type, based on available DHCD data. For each subsequent year the average costs per unit are increased by 3%. Dividing the Budget by Project Type values by the Average Cost per Unit values produces the "Potential Units Funded" totals for each HIEE project type.

Table A.4. shows our detailed calculations for the reduced energy consumption and customer bill savings that would result from the energy efficiency upgrades calculated for each revenue scenario. The total units match the values found in Tables A.2 and A.3. The Energy Savings per Unit are based on research findings reported by the Virginia Center for Housing Research at Virginia Tech. Customer bill savings are based on Virginia's average electricity rate of $0.12 / kWh in 2021, increased by 2.17% per year in ensuing years, consistent with the statewide trend from 2002-2021.

**Table A.2. Housing Model Details – Low Revenue Scenario**

| Year | Total HIEE Revenue ($Million) | Budget by Project Types | | | Average Cost per Unit | | | Potential Units Funded | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | ASNH-EE | WDR-SFH | WDR – MFH | ASNH-EE | WDR-SFH | WDR – MFH | ASNH-EE | WDR-SFH | WDR – MFH |
| 2021 | $113.82 | $96.75 | $14.51 | $2.56 | $12,190 | $13,260 | $2,170 | 7,936 | 1,094 | 1,180 |
| 2022 | $138.00* | $117.30 | $17.60 | $3.11 | $12,190 | $13,260 | $2,170 | 9,623 | 1,327 | 1,431 |
| 2023 | $150.88 | $119.09 | $17.86 | $3.15 | $12,556 | $13,658 | $2,235 | 9,485 | 1,308 | 1,410 |
| 2024 | $152.13 | $111.50 | $16.72 | $2.95 | $12,932 | $14,068 | $2,302 | 8,622 | 1,189 | 1,282 |
| 2025 | $153.13 | $104.21 | $15.63 | $2.76 | $13,320 | $14,490 | $2,371 | 7,824 | 1,079 | 1,163 |
| 2026 | $153.85 | $97.23 | $14.58 | $2.57 | $13,720 | $14,924 | $2,442 | 7,086 | 977 | 1,054 |
| 2027 | $191.80 | $112.55 | $16.88 | $2.98 | $14,132 | $15,372 | $2,516 | 7,964 | 1,098 | 1,184 |
| 2028 | $193.74 | $105.57 | $15.84 | $2.79 | $14,555 | $15,833 | $2,591 | 7,253 | 1,000 | 1,078 |
| 2029 | $195.40 | $98.86 | $14.83 | $2.62 | $14,992 | $16,308 | $2,669 | 6,594 | 909 | 981 |
| 2030 | $196.73 | $92.43 | $13.86 | $2.45 | $15,442 | $16,797 | $2,749 | 5,986 | 825 | 890 |
| **Total** | **$1,639** | **$1,055** | **$158.32** | **$27.94** | **NA** | **NA** | **NA** | **78,373** | **10,806** | **11,653** |

## Table A.3. Housing Model Details – High Revenue Scenario

| Year | Total HIEE Revenue ($Million) | Budget by Project Types | | | Average Cost per Unit | | | Potential Units Funded | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | ASNH-EE | WDR-SFH | WDR – MFH | ASNH-EE | WDR-SFH | WDR – MFH | ASNH-EE | WDR-SFH | WDR – MFH |
| 2021 | $113.82 | $96.75 | $14.51 | $2.56 | $12,190 | $13,260 | $2,170 | 7,936 | 1,094 | 1,180 |
| 2022 | $138.00* | $117.30 | $17.60 | $3.11 | $12,190 | $13,260 | $2,170 | 9,623 | 1,327 | 1,431 |
| 2023 | $150.88 | $128.25 | $19.24 | $3.39 | $12,556 | $13,658 | $2,235 | 10,214 | 1,408 | 1,519 |
| 2024 | $152.13 | $129.31 | $19.40 | $3.42 | $12,932 | $14,068 | $2,302 | 9,999 | 1,379 | 1,487 |
| 2025 | $153.13 | $130.16 | $19.52 | $3.45 | $13,320 | $14,490 | $2,371 | 9,772 | 1,347 | 1,453 |
| 2026 | $153.85 | $130.77 | $19.62 | $3.46 | $13,720 | $14,924 | $2,442 | 9,532 | 1,314 | 1,417 |
| 2027 | $191.80 | $163.03 | $24.45 | $4.32 | $14,132 | $15,372 | $2,516 | 11,536 | 1,591 | 1,715 |
| 2028 | $193.74 | $164.68 | $24.70 | $4.36 | $14,555 | $15,833 | $2,591 | 11,314 | 1,560 | 1,682 |
| 2029 | $195.40 | $166.09 | $24.91 | $4.40 | $14,992 | $16,308 | $2,669 | 11,078 | 1,528 | 1,647 |
| 2030 | $196.73 | $167.22 | $25.08 | $4.43 | $15,442 | $16,797 | $2,749 | 10,829 | 1,493 | 1,610 |
| **Total** | **$1,639** | **$1,394** | **$209.03** | **$36.89** | **NA** | **NA** | **NA** | **101,833** | **14,041** | **15,141** |

## Table A.4. Energy Savings Model Details

| Low Scenario | Total Units | Energy Savings / Unit (MMBTU) | Total Energy Savings (MMBTU) | Total Energy Savings (MWH) | Total Bill Savings ($Millions) | Energy Savings per Unit (kWh) | Bill Savings per Unit ($) |
|---|---|---|---|---|---|---|---|
| ASNH-EE | 78,373 | 13.97 | 1,094,485 | 320,775 | $48.12 | 4,093 | $613.94 |
| WDR - SFH | 10,806 | 37.10 | 400,903 | 117,498 | $17.62 | 10,873 | $1,631.01 |
| WDR - MFH | 11,653 | 4.80 | 55,934 | 16,393 | $2.46 | 1,407 | $211.02 |
| **Totals** | **100,832** | **NA** | **1,551,322** | **454,666** | **$68.20** | **4,509** | **$676.37** |
| | | | | | | | |
| **High Scenario** | **Total Units** | **Energy Savings / Unit (MMBTU)** | **Total Energy Savings (MMBTU)** | **Total Energy Savings (MWH)** | **Total Bill Savings ($Millions)** | **Energy Savings / Unit (kWh)** | **Bill Savings / Unit ($)** |
| ASNH-EE | 101,833 | 13.97 | 1,422,105 | 416,795 | $62.52 | 4,093 | $613.94 |
| WDR - SFH | 14,041 | 37.10 | 520,921 | 152,673 | $22.90 | 10,873 | $1,631.01 |
| WDR - MFH | 15,141 | 4.80 | 72,677 | 21,300 | $3.20 | 1,407 | $211.02 |
| **Totals** | **131,015** | **NA** | **2,015,703** | **590,769** | **$88.62** | **4,509** | **$676.37** |