North Carolina Energy Burdens & Affordability

Issue Brief
October 2023

Introduction

Energy affordability and access to clean energy have profound implications on human health and quality of life. How energy needs are met at home fundamentally impacts household budgets and the health of people who live there. Roughly one in ten American households report keeping their home at an unhealthy or unsafe temperature due to the inability to afford their energy bills.[1] Conversely, when households use energy beyond what they can afford, they often face difficult tradeoffs in paying for other goods and services. One in five American households forgoes or reduces the use of vital necessities such as food or medicine to make sure they can pay their energy bills.[2]

Energy cost burden is defined as the percentage of household gross income spent on home energy bills. Typically, energy cost burdens above six percent of income are considered high.[3] As a metric, household energy cost burden helps us compare energy affordability and energy equity disparities across different populations and geographic areas. It is also a key indicator of energy insecurity—the inability of a household to meet their basic energy needs.[4]

In this issue brief, we look at the distribution of energy cost burdens in North Carolina: across geographic areas, socioeconomic groups, fuel types, housing types, demographic characteristics, and utility service territories. Analyzing energy cost burdens in geographic and demographic detail is critical for understanding the scope of energy equity within the state. It is also essential for identifying the characteristics of communities and populations who may struggle to pay their energy bills and for determining priority communities, demographic groups, housing types, or utility service territories where policy interventions such as bill relief and targeted clean energy interventions are needed the most.

1 *U.S. Energy Information Administration. "Today in Energy" September 2018*. https://www.eia.gov/todayinenergy/detail.php?id=37072
2 *U.S. Energy Information Administration. "Today in Energy" September 2018*. https://www.eia.gov/todayinenergy/detail.php?id=37072
3 The 6 percent threshold is derived from combining a 1981 amendment to the 1969 Housing and Urban Development Act, which states that housing costs, including utility bills, should not exceed 30 percent of gross income, with a conventional rule of thumb that energy-related expenses should not exceed 20 percent of housing costs.
4 *Hernández D. (2013). Energy Insecurity: A Framework for Understanding Energy, the Built Environment, and Health Among Vulnerable Populations in the Context of Climate Change. American Journal of Public Health, 103(4), e32–e34.* https://doi.org/10.2105/AJPH.2012.301179

This brief is structured to first investigate statewide trends in energy affordability, then specifically for customers of North Carolina electric cooperatives, and lastly the potential of interventions that can reduce the energy bills of electric cooperative customers. Electric cooperatives are utilities that are owned by their customers while municipal utilities are publicly owned, typically by local governments, and investor-owned utilities are privately owned. There are multiple reasons to specifically highlight electric cooperatives. First, they are accountable solely to their members in contrast to profit-driven investor-owned utilities. Second, their members are typically the most geographically difficult to reach in rural areas. Third, due to their relatively smaller sizes compared to other types of utilities, each cooperative has limited capacity to perform their own studies of affordability. In addition to the analysis shared here, we also provide companion co-op specific fact sheets summarizing affordability challenges for each of the electric cooperatives in North Carolina.[5]

To quantify energy affordability, we simulate a portfolio of household energy spending broken down by end use and fuel type by expanding on previous models and methods.[6,7] Our household-level energy-use model relies on data from the American Community Survey,[8] the EIA Residential Energy Consumption Survey,[9] the American Housing Survey,[10] and climate datasets. Merging modeled energy use values with local energy rates provides simulated energy bills for all households in North Carolina and across the various utility service territories. Estimates shown here represent a best attempt to model affordability without access to private data.[11]

In addition to energy cost burden, we also look at another key metric of energy equity—the **energy affordability gap.**[12] This gap is defined as the residential energy expenditures in excess of six percent of gross income paid annually by energy-cost-burdened households. As such, the energy affordability gap measures the total annual cost needed to achieve affordable energy bills for all households across a certain territory or population and helps quantify the scale of energy inequity.

Together, the energy cost burden and the energy affordability gap metrics provide complementary information critical for developing effective policies and programs tailored towards specific communities or geographic areas. This issue brief also provides a baseline against which the effectiveness of future energy equity initiatives and energy affordability policies in North Carolina can be evaluated.

Statewide Energy Affordability Landscape

Our analysis of energy affordability in North Carolina includes the most commonly used residential energy fuels—electricity, natural gas, propane, fuel oil, and wood—as well as the most common residential end uses—space heating, space cooling, water heating, and appliances.

5 The reference fact sheets can be found at: https://equityfund.egnyte.com/fl/PhM95yPDip

6 *Min J., Zeke Hausfather, and Qi Feng Lin. "A High-Resolution Statistical Model of Residential Energy End Use Characteristics for the United States." Journal of Industrial Ecology. October 2010.* https://doi.org/10.1111/j.1530-9290.2010.00279.x

7 *Jones, C. and Kammen, D. M. "Spatial Distribution of US Household Carbon Footprints Reveals Suburbanization Undermines Greenhouse Gas Benefits of Urban Population Density." Environmental Science & Technology 48.2 (2014): 895-902.* https://doi.org/10.1021/es4034364

8 U.S. Census Bureau. "American Community Survey." Available at: www.census.gov/programs-surveys/acs

9 U.S. Energy Information Administration. "Residential Energy Consumption Survey 2015." Available at: www.eia.gov/consumption/residential/data/2015/

10 U.S. Census Bureau. www.census.gov/programs-surveys/ahs.html

11 A major methodological challenge is the assignment of customers to utilities when utility service territories overlap. We randomly assign customers to utilities based on where they live while prioritizing customers in rural census tracts for co-ops and customers in urban census tracts for municipal utilities .

12 The concept was introduced by Fisher, Sheehan, and Colton, who have provided estimates of the energy affordability gaps down to the county level across the U.S. for years. Fisher, Sheehan, and Colton: Home Energy Affordability Gap. http://www.homeenergyaffordabilitygap.com/

Several indicators that characterize energy affordability are mapped in **Figure 1**. Average household energy costs by county are shown in **Figure 1a**. The majority of households in North Carolina pay annual energy bills within the $1,500 – $3,000 range, although many individual households experience higher or lower energy costs that sometimes fall well outside of that range.

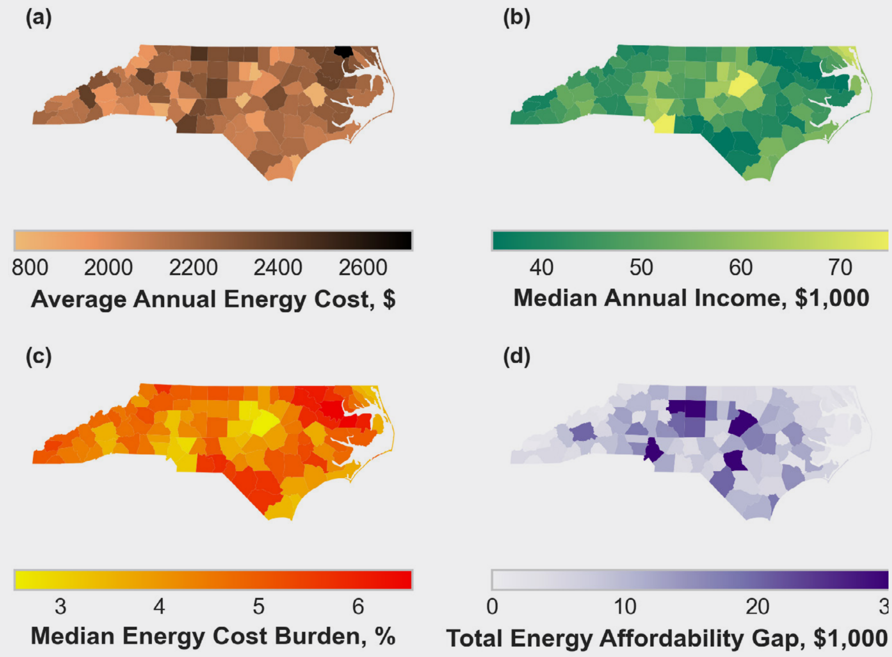


Figure 1: Energy affordability statistics by county.

By definition, variations in energy cost burden are dependent on differences in energy expenses and differences in incomes. Because household incomes vary more than energy expenses, they are the main determinant of energy cost burden. The map of median household income by county (**Figure 1b**) is thus closely related to the map of median household energy cost burden by county (**Figure 1c**). The highest median household incomes are in Wake and Union counties, which experience some of the lowest energy cost burdens in the state. In contrast, the highest energy cost burdens are in rural areas in southern and eastern North Carolina where median household incomes tend to be substantially lower than in other parts of the state.

The energy affordability gap by county is mapped in **Figure 1d**. Counties with high energy cost burden and greater populations have significantly larger energy affordability gaps. The affordability gap metric helps us quantify the financial magnitude of the energy affordability challenge for each county and the associated scale of potential bill assistance or energy savings needed to help household budgets.

Energy Affordability and Income

Income inequality is the primary driver of energy cost burden disparities. **Figure 2** shows the distribution of energy cost burdens across households with gross incomes below 200 percent of the federal poverty level (FPL) broken down into five different income brackets. Households with incomes below twice the FPL are typically characterized as low- to moderate-income (LMI).

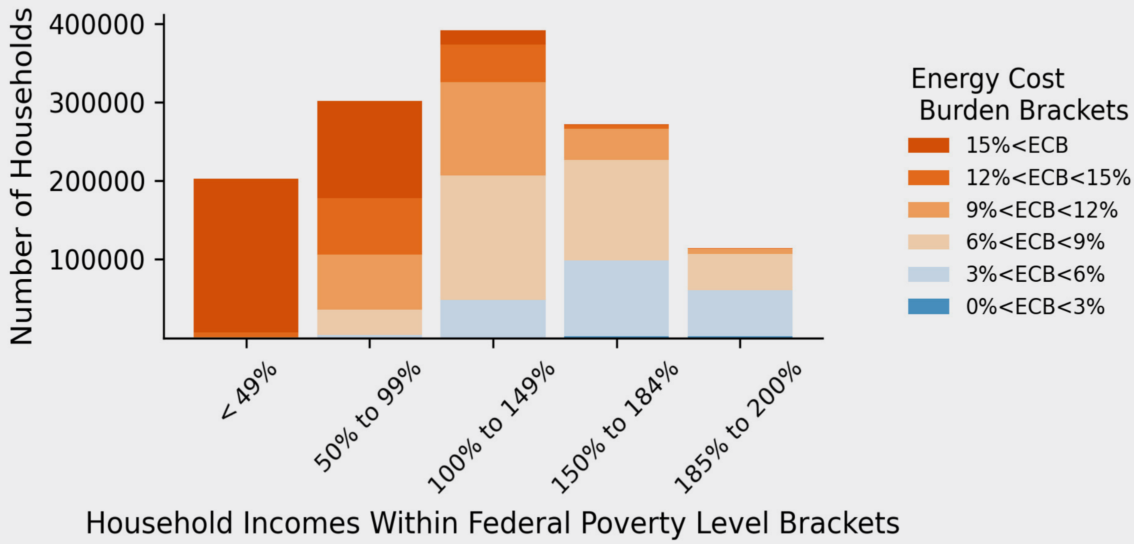


Figure 2: Number of households within federal poverty income brackets colored by their energy cost burden level.[1]

1 Energy cost burdens are calculated by dividing household energy expenses by income and exclude any potential income redistribution via after-tax transfers, bill assistance, and others.

We estimate that approximately *1.3 million* households in North Carolina, or nearly one third of the population, are low- to moderate-income. The vast majority of these households—over 80 percent—experience energy cost burdens above the six percent threshold. Over *500,000* of these households live below the federal poverty line—a staggering number. Virtually all of these households are energy-cost-burdened, and the vast majority experience extremely high energy cost burdens above 10 percent of income.

The energy affordability gap metric can capture the cumulative financial magnitude of the energy affordability challenge in the state. Our estimates indicate that North Carolina's energy affordability gap in 2021 was approximately *$900 million.* **Figure 3** shows that the energy affordability gap is largest for the two lowest income brackets, even though the number of households in these brackets is smaller than in some of the higher income brackets (see **Figure 2**).

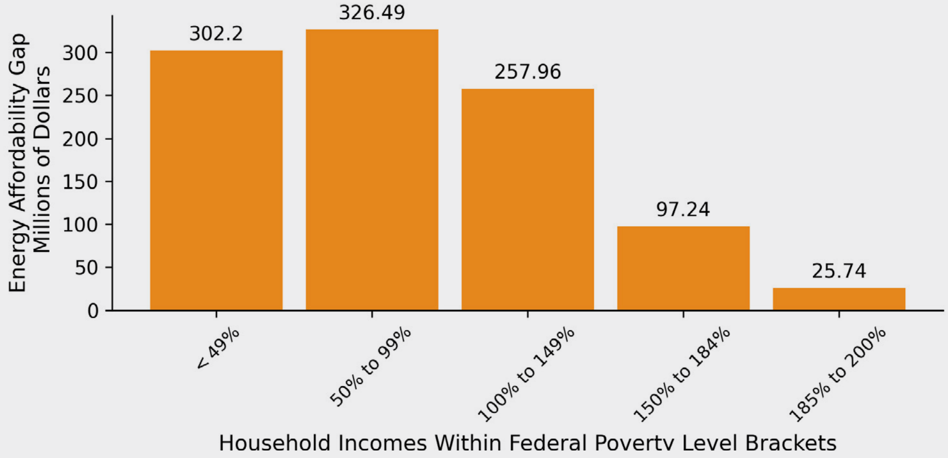


Figure 3: Energy affordability gap by federal poverty income bracket.

On average, a greater proportion of the energy bills of low-income, high-energy-burdened households must be paid down in order to reach the six percent affordability threshold. The total energy affordability gap thus represents the annual funds needed (e.g. in the form of bill assistance or similar policy interventions) to ensure that no LMI household spends more than six percent of their income on residential energy needs.

Energy Cost Burden and Fuel Type

The above analysis reveals the extent to which the lowest income households in North Carolina are disproportionately impacted by high energy cost burdens. These disparities exist despite the fact that LMI households tend to consume less energy on average.[13,14] However, while some households with lower than average energy bills may have high energy cost burdens due to very low incomes, other households may have high energy cost burdens due to higher than average annual energy bills.

Variations in energy bills are driven by diverse causes that function together in complicated ways. Some of these factors include heating fuel types and price, home type, home quality and age, renter vs. owner status, appliance efficiency, and demographics, amongst others. High energy bills and the best ways to reduce them are thus dependent on where a household lives, their energy consumption, and how they source their energy.

Table 1 shows the percentage of households in North Carolina using various heating fuel types, the respective median income and median energy cost burden by fuel type, and the average fuel prices. In 2021, natural gas was the most affordable fuel per unit energy (other than wood), propane was the most expensive *fossil* fuel per unit energy, and electricity was by far the most expensive heating fuel per unit energy overall. However, care should be taken in comparing these fuels based only on the cost per unit energy, as this does not provide

13 Krieger, E., B. Lukanov, A. McPhail, A. Smith, and A. Dillon. (2020). Equity-Focused Climate Strategies for Colorado: Socioeconomic and Environmental Health Dimensions of Decarbonization. *PSE Healthy Energy.*

14 LMI homes tend to be smaller and thus require less energy to heat. However, LMI homes may use more energy *per square foot* because they are more often in need of energy efficiency upgrades and repairs.

the full picture of energy costs. The majority of households in North Carolina are heated by electricity, and approximately 39 percent of those households use electric resistive heating with the remaining 61 percent of households using central heat pumps.[15] North Carolina has one of the highest heat pump penetrations in the nation, which is good news as using efficient electric heat pumps can often provide the lowest heating bills, in addition to providing space cooling. However, for LMI households in North Carolina, we estimate that heat pump penetration for electrically heated homes drops from 61 percent to 46 percent.[16]

Table 1: Fraction of households, median household income, average energy cost, median energy cost burden, and average 2021 rates by fuel type.

Heating Fuel Type	Percent of Households	Median Income	Average Annual Energy Cost	Median Energy Burden	Average 2021 Rate ($/MMBtu)
Electric Resistance	25%	$40K	$2,190	5.3%	34.6
Electric Heat Pump	39%	$57K	$1,890	3.2%	34.6
Natural Gas	24%	$68K	$2,302	3.3%	12.0
Propane	7%	$53K	$2,926	5.4%	20.9
Fuel Oil	3%	$36K	$2,267	6.3%	18.6
Wood	2%	$46K	$2,000	4.2%	11.5[17]

The geographic distribution of heating fuel types in North Carolina is shown in **Figure 4**. Electricity is by far the most common heating source in the state, particularly in rural areas. Natural gas is also common in urban areas where piped gas is available, such as Charlotte, Greensboro, and Raleigh-Durham. Propane is used in rural areas in the eastern parts of the state, while fuel oil is occasionally the heating source of choice in the westernmost parts of the state.

15 Energy Information Administration. 2020 Residential Energy Consumption Survey (RECS).
16 This is the weighted percentage of electrically-heated low-income RECS respondents that use heat pumps.
17 While we use state average values for the Energy Information Administration for the price of wood, the real price varies more drastically than other fuels depending on the source of the wood. For example, some households may collect their own wood and thus pay practically nothing for space heating.

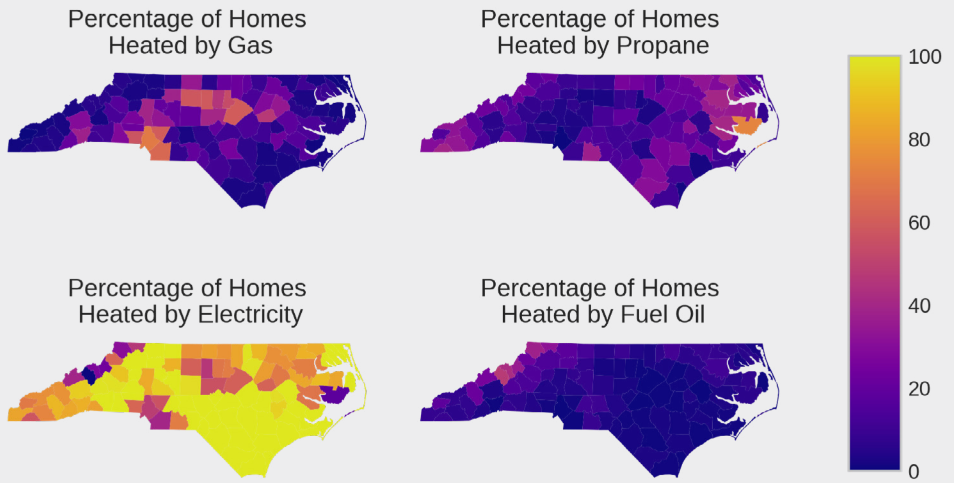


Figure 4: Geographic distribution of heating fuels in North Carolina.

Home Type and Renter Status

The type of home a household lives in is strongly correlated with energy affordability metrics. A breakdown of the average energy costs, median household incomes, median energy cost burdens, and percent renters by home type are shown in **Table 2**.

Table 2: Average annual energy costs, median household incomes, median energy cost burdens, and percent renters broken down by home type.

Home Type	Average Annual Energy Cost	Median Household Income	Median Energy Cost Burden	Percent Renters
Single Detached	$2,400	$64K	3.7%	19%
Single Attached	$1,640	$59K	2.7%	42%
Multifamily 2-4 units	$1,500	$28K	5.3%	92%
Multifamily 5+ units	$1,400	$40K	3.3%	94%
Mobile	$1,980	$36K	5.3%	37%

Households living in mobile homes and apartment buildings with 2-4 units have the highest median energy cost burdens—5.3 percent. This is driven by multiple factors including income, fuel type, geographic location, and home size, among others. We estimate that over 90 percent of households living in multifamily buildings and more than half of all LMI households in North Carolina are renters.

So far we have seen that variations in energy affordability are driven by a variety of factors that tend to work together and influence one another. To identify the populations that may benefit the most from targeted interventions, we can also visualize the size of the energy affordability gap for LMI households in North Carolina by grouping households according to multiple subcategories—for example heating fuel type and home type (**Figure 5**).

The rectangular areas in this figure are proportional to the energy affordability gap for the specific subset of households that live in a given type of home and use a given heating fuel, while the color shading represents the median household energy cost burden for the same subset of households. Figure 5 thus illustrates the interplay between the two key energy equity metrics: energy cost burden and the energy affordability gap. Large yellow blocks have lower median energy cost burdens than red ones, but the total bill assistance needs are reflected by the rectangle size.

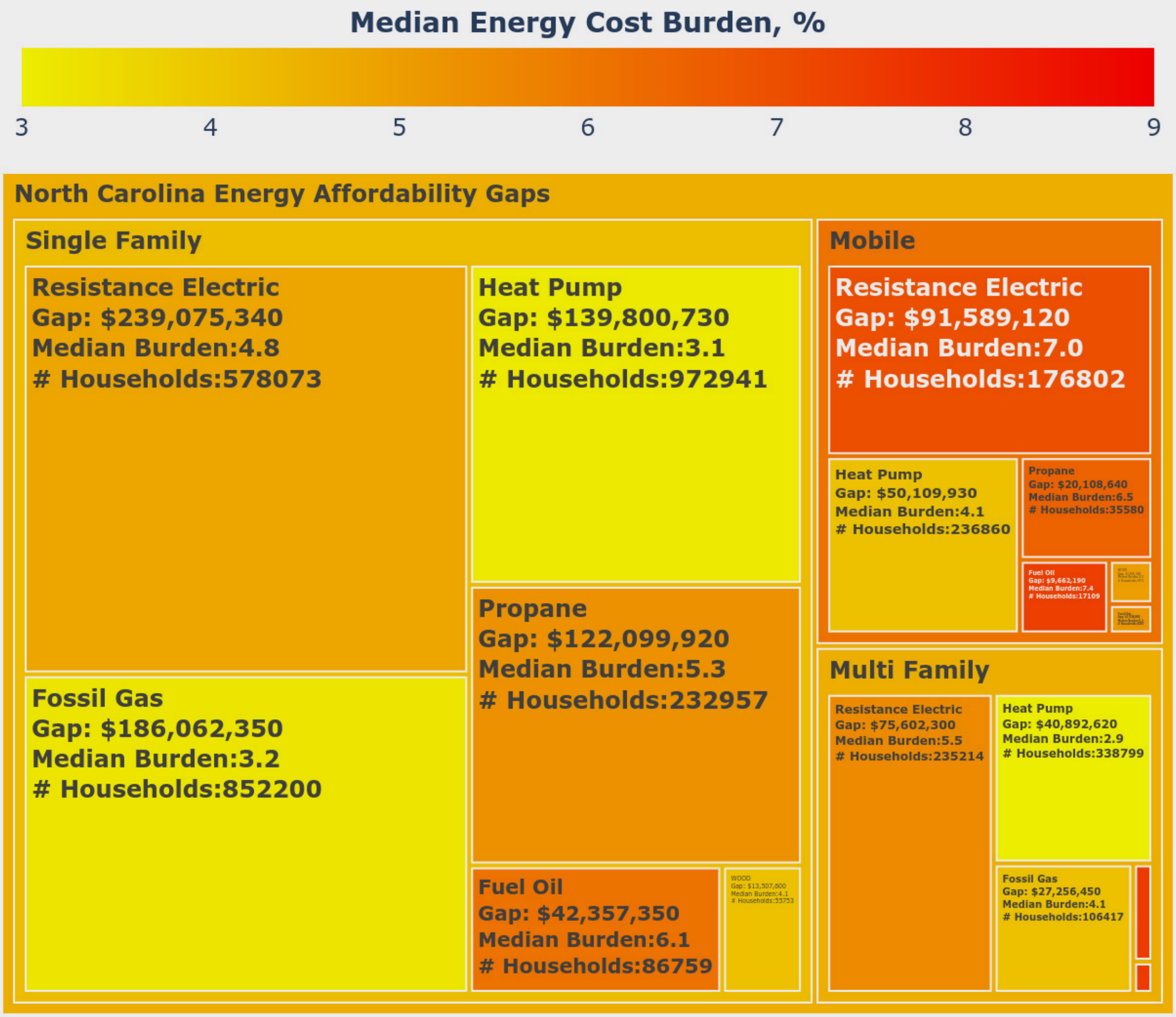


Figure 5: Treemap[1] of the breakdown of the total energy affordability gap for LMI households in North Carolina categorized by home type and fuel used for space heating. ***Color shading*** indicates the median energy cost burden and the ***rectangle size*** is proportional to the total energy affordability gap for each subset of households in that category.

1 To download this treemap for a high-resolution, zoomable version, open this **link** in a web browser, download the file, and double click the downloaded file to open it in a web browser.

As an example: for single family homes using electric resistance heating versus heat pumps, the resistance heated homes have higher energy burden, as indicated by their shading, which drives a larger affordability gap indicated by the size of their rectangle, despite the fact that there are fewer such households (~578,000 versus ~973,000). This is due to a combination of both higher uptake of heat pumps by higher income households and consequently lower energy bills due to the more efficient technology.

Race and Ethnicity

Racial demographics and home quality are two other important factors that affect energy cost burden. The median household incomes of North Carolina households identifying as White, Hispanic, and Black are $61,000, $45,000 and $38,000, respectively, with corresponding median energy cost burdens of 3.5, 4.5, and 5.0 percent. Lower income households tend to live in homes that are less energy efficient per square foot, thereby increasing energy costs, and are more likely to have problems such as mold, lead, and leaky roofs.

Energy costs tend to be disproportionately high for communities of color even when controlling for household income.[18,19,20] Systemic and structural inequities have contributed to this disparity between racial and ethnic groups, from federal government-sponsored segregation in housing, to redlining (e.g., refusing to insure mortgages in and around Black neighborhoods).[21] Because of such systemic exclusions, communities of color tend to live in less efficient and less healthy homes. These communities may experience higher costs when investing in energy efficiency upgrades and may face increased needs for home improvements to achieve the same efficiency benefit.[22,23,24]

Electric Cooperative Energy Affordability Landscape

Households in North Carolina are served by three types of utilities: investor-owned (51 percent), cooperative (33 percent), and municipal (16 percent). There were 29 separate cooperatives in the year 2021 with the largest cooperative serving just 116,000 customers, drastically smaller than the two largest investor-owned utilities which each have over one million customers. In the following analysis we highlight affordability challenges specifically facing customers in these cooperatives.

18 Kontokosta, C., V. Reina, and B. Bonczak. (2019). "Energy Cost Burdens for Low-Income and Minority Households." *Journal of the American Planning Association* 86 (1): 89–105. doi.org/10.1080/01944363.2019.1647446

19 Lyubich, E. (2020). "The Race Gap in Residential Energy Expenditures". *Energy Institute at HAAS.* WP-306

20 Krieger, E., B. Lukanov, A. McPhail, A. Smith, and A. Dillon. (2020). Equity-Focused Climate Strategies for New Mexico: Socioeconomic and Environmental Health Dimensions of Decarbonization. *PSE Healthy Energy.* https://www.psehealthyenergy.org/our-work/programs/clean-energy/western-states-deep-decarbonization/new-mexico/

21 Gross, T. (2017, May 3). A 'Forgotten History' Of How The U.S. Government Segregated America. https://www.npr.org/2017/05/03/526655831/a-forgotten-history-of-how-the-u-s-government-segregated-america

22 J. Lewis, D. Hernandez, and A. Geronimus. (2019). "Energy Efficiency as Energy Justice: Addressing Racial Inequalities through Investments in People and Places." *Energy Efficiency, 13,* 419–32. https://doi.org/10.1007/s12053-019-09820-z.

23 Reames, T. G. (2016). Targeting Energy Justice: Exploring Spatial, Racial/Ethnic and Socioeconomic Disparities in Urban Residential Heating Energy Efficiency. *Energy Policy, 97,* 549-558.

24 Reames, T.G., M. A. Reiner, and M. B. Stacey. (2018). An Incandescent Truth: Disparities in Energy-Efficient Lighting Availability and Prices in an Urban U.S. County. *Applied Energy,* 218, 95-103.

Customers of electric cooperatives pay annual home energy bills that are roughly 10 percent higher than households in the rest of the state. This is due to multiple factors. First, co-op customers are the most difficult to serve due to their rural locations and thus pay the highest average rates of 12.4 cents/kWh versus 11.5 cents/kWh in the rest of the state. However, these rates can be very different between co-ops, ranging from 11 to 16 cents/kWh as shown in **Figure 6**. Second, they rely more heavily on expensive heating fuels such as propane and fuel oil (14 percent of customers) as opposed to the rest of the state (9 percent), which is more urban and with greater access to piped gas.[25] These higher energy costs make it more difficult to pay energy bills, on average, for co-op customers.

Due in part to higher energy bills, the median energy cost burden for co-op customers is nearly 14 percent higher than in the rest of the state, as shown in **Table 3**. We estimated median incomes for the three types of utilities and found only slight differences, indicating that incomes are a smaller contributing factor to this disparity.[26] Instead, we must focus on where cost burdens are highest when both bills are high and incomes are low.

One large contributing factor toward higher energy cost burdens is a greater prevalence of co-op customers living in mobile homes (18 percent) compared to the rest of the state (12 percent). In rural areas, mobile homes are a common affordable housing option for LMI households, while in urban areas multi-family housing is more common. However, due to inefficiencies and reliance on expensive fuels, mobile homes tend to have higher energy bills than multifamily housing (see **Table 2**). This leads to greater energy burdens on low-income households in rural areas compared to urban areas.

Table 3: Number of customers and various energy affordability statistics by utility type.

Utility Type	Number of Customers	Average Annual Energy Cost	Median Energy Cost Burden	Cumulative Energy Affordability Gap	Average Electricity Price, cents/kWh	Percent Renters
Co-op	1,015,000	$2,280	4.3%	$328M	12.4	28%
Investor Owned	2,485,000	$2,110	3.6%	$615M	10.8	37%
Municipal	440,000	$2,110	3.9%	$120M	11.6	38%

25 Resistive electric heating is a more expensive form of heating, while heat pumps are often one of the most affordable methods to heat a home. However, publicly available data states only whether a home uses electricity for heating and not whether they use electric resistive heating or heat pumps. More research and data are needed to determine how many co-op customers are burdened with excessively expensive electric resistive heating.

26 Median incomes for co-ops, investor owners, and municipal customers are $52k, $54k, and $51k, respectively.

In summary, co-op customers face different challenges on average than utility customers in the rest of the state that can largely be attributed to an urban-rural divide. Moreover, these differences are likely even greater than the data here suggests due to the following gap in publicly available data: for census tracts where utility service areas overlap, which is the case for most co-ops, we cannot know which households are served by which utility in that area. However, for any given tract, the home types and demographics of those signed up to the investor-owned utility versus the co-op are likely not random. We expect that the more remote households are more likely to belong to a co-op. Despite that limitation, we still see significant differences in energy affordability that present different challenges and solutions to make energy bills more affordable to co-op customers.

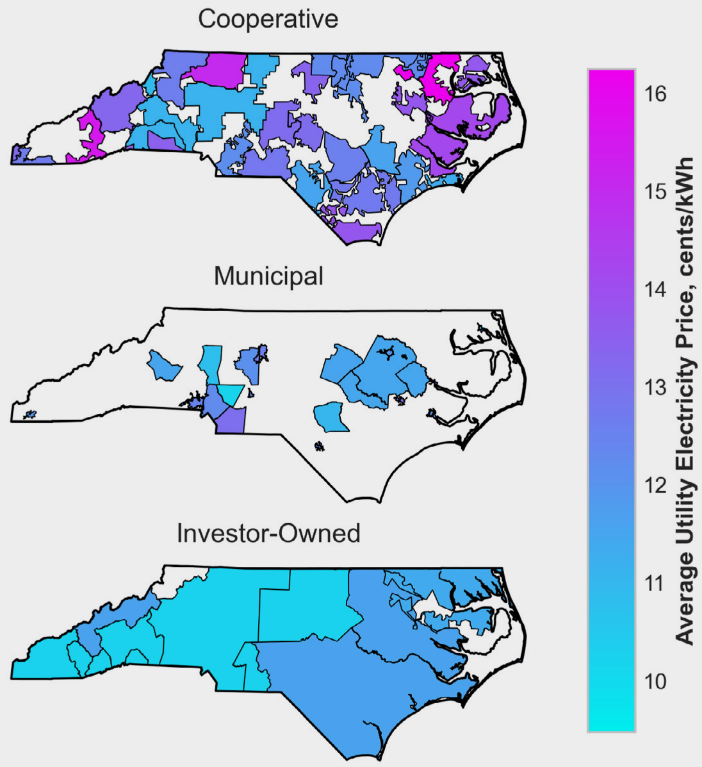


Figure 6: Average electricity rates by utility type

Key Policy Interventions and Recommendations

There are three primary ways of addressing high energy cost burdens and reducing the energy affordability gap. The first is *direct bill assistance*. The second is investments in *demand-side* energy-saving home upgrades, including energy efficiency, weatherization, heat pumps, and other clean energy technologies. The third is investing in cheaper *supply-side resources* that can lower electricity rates over time and reduce energy costs for all utility customers, not just LMI households.

Energy bill assistance

Energy bill assistance can reduce energy cost burdens immediately. Direct bill assistance payments can play a critical role in achieving energy equity goals by improving energy affordability in the short term. The federal Low Income Home Energy Assistance Program (LIHEAP) provides energy bill assistance to over five million households in the US with an annual budget of approximately $4 billion.[27] In North Carolina, the program is implemented through the state's Low-Income Energy Assistance Program (LIEAP) with an annual budget of $106 million for 2021.[28] This budget amounts to only 12 percent of the estimated $900 million annual energy

27 U.S. Department of Health and Human Services. LIHEAP ClearingHouse (2023). https://liheapch.acf.hhs.gov/Funding/funding.htm
28 https://www.acf.hhs.gov/sites/default/files/documents/ocs/COMM_LIHEAP_Second%20Funding%20ReleaseDCLAttachment%201_StatesTerrs_FY2021.pdf

affordability gap for North Carolina. In addition to insufficient funding, the program also suffers from extremely low participation rates—only 17 percent of eligible households received energy bill assistance in 2021.[29] One reason for the low participation rates may be the cumbersome documentation requirements in North Carolina, including income and social security numbers, citizenship status, lease/rental agreements, ownership and tax records, energy bills, and others.[30]

Examples from other states provide a stark contrast. The California Alternate Rates for Energy (CARE) program administered by California's investor-owned utilities has close to a 100 percent participation rate.[31] Ease of enrollment and self-attestation of income (with an audit of a small sample) is a hallmark of the California program. In Colorado, regulated utility companies are required to offer a Percent of Income Payment Plan (PIPP), which caps household energy bills at six percent.[32] Unlike lump-sum assistance programs like LIHEAP or discount rate programs like CARE, a PIPP plan has the advantage of guaranteeing that household energy bills are capped at an affordable level. *Neither co-ops, nor investor-owned and municipal utility companies in North Carolina currently offer energy bill assistance programs to their customers.*

It should be noted that while energy bill assistance can be a critical short-term lifeline for many households, it is also an inherently symptomatic treatment that does not fundamentally change the scale of the energy affordability challenge—if assistance is suddenly dropped or programs are defunded, energy cost burdens and the associated energy affordability gap would revert back to the status quo. In addition, the energy bill assistance approach does not help individual households lower their energy consumption, nor does it help achieve climate and clean energy goals, and it continues to incur persistent annual costs over time.

Demand-side investments

Demand-side investments in household energy upgrades can take time to implement but they bring about systemic long-term reductions in energy consumption that can lower energy cost burdens while simultaneously helping achieve climate goals, improve public health outcomes, and add resilience to the grid. Over time, investments in household weatherization, energy efficient appliances, and heat pumps help bring down the energy affordability gap and lower overall LMI household costs and the need for bill assistance.

29 Custom report compiled from the LIHEAP Data Warehouse at https://liheappm.acf.hhs.gov/datawarehouse
30 Low Income Energy Assistance Program, NC Department of Health and Human Services. https://www.ncdhhs.gov/divisions/social-services/energy-assistance/low-income-energy-assistance-lieap
31 Pacific Gas & Electric, Southern California Edison, San Diego Gas & Electric, and SoCalGas joint IOU report of the CARE and ESA programs. Slide deck presented at the Low Income Oversight Board Meeting, September 29, 2021, at: https://liob.cpuc.ca.gov/wp-content/uploads/sites/14/2021/09/Item-9-IOUs-Consolidated-Template-revised.pdf
32 Rules Regarding Electric Utilities 4 CCR 723-3

Because demand-side measures often require significant upfront investments, they are difficult to finance for LMI households without access to capital. On-bill financing mechanisms and grants for the lowest income households can help alleviate this problem.[33] In addition, more than half of all LMI households in North Carolina are renters, and the vast majority of these households are responsible for paying their own utility bills, creating a classic split incentive problem where renters pay for energy used while landlords are responsible for energy-saving upgrades. These and other barriers can limit access to electrification and building efficiency measures for LMI, renter, and communities of color, leading to a vastly inequitable distribution of these resources over time.

Neither co-ops, nor investor-owned and municipal utility companies in North Carolina currently offer energy bill assistance programs to their customers.

Weatherization and building efficiency can lower energy bills for LMI households by reducing overall energy consumption and the respective need for heating and cooling. Strategies include measures such as installing insulation in ceilings, walls, floors, ducts, and pipes, installing smart control systems and thermostats for heating and cooling, replacing inefficient lights and appliances, installing double-pane windows, sealing windows and doors, and others.

North Carolina implements weatherization and efficiency for LMI households through the federally funded Weatherization Assistance Program (WAP)[34] as well as the Heating and Air Repair and Replacement Program (HARRP), which works in concert with WAP.[35] Individual utilities can also run their own building efficiency programs. Both Duke Energy Progress and Duke Energy Carolinas have energy efficiency and weatherization programs geared towards low-income customers.[36] In 2019, Duke Energy Carolinas' low-income efficiency programs achieved significantly more savings for low-income customers than equivalent programs offered by Duke Energy Progress. However, other programs, such as the federal Weatherization Assistance Program, commonly achieve greater savings.[37] We are not aware of LMI weatherization programs run by individual co-ops in North Carolina.

Beneficial electrification with heat pumps can result in significant energy bill savings for most North Carolina households. Heat pumps are on average 3-4 times more efficient than conventional heating sources such as electric resistive heaters and gas/propane/fuel oil furnaces.[38] Given North Carolina's relatively mild winters, we estimate that conversion to an efficient heat pump can result in average annual heating energy savings of 66

33 Lukanov, B., A. Makhijani, K. Shetty, Y. Kinkhabwala, A. Smith, and E. Krieger. (2022). Pathways to Energy Affordability in Colorado. *PSE Healthy Energy.*
34 https://www.deq.nc.gov/energy-climate/state-energy-office/weatherization-assistance-program
35 https://www.ncdhhs.gov/divisions/social-services/energy-assistance#:~:text=Weatherization%20Assistance%20Program%20(WAP)%20and,make%20homes%20more%20energy%20efficient.
36 NCUC Docket No. E-2, Sub 1252. (2020). Direct Testimony And Exhibits Of Forest Bradley-Wright On Behalf Of The North Carolina Justice Center, North Carolina Housing Coalition, And Southern Alliance For Clean Energy. https://starw1.ncuc.gov/ncuc/ViewFile.aspx?NET2022&Id=eabde096-a281-4889-b301-5c3acba0d21c
37 Oak Ridge National Laboratory. (2015). Evaluation of the Weatherization Assistance Program During Program Years 2009-2011. Table 5.1 https://weatherization.ornl.gov/wp-content/uploads/pdf/WAPRecoveryActEvalFinalReports/ORNL_TM-2014_582.pdf
38 Lukanov, B. (2017) Heat Pumps and Their Role in a Clean Energy System. *PSE Healthy Energy.*

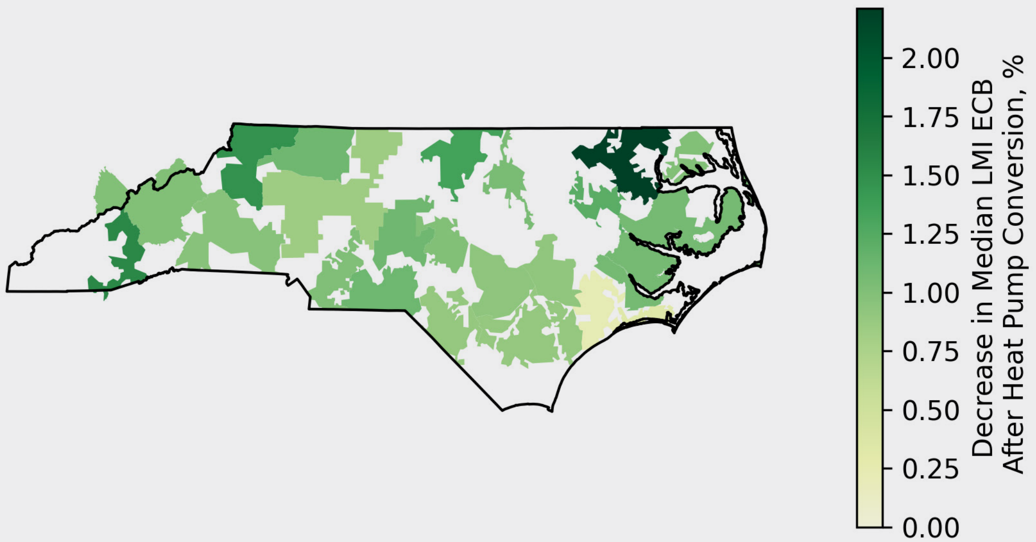
percent when replacing thermal heating sources and 60 percent when replacing resistive heating.[39] However, electricity is more expensive per unit of energy compared to fossil fuels, so bill savings for thermal generation replacements are generally lower compared with resistive heating replacements and are also dependent on local fossil fuel energy prices.

In **Figure 7**, we estimate the change in median energy cost burden for the customers of each utility co-op after conversion of all LMI households to efficient heat pumps. These impacts are driven mostly by the local electricity and gas rates, home types, reliance on propane for heating, and local climate. Most importantly, we see that all co-ops see a decline in energy cost burdens. We note that some homes with efficient gas furnaces served by piped natural gas may see an increase in energy bills from a heat pump conversion, but these households are not as common in co-ops as they are in other utility types. In addition, the benefits of heat pumps are not limited to bill-savings and peak demand reductions. Heat pumps can better control indoor humidity and provide healthier indoor air quality in humid climates like in North Carolina; they provide space cooling that many North Carolina homes currently lack—but will increasingly need as the climate warms; and they reduce the overall climate impacts of residential heating.[40]

39 This corresponds to a heat pump heating seasonal performance factor (HSPF2) of 8.5 and to efficiencies of 85 percent and 100 percent for thermal and electric resistive heating respectively.

40 *IEA, Relative CO2 emissions from the operation of air-source heat pumps compared with the most efficient condensing gas boilers by region in the Net Zero Scenario, 2010-2030, IEA,* Paris https://www.iea.org/data-and-statistics/charts/relative-co2-emissions-from-the-operation-of-air-source-heat-pumps-compared-with-the-most-efficient-condensing-gas-boilers-by-region-in-the-net-zero-scenario-2010-2030*, IEA. Licence: CC BY 4.0*

Figure 7: Estimated decrease in energy cost burden for each co-op utility after conversion of all LMI households to heat pumps. Only heating bill impacts were considered. Improved efficiency of cooling would further decrease cost burdens.



Demand Response entails financial incentives for households to reduce their energy use when energy demand is the highest. Most utility co-ops pay fees associated with the peak amount of electricity they consume, and so reducing these peaks saves both co-ops and their customers money. In 2021, at least nine electric co-ops reported customers in residential demand response programs. The biggest program, Connect to Save, spans seven co-ops and pays for the ability to reduce demand through smart thermostats and water heaters with typical annual incentives of $50.[41] Incidentally, the co-ops providing demand response are primarily in the southern part of the state where electric heating is the most prevalent. However, these programs are severely under-enrolled. Investor-owned utilities enroll approximately 20 percent of their customers while co-ops enroll only 0.6 percent of all their customers.[42] As such, we expect there is a significant potential for expanded demand response programs which can help reduce LMI energy bills.

Supply-side investments

Supply-side options can bring additional savings for LMI households. Co-ops in North Carolina are members of one of the largest generation and transmission (G&T) electric cooperatives in the nation—the North Carolina Electric Membership Corporation (NCEMC). NCEMC purchases electricity directly from wholesale markets and owns its own power generation assets, including a majority share of the Catawba Nuclear Station's Unit 1, a 13 percent share of the W.S. Lee Station combined-cycle natural gas plant, and several natural gas peaker plants and generators.[43] More than half of NCEMC's power comes from nuclear generation, which makes its energy mix relatively carbon-free compared to other parts of the country.

The costs of **utility-scale wind and solar** have declined by 40 percent and 82 percent, respectively, over the past ten years,[44,45] making them now the lowest-cost resources in many states in the US, including North Carolina. Sourcing a larger fraction of electricity from renewable energy resources, such as wind and solar, can therefore lower electricity rates for all customers. However, co-ops may sometimes be tied to long-term contracts with their respective G&T and may be restricted[46] in terms of how much solar and wind energy they can procure outside of the G&T (or face high exit fees).

41 https://marketplace.connecttosavenc.com/
42 Energy Information Administration Form EIA-861
43 https://www.ncelectriccooperatives.com/energy/our-power/
44 Wiser, R., M. Bolinger, B. Hoen, D. Millstein, J. Rand, G. Barbose, N. Darghouth, W.l. Gorman, S. Jeong, A. Mills, and B. Paulos. (2021). Land-Based Wind Market Report: 2021 Edition. *Lawrence Berkeley National Laboratory.* https://www.osti.gov/servlets/purl/1818841/
45 Feldman, D., V. Ramasamy, R. Fu, A. Ramdas, J. Desai, and R. Margolis. (2021). U.S. Solar Photovoltaic System Cost Benchmark: Q1 2020. *National Renewable Energy Laboratory.* https://www.nrel.gov/docs/fy21osti/77324.pdf
46 Co-ops may seek to incorporate more renewable generation from their contracted G&T in line with state-wide and federal targets and related compulsory policies such as Renewable Portfolio Standards or Renewable Energy Credits. An evaluation of such policies was not conducted in this analysis but should be evaluated in future research.

Distributed energy resources, such as rooftop and community solar, are another critical strategy for providing discounted electricity and reducing energy cost burdens through behind-the-meter net-energy-metering tariffs, and this impact will continue to grow as more homes are electrified. Community solar in particular can be accessible to those who do not own their own rooftops and can be a more cost-effective strategy for LMI households than rooftop installations owned by individuals.

As weather extremes become more common due to climate change, community and rooftop solar paired with energy storage systems (batteries) can provide valuable resilience benefits in vulnerable low-income rural communities.

Historically, rooftop solar has been disproportionately adopted by higher-income households due to the high upfront costs and other barriers to entry.[47,48] As a result, LMI, renter, and other disadvantaged populations have been unable to reap the bill-stability and cost-reduction benefits of rooftop solar enjoyed by higher-income, solar-adopting households, which is why we emphasize the benefits of community solar for LMI households. To date, eleven North Carolina electric cooperatives have installed 18 community solar farms totaling over two megawatts to serve their co-op members. In most cases, co-op members voluntarily purchase the energy rights of solar panels from the co-op in return for a credit on their monthly electric bill.

In addition, as weather extremes become more common due to climate change, community and rooftop solar paired with energy storage systems (batteries) can provide valuable resilience benefits in vulnerable low-income rural communities. Community solar plus storage can be used in lieu of polluting back-up generators to ensure reliable access to electricity for rural households during climate-related disasters such as heat-waves or extreme cold spells, and for households that would benefit from enhanced resilience for health reasons.

While we emphasize community solar to address the many barriers for rooftop solar adoption by LMI households and the split incentive problem for renter populations, supply-side solutions should also include **upgrading as many housing stock units to renewables as possible.** Thus, financial incentives to housing providers to upgrade their units with rooftop solar or other renewable solutions should also be considered. A full cost benefit analysis of how much subsidization and incentivization is needed would be helpful to evaluate the efficacy in NC, but is beyond the scope of this analysis.

Funding Sources for Rural Co-ops

The Inflation Reduction Act (IRA) provides significant federal funding available for rural electric cooperatives to invest in clean energy, weatherization, energy efficiency, and modernizing the grid.

47 Lukanov, B. R., and E. M. Krieger. (2019). Distributed Solar and Environmental Justice: Exploring the Demographic and Socio-Economic Trends of Residential PV Adoption in California. Energy Policy 134, 110935. https://doi.org/10.1016/j.enpol.2019.110935

48 Barbose, G., N. Darghouth, B. Hoen, and R. Wiser. *"Income Trends of Residential PV Adopters: An Analysis of household-level income estimates". April 2018.* https://eta-publications.lbl.gov/sites/default/files/income_trends_of_residential_pv_adopters_final_0.pdf

The biggest IRA program for rural co-ops is the *New Empowering Rural America Program (New ERA)*, with *9.7 billion* in funding.[49] Maximum awards amount to $970 million and can be in the form of loans (including 0% interest loans in energy communities) and grants of up to 25% of the project costs. Funds can be used to make energy efficiency improvements, build or deploy renewable energy, zero-emission systems, carbon capture storage systems, or to purchase renewable energy. Other options are also possible as the priority is greenhouse gas reductions rather than requiring the use of specific technologies.

Another federal program for rural co-ops is the *Powering Affordable Clean Energy (PACE)* program with *$1 billion* in funding.[50] This program provides partially forgivable loans for utility-scale clean energy projects. USDA's Rural Utilities Service (RUS) will forgive up to 60 percent of loans for renewable energy projects that use wind, solar, hydropower, geothermal, or biomass, as well as for renewable energy storage projects.

A third federal program aimed at helping rural areas is the *Rural Energy for America Program (REAP).*[51] This USDA program focuses on farms and small businesses, offering grants for renewable energy systems and energy efficiency projects. The maximum grants are $1 million for renewable energy and $500K for energy efficiency projects.

In addition to the programs for rural co-ops outlined above, another significant source of federal funding for LMI communities is the *Greenhouse Gas Reduction Fund (GGRF).*[52] With *$27 billion* in funding, this EPA-administered fund is the single largest IRA investment in low-income communities. It will be implemented via three grant competitions: the *$14 billion* National Clean Investment Fund, the *$6 billion* Clean Communities Investment Accelerator, and the *$7 billion* Solar for All competition.

- The *National Clean Investment Fund* will provide grants to 2–3 national nonprofit financing institutions (Green Banks) that will provide financing for clean energy projects across the country, with at least 40 percent of the capital flowing into low-income and disadvantaged communities.[53]
- The *Clean Communities Investment Accelerator* will provide grants to 2–7 hub nonprofits (Green Banks), which will deliver funding for local community lenders. 100 percent of the funds will be dedicated to low-income and disadvantaged communities.[54]
- The *Solar for All* competition will award up to 60 grants to states, Tribal governments, municipalities, and nonprofits to expand distributed rooftop and community solar adoption in low-income and disadvantaged communities.[55]

49 https://www.rd.usda.gov/programs-services/electric-programs/empowering-rural-america-new-era-program
50 https://www.rd.usda.gov/programs-services/electric-programs/powering-affordable-clean-energy-pace-program
51 https://energycommunities.gov/funding-opportunity/rural-energy-for-america-program-reap/
52 https://www.epa.gov/greenhouse-gas-reduction-fund/about-greenhouse-gas-reduction-fund
53 https://www.epa.gov/greenhouse-gas-reduction-fund/national-clean-investment-fund
54 https://www.epa.gov/greenhouse-gas-reduction-fund/clean-communities-investment-accelerator
55 https://www.epa.gov/greenhouse-gas-reduction-fund/solar-all

Finally, IRA also includes *$8.8 billion* in rebates for home energy efficiency and electrification projects:[56]

- *The High Efficiency Electric Home Rebate Act (HEEHRA)* or "Home Electrification Rebates" include *$4.5 billion* in direct rebates to low- and moderate-income households for heat pumps that will cover up to 100 percent of the installation costs.
- *The Home Owner Managing Energy Savings (HOMES)* or "Home Efficiency Rebates" include *$4.3 billion* for whole-house rebates, including upgrades like insulation, air sealing, ventilation, and others, to improve the overall energy performance of single- and multi-family buildings.

56 https://www.energy.gov/scep/home-energy-rebate-program

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