ENERGY COST BURDEN IN NYC

Understanding the Landscape of High Energy Cost Burden in New York City and Implications for Policy

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IN THE CITY OF NEW YORK

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Foreword

The Master of Public Administration in Environmental Science and Policy (MPA-ESP) trains sophisticated managers and policymakers, who apply innovative, systems-based thinking to environmental issues. Graduates join a growing profession of earth systems problem-solver: individuals prepared for leadership positions in local, state, and federal agencies, as well as in non-profits and environmental divisions of private corporations. They are also well suited for designing cost-effective programs and implementing policies. Most importantly, **a deep understanding of earth systems informs their work, allowing them to craft solutions to increasingly complex environmental problems.**

The milestone component of the MPA-ESP program educates these future environmental professionals through a process of learning by doing. Groups of 10 to 12 students are advised by a member of the faculty as they integrate their knowledge and apply management and analytical skills to solve problems for real-world clients. Through this experience, these **MPA-ESP candidates tackle cutting edge environmental and sustainability subjects, providing a free source of high quality management and policy analysis for clients** who otherwise might not have the resources to undertake such work.

Over the years, the MPA-ESP candidates have worked with public and non-governmental organizations both nationally, and internationally, helping these partners place critical issues on the agenda and learn from the best practices of other organizations attempting similar tasks.

This year, our MPA-ESP candidates are working with the following local and international organizations:

- **New York City Mayor's Office of Recovery and Resiliency**
- **Office of New York City Council Member Rafael L. Espinal Jr.**
- **New York City Department of Sanitation**
- **International Union for Conservation of Nature**
- **New York City Mayor's Office of Media and Entertainment**

This report is informed by their 16-week interaction with the respective organizations and provides concrete policy analysis and recommendations.

Steve Cohen
Executive Director
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Contents

Executive Summary

This report provides an initial analysis of the demographic and spatial trends in energy cost burden across New York City. It builds upon previous nation-wide research that has identified disproportionately high energy cost burdens for certain demographics, particularly low-income households. Low-income populations are highly relevant in New York City, where 44% of the population is in or near poverty. The first half of this report provides quantitative and geospatial analyses of the energy cost burden landscape in New York City, including an assessment of the subsidy amount needed to reduce the high energy cost burden experienced by households in or near poverty. The second half of this report discusses three types of existing policy interventions that mitigate high energy cost burden: subsidies, energy efficiency, and demand response, and suggests possible best practices that New York City could adopt.

Energy cost burden is the proportion of a household's annual income spent on energy costs, including electricity, gas, and other heating fuel costs. A high energy cost burden, defined as being between 6-11%, can have severe negative health and economic impacts for families. In NYC, some factors can exacerbate the already high energy cost burdens for households, including high poverty and energy rates, seasonal fluctuations in energy needs, the prevalence of shared energy services, housing stock characteristics, and the large number of renters.

By analyzing the 2015 American Community Survey, which was augmented by the New York Mayor's Office of Economic Opportunity, **we found that in New York City, low-income households experience a disproportionately high energy cost burden.** Specifically, households below the NYC poverty line of $31,756 and near poverty line of $47,634 are susceptible to a disproportionately high energy cost burden of 9.99% and 7.96%, respectively. In comparison, we found the median energy cost burden in NYC to be 3.51%. Furthermore, the relationships between income and energy costs for households above and below the poverty line are very different. For every $10,000 increase in income for households below the poverty line, energy costs increase by $14.62 per month. For every $10,000 increase in income for households above the poverty line, energy costs increase by $1.40 per month, meaning that below poverty households face a proportionately higher increase in energy cost as their income increases compared to households above poverty.

In addition to households below the NYC poverty thresholds, our findings reveal that **Black and American Indian households have a higher median energy cost burden of 4.57% and 5.23%, respectively, compared to White (2.84%) and Asian (3.17%) households.** This confirms that certain races are bearing higher median energy cost burdens than the city median and compared to other races.

Understanding which boroughs have disproportionately high energy cost burdens can also help create targeted policy interventions. **Our geospatial analysis reveals that Southern Bronx, Central/Eastern Brooklyn, and Staten Island have higher energy cost burdens compared to the rest of the city**. Furthermore, a geospatial analysis of median energy cost burden for households in or near poverty reveals areas where households are experiencing unduly high energy cost burdens – areas that are not necessarily apparent in the map of median energy cost burden for all income groups

While previous nation-wide research reveals that renters typically have a significantly higher energy cost burden than homeowners in large metro areas, in New York City, **renters have a median energy cost burden of 3.42%, which is below the city-wide median for homeowners of 3.60%**. This result is likely because many residents in NYC rent their residences, regardless of income.

Many studies of urban areas around the country have shown that inefficiencies in housing stock and household appliances play a major role in high energy cost burden. Increased efficiency reduces energy use, which brings down energy costs, and subsequently decreases high energy cost burden. A quantitative analysis of energy efficiency requires data on square footage, which is not included in our dataset and outside the scope of our research. However, a literature review reveals that improving the efficiency of housing stock can substantially alleviate high energy cost burden in New York City. Energy efficiency programs can offer a range of financing and technical options to encourage landlords and renters to participate. Our report outlines the challenges and best practices of low-interest loans, technical assistance, rebates and incentives, retrofits and weatherization, and demand response.

To complement these findings on the energy cost burden landscape in NYC, we performed a subsidy analysis to understand the subsidies required to reduce the energy cost burden for below poverty households below 6%. Subsidies reduce energy cost burden by providing direct assistance to customers through decreasing their energy bill. Since energy costs are the highest controllable expense for many households, directly reducing these costs allows residents to spend more on other critical needs such as food, transportation, and childcare. We based our analysis on various subsidy amounts proposed in the pending New York State Energy Affordability Policy. **For households with an annual income of $1-$12,015, a $77 monthly subsidy would bring down their median energy cost burden from 17.5% to 5.17%. For households with an annual income of $12,015-$22,028, a $35 monthly subsidy would bring their energy cost burden from 8.99% to 6.35%.** This analysis shows that when appropriate levels of subsidies are offered based on customer income, energy cost burden can be significantly reduced for households in the lowest income brackets. However, subsidies are not a long-term solution and do not address the multitude of issues related to energy insecurity.

In turn, a potential rise in energy costs would result in a proportionally higher increase in energy cost burden for below poverty households. An additional $5 per month rate increase for households making $1 - $12,015 annually would raise their energy cost burden from 17.5% to 18.27%. For households making $12,015 - $22,028 annually, a $5 per month rate increase would raise their energy cost burden from 8.99% to 9.43%. This is particularly important to keep in mind when pursuing NYC's ambitious climate goals. Clean energy policies present both opportunities and challenges for low-income households. Improvements in energy efficiency can alleviate high energy cost burden; however, some energy initiatives pass on costs to ratepayers, increasing their energy cost burden. As New York City takes steps to reduce emissions, it is essential to consider multiple approaches to addressing high energy cost burden for vulnerable New Yorkers. This report identifies best practices for implementing subsidies, energy efficiency and demand response initiative.

Lastly, this report identifies and recommends opportunities for intervention in NYC to address high energy cost burden. **There is not one solution that can adequately address this issue, but rather a combination of targeted solutions aimed towards specific income groups, geographic locations, and building characteristics.** Expanding and enhancing in or near poverty energy efficiency programs, developing separate programs for landlords and tenants, and working with utilities to develop incentive and rebate programs can all be effective strategies for reducing energy cost burden.

1) Introduction

I. What is Energy Cost Burden?

Energy cost burden (ECB) is the total annual energy costs of a household as a percentage of its gross annual household income. Total energy cost is the sum of electricity, gas and other heating fuel costs that, combined, represent the following energy services: electricity use, cooking, and heating. Transportation is another significant energy cost burden; however, this study focuses specifically on home energy costs.

$$Energy\ Cost\ Burden = \frac{Electricity\ +\ Gas + Other\ Heating\ Fuels\ Cost}{Total\ Gross\ Household\ Income}$$

Because energy cost burden is the proportion of income spent on household energy, the two main factors that can drive high energy cost burden for a household: low-income and high energy cost. The latter is a product of energy source and higher energy use, which is often due to inefficiencies in housing stock and household characteristics.

There is no standard threshold for high energy cost burden. Some researchers suggest that energy bills totaling more than 6% of gross annual income pose an unaffordable energy cost burden, while others advocate for a higher threshold of 10-11%.[1,2] In New York City, the median metro-level energy cost burden is 3.67%.[3]

II. Why is Energy Cost Burden Important?

Energy is an essential service that no family should live without. High energy cost burdens have serious implications for health and overall well-being of individuals and families.

Three main consequences of high energy cost burden include:
1) illness and stress
2) financial challenges
3) housing instability

The stress related to high energy bills or debt associated with paying bills can exacerbate already present poor health conditions. If residents are consistently unable to pay energy bills, power shut-offs happen more frequently, and the ability of a resident to secure healthy housing can reduce.[4]

Persistent poverty, insufficient access to bill assistance programs, and certain utility rate designs further exacerbate high energy cost burden.[5] Spending patterns show that when forced to choose between energy and other necessities, households

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[1] Hernández, Diana, and Stephen Bird. "Energy Burden and the Need for Integrated Low-Income Housing and Energy Policy." *Poverty & Public Policy*. 2010.
[2] APPRISE and Fisher, Sheehan, Colton. *Ratepayer-Funded Low-Income Energy Programs: Performance and Possibilities*.
[3] Drehobl, Ariel, and Lauren Ross. *Lifting the High Energy Burden in America's Largest Cities: How Energy Efficiency Can Improve Low-Income and Underserved Communities*, 2016.
[4] Hernández, Diana, and Stephen Bird. "Energy Burden and the Need for Integrated Low-Income Housing and Energy Policy." *Poverty & Public Policy*, 2010.
[5] "Report: 'Energy Burden' on Low-Income, African American, & Latino Households up to Three Times as High as Other Homes, More Energy Efficiency Needed." 20 Apr. 2016.

with high energy cost burdens often cut back on necessary energy use. For example, these households will heat fewer rooms and reduce lighting use.[6] Higher energy cost burden is associated with lower general health status, higher malnutrition and hunger, and more frequent iron deficiency.[7,8] This leads to negative health consequences, including asthma, respiratory problems, heart disease, arthritis, and rheumatism.[9] These consequences of financial and social stress create additional barriers to moving out of poverty, perpetuating a cycle that is hard to break.[10]

Often, populations with high energy cost burdens also face built environmental hazards.[11] Research suggests that low-income residents often reside in low-quality housing stock, where poor maintenance makes these negative health effects even more acute.[12] Cold, drafty or hot homes with poor ventilation can lead to illness or death during seasonal extremes. The "heat or eat" phenomenon is supported by research correlating cold temperatures in housing and underweight children.[13] Living in lower quality units means that residents risk being exposed to building hazards, for example, leaky windows, poorly insulated walls, boilers or water heaters that are past their replacement date. Living in inefficient buildings can have non-monetary costs, including air pollution and public health issues.[14] Residents in poorly maintained housing can face higher social isolation, less educational attainment, reduced emotional resilience, and improper nutrition habits, especially for children.[15]

Residential energy expenditures are key factors for determining housing affordability and thus poverty. High energy cost burden can become one of many intertwined factors that create a negative feedback loop of poverty that is hard to escape.

III. Who is Affected by Energy Cost Burden?

Research conducted on major metropolitan areas in the United States suggests that households with certain demographic characteristics tend to face higher energy cost burden. These include low-income households, African American and Latino households, and renters.

Nationally, the largest demographic facing disproportionately high energy cost burdens is low-income households.[16,17] Some studies find that both low-income and low- to moderate- income households face high energy cost burdens. According to the US Department of Housing and Urban Development, low- to moderate-income households are those whose income does not exceed 115% of the median income for the area when adjusted for family size. While actual energy costs for low-income households can be comparable to other income groups, their energy costs are a significantly larger percentage of their income. Low-income households' energy costs are typically only 30% lower than other households, despite smaller living spaces.[18] Inefficient housing stock causes over one-third of low-income household's excess energy cost

[6] Brunner, Karl-Michael, et al. "Experiencing Fuel Poverty. Coping Strategies of Low-Income Households in Vienna/Austria."
[7] Eisenberg, Joel F. Short and Long-Term Perspectives: *The Impact on Low-Income Consumers of Forecasted Energy Price Increases in 2008 and a Cap-and-Trade Carbon Policy in 2030*. Oak Ridge National Laboratory, 2007
[8] Frank, Deborah A., et al. "Heat or Eat: The Low-income Home Energy Assistance Program and Nutritional and Health Risks Among Children Less Than 3 Years of Age." Pediatrics,
[9] Hernández, Diana, and Stephen Bird. "Energy Burden and the Need for Integrated Low-Income Housing and Energy Policy." *Poverty & Public Policy*, 2010.
[10] Drehobl, Ariel, and Lauren Ross. *Lifting the High Energy Burden in America's Largest Cities: How Energy Efficiency Can Improve Low-Income and Underserved Communities*.
[11] Levy, Jonathan I, et al. "The Public Health Benefits of Insulation Retrofits in Existing Housing in the United States." *Environmental Health*, 2003.
[12] WE ACT for Environmental Justice. *Healthy Homes*. www.weact.org/whatwedo/areasofwork/healthy-homes/.
[13] Heffner, Grayson, and Nina Campbell. *Evaluating the Co-Benefits of Low-Income Energy-Efficiency Programmes.* International Energy Agency, 2011.
[14] Levy, Jonathan I, et al. "The Public Health Benefits of Insulation Retrofits in Existing Housing in the United States." *Environmental Health*, 2003.
[15] Shear, Keith B. G., and Anthony J. McMichael. "Editorial: The Health Impacts of Cold Homes and Fuel Poverty." *BMJ*, 2011.
[16] Drehobl, Ariel, and Lauren Ross. *Lifting the High Energy Burden in America's Largest Cities: How Energy Efficiency Can Improve Low-Income and Underserved Communities*, 2016.
[17] Swinnen, Hugo. *Towards an Alleviation of Housing Cost Burden on Low-Income Households in Luxembourg?* European Social Policy Network, 2017.
[18] Lee, A.D., Chin, R.I., and Marden, C.L. *Affordable housing: Reducing the energy cost burden*, 1995.

burden.[19] The American Council for an Energy-Efficient Economy researchers Drehobl and Ross reviewed 48 major metropolitan areas in the United States and found that 35% of excess energy burden for low-income households could be eliminated if their housing stock was brought up to the median household efficiency level.[20]

Additionally, when low-income households are unable to pay their electricity bills and shut-offs occur, the housing affordability in the surrounding region can be impacted. In this situation, not only do residents face outages and debt concerns, but utilities' debt also increases. Shut-off costs are borne by all consumers, suggesting that increased energy cost burden for certain populations leads to higher energy burdens across all households.[21] Therefore, reducing energy costs can contribute toward improving overall housing affordability in a region.[22]

Literature also suggests that African-American and Latino households experience a disproportionately high energy cost burden.[23] A national study published by the American Council for an Energy-Efficient Economy found that African American households have a median energy cost burden of 5.4% compared to the median energy cost burden of white households of 3.3%, meaning the median energy cost burden for African-American households is 64% greater. Latino households have a median energy cost burden of 4.1%, which is 24% greater than white households.[24] African-American and Latino households are also largely impacted by household inefficiencies. Bringing up their efficiency levels to those of the median household would alleviate 42% of excess energy burden for African-American households and 68% for Latino households.

Drehobl and Ross's research indicates that nationally, renters have a higher energy cost burden than homeowners.[25] The median energy cost burden for renters is 4% compared to the median energy cost burden of owners, which is 3.3%.[26] However, several statistics in New York City suggest the contrary. Energy use is 10% lower in owner-occupied housing than in rented homes built since 1980.[27] This is significant since 79% of all multifamily units in NYC were built before 1980, suggesting they will have more inefficient housing stock and appliances.[28] Around 97% of excess energy burden for renters is due to household inefficiencies, the highest of all the demographics.[29] Not only do low-income, African-American, Latino, and renter households bear higher energy cost burdens, but they also pay more for energy per square foot,[30] ranging 11-15% more per square foot. Renters use more energy per square foot while having less space per person.[31] This confirms that factors beyond income are impacting high energy cost burden.

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[19] "Report: 'Energy Burden' on Low-Income, African American, & Latino Households up to Three Times as High as Other Homes, More Energy Efficiency Needed." 20 Apr. 2016.
[20] Ibid.
[21] "Report: 'Energy Burden' on Low-Income, African American, & Latino Households up to Three Times as High as Other Homes, More Energy Efficiency Needed." 20 Apr. 2016.
[22] Lee, A.D., Chin, R.I., and Marden, C.L. *Affordable housing: Reducing the energy cost burden*, 1995.
[23] "Report: 'Energy Burden' on Low-Income, African American, & Latino Households up to Three Times as High as Other Homes, More Energy Efficiency Needed." 20 Apr. 2016.
[24] Ibid.
[25] Ibid.
[26] Ibid.
[27] Johnson, Kate, and Eric Mackres. *Scaling Up Multifamily Energy Efficiency Programs: A Metropolitan Area Assessment*. American Council on Energy-Efficient Economy, 2013.
[28] Johnson, Kate, and Eric Mackres.
[29] "Report: 'Energy Burden' on Low-Income, African American, & Latino Households up to Three Times as High as Other Homes, More Energy Efficiency Needed." 20 Apr. 2016.
[30] Ibid.
[31] Carliner, Michael. *Reducing Energy Costs in Rental Housing: The Need and the Potential*. 2013.

2) What is Unique About New York City?

I. Background of NYC Climate Policy

In the past ten years, New York City has adopted a bold sustainable growth vision through 2050. This long-term strategy, initially outlined in PlaNYC and subsequently updated in *One New York: The Plan for a Strong and Just City (OneNYC)*, identifies four key priority areas: growth, equity, sustainability, and resiliency.[32]

A key component of this strategy is an enormous reduction in greenhouse gas (GHG) emissions. In 2014, the City of New York committed to reducing its GHG emissions by 80% from its 2005 baseline levels by 2050, with an interim target of a 40% reduction by 2030.[33] To meet this ambitious goal, the City has created the *Roadmap to 80x50* detailing the timeline, scale, and potential emission reductions from proposed policies and programs, including those analyzed in the subsequent sections of this report. [34] An overview of this roadmap is presented in **Figure 1** below.

Policies that target buildings and energy, the city's two largest sources of GHGs, present a significant opportunity to achieve these climate change mitigation goals.[35] Practical steps to achieve the emission reductions include making buildings more energy efficient and transitioning to renewables-based power grids, as described in **Figure 1** below.

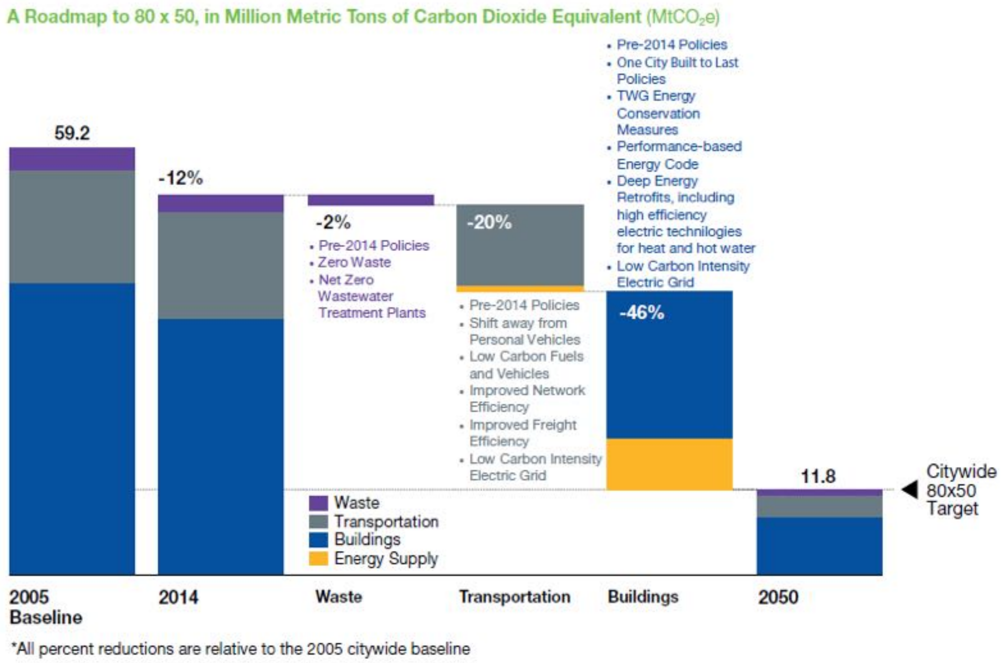

Figure 1: NYC's plan for reducing GHG emissions 80% by 2050. The two largest sectors regarding projected emissions reductions are buildings and power.[36]

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[32] *OneNYC*, New York City Mayor's Office of Recovery and Resiliency, www1.nyc.gov/site/orr/onenyc/onenyc.page.
[33] New York City Mayor's Office of Sustainability. *New York City's Roadmap to 80 x 50*. 2016.
[34] Ibid.
[35] Reina, Vincent, and Constantine Kontokosta. *Low Hanging Fruit? Energy Efficiency and the Split Incentive in Subsidized Multifamily Housing*. NYU Furman Center, 2016.
[36] New York City Mayor's Office of Sustainability.

While *OneNYC* places emphasis on equitable sustainable development, the impacts of this transition to a low-carbon economy on households in NYC requires further study. Clean energy policies present both opportunities and challenges for low-income populations. On the one hand, improvements in energy efficiency could help alleviate energy cost burden, since energy efficiency reduces energy expenditures. On the other hand, clean energy initiatives might increase residential energy rates, passing the cost of the reduction in greenhouse emissions to consumers. In providing the first analysis of energy cost burden across the community districts of NYC, this report considers the potential impacts of this low-carbon transition and how policies can address negative externalities for vulnerable populations.

II. Drivers of High Energy Cost Burden in New York City

In NYC, some factors impact energy cost burden, including high poverty and energy rates, seasonal fluctuations in energy needs, the prevalence of shared energy services, housing stock characteristics, and a large number of renters. These combined factors are important to consider when developing policy interventions to reduce high energy cost burden. This report focuses on in or near poverty households in NYC, which is a subset of low-income households. New York City Mayor's Office of Economic Opportunity (New York City Opportunity) identifies in or near poverty households using the NYCgov Poverty Measure, which includes a threshold that accounts for the higher living costs in NYC, unlike the official U.S. measure of poverty. The NYC poverty measure also adjusts family incomes for benefits they receive, such as the Supplemental Nutritional Assistance Program (SNAP) and the Earned Income Tax Credit. The threshold for in poverty households corresponds to an annual household income of $31,756 and the threshold for near poverty households corresponds to an annual household income of $47,634.

NYC is home to 8.5 million people, which is twice the size of the second-largest U.S. city (Los Angeles), and has the highest population density of any city in the U.S.[37] Poverty, income inequality, and relatively high energy costs are key drivers for high energy cost burden in the City.

While the national poverty rate hovers around 14%,[38] the poverty rate for NYC, as calculated by the New York City Opportunity, is 19.%.[39] With nearly 44% of residents in or near poverty, a substantial proportion of residents is vulnerable to housing, transportation, and energy burdens. In addition, income inequality has increased in large cities throughout the U.S. at a much more rapid rate than the national average.[40] NYC shares this pattern of income inequality with 20% of the population making below $18,000 and another 20% of the population making above $115,000.[41] High poverty rates and income inequality contribute to the high energy cost burdens often experienced by large populations in cities such as NYC.[42] Energy costs in New York City are some of the highest in the continental United States and are projected to continue to rise.[43] From 2004 to 2014, average US residential electricity prices increased from 9 cents/kWh to 12.5 cents/kWh, an increase

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[37] New York City Department of Planning. *NYC Population Facts*, www1.nyc.gov/site/planning/data-maps/nyc-population/population-facts.page.
[38] UC Davis Center for Poverty Research. "What Is the Current Poverty Rate in the United States?", 18 Dec. 2017, poverty.ucdavis.edu/faq/what-current-poverty-rate-united-states.
[39] New York City Mayor's Office for Economic Opportunity. *Poverty Measure*. www1.nyc.gov/site/opportunity/poverty-in-nyc/poverty-measure.page.
[40] Holmes, Natalie, and Alan Berube. *City and Metropolitan Inequality on the Rise, Driven by Declining Incomes*. Brookings Institution, 2016.
[41] Statistical Atlas. *Household Income in New York, New York (City)*, statisticalatlas.com/place/New-York/New-York/Household-Income.
[42] Drehobl, Ariel, and Lauren Ross. *Lifting the High Energy Burden in America's Largest Cities: How Energy Efficiency Can Improve Low-Income and Underserved Communities*, 2016.
[43] United States Energy Information Administration. *Electric Power Monthly for January 2018*, www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_5_6_a.

of 39%,[44] while average adjusted income grew only 0.9%.[45] If income in NYC does not increase proportionately to rising energy costs, energy cost burdens will worsen, particularly for low-income residents.

The geographic location of NYC further contributes to high energy cost burden, because large seasonal fluctuations result in higher energy costs for families. In regions where there are seasonal temperature extremes, such as NYC, heating and cooling a household can be a necessity rather than a matter of preference.[46] Likewise, in regions with a milder climate, less energy is required to maintain a livable household environment. The need for both heating and cooling increases energy costs, thus contributing directly to high energy cost burden.[47]

A large number of shared energy services in NYC is another major consideration when discussing energy cost burden. Shared energy services are when a building has a single energy source and the costs are distributed across the units, with cost distribution not necessarily proportional to use. Master-metered buildings are a subset of shared energy services, with the nuance that these buildings share a single heat or electricity meter, and households pay proportional to energy use or unit size. When energy costs are included in the rent, individual households have limited control over their energy costs and services. This is linked to higher energy consumption and higher energy cost burden.[48,49] Shared energy services are prevalent in large cities, particularly NYC. Approximately 40% of all residents in NYC live in multifamily buildings that contain more than five apartment units.[50] Often, these larger buildings have shared energy services, rather than in each unit. Out of the sample of 25,000 buildings analyzed in this report, almost half had shared energy services. NYC requires building owners to provide heat and hot water from October to May,[51] with high fines for landlords who don't meet minimum heating requirements. While this requirement does provide tenant protections and safeguard public health, it may have an adverse impact on low-income residents if these energy costs are subsequently included in rent.

The cost of energy services for a unit is closely related to a building's energy efficiency and energy infrastructure. Older building stock, insulation inefficiency, and inefficient heating systems and appliances can all lead to increased energy cost burden.[52] Older buildings are an important consideration in New York City, given that the median age of residential buildings is about 90 years old.[53] Across the United States, homes built before 1940 use almost twice as much energy per square foot as homes built in 2000 or later.[54] Since lower-income residents often live in older buildings that are less energy efficient, this can exacerbate their high energy cost burden and reduce their ability to pay for energy efficiency upgrades.[55] Low-income residents consume 14-22% more energy per square foot, potentially due to housing inefficiency and older heating systems

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[44] United States Energy Information Administration. *Short-Term Energy Outlook (STEO)*. 2016.
[45] United States Census Bureau. *Historical Income Tables: People*. www.census.gov/data/tables/time-series/demo/income-poverty/historical-income-people.html.
[46] "Report: 'Energy Burden' on Low-Income, African American, & Latino Households up to Three Times as High as Other Homes, More Energy Efficiency Needed." 20 Apr. 2016.
[47] Drehobl, Ariel, and Lauren Ross. *Lifting the High Energy Burden in America's Largest Cities: How Energy Efficiency Can Improve Low-Income and Underserved Communities*, 2016.
[48] Habitat for Humanity. *Transforming Low-Income Communities through Energy Efficiency*. www.habitat.org/stories/transforming-low-income-communities-through-energy-efficiency.
[49] Reina, Vincent, and Constantine Kontokosta. *Low Hanging Fruit? Energy Efficiency and the Split Incentive in Subsidized Multifamily Housing*. NYU Furman Center, 2016.
[50] Reina, Vincent, and Constantine Kontokosta. *Low Hanging Fruit? Energy Efficiency and the Split Incentive in Subsidized Multifamily Housing*. NYU Furman Center, 2016.
[51] New York City Housing Preservation & Development. *Heat and Hot Water*. www1.nyc.gov/site/hpd/renters/important-safety-issues-heat-hot-water.page.
[52] Habitat for Humanity. *Transforming Low-Income Communities through Energy Efficiency*. www.habitat.org/stories/transforming-low-income-communities-through-energy-efficiency.
[53] RentHop. "Building Ages and Rents in New York." 2017.
[54] Carliner, Michael. *Reducing Energy Costs in Rental Housing: The Need and the Potential*. 2013.
[55] Lee, A.D., Chin, R.I., and Marden, C.L. *Affordable housing: Reducing the energy cost burden*, 1995.

and lack of energy education.[56] One possible contribution of low-income residents using more energy is that this income group reports setting their thermostat above 70 degrees more often than non-low-income residents.[57]

NYC has a substantially higher percentage of renters when compared to other cities—over two-thirds of residents rent. Nationally, low- to moderate-income households are even more likely to rent than residents with higher incomes.[58] As discussed above, renters typically have higher energy cost burdens than homeowners. However, this is not the case in our analysis. NYC is unique in that renting property, rather than owning, does not necessarily correlate with limited income, as is often the case in other parts of the country. Renters often experience higher energy cost burden due in part to a large number of people relative to area in renter households, increasing consumption of energy, as well as the split incentive for energy efficiency investments between landlords and tenants. Split incentives are a type of principal-agent problem defined as "a circumstance in which the flow of investments and benefits are not properly rationed among the parties to a transaction, impairing investment decisions.[59] The result of landlord-tenant split incentives is that the renter and landlord have very different goals and access to information. Additionally, the split-incentive dilemma makes energy upgrades difficult to justify from a fiscal perspective and reduces the overall energy efficiency of housing stock.[60]

Further considerations that can impact energy cost burden include utility-related debt, energy shut-offs, lack of sufficient funding, limited policy coordination, and the absence of widespread education on energy savings programs; however, these are not specifically analyzed in this report.[61]

III. Potential Implications for Policy Makers

Addressing energy affordability in urban areas such as New York is critical for reducing poverty, improving public health and ultimately increasing economic development. Interventions need to be comprehensive, encompassing housing, public health, and environmental policies to achieve both social and climate change mitigation objectives. Policy needs to be informed by a better understanding of the energy cost burden landscape, which enables the development of targeted interventions.[62] Given the limited availability of in-depth research on the variation in energy cost burden across the boroughs and neighborhoods in NYC, this report is the first study to map and understand energy cost burden more comprehensively in the city.

[56] Cluett, Rachel, et al. *Building Better Energy Efficiency Programs for Low-Income Households. American Council on Energy-Efficient Economy*, 2016.
[57] Ibid.
[58] WE ACT for Environmental Justice. *Healthy Homes*. www.weact.org/whatwedo/areasofwork/healthy-homes/.
[59] California Sustainability Alliance. *Green Leases Toolkit: Glossary*, sustainca.org/green_leases_toolkit/glossary.
[60] Hernández, Diana, and Stephen Bird. "Energy Burden and the Need for Integrated Low-Income Housing and Energy Policy." *Poverty & Public Policy*, 2010.
[61] Ibid.
[62] "Report: 'Energy Burden' on Low-Income, African American, & Latino Households up to Three Times as High as Other Homes, More Energy Efficiency Needed." 20 Apr. 2016.

3) Project Purpose and Research Methodology

I. Research Objective

This research project was conducted for the NYC Mayor's Office of Recovery and Resiliency, with the following primary goals:

- Use data-driven approaches to determine the energy cost burden across different NYC census districts and demographic groups.
- Conduct comparative analysis of existing policy interventions that mitigate the high energy cost burden at the regional and international levels, and provide an overview of the most effective practices in the context of the City's ambitious GHG emissions reduction goals.

The ultimate objective of this research is to inform more targeted and effective policy initiatives that address the high energy cost burden experienced by certain households in New York City.

II. Data Analysis

Description of Available Data

The dataset used in this research is the 2015 American Community Survey (ACS) augmented by New York City Opportunity,[63] which includes energy use data collected as part of the ACS survey and the poverty metrics specific to New York City (New York City Government Poverty Measure). The dataset contains 69,103 individual responses across the 55 Public Use Microdata Area (PUMA) districts in New York City. Since energy cost burden is defined as a percentage of a household's -- not an individual's -- income, the individual responses were aggregated to sue households as the main unit of analysis. The sample analyzed contains data on 26,833 households. **Appendix A** provides additional details on the dataset.

In addition, the GIS analysis uses data from the NYC Department of Housing Preservation (HPD) listing the rental units in violation of the NYC Maintenance Code (HMC) or the New York State Multiple Dwelling Law (MDL) since October 1, 2012 that have not been resolved. For more information regarding this methodology, please see **Appendix E**.

Estimation of Energy Cost Burden

Energy cost burden is the total annual energy cost of a household as a percentage of its gross, pretax annual household income. Total energy cost is the sum of electricity, gas, and other possible heating fuel costs. These costs combined represent electricity use, cooking, and heating, which are basic and necessary energy services.

$$Energy\ Cost\ Burden = \frac{Electricity\ +\ Gas + Other\ Heating\ Fuels\ Cost}{Total\ Gross\ Household\ Income}$$

[63] New York City Mayor's Office for Economic Opportunity. *Poverty Data*. www1.nyc.gov/site/opportunity/poverty-in-nyc/poverty-data.page.

The representative ACS data sample was used to calculate energy cost burden for households, where the variable "PreTaxIncome" is used for gross household income and the total energy costs are the sum of the variables 1) "ELEP" - Electricity cost per month, 2) "FULP" - Annual fuel (not gas), and 3) "GASP" - Gas cost per month. Therefore:

$$Energy\ Cost\ Burden = \frac{(ELEP\ x\ 12) + (GASP\ x\ 12) + FULP}{PreTaxIncome}$$

In this dataset, 14,463 households have transparent energy costs, meaning that all energy costs were reported in some way - either as monetary values or indicated that the expense is included in another category. For the data points where all energy variables costs were reported, the data were summed to find the total energy cost. If gas and heating fuel costs were reported to be included in the electricity bill, the total energy cost was based only on the electricity bill.

Approximately 11,011 households did not report energy costs or indicated that energy services were included in rent payments. Considering the prevalence of shared/master-metered energy services in New York City residences, the inclusion of these households in the calculations was deemed necessary to increases the robustness of our analyses and makes them more representative of New York City.

For these households without transparent energy costs, the total energy cost was estimated using an extrapolation method based on the assumption that households with transparent energy costs have similar energy use and cost patterns to those that are master-metered. To account for variation of rent based on locality, rent bins were created within PUMAs, thus accounting for household similarities within PUMAs and variations between PUMAs. The average energy cost was calculated for each rent bin using those households with transparent energy costs. This average was used to estimate the average energy cost for households within these rent bins. Roughly 1000 households had to be removed from the dataset due to missing rent data and energy cost data, making it impossible to assign energy costs. For further details on the statistical methodology for creating rent bins, see **Appendix B**.

Correlational Analysis of Energy Costs and Demographics

After the data was pared down to the 25,475 households with transparent and assigned energy costs, the energy cost and energy cost burdens were assessed against socio-demographic variables to identify any strong relationships. We performed several correlational and regression analyses as well as hypothesis tests to find statistically significant relationships between energy cost and energy cost burdens with:

1. Income
2. Rent
3. Age
4. Head of Household Race
5. Year Building was Originally Built
6. Number of Units in Building (home-type)
7. Number of Rooms in Household

For example, to determine if there is a relationship between energy cost burden and head of household race, we ran an ANOVA test on energy cost burden against head of household race. The ANOVA test indicated that there was a statistically significant difference of means between one of the group pairs. Then, we ran a post hoc Bonferroni Scheffe test to identify those pairs.

The result section gives a summary of all findings, and **Appendix C** gives the specific type of tests performed and the code(s) we used to arrive at those results.

Sensitivity Analysis of Energy Cost Burden to Subsidies and Premiums

This study elucidates how energy costs and energy cost burden affect those households that lie below the poverty threshold of $31,756 and near poverty threshold of $41,756 in New York City. To see if energy cost burden can be mitigated, we performed two types of analyses to examine the impact of subsidies and the impact of premiums on energy cost burden for households.

Subsidy Analysis: Households that fall below a certain poverty threshold are entitled to subsidies from utilities to help alleviate energy costs. Definitions of low-income and low-to-moderate-income for subsidies vary across programs, ranging from 50-120% of the state or county median income across New York State (NYS) and NYC.[64] These costs are directed towards either their energy expenditure or a portion of their energy expenditure (electricity, gas or heat). We performed a sensitivity analysis on how much energy cost burden changes based on subsidy amounts for in or near poverty households. A policy recommendation can be made on the best subsidy deployment to help households at or near poverty levels to adequately reduce energy cost burdens. Under the Energy Affordability Policy proposed for NYS, subsidies would be provided for low-income NYS residents to keep energy cost burden below 6%.[65] **Table 6** in the Results section shows the reduction in energy cost burden as a function of subsidy amount.

Energy Cost Premium Analysis: It is important to analyze how potential increases in energy costs would affect energy cost burden for households in or near poverty. To examine the relationship between energy cost burden and increased energy costs at numerous amounts, we performed a sensitivity analysis of incremental increases in energy cost. This can inform recommendations on minimizing energy costs for in or near poverty households during NYC's energy transition. **Table 7** shows the impact of premiums on median energy cost burden for different income brackets.

III. Policy Analysis

A preliminary literature review on energy cost burden and energy efficiency both in New York City and the rest of the United States was conducted to understand the extent of unduly high energy cost burden and the opportunity of energy efficiency as a solution.

Assessment of the Current Regulatory Landscape in NYC: Case Study Data Collection and Interviews

The existing energy efficiency policy environment in NYC was analyzed through the lenses of energy cost burden and low-income housing. A policy matrix was developed with over fifty programs to compare the impacts of NYC energy and building GHG reduction goals from NYC's 80X50 plan. Several identified policies are promising mechanisms for reducing energy cost burden.

Multi-city Comparative Analysis

Case studies were collected from outside NYC to build on the NYC policy context. Successful initiatives within and outside of NYC were reviewed and analyzed for application to our findings.

Program Evaluation Methods

[64] New York State Energy Research and Development Authority. *Green Jobs - Green New York Low to Moderate Income (Low- To Moderate-Income) Working Group Recommendations - Final Report*. 2015.
[65] "Governor Cuomo Announces New Energy Affordability Policy to Deliver Relief to Nearly 2 Million Low-Income New Yorkers." 19 May 2016.

Interviews conducted with experts in the field, either staff at government agencies or published authors, are summarized in **Appendix H**. The goal of these interviews was to learn about energy cost burden, cost burden interventions, methods of program evaluation, and additional sources of information. The interviews informed our case study research and pointed to sources of evidence that support or oppose the identified alternative policies.

IV. Limitations

The key limitation of data and policy analyses in this study relate to certain gaps in the data, requiring estimation and assessment of the extent to which the sample is representative, and the lack of publicly available data about the effectiveness of the existing policy measures.

Is the Sample Representative?

While the dataset provided by New York City Opportunity was conducted by the U.S. Census Bureau, it is from a voluntary survey, meaning self-selection biases may exist.

Gaps in the Data and Missing Proxies

Square footage of household units is not included in the survey responses, making it impossible to calculate energy efficiency and subsequent interventions. Additionally, a large percentage of the data points were missing transparent energy costs, making estimations necessary. This estimation is based on the assumption that households with transparent energy costs are similar to households that are master-metered. It is possible that there are differences in energy use patterns or costs between the buildings with fully transparent costs in our sample and those without.

Exclusion of NYCHA Residents from Dataset

The New York City Housing Authority (NYCHA) provides affordable housing for 6.9% of NYC residents in or near poverty.[66] The data used in this analysis does not include NYCHA residents. NYCHA residents also experience high levels of energy insecurity. Since 2002, federal assistance to NYCHA has been reduced, leading to a funding gap of billions of dollars. One result from the lack of funding is reduced maintenance. Between October 1, 2017 and January 22, 2018, 80% of NYCHA residents experienced heat outages lasting 48 hours on average.[67] While NYCHA residents do not pay for energy costs, their experiences contribute to the landscape of energy insecurity in NYC.

Lack of Program Evaluation and Performance Measurement Data

From the policy analysis perspective, many recently enacted city and state programs targeted at decreasing energy cost burden have either not been comprehensively reviewed for program effectiveness or not made evaluations publicly available. Of the 30 policies analyzed, no policy had a publicly posted evaluation. This is a limitation because policy effectiveness is not quantitatively verified. To supplement this gap in information, a qualitative review of policy effectiveness was conducted. This included a literature review on similar policies, national policies, expert opinions through blogs or think pieces, as well as conducting interviews with policy experts.

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[66] New York City Housing Authority. *NYCHA 2017 Fact Sheet*. 2017.
[67] Neuman, William. "As 4 of 5 in Public Housing Lost Heat, a Demand for an Apology Is Unfulfilled." *The New York Times*, 6 Feb. 2018.

4) Results: Energy Cost Burden Landscape in New York City

Based on the statistical and geospatial analysis of the sample of nearly 27,000 household responses in the 2015 American Community Survey, we have made observations about the variation in energy cost burden across New York City. The findings are broken down into the following sections:

I. Overview of Energy Cost Burden in New York City
II. Demographic Analysis of Energy Cost Burden
  - Energy Cost Burden and Income
  - Energy Cost Burden and Head of Household Race
  - Energy Cost Burden and Head of Household Age / Language
  - Energy Cost Burden and Ownership Status
III. Geospatial Trends in the Distribution of Energy Cost Burden Across the City
IV. Building Characteristics Impact on Energy Cost Burden
V. Potential Impact of a Subsidy and a Premium on Energy Cost Burden

I. Overview of Energy Cost Burden in New York City

We found the following median energy cost and energy cost burden for all households in New York City, as summarized in **Table 1**. The median energy cost burden is 3.51%, which is consistent with previous research conducted by the American Council on Energy-Efficient Economy on energy cost burden. This table also includes the income thresholds for below and near poverty households, as well as the number of households below or near poverty.

Table 1: General summary statistics from NYC Mayor's Office, Center for Economic Opportunity Imputed Dataset.

Category	Values
Median Total Energy Cost for city	$140/month
Median Energy Cost Burden for city	3.51%
Income threshold, below poverty (NYCgov threshold)	$31,756 annually (gross household income)
Income threshold, near poverty (NYCgov threshold)	$47,634 annually (gross household income)
Number of households below poverty	7,836
Number of households below near poverty	10,956

II. Demographic Analysis of Energy Cost Burden

Understanding the landscape of energy cost burden across New York City requires an analysis of the demographics in NYC to determine which groups experience disproportionately high energy cost burdens. Our research shows that in NYC, households in or near poverty have significantly higher energy cost burdens compared to other groups. Black, American Indian, and "Some Other" (an ACS designation) households have higher median energy cost burdens compared to White and Asian households. Head of household age and language revealed no significant statistical relationship with energy cost burden, and, surprisingly, there was no statistical relationship between the energy cost burden of renters and homeowners. The key findings are summarized in **Table 2** and elaborated upon in the following subsections.

Table 2: Summary statistics of findings from the socio-demographic analysis.

	Household Type	Number of Households Analyzed	Median Gross Annual Household Income	Median Monthly Energy Cost	Median Energy Cost Burden
Income Type	In Poverty Threshold (<$31,756)	7,836	$16,020	$115	9.99%
	Near Poverty Threshold (<$47,634)	10,956	$22,028	$120	7.96%
	Above Poverty Threshold (>$31,756)	17,638	$84,306	$160	2.33%
	Above Near Poverty Threshold (>$47,634)	14,518	$100,126	$170	2.00%
Ownership Status	Renters	15,280	$42,053	$113	3.42%
	Owners	9,881	$88,512	$270	3.60%
Building Type	Single Family Buildings	12,377	$74,093	$270	4.38%
	Multifamily Buildings	13,050	$48,060	$110	2.95%
Head of Household Race	Latino	5,404	$38,048	$130	4.62%
	African American	5,840	$47,635	$150	4.57%
	White	12,862	$68,587	$140	2.84%
All Households		**25,474**	**$57,272**	**$140**	**3.51%**

Energy Cost Burden and Income

To examine the relationship between energy cost burden and household income, we performed regression analyses on both energy cost and energy cost burden. Our tests revealed, unsurprisingly, a positive relationship between energy cost and income and a negative relationship between energy cost burden and income. This means that as household income increases, so do energy costs, but at a rate less than the increase in income. Therefore, with increasing income comes decreasing energy cost burden.

We further investigated how energy costs behave for the households above and below the NYC poverty threshold of $31,756. Our findings reveal a different relationship between income and energy costs for those above and below the poverty line. For every $10,000 increase in income for households below the poverty line, energy costs increase by $14.62 per month. For every $10,000 increase in income for households above the poverty line, energy costs increase by $1.40 per month. Households below the poverty line have energy costs that increase at a larger rate per increase in income than households above the poverty line. This relationship demonstrated in **Figure 2** below.

Since income is the denominator for calculating energy cost burden, we should expect to see a strong relationship between energy cost burden and gross annual household income. However, the relationship that we found interesting is that below the poverty line of $31,756, energy cost burden increases at a much faster rate as income decreases compared to above the poverty line. Additionally, the energy cost burden for households in or near poverty households, and particularly in poverty, are more likely to have high energy cost burdens above the 6% threshold. Therefore, we focus on in or near poverty households as our critical subset. This is visualized in **Figure 3**.

Regarding median energy cost burden, in poverty households (below $31,756 annual income) and near poverty households (below $47,634 annual income) experience disproportionately high energy cost burdens of 9.99% and 7.96%, respectively. The median energy cost burden for the upper quartile of these two groups is 17.99% and 15.73%, respectively. These statistics are summarized in **Table 3**, below. Our results demonstrate the susceptibility of the poor to rapidly increasing energy cost burdens compared to the households above the poverty line. With 44% of New Yorkers in or near poverty, these findings are particularly significant when considering policy interventions.

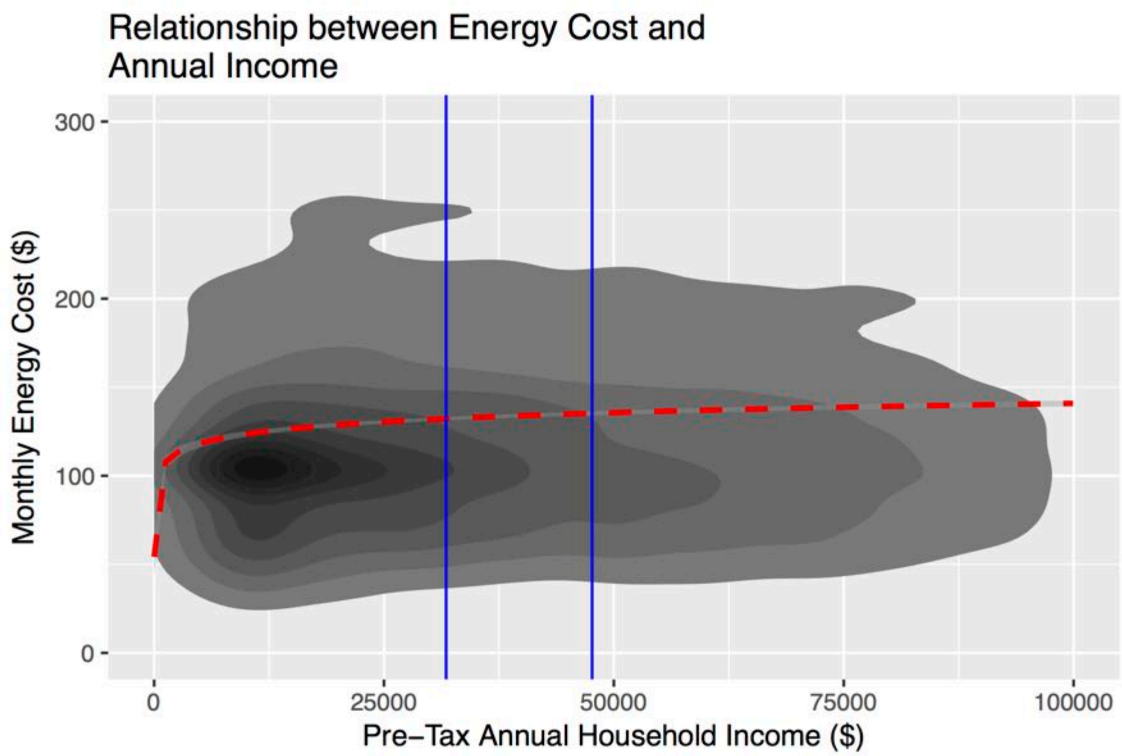

Figure 2: Density graph of Energy Cost versus Pre-Tax Annual Household Income. The darker gray areas represent areas with a higher density of data points, and the lighter gray areas represent areas with a lower density of data points. The red dashed line is an exponential regression fitted to the data, and the blue lines represent the in-poverty line and near-poverty line.

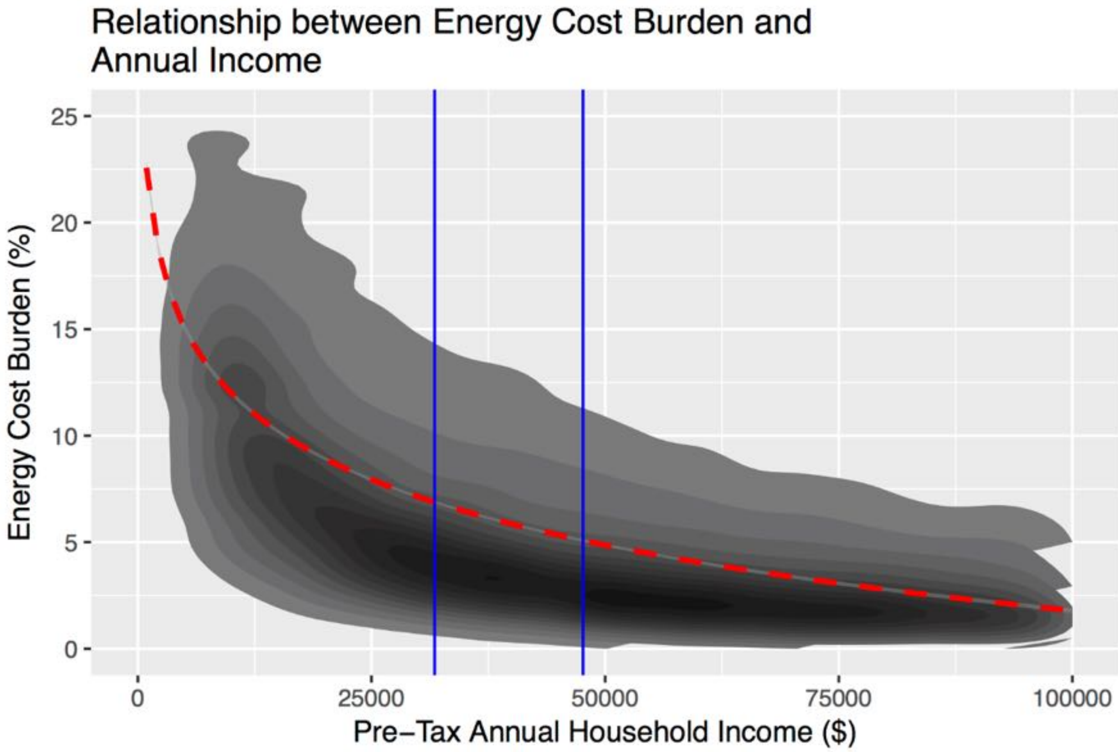

Figure 3: Density graph of Energy Cost Burden versus Pre-Tax Annual Household Income. The darker gray areas represent areas with a higher density of data points, and the lighter gray areas represent areas with a lower density of data points. The red dashed line is an exponential regression fitted to the data, and the blue lines represent the in poverty line and the near poverty line.

Table 3: Low, median, and highest energy cost burden quartiles for in or near poverty households.

Household Type	Lower Quartile Energy Cost Burden	Median Energy Cost Burden	Upper Quartile Energy Cost Burden
Poverty Threshold ($31,756)	5.89%	9.99%	17.99%
Near Poverty Threshold ($47,634)	4.42%	7.96%	15.73%

Energy Cost Burden and Head of Household Race

Certain races experience higher energy cost burdens in comparison to others. Black (4.57%) and American Indian (5.23%) households have higher median energy cost burdens compared to White (2.84%) and Asian (3.17%) households. Additionally, ACS head of household responses of "Some other Race" had a high median energy cost burden of 5.23%. These medians are presented in **Figure 4**. Categories for head of household race come from the American Community Survey and does not include Hispanic or Latino ethnicity. However, we were able to calculate the median energy cost burden for Latino households, 4.62%, by looking at a variable called HISP, which asks for Hispanic origin ethnicity.

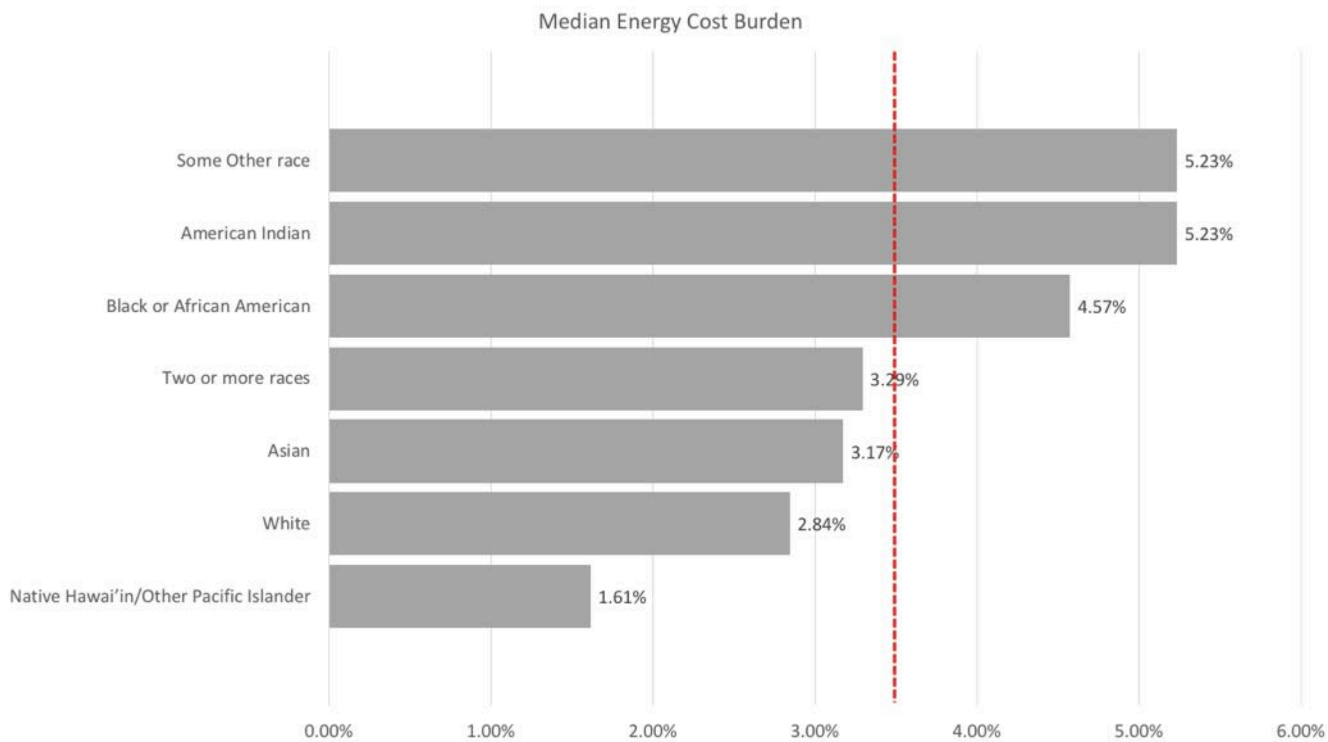

Figure 4: Median energy cost burden by race as compared to city-wide median shown by the red dotted line.

Energy Cost Burden and Head of Household Age / Language

We also investigated the relationship between head of household age and energy cost burden. We performed a regression analysis and found that the coefficient of determination was ~1.70%, suggesting a very weak correlation and an insignificant relationship between age and energy cost burden.

Our analysis of the relationship between head of household language and energy cost burden revealed no statistical significance between the two variables. This finding is of particular importance in deciding the language of government communications and outreach surrounding the topic of energy cost burden.

Energy Cost Burden and Ownership Status

Previous research indicates that renters often have disproportionately high energy cost burdens; therefore, we investigated the energy cost burden for renters versus homeowners in New York City. Interestingly, the hypothesis tests found no statistically significant difference in the median energy cost burdens for owners versus renters, with the coefficient of determination at ~3%. The median energy cost burdens for owners and renters are 3.60% and 3.42% respectively. This is likely because most residents in NYC rent their residences, regardless of income.[68] We did find a weak, positive relationship between energy cost and rent cost. This is expected, as homes with more expensive rents are most likely larger and thus have higher associated energy costs.

[68] WE ACT for Environmental Justice. *Healthy Homes*. www.weact.org/whatwedo/areasofwork/healthy-homes/.

Geospatial Trends in the Distribution of Energy Cost Burden Across the City

The median energy cost burden by borough for all households is summarized in **Table 4**. Manhattan has the consistently lowest median energy cost burden compared to the other boroughs, and the Bronx has the highest. A detailed geospatial mapping of energy cost burden in NYC by PUMA is shown in **Figure 5.** Our research found that the Southern Bronx, Central/Eastern Brooklyn, and Staten Island have disproportionately high energy cost burdens compared to the rest of the city.

While **Figure 5** shows median energy cost burden for all income groups in NYC, **Figure 6** shows the median energy cost burden for households in or near poverty. Focusing on this critical subset of households is important because it reveals areas where households are experiencing unduly high energy cost burdens – areas that are not necessarily apparent in the map of median energy cost burden for all income groups. For example, the map with median energy cost burden for all incomes only shows a low median energy cost burden for Queens. However, the map with median energy cost burden for in or near poverty households reveals that there are households in Queens with unduly high energy cost burdens of 9.21% to 12.48%.

To further analyze energy cost burden for in or near poverty households, we calculated the low, median, and upper energy cost burden quartiles by PUMA for in or near poverty households. This provides a more detailed look at the range of energy cost burden for in or near poverty households in specific neighborhoods. This is visualized in **Figure 7**.

Table 4: Summary statistics for energy cost burden by borough.

	Bronx	Brooklyn	Manhattan	Queens	Staten Island
Lower Quartile Energy Cost Burden	2.70%	1.70%	0.70%	1.90%	2.40%
Median Energy Cost Burden	5.10%	3.60%	1.70%	3.60%	4.20%
Upper Quartile Energy Cost Burden	11.20%	8%	4.90%	7.40%	8.30%

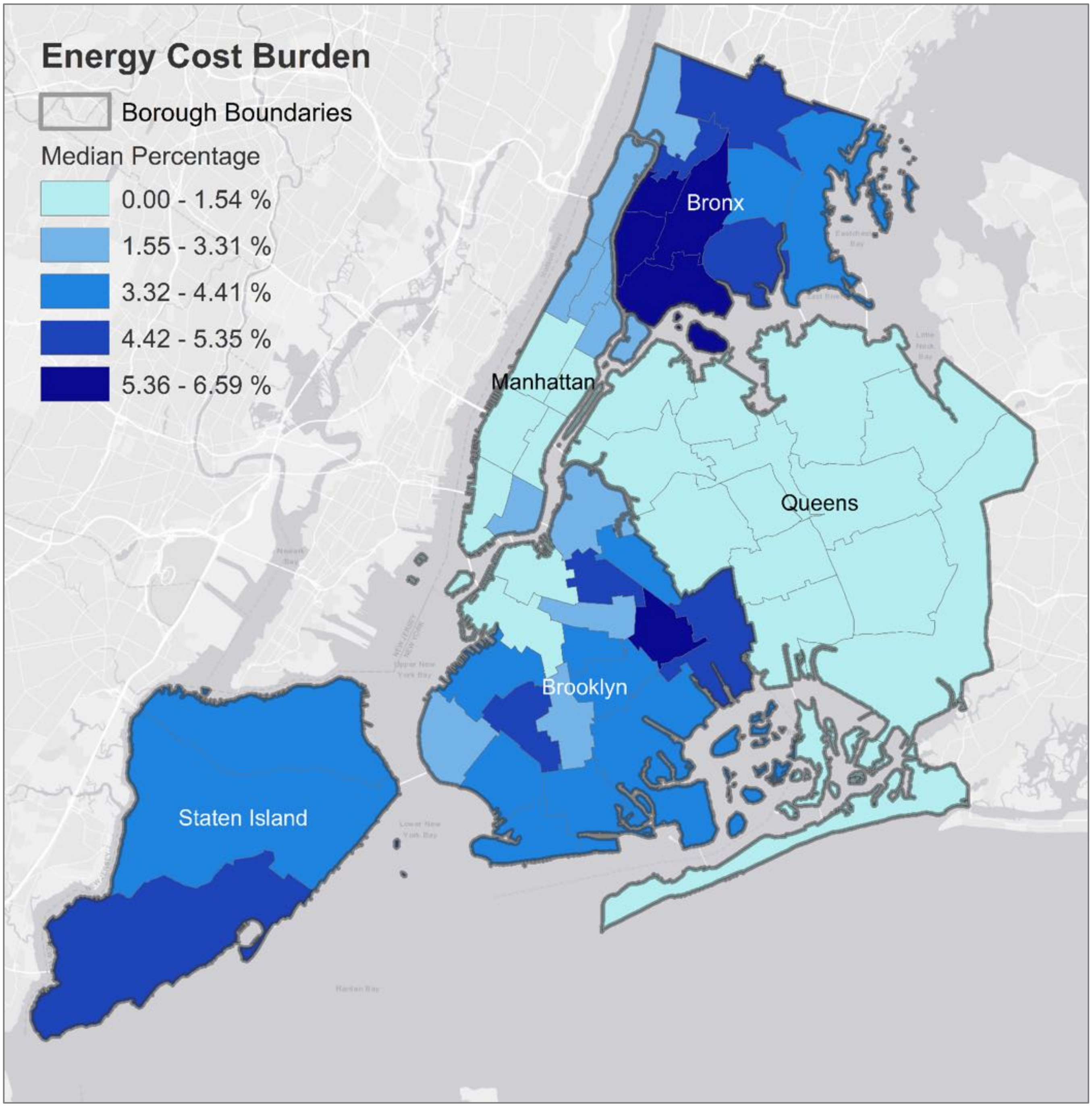

Figure 5: Geospatial map of median energy cost burden by PUMA. For more detail regarding Geographic Information System (GIS) methodology, please see **Appendix E**.

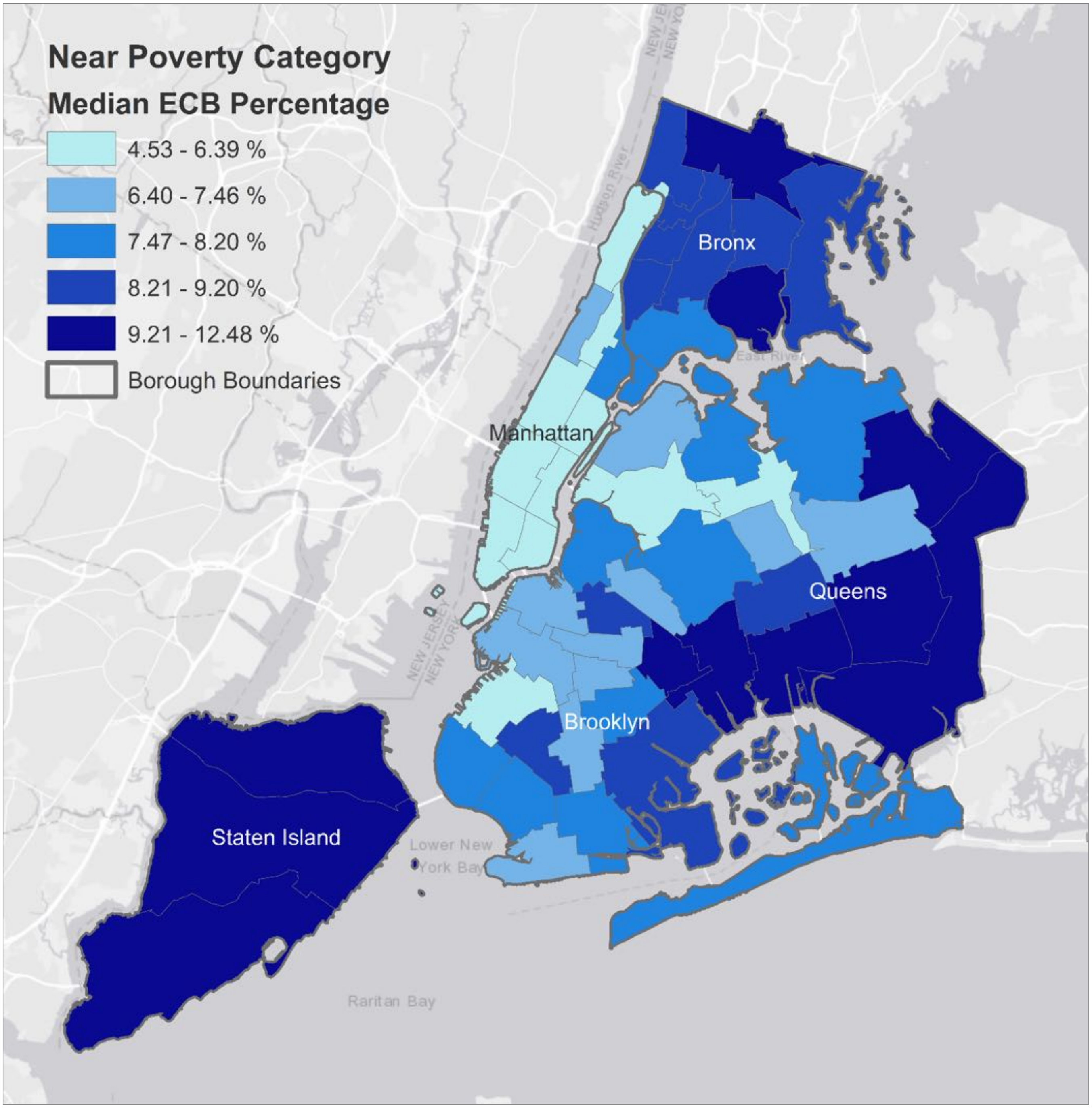

Figure 6: Geospatial map of median energy cost burden by PUMA boundary for near poverty households.

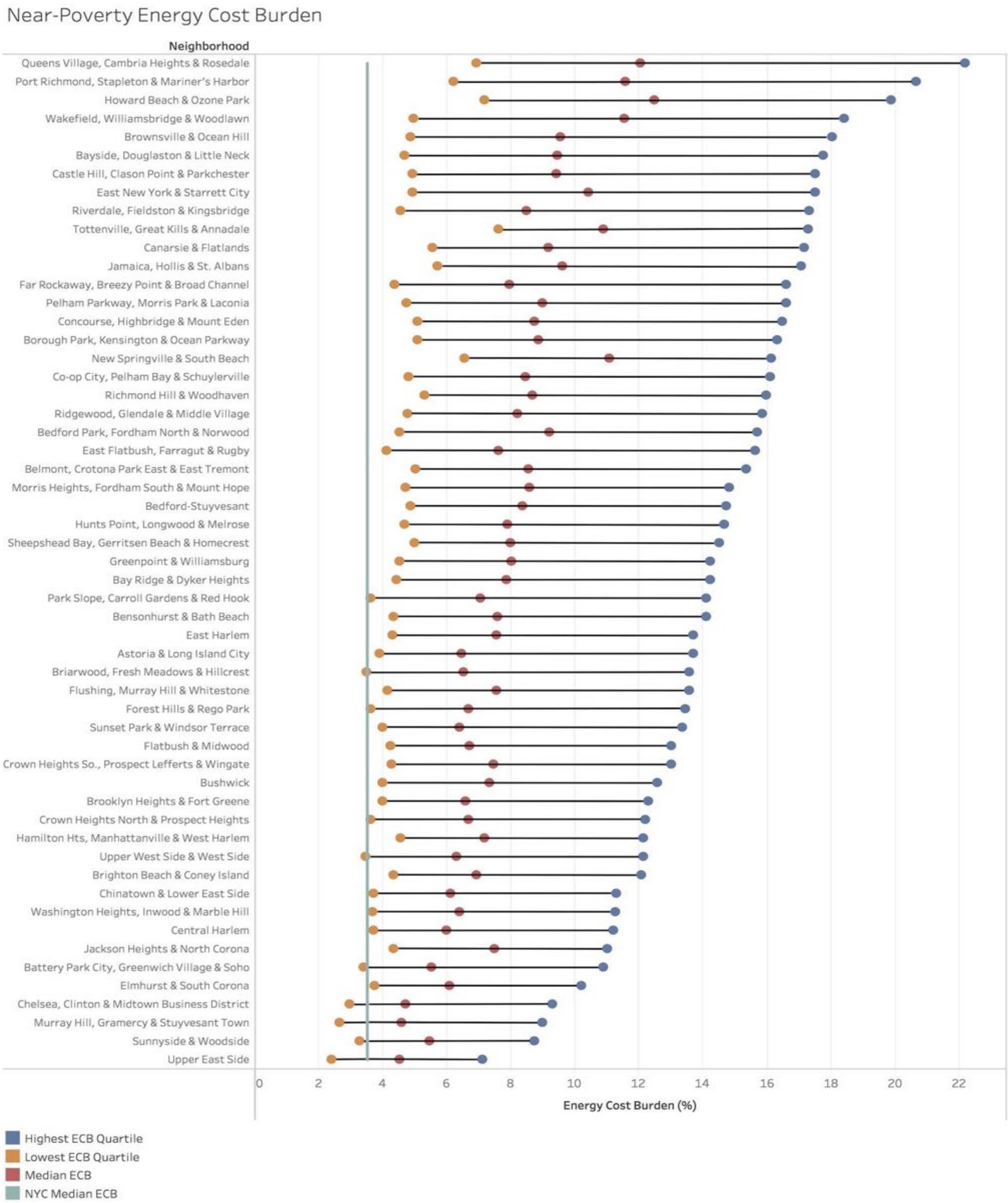

Figure 7: Low, median, and upper energy cost burden quartiles by PUMA. Please see **Appendix F** for a summary table of lower, median and upper quartile energy cost burden of near poverty households by PUMA.

III. Building Characteristics Impact on Energy Cost Burden

Previous research indicates that inefficiencies in housing stock and household appliances play a major role in high energy cost burden. Therefore, we analyzed this relationship, assuming the age of building could be a strong indicator of housing stock and appliance efficiency, and ultimately energy costs. We did not find a statistically significant relationship between the age of buildings and energy cost burden. The breakdown of energy cost burden of structures by the year built is shown in **Figure 8**. We also performed a correlation analysis on energy cost burden with building characteristics, such as the number of units in structure and the number of rooms in the unit, and found no strong correlation between energy cost burden and any of these building characteristics. This is likely due to the absence of documentation of retrofits of older buildings in our dataset. New York City has implemented many building retrofit and weatherization programs, as discussed later in the policy section, not reflected in this dataset. For more information on the impact of building characteristics on energy cost burden, please see **Appendix D**.

To better understand the relationship between low-quality housing and energy cost burden, housing code violations were mapped against the median energy cost burden by PUMA in **Figure 9**. This analysis uses data from the NYC Department of Housing Preservation (HPD) that identifies the rental units in violation of the NYC Maintenance Code (HMC) or the New York State Multiple Dwelling Law (MDL) since October 1, 2012 that have not been resolved. This map reveals that there are areas with high median energy cost burdens that have a substantial number of housing code violations. However, there are also areas, such as Upper Manhattan, that have relatively lower energy cost burdens and still have a substantial number of housing code violations. For more information regarding the GIS methodology, please see **Appendix E**.

Research suggests that nationally, multifamily buildings have more low-income residents than non-low-income residents.[69] These buildings are also the least likely housing type to have energy efficiency upgrades or retrofits.[70] In NYC, 29% of GHG emissions from buildings comes from multifamily buildings, compared to the 19% of GHG emissions coming from single-family homes.[71] Additionally, 41% of the building area in NYC is comprised of multifamily homes, compared to the 27% of single-family homes.[72] **Figure 10** shows the average number of units per building across NYC to understand where these multifamily buildings are mainly located. Our quantitative analysis reveals that the median energy cost burdens for single-family and multifamily homes are 4.38% and 2.95%, respectively. A further breakdown of in or near poverty households shows that the median energy cost burden for single-family homes in or near poverty is 10.49%, compared to the median energy cost burden for multifamily homes in or near poverty of 6.50%.

We also calculated the average cost for different utility types as a percent of total energy cost: electricity, gas, and other fuel. Since different sources of energy have varying costs, it is important to know how much a household is purchasing of each. For example, heating with fuel oil is more expensive than gas; therefore, if an older heating system is relying on this more expensive energy source, this can mean higher energy cost burden for these households, compared to those that do not use fuels. **Table 5** breaks down the household survey responses by reported energy costs and shows the percentage of spending on each energy source.

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[69] American Council on Energy-Efficient Economy.
[70] American Council on Energy-Efficient Economy.
[71] New York City 80 x 50 Buildings Technical Working Group. *One City Built to Last: Transforming New York City Buildings for a Low-Carbon Future: Technical Working Group Report*. New York City Mayor's Office of Sustainability.
[72] New York City 80 x 50 Buildings Technical Working Group.

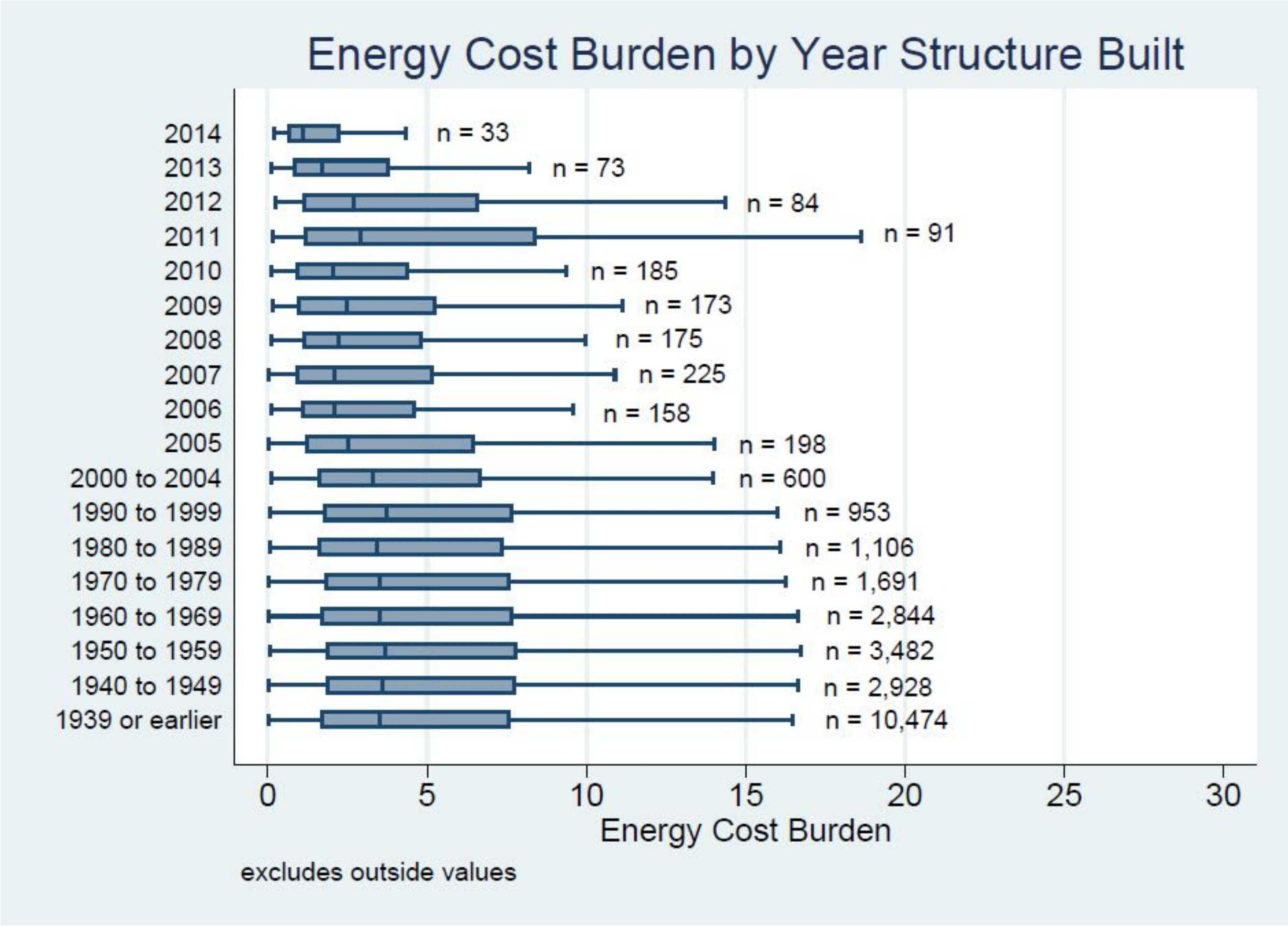

Figure 8: Box Plots (depicting medians as lines within the box) of the construction year the building and the respective range of energy cost burdens. Outliers are excluded, and "n" represents the sample number of households in each category.

Table 5: Types of individual utility costs from monthly energy bills for households stating transparent energy costs in the survey.

Type of Utilities				Number of Households	Median ECB
Reported Costs	Average Electricity Cost as Percent of Total Energy Cost	Average Gas Cost as Percent of Total Energy Cost	Other Fuel Cost as Percent of Total Energy Cost		
Electricity and Gas	62%	36%	N/A	13,372	3.86%
Electricity, Gas, and Fuel	37%	19%	44%	842	4.66%
Electricity and Fuel	51%	N/A	49%	249	7.32%

*The Gas cost does not specific heating or cooking
*The Fuel cost is solely for heating but excludes Gas as a heating element (all Fuels except Gas)

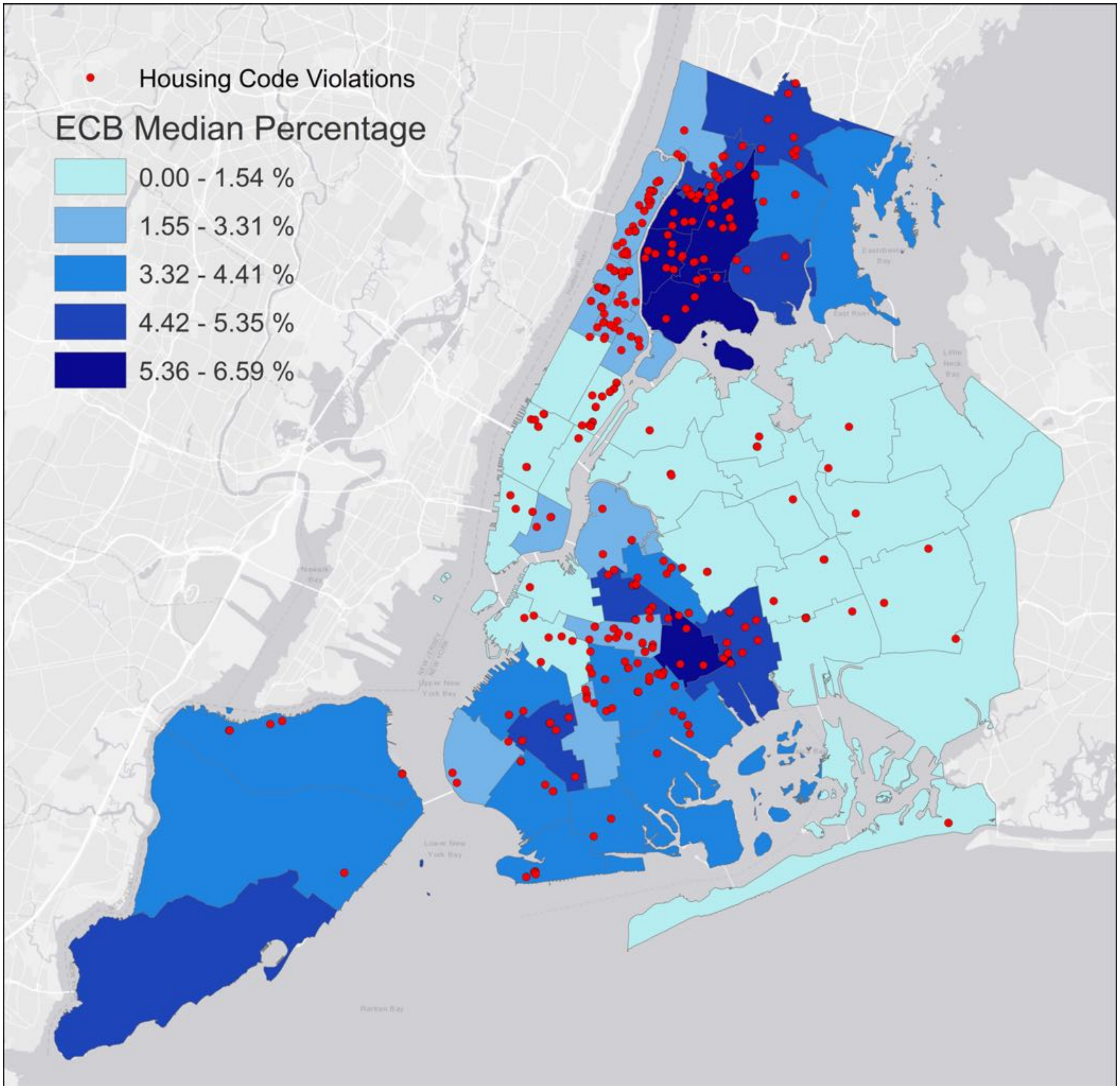

Figure 9: Geospatial map of energy cost burden and housing code violations in NYC.

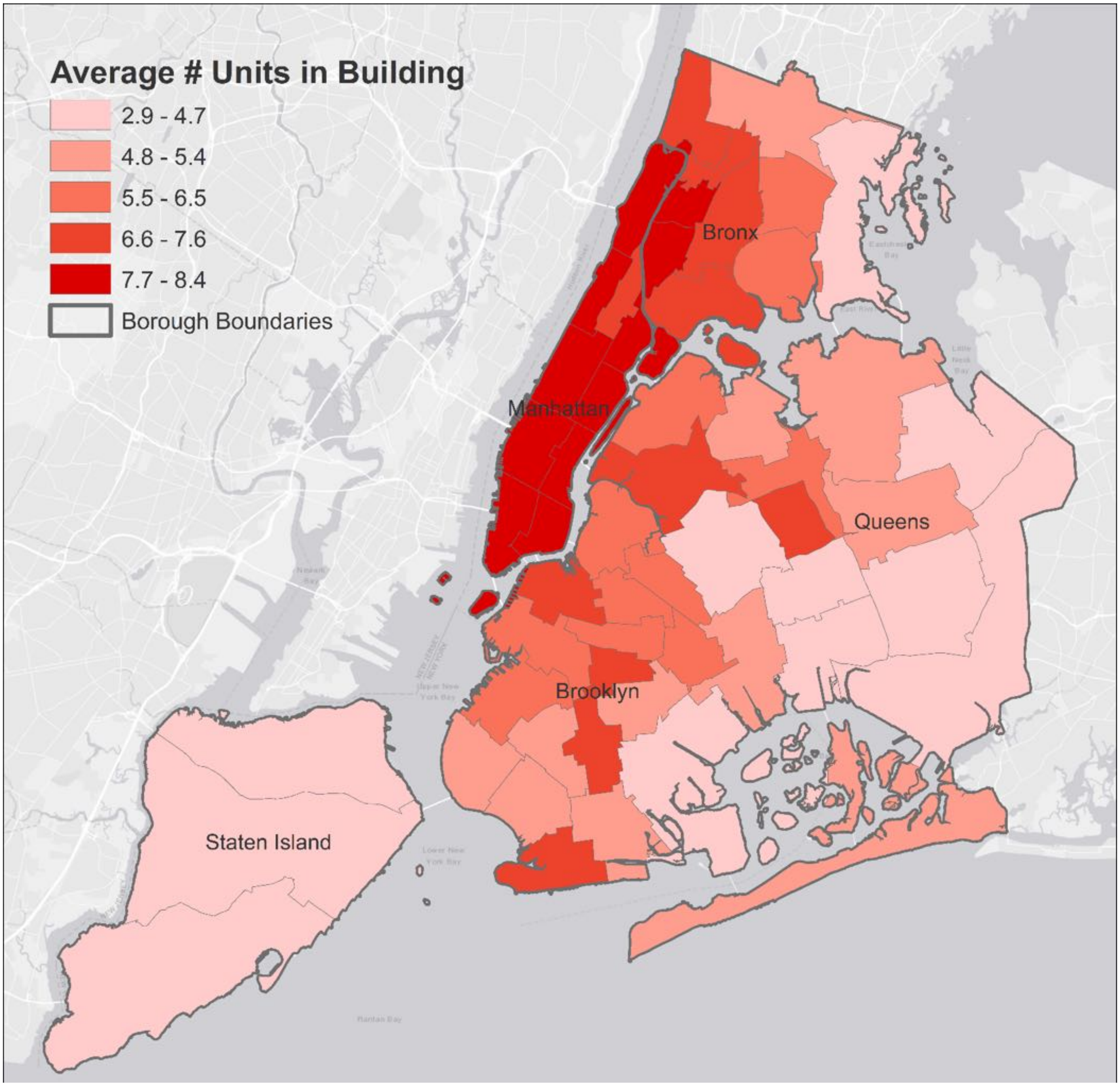

Figure 10: Geospatial map of the average number of units per building

IV. Potential Impact of Subsidies and Premiums on Energy Cost Burden

One policy intervention for households with disproportionately high energy cost burdens is a subsidy on monthly energy bills. We performed a sensitivity analysis of energy cost burden by applying various subsidies to determine the amount needed to bring the energy cost burden for near poverty households below 6% (the cutoff above which households can be considered to have a high energy cost burden in this analysis). We used the median energy cost for households below poverty, $115/month. For households with an annual income between $1-$12,015, a $77 monthly subsidy would bring down their median energy cost burden from 17.50% to 5.17%. This is the most vulnerable 10% of New York City households experiencing unduly high energy cost burdens. While a subsidy would not provide permanent relief, this analysis quantifies the subsidy needed to alleviate unduly high energy cost burden.

For households with an annual income of $12,015-$22,028, a $56 monthly subsidy would bring down their energy cost burden by nearly half, from 8.99% to 4.62%. A $35 monthly subsidy would bring their energy cost burden to 6.35%. Households in the $22,028-$33,642 and $33,642-$47,571 income brackets do not need a subsidy to have an energy cost burden below 6%. A summary of possible subsidies and their impact on energy cost burden for near poverty households is in **Table 6**. It is important to remember that these households are representative of hundreds of thousands of households throughout NYC. Considering there are around 700,000 households in NYC with annual income levels below $22,028, this subsidy would cost millions of dollars per month.[73] For example, if we assume that half of the households below $22,029 requires a subsidy of $77/month, and the other half requires a subsidy of $56/month, then it would cost NYC $558.6 million per year.

Table 6: Applying subsidies to monthly energy bills for different quartiles of income within the near poverty threshold in NYC to see a drop in median energy cost burden.

Quartiles of households lying below near poverty (<$47,634)	Percentages of household that lie within this bracket	Median Energy Cost Burden				
		Original Median ECB without Subsidy	Subsidy of $14 monthly	Subsidy of $35 monthly	Subsidy of $56 monthly	Subsidy of $77 monthly
$1-$12,015	10.23% of all households	17.50%	15.24%	11.86%	8.52%	5.17%
$12,015-$22,028	11.3% of all households	8.99%	7.95%	6.35%	4.62%	3.14%
$22,028-$33,642	10.69% of all households	5.57%	4.98%	4.07%	3.15%	2.24%
$33,642-$47,571	10.75% of all households	4.09%	3.66%	3.01%	2.40%	1.77%

* Income categories were determined by dividing the total number of households earning $1-$47,643 into four groups with a quarter of those households in each group. The second column shows what percentage of households citywide are in that income bracket.

[73] Weissman Center for International Business. "Income and Taxes - New York City - Number of Households - By Income Range." *NYCdata*, Baruch College.

A potential rise in energy costs would result in proportionally higher increases in energy cost burden for in or near poverty households. An additional $5/month rate increase for households making $1 - $12,015 annually would increase their energy cost burden from 17.50% to 18.27%. A $50 energy cost increase would raise their median energy cost burden to 25.38%. For households making $12,015 - $22,028 annually, a $5 rate increase would raise their energy cost burden from 8.99% to 9.43%. A $40/month energy cost increase would raise their median energy cost burden to 12.84%. For a summary of the impact of raised energy costs on median energy cost burden for near poverty households, refer to **Table 7**.

Table 7: Increasing costs to monthly energy bills for different quartiles of income within the near poverty threshold to understand the impacts of different groups median energy cost burden.

Income Brackets for all households lying below near poverty (<$47,634)	Percentages of household that lie within this bracket	Median Energy Cost Burden				
		Original Median ECB without Subsidy	Additional charge of $5 on monthly bill	Additional charge of $10 on monthly bill	Additional charge of $25 on monthly bill	Additional charge of $50 on monthly bill
$1-$12,015	10.23% of all households	17.50%	18.27%	19.18%	21.57%	25.38%
$12,015-$22,028	11.3% of all households	8.99%	9.43%	9.82%	10.91%	12.84%
$22,028-$33,642	10.69% of all households	5.57%	5.78%	5.99%	6.68%	7.82%
$33,642-$47,571	10.75% of all households	4.09%	4.26%	4.40%	4.84%	5.62%

V. Summary of Findings

Overview of Energy Cost Burden in New York City

The median energy cost burden is 3.51% with a median total energy cost of $140 per month.

Demographic Analysis of Energy Cost Burden

Energy Cost Burden and Income

In and near poverty households (< $31,756 and < $47,634 annual income, respectively) experience disproportionately high energy cost burdens of 9.99% and 7.96% respectively. The relationship between income and energy costs for households above and below the poverty line are very different. For every $10,000 increase in income for households below the poverty line, energy costs increase by $14.62 per month. For every $10,000 increase in income for households above the poverty line, energy costs increase by $1.40 per month.

Energy Cost Burden and Head of Household Race

Black (4.57%), and American Indian (5.23%) have higher median energy cost burdens compared to White (2.84%) and Asian (3.17%) households.

Energy Cost Burden and Head of Household Age / Language

Our analysis showed no significant relationship between energy cost burden and head of household age. There is also no significant relationship between energy cost burden and head of household language.

Energy Cost Burden and Ownership Status

There is no statistically significant difference in the median energy cost burden for renters versus homeowners, with median energy cost burdens of 3.42% and 3.60% respectively. However, increasing rents trend towards higher energy costs but lower energy cost burdens.

Geospatial Trends in the Distribution of Energy Cost Burden Across the City

Southern Bronx, Central/Eastern Brooklyn, and Staten Island have disproportionately high energy cost burdens compared to the rest of the city. Our analysis revealed areas of unduly high energy cost burden for in or near poverty households, such as parts of Queens, Staten Island, and the Bronx, that may not be apparent when looking at the median for all income groups.

Building Characteristics Impact on Energy Cost Burden

Our dataset did not reveal a significant relationship between energy cost burden and building age, likely attributed to a large number of retrofits not reflected in the data. There was also no significant relationship between energy cost burden and number of units in structure, but this relationship is explored further with our geospatial analysis.

Potential Impact of a Subsidy and a Premium on Energy Cost Burden and Energy Costs

For households with an annual income of $1-$12,015, a $77 monthly subsidy would bring down their median energy cost burden from 17.50% to 5.17%. For households with an annual income of $12,015-$22,028, a $35 monthly subsidy would bring their energy cost burden from 8.99% to 6.35%. Most households in the $22,028-$33,642 and $33,642-$47,571 income brackets do not need a subsidy to have an energy cost burden below 6%.

If the $77 and $35 monthly subsidies are applied to the approximate 700,000 households in NYC that lie in the $1-$12,015 and $12,015-$22,028 income brackets respectively, this would cost NYC roughly $558.6 million per year.

Alternatively, an increased energy premium would increase energy cost burden. An additional $5 rate increase for households making $1 - $12,015 annually would raise their energy cost burden from 17.50% to 18.27%. A $50 rate increase would raise their median energy cost burden to 25.38%. For households making $12,015 - $22,028 annually, a $5 rate increase would raise their energy cost burden from 8.99% to 9.43%. A $40 rate increase would raise their median energy cost burden to 12.84%.

5) Comparative Analysis of Policies and Programs that Address High Energy Cost Burden

Based on our analytical findings, several policy areas were evaluated for their approach to reducing energy cost burden through decreasing energy payments and consumption. The types of policy interventions analyzed in this report fall under the following categories:

I. Subsidies,
II. Energy efficiency,
III. Demand response.

Our criteria for evaluating program success hinges primarily on a program's ability to reduce energy cost burden in low-income households while also contributing to GHG reductions to meet NYC's ambitious mitigation targets for the building and energy sectors. For a summary of policy interventions based on key benefits offered, see **Appendix G**.

I. Subsidies

High energy cost burden can be addressed directly through various options in subsidy programming. By providing direct assistance to customers through decreasing their energy bill, energy cost as a percentage of income decreases. Subsidies are applied as one-time assistance, a percentage of customer income, on a seasonal basis, or as year-long energy bill assistance. A summary of the benefits of subsidies are in **Table 8**, and subsidy barriers are summarized in **Table 9**, in addition to recommendations for subsidy implementation.

Why Consider Subsidies as a Solution for Energy Cost Burden?

Energy costs are the highest controllable expense of residents in multifamily housing units, which means that reducing energy cost burden allows residents to spend income on other critical needs such as food, transportation, and childcare.[74] Reducing energy cost burden for residents in or near poverty may make a significant difference in their quality of life. Subsidies can be an effective tool for reducing energy cost burden, particularly because they directly impact the customer by minimizing monthly energy costs.

Impact of Subsidies on Greenhouse Gas Emissions

Offering subsidies to households with high energy cost burden results in stable or increased GHG emissions. Subsidy programs that allow customers to pay fixed amounts regardless of usage patterns have shown increased consumption ranging from 0.9-3.8% of pre-subsidy consumption.[75] This increased energy usage is likely because those households were previously keeping their homes at unsafe temperatures, or service was disconnected previously. Decreased GHG emissions can only occur if subsidy programs are paired with demand response programs and referral programs that offer energy efficiency retrofits.[76]

What Subsidy Programs Exist in NYC?

[74] Drehobl, Ariel, and Lauren Ross. *Lifting the High Energy Burden in America's Largest Cities: How Energy Efficiency Can Improve Low-Income and Underserved Communities*, 2016.
[75] APPRISE. *Illinois PIPP Program Impact Evaluation - Draft Report*. 2009.
[76] APPRISE. *Allegheny Power Universal Service Programs - Final Evaluation Report*. 2010.

Current subsidy programs in NYC available to low-income residents include the New York State Home Energy Assistance Program (HEAP) and payment plans and assistance provided by Con Edison, the major energy provider in the city. The two types of HEAP benefits include regular and emergency benefits. Through a regular HEAP benefit, a lump sum subsidy is given to a household each program year. A household is given emergency benefits if it is at risk of having their services shut off.[77] Eligibility varies based on income, household size, primary heating source and age of household members.[78] Con Edison works directly with customers to assist with payment plans such as payment extensions, payment agreements that keep customers from having services terminated, and level payment plans that allow for even energy expenses all year rather than spikes during peak seasons.[79] Payment assistance plans vary by customer and can include assistance such as a $10 reduction in fixed prices on an energy bill.

Innovative Interventions from Other Cities

Percent of Income Payment Plan (PIPP) is an innovative pilot program in Illinois that exists to alleviate energy cost burden for people in or near poverty. The PIPP program was piloted from July 2008 to May 2009. Customers of the program were asked to pay monthly utility bills of up to 10% of their income, rather than the price of their standard bill.[80] The customer was required to pay a minimum of $10 per month, and the maximum subsidy allotment was $1,800. At the beginning of the program, customers received a one-time arrears forgiveness benefit. Overall, the PIPP pilot program was effective in decreasing energy cost burden for most of the participating customers, and results showed that the program particularly increased energy security for the elderly and households with children.[81] Arrears forgiveness was seen to be a major contributor to customers' ability to make future payments. While this program was effective in decreasing energy cost burden for participants, customers with very low utility bills were not incentivized to pay bills consistently or decrease their energy use. [82] This program suggests that while subsidies can be effective in reducing energy cost burden, they require active customer engagement and do not always address high energy use and emissions.

Using Subsidies to Reduce Energy Cost Burden in NYC

The basis of our analysis on various subsidy amounts applied to the average monthly energy bill cost in NYC for residents at or near the poverty line comes from the proposed subsidy amounts in the New York State Energy Affordability Policy. The Energy Affordability Policy was proposed by Governor Cuomo in 2016 and approved by the State of New York Public Service Commission in 2017. It suggests electricity subsidies of $11-44, and gas subsidies of $3-33 to meet the goal of keeping energy cost burden below 6%.[83] Combining gas and electricity subsidies in our statistical analysis, we determined the level of subsidy that would be required to decrease household energy cost burden to 6% for most homes in NYC. For a household with an annual income of $1-12,015 a subsidy of $77 on the median energy bill of $115 would reduce energy cost burden to 5.17%. This is a 12.13% reduction from the median energy cost burden of 17.50% for this income range. For households with annual income of $12,015-22,028, a subsidy of $35 on a $115 energy bill would reduce energy cost burden to 6.35%, as shown in **Table 6**.

While a subsidy can be effective for reducing high annual energy cost burden for NYC residents in or near poverty, current HEAP and Con Edison programs assist at a level that does not meet the need in NYC. Existing Con Edison assistance programs provide a monthly subsidy of$10 for all recipients of Low-Income HEAP (LIHEAP), which does not substantially impact overall energy cost burden, as shown in **Table 6**, by the limited impact of the $14 subsidy on energy cost burden. Our analysis does show that when appropriate levels of subsidy are offered to households in or near poverty, high energy cost

[77] New York State Office of Temporary and Disability Assistance. *Home Energy Assistance Program (HEAP)*. otda.ny.gov/programs/heap/#regular-benefit.
[78] Ibid.
[79] Con Edison. *Payment Plans and Assistance*. www.coned.com/en/accounts-billing/payment-plans-assistance.
[80] APPRISE. *Illinois PIPP Program Impact Evaluation - Draft Report*. 2009.
[81] Ibid.
[82] Ibid.
[83] "Governor Cuomo Announces New Energy Affordability Policy to Deliver Relief to Nearly 2 Million Low-Income New Yorkers." 19 May 2016

burden is significantly reduced to below the 6% threshold. However, subsidies are not effective long-term solutions, because they do not address all energy cost burden drivers, including energy inefficiency, and do not mitigate GHG emissions.

Best Practices

Program reviews by the Applied Public Policy Research Institute for Study and Evaluation (APPRISE) have identified the areas of best practice that can be incorporated into subsidy programs to achieve the maximum reduction in energy cost burden for the consumer. To ensure the greatest reduction of energy cost burden of households in poverty, subsidy programs should offer long-term energy bill assistance, arrears forgiveness, case management, and long-term collaboration with energy service providers, as well as demand response programs. A program review of the New Jersey Universal Service Program demonstrated that providing clients incentives to make regular payments through arrears forgiveness was effective in receiving regular payments and decreasing energy cost burden for the customer.[84] The Review of the Illinois PIPP pilot program showed that arrears forgiveness at the beginning of the program improved customers' ability to make future payments.[85] For low-income customers who continue to face challenges paying their bills even while on a subsidy program, individual case management has been effective in keeping customers engaged in the program.[86] Subsidy program collaboration with energy service providers has proven to be effective in keeping customers on track with payments, particularly when there is regular communication from energy service providers about payment expectations, this has been seen to keep customers on track with payments.[87]

Table 8: The benefits of subsidies.

Resident	Utility	Society
Positive health and social outcomes	Increased regularity of payments from customers	Reduced public health expenditures
Increased financial insecurity	Reduced arrears and debt	Fewer shut-offs and service interruptions funded by all ratepayers

Table 9: Barriers and recommendations for the implementation of subsidies.[88]

Barriers	Recommendations
Needs to be paired with other programs to reduce energy consumption	Incorporate demand response education and energy efficiency retrofit opportunities into subsidy programs
High costs to city or utility	

[84] APPRISE. *Impact Evaluation and Concurrent Process Evaluation of the New Jersey Universal Service Fund - Final Report*. 2006.
[85] APPRISE. *Illinois PIPP Program Impact Evaluation - Draft Report*. 2009.
[86] APPRISE. *PECO Energy Customer Assistance Program For Customers Below 50 Percent of Poverty - Final Evaluation Report.* 2006.
[87] APPRISE. *T.W. Phillips Energy Help Fund Program Evaluation - Final Report*. 2004.
[88] Federal Energy Regulatory Commission Staff. 2010 Assessment of Demand Response and Advanced Metering Staff Report. 2011.

II. Energy Efficiency

Energy efficiency represents a ratio of the amount of energy consumed to the output produced.[89] For example, a building's heating system can be made more efficient by replacing windows to reduce heat leaking out of the building. Decreasing the amount of energy used for each unit of output has thus been the main goal of energy efficiency projects. We see this in the increased regulatory focus requiring more efficient appliances and green building codes for new construction. Most recently, government agencies have focused on increasing energy efficiency for older building stock by requiring building retrofits and promoting weatherization programs. After addressing potential unintended consequences and barriers to participating in energy efficiency programs, this section addresses different options for implementing energy efficiency programs, including low-interest loans, technical assistance, rebates and incentives, and retrofits and weatherization. Benefits of energy efficiency are summarized in **Table 10**, and barriers to energy efficiency as well as best practices are summarized in **Table 11**.

Barriers to Participating in Energy Efficiency Programs

Energy efficiency poses a tremendous opportunity for reducing energy cost burden,[90] however incentives to invest in energy efficiency vary. One NYC-specific study suggests that low-income homeowners experience the most direct benefits from energy efficiency investments. In contrast, for renters, the role their landlords play in the maintenance of rental units substantially impacts their ability to benefit from energy efficiency improvements. Landlords want to recover the capital invested in energy efficiency improvements and are better incentivized to invest in energy efficiency retrofits if they provide electricity, heating or both for tenants and can pass these costs.[91] Even landlords of rent-stabilized units that pay for utilities can apply to the NYS Division of Housing and Community Renewal for approval to raise rent to cover energy efficiency upgrades and other Major Capital Improvements (MCI).[92] If these costs are not passed on to tenants, investment in energy efficiency may be suboptimal.

These landlord-tenant incentive issues are particularly important considerations for policy initiatives targeted at improving energy efficiency for in-or-near poverty households. Across the U.S., only 18% of energy efficiency program expenditures target low-income households, despite 33% of the population categorized as such.[93] Similarly, only 33% of all Green Jobs Green NY loans went to households in this income bracket.[94] Moreover, enrollment in low-income energy efficiency programs is low, with LIHEAP reaching less than 25% of eligible participants.[95],[96] Low-income homes are less likely to have efficient lighting than average income populations, and more likely to have energy-intensive space heaters and window air conditioning units.[97] They are also more likely to have electric water heaters, which are more expensive (unless it is a heat pump water heater).[98] Additionally, investing in low-income energy efficiency generates economic development, as

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89 International Energy Agency. *Capturing the Multiple Benefits of Energy Efficiency*. 2014.
90 Heffner, Grayson, and Nina Campbell. *Evaluating the Co-Benefits of Low-Income Energy-Efficiency Programmes.* International Energy Agency, 2011.
91 Banerjee, Julie, and Diana Hernández. "Diana Hernández Expert Interview." 23 Mar. 2018.
92 New York State Division of Housing and Community Renewal Office of Rent Administration. *Fact Sheet #24 Major Capital Improvements (MCI) Questions and Answers*. 2017.
93 Cluett, Rachel, et al. *Building Better Energy Efficiency Programs for Low-Income Households. American Council on Energy-Efficient Economy*, 2016.
94 New York State Energy Research and Development Authority. *Green Jobs - Green New York Low to Moderate Income (Low- To Moderate-Income) Working Group Recommendations - Final Report*. 2015.
95 Pearl, Libby. *LIHEAP: Program and Funding*. Congressional Research Service, 2013.
96 Berelson, Serj. "Myths of Low-Income Energy Efficiency Programs: Implications for Outreach." American Council on Energy-Efficient Economy, *2014 ACEEE Summer Study on Energy Efficiency in Buildings*, 2014.
97 Ibid.
98 Cluett, Rachel, et al. *Building Better Energy Efficiency Programs for Low-Income Households. American Council on Energy-Efficient Economy*, 2016.

demonstrated by with every dollar in LIHEAP investment generating $1.13 in activity[99] along with other non-energy benefits.[100]

A. Energy Efficiency Program Offering: Low-interest Loans

Why Consider Low-interest Loans for Energy Efficiency Programs?

Increasing energy efficiency can significantly decrease energy cost burden in low- and moderate-income households, but limited access to capital prevents investment into energy efficiency improvements.[101] Finance options that allow for reduced up-front cost on behalf of the building owner are a valuable tool to encourage energy efficiency measures that could benefit low- to moderate-income consumers. However, maximizing energy savings requires that as many cost-effective measures as possible are installed together.[102] If the building owner is unsure of what actions are the most impactful for their building, access to low-interest loans may not be an effective strategy unless paired with education and technical assistance.

Impact of Energy Efficiency Low-interest Loans on Greenhouse Gas Emissions

Increasing access to energy efficiency low-interest loans will likely increase the prevalence of energy efficiency retrofits and increase the efficiency of NYC housing stock, which can contribute to lower energy costs burdens and reduce GHG emissions.

What Energy Efficiency Low-interest Loan Programs Exist in NYC?

NYC Department of Housing Preservation and Development, the NYC Housing Development Corporation, and New York City Energy Efficiency Corporation (NYCEEC) all offer low and no-cost financing options for New York City building owners who want to make energy efficiency improvements.[103] Low and no interest loans are a valuable tool in encouraging energy retrofits because they make retrofits more accessible to building owners. The high up-front cost of paying for energy efficiency is made even more untenable for some building owners with limited financing options at high-interest rates. Other examples of low-interest loans available in NYC are offered through the New York State Energy Research and Development Authority (NYSERDA), which offers residential financing options for home energy assessments for homeowners as well as RFP 8[104], an ongoing energy efficiency financing program targeted at commercial and multifamily building owners.

On a much larger scale, innovative financing options are already available in NYC through the New York City Energy Efficiency Corporation or NYCEEC. This non-profit financial services firm provides loans to building owners for energy efficiency and clean energy projects, often combining traditional with non-traditional financing mechanisms to maximize the outputs of the project. One such project occurred in 2013, when NYCEEC worked with the building owners of Roosevelt Landings, a mixed-income residential development on Roosevelt Island, to underwrite the energy efficiency retrofits implemented in the development.[105] The savings were used as loan collateral to the energy services company implementing the project design. The project is notable because it combined a power purchase agreement (PPA) and an energy services agreement (ESA) as a joint tool. By combining a PPA and ESA into this project, Roosevelt Landings was able to gain the confidence of investors behind the building owner, because both agreements require savings and financial return calculations made up front. This resulted in an additional equity investment in the energy services company executing the

[99] Blinder, Alan S., and Mark Zandi. *How the Great Recession Was Brought to an End*. 2010.
[100] Drehobl, Ariel, and Fernando Castro-Alvarez. *Low-Income Energy Efficiency Programs: A Baseline Assessment of Programs Serving the 51 Largest Cities*. American Council on Energy-Efficient Economy, 2017.
[101] New York State Energy Research and Development Authority. *Clean Energy Fund Investment Plan: Low- to Moderate-Income Chapter*. 2017.
[102] Applied Public Policy Research Institute for Study and Evaluation. *Low-Income Energy Efficiency - Opportunities Study*. 2017.
[103] NYC Retrofit Accelerator. "Resources." *Ways to Save | NYC Retrofit Accelerator*, retrofitaccelerator.cityofnewyork.us/resources.
[104] NY Green Bank. *RFP 8: Efficiency & Renewables Financing Arrangements: Building & Property Owners*. portal.greenbank.ny.gov/CORE_Solicitation_Detail_Page?SolicitationId=a0rt000000QnyNAAS
[105] NYCEEC. *Clean Energy Pays Off in the Multifamily Market. Clean Energy Pays Off in the Multifamily Market*.

PPA and ESA, giving them an additional stake in the performance. Initial savings from the completed project over the first year resulted in over 1 million dollars in PPA and ESA revenue for the energy services company, over 1700 metric tons of GHG emission savings, and a 21% reduction in energy use compared to the Roosevelt Landing's baseline.[106]

Innovative Low-interest Loan Interventions from Other Cities

Low-interest loans allow residents to expedite the process of selecting and installing energy efficiency measures. An example in the State of Maine shows how loans can reduce or eliminate the barrier to making cost-saving investments in home energy efficiency. The home energy loans offered through Efficiency Maine, an independent administrator, showcased the advantage of installing a $3,000 ductless heat pump before winter with the help of a low-interest loan because it lowered the resident's winter heating costs by $1000 a year. Residents benefited because the loan allowed them to install a high-efficiency heating system in the off-season so that they could prepare for the cold weather, and resulting energy cost savings cut their heating cost in half.[107]

B. Energy Efficiency Program Offering: Technical Assistance

Why Consider Technical Assistance for Energy Efficiency Programs?

Technical assistance for energy efficiency programs is often just as important as financial assistance because applying the most effective energy-saving technologies is key to getting the greatest return on investment. If the energy-saving potential of a building project cannot be identified, the financial scope of the project will be unclear. Lack of technical background or knowledge can be a barrier to the implementation of energy efficiency measures even if favorable financing options are in place.

Impact of Energy Efficiency Technical Assistance on Greenhouse Gas Emissions

The increase of technical assistance and outreach to understand energy efficiency options will help to expand efficiency adoption. This will lead to increased awareness of actual energy savings and guidance for more effective, targeted strategies based on building type. Through these actions, a decrease in GHGs should occur.

What Energy Efficiency Technical Assistance Programs Exist in NYC?

NYC Retrofit Accelerator and Community Retrofit NYC are two examples of programs in the city working to offer technical assistance and resources to building owners. This includes providing a list of approved contractors for building system upgrades, efficiency advisors to offer solutions for energy waste and project finance tools. Individual residents, whether they rent a single unit in a multifamily building or they own a house in NYC, can access technical assistance from a Community Energy Advisor through a partnership between NYSERDA and The Center for New York City Neighborhoods. The combination of finance and technical expertise has been utilized in NYC through non-profits such as NYCEEC, which offer not only a variety of loan structures, but also engineering support and technical guidance to help borrowers (both landlords and tenants) maximize cost and energy savings. French Apartments in Manhattan had steam heating upgrades undertaken with the help of voluntary energy audit, under NYSERDA's FlexTech program, which offers energy efficiency technical analyses and strategic energy management assistance to facilities.[108]

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[106] Ibid.
[107] Efficiency Maine. *Bill Case Studies*, www.efficiencymaine.com/docs/BillCasestudies_web_5.5x8.5.pdf.
[108] NYSERDA. *FlexTech Program (PON 1746)*, portal.nyserda.ny.gov/CORE_Solicitation_Detail_Page?SolicitationId=a0rt000000Q0bJAAS.

Innovative Technical Assistance Interventions from Other Cities

The Sustainable Urban Neighborhoods (SUN) program in Belgium utilizes a "guided group purchasing" methodology to increase adoption of energy retrofits in homes. This approach provides support and guidance for homeowners and renters as well as group purchasing of services to reduce costs. Within a few months, the pilot retrofitted 80 homes.[109] In Detroit, a SUN pilot program is being developed, which focuses on conducting workshops and surveys within a small, low-income neighborhood. The program will offer assistance to the residents and gauge the current understanding of available energy efficiency options. Estimated cost savings for the entire project area range from $129,465 and $166,866.[110]

C. Energy Efficiency Program Offering: Rebates and Incentives

Why Consider Rebates for Energy Efficiency Programs?

Pairing rebate programs with renewable energy or energy reducing technology can further decrease energy costs and alleviate energy cost burden. Solar water heaters (SWH) were found to reduce energy costs by 70% in addition to providing social benefits that were not quantified. An evaluation of NYSERDA's EmPower program identified a statistically significant number of houses experienced lower costs after access to rebates and incentives; however, some households started using more energy after appliance installation, a phenomenon identified as snapback or rebound effect.[111] This was confirmed by a billing analysis that calculated their base point energy use before the installation. The study mentioned relationships between appliance installation, and increased energy use would need to be further analyzed in a study comparing pre- and post-installation metering.

Impact of Energy Efficiency Rebates on Greenhouse Gas Emissions

If snapback does occur after rebate programs, GHG emissions will increase. By conducting a literature review of rebate programs in the United States, it was found that snapback has not been identified as a common consequence in programs. Therefore, it is more likely that rebates for energy efficient appliances and audits lead to improved energy efficiency and reduced GHG emissions. Solar products such as SWH could negate this concern and should be considered to substantially reduce GHG emissions.

What Energy Efficiency Rebate Programs Exist in NYC?

Rebate programs are used for household energy audits and appliance replacement programs. Creating programs that target low-income individuals or families result in more energy savings and are considered more effective.[112] Two programs currently offered by NYSERDA are the Assisted Home Performance with Energy Star and the previously mentioned EmPower New York. Both target low-income homeowners and renters, creating incentives to improve residential energy efficiency. While the first program provides low-interest loans, EmPower covers the entire cost of appliance replacement and is available to individuals that qualify for HEAP.[113]

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[109] Ruelle, Christine, and Jacques Teller. "Guided Group Purchases of Energy Renovation Services and Works in Deprived Urban Neighbourhoods." *Energy Efficiency*, 2015.

[110] Cooper, Lauren Terese, et al. "The Detroit Sustainable Urban Neighborhood Project." University of Michigan, 2011.

[111] ERS. *NYSERDA EmPower Program and National Fuel Gas Distribution Corporation's Low-income Usage Reduction Program Impact Evaluation (2010–2011) - Final Report*. 2015.

[112] Maine State Planning Office, Hart, Patricia H. "Reducing Household Energy Consumption in Maine: What It Would Take to Achieve a 25% Reduction by 2011." 2002.

[113] New York State Energy Research and Development Authority. *EmPower New York Eligibility Guidelines - NYSERDA*. www.nyserda.ny.gov/all-programs/programs/empower-new-york/eligibility-guidelines.

Innovative Rebate Interventions from Other Cities

Rebates for appliances that require less energy can significantly improve energy efficiency in residential households. In particular, space and water heating can make up more than 80% of a low-income family's energy use.[114] International case studies identified SWH as improving the social and economic well-being of low-income residents in South Africa and China through reducing energy costs.[115] Applied to the context of NYC, rebates for SWH could be a promising mechanism to reduce electricity use, improve air quality, and reduce mental stress related to energy insecurity. Issues accompanying the installation of SWH included the need for maintenance and a workforce familiar with the repair procedures. Solar availability, as well as the capacity of the solar water heaters, may vary between the research countries and NYC, leading to different levels of success.

D. Energy Efficiency Program Offering: Retrofits and Weatherization

Why Consider Retrofits and Weatherization for Energy Efficiency Programs?

In a study titled "Recognizing the Value of Energy Efficiency's Multiple Benefits,"[116] the authors found that building retrofits can bring direct savings to occupants and improve the health and safety of buildings. In single-family homes, retrofits produce non-energy benefits equal to 50-300% of the energy costs saved. In multifamily buildings, additional benefits such as improved property values, reduced maintenance costs, and occupancy turnover has been experienced in addition to reduced energy costs. Benefits extend to the utilities themselves as energy efficiency measure such as retrofits have been found to reduce bill arrears, bad debt write-offs, and less need for low-income subsidy programs. Low-income programs cost more per unit of energy saved than market rate programs.[117]

Impact of Retrofits and Weatherization on Greenhouse Gas Emissions

According to the U.S. Department of Energy's Weatherization Assistance Program, weatherization measures reduce carbon dioxide emissions by one metric ton per weatherized home. This is equivalent to roughly one-third the average emissions of an automobile.[118]

Weatherization and energy retrofits in single and multifamily residential units in New York City can have a significant impact on overall GHG emission reduction because they make up the greatest percentage of GHG emissions overall. According to the NYC Mayor's Office of Sustainability, the residential building sector makes up 37% of the city's GHG emissions.[119] Recognizing this, in 2013, New York City launched the NYC Carbon Challenge for Multifamily Buildings to engage the largest NYC residential property management companies in committing to reduce GHG emissions by at least 30 percent over the next decade through energy efficiency improvements. In total, there are 22 New York City-based residential property management firms participating in the challenge and includes over 3,500 multifamily buildings that represent 8 percent of the City's residential square footage.[120] In 2016, it was reported that the NYC Carbon Challenge has resulted in an 11% reduction of CO2 equivalent per square foot.[121]

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114 Maine State Planning Office, Hart, Patricia H. "Reducing Household Energy Consumption in Maine: What It Would Take to Achieve a 25% Reduction by 2011." 2002.
115 Wlokas, Holle Linnea. "What Contribution Does the Installation of Solar Water Heaters Make towards the Alleviation of Energy Poverty in South Africa?" *Journal of Energy in Southern Africa*, 2011.
116 Russell, Christopher, et al. *Recognizing the Value of Energy Efficiency's Multiple Benefits*. American Council on Energy-Efficient Economy, 2015.
117 Cluett, Rachel, et al. *Building Better Energy Efficiency Programs for Low-Income Households. American Council on Energy-Efficient Economy*, 2016.
118 United States Department of Energy. *Weatherization and Intergovernmental Program*. 2009.
119 New York City 80 x 50 Buildings Technical Working Group.
120 New York City Mayor's Office of Sustainability. "The NYC Carbon Challenge for Multifamily Buildings." *Green Buildings and Energy Efficiency*.
121 Ibid.

What Retrofit and Weatherization Programs Exist in NYC?

NYS's Weatherization Assistance Program (WAP), is designed to reduce the heating and cooling costs of low-income households through audits that identify opportunities for energy efficiency and health and safety measures. Example measures include: sealing cracks and holes, heating system repairs, indoor air quality improvements, window replacement and installation of energy efficient lighting and refrigeration.[122] In NYS, WAP recipients have an annual savings of 20%,[123] and report lower energy bills after weatherization, leading to increased housing security, community resiliency and lower residential mobility.[124] Energy efficient buildings are protected against potential changes in price fluctuations, potentially protecting low-income households from increasing energy costs due to the transition to the low-carbon economy.[125] Additionally, this makes energy efficient buildings better investments.

Innovative Retrofits and Weatherization Interventions from Other Cities

Low-Income Energy Affordability Network (LEAN) is a network of community action agencies in Massachusetts that has successfully partnered utilities with Weatherization Assistance Programs (WAP) to oversee energy efficiency measures in a service area.[126] Since WAP and the utilities offer energy efficiency measures to consumers, the combined implementation of both helps streamline program administration and leverage resources more efficiently than each entity could do on their own.

A case study released by LEAN demonstrated the power of leveraging multiple programs and funding sources for low-income, multifamily housing. The largest issue was the outdated boiler controls that did not allow tenants or their landlord to effectively adjust building temperature. After new controls were put in, LEAN also coordinated a short study to be conducted to ensure the new controls were reducing energy use. The results revealed that space heating energy consumption was reduced by 12.7% to 18.4% for three multifamily housing buildings.[127] The total cost saved for all three buildings was approximately $7,200, with a payback period of less than four years. Space heating energy consumption was reduced by 12.7% to 18.4% (average of 16.3%) for the three buildings. Total cost saved for all three buildings was approximately $3,600.[128] Savings for a full heating season is expected to be up to twice this amount, with an eventual simple payback period of less than four years.[129] Since landlords paid for heat, and the tenants were paying for extra electricity to use space heaters, the efficiency project reduced the energy cost burden for both parties.

E. Energy Efficiency Best Practices

Offer a Range of Eligible Measures, Including Rebates and Incentives for Appliances

Low-income houses are more likely to have older appliances, leading to greater potential savings through an upgrade.[130] Energy efficiency programs should be available to tenants if they are ratepayers and are interested in energy efficiency programs, even though their landlord doesn't have an incentive to participate.[131]

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[122] New York State Homes and Community Renewal. *Weatherization Assistance Program (WAP)*. www.nyshcr.org/programs/weatherizationassistance/.
[123] Ibid.
[124] Tonn, Bruce, et al. *Health and Household-Related Benefits Attributable to the Weatherization Assistance Program*. Oak Ridge National Laboratory, 2014.
[125] McCabe, MJ. *High-Performance Buildings – Value, Messaging, Financial and Policy Mechanisms*. United States Department of Energy, 2011.
[126] *Mass LEAN*, masslean.org/.
[127] ARIES Collaborative. *Columbia CAST Controls Retrofit Research: 2011-2012 Heating Season Results and Planned Future Work*. 2012.
[128] Ibid.
[129] Ibid.
[130] Drehobl, Ariel, and Fernando Castro-Alvarez. *Low-Income Energy Efficiency Programs: A Baseline Assessment of Programs Serving the 51 Largest Cities*. American Council on Energy-Efficient Economy, 2017.
[131] Ibid.

Include Non-Energy Benefits in Cost-effectiveness Testing

Evaluating co-benefits is often more challenging than determining direct energy savings. Some of these benefits include reduced frequency of moving, improved attendance at school and work, and household comfort improvements.[132] One study found that the incidence of anxiety or depression was decreased by half after energy efficiency measures were introduced.[133] Typically, Total Resource Cost tests occasionally use water and fuel savings, reduced maintenance and maybe a general adder to capture the value of multiple benefits.[134] Specifically within multifamily buildings, costs and benefits should be evaluated in terms of accrual to tenants, including comfort and satisfaction, and how that impacts the building owner's bottom line.[135] A national study found that benefit-to-cost ratios for energy efficiency ranged from 1.8-3.1 across the states.[136]

Provide Quality Assurance

Before deploying a program, operators should ensure that the retrofits will provide the levels of savings promised.[137]

Streamline Programs

When there are multiple programs and parties, residents can be unresponsive.[138] Creating a one-stop shop can be beneficial for creating simple, easy to use programs.[139] Coordinating with bill assistance programs, WAP and other utilities in "fuel blind" programs can increase the cost-effectiveness of energy efficiency programming and expand participation.

Address Health and Safety

Adopt an approach that integrates public health and energy efficiency. Energy efficiency is just one component of creating a healthy home. A healthy home is defined as a home that has no health and safety threats (lead, indoor allergens, radon or carbon monoxide) and supports physical, social and environmental well-being.[140] Energy efficiency is just one of the many structural considerations for buildings housing low-income individuals. Not only does energy efficiency reduce energy consumption and associated GHG emissions, but it also produces a multitude of social and economic benefits. **Figure 11** from the International Energy Association shows some of the most prominent benefits of these programs.[141] Several health and safety interventions could be integrated into energy efficiency retrofit work to improve public health, as these measures can increase self-rated health and reduce both days off from work and school as well as the number of visits to healthcare practitioners.[142] Emphasize on the social and environmental benefits: increases economic activity/expenditure elsewhere, reduce asthma, missed school days.[143] Public health, safety, equity, and economic development are a component of energy efficiency programs. While targeting large C&I buildings through programs such as the Retrofit Accelerator is helpful and has the largest return on emissions, it doesn't contribute toward the health and safety of all New Yorkers. Improvements in housing stability, affordability, and quality (non-energy benefits) are obtained from investments in energy efficiency and weatherization.[144] Pairing energy efficiency and weatherization in integrated housing programs can address health,

[132] Kuholski, Kate, et al. "Healthy Energy-Efficient Housing." *Journal of Public Health Management and Practice*, 2010.
[133] Centre for Regional, Economic, and Social Research. *Warm Front Better Health: Health Impact Evaluation of Warm Front Scheme*. Sheffield Hallam University, 2008.
[134] Cluett, Rachel, and Jennifer Amann. *Multiple Benefits of Multifamily Energy Efficiency for Cost-Effectiveness Screening*. American Council on Energy-Efficient Economy, 2015.
[135] Cluett, Rachel, and Jennifer Amann. *Multiple Benefits of Multifamily Energy Efficiency for Cost-Effectiveness Screening*. American Council on Energy-Efficient Economy, 2015.
[136] Mosenthal, Phil, and Matt Socks. Potential for Energy Savings in Affordable Multifamily Housing - Final Report. Optimal Energy, 2015.
[137] Henderson, Phillip, and William Prindle. *Program Design Guide: Energy Efficiency Programs in Multifamily Housing*. Energy Efficiency for All, 2015.
[138] Ibid.
[139] Ibid.
[140] WE ACT for Environmental Justice. *Healthy Homes*. www.weact.org/whatwedo/areasofwork/healthy-homes/.
[141] Ibid.
[142] Howden-Chapman, Phillipa, et al. "Effect of Insulating Existing Houses on Health Inequality: Cluster Randomised Study in the Community." BMJ, 2007.
[143] Behrendt, Jenna, and Lindsay Robbins. "Lindsay Robbins Expert Interview." 19 Mar. 2018.
[144] Norton, Ruth Ann, et al. *Non-Energy Benefits of Energy Efficiency and Weatherization Programs in Multifamily Housing: The Clean Power Plan and Policy Implications.* Green and Healthy Homes Initiative, 2016.

economic stability, and built environment.[145] An incorporated approach can reduce heat-related illness and deaths and lower the risk of fires in homes.[146]

- The English House Condition Survey (EHCS) created a Health and Safety Rating System which matched data on housing conditions, related to maintenance and energy efficiency and health records, based on postal code. This has made it possible to estimate the health-related costs of inefficient housing.[147]
- The Healthy Homes Healthy Kids Program in Philadelphia works with St. Christopher's Hospital for Children and EnergyFIT Philly to mitigate conditions that lead to asthma through developing an environmental action plan that improves environmental health and safety through removing mold, conducting energy audits and increasing weatherization. This program has reduced child hospital visits by 67%. Homes in the EnergyFIT Philly program typically experience 40% energy reductions.[148]

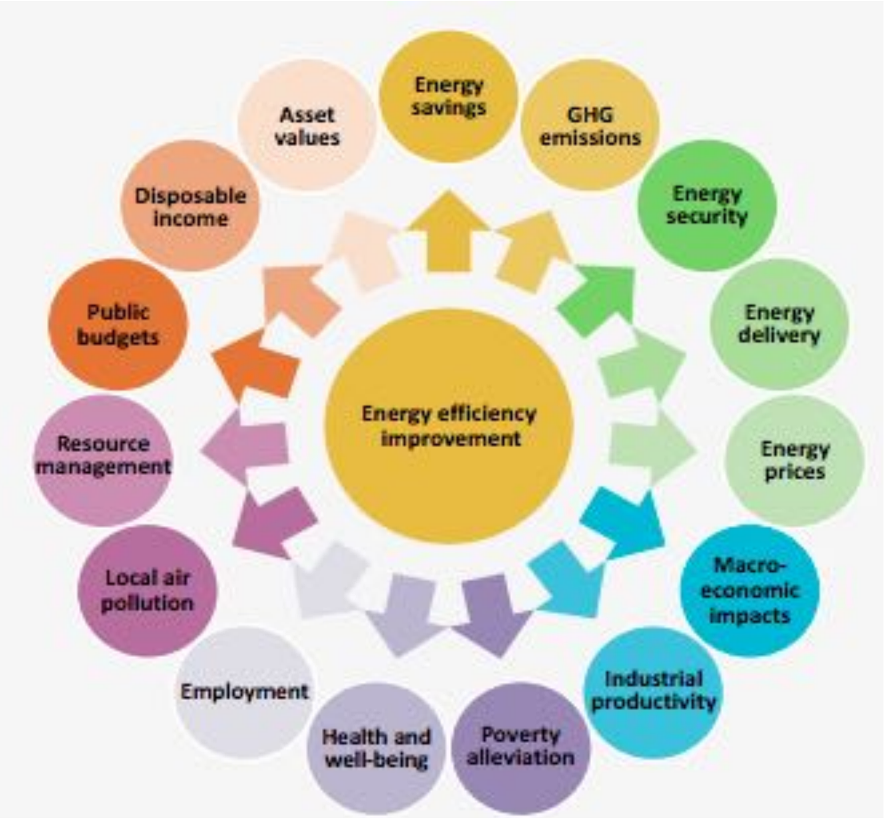

Figure 11: The co-benefits of energy efficiency improvements.[149]

Collect Data on Existing Utility Low- to Moderate-Income Programs & Develop Analytical Models Specifically on Low- to Moderate-Income

Across the US, cities with limited investment in utility energy efficiency programs had higher average energy cost burdens. However, there is no guarantee the low-income populations will benefit from these programs. Collecting data on program beneficiaries is critical,[150] considering the limited data from utilities across the U.S. on low- to moderate-income programs

[145] Ibid.
[146] Kuholski, Kate, et al. "Healthy Energy-Efficient Housing." *Journal of Public Health Management and Practice*, 2010.
[147] Heffner, Grayson, and Nina Campbell. *Evaluating the Co-Benefits of Low-Income Energy-Efficiency Programmes.* International Energy Agency, 2011.
[148] Hancher, Julie. "How Energy Efficiency Can Alleviate Philly's Poverty Problem." *Green Philly*, 2017.
[149] Russell, Christopher, et al.
[150] Drehobl, Ariel, and Lauren Ross. *Lifting the High Energy Burden in America's Largest Cities: How Energy Efficiency Can Improve Low-Income and Underserved Communities*, 2016.

regarding program spending, savings and customers served. Demographic data on low-income program participation would enable evaluation of how successful programs have been to date at targeting vulnerable households and communities.[151] Little data has been collected on the participation levels of single-family versus multifamily homes in energy efficiency programs, which is needed to understand how well these communities are being reached and how energy efficiency programs can be better expanded into the market.[152] The impact of energy efficiency programs on energy consumption, type of measures adopted and motivators for participation should be collected.[153] This data should also be applied to cost-effectiveness testing to better account for the impacts of energy efficiency.[154] Program operators should not only track participation and energy cost reductions, but also the specific types of programs, retrofits and audiences reached.[155]

Resolve Split Incentives Through Rebates and Targeted Initiatives

Split incentives can be resolved through streamlining rebates and incentivize in-unit measures, specifically for tenants.[156] Calculating the non-energy benefits for landlords, including decreased vacancy rates, can incentivize landlord investment in energy efficiency measures despite the presence of split incentives. An evaluation of three affordable multifamily buildings in Chicago found introducing energy efficiency upgrades reduced vacancy by 27%, increasing the cash flow for landlords to cover energy efficiency payments.[157]

Table 10: Benefits of energy efficiency.[158,159,160]

<table>
<tr><th>Resident</th><th>Landlord</th><th>Utility</th><th>Society</th></tr>
<tr><td>Reduced mobility</td><td>Reduced vacancy</td><td>Fewer shut-offs funded by all ratepayers</td><td>Improved workforce from health and education outcomes</td></tr>
<tr><td rowspan="2">Improved comfort, health, and safety</td><td>Higher property values</td><td rowspan="2">Subsidies avoided</td><td>Environmental benefits</td></tr>
<tr><td>Rent more likely to be paid on time</td><td>More local spending</td></tr>
</table>

[151] Drehobl, Ariel, and Fernando Castro-Alvarez. *Low-Income Energy Efficiency Programs: A Baseline Assessment of Programs Serving the 51 Largest Cities*. American Council on Energy-Efficient Economy, 2017.
[152] Ehrendreich, Greg, and Julia Friedman. *Well-Suited Energy Efficiency: Tailoring Programs for Multifamily Buildings*. Midwest Energy Efficiency Alliance, 2016.
[153] Cluett, Rachel, and Jennifer Amann. *Multiple Benefits of Multifamily Energy Efficiency for Cost-Effectiveness Screening*. American Council on Energy-Efficient Economy, 2015.
[154] Ibid.
[155] Ehrendreich, Greg, and Julia Friedman. *Well-Suited Energy Efficiency: Tailoring Programs for Multifamily Buildings*. Midwest Energy Efficiency Alliance, 2016.
[156] Johnson, Kate. *Apartment Hunters: Programs Searching for Energy Savings in Multifamily Buildings*. American Council on Energy-Efficient Economy, 2013.
[157] Philbrick, Deborah, et al. *Preserving Affordable Multifamily Housing through Energy Efficiency: Non-Energy Benefits of Energy Efficiency Building Improvements*. Elevate Energy, 2014.
[158] Heffner, Grayson, and Nina Campbell. *Evaluating the Co-Benefits of Low-Income Energy-Efficiency Programmes.* International Energy Agency, 2011.
[159] United States Department of Energy Office of Electricity Delivery and Energy Reliability. *Advanced Metering Infrastructure and Customer Systems: Results from the Smart Grid Investment Grant Program*. 2016.
[160] Heffner, Grayson, and Nina Campbell. *Evaluating the Co-Benefits of Low-Income Energy-Efficiency Programmes.* International Energy Agency, 2011.

Table 11: Barriers and best practices for energy efficiency.

Barriers[161]	Recommendations
Access to technical assistance once consumers are aware of the program and interested Multiple utility offerings complicate marketing and outreach	**Create a one-stop shop** for different types of energy efficiency across fuel types
Split incentives	**Offer a range of measures** for all household types **Incorporate health and safety** into energy efficiency offerings
Time and resource constraints, especially for low-income residents	**Gather information on low-income energy efficiency program participation** to inform future development
Complex decision-making structures	Increase trust and enrollment through **energy savings assurance**
Challenges of loan process for consumers	**Easy access to information** on loan options

III. Demand Response

Demand response refers to changes in electric use of demand-side resources following changes in electricity prices or incentives.[162] Existing programs throughout the US can offset up to 4% of US peak demand.[163] During peak demand times, energy rates are higher, due to reduced supply. By shifting some of the energy load to non-peak times, utilities can reduce their capacity at peak times. Utilities benefit from reduced service and operational costs due to reduced peak energy use and more accurate readings, which reduces maintenance costs, outage costs, and operational inefficiencies.[164] Customers have increased control over their energy use and expenses and experience more reliable energy services.[165] By having access to real-time energy data, customers can take advantage of incentives or reduced rates during off-peak times. Example demand response technologies include: web portals with real-time energy information, smart A/Cs, smart thermostats and advanced metering infrastructure (AMI). AMI is a system of integrated smart meters, communication networks, and data management systems to enable two-way communication between utilities and their customers.[166] AMI system's meter and record data at hourly intervals and provide energy information at least once a day.[167] AMI helps customers make informed decisions about their energy consumption and provides access to energy services that meet their needs and values.[168] The

[161] Federal Energy Regulatory Commission Staff. 2010 Assessment of Demand Response and Advanced Metering Staff Report. 2011.
[162] Federal Energy Regulatory Commission Staff. *2010 Assessment of Demand Response and Advanced Metering Staff Report*. 2011.
[163] Federal Energy Regulatory Commission Staff. *National Action Plan on Demand Response*. 2010.
[164] United States Department of Energy Office of Electricity Delivery and Energy Reliability. *Advanced Metering Infrastructure and Customer Systems: Results from the Smart Grid Investment Grant Program*. 2016.
[165] Ibid.
[166] Ibid.
[167] Federal Energy Regulatory Commission Staff. *2010 Assessment of Demand Response and Advanced Metering Staff Report*. 2011.
[168] Con Edison. *Advanced Metering Infrastructure Business Plan*. 2015.

benefits of demand response are summarized in **Table 12**, and barriers to demand response implementation as well as recommendations are displayed in **Table 13**.

Why Consider Demand Response as a Solution to Energy Cost Burden?

Although it does meet some criteria for reducing energy cost burden, like increasing transparency, more information is needed to better understand how these systems will impact energy cost burden for households in poverty. Limited pilots have specifically evaluated the impact of AMI or smart meters on low-income households. Low- to moderate-income households are less likely to have programmable thermostats than non-low- to moderate-income homes, 24% to 47%, respectively,[169] suggesting there is significant potential for installing demand response measures in low- to moderate-income homes. Research performed by ConEd found there is an interest among low- to moderate-income in smart meter technology.[170] Demand-side response programs may help to ease renters' energy cost burdens, although that is not their main purpose - primarily they focus on reducing peak-demand.[171]

Impact of Demand Response on Greenhouse Gas Emissions

If energy consumption is decreased, emissions will also decrease. However, demand response primarily focuses on reducing peak-demand, and shifting that energy consumption to a time when the grid is less stressed. It is possible it may not lead to a reduction in energy consumption, only a reduction in energy costs.

Innovative Demand Response Interventions from Other Cities

Oklahoma Gas & Electric reported average annual electricity savings of $191.78 for all participating residential customers and $570.02 for commercial after adopting AMI technology.[172] Central Lincoln Peoples Utility District's AMI program resulted in a 2% energy savings across consumers.[173] However, not all AMI deployments have been popular. In California and Texas, perceptions of AMI negatively impacted adoption. In both regions, residents were concerned about utility access to personal information and electricity data as well as the accuracy of the meters. AMI was more accurate than the previous utility meters, and consumers were surprised by the changes in their energy bills and credulous of its accuracy.[174]

Table 12: Benefits of demand response.

Resident	Landlord	Utility	Society
Increased reliability	Higher property values	Reduced service and operational costs	Environmental benefits
Improved comfort, health, and safety		Increased reliability and safety	
Increased transparency of energy use and costs		Reduced peak demand	

[169] United States Energy Information Administration. *Heating and Cooling No Longer Majority of U.S. Home Energy Use*. 7 Mar. 2013.
[170] Con Edison. *Advanced Metering Infrastructure Business Plan*. 2015.
[171] Carliner, Michael. *Reducing Energy Costs in Rental Housing: The Need and the Potential*. Joint Center for Housing Studies for Harvard University, 2013.
[172] United States Department of Energy Office of Electricity Delivery and Energy Reliability. *Advanced Metering Infrastructure and Customer Systems: Results from the Smart Grid Investment Grant Program*. 2016.
[173] Ibid.
[174] Federal Energy Regulatory Commission Staff. *2010 Assessment of Demand Response and Advanced Metering Staff Report*. 2011.

Table 13: Barriers and best practices for demand response.

Barriers	Recommendations
Customer confusion regarding information transmissions	**Create consistency in data formats** to increase consumer understanding **Develop web-tools and apps** that are suited to people's lifestyles and needs
Limited cost recovery and incentives for AMI technologies for utility investment	**Increase state and municipal financing** options for AMI infrastructure
Additional stresses from fluctuating energy prices	**Research impact of time of use rates** on financial stress for energy cost burdened homes **Evaluate the ability for low- to moderate-income households to alter their energy use** when low-to-moderate-income households may have other barriers, beyond access to information that prevents them from shifting their energy consumption and benefiting from those financial incentives
Customers must opt-in to the time of use rates, leading to a smaller customer base	**Prioritize education and outreach** before implementation to ensure consumers understand the benefits of AMI and alleviate deployment concerns

6) Recommendations

In some cases, policymakers should be prepared for solutions that are not "one-size fits all," but are created specifically for different demographic groups, home ownership, housing stock types. In addition, addressing the issue of energy cost burden should not be left solely to policy makers given the multitude of stakeholders. Programs should be based on analysis of local housing market characteristics, existing programs, and policy environment.

I. Opportunities for Intervention Across Income Groups, Geographic Locations, and Building Characteristics

Table 14: Specific policy recommendations to mitigate the high energy cost burden among the most affected demographic groups while supporting NYC climate change mitigation efforts.

Policy Recommendation	Rationale	Policy Action
Expand and Enhance In or Near Poverty Energy Efficiency Programs	Based on our analysis, in or near poverty households are in critical need of energy assistance. Upfront costs of upgrades are highly burdensome for them, necessitating focused financial and technical assistance programs. Given the prevalence of energy inefficiencies in the homes of in or near poverty households, their energy savings potential is likely higher than other income groups.[175]	Efforts to engage this population should include expanded outreach and engagement. For in or near poverty residents, auto-enrollment is often more successful than voluntary programs.[176] Additionally, eligibility criteria for low-income programs should include NYC residents that do not reside in subsidized housing, creating more opportunities for NYC residents in or near poverty.[177]
Create Streamlined Approaches for Energy Efficiency Measures	The quantity and access of current programs can prove difficult for residents to navigate, particularly if the households receive energy services from multiple providers.	The City should expand access to information from a central location for the multiple energy efficiency programs already in place. Integration between gas and electric programs offered by Con Edison and the National Grid can enhance the cost-effectiveness of energy efficiency programs.
Develop Separate Programs for Landlords and Tenants	Landlords of rented apartments may be reluctant to invest in energy efficiency, if they cannot recover those costs by passing them onto their tenants,[178] resulting in under-investment in energy efficiency and unnecessarily high energy cost burdens for tenants.	Strategies to avoid this split incentive issue include: • Subsidies to incentivize property owners that do not pay for energy to invest in efficiency.[179] • Programs that incentivize utilities, tenants, and landlords, such as the Metered Energy Efficiency Transaction (MEETS) that addresses the split incentives issue in commercial buildings

[175] APPRISE. *NYSERDA Low- to Moderate-Income Market Characterization Study: Special Topic Report - Low- To Moderate-Income Market Segments*. New York State Energy Research and Development Authority.
[176] Berelson, Serj. "Myths of Low-Income Energy Efficiency Programs: Implications for Outreach." American Council on Energy-Efficient Economy, *2014 ACEEE Summer Study on Energy Efficiency in Buildings*, 2014.
[177] Corso, Abigail, et al. *Segmenting Chicago Multifamily Housing to Improve Energy Efficiency Programs*. Elevate Energy, 2017.
[178] Johnson, Kate, and Eric Mackres. *Scaling Up Multifamily Energy Efficiency Programs: A Metropolitan Area Assessment*. American Council on Energy-Efficient Economy, 2013.
[179] Carliner, Michael. *Reducing Energy Costs in Rental Housing: The Need and the Potential*. 2013.

		through a long-term power purchasing agreement.
Make Energy Efficiency Data more transparent for the NYC Real Estate Market	Increasing the transparency of energy efficiency performance of housing units would result in more informed and efficient housing selections.[180] It would also provide an incentive for landlords to improve the efficiency of their units, as it would make them more attractive to potential renters and buyers.	New York City may consider mandating energy performance certificates for all properties, similarly to the United Kingdom.
Target Multifamily Rental Housing to Sustain the Affordable Housing Stock	Although our analysis did not find a statistically significant relationship between the number of units in a building and energy cost burden, research suggests that they present a significant opportunity for policymakers. Most utility-funded programs typically focus on single-family and small rental properties, while, multifamily households comprise 40% of total housing stock in NYC, making it an ideal target for GHG emissions reduction,[181] and high energy cost burden mitigation. Additionally, multifamily housing is well-organized, with robust local networks of managers and owners that can facilitate the spread and adoption of multifamily programs, magnifying impact.[182]	To reach this population, NYC should segment its multifamily housing sector to understand better the demographics of its inhabitants, based on building size, age, fuel type, management scheme,[183] metering, and construction material to determine which buildings are most in need of upgrades and retrofits.[184] • Coordination between these programs and initiatives addressing the split incentive issue is necessary to achieve the best outcome and increase participation. • Specific offerings for multifamily housing should include direct installation of no-cost energy efficiency measures such as lighting, weather-stripping aerators,[185] and equipment and product rebates; or incentives for the installation of HVAC systems, appliances, insulation, and water heating systems.[186] • Potentially, NYC could work with the Pratt Center to develop a program for multifamily homes similar to the EnergyFit pilot developed by the Pratt Center that develops standard procedures for single-family homes. Developing a standard approach across all multifamily housing and removing the need for an individual energy audit could increase participation and decrease administrative costs.[187]

[180] Carliner, Michael. *Reducing Energy Costs in Rental Housing: The Need and the Potential*. 2013.
[181] Reina, Vincent, and Constantine Kontokosta. *Low Hanging Fruit? Energy Efficiency and the Split Incentive in Subsidized Multifamily Housing*. NYU Furman Center, 2016.
[182] Ibid.
[183] Cluett, Rachel, and Jennifer Amann. *Multiple Benefits of Multifamily Energy Efficiency for Cost-Effectiveness Screening*. American Council on Energy-Efficient Economy, 2015.
[184] Corso, Abigail, et al. *Segmenting Chicago Multifamily Housing to Improve Energy Efficiency Programs*. Elevate Energy, 2017.
[185] Johnson, Kate. *Apartment Hunters: Programs Searching for Energy Savings in Multifamily Buildings*. American Council on Energy-Efficient Economy, 2013.
[186] Ibid.
[187] *EnergyFit NYC*. Pratt Center for Community Development, prattcenter.net/energyfit-nyc.

Focus on Minority Populations	Our statistical analysis found that Black and American Indian households have higher energy cost burdens compared to White and Asian households.	Energy efficiency programs could focus on areas such as Harlem, Brooklyn, and the Bronx, which have larger minority populations and higher energy cost burdens.[188] Equity should be included in program design to ensure that programs are created with these populations in mind. Engaging with community groups will help disseminate this message to hard-to-reach groups and increase trust for energy efficiency programming.
Create Fuel-blind Energy Efficiency Programs	Creating programs that increase efficiency for both electricity and heat are more cost-effective and better integrated.[189]	Integration between these two programs can enhance the cost-effectiveness of energy efficiency programs.
Establish a Policy-relevant Definition of Energy Cost Burden	For the most vulnerable populations, even a 6% energy cost burden is an unaffordable burden, given their limited income available for other necessities, including rent, healthcare, and food.	NYC's approach to resolving energy cost burden should not necessarily mirror NYS Energy Affordability threshold of below 6% as an affordable burden, but instead use a dynamic threshold that varies based on income.

I. Possible Criteria for Further Evaluation of Programs and Initiatives

Because energy cost burden is a multi-dimensional issue of economic, behavioral, and physical components, programs and initiatives need to be evaluated against multi-faceted criteria. Best practices also show that situationally, specific programs, such as those focused on multifamily homes or low-income residents, are more impactful. Process and impact measurements should be considered when evaluating the programs through a formal evaluation plan. Potential metrics to be developed in a program focused on reducing energy cost burden include, but are not limited to, the following:

- Proportion of ratepayer dollars supporting in or near poverty programs to the proportion of NYC population, since these programs are typically underfunded.
- Percentage increase in multifamily in-unit retrofits, since that demographic is hard to reach.
- Number of initiatives focused on equity in program design and evaluation.[190]
- Number of non-energy benefits included in cost-effectiveness testing.[191]
- Energy conserved (kWh).
- Percentage of increased capacity from what is available from conservation, demand response, and energy efficiency programs, and not from increased load capacity.

[188] Furman Center for Real Estate and Urban Policy. *The Changing State of the New York City's Property Tax Racial and Ethnic Makeup of New York City Neighborhoods*. New York University.
[189] Kushler, Martin, et al. *Meeting Essential Needs: The Results of a National Search for Exemplary Utility-Funded Low-Income Energy Efficiency Programs*. American Council on Energy-Efficient Economy, 2005.
[190] Ibid.
[191] Russell, Christopher, et al. *Recognizing the Value of Energy Efficiency's Multiple Benefits*. American Council on Energy-Efficient Economy, 2015.

II. Opportunities for Further Research

While there is a significant amount of research on energy cost burden, there are areas that need to be further explored to develop a more robust understanding of energy cost burden challenges specific to NYC. Areas of further exploration include the following:

Collect and analyze data on the energy efficiency of households

Due to the absence of information about the square footage of the units in the 2015 American Community Survey (ACS), this study did not calculate and analyze their energy efficiency. Given that energy cost burden is closely linked to energy efficiency, further analysis of this issue would benefit from a further analysis of energy efficiency improvement this additional data.

Conduct a Healthy Homes Feasibility Study for NYC

NYSERDA has recently started the process of developing an integrated energy, housing and health service delivery model in NYS. Once this study is completed, it could be used to inform NYC's approach, but given the variety of unique factors in NYC, a separate study should be conducted. By doing so, administrative efficiencies across the energy, housing and healthcare sectors could be improved.[192] Validating the healthcare impacts from energy and housing improvements could reduce barriers and better enable additional funding mechanisms to support energy improvements.[193] Expanding Medicaid approved funding under the New York Delivery System Reform Incentive Payment Program (DSRIP) to include some energy efficiency measures that improve public health.[194]

Increase Energy Use Data Collection of In or Near Poverty Households in NYC

This would allow for the development of targeted programs and opportunities for investments in energy efficiency. A larger dataset would allow for analysis of programs and opportunities beyond the group that was analyzed in this study.

Investigate Opportunities and Impacts of Community Solar or Low-income Solar Projects

This study did not devote significant attention to community solar opportunities in NYC, because there is not enough robust research linking solar energy and decreased energy cost burden for households at or near the poverty thresholds. Further research should be conducted to understand the impacts of community solar in NYC.

Analyze the Expansion of the Clean Heat Program

Clean Heat was an incredibly successful city-wide program, reducing air pollution dramatically in a short time frame. Given its tremendous impact on air pollution and GHG emissions, further research could be conducted to evaluate the impact of accelerating the transition from #4 to # 2 oil, or from #2 oil to natural gas on energy cost burden.

[192] New York State Energy Research and Development Authority. *Clean Energy Fund Investment Plan: Low- to Moderate-Income Chapter*. 2017.
[193] Ibid.
[194] "DSRIP Year 3: A Look at the Year Ahead." Performance by Jason Helgerson, 2017.

7) Conclusion

Our research reveals that in New York City, households in or near poverty and residents from certain boroughs have disproportionately high energy cost burdens. Additionally, for below poverty households, as income increases, there is a proportionately higher increase in energy cost compared to households above poverty. These unduly high energy cost burdens for certain demographics result in persistent financial stress and a multitude of negative long-term health effects.

In addition to analyzing the high energy cost burden in NYC, this report explores policies that can be classified as either subsidies, energy efficiency, or demand response interventions. When implementing these policy interventions, it is important to follow best practices, which this report identifies using various examples of successful and creative policies both from New York City and other cities.

In particular, this study suggests that subsidies are an effective short-term tool to alleviate high energy costs burdens for the most vulnerable income groups. Financial assistance ranging from $35-$77 per month, proposed in the New York State Energy Affordability Policy, could bring the energy cost burden for below poverty households to below 6%. To achieve the maximum impact, subsidy programs can offer long-term energy bill assistance, arrears forgiveness, case management, long-term collaboration with energy service providers, and demand response programs.

Increasing energy efficiency is another effective strategy for reducing high energy cost burden. In implementing energy efficiency programs, it is important to distinguish between policies that target landlords versus tenants. Landlords often recover capital investments by passing the costs along to tenants, so policymakers need to be strategic in their program creation and implementation. Some options for energy efficiency programs include low-interest loans, technical assistance, rebates and incentives, retrofits and weatherization, and demand response initiatives. When implemented properly, energy efficiency programs can benefit landlords and utilities while directly reducing disproportionately high energy cost burdens for households.

To conclude, this analysis recommends that policymakers need to use these and other interventions in tandem, targeting specific demographics, to ensure equitable energy cost burdens for all households.

References

American Council on Energy-Efficient Economy. *Recommendations for Scaling Up Modest Low-Income Multifamily Energy Efficiency Programs*. 2017, aceee.org/sites/default/files/pdf/scaling-up-modest-lowincome.pdf.

Applied Public Policy Research Institute for Study and Evaluation (APPRISE). *Allegheny Power Universal Service Programs - Final Evaluation Report*. 2010, www.appriseinc.org/wp-content/uploads/2016/05/Final-Allegheny-Universal-Service-Program-Evaluation-Report.pdf.

Applied Public Policy Research Institute for Study and Evaluation (APPRISE). *Illinois PIPP Program Impact Evaluation - Draft Report*. 2009, www.appriseinc.org/wp-content/uploads/2016/05/Illinois-PIPP-Impact-Report-FINAL.pdf.

Applied Public Policy Research Institute for Study and Evaluation (APPRISE). *Impact Evaluation and Concurrent Process Evaluation of the New Jersey Universal Service Fund - Final Report*. 2006, www.appriseinc.org/wp-content/uploads/2016/05/NJ-USF-2006.pdf.

Applied Public Policy Research Institute for Study and Evaluation (APPRISE). *Low-Income Energy Efficiency - Opportunities Study*. 2017, www.appriseinc.org/wp-content/uploads/2018/02/APPRISE_Low-Income-Energy-Efficiency-Opportunities-Study-2017_FINAL.pdf.

Applied Public Policy Research Institute for Study and Evaluation (APPRISE). *NYSERDA Low- to Moderate-Income Market Characterization Study: Special Topic Report - Low- to Moderate-Income Market Segments*. New York State Energy Research and Development Authority, www.nyserda.ny.gov/-/media/Files/Publications/PPSER/Program-Evaluation/2017ContractorReports/Low- To Moderate-Income-Special-Topic-Rpt---Market-Segmentation.pdf.

Applied Public Policy Research Institute for Study and Evaluation (APPRISE). *PECO Energy Customer Assistance Program For Customers Below 50 Percent of Poverty - Final Evaluation Report.* 2006, www.appriseinc.org/wp-content/uploads/2016/05/PECO-Below-50pct.pdf.

Applied Public Policy Research Institute for Study and Evaluation (APPRISE). *T.W. Phillips Energy Help Fund Program Evaluation - Final Report*. 2004, www.appriseinc.org/wp-content/uploads/2016/05/T.W.-Phillips-EHF.pdf.

Applied Public Policy Research Institute for Study and Evaluation (APPRISE) and Fisher, Sheehan, Colton. *Ratepayer-Funded Low-Income Energy Programs: Performance and Possibilities*. Jul. 2007, www.operationfuel.org/wp-content/uploads/2016/04/13StateAPPRISEStudy.pdf.

ARIES Collaborative. *Columbia CAST Controls Retrofit Research: 2011-2012 Heating Season Results and Planned Future Work*. 2012, www.masslean.org/wp-content/uploads/2012/05/Columbia-Cast-YR-1-Control-Results-Study1.pdf.

Berelson, Serj. "Myths of Low-Income Energy Efficiency Programs: Implications for Outreach." American Council on Energy-Efficient Economy, *2014 ACEEE Summer Study on Energy Efficiency in Buildings*, 2014, aceee.org/files/proceedings/2014/data/papers/7-287.pdf.

Banerjee, Julie, and Diana Hernández. "Diana Hernández Expert Interview." 23 Mar. 2018.

Behrendt, Jenna, and Lindsay Robbins. "Lindsay Robbins Expert Interview." 19 Mar. 2018.

Behrendt, Jenna, and Rebekah Morris. "Rebekah Morris Expert Interview." 27 Mar. 2018.

Benningfield Group. *Defines the Economic and Achievable Energy Efficiency Potential in the Nation's Existing Multifamily Sector in the United States by 2020*. Energy Efficiency for All, 2009, energyefficiencyforall.org/sites/default/files/Final_MF_EE_Potential_Report_Oct_2009_v2.pdf.

Blinder, Alan S., and Mark Zandi. *How the Great Recession Was Brought to an End*. 2010, www.princeton.edu/~blinder/End-of-Great-Recession.pdf.

Brunner, Karl-Michael, et al. "Experiencing Fuel Poverty. Coping Strategies of Low-Income Households in Vienna/Austria." *Energy Policy*, vol. 49, no. C, 2012, pp. 53–59., doi:10.1016/j.enpol.2011.11.076.

California Sustainability Alliance. *Green Leases Toolkit: Glossary*, sustainca.org/green_leases_toolkit/glossary.

Carliner, Michael. *Reducing Energy Costs in Rental Housing: The Need and the Potential*. Joint Center for Housing Studies for Harvard University, 2013, Research Briefing 13-2. www.jchs.harvard.edu/sites/jchs.harvard.edu/files/carliner_research_brief_0.pdf.

Cavanagh, Ralph. "State of the Energy Efficiency Industry: The Utility Story." National Resources Defense Council, 10 Apr. 2017, www.nrdc.org/experts/ralph-cavanagh/state-energy-efficiency-industry-utility-story.

Centre for Regional, Economic, and Social Research. *Warm Front Better Health: Health Impact Evaluation of Warm Front Scheme*. Sheffield Hallam University, 2008, www4.shu.ac.uk/research/cresr/sites/shu.ac.uk/files/warm-front-health-impact-eval.pdf.

Cluett, Rachel, and Jennifer Amann. *Multiple Benefits of Multifamily Energy Efficiency for Cost-Effectiveness Screening*. American Council on Energy-Efficient Economy, 2015, aceee.org/sites/default/files/publications/researchreports/a1502.pdf.

Cluett, Rachel, et al. *Building Better Energy Efficiency Programs for Low-Income Households. American Council on Energy-Efficient Economy*, 2016, www.southeastsdn.org/wp-content/uploads/2016/11/Building-Better-Efficiency-Programs-for-Low-Income-Households.pdf.

Con Edison. *Advanced Metering Infrastructure Business Plan*. 2015, nyssmartgrid.com/wp-content/uploads/Con-Ed-AMI-Business-Plan.pdf.

Con Edison. *Payment Plans and Assistance*. www.coned.com/en/accounts-billing/payment-plans-assistance.

Cooper, Lauren Terese, et al. "The Detroit Sustainable Urban Neighborhood Project." University of Michigan, 2011, deepblue.lib.umich.edu/bitstream/handle/2027.42/83537/DetroitSUNProject_Report_Final.pdf?sequence=1&isAllowed=y.

Corso, Abigail, et al. *Segmenting Chicago Multifamily Housing to Improve Energy Efficiency Programs*. Elevate Energy, 2017, www.elevateenergy.org/wp/wp-content/uploads/Chicago-Multifamily-Segmentation.pdf.

Drehobl, Ariel, and Fernando Castro-Alvarez. *Low-Income Energy Efficiency Programs: A Baseline Assessment of Programs Serving the 51 Largest Cities*. American Council on

Drehobl, Ariel, and Lauren Ross. *Lifting the High Energy Burden in America's Largest Cities: How Energy Efficiency Can Improve Low-Income and Underserved Communities*. American Council on Energy-Efficient Economy, 2016, aceee.org/research-report/u1602.

"DSRIP Year 3: A Look at the Year Ahead." Performance by Jason Helgerson, 2017. *Youtube*, www.youtube.com/watch?v=p9ZyCvLIMu4&feature=youtu.be.

Efficiency Maine. *Bill Case Studies*, www.efficiencymaine.com/docs/BillCasestudies_web_5.5x8.5.pdf.

Ehrendreich, Greg, and Julia Friedman. *Well-Suited Energy Efficiency: Tailoring Programs for Multifamily Buildings*. Midwest Energy Efficiency Alliance, 2016, www.mwalliance.org/sites/default/files/media/MEEA_2017_Well-Suited-Multifamily-EE_Feb2017.pdf.

Eisenberg, Joel F. Short and Long-Term Perspectives: *The Impact on Low-Income Consumers of Forecasted Energy Price Increases in 2008 and a Cap-and-Trade Carbon Policy in 2030*. Oak Ridge National Laboratory, 2007, weatherization.ornl.gov/pdfs/ORNL_CON-503.pdf.

Electricity Local. *New York Electricity Rates and Consumption.* www.electricitylocal.com/states/new-york/.

"Energize Community First! Village." *Gridmates | Donate Energy and Improve People's Lives*, www.gridmates.com/events/7.

Energy Action Scotland and National Energy Action. *The Cost of Affordable Warmth*. 2009, new.theclaymoreproject.com/uploads/entities/1230/files/Publications/Cost_Affordable_Warmth_FINAL_VERSION.pdf.

Energy-Efficient Economy, 2017, aceee.org/sites/default/files/low-income-baseline-1117.pdf.

EnergyFit NYC. Pratt Center for Community Development, prattcenter.net/energyfit-nyc.

ERS. *NYSERDA EmPower Program and National Fuel Gas Distribution Corporation's Low-income Usage Reduction Program Impact Evaluation (2010–2011) - Final Report*. New York State Energy Research and Development Authority and National Fuel Distribution

Corporation, 2015, www.nyserda.ny.gov/-/media/Files/Publications/PPSER/Program-Evaluation/2015ContractorReports/2015-EmPower-National-Fuel-Gas-Evaluation-Report.pdf.

Federal Energy Regulatory Commission Staff. *2010 Assessment of Demand Response and Advanced Metering Staff Report*. 2011, www.ferc.gov/legal/staff-reports/2010-dr-report.pdf.

Federal Energy Regulatory Commission Staff. *National Action Plan on Demand Response*. 2010, www.energy.gov/sites/prod/files/oeprod/DocumentsandMedia/FERC_NAPDR_-_final.pdf.

Forster, Hilary, et al. *2016 State of the Efficiency Program Industry, CEE Annual Industry Report*. Consortium for Energy Efficiency, 2017, library.cee1.org/system/files/library/13159/2016_CEE_Annual_Industry_Report.pdf.

Frank, Deborah A., et al. "Heat or Eat: The Low-income Home Energy Assistance Program and Nutritional and Health Risks Among Children Less Than 3 Years of Age." Pediatrics, vol. 118, no. 5, Nov. 2006, pp. 1293–1302., doi:10.1542/peds.2005-2943.

Furman Center for Real Estate and Urban Policy. *The Changing State of the New York City's Property Tax Racial and Ethnic Makeup of New York City Neighborhoods*. New York University, furmancenter.org/files/sotc/The_Changing_Racial_and_Ethnic_Makeup_of_New_York_City_Neighborhoods_11.pdf.

"Governor Cuomo Announces New Energy Affordability Policy to Deliver Relief to Nearly 2 Million Low-Income New Yorkers." 19 May 2016, www.governor.ny.gov/news/governor-cuomo-announces-new-energy-affordability-policy-deliver-relief-nearly-2-million-low.

Habitat for Humanity. *Transforming Low-Income Communities through Energy Efficiency*. www.habitat.org/stories/transforming-low-income-communities-through-energy-efficiency.

Hancher, Julie. "How Energy Efficiency Can Alleviate Philly's Poverty Problem." *Green Philly*, 19 Jan. 2017, www.greenphillyblog.com/energy/phillys-poverty-problem-can-reduced-energy-efforts/.

Heffner, Grayson, and Nina Campbell. *Evaluating the Co-Benefits of Low-Income Energy-Efficiency Programmes.* International Energy Agency, 2011, ww.iea.org/publications/freepublications/publication/low_income_energy_efficiency.pdf.

Henderson, Phillip, and William Prindle. *Program Design Guide: Energy Efficiency Programs in Multifamily Housing*. Energy Efficiency for All, 2015, www.energyefficiencyforall.org/sites/default/files/Full Program Design Guide.pdf.

Hernández, Diana, and Stephen Bird. "Energy Burden and the Need for Integrated Low-Income Housing and Energy Policy." *Poverty & Public Policy*, vol. 2, no. 4, 23 Nov. 2010, pp. 668–688., doi:10.2202/1944-2858.1095.

Hernández, Diana, and Douglas Phillips. "Benefit or Burden? Perceptions of Energy Efficiency Efforts among Low-Income Housing Residents in New York City." *Energy Research & Social Science*, vol. 8, 2015, pp. 52–59., doi:10.1016/j.erss.2015.04.010.

Holmes, Natalie, and Alan Berube. *City and Metropolitan Inequality on the Rise, Driven by Declining Incomes*. Brookings Institution, 2016, www.brookings.edu/research/city-and-metropolitan-inequality-on-the-rise-driven-by-declining-incomes/.

Howden-Chapman, Phillipa, et al. "Effect of Insulating Existing Houses on Health Inequality: Cluster Randomised Study in the Community." *BMJ*, vol. 334, no. 7607, 21 Feb. 2007, doi:10.1136/bmj.39246.620486.ae.

International Energy Agency. *Capturing the Multiple Benefits of Energy Efficiency*. 2014, www.iea.org/publications/freepublications/publication/Multiple_Benefits_of_Energy_Efficiency.pdf.

Johnson, Kate. *Apartment Hunters: Programs Searching for Energy Savings in Multifamily Buildings*. American Council on Energy-Efficient Economy, 2013, aceee.org/sites/default/files/publications/researchreports/e13n.pdf.

Johnson, Kate, and Eric Mackres. *Scaling Up Multifamily Energy Efficiency Programs: A Metropolitan Area Assessment*. American Council on Energy-Efficient Economy, 2013, aceee.org/sites/default/files/publications/researchreports/e135.pdf.

Kuholski, Kate, et al. "Healthy Energy-Efficient Housing." *Journal of Public Health Management and Practice*, vol. 16, no. 5, 2010, pp. S68–S74. *Supplement*, doi:10.1097/phh.0b013e3181ef4aca.

Kushler, Martin, et al. *Meeting Essential Needs: The Results of a National Search for Exemplary Utility-Funded Low-Income Energy Efficiency Programs*. American Council on Energy-Efficient Economy, 2005, aceee.org/sites/default/files/publications/researchreports/U053.pdf.

Lee, A.D., Chin, R.I., and Marden, C.L. *Affordable housing: Reducing the energy cost burden.* United States: N. p., 1995. Web. doi:10.2172/10119240

Levy, Jonathan I, et al. "The Public Health Benefits of Insulation Retrofits in Existing Housing in the United States." *Environmental Health*, vol. 2, no. 1, 11 Apr. 2003, pp. 1–16., doi:10.1186/1476-069x-2-4.

Maine State Planning Office, Hart, Patricia H. "Reducing Household Energy Consumption in Maine: What It Would Take to Achieve a 25% Reduction by 2011." *Reducing Household Energy Consumption in Maine: What It Would Take to Achieve a 25% Reduction by 2011*, 15 Jan. 2002. digitalmaine.com/cgi/viewcontent.cgi?article=1068&context=spo_docs.

Mass LEAN, masslean.org/.

McCabe, MJ. *High-Performance Buildings – Value, Messaging, Financial and Policy Mechanisms*. United States Department of Energy, 2011, www.pnnl.gov/main/publications/external/technical_reports/PNNL-20176.pdf.

Mosenthal, Phil, and Matt Socks. *Potential for Energy Savings in Affordable Multifamily Housing - Final Report*. Optimal Energy, 2015, energyefficiencyforall.org/sites/default/files/EEFA Potential Study.pdf.

National Housing Trust. *Unleashing Utility Resources to Energy Retrofit Affordable Multifamily Housing*. energyefficiencyforall.org/sites/default/files/nht_mf_utility_programs_fact_sheet.pdf.

Neuman, William. "As 4 of 5 in Public Housing Lost Heat, a Demand for an Apology Is Unfulfilled." *The New York Times*, 6 Feb. 2018, www.nytimes.com/2018/02/06/nyregion/heat-cold-nycha-nyc-olatoye.html?rref=collection/sectioncollection/nyregion.

New York City 80 x 50 Buildings Technical Working Group. *One City Built to Last: Transforming New York City Buildings for a Low-Carbon Future: Technical Working Group Report*. New York City Mayor's Office of Sustainability, www.nyc.gov/html/gbee/downloads/pdf/TWGreport_2ndEdition_sm.pdf.

New York City Department of Planning. *NYC Population Facts*, www1.nyc.gov/site/planning/data-maps/nyc-population/population-facts.page.

New York City Housing Authority. *NYCHA 2017 Fact Sheet*. 13 Apr. 2017, www1.nyc.gov/assets/nycha/downloads/pdf/factsheet.pdf.

New York City Housing Preservation & Development. *Heat and Hot Water*. www1.nyc.gov/site/hpd/renters/important-safety-issues-heat-hot-water.page.

New York City Mayor's Office for Economic Opportunity. *Poverty Data*. www1.nyc.gov/site/opportunity/poverty-in-nyc/poverty-data.page.

New York City Mayor's Office for Economic Opportunity. *Poverty Measure*. www1.nyc.gov/site/opportunity/poverty-in-nyc/poverty-measure.page.

New York City Mayor's Office of Sustainability. *Handbook for Multifamily Buildings*. 2016, www.nyc.gov/html/gbee/downloads/pdf/nyc_carbon_challenge_handbook_for_multifamily_buildings.pdf.

New York City Mayor's Office of Sustainability. *New York City's Roadmap to 80 x 50*. 2016, www1.nyc.gov/assets/sustainability/downloads/pdf/publications/New York City's Roadmap to 80 x 50_20160926_FOR WEB.pdf.

New York City Mayor's Office of Sustainability. "The NYC Carbon Challenge for Multifamily Buildings." *Green Buildings and Energy Efficiency*, www.nyc.gov/html/gbee/html/challenge/multifamily-buildings.shtml.

New York State Division of Housing and Community Renewal Office of Rent Administration. *Fact Sheet #24 Major Capital Improvements (MCI) Questions and Answers*. 2017, www.nyshcr.org/Rent/FactSheets/orafac24.pdf.

New York Green Bank. *RFP 8: Efficiency & Renewables Financing Arrangements: Building & Property Owners*. portal.greenbank.ny.gov/CORE_Solicitation_Detail_Page?SolicitationId=a0rt00000000QnyNAAS.

New York State Energy Research and Development Authority. *Clean Energy Fund Investment Plan: Low- to Moderate-Income Chapter*. 2017, documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={07D0B228-9D92-48CD-96C4-D348FEEC4283}.

New York State Energy Research and Development Authority. *EmPower New York Eligibility Guidelines - NYSERDA*. www.nyserda.ny.gov/all-programs/programs/empower-new-york/eligibility-guidelines.

New York State Energy Research and Development Authority (NYSERDA). *FlexTech Program (PON 1746)*, portal.nyserda.ny.gov/CORE_Solicitation_Detail_Page?SolicitationId=a0rt00000000Q0bJAAS.

New York State Energy Research and Development Authority. *Green Jobs - Green New York Low to Moderate Income (Low- to Moderate-Income Working Group Recommendations - Final Report*. 2015, www.nyserda.ny.gov/-/media/Files/EDPPP/GJGNY/Advisory-Council-Updates/GJGNY-Low- To Moderate-Income-Working-Group-Recommendations.pdf.

New York State Homes and Community Renewal. *Weatherization Assistance Program (WAP)*. www.nyshcr.org/programs/weatherizationassistance/.

New York State Office of Temporary and Disability Assistance. *Home Energy Assistance Program (HEAP)*. otda.ny.gov/programs/heap/#regular-benefit.

Norton, Ruth Ann, et al. *Non-Energy Benefits of Energy Efficiency and Weatherization Programs in Multifamily Housing: The Clean Power Plan and Policy Implications.* Green and Healthy Homes Initiative, 2016, www.greenandhealthyhomes.org/sites/default/files/Binder3.pdf.

NYC Retrofit Accelerator. "Resources." *Ways to Save | NYC Retrofit Accelerator*, retrofitaccelerator.cityofnewyork.us/resources.

NYCEEC. *Clean Energy Pays Off in the Multifamily Market. Clean Energy Pays Off in the Multifamily Market*, nyceec.com/wp-content/uploads/Roosevelt-Landings-case-study-NYCEEC-web.pdf.

OneNYC, New York City Mayor's Office of Recovery and Resiliency, www1.nyc.gov/site/orr/onenyc/onenyc.page.

"OneNYC The Plan for a Strong and Just City: Vision 3 Sustainability." *OneNYC*, onenyc.cityofnewyork.us/visions/sustainability/goal-1-sustainability/.

Pearl, Libby. *LIHEAP: Program and Funding*. Congressional Research Service, 2013, neada.org/wp-content/uploads/2013/08/CRSLIHEAPProgramRL318651.pdf.

Philbrick, Deborah, et al. *Preserving Affordable Multifamily Housing through Energy Efficiency: Non-Energy Benefits of Energy Efficiency Building Improvements*. Elevate Energy, 2014, www.elevateenergy.org/wp/wp-content/uploads/Preserving_Affordable_Multifamily_Housing_Through_Energy_Efficiency.pdf.

Public-Private Partnership in Infrastructure Resource Center. *Power Purchase Agreements (PPAs) and Energy Purchase Agreements (EPAs)*. World Bank Group, 15 Feb. 2017, ppp.worldbank.org/public-private-partnership/sector/energy/energy-power-agreements/power-purchase-agreements.

Reina, Vincent, and Constantine Kontokosta. *Low Hanging Fruit? Energy Efficiency and the Split Incentive in Subsidized Multifamily Housing*. NYU Furman Center, 2016, furmancenter.org/files/NYUFurmanCenter_EnergyEfficiency_WorkingPaper_July2016.pdf.

RentHop. "Building Ages and Rents in New York." *Apartments for Rent | RentHop.com*, 24 Aug. 2017, www.renthop.com/studies/nyc/building-age-and-rents-in-new-york.

"Report: 'Energy Burden' on Low-Income, African American, & Latino Households up to Three Times as High as Other Homes, More Energy Efficiency Needed." 20 Apr. 2016, aceee.org/press/2016/04/report-energy-burden-low-income.

Ruelle, Christine, and Jacques Teller. "Guided Group Purchases of Energy Renovation Services and Works in Deprived Urban Neighbourhoods." *Energy Efficiency*, vol. 9, no. 4, 14 Oct. 2015, pp. 861–874., doi:10.1007/s12053-015-9401-z.

Russell, Christopher, et al. *Recognizing the Value of Energy Efficiency's Multiple Benefits*. American Council on Energy-Efficient Economy, 2015, kms.energyefficiencycentre.org/sites/default/files/ie1502.pdf.

Seoul: Public-Private Partnership Prevents Energy Poverty. The Global Opportunity Explorer, 15 Sept. 2016, explorer.sustainia.me/cities/seoul-public-private-partnership-prevents-energy-poverty.

Shear, Keith B. G., and Anthony J. McMichael. "Editorial: The Health Impacts of Cold Homes and Fuel Poverty." *BMJ*, 11 May 2011, www.bmj.com/content/342/bmj.d2807.

Statistical Atlas. *Household Income in New York, New York (City)*, statisticalatlas.com/place/New-York/New-York/Household-Income.

Swinnen, Hugo. *Towards an Alleviation of Housing Cost Burden on Low-Income Households in Luxembourg?* European Social Policy Network, 2017, ec.europa.eu/social/BlobServlet?docId=18001&langId=en.

Tonn, Bruce, et al. *Health and Household-Related Benefits Attributable to the Weatherization Assistance Program*. Oak Ridge National Laboratory, 2014, weatherization.ornl.gov/Retrospectivepdfs/ORNL_TM-2014_345.pdf.

UC Davis Center for Poverty Research. "What Is the Current Poverty Rate in the United States?", 18 Dec. 2017, poverty.ucdavis.edu/faq/what-current-poverty-rate-united-states.

United States Census Bureau. *Historical Income Tables: People*. www.census.gov/data/tables/time-series/demo/income-poverty/historical-income-people.html.

United States Department of Energy. *Weatherization and Intergovernmental Program*. 2009, www1.eere.energy.gov/wip/pdfs/wap_factsheet.pdf.

United States Department of Energy Office of Electricity Delivery and Energy Reliability. *Advanced Metering Infrastructure and Customer Systems: Results from the Smart Grid Investment Grant Program*. 2016, www.energy.gov/sites/prod/files/2016/12/f34/AMI Summary Report_09-26-16.pdf.

United States Energy Information Administration. *Electric Power Monthly for January 2018*, www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_5_6_a.

United States Energy Information Administration. *Heating and Cooling No Longer Majority of U.S. Home Energy Use*. 7 Mar. 2013, www.eia.gov/todayinenergy/detail.php?id=10271&src=‹ Consumption Residential Energy Consumption Survey (RECS)-b1.

United States Environmental Protection Agency. *National Action Plan for Energy Efficiency: Energy Efficiency Program Best Practices*. 2006, www.epa.gov/sites/production/files/2015-08/documents/napee_report.pdf.

United States Energy Information Administration. *Short-Term Energy Outlook (STEO)*. 2016, www.eia.gov/outlooks/steo/archives/feb16.pdf.

Urban Green Council. *New York City's Energy and Water Use 2014 and 2015 Report*. 2017, www.nyc.gov/html/gbee/downloads/pdf/UGC-Benchmarking-Report-101617-FINAL.pdf.

WE ACT for Environmental Justice. *Healthy Homes*. www.weact.org/whatwedo/areasofwork/healthy-homes/.

Weissman Center for International Business. "Income and Taxes - New York City - Number of Households - By Income Range." *NYCdata*, Baruch College, www.baruch.cuny.edu/nycdata/income-taxes/hhold_income-numbers.htm.

Wlokas, Holle Linnea. "What Contribution Does the Installation of Solar Water Heaters Make towards the Alleviation of Energy Poverty in South Africa?" *Journal of Energy in Southern Africa*, vol. 22, no. 2, 12 May 2011, pp. 27–39., www.scielo.org.za/pdf/jesa/v22n2/04.pdf.

Appendix A: Dataset Summary

Table A1: Summary of New York City Opportunity Dataset. Responses were agglomerated into households for our analysis.

Summary	Value
Total number of responses	69,103
Total number of households	26,833
Median income	$57,272
Range of rents in survey (gross rent per month)	$4-$4500
Number of households with no rent reported	11,058
Number of households with no rent reported & reported energy costs	8,577
Number of PUMAs	55

Appendix B: Statistical Methodology for Creating Rent Bins

To create rent bins, we used the hierarchical clustering (or HCA) method in R. In data mining and statistics, this method of seeks to build a hierarchy of clusters using one of the two strategies:

- Agglomerative: This is a "bottom-up" approach: each observation starts in its own cluster, and pairs of clusters are merged as one moves up the hierarchy.
- Divisive: This is a "top-down" approach: all observations start in one cluster, and splits are performed recursively as one moves down the hierarchy.

Characteristics of our hierarchical clustering method:

1. Rent data was divided into 5 "bins."
2. The average energy cost as a percentage of rent within each of these bins was calculated.
3. This average energy cost was applied for all households with energy costs "included in rent or condo fee," as reported in the dataset.

This method allows us to estimate energy costs for master-metered buildings.

Appendix C: Correlational Analysis Tests Performed

Table C1: Statistical tests performed by variables analyzed.

Variable 1	Variable 2	Tests
Trimmed ECB- between 0-100%	Head of household race	Shapiro-Wilk test, Levene's test, ANOVA, Independent 2-group t-test
Trimmed ECB- between 0-100%	PreTaxIncome	Linear regression, power regression
Trimmed ECB- between 0-100%	Rent	Linear regression
Trimmed ECB- between 0-100%	Head of household age	Linear regression
Trimmed ECB- between 0-100%	Year building was built	Linear regression
Trimmed ECB- between 0-100%	Home type	Linear regression
Trimmed ECB- between 0-100%	Rooms in household	Linear regression
Energy Cost	Income	Linear regression
ECB	FS (Food Stamps)	Independent 2-group t-test
ECB	LNGI (Limited English Speaking Household)	Independent 2-group t-test
ECB	MULTG (Multigenerational household)	Independent 2-group t-test
ECB	DEAR (Hearing difficulty)	Independent 2-group t-test
ECB	DEYE (Vision Difficulty)	Independent 2-group t-test
ECB	DREM (Cognitive Difficulty)	Independent 2-group t-test
ECB	PRIVCOV (Private Health Insurance Coverage)	Independent 2-group t-test
ECB	PUBCOV (Public Health Insurance Coverage)	Independent 2-group t-test
Trimmed ECB (above poverty line)	PreTaxIncome	Linear regression
Trimmed ECB (below poverty line)	PreTaxIncome	Linear regression
Trimmed ECB (above near poverty line)	PreTaxIncome	Linear regression

Trimmed ECB (below near poverty line)	PreTaxIncome	Linear regression
Trimmed ECB	Borough	Levene's test, Independent 2-group t-test
Trimmed ECB	BLD (Units in Structure)	Independent 2-group t-test
Trimmed ECB	RMSP (Rooms in Residence)	Independent 2-group t-test
Trimmed ECB	TEN (Ownerships Status of Residence)	Independent 2-group t-test
Income (below near poverty line)	Head of Household Race	Shapiro-Wilk test, Levene's test, Kruskal-Wallis test by ranks
Income (below poverty line)	Head of Household Race	Shapiro-Wilk test, Levene's test, Kruskal-Wallis test by ranks

Appendix D: Building Characteristics vs. Energy Cost Burden

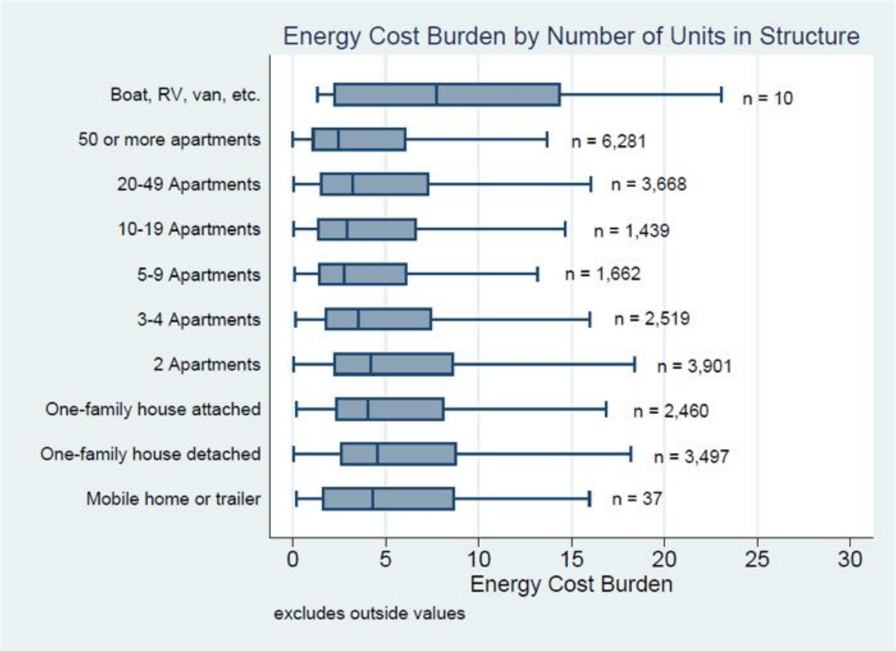

Figure D1: Box Plots (depicting medians as lines within the box) of number of units in building and their range of energy cost burdens. Outliers have been excluded.

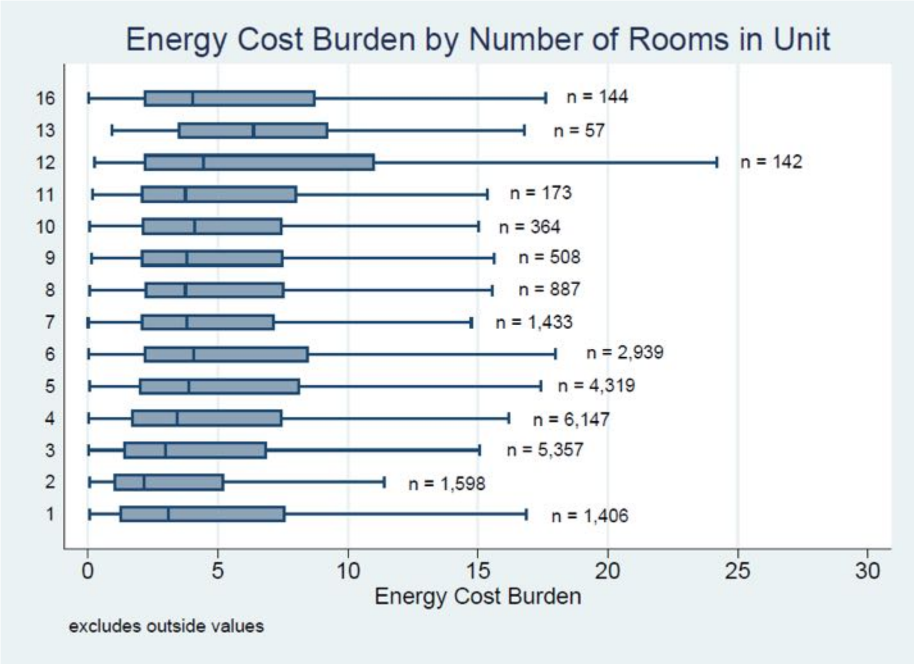

Figure D2: Box Plots (depicting medians as lines within the box) of number of rooms in unit and their range of energy cost burdens. Outliers have been excluded.

Appendix E: GIS Methodology

All maps were created using the Geographic Coordinate System NAD_1983 and the Projected Coordinate System NAD_1983_2011_StatePlane_NewYork_LongIsland_FIPS_3104_USFeet.

The Energy Cost Burden by PUMA was created using the dataset created and analyzed by the quantitative team and PUMA boundaries from the U.S. Census Bureau. The ECB was classified into five classes using the natural breaks classification method.

The Housing Code Violation Map was created by overlaying housing code violation data from the city, on the previously created ECB map. The violations are provided as an excel document with Building-Block-Lot (BBL) identifiers. To map these, the violation data was joined to the city's PLUTO shapefile which includes BBL. Once the violations were mapped, they were summed by PUMA and joined to the PUMA boundaries shapefile.

Appendix F: Energy Cost Burden for Near Poverty Households by PUMA

Table F1: Energy cost burden of those near or in poverty by PUMA. Upper quartile represents the 75th percentile of energy cost burden, and lower quartile represents the 25th percentile of energy cost burden.

Borough	Neighborhood	PUMA #	Lower Quartile	Median	Upper Quartile
Bronx	Pelham Parkway, Morris Park & Laconia	3704	6.51	12.20	24.32
	Riverdale, Fieldston & Kingsbridge	3701	7.34	11.10	24.13
	Co-op City, Pelham Bay & Schuylerville	3703	7.13	12.80	22.48
	Wakefield, Williamsbridge & Woodlawn	3702	8.37	13.60	21.00
	Castle Hill, Clason Point & Parkchester	3709	6.97	11.80	20.54
	Belmont, Crotona Park East & East Tremont	3705	6.47	10.80	18.86
	Concourse, Highbridge & Mount Eden	3708	5.99	9.99	18.71
	Bedford Park, Fordham North & Norwood	3706	6.83	11.40	18.23
	Morris Heights, Fordham South & Mount Hope	3707	7.16	12.00	17.48
	Hunts Point, Longwood & Melrose	3710	6.18	9.99	17.27
Brooklyn	Brownsville & Ocean Hill	4007	7.26	12.40	26.00
	East New York & Starrett City	4008	7.24	12.70	23.32
	Canarsie & Flatlands	4009	7.02	12.10	22.67
	Park Slope, Carroll Gardens & Red Hook	4005	5.59	10.20	19.97
	East Flatbush, Farragut & Rugby	4010	5.27	10.30	19.73
	Bushwick	4002	5.71	9.22	19.59
	Borough Park, Kensington & Ocean Parkway	4014	6.23	10.20	19.05
	Bay Ridge & Dyker Heights	4013	6.16	8.93	17.72
	Bedford-Stuyvesant	4003	5.88	9.84	17.12
	Greenpoint & Williamsburg	4001	6.43	10.00	16.71

	Sunset Park & Windsor Terrace	4012	5.09	7.28	16.63
	Flatbush & Midwood	4015	5.71	8.57	16.52
	Sheepshead Bay, Gerritsen Beach & Homecrest	4016	5.99	9.16	16.46
	Bensonhurst & Bath Beach	4017	5.62	9.34	15.98
	Crown Heights So., Prospect Lefferts & Wingate	4011	5.82	9.62	15.67
	Crown Heights North & Prospect Heights	4006	5.72	9.32	15.36
	Brooklyn Heights & Fort Greene	4004	5.31	8.07	15.07
	Brighton Beach & Coney Island	4018	5.38	8.47	12.77
Manhattan	Battery Park City, Greenwich Village & Soho	3810	4.90	7.73	17.58
	Murray Hill, Gramercy & Stuyvesant Town	3808	4.59	7.95	14.48
	East Harlem	3804	6.06	9.58	14.47
	Upper West Side & West Side	3806	5.07	8.10	14.27
	Washington Heights, Inwood & Marble Hill	3801	4.84	8.39	13.58
	Hamilton Hts, Manhattanville & West Harlem	3802	5.42	9.26	13.21
	Chinatown & Lower East Side	3809	4.79	7.49	13.11
	Chelsea, Clinton & Midtown Business District	3807	3.75	6.36	12.48
	Central Harlem	3803	4.82	7.61	12.21
	Upper East Side	3805	4.31	6.24	11.87
Queens	Queens Village, Cambria Heights & Rosedale	4105	9.50	16.00	28.05
	Bayside, Douglaston & Little Neck	4104	6.22	11.80	25.82
	Ridgewood, Glendale & Middle Village	4110	6.50	12.00	23.97
	Howard Beach & Ozone Park	4113	9.12	15.80	23.54
	Jamaica, Hollis & St. Albans	4112	7.14	12.10	22.40
	Far Rockaway, Breezy Point & Broad Channel	4114	6.75	13.00	20.74
	Richmond Hill & Woodhaven	4111	7.60	11.00	18.73

	Briarwood, Fresh Meadows & Hillcrest	4106	4.32	8.79	18.61
	Forest Hills & Rego Park	4108	5.30	8.98	17.60
	Flushing, Murray Hill & Whitestone	4103	5.82	8.92	16.24
	Astoria & Long Island City	4101	5.43	8.53	15.54
	Sunnyside & Woodside	4109	5.12	6.81	14.39
	Jackson Heights & North Corona	4102	5.42	8.60	13.32
	Elmhurst & South Corona	4107	4.72	7.80	12.57
Staten Island	Port Richmond, Stapleton & Mariner's Harbor	3903	8.42	16.20	27.87
	Tottenville, Great Kills & Annadale	3901	8.88	14.80	22.78
	New Springville & South Beach	3902	8.71	12.00	20.92

Appendix G: Solutions Matrix

Figure G1: Solutions matrix. Selected squares highlight a potential solution to address the listed problem.

Problems/ Potential Solutions	Split Incentive	Distrust	Poverty	Lack of Upfront Costs	Limited Energy-use / Master-metering	Financial Stress	Health Issues	Housing Stock/ Building Characteristics	Lack of education /information
Energy Improvement District				X					
Demand Response					X				X
Retrofits	X						X	X	
Targeting programs based on demographics and ownership (landlords, tenants, and homeowners)	X						X	X	X
Subsidies			X			X			

Public display of energy information	X							X	X
Green building codes								X	
Community-based education and outreach		X	X			X	X		X
Better incorporate stakeholders		X	X						X
Low- to moderate-income Specific Tools/Analysis			X			X	X	X	
Increase data collection on energy efficiency program success for low- to moderate-income New Yorkers to improve them		X	X	X					
Develop partnerships with utilities				X				X	X
Incorporate the non-energy benefits of energy efficiency when designing program, including health and safety			X				X	X	

Appendix H: Experts Interviewed

Table H1: List of experts interviewed.

Expert Name	Institution	Date of Interview
Daniel Bausch	Applied Public Policy Research Institute for Study and Evaluation	March 27, 2018
Diana Hernandez	Columbia University, Mailman School	March 20, 2018
Rebekah Morris	Pratt Center for Community Development	March 27, 2018
Lindsay Robbins	Natural Resources Defense Council	March 19, 2018
Lauren Ross	American Council for an Energy-Efficient Economy	March 28, 2018
Mark Ginsberg	Ginsberg Green Strategies, LLC	March 20, 2018
Commissioner Dan Burgess	Massachusetts Office of Energy and Environmental Affairs	March 28, 2018
Shaun Hoyte	ConEdison Electric and Gas	March 30, 2018

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