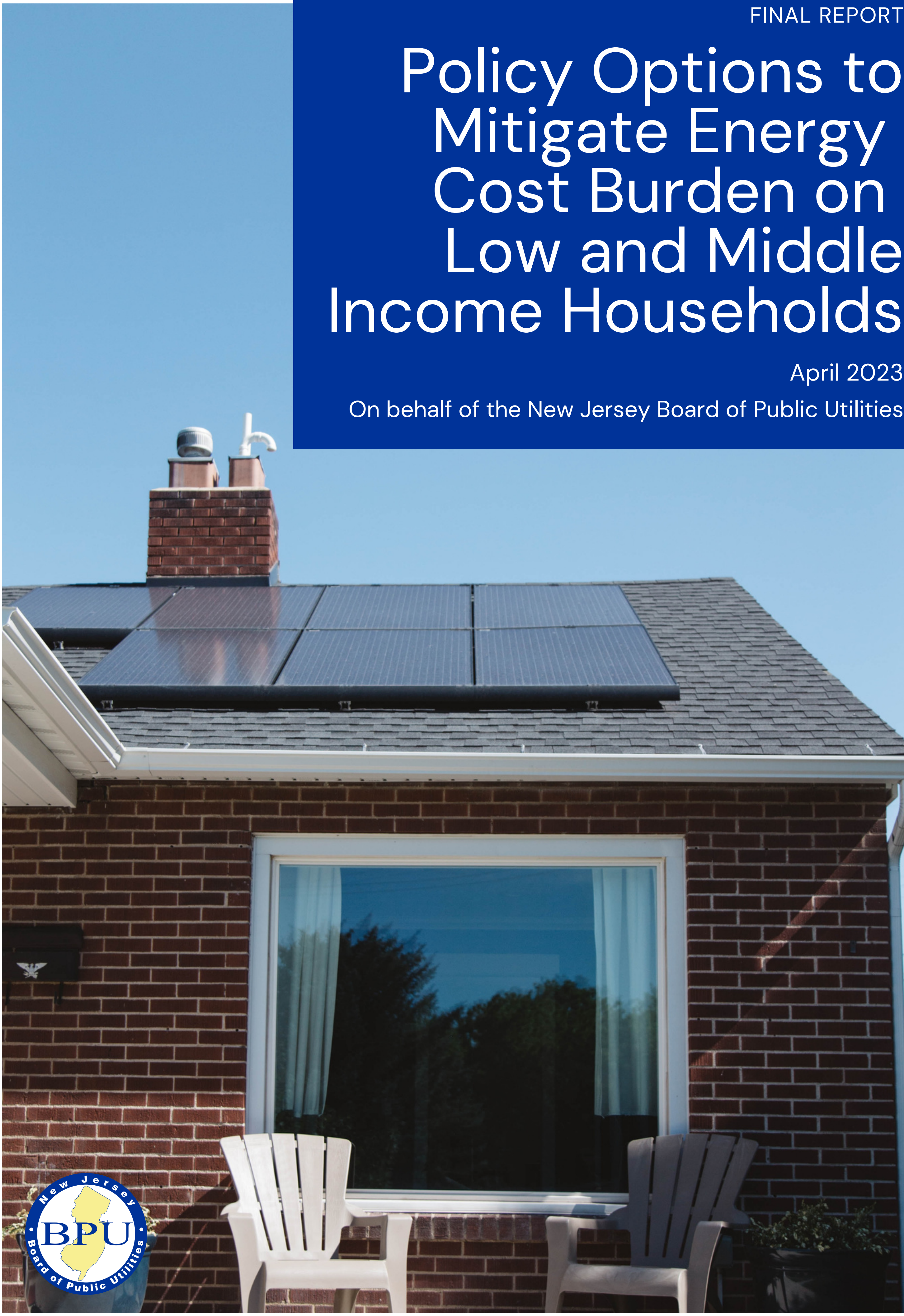
FINAL REPORT

Policy Options to Mitigate Energy Cost Burden on Low and Middle Income Households

April 2023

On behalf of the New Jersey Board of Public Utilities



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Executive Summary

As state and national governments move towards a renewable energy future, it is important to consider the ways decarbonization could impact different income groups in the short-term. Wealthier households will have more resources to electrify, meaning they will move away from natural gas more quickly. This leaves **low-to-moderate income (LMI)** households with an increasing portion of natural gas infrastructure costs, resulting in higher energy costs for an income bracket that already suffers from disproportionate **energy burdens**. This puts these households at risk for accumulating unpaid bills, which can result in utility disconnections.

New Jersey has a high proportion of households that suffer from large energy burdens, with 14% of the state's population spending at least 4% of their household income on energy.[1] While experts consider energy burdens of 6% or greater to be high, households with energy burdens from 4-7% are considered energy stressed.[2] This has the potential to be exacerbated by the state's ambitious climate goal of reaching 100% renewable energy by 2035, unless policies are implemented to protect LMI households. Alarmed at this potential effect, the **New Jersey Board of Public Utilities (NJBPU)** tasked our team with exploring solutions to lighten the energy burden of LMI households as the state continues to electrify. We were asked to consider both rate design and other policy options that could improve the equity of the transition, while also maintaining revenue neutrality for the state's utilities.

Through the process of extensive research into existing and novel rate design options, interviews with stakeholders, qualitative evaluation, and quantitative modeling of various scenarios, our team selected two options, an **inverted block rate (IBR)** and an **income-based fixed charge (IBFC)**. These emerged from a larger set of options after applying the following evaluation criteria: (1) political feasibility, (2) alignment with New Jersey climate goals, (3) low barriers to participation, (4) technological feasibility within five years, (5) demonstrated deployment elsewhere, and (6) low administrative cost. Eliminated options included **natural gas exit fees**, targeted electrification, community solar, and **time-of-use (TOU)** rates. Each of these options are explored later in this report.

Through quantitative modeling of New Jersey's energy utility cost recovery, we found that both IBR and IBFC can reduce energy burden for LMI households. We also believe that the two options balance each other's weaknesses and would be most effectively employed in combination. We recommend increasing the **fixed charge** portion of customer bills and pricing it according to income to create a progressive structure that is guaranteed to benefit low-income households.

Our team also analyzed New Jersey's existing energy assistance programs to determine how they could best function alongside rate design to mitigate the impacts of energy burden on LMI households. Through conversations with New Jersey's two most prominent nonprofits, we learned that the number of households seeking aid is increasing to the point of straining existing programs. In conjunction with our rate design options, we recommend strengthening existing programs by reducing barriers to apply in order to maintain a strong safety net for customers. A progressive rate design and robust energy assistance programs are both needed to ensure that New Jersey's transition to renewable energy is equitable.

Glossary

Advanced Metering Infrastructure (AMI)
an integrated system of smart meters, communication networks, and data management systems that allow for two-way communication between utilities and their customers

Arrearages
unpaid or overdue utility bills

Community-Based Organization (CBO)
nonprofit organizations which provide services to a small, local network of community members

Compound Annual Growth Rate (CAGR)
a financial metric used to measure the average annual rate of return for an investment over a specific period of time

Critical Peak Pricing (CPP)
an electricity pricing strategy where the price of electricity is higher during peak demand to incentivize consumers to reduce energy usage during peak hours and shift their usage to off-peak times

Cross-Subsidization
the effect of spreading a high price per kWh across all consumers without regard to their contribution to the high demand

Distributed Energy Resources (DERs)
small-scale electricity generation or storage units that are interconnected to the grid; can be renewable or non-renewable

Distributional Equity
also known as distributive justice; refers to the fair and just distribution of environmental benefits and burdens among different social groups, particularly in relation to energy resources and access

Energy Burden
the percentage of total income that a household spends on energy

Energy Master Plan (EMP)
a comprehensive roadmap that outlines New Jersey's strategy for ensuring a reliable, affordable, and sustainable energy future for all its residents; sets forth goals, policies, and action items across all aspects of energy use and production, including electricity, transportation, buildings, and industry

Fixed Charge
charges set based on the customer's rate class that do not change regardless of usage or demand figures (i.e. Monthly Service Charge: a fixed monthly charge that includes the cost to maintain an account for a customer, including metering, billing, and Infrastructure Improvement Program (IIP) charges.)

Heat Island Effect
a phenomenon where urban areas experience higher temperatures than surrounding rural areas due to the absorption and retention of heat by buildings and pavement

Income-Based Fixed Charge (IBFC)
a rate design option where the fixed portion of a monthly energy charge is pegged to a household's annual income

Internal Combustion Engine (ICE)
conventional engines where ignition and combustion of the fuel occur within the engine itself

Inverted Block Rate (IBR)
a consumption-based rate structure that is used to incentivize consumers to lower their consumption of a specific resource or good

Low-Income Energy Affordability Data (LEAD) Tool
a web-based, interactive platform that provides data, maps, and graphs to help stakeholders understand energy affordability for low-income households

Low-to-Moderate Income (LMI)
Households earning less than 400% of the federal poverty level, as defined by New Jersey's Universal Service Fund, a ratepayer-funded energy payment assistance program

Natural Gas Exit Fee
a one-time charge on customers who disconnect their gas service account and leave the gas grid, usually after electrifying end-uses previously serviced by natural gas

New Jersey Board of Public Utilities (NJBPU)
a state agency that oversees regulated utilities such as natural gas, electricity, water, telecommunications, and cable television, ensuring safe and adequate services at reasonable rates for customers in New Jersey; responsible for general supervision and regulation of public utilities and their property, property rights, equipment, facilities, and franchises

New Jersey Department of Community Affairs (NJDCA)
a government agency in the state of New Jersey that is responsible for promoting and protecting the quality of life of New Jersey's residents by providing and administering programs and services that promote affordable housing opportunities, economic opportunities, and community revitalization

Peak Load
the period of highest electricity demand

Peaker Plants
power plants that are generally only used to provide electricity during periods of high demand for electricity with a higher price

Randomized Control Trial (RCT)
a research design used in various fields to evaluate the effectiveness of an intervention or treatment by randomly assigning participants to treatment or control groups

Rate Base
the value of a utility company's assets that are used to provide service to its customers, upon which the company is allowed to earn a regulated rate of return

Ratepayer Base
the total number of customers or consumers who pay rates to a utility company for services such as electricity, gas, or water

Renewable Energy Certificates (RECs)
tradable certificates that prove that a certain amount of electricity was generated from renewable sources.

Residual Costs
utility costs that cannot be attributed to additional customer consumption

Societal Benefits Charge (SBC)
a fee that is added to electric bills to support state-mandated energy programs; also known as the Public Benefits Charge (PBC)

Stranded Assets
investments, particularly in the energy sector, that become obsolete or unprofitable before the end of their expected economic life

Time-Of-Use (TOU)
a rate structure where electricity prices are determined by the time of day, with higher prices during peak hours and lower prices during off-peak hours

Time-Varying Rates (TVR)
a rate structure where electricity prices vary over time, with prices typically higher during peak demand periods and lower during off-peak periods

Volumetric Rates
portion of a customer's bill that is calculated based on consumption; may be attributed to wholesale purchase or distribution

Section A
Background

Problem Statement

The ability for New Jersey residents to pay their utility bills has been strained by the pandemic, resulting in a large number of accounts with overdue balances and high total **arrearage**. Despite this, participation rates for New Jersey's energy assistance programs have remained low - around 30% of eligible users.[3]

As more high-income households switch to electric vehicles and heating, the cost of gasoline and natural gas infrastructure will be distributed among a shrinking group of users for whom electrification is cost-prohibitive. This will result in energy prices being driven steadily upwards for this group, which will be compounded by the push towards 100% renewable energy under the New Jersey's **Energy Master Plan (EMP)**. This will further increase the amount of New Jersey residents unable to afford their electricity bills.

Without addressing the inequality of household energy spending, the transition to a sustainable economy will result in the burden of traditional energy costs, gasoline and natural gas, falling increasingly disproportionately on LMI households. We define LMI households as those which earn less than 400% of the **federal poverty level (FPL)**. This is consistent with the eligibility threshold of New Jersey's ratepayer-funded energy payment assistance program.

The objective of our team is to explore various policy options, including altering utility rates and proposing changes to other existing systems, to curb energy burden increase among LMI households in New Jersey as the state takes action to reach its EMP goals.

Household Energy Burden

As the world works towards the goal of a net-zero economy by 2050 or sooner, renewable energy has become an integral part of the solution to reducing carbon emissions and combating climate change. However, the benefits of renewable energy may not be equal for everyone. According to the **International Energy Agency (IEA)**, low-income families' global energy spending increased by 25% between 2010 and 2018, whereas high-income households' spending fell by 17%.[4] The percentage of total income that a household spends on energy is known as the **energy burden** of that household. As more wealthy families install off-grid renewable solutions with high upfront costs and use less electricity from the grid, households with low and moderate incomes will likely pay even higher energy prices, further exacerbating energy burden inequality.

In a literature review conducted by Brown et al., the authors reported that, while experts consider energy burdens above 6% to be high, even 4% energy burdens can present significant challenges for families.[2] The premise for this benchmark is that a household should not spend more than 30% of its income on housing expenses and that utility costs should not exceed 20% of these expenses.[5] Higher energy burdens put families at risk of utility disconnection from missed payments. Disconnections prevent households from adequately heating or cooling their homes and from preparing food, creating significant health impacts, especially for vulnerable populations such as the elderly.

Table A-1

HOUSEHOLD ENERGY BURDEN	HOUSEHOLD ENERGY CATEGORY
4% - 7%	Energy Stressed
7% - 10%	Energy Burdened
Over 10%	Energy Impoverished

Table A-1: Categories of Energy Burden according to Cook et al., 2018 [6]

Projected Energy Burden in New Jersey

Current LMI Energy Burden in NJ

According to the U.S. Department of Energy (DOE)'s **Low-Income Energy Affordability Data (LEAD) Tool**, the average New Jersey resident spends 2% of their income on energy needs in their home. However, this experience is very different for LMI households. According to the LEAD Tool, New Jersey households that earn less than 400% of the FPL have an average energy burden of 5%.[1] *Figure A-1* shows how energy burdens increase dramatically for lower income levels, exceeding 16% for those below the FPL.

Effects of Decarbonization on Energy Burden

Under its EMP, the state of New Jersey plans to reach 100% renewable energy by 2050. In 2023, Governor Murphy accelerated this timeline to reach 100% by 2035.[7] As a result of concerns regarding costs to lower-income consumers, a consulting firm, the Brattle Group, was hired to conduct a ratepayer impact study of the EMP.

The study examined the effect of the EMP goals on energy spending of four different customer profiles who invest in varying levels of energy efficiency and electrification. According to the results of the study (*Figure A-2*), achieving the goal of 100% renewable energy by 2050 will increase the energy burden on Profile [1] customers by ~20% compared to 2020. Profile [1] customers use natural gas heating, do not invest in electricity or heating efficiency measures, and drive **internal combustion engine (ICE)** vehicles. Because of the high upfront costs of efficiency and electrification measures, LMI households are more likely to belong to this group. Customers in Profile [4] (those using electric heating, energy efficiency measures, and electric vehicles who are likely higher-income) will have much lower annual energy costs at around $4,000. This is compared to an average of $5,700 (42.5% higher) for Profile [1] customers.[8]

The figure also shows a comparison of the number of households in each bracket. Using the energy burden criteria from *Table A-1*, around 9% of New Jersey households are energy impoverished, 13% are energy burdened, and 24% are energy stressed.

Figure A-1

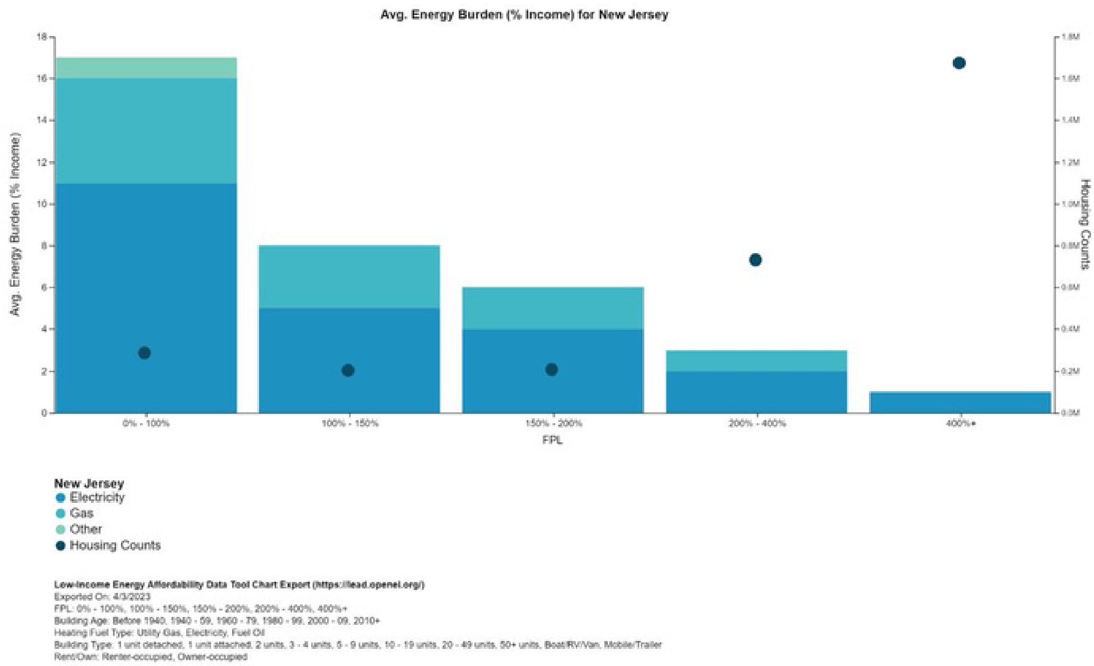


Figure A-1: Energy burden and housing counts by income, categorized by percent of FPL. Data and plot obtained from the DOE's LEAD Tool

Figure A-2

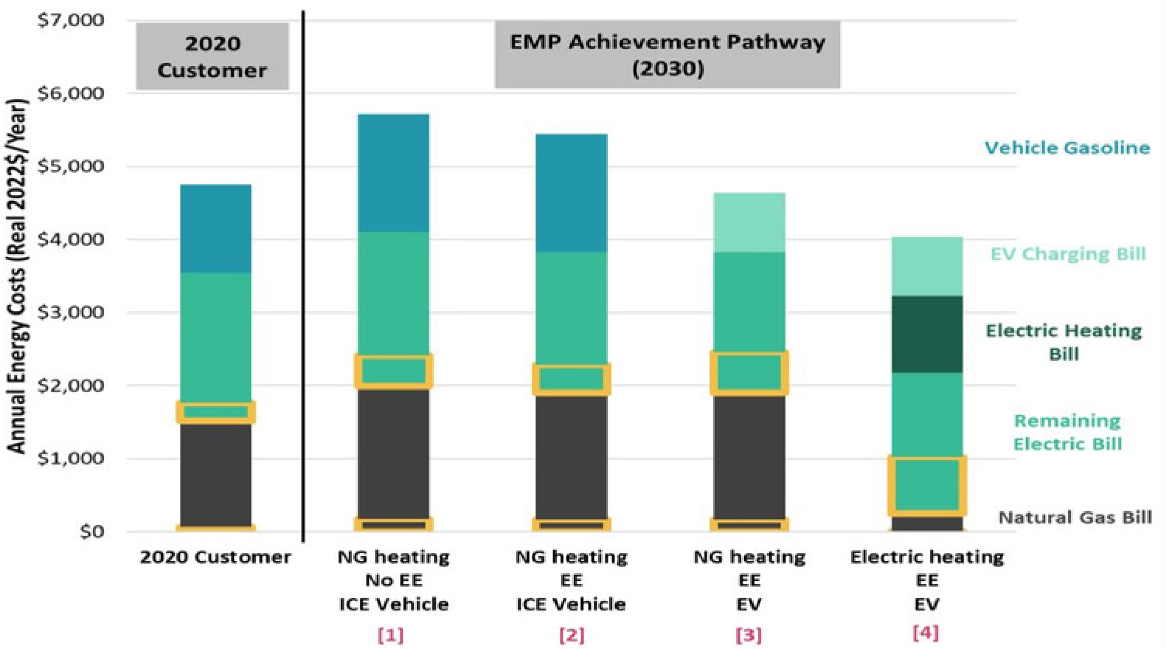


Figure A-2: Annual energy costs for customers at different levels of electrification under the EMP pathway

New Jersey Board of Public Utilities

As New Jersey's utility regulating agency, the NJBPU will design and implement many of the policies which will advance the EMP goals. Through negotiations with utilities, rate-payer advocates, and other stakeholders, the NJBPU sets natural gas and electricity rates that promote fair pricing, ensure energy reliability, and reduce pollution and greenhouse gas emissions. The results of the EMP ratepayer impact study have stimulated interest in redesigning natural gas and electricity price structures to make these necessities affordable for LMI customers. As discussed above, LMI households in New Jersey face high burdens already, and without intervention those burdens will increase. This is a problem that the NJBPU is uniquely positioned to address through its price regulation capacity and its oversight of ratepayer funded energy assistance programs.[9]

Existing Energy Assistance Programs

While rate design represents one avenue for solving New Jersey's energy burden inequality, another area of opportunity for improvement exists in the form of the state's existing energy assistance programs. These programs are primarily overseen by the **New Jersey Department of Community Affairs (NJDCA)** and individual utilities. They are funded either by the state, the federal government, or the utilities. The state has two types of energy assistance programs, those that provide direct payment assistance in the form of credits on energy bills or grants and those that provide energy efficiency assistance through energy conservation and weatherization measures. The programs' existing structures are described below.

Direct Payment Assistance

- **Low Income Home Energy Assistance Program (LIHEAP)**

LIHEAP provides heating and cooling assistance as well as emergency energy assistance via funding from the U.S. Department of Health and Human Services. Applicants are reviewed on a first-come-first-serve basis.[10] Benefits are paid out once per year.

- **Universal Service Fund (USF)**

USF uses money collected through the **societal benefits charge (SBC)** to pay monthly installments of heating and electricity assistance. The program provides the necessary benefit to bring natural gas and electricity bills down to 2% of the household's income. USF uses the LIHEAP application to reduce extraneous paperwork.

The USF Fresh Start sub-program offers debt forgiveness on the accumulated missed payments of customers who make twelve on-time monthly utility payments.

- **Lifeline**

The Lifeline program provides utility assistance for disabled and elderly customers. Eligibility for this program is tied to the federal Pharmaceutical Assistance to the Aged and Disabled (PAAD) and Supplemental Security Income (SSI) programs.[11]

- **Payment Assistance for Gas & Electric (PAGE)**

The PAGE program targets middle income households for "back on your feet" grants to cover emergency lapses in utility payments.

Moderate income households between 65% and 100% of the state median income qualify for annual grants of up to $700. Low income households below 65% of the median income may receive up to $400. Households which fall below the median income level but do not otherwise qualify for LIHEAP may also receive grants up to $700. The PAGE program is currently administered by the nonprofit Affordable Housing Alliance.

- **New Jersey SHARES**

NJ SHARES is a nonprofit originally started by utility companies, and today is largely funded by donations.[12] NJ SHARES previously administered the PAGE program and its grant program still resembles that model.

Energy Efficiency Assistance

- **Comfort Partners**

Comfort Partners performs energy audits, provides suggestions for energy conservation, and installs weatherization measures at no cost to the customer. It is funded and administered by the NJBPU and additionally administered by the electric and gas utilities. Households at or below 250% of the FPL are eligible. If a household does not meet the income requirement but qualifies for LIHEAP, USF, Lifeline, or other non-electricity focused programs they still may be able to qualify.

- **Home Weatherization Program**

The Home Weatherization Program is provided by New Jersey utility Public Service Electric & Gas Company (PSE&G). The program offers free energy efficiency assessments and up to $7,500 in assistance for energy efficiency, health, and safety home upgrades for households with incomes between 250 and 400% of the FPL that are participants in NJ SHARES and located in a pre-qualified moderate-income census tract.[13]

- **Quick Home Energy Checkup**

Quick Home Energy Checkups are provided by New Jersey's utilities at no cost to homeowners. The in-home assessments give homeowners energy efficiency recommendations from professionals as well as installations of energy efficiency products at a discount or for free.[14] Households must be single-family, townhomes, condos, or in a multifamily building with less than four units to qualify.[15]

- **Weatherization Assistance Program (WAP)**

The WAP is a federal program by the DOE that aims to reduce energy burden for low-income households by providing grants to states that they can distribute through programs implementing energy efficiency measures.[16] In New Jersey specifically, WAP funds are distributed to community-based agencies focused on assisting low-income households and to low-income households themselves. The funds are provided by the DOE and LIHEAP.

Effects of the COVID-19 pandemic

Since the start of the COVID-19 pandemic, the amount of New Jersey residents in need of energy assistance has greatly increased. Total residential energy arrearages have nearly doubled. In 2019, combined overdue bills on electricity and gas were $230 million. By 2020, they had risen 97% to $453 million.[17] This number continued to rise in 2021 and 2022, but in the past year has subsided to 2020 levels. Energy arrearages from nearly 900,000 residential accounts totaled $459 million as of February 2023, a 33% decrease from 2022.[17]

Each winter, New Jersey utilities are prohibited from disconnecting households who receive energy assistance benefits or are otherwise unable to make payments due to illness or unemployment. This program is called the Winter Termination Program and lasts from November 15th through May 15th. At the start of the pandemic, this moratorium on shutoffs was extended to all residents throughout the entire year, through an executive order.[18] A subsequent executive order suspended the end of the moratorium until March 15, 2022.[19] When the Winter Termination Program ended in March 2023, however, all of the accounts with overdue bills became at risk of gas and electric shutoffs.

In addition to the Winter Termination Program, the NJBPU and the NJDCA expanded the LIHEAP and USF program eligibility during the pandemic. The USF program eligibility threshold increased from 185% of the FPL to 400%. This change has received public support from utilities who benefit from the improved recoupment of arrearages.[20]

Section B

Review of Literature on Progressive Rate Structures

To begin the process of devising a solution to this problem, our team reviewed existing literature on various rate design policies that have been previously proposed or attempted and are relevant to the context of New Jersey. In this section, we describe several key concepts of the utility cost recovery model and rate design as well as six policy options for addressing high energy burdens for LMI customers.

Utility Cost Recovery Model and Surrounding Issues

In many countries and across much of the U.S., utilities act as regulated monopolies. They experience large economies of scale and can provide services at relatively low costs. To prevent undesired monopolistic behavior, states review and regulate the utilities' expenditures and prices.

Total expenditure of a utility includes its procurement costs which vary with customer demand. Costs also include overhead administrative costs and infrastructure investments. Infrastructure investments fall into a special category of expenditure known as the utility's **rate base**. Regulators allow a given percent of the rate base spending to be recouped as profit. Utilities add up their profit, rate base spending, administrative and procurement costs into a single sum which represents their allowed revenue. Utilities raise this total revenue through their customer charges, which are allocated often based largely on usage.

Utility costs which cannot be attributed to additional customer consumption are known as **residual costs**. A utility's price structure determines how these residual costs are distributed. Generally, when one group of customers reduces their consumption they push more of these residual costs onto other groups. When customers exit a utility's network, the residual costs covered by those customers are redistributed to those who remain. The resulting increase in price can drive more customers to reduce their demand, further exacerbating the price increases.

A final consideration for utilities is the rate of customer demand at a given time. In particular for electric utilities, high volumes of demand over a short period can be expensive to provide. Electric utilities commonly purchase wholesale electricity from third party generators on a bidding market.

During periods of low demand, utilities can purchase from inexpensive power generators such as nuclear or wind, paying a low price for the entire volume purchased. During periods of high demand, known as **peak load**, utilities must offer much higher prices in order to buy from more expensive and less efficient generators, often called **peaker plants**. This higher price is paid to all electricity providers, greatly increasing the marginal cost of providing service during these times.[21]

Income Based Fixed Charge

Utility bills in New Jersey are usually comprised of per-kilowatt-hour (kWh) charges, known as **volumetric rates**, which vary with consumption, and static charges that do not vary with consumption , known as fixed charges. Fixed charges are usually levied to recover metering and billing infrastructure costs. As an example, a sample PSE&G electricity bill from 2018 highlights a monthly fixed charge of $2.83.[22]

An IBFC is a rate design option where the fixed portion of a monthly energy charge is pegged to a household's income, which is usually annual. Typically, this option is progressive, with high-income households paying a higher fixed charge than lower-income households.

An IBFC was proposed in the paper "Designing Electricity Rates for An Equitable Energy Transition" by Severin Borenstein, Meredith Fowlie, and James Sallee at the Energy Institute at Haas (UC Berkeley). This paper proposes an IBFC as a form of rate reform that recovers long-term system capital costs more efficiently and progressively than the current California rate design. In the current rate design, California ratepayers pay some of the nation's highest volumetric rates for electricity to not only recover fixed transmission and distribution costs but also to raise revenue for other programs. The authors argue that the current system is a highly regressive form of rate design, because income and annual electricity expenditure are only moderately correlated. By levying an IBFC, the fixed costs of the electricity system can be recovered in a more progressive manner while reducing volumetric rates, preserving the incentive to electrify.

This paper is also notable in terms of its implementation proposals for the IBFC. It proposes four options, with varying degrees of administrative complexity:

- **Revenue balancing with the California Franchise Tax Board (FTB)**

All residents are charged an equal rate initially to meet utility revenue requirements.
The utility submits information to the FTB that states the fixed charges paid and the amount of months of electricity consumed by each customer. At the time of state income tax reconciliation, customers who paid more than their income bracket would receive a credit, while those who underpaid would pay the difference.

- **Opt-in verification only**

In this model, utilities would have to verify income directly from customers without FTB support. Customers would have an incentive to misreport their incomes. Addressing this problem would entail the build-out of costly income verification infrastructure and personnel for utilities.

- **Information sharing without revenue collection**

Under this option, customers would either verify their income directly with utilities, which could result in data privacy concerns, or the FTB would provide income information directly to utilities to adjust the fixed charges.

- **Presumptive charges by location**

In this approach, geographic location identified through U.S. Census blocks would serve as a proxy for income.

Customers would be charged a fixed charge based on their geographic location. Low-income customers in higher-income census blocks would have an option to verify their income and adjust their fixed charge.

The paper also finds that this rate design option would redistribute the burden of electricity fixed-cost recovery from lower-income to higher-income households. Within income brackets, households who consume more electricity would benefit from having lower volumetric rates than status quo but pay the same fixed charge.[23]

There has been strong opposition to the California proposal to levy an IBFC across different dimensions. The following concerns have been raised by an article by Jim Lazar, an electricity rate design expert, in Energy Central:

- The IBFC constitutes an overreach of the California Public Utilities Commission (CPUC)'s authority in accessing customers' incomes.
- Middle-income consumers will face a spike in electricity, on top of California having some of the highest electricity rates in the country.
- Customers do not want to share their income tax returns with their utility company, leading to low rates of compliance.
- Implementation will be challenging for residences without sub-metering or where different individuals own the electric service account. This may incentivize households to register the account under family members who do not make an income or earn a low income.[24]

Ahmad Faruqi, another notable energy rate design expert, has also critiqued the IBFC in Energy Central across the following points:

- Customers with low or average usage within the same income bracket will experience bill spikes. This will nullify the cost savings from energy efficiency and solar PV that customers have invested in and disincentivize the move to electrification, contradicting California's climate goals.
- The proposal violates foundational electricity rate design by decoupling electricity demand from price.[25]

The California Senate Republican caucus has also vehemently criticized the proposal on the grounds that the legislation was rushed through the Assembly with little deliberation and represents another form of income tax.[26]

Inverted Block Rate

An IBR is a consumption-based rate structure that is used to incentivize consumers to lower their consumption of a specific resource or good. The basic rate structure is composed of several consumption level tiers or blocks. Using electricity as an example, blocks may be delineated as such: 0 - 500 kWh, 501 - 1000 kWh, 1001 - 1500 kWh, etc. A dollar per kWh rate is then assigned to each block, with the lowest rate aligning with the lowest consumption block and increasing along with consumption. Similar to the U.S. income tax structure, each unit of electricity is charged at the rate of the block it falls into, rather than the entire amount of electricity being charged at the highest block of total consumption. Using the blocks outlined above, a household that uses 1300 kWh per month will be charged the lowest rate on the first 500 kWh, a higher rate for the usage between 501 and 1000 kWh and an even higher rate for the final 300 kWh usage. These inclining rates provide a clear incentive to reduce consumption to lower or eliminate consumption charged at a higher rate.

IBR is a mature concept with data on implemented systems as well as studies of its efficacy for reducing LMI energy burden available for review. The most relevant case study is electric utilities in California who have had IBR as the default option for their customers since the 1980s, converting from a 2-tier design to 5-tier in 2001.

In a 2012 study, Borenstein found that IBR achieves modest wealth redistribution, with electric bills for the lowest income groups decreasing by an average of 8-29%, and the lowest income individual customers seeing decreases of nearly 40%. This is in contrast to the highest income groups who see their electricity bills increase by an average of 10-26%, with the highest income individual customers seeing roughly a 30% increase.[27] For customers at the lowest end of the high-income bracket, this translates to only half a percentage point of their yearly income, but for those at the FPL, the savings translate to 1.5% of their yearly income.

In 2004, Nova Scotia's utility regulators published a report which discussed the improved **distributional equity** of IBR over typical flat rates. The cost per kilowatt-hour of electricity increases steeply at times of high overall customer demand. Flat rate structures charge the same price per kWh, which has the effect of spreading these high costs across all consumers without regard to their contribution to the high demand. This effect is known as **cross-subsidization**. In the Nova Scotia report, the authors found that low-income customers tend to consume electricity in lower volumes and more evenly throughout the day compared to their higher income counterparts. By increasing the price for high-usage, high-income customers whose demand contributed more to the overall cost of providing electricity, IBR in Nova Scotia achieved a more equitable price structure.[28]

For IBR to work properly, it is important that the proportion of high-income and high-consumption customers is large enough in the total customer base to adequately redistribute wealth. This effect was illustrated in a 2022 study by Klug et al.[29] As 54% of New Jersey households residents fall above 400% of the FPL, this requirement should not be an obstacle to the success of IBR in addressing LMI energy burden.[30]

In examining the impact of IBR on water bills in Mauritius, Yeti found that when implemented in a time of increasing demand, inverted rates had the potential to increase the equity of water bill prices across income groups.[31] This study is of interest as it illustrates the potential of inverted rates when aligned with the mechanism we are leveraging - increased electricity demand for high-income customers. However, this correlation should be examined with attention to the differing elasticity of demand between water and electricity.

Lastly, we will examine IBR's potential to incentivize energy conservation and efficiency. While this is not the primary goal of our group's analysis, it is a core part of New Jersey's EMP. Several provinces in China implemented inverted block pricing for electricity in 2012. Using data on electricity consumption from 2009 to 2015, Wang & Yu analyzed the impact this had on residential electricity use. They found that the tiered pricing structure reduced electricity use by an average of 6.1%, however the decrease was larger for regions with a greater percentage of high-consumption users.[32] This data suggests that IBR has the potential to significantly lower electricity use in a state such as New Jersey that has a large percentage of high-income households.

However, the application of IBR could also lead to a potential risk - an aggregation of deadweight loss.[33]

Due to the revenue constraint mandated by regulatory agencies, the electricity rates are usually set below the marginal cost of utilities, which results in an efficiency loss from the price gap. Under the IBR condition, the high consumption customers would face an electricity rate for marginal consumption equal to the marginal cost of utilities, thus no efficiency loss is being revealed in this group. For low consumption customers, it is expected that they would increase their consumption, which leads to an efficiency loss. In addition, while IBR can lead to conservation and energy efficiency, it can also lead to a reduction in overall economic output and efficiency if consumers reduce their consumption to a level that is below their optimal level.

Time of Use

A TOU rate is a pricing strategy used by electricity utilities to charge customers different rates for electricity consumption based on the time of day, day of the week, and season. This means that the cost of electricity varies depending on when it is used.

Under a TOU rate, electricity rates are typically higher during peak demand periods, such as weekdays in the late afternoon and early evening, and lower during off-peak periods, such as nights, weekends, and holidays.

The idea behind TOU rates is to encourage customers to shift their electricity usage to off-peak periods when the cost of generating electricity is lower and the demand on the grid is lower, thereby reducing the need for utilities to build additional capacity to meet peak demand.

TOU rates can help utilities manage their peak loads more effectively, reduce the need for expensive power plants and transmission infrastructure, and encourage customers to use electricity more efficiently. However, they can also be complex and require customers to be more conscious of their electricity usage habits to take advantage of the lower rates during off-peak periods.

However, it is noted that the installation of **Advanced Metering Infrastructure (AMI)** is essential to the development of TOU rates. AMI refers to an integrated system of equipment, communications, and information management systems that allow for utilities to remotely collect customer electricity usage data in real time, according to the DOE.[34] The deployment of AMI technologies unlocks new capabilities for utilities to offer time-based rates that encourage customers to reduce electricity use, primarily during peak periods.

The question of how different customer groups respond to TOU rates has received increasing attention from researchers in recent years.

We reviewed two seminal articles on the topic to explore this issue. The article "Are vulnerable customers any different than their peers when exposed to critical peak pricing: Evidence from the U.S." by Cappers, P., Spurlock, C. A., Todd, A., & Jin, L. (2018) aims to investigate whether vulnerable customers, defined by authors as low income, elderly and chronically ill customers, are any different than their peers when exposed to **critical peak pricing (CPP)**, a TOU program, in the U.S. The study used a **randomized control trial (RCT)** to assess the impact of CPP on vulnerable customers compared to their non-vulnerable peers. The data was collected from Green Mountain Power (GMP) and Sacramento Municipal Utility District (SMUD) over a two-year period.

The findings of the study suggest that there is no significant difference in the response to CPP between vulnerable and non-vulnerable customers. Both groups showed a reduction in their peak demand during the CPP event, and there was no significant difference in the reduction in peak demand between the two groups. The authors also found that vulnerable customers were more likely to enroll in the TOU program, and the authors suggest that this may be due to their increased awareness of energy costs.

The article contributes to the growing body of literature on TOU programs and their impact on vulnerable customers. The authors provide evidence that vulnerable customers are not inherently different from their peers in terms of their response to CPP. This suggests that TOU programs can be effective for vulnerable customers and may help to reduce their energy bills.
The authors also suggest that targeted outreach and education may be necessary to increase participation among vulnerable customers.

Overall, the article provides valuable insights into the impact of CPP on vulnerable customers and contributes to the ongoing discussion of how to design effective TOU programs that are equitable and inclusive. The study's findings highlight the importance of considering vulnerable customers' unique needs and circumstances when designing and implementing demand response programs. However, because only two utilities in the U.S. provided the data for the research, it may not be representative of all situations. To further validate the study's findings, future research might benefit from examining data from other areas and utility companies.[35]

The article "The Impact of Dynamic Pricing on Residential and Small Commercial and Industrial Usage: New Experimental Evidence from Connecticut" by Faruqui, A., Sergici, S., & Akaba, L. (2014) presents the results of an experimental study conducted in Connecticut to examine the effects of dynamic pricing on residential and small commercial and industrial (C&I) electricity usage.

The study utilizes RCTs to test the effectiveness of TOU programs such as **time-varying rates (TVR)** and CPP on reducing peak demand and overall electricity consumption.

The findings indicate that TVR and CPP are effective in reducing peak demand for both residential and small C&I customers. The authors found that residential customers reduced their peak demand by 11% during TVR events and 25% during CPP events. Small C&I customers reduced their peak demand by 13% during TVR events and 23% during CPP events. The authors also found that these demand reductions did not result in a significant increase in off-peak demand or overall electricity consumption.

The study provides valuable insights into the potential effectiveness of TOU as a demand response strategy. The authors suggest that TVR and CPP could be effective tools for reducing peak demand and improving the efficiency of the electricity grid. The study's use of RCTs increases the internal validity of the findings and provides confidence in the accuracy of the results. However, as with the previous article, the study's applicability may be limited, as the data was collected from a single utility company in Connecticut, and only examines short-term impacts. Future research could benefit from analyzing data from multiple utility companies and examining the long-term impacts of dynamic pricing on electricity usage.[36]

Nevertheless, there are some controversies around the use of TOU rates in terms of the constraint in consumption behavior.[37]

TOU would lose its effectiveness if customers are unable to shift their consumption away from peak hours. Additionally, customers would face decreased flexibility in the timing of their electricity use. Further research is required to figure out how to overcome the loss-aversion issue for electricity users.

Natural Gas Exit Fee

A natural gas exit fee levies a one-time charge on customers who disconnect their gas service account and leave the gas grid, usually after electrifying end-uses previously serviced by natural gas.

The rationale for levying an exit fee is to recover sunk fixed costs for the natural gas distribution infrastructure. The investment costs are typically made based on load forecasts dependent on existing customers staying on the grid over a certain time frame, so any customers who exit from the grid reduce the **ratepayer base** over which the investment cost can be recovered. As a result, the exit fee is a mechanism for the utility to collect revenue to compensate for the loss of natural gas customers.

The natural gas exit fee was raised as a mechanism to transform rate design in "Modernizing Rate Design", a policy option research document created by the Brattle Group by Ahmad Faruqui, Ryan Hledik, and Long Lam on behalf of ATCO Electric & Gas to comply with the Alberta Utility Commission's inquiry.[38]

This option was also highlighted in "*Who Will Pay for Legacy Utility Costs"* by Lucas David and Catherine Hausman of the Energy Institute at Haas, UC Berkeley. The proposal is characterized the same way as "*Modernizing Rate Design*" - however this paper delves deeper by highlighting that exit fees have to be sufficiently high - up to $1,000 - to cover the discounted capital, operating, and maintenance costs of the infrastructure they leave behind.[39]

The exit fee was also proposed by Oklahoma Natural Gas, a natural gas utility in the state of Oklahoma, to the Oklahoma Corporation Commission. In February 2022, this proposal was rejected.[40]

The literature review highlights that while the exit fee can be highly effective in reducing cost shifts, it can be politically infeasible, both in terms of customers who were unaware of this stipulation when joining, and also for customers who perceive it as a tax on electrifying. The latter also makes this proposal directly contradict the electrification goals that are integral to New Jersey's EMP.

Community Solar

Existing literature has identified the increasing adoption of **distributed energy resources (DERs)** as a source of inefficiency in many of the prevailing electricity tariff structures in the U.S. and elsewhere.[41] Costs of electric utility service that cannot be attributed to an individual customer's electricity usage are referred to as residual costs. Historically, utilities have recouped their residual costs through volumetric charges on customers' bills. This has allowed adopters of DERs to lower their share of contribution to the residual costs by lowering their consumption, while continuing to benefit from grid access.[42]

Community solar projects provide access to DERs for customers who do not have available capital or other necessary resources such as roof access for solar panels. Customers buy or lease a portion of a remote solar panel array. They may then use the electricity generated by these solar panels to offset their own electricity consumption charges the same way that someone would utilize rooftop solar on their home. Community solar may provide a way for LMI households to skirt some of the costs and resource restrictions of typical DERs, thus reducing the inequity in how DERs redistribute utilities' residual costs.

The National Renewable Energy Lab reviewed Colorado's 2015 Low-Income Community Solar (LICS) pilot program which was provided through an affordable renewable energy non-profit and eight rural cooperative electric utilities. The resulting eight solar projects ranged in size from 26.4 kW with seven subscribers to 700 kW with 140 subscribers. The largest project managed to break even and reduce subscriber electricity spending by 30%.

However, on average the projects returned smaller profits to the utilities than business as usual (BAU). The largest project succeeded due to its superior economies of scale and ability to earn **Renewable Energy Certificates (RECs)**. Successful LICS programs will require cooperation across many entities to achieve large scales and will require a favorable regulatory environment.[43]

In a 2022 report, the Rocky Mountain Institute called for increased adoption of community solar and storage projects in cities, a plan which they named Solar Plus. They claim that positioning solar projects in densely packed urban areas allows for greater combined benefits relative to siting in remote fields. Solar projects can offer shaded parking to reduce the **heat island effect** and generate additional revenue for the project. Energy storage components can also provide resiliency for local communities during grid failure. The authors refer to existing and future community solar projects in San Antonio, Denver, and the DC Metro area. These projects have provisions that ensure LMI benefits such as a minimum 20% low-income subscriber ratio.[44]

Targeted Geographic Electrification

Targeted electrification refers to the designation of geographic areas for full electrification and disinvestment of the natural gas system. In practice, targeted electrification requires regulators to draw boundaries delineating where natural gas utilities can and cannot invest in expansion or modernization projects. Simultaneously, state and local governments will need to provide support to community members in making whole-home transitions off of natural gas. This strategy would reduce future **stranded assets** and mitigate the rising costs of natural gas.[8]

Recent research from UC Berkeley's Haas Institute lends credence to the prediction from the Impact Study that natural gas utilities will respond to electrification by increasing prices to cover their fixed costs. In a 2022 paper, researchers examined the infrastructure investment behavior of 320 natural gas utilities that had increasing customer bases and 250 that had declining customer bases. They found that a 10% increase in the customer base led utilities to expand their pipeline network, but declining bases led to no commensurate decline in pipeline network. Due to this asymmetry in costs, researchers also found that utilities' revenues only decreased by 5% per 10% reduction in the customer base, compared to a 10% increase in revenue per 10% increase in the customer base.[45]

This research highlights the need to cover the remaining legacy infrastructure costs, maintenance, and administrative overhead that does not reduce with the natural gas customer base. The authors propose targeted electrification to eliminate maintenance costs in regions that experience dwindling populations. This prevents the few households that remain on the gas system from imposing their infrastructure costs on other users who may reside in more densely populated areas that are less expensive to service. Areas could be selected by their customer-to-mile-pipeline ratio, age, or feasibility of reaching full electrification. Selecting for age may be particularly desirable as it would prevent future capital cost payments on current modernization projects.

In a white paper prepared by Common Spark Consulting for the Building Decarbonization Coalition, authors explored options for targeted geographic electrification in California. Their recommendations relied, in part, on a case study of electrifying low-income neighborhoods in San Joaquin Valley in central California, which relied on propane heating.

The authors identified the need for deliberate communication with stakeholders including community members who will need support investing in electrification measures and electricity providers who will need to prepare for increased loads. They recommend that regulators create unambiguous limits on which regions natural gas investment will be prohibited in and when it will be prohibited. Other recommendations include the acceleration of depreciation schedules to pay off more infrastructure before the ramp up of electrification.[46]

Section C
Policy Option Selection

From the list of six policy options we researched in the literature review, the Capstone team narrowed our scope of investigation after conversations and feedback from the NJBPU staff and after applying the following considerations. We used these considerations as the main factors in our qualitative evaluation of our policy options.

1

Alignment with EMP goals

New Jersey's EMP created mandates for the NJBPU to implement incentives for decarbonization. We reviewed the literature to understand the implications of each policy on these goals. We eliminated policies which actively disincentivized electrification and energy efficiency.

2

Political feasibility

Changes to regulation and utility price structures undergo extensive negotiations before they are finalized. We avoided policies which would meet significant resistance from key stakeholders, including utility companies and ratepayers. When evaluating our policy options, we considered impact predictions from the relevant literature and reviewed stakeholder comments submitted to the NJBPU and other utility regulating agencies.

3

Barriers to participation

Through interviews with NJBPU staff and directors of nonprofits, we gathered information on barriers preventing LMI households from applying for energy assistance. Anecdotal evidence points towards proof of income documentation requirements and confusion regarding which program to pursue as major hurdles for households. We chose policies which would reduce LMI energy burdens automatically, with little to no action required by the consumer.

4

Technological feasibility within five years

We decided that the policy should not rely on new technology such as AMI which has not been fully deployed across the state. The four major New Jersey electric utilities have announced deadlines for full AMI deployment in their territories ranging from 2024 to 2026.[47, 48, 49, 50] NJBPU staff recommended that we assume a longer time horizon for AMI, with full deployment sometime after 2030.

5

Demonstrated deployment elsewhere

Where possible we reviewed literature to find examples of the policy in use. This was not possible for all options, as some are highly novel. For mature policies, however, we considered the successes seen elsewhere and their applicability to the New Jersey context.

6

Administrative cost

We considered the amount of information that would need to be collected for each policy option and the level of difficulty of collecting that information. We determined that rate designs based on volumetric consumption would be easily implementable as utilities already monitor this data to charge their customers. Income-based interventions were considered to be more costly to administer as they would require utilities to develop systems to gather new types of customer data or collaboration with state agencies.

Using these selection criteria, we focused on the rate design restructures that provided the most automatic and direct impact on energy burden. This resulted in IBR and IBFC being chosen as our options for further analysis.

Other options such as a natural gas exit fee and targeted electrification suffered from a lack of political feasibility. The former would discourage customers from electrifying, while the latter would directly conflict with the interests of natural gas utilities. While community solar remains a promising way to increase equity of access to distributed electricity generation, it requires significant action on the part of the consumer to participate, as demonstrated in New Jersey's pilot solar program.

TOU pricing will become an important tool in controlling peak demand as AMI reaches higher penetration, electric vehicle charging increases load on the electricity grid, and intermittent renewable electricity generation becomes more prevalent. However, given that the technological feasibility has a five-to-ten-year horizon, we chose to not consider it as a stand-alone option for reducing LMI energy burdens.

The following two sections cover our evaluation of IBR and IBFC in greater detail. We will discuss each policy's impact on energy burden, as well as its ability to satisfy the six considerations discussed above.

Evaluation of Inverted Block Rates

IBR has been shown to reduce energy burden for households at the FPL by 1.5%. It does this by making electricity more affordable for households who consume less electricity than typical households. Results from a 1990 study of South Carolina electricity consumers showed that lower income households tend to use less electricity, largely due to relationships between income and home size as well as number of electric appliances.[51] Recent studies confirm these results and also show how differences in appliances can determine how a household responds to changing electricity prices.[52, 53] Because of this dependence on conditions such as home size and number and efficiency of appliances, not all LMI households will necessarily benefit from this change. Those living in large homes with aging technology may even see dramatic increases in energy burdens if considerations are not made for these differences between households.

In terms of the evaluation criteria, IBR at least partially satisfies each requirement, but faces some potential challenges in terms of political feasibility.

- **Alignment with EMP goals**

IBR is highly supportive of energy efficiency goals. By offering a lower rate for lower energy usage, IBR gives households a financial incentive to reduce their energy consumption. This is in alignment with the EMP's overarching strategy of maximizing energy efficiency and conservation and reducing peak demand.[54]

- **Political feasibility**

Historically, IBR has seen support from diverse groups of stakeholders such as the New England Demand Response Initiative as a means of limiting demand and thereby consumer costs.[55]

Today, New Jersey utilities including Atlantic City Electric employ tiered summer rates, known as excess rates, to reduce the impact of electricity demand for cooling. Expanding the use of IBR in New Jersey to specifically promote energy affordability may face pushback from high energy consumption, high-income households, who will face higher bills. Another challenge may be the resistance of utilities or ratepayers to change from traditional rate structures.[56]

- **Barriers to participation**

As a rate design proposal, IBR would have little-to-no barriers to participation for customers, who would automatically be switched to the new rate structure.

- **Technological feasibility within five years**

IBR would be feasible to implement within a five-year time frame. Utilities already have the billing and metering infrastructure to adjust block rates and track energy consumption, meaning no new technology would need to be developed.

- **Demonstrated deployment elsewhere**

As mentioned previously, IBR has already been in use in California for decades. The fact that it has been in use for so long could be used as justification for implementing the rate design.

- **Administrative cost**

IBR is relatively simple to implement and administer compared to income-based rate structures. The capital costs of the design are low because the billing and metering infrastructure already exists. Operating costs are also low because tracking energy consumption in block rate tiers only requires marginal effort and investment. In addition, IBR is designed to allow utilities to maintain their board approved rate of return on their rate base.

IIn addition to being implemented on its own, IBR can be combined with other energy burden reduction tools or energy efficiency incentives such as TOU, customer assistance programs and active or passive price signals.

IBR may also be appropriate where obstacles exist for other progressive rate designs such as concerns regarding customer data privacy.

Overall, IBR is a promising policy solution that could be used in conjunction with other policy tools to address energy affordability and promote sustainable energy use.

Evaluation of Income-Based Fixed Charge

An IBFC would directly and immediately reduce the energy burden on LMI households. It would do so by shifting the majority of the fixed costs onto the higher-income households that comprise the majority of the population in New Jersey. This would be done by pegging energy burden to income, either directly through verification or indirectly through geographic targeting. Using IBFC to ensure that the energy burden of LMI households stays below 6% should not overly burden the majority of high-income households given the large wealth disparity in the state. In this way, the fixed costs of the New Jersey energy grid would be recovered in a progressive manner. Additionally, the IBFC is structured to allow utilities to maintain their approved rate of return on their rate base of fixed assets.

While IBFC satisfies the evaluation criteria of low barriers to participation and technological feasibility within five years, it faces challenges in terms of its alignment with EMP goals, political feasibility, lack of demonstrated deployment elsewhere, and administrative costs.

- **Alignment with EMP goals**

Since the IBFC does not target volumetric rates, it does not incentivize households to conserve energy and, by extension, invest in energy efficiency. This runs counter to New Jersey's EMP goals. High fixed charges could, however, potentially incentivize solar PV installation to avoid the charges.

- **Political feasibility**

IBFC has the potential to face significant residential customer pushback due to concerns regarding data privacy and high-income customers perceiving it as another form of income tax. Some implementation options involve residents declaring their annual income through ID verification (e.g. Social Security) to utilities or the Department of Taxation sharing income details with utilities. This would place sensitive personal information in the hands of utilities who customers are not used to trusting with this information. Recent residential comments from the CPUC's evaluation of IBFC include concerns that this charge will automatically lead to higher bills and that the charge differential between low and high-income households is too high and unfair to high earners. The comments also included demands to see how the charge would affect real-world bills. These concerns could definitely surface in New Jersey where high-income households comprise more than 50% of the population and can organize with enough critical mass to oppose this proposal.

- **Barriers to participation**

As with IBR, IBFC has little-to-no barriers to participation because it can be implemented as a rate design without customers needing to sign up for it. The implementation option where residents would need to declare their annual income through ID verification could be an obstacle to participation if not designed in a way that makes it easy for customers.

- **Technological feasibility within five years**

IBFC does not require new technology to be developed, so it would be technologically feasible within five years. It also would be compatible with smart metering. Because it targets fixed costs, the IBFC can be used in conjunction with any rate design that is dependent on the amount of electricity consumed by a household. This is important in the New Jersey context due to the huge push being made towards smart metering in the state.

- **Demonstrated deployment elsewhere**

As of now, IBFC has no example of demonstrated deployment elsewhere. There is no previous case study or pilot program that can prove its efficacy, although the CPUC is currently evaluating enacting an IBFC for all the utilities under its purview.[57] The novelty of this solution means there is no data to evaluate its effectiveness in reducing electricity burden or on energy affordability. Imposing a charge that could materially impact customer energy costs without prior data is inherently risky.

- **Administrative cost**

IBFC is likely to have high administrative costs due to its added complexity. Depending on the system chosen (geographic targeting vs. income verification), the administrative costs would include unprecedented levels of inter-agency collaboration and new infrastructure buildout. While the capital costs relative to typical utility investments would be low, operating costs to manage income verification would be medium-to-high. Setting up the information infrastructure and collaboration practices between utilities and the Department of Taxation will require high effort. While this cost could be passed on to the consumers through the fixed charges, this would increase the highest income households' charges even further. Implementing either the geographic targeting or the income verification would also add much more complexity to the energy pricing system itself in New Jersey.

Overall, IBFC is an unproven and expensive yet promising policy solution that could be used effectively in conjunction with other rate design tools to directly address energy affordability in New Jersey.

Side-by-Side Comparison of IBFC and IBR

DIMENSION	IBR	IBFC
Effective in reducing burden?	**Yes**	**Yes**
Does it help EMP goals?	**Yes**	**Mixed**
Expected administrative rollout	**Low effort**	**High effort**
Implementation costs	**Low**	**Mixed**
Political feasibility	**Moderate**	**Low**
Demonstrated elsewhere?	**Yes**	**No**

Section D
Quantitative Analysis

Introduction to the Modeling Strategy

In order to investigate the impact of progressive electricity rate designs, we developed a model which forecasted energy spending from 2023 to 2030. This model predicted energy spending for New Jersey natural gas and electricity customers, grouped by income. To accomplish this, we used historic electric and gas utility revenues from the residential sector and applied annual growth rates for inflation and energy costs. To predict demand, we applied population growth and historic demand changes to 2022 household counts and energy spending, again broken down by income level. This provided total system wide energy spending which could be allocated to customers either by demand or income according to different policy options. The model returned energy burdens for each income group under BAU and progressive rate intervention scenarios. A schematic for the model is shown in *Figure D-1*.

Figure D-1

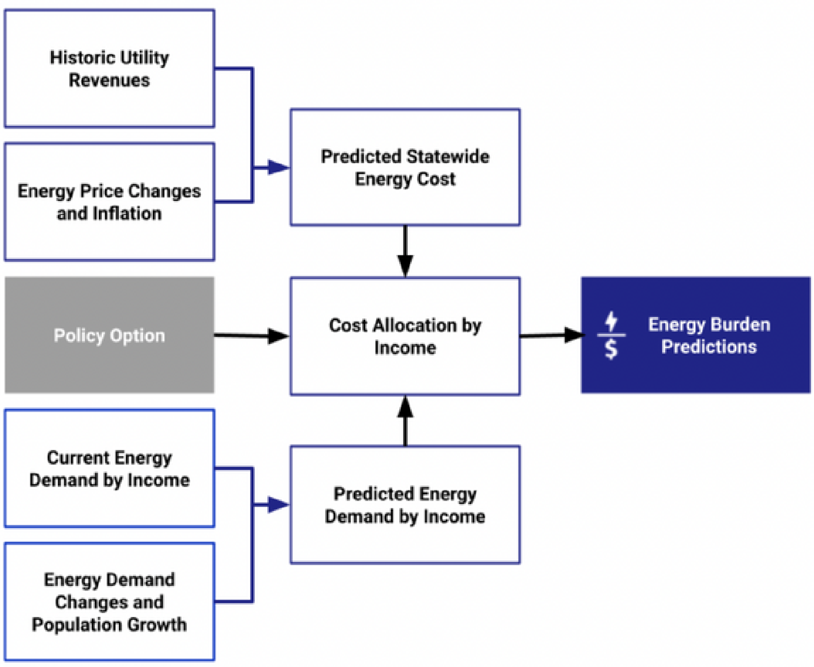


Figure D-1: Schematic of the energy burden forecasting model used in quantitative analysis.

Detailed Description of the Model

Data and Assumptions

- **Income Groupings**

We used income groups based on the federal poverty level as is used in the American Community Survey (ACS). These groups are 0-100%, 100-150%, 150-200%, 200-400%, and above 400%. The ACS dataset is used in the LEAD tool, which we sourced for much of our data. Additionally, multiple New Jersey assistance programs use 400% of the FPL as their threshold for eligibility, so choosing these groupings allowed for easy comparison between our results and populations of interest to the NJBPU.

- **Historic Utility Revenue and Energy Price Changes**

We sourced New Jersey's residential electricity revenue from the Annual Electric Power Industry Report provided by the U.S. Energy Information Administration.[58] To project future electricity costs, we utilized the **compound annual growth rate (CAGR)** of 2015-2021 historic revenues. The gas price was adjusted according to the rates predicted by the Ratepayer Impact Study under the EMP Achievement Scenario.

- **Inflation**

Inflation was projected at 2.5%, slightly above the Federal Reserve's long-term inflation target given the recent high inflation. This projection was based on conversations with the NJBPU.

- **Current Energy Demand**

From the LEAD Tool,[1] we found the current average electricity cost per household and current energy spending by income category. Assuming a fixed volumetric rate design, we calculated average annual electricity usage by income category.

- **Energy Demand Changes**

To account for future changes, we estimated that electricity consumption per household will increase by 1% due to greater adoption of electrification. The Ratepayer Impact Study was used as our assumption of the decrease in the rate of natural gas consumption.

- **Population Growth**

We obtained historical median household income and population data in New Jersey from the U.S. Census Bureau and the World Population Review. The number of households, or house count, is estimated to increase by a weighted percentage based on a population growth rate of 0.7%. This was found by considering the historic New Jersey population growth from 2015 to 2022 as provided by the sources listed above.

Applying Different Policy Options

When applying IBFC to find cost allocation, we set a target energy burden of 6%. Costs were first assigned to the lowest two income groups. The costs assigned were equal to 6% of total income within the group. This brought down the average energy burden to our target for each group. Remaining costs were then divided among the remaining groups according to the number of households in each group. This resulted in an equal average charge between households in these higher income groups.

When applying IBR, we began by defining usage tiers. The first consumption tier ranged from 0% to 90% of the average household electricity consumption. Additional tiers were defined as additional 5% of average household consumption. Costs were assigned to the income groups based on their average consumption. We tested multiple schemes for assigning prices to these tiers, as discussed in the model results section. They needed to be assigned such that total spending from all households equaled the total revenue of the utility.

Once costs were assigned, average energy burden for each group was calculated by dividing their total energy spending by total income. Overall, this methodology allows for a high-level projection of household energy costs in New Jersey, accounting for various factors such as income, population growth, electricity and gas consumption rates, and pricing structures.

Model Results and Sensitivity Analysis

Our model allowed us to quantify the impacts of redistributing electricity costs to keep energy burden below 6% for all customers in 2023. We found that the necessary reduction of electricity costs borne by households earning below 150% of the FPL could be transferred to higher income households while only causing a small percent increase in spending for the latter group. Even though reducing energy burden to our target required a more than 55% reduction in spending for the below FPL group, no other group saw energy spending increase by more than 5%. The small impact on higher income customers is largely attributable to the small number of households below 150% of the FPL relative to the higher income groups.

Figure D-2 shows the total energy utility costs faced by New Jersey residents divided by sector and income level. Costs per household are represented on the y-axis. The width of each block is proportional to the number of households within that income group. The area of each box represents the total spending for that income group. We required that the utilities recover the same revenue for all rate structures. Due to this constraint the total area of all the boxes remains constant between the two scenarios shown in *Figure D-2*. Examining the widths of different income brackets and the changes in average energy spending between the two scenarios provides some insight into how dramatic cost reduction for low-income households can be achieved with a low impact on their higher-income counterparts.

Following these initial results, we modeled the use of IBFC and IBR following the methodology described in the model description. While modeling IBFC, we assumed that pricing did not depend on consumption. Under these assumptions, our model recreated our initial results with the lowest income customers paying around $20 per month for electricity services and highest income customers paying around $150 per month.

Figure D-2a

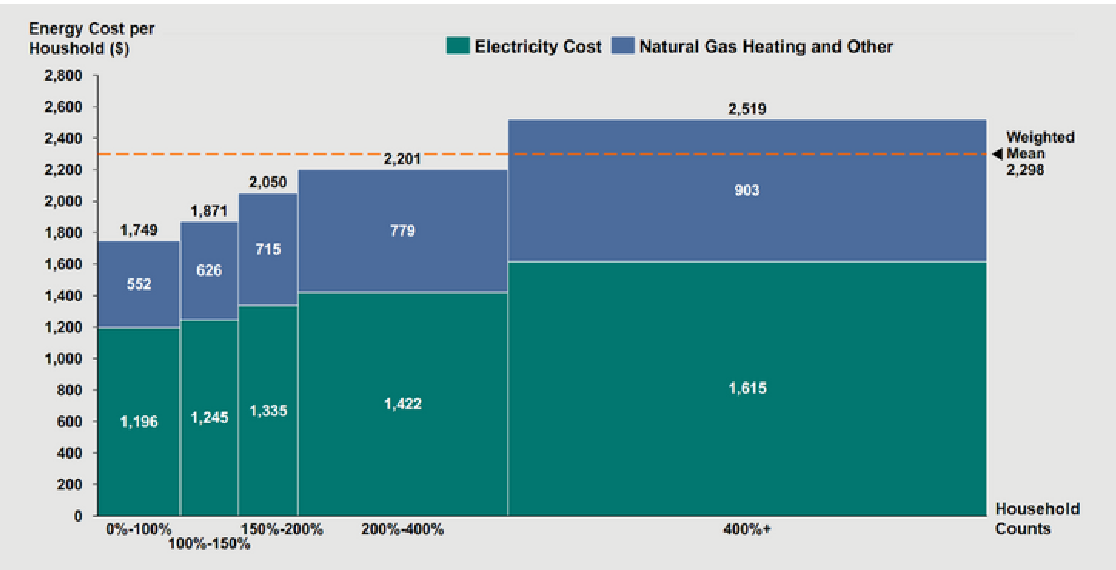


Figure D-2b

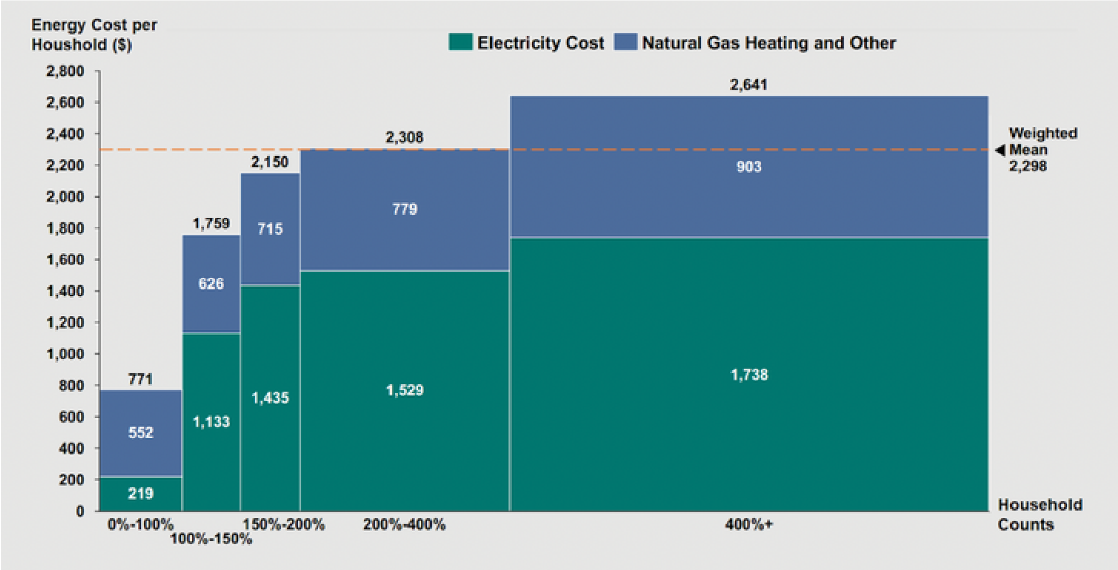


Figure D-2: Total New Jersey residential electricity revenue in 2023. The horizontal axis shows the number of households per income bracket as defined by the FPL. The vertical axis shows average energy spending per household. **Figure D-2a** shows the results where each income bracket contributes the same portion of energy utility revenue as 2018. **Figure D-2b** shows the effect of a progressive redistribution of energy costs.

While modeling IBR, we assumed that customers' prices were calculated entirely on their consumption, with fixed customer charges constituting only a negligible portion of each bill. Under IBR, we found that limiting energy burden to below 7% for all customers would require charging very high prices for the highest consumption blocks, more than six times the B price. We chose to limit this top block to three times the average price of electricity. We then used an optimization algorithm to minimize energy burden for customers below the FPL. The result was the pricing structure shown in *Table D-1*.

Table D-1

CONSUMPTION RANGES		BLOCK PRICING	
By Percent of Average Consumption	Using 2022 Average Annual Consumption	By Percent of Average Price	Using 2022 Average Price
0-90%	0-7.6 MWh	74%	13 ¢/kWh
90-95%	7.6-8.1 MWh	95%	16 ¢/kWh
95-100%	8.1-8.5 MWh	180%	31 ¢/kWh
100-105%	8.5-8.9 MWh	200%	34 ¢/kWh
105-110%	8.9-9.3 MWh	250%	43 ¢/kWh
Above 110%	Above 9.3 MWh	300%	51 ¢/kWh

Table D-1: IBR Pricing Structure. Consumption ranges are determined according to the average electricity price, which is total revenue divided by total electricity consumption.

Table D-2

SENSITIVITY ANALYSIS VALUES		
	Inflation and Salary Growth	Electricity Price Growth
High	**1%**	**0%**
Typical	**2.5%**	**2%**
Low	**4%**	**8%**

Table D-2: High, typical, and low inflation/salary growth and electricity price growth values used for the sensitivity analysis conducted using our model

Finally, we conducted a sensitivity analysis in which we allowed our assumptions of electricity price growth as well as inflation and household income to vary. We chose high, typical, and low values for each of these variables (*Table D-2*) and repeated our model calculations for each. We determined electricity price change rates from historical U.S. average annual nominal prices published by the Energy Information Administration.[59] From these prices we calculated growth rates for ten-year rolling windows and selected low, medium, and high values from the 10%, 50% , and 90% percentiles of the resulting distribution. We selected a typical inflation rate based on the federal inflation target of 2% with adjustment for current high inflation. The results are summarized in *Figure D-3*. Each bar shows the difference between minimum and maximum energy burden calculated in the sensitivity analysis.

A stark result from our sensitivity analysis was the asymmetry in how price differences are experienced by different consumers. Small differences in price resulted in large differences in energy burden for low-income consumers. A difference in a few hundred dollars constitutes a large portion of income for the lowest income groups. The direct intervention of IBFC limits this uncertainty in costs for low-income groups since the rate structure is designed to cap energy burdens for all households below 6%. When utilities experience higher than typical costs, the additional costs are passed on to higher income brackets, and these groups do not experience higher than average prices. IBR does not provide such a cap and thus all incomes are subject to variable prices, which results in large ranges in energy burdens for the lowest income groups.

Figure D-3

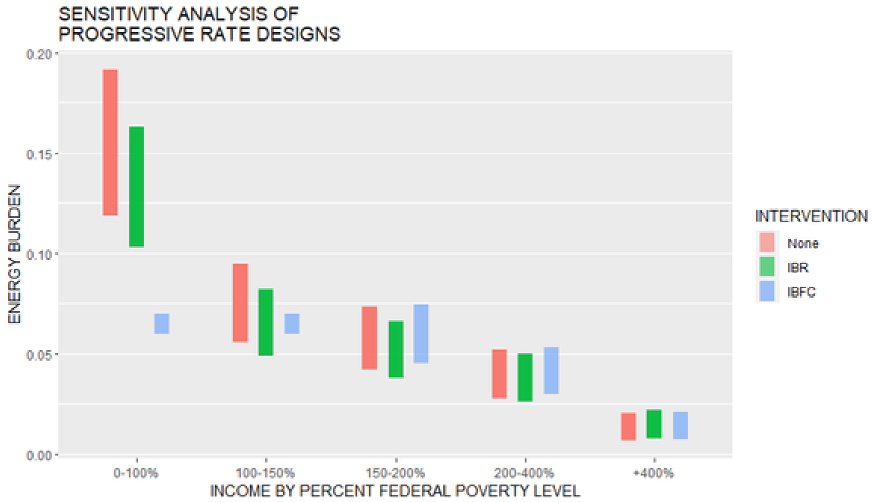


Figure D-3: Results of sensitivity analysis given different levels (high, medium, and low) of electricity price growth, inflation, and household income with energy burden on the y-axis and income by percentage of the FPL on the x-axis. Each bar represents the difference between minimum and maximum energy burden for a given combination of energy burden, income level, and type/lack of intervention.

Generalizing the Model

After applying IBR and IBFC separately, we considered the effect of applying both together. To do this, we divided statewide electricity costs into costs recovered through fixed charges and costs recovered through volumetric charges. The fixed charges were then allocated according to the same income groupings used previously. Similarly, volumetric charges were allocated according to usage, calculated from 2018 annual electricity spending data from the LEAD tool, assuming $60 in fixed annual fees and 15¢ per kWh electricity price.

In order to improve the accuracy of our predictions of the impact of varying volumetric prices and to explore the impact of applying income based charges by location, we downloaded the American Community Survey dataset used by the LEAD tool. This provided average electricity and natural gas spending for over 450,000 groupings of New Jersey households. The LEAD tool authors, Ma et al., refer to these groupings as cohorts.[1] The cohorts are defined using six location and housing characteristic variables, described in *Table D-3*. We assumed that the energy usage habits within these smaller cohorts were more consistent between households compared to the statewide averages used in our first model.

Figure D-4 shows a schematic of the cost allocation model used. It used five policy option inputs to determine cohort electricity spending, represented by the gray boxes. Volumetric and fixed charges were assigned using a set of five weights. The weights were applied to the charges to determine relative pricing between income groups for IBFC and between usage tiers for IBR. The IBR block cutoff thresholds were determined by four inputs representing the percentile of annual household energy usage.

Table D-3

VARIABLE	NUMBER	DESCRIPTION OF VALUES
Location Code	1,994	**Census Block FIP Codes**
Tenure	2	**Owner, Renter**
Construction Year	6	**Before 1940, 1940-59, 1960-79, 1980-99, 2000-09, After 2010**
Building Type	10	**Single Family Detached Home, Single Family Attached Home, 2, 3-4, 5-9, 10-19, 20-49, 50+ Unit Multifamily Apartment, Mobile Trailer Home, Van/ RV/ Boat**
Heating Fuel	9	**Utility Gas, Bottled Gas, Electricity, Fuel Oil, Coal, Wood, Solar, Other, None**
Income Group	5	**0-100%, 100-150%, 150-200%, 200-400%, 400%+ of Federal Poverty Level**

Table D-3: The variables used to define cohorts in the LEAD tool/ American Community Survey dataset. The intersections of these six variables are defined over 450,000 cohorts, which were assumed to have similar energy use behavior.

Figure D-4

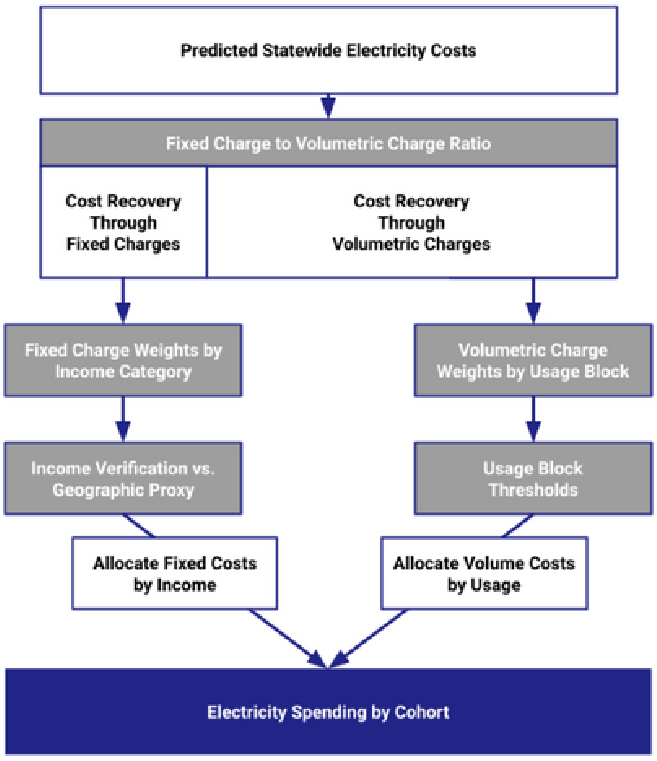


Figure D-4: A schematic of the generalized cost allocation model. Gray boxes represent policy option inputs.

We performed a 500-trial Monte Carlo sensitivity analysis, allowing both scenario assumptions and policy inputs to vary. For a conservative estimate, we used uniform distributions for each variable. The ranges are summarized in *Table D-4*. In this analysis we compared four policies to BAU flat pricing. In our IBR-only model, we used a consistent fixed charge to volumetric charge ratio of 1:19, consistent with typical BAU pricing. For IBFC only, we used a ratio of 1:1. We used two hybrid models; one in which IBFCs were assigned by each cohort's income group, and one in which IBFCs were assigned by census tract. In each trial, we calculated the reduction in household units experiencing energy burdens above 6%, compared to BAU. The results are summarized in *Figure D-5*.

Table D-4

ASSUMPTION VARIABLE	MIN.	MAX.
Population Growth Rate	0.43%	0.73%
Inflation and Income	1%	5%
0-400% FPL Gas Usage Change Rate	-0.2%	-0.2%
400%+ FPL Gas Usage Change Rate	-5%	0%
Electricity Systemwide Revenue Change Rate	0.25%	0.5%
0-200% FPL Electricity Usage Change Rate	-0.2%	0.2%
200-400% FPL Electricity Usage Change Rate	-0.2%	1%
400%+ FPL Electricity Usage Change Rate	-0.1%	5%
Other Fuels Price Change Rate	-0.2%	0.2%

POLICY INPUT VARIABLE	VALUE
IBFC and IBR Weight (tier 1)	$Wt_1 = 1$
IBFC and IBR Weights (tier 2)	$Wt_2 = U(min = 1, max = 1.25)$
IBFC and IBR Weight (tiers 3, 4)	$Wt_n = Wt_{n-1} \times U(min = 1, max = 1.5)$
IBFC and IBR Weights (tier 5)	$Wt_5 = Wt_4 \times U(min_{IBR} = 1.2, max_{IBR} = 1.5, min_{IBFC} = 1.5, min_{IBFC} = 3)$
IBR Block Threshold (percentile 1)	$Th_1 = U(min = 0.05, max = 0.5)$
IBR Block Threshold (percentiles 2-4)	$Th_n = (1 - Th_{n-1}) \times U(min = 0.1, max = 0.8) + Th_{n-1}$
% Electricity Cost from Fixed Charges	$U(min = 0.1, max = 0.5)$

Table D-4: List of values used in the sensitivity analysis of the generalized allocation model. Random variables drawn from a uniform distribution are represented by U, with maximum and minimum values in parentheses.

Figure D-5

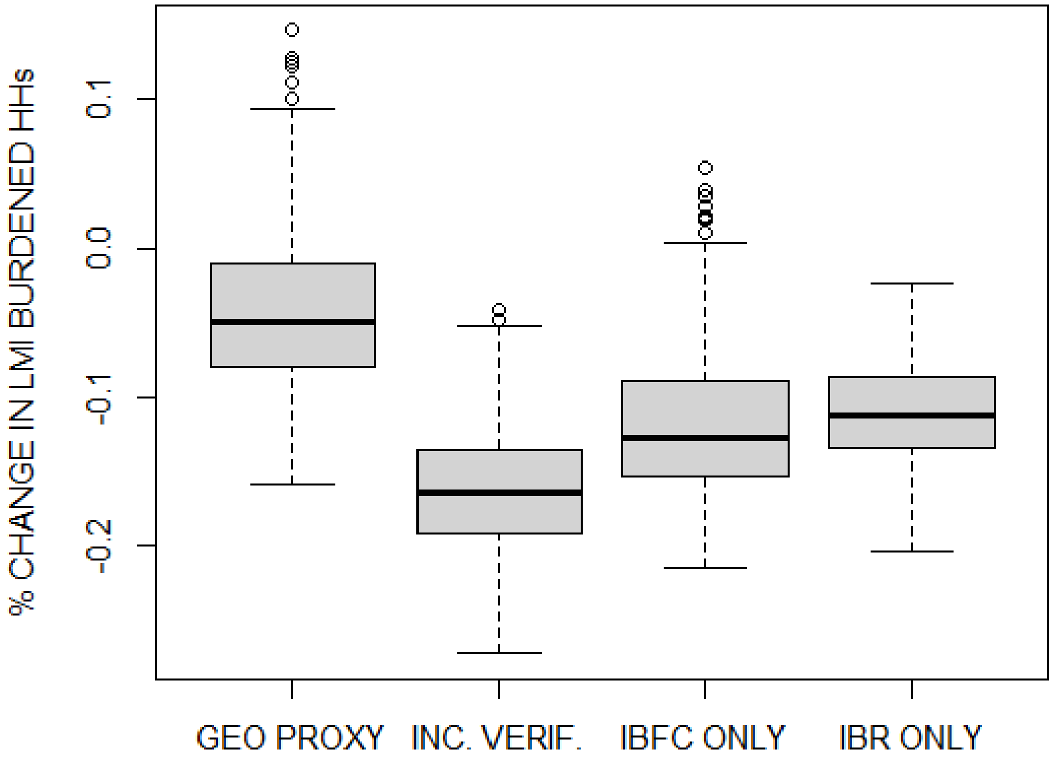


Figure D-5: Comparison of different electricity cost allocation policies on number of energy burdened households, relative to BAU.

As seen in *Figure D-5*, we found that under our assumptions, IBR performed as well as the income verification hybrid model in reducing the number of energy burdened households. Both showed considerable reductions in energy burdened households and low risks of increasing the number of energy burdened households.

Our geographic-proxy hybrid model did not perform as well as its income verification counterpart. Similarly, IBFC alone was less effective. Both IBFC alone and the geographic-proxy hybrid model showed significant risk of increasing the number of burdened households. *See Appendix for further detail on modeling.*

Section E
Discussion and Recommendations

Rate Design Discussion

The Capstone team recognizes that there are inherent tradeoffs to the options we have presented for progressive rate design. We have explored these tradeoffs by applying them in an energy spending forecast model and through stakeholder analysis. Below, we discuss what we believe are the most salient pros and cons of each rate design.

Throughout our analysis, we considered our two chosen rate design options separately and together as a hybrid option in which income based pricing was applied to the fixed portion of customer bills and inverted block pricing was applied to the variable, consumption-based charges. When we modeled each of these separately, we assumed that the fixed or variable portions constituted the entirety of the bill. Under these assumptions, we realized that IBFC pricing gives regulators and utilities a high level of control over costs to electricity customers. This allowed for direct intervention in addressing high energy burdens, but would not be realistic as it requires a large departure from current rates in which fixed charges constitute a small percentage of billing.

We found that IBFC, even applied to small fixed charges, may experience significant political and administrative drawbacks. Achieving adequate targeting of low-income households requires utilities to have knowledge of their customers' incomes. This may be resisted by customers due to privacy concerns. Utilities could instead use a proxy for income such as location, but this would result in reducing the benefit to some low-income customers. In our model, assigning income-based charges by geographic proxy performed poorly, sometimes resulting in increases to energy burdened households. Achieving any meaningful reduction in energy burden would require increasing the size of fixed charges, which would reduce price signaling. This would be undesirable to regulators and policymakers who support decarbonization as it removes incentives for conservation. Customers also may reject this policy because it would limit their ability to reduce their bills through adoption of conservation or efficiency measures.

Our initial IBR models showed reductions in energy burdens for all customers below 400% of the federal poverty level. However, IBR's capacity to reduce energy burden was limited compared to the direct intervention of IBFC. Reducing energy burdens to below 6% for low-income households required offering high reductions in price. This price reduction was offered to all customers on the majority of their electricity consumption. In order to recover utility costs and provide large energy burden relief to low income households, extremely high rates were applied at high volumes of consumption. We decided on 300% of average electricity price as the highest tolerable level for the final price tier. This resulted in a drop in energy burden for below poverty level households from a predicted 13% to 11%.

While the model results did not produce as dramatic a reduction in energy burden as IBFC, we believe IBR remains an important tool for consideration. From an economic perspective, it represents a fairer pricing structure. Customers pay based on what they consume. Additionally, as long run utility costs are driven by investment in upgrading for higher future demands, IBR likely captures some of this demand cost by charging higher rates to high volume consumers. Politically, IBR already has momentum. New Jersey electric utilities already use a form of IBR during summertime when demand is highest.

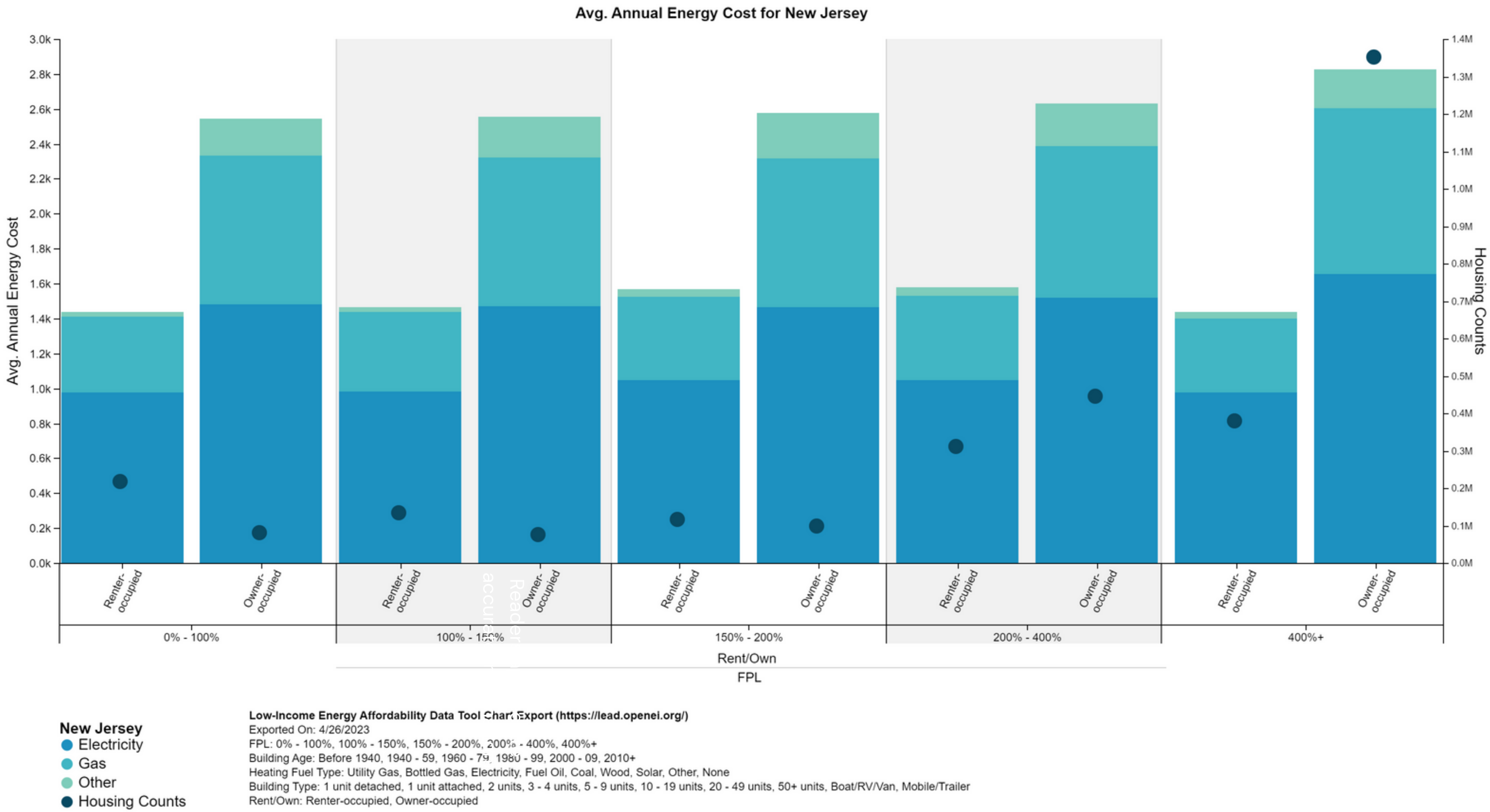
Finally, when we examined a hybrid model in which fixed charges were higher than they are now (10% - 50%) but lower than our initial model, we found it performed similarly to IBR alone. However, our policy assumptions limited income-based charges for households above 400% of the poverty level to below 3.5 times those of households below the poverty level. Eliminating fixed charges for households below the poverty level or incorporating a steeper progression of charges would improve the rate design's ability to address energy burdens.

Together, the two strategies could complement one another. Increasing the fixed charge portion of customer bills and pricing it according to income would create a progressive structure that is guaranteed to benefit low-income households. Higher fixed charges would also help to recover some of the residual costs of electrical infrastructure that adopters of DERs avoid paying. Combining this with IBR would provide additional redistributive effect but would not require the pricing tier to be as low.

Additionally, if utilities collect income information on their customers, they can provide exemptions from the highest pricing tiers to their low-income customers. *Figure E-1* shows that families above 400% of the poverty level are much more likely to own their homes compared to other income brackets. Families who own their homes are much more likely to consume higher volumes of electricity, thus would pay higher electricity prices in an IBR system. This could severely disadvantage low-income homeowners who would be forced to cover higher electricity costs on a small budget. Using the same information they use to provide progressive fixed charges, utilities could allow these customers to purchase electricity at the lower tiers despite consuming more electricity than average for their income.

Figure E–1

Average annual energy cost for households in New Jersey broken down into type of energy cost; illustrates the differences in energy spending across different incomes and between renters and homeowners



The Role of Energy Assistance Programs

Our findings show that a progressive restructuring of electricity rate designs in New Jersey could help to alleviate the energy burdens of the state's lowest income groups. However, even under a well-designed rate system, structural inequality will result in many families struggling to pay their energy bills. Therefore, the state will continue to need a well-funded safety net to protect its most vulnerable residents. In particular, without heavy, cost-cutting regulation of natural gas companies, the predicted decrease of high-income customers on the natural gas distribution system will drive up heating costs for LMI households. Rate design is a limited tool in this context because utilities must distribute their costs over a shrinking customer base.

Two of the primary state-operated, low-income energy payment assistance programs in New Jersey, USF and LIHEAP, have a wide reach. In 2021, 276,000 New Jersey families received assistance through these programs. They succeed at targeting and assisting vulnerable populations. Of the 276,000 families that received aid from LIHEAP, 71% contained a vulnerable member (an infant, elderly person, or disabled individual).[60] USF and LIHEAP grants are dispersed through the assistance of nonprofits and **community-based organizations (CBOs)**. This allows these organizations to help customers navigate the applications on a person-by-person basis.

The assistance programs as they exist today are strained. Following the COVID-19 pandemic, income thresholds for assistance were raised to allow more customers to apply. Informing eligible customers and assisting them through the application process can be challenging and many eligible customers do not seek assistance. Currently, less than 30% of families eligible for LIHEAP receive benefits. According to conversations with some of the nonprofits administering these programs, language barriers and lack of trust in government may explain some of this low uptake.

The lack of uptake in payment assistance programs may also stem from the fact that the assistance is not always directly helpful to customers. Payments are typically made direct to the utility companies, so customers have little to no agency in how they spend the money. This can be very helpful for customers at risk of shut-offs with small-to-medium overdue bills. However, the benefits of such payment programs may not be salient to the needs of customers who have accumulated large overdue bills. In conversations with program administrators, we heard stories of customers who had accumulated thousands of dollars in overdue bills during the shut-off moratorium since 2020. Assistance programs are not equipped to cover the entirety of bills this large, and customers do not experience the benefit of the assistance if they cannot pay the remainder.

NJ SHARES indicated that they have already seen large changes in the effectiveness of assistance programs over recent years. The NJ SHARES program is designed to provide "get back on your feet" assistance. Recently, they have seen more repeat applicants, indicating that programs meant to provide continual assistance like USF are not reaching the entire population that needs them. Increasing utility bills due to rapid electrification threatens to further strain this assistance system. As the number of high energy burden households increase, the ratio of applicants to CBO and nonprofit staff will increase. This reduces these organizations' important ability to work directly with customers who need assistance. The key strength of these organizations is their ability to navigate the complex system of assistance programs. Higher numbers could reduce their ability to service customers effectively.

Adopting progressive rate designs could function cooperatively with increasing funding to assistance programs. When energy is priced well above what customers can pay, assistance programs are less effective at providing assistance and less enticing to eligible applicants. Making energy more affordable will reduce the pool of eligible applicants, allowing community organizations and nonprofits to directly contact and assist a higher proportion of those in need. It will also bring down customers' bills to a level where they are able to pay in full with assistance, providing effective relief from energy insecurity.

Continuing funding of assistance programs allows regulators and utilities some insurance with changing rate structures. Progressive elements of rate design can be applied with a broad brush with the knowledge that customers have an easily accessible avenue for aid in making payments. These programs also function as revenue insurance for utility companies who may worry that increasing prices on some customers will result in missed payments.

Recommendations

Given the looming energy price increases predicted in the EMP Ratepayer Impact Study, we recommend the NJBPU aggressively pursue the implementation of progressive energy pricing in order to promote energy affordability for LMI households. When energy is prohibitively expensive, LMI households experience disconnections and their related health risks. Additionally utilities experience missed revenue, which may eventually be borne by other ratepayers. It is in the interest of utilities and ratepayers to design energy prices that can be paid by all.

From the policies we investigated, our team recommends that the NJBPU ask electric utilities to use data available to them to research the feasibility and impact of increasing their current fixed customer charges for high-income customers while using this added revenue to create a discounted price low volume consumption tier. This would constitute a first step towards a hybrid IBR-IBFC pricing structure.

Significant hurdles remain for determining income. We were not able to determine the legal implications of information sharing between utilities and the New Jersey Division of Taxation. If direct sharing of income data is untenable or if establishing channels of communication between utilities and the relevant state agencies would take significant time, using housing location as an indicator of income may be a useful substitute, but significant care would need to be taken to mitigate against misallocation of costs.

Alternatively, utilities could determine income using enrollment in energy assistance or other income-supporting programs such as SNAP. However, we have found that many eligible households do not enroll in these programs, so these same households would also miss out on the benefits of the rate design change. For this reason, we believe that if future energy rate structures use enrollment in assistance programs as a proxy for income, this should be accompanied by other indicators as well.

In addition to the rate designs mentioned above, we believe the following actions could help to strengthen New Jersey's existing energy assistance programs.

The NJDCA should continue to reduce barriers to application for eligible families. The NJDCA should consider expanding the number of languages in which assistance program information is disseminated and provide applications in more languages commonly spoken in New Jersey.

Behavioral studies have shown that reducing cognitive barriers to applications can greatly improve uptake of assistance programs. Creating a single stream application for all state operated programs, as was done for LIHEAP and USF, could reduce confusion amongst applicants. Additionally, utilities could send partially filled out applications with bills to likely eligible customers.

Conclusion

A progressive electricity pricing system could offer benefits to utilities and ratepayers alike, especially New Jersey's most vulnerable populations and as energy prices are expected to rise through the transition to renewable energy. Through examining the DOE's data on low income energy affordability, we have found that relieving extreme energy burdens for New Jersey households below the poverty level can be accomplished through redistribution of electricity costs. This can be done with little relative impact to prices for higher income levels. However, finding the right policy to achieve this end will be difficult. Every policy option involves trade-offs between fairness to ratepayers, incentives for energy conservation, and risk of missed utility revenue. We believe that progressively priced higher fixed charges and increasing volume consumption tiers together will provide an effective method of automatically reducing LMI energy burdens. This will reduce strain on the state's energy assistance programs, making them more effective at helping customers who do not immediately benefit from the rate changes. In all, we believe the measures we recommend could play a role in ensuring a more equitable energy transition in New Jersey.

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Manager: Eric Smith
Deputy Manager: Ishaan Ghose

Report Editor: Vanessa Lincoln
Report Designer: Ziqi Liu

Contributors: Rafae Ghani, Manasi Gupta, Jinming He, Zheqi Li, Songze Qu, Brett Wieland

APPENDIX
Sensitivity Analysis Ranges

We selected ranges for our sensitivity analysis assumption variables with consideration of existing literature where possible and using conservative estimates elsewhere.

For population growth rate, we used the New Jersey Department of Labor's 2034 population growth projections. For our maximum value, we calculated historic growth rate from U.S. Census Bureau data.

For natural gas and electricity cost changes, we selected values which aligned our 2030 predictions with the New Jersey EMP Ratepayer Impact Study projections for 2030 costs. Our minimum values were chosen to match the study's Current Policy Pathway scenario and the maximum values were chose to match the Ambitious Pathway scenario.

Electricity and natural gas consumption for households below 400% of the FPL were assumed to hold stable. Higher income households' electricity consumption growth was allowed to remain the same or increase dramatically, a cumulative 240% from 2018 to 2030. Meanwhile, high income natural gas demand was allowed to hold steady or decrease a cumulative 40% of 2018 demand by 2030.

For our policy variables, we chose ranges which allowed for a wide set of implementation strategies for each policy. The formulas used to calculate the pricing weights ensured that policies would always be progressive, with higher usage or higher income tiers paying higher portions of utility costs. The ranges applied in our sensitivity analysis allowed for these weights to range from nearly flat to much more progressive.

The highest possible IBR tier charged 4.2 times the lowest tier price. This is much higher than the ratios used by California utilities Southern California Edison or Pacific Gas and Electric, which charge their top tiers at 2 and 2.75 times, respectively. The median value for this input, however, was 2.4, which placed it within the range of these prominent examples.

At their minimum, IBFC weights were allowed to be largely flat, just as was the case for IBR prices. However, the highest possible ratio of highest income to lowest income charge was more than 8. We wanted to allow these income-based charges to be more progressive since they applied directly to incomes. The median ratio for lowest fixed charge to highest fixed charge in our sensitivity analysis was 3.98, just above the ratio of the median income of the highest income group to the median income of the lowest income group, 3.74.

APPENDIX
Geographic Proxy Strategy

In our hybrid implementation which assigned IBFCs according to census block, we relied on the same five income categorizations used in the LEAD tool data. We set a threshold between 2.5% and 35% and identified all census blocks where the portion of households earning less than the poverty level exceeded that threshold. All households in these blocks were charged according to the lowest fixed income prices. For the remaining census blocks, we repeated this process for households below 150% of the poverty level. We continued this strategy for 200% and 400% FPL thresholds, until all census blocks were assigned fixed charges.

We chose this strategy to conservatively capture low income households. We expected LMI households to benefit from low thresholds, thereby assigning more low income households to the lowest pricing tier. However, our model returned the opposite relationship. Higher thresholds resulted in greater reductions in LMI households. See *Figure APP-1*. This could be the result of categorizing too many blocks as low income, ultimately resulting in a flat fixed rate.

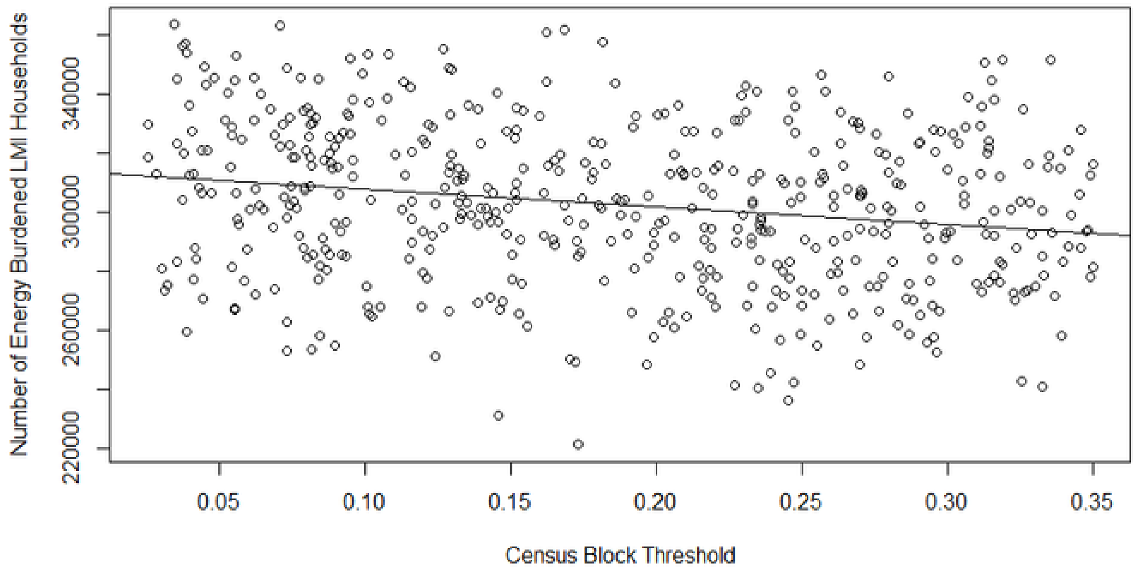

Figure APP-1: Sensitivity analysis results: plot of energy burdened LMI households over the census block threshold for assigning fixed income charges.