EQUITY AND ELECTRIFICATION-DRIVEN RATE POLICY OPTIONS

Edward Yim and Sagarika Subramanian

September 2023

ACEEE
Smart Energy. Clean Planet. Better Lives.

Contents

About ACEEE

The **American Council for an Energy-Efficient Economy** (ACEEE), a nonprofit research organization, develops policies to reduce energy waste and combat climate change. Its independent analysis advances investments, programs, and behaviors that use energy more effectively and help build an equitable clean energy future.

About the Authors

Edward Yim directed ACEEE's state and utility policy program and strategized how transformative energy efficiency can be incorporated in utility programs and practices, including infrastructure planning for reliability and resiliency, at state and local levels. He advocated for policies and programs that lead with low demand and energy efficiency strategies to combat climate change and to realize greater energy independence. Edward holds a juris doctor from Villanova University with a license to practice in Pennsylvania and New Jersey, and a bachelor of architecture from Virginia Tech.

Sagarika Subramanian is a senior research analyst in ACEEE's state and utility policy program, where she conducts research and analysis on state policies for ACEEE's *State Scorecard* and supports crosscutting research across the organization. Prior to joining ACEEE, Sagarika worked at the University of California, Los Angeles (UCLA) as a research assistant and as an intern at the Alliance to Save Energy. Sagarika holds a master of environmental management from the Yale School of the Environment and a bachelor's degree in environmental science from UCLA.

Acknowledgments

This report was made possible through the generous support of E4TheFuture. The authors gratefully acknowledge external reviewers, internal reviewers, colleagues, and sponsors who supported this report. External expert reviewers included Jim Lazar, Mark LeBel from the Regulatory Assistance Project (RAP), Sanem Sergici from The Brattle Group, Jake Wise from Portland General Electric, and Nicole L. Zeichner and Mark Szybist from the Office of People's Counsel in Maryland. Internal reviewers included Amanda Dewey, Mark Kresowik, and Steve Nadel. External review and support do not imply affiliation or endorsement. Last, we would like to thank Ethan Taylor for managing the editing process, Mariel Wolfson for developmental editing, Keri Schreiner for copy editing, Roxanna Usher for proofreading, and Kate Doughty for graphics design.

Suggested Citation

Yim, E., and S. Subramanian. 2023. *Equity and Electrification-Driven Rate Policy Options*. Washington, DC: ACEEE. https://www.aceee.org/white-paper/2023/09/equity-and-electrification-driven-rate-policy-options.

Data and Licensing Information

Key Findings

- Finding equitable and sustainable ways of paying for the costs of climate change—both for mitigation and adaptation—is a new problem that utility regulators will be increasingly called on to resolve.
- Building electrification is a critical climate mitigation strategy for states and utilities. Its success will depend in significant part on pairing it with policies to improve equity and reduce energy burdens.
- Building electrification can decrease energy costs by eliminating fossil fuel use and avoiding the need for gas system investment; it can also put downward pressure on electricity rates through more efficient use of the existing electric system. However, inefficient building electrification approaches can actually increase electric bills and put upward pressure on electricity rates due to the need for new electric infrastructure.
- Electricity rates can be designed to lower total energy bills—especially for low- and moderate-income (LMI) households—and to better use the electric system following electrification. Multiple electricity rate designs can provide bill affordability and capture the benefits of efficient building electrification.
- For LMI households, bill affordability remains an acute, ongoing issue. More policies aimed at ensuring bill affordability may be necessary; while many jurisdictions provide bill discounts for low-income ratepayers, such discounts do not always result in an affordable bill.
- Percentage of income payment programs (PIPPs) are a rate policy tool designed to ensure that the utility bill will not exceed an energy burden ceiling for low-income customers.
- California regulators are exploring an approach that adjusts fixed electric charges based on income level. While the proposed income-graduated fixed charge is more equitable than historical proposals to recover utilities' costs via high, flat fixed charges, the new proposal remains controversial for a variety of reasons.
- Electric rates designed around the operational efficiency of heat pumps—such as time-based volumetric rates and seasonal rates with appropriate peak periods—could also help shift newly electrified heating demand to make better use of the electric system and reduce costs.
- Many of the rate policy options that deliver the most cost savings are complex. Regulators should engage in a transparent and inclusive rate-making process when choosing options to maximize the benefits of building electrification.

Introduction

In this paper, we focus on options to improve the economics of building electrification and deliver on the imperative to lower energy burdens for low- and moderate-income (LMI) households as utilities grapple with the costs of adapting to climate change and decarbonization mandates. Building electrification is a critical component of state and utility strategies to fight climate change.[1] The main component of building electrification consists of switching from fossil-fuel heating appliances, such as boilers or furnaces combusting gas or heating oil, to electric appliances, such as air source heat pumps or heat pump water heaters. Many programs already exist to incentivize adoption of efficient heat pumps for space conditioning and water heating, which is key to efforts aimed at reducing U.S. greenhouse gas (GHG) emissions.

Many utility customers are already struggling to pay their bills. Our research has found that on average, 25% of all U.S. households shoulder a high energy burden—that is, they pay more than 6% of their income on utility bills (Drehobl, Ross, and Ayala 2020). At the same time, utility bills have been increasing due to extreme weather events such as severe storms and wildfires and the recent sharp increases in fossil fuel prices due to the war in Ukraine. Moreover, traditional rate designs have been focused on consumption–based cost recovery, which may not adequately reflect the ability of utility customers to pay. To address these issues, states and utilities often provide significant rate or bill discounts to low-income customers, but more assistance may be needed to lower energy burdens. Utilities therefore face a near-term challenge: to ensure bill affordability as customers engage in fuel-switching.[2]

When the price difference between natural gas and electricity is not significant, fuel-switching should lower most customers' bills, as electric heat pumps generally offer superior performance efficiencies. However, those who are slower to transition from gas to efficient electric appliances will face a high burden of paying for the remaining cost of the gas system as gas utilities have fewer customers from which to collect revenues (Nadel 2023).

When electric rates are high, fuel-switching can increase the overall energy bill for participating customers. In those circumstances, utilities should find ways to lower the operating costs of electrified appliances, especially for LMI households. California and New

[1] Electrification is defined as the conversion of fossil-fuel-based equipment to electric equivalents used to power vehicles, buildings, and some industrial processes. The Regulatory Assistance Project (RAP) defines beneficial electrification as meeting "one or more of the following conditions without adversely affecting the other two: saves consumers money over the long run, enables better grid management, and reduces negative environmental impacts" (Farnsworth et al. 2018).

[2] The cost of building electrification should be lowered significantly by maximizing the residential efficiency rebates under the Inflation Reduction Act, and the load growth from transportation electrification and heating electrification could stabilize electric rates.

England are two areas in which electricity rates are significantly above average; in the rest of the United States, electrification will often produce lower total energy bills (EIA 2022).

Fuel-switching could decrease electricity rates, particularly if the increased sales of electricity occur during times when the existing grid is not stressed; this rate decrease is especially likely for those grids with ample existing capacity to absorb new loads. There is also growing capacity for using distributed energy resources, including energy efficiency and demand response, to reduce peak demand (the maximum demand by utility customers during specific periods), which should reduce the strain on system capacity.

However, where the grid capacity is already constrained, new electric loads from building electrification could require significant grid upgrades, especially in colder U.S. regions where electrified winter heating loads can be quite high. These effects could add to the increasing energy burden of many residents, particularly LMI residents, households of color, and other people in disinvested communities who are already struggling with a higher energy burden, often driven by structural factors and policies.[3] It is thus critical to add new electricity demand efficiently; energy burdens could be lowered if electricity rate designs fairly allocate costs and send adequate price signals to inform and give customers opportunities to reduce system costs by changing consumption patterns at high-cost hours.

Without policy action to lower energy burdens for LMI households and efficiently incorporate new demand for electricity, higher electric bills could deter consumers using fossil-fuel appliances from switching to electric end uses.

To explore how these undesirable results could be avoided or mitigated, we highlight a few of the rate policy options for reducing energy burdens for LMI households while encouraging building electrification. This paper is not intended to provide a comprehensive survey of such options, nor to evaluate or promote certain options over others. Rather, our goal here is to illustrate the types of solutions that are being recommended or considered in various jurisdictions in order to facilitate a dialogue that will help each state develop a solution that best meets its needs.

The options we highlight include modifying electricity rate components and using income-based tools such as a percentage of income payment program (PIPP), notwithstanding the complexity of introducing the element of income in utility rate designs. Policies to protect the energy affordability of LMI ratepayers will be critical to scaling up building electrification.

[3] The term “energy burden” is defined as the percentage of household income spent on energy bills. For more on the energy burden definition and the structurally driven patterns of energy burden, see "How High Are Household Energy Burdens?" (Drehobl, Ross, and Ayala 2020). While the state-specific numbers vary, taken as a national average, the energy burden of non-low-income households is less than 3% of their monthly income, while it is around 8% for low-income households.

Background

Rates are designed to meet the utility's revenue requirement, or cost of service,[4] as determined by the utility regulator. The overall cost is generally identified or functionalized by activity (e.g., generation, transmission, and distribution). Residential rate design for electric customers has typically relied on two rate components: customer charge and volumetric price (cents/kWh). The customer charge has historically been fixed and generally covers customer-specific costs for meters, billing, collection, and the line drop from the distribution system into a customer's home, while the volumetric rate, or the price of energy consumed, recovers the remaining distribution network and power supply costs to provide electric service (Baatz 2017).

Utilities can charge for kWh consumption in several ways. A full summary of residential rate design options is beyond our scope here, but many primers on the topic are available (Lazar 2013; Faruqui 2021). Table 1 shows a simplified illustration of various rate design options in use.

Table 1. Rate options for energy charges

Rate Type	Description	Customer Risk/Reward	Smart Meter
Single Average	Traditional rate where all hours consumed are charged the same rate.	None	Not needed
Seasonal	Traditional rate that varies depending on the season, usually summer rates are higher for a summer peaking utility.	Low	Not needed
Inverted	Rates vary depending on the level of consumption blocks. Usually the first 500 kWh are cheaper with additional consumption leading to higher rates.	Low to medium depending on consumption level	Not needed
Peak Time Rebate (PTR)	Traditional rate with the customer option of curtailing use when utility signals a "peak event day."	No Risk, opportunity for reward	Yes
Time of Use (TOU)	Rates vary by the time of day, with the lowest rate being off-peak, and shoulder and peak blocks being charged higher.	Medium risk and reward	Yes
Critical Peak Pricing (CPP)	Rates are significantly higher during the period when a utility calls a "peak event."	Higher risks and reward	Yes
Variable Peak Pricing (VPP)	Hybrid of time-of-use and real-time pricing where different periods for pricing are defined in advance, but peak pricing based on utility and market conditions.	Very High	Yes
Real Time Pricing (RTP)	Rate can vary on an hourly basis.	Highest	Yes

Source: Table on slide 32 (Types of Rates) from Lazar and Gonzalez 2015

As the table shows, the potential for bill savings increases with more complex options, but the risk of bill volatility increases as well. Finding a balance that accomplishes the multiple objectives of bill affordability, fair allocation of costs, and robust price signals—all in a way that is simple and acceptable to regulators and ratepayers—has eluded utilities and

[4] The revenue requirement is typically determined using the following formula: Revenue Requirement = (Rate Base * Rate of Return) + Operating Costs + Depreciation Expenses + Taxes + Other Costs (e.g., franchise fees).

regulators. Differing opinions on what is preferable indicate that there is no one-size-fits-all rate design option for all electric utilities, and that utility regulators will need to develop or choose a design that best reflects their circumstances and policy choices (APPA 2019).

In the following sections, we examine an affordability policy for LMI households that approximately 12 states currently use; the policy attempts to ensure that utility bills for LMI ratepayers are capped at an affordable percentage of their monthly income. We then discuss a few approaches to modify rate components so that the rates (1) better reflect ratepayers' ability to pay (using an example from California) and (2) help accelerate adoption of electric heat pumps while minimizing the potential electric bill increases by designing specific rates for heat pump users (using an example from Maine and a study from Brattle). We describe these approaches to begin identifying how some jurisdictions are responding to the challenge, as well as to contribute to ongoing discussions about how the challenge can best be met.

Policy Options

OPTION 1: PERCENTAGE OF INCOME PAYMENT PLANS

PIPPs reduce energy burdens for low-income households by capping utility bill payments at a set percentage of a participant's income. PIPPs are one of the three main types of utility affordability programs in the United States, and they are tailored to a household's income to achieve an affordability goal (Farley et al. 2021). This policy can be particularly helpful for low-income households as it keeps energy bills affordable regardless of increases in utility rates. Given this, PIPPs can be considered as a complementary policy to any rate design changes that might adversely impact low-income households and other communities that experience high energy burdens, including Black, Hispanic, and Native American households, renters, older adults, and manufactured housing residents (Drehobl, Ross, and Ayala 2020).[5]

While PIPPs could be an important strategy to reduce energy burdens in the short term, they should be combined with longer-term investments in improved health and safety conditions for the home, such as energy efficiency and weatherization, to produce long-lasting bill affordability for households. Weatherization programs typically improve building envelope efficiency through better insulation and improved air sealing, and better windows. Energy efficiency programs include replacement of inefficient appliances, heating and cooling systems, and lighting. These programs can produce lasting results to reduce utility bills for low-income ratepayers, who disproportionately live in older and inefficient housing compared to higher-income residents. A recent ACEEE report evaluating ratepayer-funded utility low-income programs estimated that these programs reduced energy bills by $83

[5] While PIPPs are useful, they face challenges, including higher administrative costs than flat or tiered discount programs and barriers to reaching relevant households, resulting in low participation rates.

million for low-income households across the United States in 2020 (Morales and Nadel 2022). An energy-efficient home can also reduce the size and cost of some electrification technologies (such as heat pumps) that are required to serve the home (Hayes et al. 2022).

Flat percentage discounts and tiered discounts are two other types of ratepayer-funded affordability programs that utilities offer. Through a flat percentage discount, the total utility bill is reduced by a specific percentage or flat amount for all income-eligible program participants. This model has low administrative costs, but it is not adjusted to a household's specific income level. Because a flat percentage discount would shield households from rate increases only if the discount was recalculated every time rates went up, it may not be as effective as PIPPs at meeting the energy burden target.

Tiered discounts incorporate elements from PIPPs and flat discount rates. This approach calculates different levels of income tiers and applies a separate discount rate to each tier. Tiered discounts reduce utility bills to a set affordability goal based on the income tier midpoint (Farley et al. 2021).[6] While tiered discounts are also tailored to a household's income level, they may not ensure that the desired energy burden target is met.[7]

PIPPs are not new. Utilities have offered PIPPs or similar programs for several years in states such as Ohio, Colorado, Illinois, Nevada, Pennsylvania, Connecticut, California, New Jersey, and Maine. Virginia is the most recent state to pass legislation directing investor-owned utilities to offer a PIPP. Many PIPPs are established through a legislative mandate for state public utility commissions (PUCs) to create and administer them. In some states, such as Colorado and New Jersey, residents that apply and qualify for the Low-Income Home Energy Assistance Program (LIHEAP)—a federally funded program that assists families with energy costs—are automatically enrolled in PIPPs. Therefore, these PIPPs rely on the LIHEAP income verification procedures. In other states, households are required to show proof of their monthly income for the previous 30 days (Offenstein et al. 2020).

In general, PIPPs or PIPP-type programs let eligible low-income customers pay a set percentage of their income toward their monthly utility bill. For example, Ohio's PIPP allows income-eligible residents whose income is at or below 175% of the federal poverty level to pay 5% of their monthly household income if they use natural gas for heating or 10% of their monthly household income if they heat with electricity (LIHEAP Clearinghouse 2014;

[6] For New York's tiered discount programs, for example, the NYS Public Service Commission in February 2021 directed utilities to update their bill discounts based on the midpoint income calculation for each tier and to revise the discounts whenever the utility files tariff compliance for a new rate plan (New York PSC 2021).

[7] For comparison of pros and cons of these three approaches, see table 2 in a 2021 report, *Advancing Equity in Utility Regulation* (Farley et al. 2021).

PUCO 2023). The remainder of the utility bill is usually recovered through a surcharge to all utility customers. PIPPs can also be paid for via taxpayer funds, but the PIPPs currently in practice are ratepayer funded. While this is the basic structure of all PIPPs, other elements—such as income-eligibility levels and the specific affordability or percentage of income spent on the energy goal—differ by state.

Following are examples of three distinct PIPPs that show the variations in how states design and implement this policy.

Example: Virginia's Percentage of Income Payment Program

In 2021, Virginia passed a law establishing a PIPP for low-income households by capping monthly electric utility bills at 6% of income for participants whose heating source is not electric or 10% for households that use electric heat (Code of Virginia 2020). The program will be funded through a universal service fee to be collected from all retail electric utility customers of Dominion Energy Virginia and Appalachian Power Company. Importantly, the law states that one objective of the PIPP is to reduce electricity and/or energy use from participating households through weatherization or energy efficiency programs. These include existing utility low-income programs and programs offered at the federal, state, local, or nonprofit level. The Department of Social Services will perform analyses to determine if there are gaps in serving customers that are not already served by existing energy efficiency programs and resources. This additional component of the law is critical to delivering energy savings and further bill reductions for low-income households. Virginia's PIPP is still in the early stages of implementation.

Example: Nevada's Energy Assistance Program

Nevada's PIPP-type program includes an affordability goal that it calculates differently than most state goals. Many PIPPs' affordability goals conform with energy burden thresholds defined by ACEEE and other organizations (i.e., energy burden is considered high if 6% or more of income is spent on utility bills and severe if it is 10% or more). However, on average, U.S. households spend 3.1% of their income on energy bills (Drehobl, Ross, and Ayala 2020). Ideally, utility affordability policies and programs should strive to substantially reduce energy burdens for low-income households to the same affordable level of energy burdens that moderate-income households face (Howat, Lusson, and Wein 2020). Nevada's Energy Assistance Program (EAP) aims to do this. The EAP provides income-eligible households with a Fixed Annual Credit (FAC) benefit that is calculated for each program participant. The FAC is enough to reduce the energy burden of participating households to the statewide median household energy burden, which is also calculated on an annual basis. For Fiscal Year 2023, the household energy burden for a median-income Nevada household ($85,150) is 2.29% (Nevada DWSS 2022).

Example: Colorado's Percentage of Income Payment Program

In 2012, all investor-owned electric and gas utilities in Colorado started offering a PIPP to income-eligible households. The state caps electricity costs at 6% of income for homes that are heated only with electricity. If the heating source is gas, then costs are capped at 3% each for gas and electricity bills (Colorado PUC 2023). This ensures that bills are always capped at 6% of income for households regardless of the heating source.

A recent report evaluated Colorado's PIPP between November 2016 and October 2019 and found that it had low participation rates. Although 11% of households across Colorado were eligible to participate, only 8% of those eligible households were actually enrolled in the PIPP (Offenstein et al. 2020). Cited participation barriers included a lack of awareness of the program, inconsistent use of the program name by utilities, and levelized billing (i.e., the resident is billed a flat/predictable amount based on average bills for the previous 11–12 months). Surveys revealed that some participants disliked levelized billing because they wanted to know their energy usage each month and that some participants owed money at the end of the year and did not understand the benefit that the PIPP was providing them. Another report assessing pathways to energy affordability in Colorado concluded that the PIPP could see higher enrollment if it automatically enrolled households that receive other forms of assistance, conducted better outreach to eligible households, and allowed self-certification of income rather than requiring proof of income (Lukanov et al. 2022). Colorado administers several energy affordability programs that offer bill assistance, weatherization services, and energy efficiency and conservation to LMI households.

Better and more accurate data on household eligibility for low-income programs could help utilities and administrators establish a participation goal for these programs and therefore facilitate higher participation rates. In addition, PIPPs should be closely coordinated with weatherization and energy efficiency programs for low-income households to permanently reduce energy burdens over time.

OPTION 2: RATE DESIGNS THAT ENABLE HEATING ELECTRIFICATION

The economic case for heating electrification has been growing more compelling as upfront costs of technology and installation decline, appliance efficiency improves, and government support through rebates, tax credits, grants, and loans increases. However, heating electrification means an increase in electricity usage and demand, which could decrease or increase the overall energy bill of the electrified household depending on the circumstances. We briefly discuss ideas for modifying rate components to make heating electrification more affordable.

In this section, we review how specific rate components of electric bills could be designed to minimize the bill impact of heating electrification.[8] The two approaches we describe illustrate different ways to make residential electric heating more affordable.

Heat-Pump Friendly Cost-Based Rate Designs

A couple ways to reduce utility bills through rate design are by incentivizing ratepayer behavior change through some version of time-varying rates and by designing rates that are tailored to the operational characteristics of ratepayer appliances. One study sought to show how such tools can be used to reduce the bill impact of fuel-switching in the context of higher electric rates than the national average. The Brattle Group study used a sample of bills from a dual-fuel utility's actual customers who had above-average electric rates to demonstrate how modifying various rate component designs could reduce total energy bills for customers who switch from gas heating to electric heat pumps (Sergici et al. 2023). An important objective of the study was to show that it is possible to design rates for heating electrification customers that make the economics work without subsidizing these customers (see figure 1).

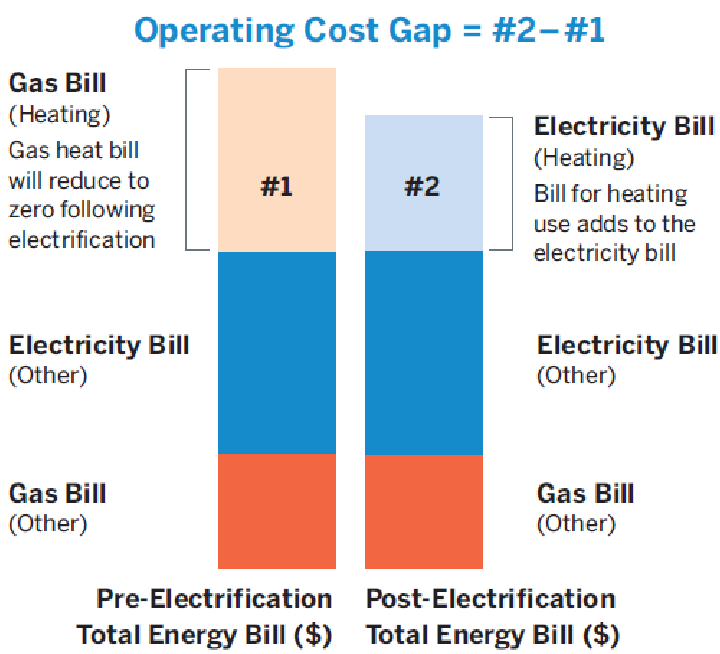


Figure 1. Illustration of a negative operating cost gap. Source: Sergici et al. 2023.

[8] This paper examines a sample of rate design ideas that are being discussed or implemented to make heating electrification more affordable without cross-subsidization; it is not a comprehensive survey of all ideas and proposals. We chose our examples to illustrate some of the key themes of the emerging ideas.

As table 2 shows, the study considered the utility bill results of fuel-switching under four rate structures.

Table 2. Four rate design options

	Season	Rate I	Rate II	Rate III	Rate IV
Customer charge ($/month)	All year	$18	$45	$23	$28
Supply charges ($/kWh)	Summer	$0.09	$0.09	Peak: $0.265 Off-peak: $0.035	Peak: $0.215 Off-peak: $0.065
	Non-summer	$0.09	$0.09	Peak: $0.115 Off-peak: $0.035	Peak: $0.165 Off-peak: $0.065
Delivery charges, volumetric ($/kWh)	Summer	$0.155	$0.125	Peak: $0.215 Off-peak: $0.055	$0.015
	Non-summer	$0.145	$0.105	Peak: $0.075 Off-peak: $0.055	$0.015
Delivery charges, demand ($/kW)	Summer	–	–	–	Peak: $20.00 Off-peak: $5.50
	Non-summer	–	–	–	Peak: $15.00 Off-peak: $5.50
Peak definition	All year	–	–	8 AM-midnight on all days including holidays	Noon-8 PM on weekdays except holidays

Note: For electricity rates, summer is defined as June-September, while non-summer is defined as October-May.

Source: Sergici et al. 2023

The study identified "Rate I" as the existing current electric rate structure, comprising fixed customer charges, volumetric supply charges, and seasonal volumetric delivery charges.[9] The study then reviewed operational characteristics of air source heat pumps to identify rate components that could leverage those characteristics. For example, the study made the following observations regarding operational characteristics of heat pumps:

- Heat pumps lead to higher electricity usage, which means that lower volumetric rates would favor heat pump usage, all else being equal.
- Most of the heat pump load materializes in the non-summer months; therefore, seasonally differentiated rates in summer-peaking systems (with lower non-summer rates) might favor heat pump usage, all else being equal.[10]

[9] These rates are likely higher than the national average.

[10] Many utilities adopting heating electrification will likely become winter-peaking, resulting in additional grid upgrade costs; utilities will need to deploy additional peak load reduction strategies to minimize those costs.

- A significant portion of the heat pump load tends to fall into off-peak periods, which implies that various cost-based time-of-use (TOU) rates[11] might favor heat pump usage, all else being equal.[12]
- Heat pumps tend to have high load factors for most of the hours,[13] meaning that their electricity usage is more constant and less "peaky"; this implies that demand-based rates might favor heat pump usage, all else being equal.

The study developed alternative rate options, designed to be revenue-neutral in Rates II, III, and IV, that incorporate the potential bill-reducing operational aspects of heat pumps.

Rate II consists of a lower volumetric delivery charge to offset the higher electricity usage, but it has a much higher customer charge compared to Rate I (a 150% increase) to make up for the utility cost.

Rate III consists of a somewhat higher customer charge compared to Rate I (a 28% increase), and seasonal volumetric charges for supply and delivery with peak (8 a.m. to midnight) and off-peak rates. Compared to Rate I, the supply charges are slightly higher during non-summer months; the delivery charges are significantly lower; and both the supply and delivery charges are significantly lower for off-peak hours, roughly one-third of Rate I's rate. The rate difference between summer and non-summer periods is drastic (136% for supply charges and 187% for delivery charges). This rate heavily favors non-summer, off-peak electricity usage, with only an incremental increase to the customer charge.[14] The make-up cost for the utility will come from appliances that are highly used during daily peak hours and summer months (PG&E 2023).

Rate IV consists of a higher customer charge (36% increase), seasonal supply charges similar to Rate III (but with a less drastic cost difference), and delivery charges that are only 10% of Rate I's delivery charges. Rate IV adds seasonal charges for peak and off-peak periods per kW of demand, with lower charges for non-summer months. Here, demand is defined

---

[11] Time-of-use (TOU) rates must be well designed and implemented, and not all ratepayers may benefit from them. For example, researchers have found that some elderly and disabled ratepayers—as well as low-income ratepayers living in poorly weatherized homes with inefficient appliances—did not fare well under TOU rates. Such evidence indicates a need for caution in designing and implementing TOU rates and giving options to these ratepayers (White and Sintov 2020).

[12] Although the electric bill will still be larger post-electrification, the desired outcome is smaller energy bills overall due to the much smaller (or nonexistent) fossil-fuel heating bill.

[13] Heat pump performance declines when temperatures fall. Prior ACEEE research has found that, to minimize lifecycle costs including costs of increased winter peaks, hybrid systems (cold climate heat pumps backed up with fuel-based systems) should be used for locations that regularly experience temperatures below 5º F (Nadel and Fadali 2022).

[14] Favoring non-summer loads is sensible where fossil fuel or wind is the prevailing fuel source.

somewhat atypically as the average demand of the four highest hours of demand for the month. This rate favors appliances that would see a lower bill under Rate III, and it has an especially low delivery charge, while disincentivizing appliances that are used during high demand hours.

Rate IV's introduction of the residential demand charge is likely to be controversial. The idea of charging customers for demand on a kW basis is premised on the notion that customers should pay for their contribution to system capacity costs. Others have argued, however, that demand charges may not be a good approximation of residential customers' fair share of such costs, as residential demand is charged based on the customer's highest usage in a month without considering whether that high usage coincided with any of the various system component peaks (e.g., circuit peak, line transformer peak, substation peak) or the overall system peak. This triggers the concern that residents—and particularly LMI residents—may end up paying much more than their fair share of system costs (Lazar 2015). The Brattle study noted that the four rate choices would be optional for customers.

Figure 2 shows the results for the study's four rate design scenarios.

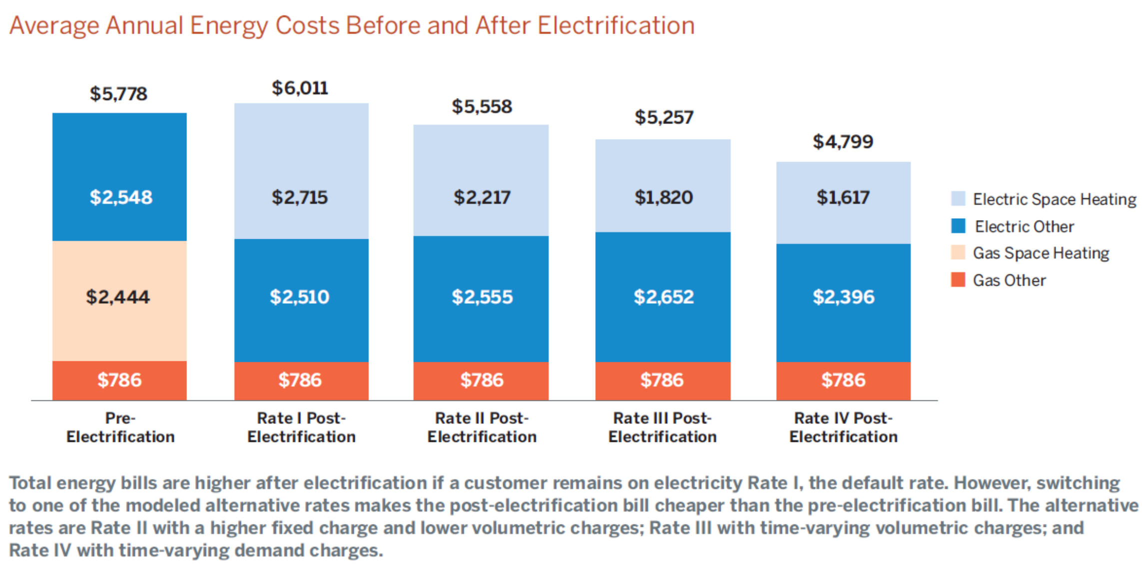


Figure 2. Average annual energy costs before and after electrification. Source: Sergici et al. 2023.

Under Rate I, the bill result of electrification indicates the problem that the study addresses—that is, with the status quo rate structure (lower customer charge and non-time-varying volumetric charges for supply and delivery), the total bill will increase following heating electrification. However, given the results with Rates II, III, and IV, the study indicates that it is possible to design rates that have a positive bill impact for heating electrification without subsidizing those customers. The study also reinforces the notion that it would be unwise to simply implement fuel-switching without considering the existing rate structure and bill affordability.

Given that this study relies heavily on TOU rates, their oft-discussed advantages and disadvantages should be considered as well. Other reports offer full evaluations of TOU and other time-based rates, which are beyond our scope here. However, the success of TOU designs often hinges on successful education of TOU ratepayers in terms of the benefits and risks (Sergici, Faruqui, and Tang 2023; Littell and Sliger 2020), and a thoughtful TOU design should also be based on an evaluation of any changing residential usage and load patterns post-COVID.

Overall, the Brattle study indicates that it is possible to design rates that produce a total lower energy bill for heating electrification customers without subsidizing them. While some of those rate design parameters—for example, the definitions of demand and peak hours are open to debate, and using a demand charge typically remains controversial—the study shows that positive bill results could be obtained for heating electrification customers using existing tools such as seasonal rates and time-varying rates.

Maine's Residential Rates: Seasonal Rate Pilot and Electric Technology Rate

Maine is exploring simpler approaches to using rate components to reduce utility bills for electric heating customers.[15] Currently, fuel oil is the state's prevailing source of home heating. In December 2022, the Maine Public Utility Commission approved two residential service rate proposals by Central Maine Power (CMP) for households with heat pumps. One is a pilot rate proposal that introduces a seasonal component for the residential service (see table 3).[16] Although it is not a TOU rate, under the pilot rate, volumetric delivery charges from November to April would be less than 2% of the rate charged from May to October. This pilot rate is optional for 5,000 customers and will terminate before November 2024.

Table 3. Central Maine Power's seasonal rate pilot

Charges	Winter	Non-winter
Customer	$31.67/month	$31.67/month
Energy	$0.004/kWh	$0.158/kWh

To afford this extremely low rate during winter months, the pilot rate's fixed monthly charges are more than doubled, and the rate during the non-winter months is higher than the existing rate for peak hours (defined as 7 a.m. to noon and 4 p.m. to 8 p.m.). Table 4

[15] With these rate proposals, CMP (Maine's largest investor-owned utility) joins Versant Power, another Maine investor-owned utility with a much smaller footprint, which already has a TOU rate and an electric technology rate for heat pumps, electric vehicles (EVs), and electric battery storage systems.

[16]See the December 13, 2022, order, Docket No. 2021-00325.

shows the existing standard rate. This approach of artificially removing the winter delivery costs from rates may help achieve the aim of lowering the winter electric bills for heating electrification customers, but it does so at the expense of a key rate design principle: that rates should reflect costs. It remains to be seen if this rate will lower the total energy bill for CMP customers on an annual basis and without cross-subsidization.

An even simpler rate design, the "Electric Technology Rate" is available for CMP households with heat pumps (see table 5). This rate option has the same monthly fixed charges, but its volumetric charges do not vary by season, and the rate is 5 cents per kWh, which lies between the seasonal rate pilot's 0.4 cents/kWh (winter) and 15 cents/kWh (summer).

These rate proposals seem to imply that cost recovery of heating electrification via fixed charges is inescapable—a notion that is refuted somewhat by the Rate III example in the Brattle study. Fixed charges have a regressive nature when rate solutions overly rely on them, unless those fixed charges can be modified to become more progressive, as proposed in California (as we describe later). Nonetheless, the Maine PUC is likely aiming to prioritize the simplest way to reduce winter heating costs for Maine residents that use electric heat pumps, and simplicity is key to successful adoption.

Table 4. Central Maine Power's default electric rate: distribution delivery charges (not including energy)

Charges	Non-TOU rates	TOU rates	
	Non-seasonal		
Customer	$13.66 for first 50 kWh or less		$13.44/month
Energy	$0.08 /kWh in excess of first 50 kWh	Peak	$0.13/kWh
		Shoulder	$0.13/kWh
		Off-peak	$0.06/kWh

Table 5. Central Maine Power's electric technology rate: distribution delivery charges (not including energy)

Charges	Non-seasonal
Customer	$31.67/month
Energy	$0.052/kWh

Rate Design Option for Reducing Winter Peaks in Cold Climate

Rates can also be designed around the operational efficiency of heat pumps in relation to the local or regional climate. We offer a specific example here involving a cold climate region, that is, areas that have more than 6,000 heating degree days.[17]

Harvey Michaels and his research group at the Massachusetts Institute of Technology (MIT) conducted detailed modeling of heat pumps for Massachusetts, examining local climate, regional grid emissions profile, electric demand, and rates. They found that heat pumps can be cheaper to operate at outdoor temperatures above approximately 35°F. They also found that at temperatures down to approximately 15°F (and often lower), the regional electric grid had available power; however, for approximately 150 hours per winter—primarily very cold early mornings (6–9 a.m.) and evenings (6–9 p.m.)—winter power costs and emissions increased due to use of oil and sometimes coal-fired power plants. This finding leads to their recommendation that discounted rates be offered for heat pumps to encourage use of heat pumps outside of those 150 hours of winter peak, but that backup fuel-based systems be retained and used when these winter peaks occur. It should be noted that this recommendation of retaining backup fuel-based systems becomes complicated where heating is predominantly served by a natural gas utility, as such a utility would find it difficult to remain viable when serving only as a backup heating source.

The level of discount must be enough to encourage heat pump use, but still be above the marginal cost of producing the discounted electricity. The authors suggest that utilities offer demand response incentives during winter peaks for homes with heat pumps that agree to shut off those pumps during winter peaks and use a backup system instead. They also suggest offering the discounted heat pump rate to highly efficient houses and houses with a ground-source heat pump and without a backup fossil fuel or electric resistance heating system (see Michaels and Nachtrieb 2022; H. Michaels, lecturer in energy management innovation and principal investigator, Clean Heat Transition Project, MIT, pers. comm., June 2023).

OPTION 3: MAKING FIXED CHARGES MORE PROGRESSIVE IN CALIFORNIA

Implementing an income-based fixed charge is a novel rate design approach to keep bills affordable while encouraging electrification. Electricity bills usually have two components: a volumetric charge and a fixed charge. Volumetric charges vary by electricity use; the more electricity consumed, the higher the bill's volumetric portion. Fixed charges do not vary by electricity use and are typically used to collect the customer-specific costs of metering, customer service, billing, and the service drop, although more utilities are seeking to recover distribution infrastructure costs in this charge (Baatz 2017). It is worth noting that few utility

[17] For a map of cold climate regions in the United States, see figure 2 in Nadel and Fadali 2022.

costs are fixed, and most costs vary with energy and demand. In addition, fixed costs are often conflated with sunk costs, that is, costs already incurred that must be recovered regardless of future energy use.

Most electric rate structures today have fixed charges based on the cost of metering, billing, and collection, and high volumetric charges to recover power supply and shared distribution costs. Historically, policymakers and energy efficiency advocates supported these structures as a way to encourage energy efficiency and conservation and lower bills. High fixed charges can also create inequitable outcomes, particularly for LMI households that have low electricity usage or that cannot afford high fixed charges.

In California, this rate structure (high volumetric rates and standard fixed charges for all customers) has been more extreme, as the state has zero (or near zero) fixed charges as part of a past policy to encourage frugal use of electricity. This has become problematic due to the spike in volumetric energy charges in recent years, making California's volumetric rates one of the highest in the nation (EIA 2023), which has discouraged electrification.

Volumetric rates are inordinately high in California in part because these prices encompass much more than the utility's actual cost of supplying electricity. The reasons for the volumetric increases are complex, including transmission and distribution infrastructure costs, including wildfire-related costs; undergrounding; renewable integration costs; increases in energy procurement costs; reduction in customer usage due to efficiency and solar; a large discount to income-qualified customers; and numerous other mandated programs, including the Renewable Portfolio Standards (CPUC 2021; Bushnell 2023).

Many of these costs result from state policies and strategies aimed at mitigating the effects of climate change and reducing GHG emissions. Such costs are rising rapidly and being overly reliant on volumetric rates to pay for them has been challenging for California's pursuit of electrification goals.

One solution would be to fund climate change and social policy costs using sources outside a utility's rates, such as through the state budget. This could be paired with the implementation of cost-based fixed charges and time-varying rates.

One example of cost-based fixed charges and time-varying rates is an optional TOU rate offered by Burbank Water and Power, which is a municipal utility in Southern California. While Burbank is a relatively high-cost utility by national standards, this rate remains attractive to electric heat pump water heating and to EVs, both of which can be concentrated into the off-peak rate period. The "service size charge" in Burbank is based on the customer maximum demand, but recovers only localized capacity costs, not shared primary distribution costs.

City of Burbank Optional TOU Rate

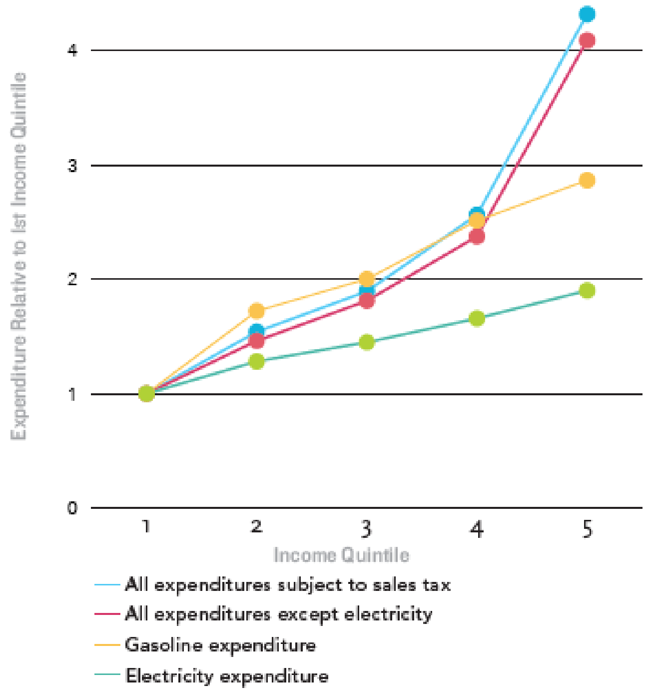
- Customer Charge: $9.76/month
- Service Size:
    - Apartments: $1.48
    - Single-Family: $3.00
    - Large Single-Family: $8.99 (over 200-amp panel)
- Off-Peak: $0.0887/kWh
- Mid-Peak: $0.1776/kWh
- On-Peak: $0.2664/kWh

Absent non-ratepayer funding sources, fixed charges can reduce volumetric rates so that they better mirror the incremental cost of generating and delivering electricity and can help achieve decarbonization policy goals. If income-graduated, they can also avoid disproportionately burdening households that experience severe energy burdens.[18]

The income-based fixed charge approach is quite novel and controversial, as it is a major departure from traditional rate design principles and practices. As such, it could evince a view in California that existing rate design options—such as better calibrated time-based rates designed to reduce usage and peak demand—might be insufficient to encourage electrification of existing dwellings in the near term.

California's electricity expenditures are more regressive than other common household expenditures, according to a report by Next 10 and the Energy Institute at the UC Berkeley Haas School of Business (Borenstein, Fowlie, and Sallee 2021). The report shows data on expenditure by income quintile: households in income quintile 5 spend five times as much as households in income quintile 1 (see figure 3). As the figure shows, unlike the electricity expenditure, total expenditures—both "subject to sales tax" and "except electricity"—rise much more proportionally to income. For these expenditures, households in income quintile 5 only pay nearly twice as much as the poorest households on electricity expenditures.

[18] We have noted in the past that utility proposals that significantly increase the customer charge are one form of rate design that disproportionately affects low-usage customers. See Baatz, *Rate Design Matters: The Intersection of Residential Rate Design and Energy Efficiency*, March 2017, p. 31, https://www.aceee.org/sites/default/files/publications/researchreports/u1703.pdf.



Source: Authors' calculations of data from the Consumer Expenditure Survey in 2017-2018. Source data at https://www.bls.gov/cex/2017/research/income-ca.htm

Figure 3. Expenditures per household by income quintile. Source: Figure 7 from Borenstein, Fowlie, and Sallee 2021.

Given these findings, the status quo is likely not an option; reforming current rate structures will be necessary to meet aggressive decarbonization goals through electrification while lowering household energy burdens.[19] Rates are currently the main vehicle to recover the costs of state decarbonization mandates and other social and environmental policies. It would be useful to fully examine whether this funding practice still makes sense.

In the meantime, an income-graduated fixed charge has been proposed as an alternative to make electricity bills more progressive and improve energy affordability. An income-based fixed charge would require customers in higher-income tiers to pay more than customers in lower-income tiers. As we noted earlier, utilities recover their revenue through customer rates. If a utility's revenue is recovered from a higher fixed charge, then variable or

[19] The Local Government Sustainable Energy Coalition, a party to the income-graduated fixed charge proceeding, has proposed that new loads resulting from electrification would be eligible for a discounted rate. This is similar to "economic development rates" that have been implemented in many states, where only new loads are eligible (Jim Lazar, pers. comm., June 15, 2023).

volumetric charges can be reduced as less revenue is needed from that bill portion. Because a flat fixed charge can be more burdensome to low-income households, an income-based fixed charge can both mitigate this burden and promote electrification. That said, some stakeholders are concerned that this approach would penalize middle-income customers with low energy usage; it also suffers from other problems, as we discuss below.

California is currently considering this approach. In June 2022, Governor Gavin Newsom signed Assembly Bill 205 into law, requiring the California Public Utilities Commission (CPUC) to establish an income-graduated fixed charge with at least three income thresholds in order to lower monthly bills for low-income households without any changes to electricity consumption (California State Legislature 2022). Under AB 205, the CPUC is required to authorize a fixed charge for residential customers by July 2024 and to ensure that these charges do not hinder beneficial electrification and GHG reduction.

In July 2022, the CPUC initiated a rulemaking, "Order Instituting Rulemaking to Advance Demand Flexibility through Electric Rates" (R. 22-07-005), through which an income-based fixed charge for residential rates will be established by mid-2024 (CPUC 2023a). This proceeding aims to modify the state's electric rates to achieve several objectives, including "enhancing electric system reliability, making electric bills more affordable and equitable, enabling widespread electrification of buildings and transportation, and reducing long-term system costs through efficient electricity prices." While such objectives are necessary and laudable, finding a single rate solution that accomplishes them all may prove challenging.

The proceeding's first phase is split into two tracks: Track A aims to establish income-graduated fixed charges, and Track B focuses on updating the state's existing rate design principles and adopting demand flexibility rates for large investor-owned utilities. As the Phase 1 Scoping Memo and Ruling Stakeholders outlines, the CPUC will address the following questions (CPUC 2022):

- *Should the CPUC establish an income-graduated fixed charge for all residential rates or only certain residential rates?*
- *What costs should be recovered through the fixed charge and what methodology should be used to calculate these costs?*
- *What income thresholds should the CPUC establish for the income-graduated fixed charge?*
- *How should the fixed charge vary by income threshold?*
- *How should the fixed charge be designed so that a typical low-income customer would realize a lower average monthly bill without making any changes to usage?*
- *How should the fixed charge vary between default residential rates and non-default residential rates?*
- *How should income levels be verified, and how often should verification occur?*
- *How should customers be informed about the fixed charge and impacts on their bills?*

Track A will determine how to modify volumetric rates to reflect changes to fixed charges. Proponents of an income-based fixed charge approach expect to see volumetric rates reduced enough to encourage electrification and allocate a utility's fixed costs more equitably to customers. For the CPUC proceeding, stakeholders will have access to a Fixed Charge Tool that allows them to compare the bill impacts of the proposed rate design with the current rates (CPUC 2023b).

In April 2023, California's investor-owned utilities—Southern California Edison (SCE), Pacific Gas & Electric (PG&E), and San Diego Gas & Electric (SDG&E)—submitted a joint plan with their proposed designs for implementing income-based fixed charges (CPUC 2023a). Other stakeholders and environmental organizations also submitted proposals. The utilities propose four income tiers, with the lower two applying to low-income customers who participate in California's bill assistance program. According to the proposal, average monthly fixed charges would be $53, $74, and $49 for PG&E, SDG&E, and SCE customers respectively, and would reduce the volumetric rate by 33–43% for the three utilities (California Joint IOUs 2023). Other plans, such as one submitted jointly by the National Resources Defense Council and The Utility Reform Network, propose lower monthly average fixed charges ($37) across three income brackets, which are estimated to reduce the volumetric rate by 20–25% (Ashford and Chhabra 2023).

Some stakeholders have expressed concerns about the potential for electric bill increases of high fixed charges for efficient households in middle- and higher-income brackets (Faruqui 2023). In the past, energy efficiency advocates have criticized increases in fixed charges or demand charges, in part because of the accompanying decrease in volumetric rates. Lower volumetric rates can encourage inefficient behavior through higher electricity consumption. Low volumetric rates also affect the payback period of energy efficiency investments (Baatz 2017). Payback periods—that is, how long it takes customers to recover their energy efficiency investments—are longer if volumetric rates are low. However, income-graduated fixed charge proponents contend that new and lowered volumetric rates will still not reflect the actual costs of electricity generation and delivery, and that such rates will continue to be high enough to encourage energy efficiency but low enough to also propel electrification in households (Borenstein 2023). There have also been concerns about the administrability of this approach (Lazar 2023).

Some stakeholders have asserted that higher fixed charges give customers less control over their bills and may be less equitable for customers who do not consume a lot of energy. There are also debates over the best way to recover utility system costs through fixed charges. Some maintain that fixed charges should include only costs related to billing and metering and should not recover additional distribution infrastructure costs for the utilities (Lazar 2015). These stakeholders argue for using time-varying volumetric rates instead.

Additionally, implementing income-graduated fixed charges poses regulatory and administrative challenges due to the income verification required for this rate design.[20] Other implementation issues include customer outreach to ensure that households have the necessary information to understand how their bills will be affected and any educational materials needed to pursue electrification. Customers also require a robust, transparent process to easily identify their income bracket and to easily work with the utilities to rectify any issues if they are misclassified. New databases and billing systems will be required for implementation, and utilities will need sufficient marketing and outreach to ensure that customers can familiarize themselves with the new system. The Energy Institute at Haas and CPUC workshop stakeholders identified the pros and cons of different methods to collect and verify income information; table 6 offers a summary.

Table 6. Potential methods of income verification

Method	Pros	Cons
Allow self-attestation of income and use existing income verification process	Easy system for utilities to implement; could use data from existing income-eligible programs (though these have had a few issues with inaccuracy)	Some higher-income customers may be incentivized to inaccurately report income level of entire household in order to receive lower fixed charges
Predictive data modeling based on income of geographic community	Reduces need for household-level income verification and eases access to datasets	Initial data sources must be accurate; the few high-income households in low-income geographies would unfairly receive lower charges
Leverage information from government agencies such as state tax agencies or state Supplemental Nutrition Assistance Program (SNAP)	Likely to have the most accurate income data of the three methods	Not all customers file tax returns or participate in SNAP, coordination across agencies may be costly, and information sharing raises legal concerns

Sources: Borenstein, Fowlie, and Sallee 2021 and CPUC 2023b

Legally, due to privacy concerns, utilities and regulators do not have access to individual customers' income-tax data. Given this, some parties have suggested that a third-party administrator be created for income-verification purposes.

Another option might be to have a standard fixed charge and a lower fixed charge for low-income households that opt-in to the program by demonstrating that they qualify in one of

[20] There may be legal challenges to the income-graduated fixed charge initiative as well, but our focus here is on the initiative's programmatic aspects.

a variety of ways.[21] Ultimately, to succeed, the verification process will have to balance multiple objectives: minimal administrative complexity, data accuracy, privacy protection, and protection of low-income customers (Chhabra and Ashford 2023).

Proponents of an income-graduated fixed charge have noted that, for jurisdictions outside of California, an income-based fixed charge approach might require a legislative change to authorize higher levels of fixed charges, as well as regulatory support to execute the new rate design (Chhabra 2022).

Conclusions

Building electrification is a key strategy for fighting climate change, and its success depends on whether stakeholders can couple building electrification with efforts to avoid inequitable outcomes. Rate design, bill affordability policies, energy efficiency programs, or some combination of all of these could reduce energy burdens and facilitate an affordable transition off fossil fuels.

Bill affordability remains an acute, ongoing issue for LMI households, and more remedies aimed at ensuring bill affordability may be necessary. While many jurisdictions provide bill discounts for low-income ratepayers, such discounts do not always result in a bill that they can afford. PIPPs, despite their own implementation challenges, are designed to ensure that the utility bill will not exceed the energy burden ceiling for low-income customers. Although existing PIPPs are typically ratepayer-funded programs, they could also be funded through taxpayer funds. Pressures on utility bills could also be tamped down through carefully considered rate designs. Regardless, it remains to be seen whether utility rates can continue to be the main vehicle for funding state environmental, social, and climate-related mandates. Although they are designed to efficiently allocate the cost of service to customers, utility rates are generally regressive in that—aside from low-income discount programs—they do not reflect income or the ability to pay. Utility rate regressivity could be pronounced and punitive in the case of fixed charges because often there is little that customers can do to affect their bill's outcome.

A common solution to high utility bills is to offer ways to reduce consumption, such as through energy efficiency, an area in which California has been a leader. Another option is to

[21] The opt-in system could be the same one used in two existing programs: the California Alternate Rates for Energy (CARE) Program, which offers a bill discount for those who opt-in and provide income verification, and the Family Electric Rate Assistance (FERA). Participation rates in these programs are extremely high, covering about one-third of the electricity customers served by California's investor-owned utilities. The Solar Energy Industries Association proposed a low fixed charge for CARE customers, a slightly higher charge for FERA customers, and a uniform cost-based rate for all other customers. That option could solve the income verification challenge and be implemented without delay because it relies on existing income verification processes for the two low-income discount programs.

offer discounts for income-qualified consumers. A third approach is to use time-based volumetric rates to incent customers to consume energy during the hours when electricity can be generated and delivered at a lower cost. This approach can encourage flexible load usage through EVs, electric water heaters, and battery storage.

Also, for customers who switch from fossil-fuel-based heating appliances to efficient electric heat pumps, the time-based volumetric rate approach could achieve significant bill savings by aligning these time-based rates with daily and seasonal characteristics of heat pump usage. Such rates can also be designed around operational efficiency of heat pumps to anticipate and reduce high winter peak loads in cold regions (as in the Massachusetts proposal discussed earlier).

In general, we find that bill savings tend to increase with more complex rate designs. Given this, regulators and utilities may deliver greater benefits by taking the time to navigate a transparent, inclusive stakeholder process to generate support for—and choose a rate design that works for—their particular goals and circumstances.

Although well-designed time-based rates could benefit low-income ratepayers, they may also present challenges that need to be further explored and remedied. It also remains to be seen whether time-based rates can adequately lower utility bills when the price of electricity is inordinately high, while also equitably allocating all of the costs related to climate change mitigation and adaptation. This issue may be especially pronounced when those costs—such as costs for protecting against wildfires—are not necessarily driven by or related to energy consumption.

In the case of California, electricity prices have drastically soared in recent years. Utilities have proposed recovering most of those costs as fixed charges; among the options that regulators are examining is the novel approach of adjusting fixed charges based on income level. Rate design has traditionally avoided income as a criterion—except for income-qualified customer discounts—and considering it now may indicate a need to find ways of paying for utility costs that will result in more equitable outcomes. While the latest proposed income-graduated fixed charge is more equitable than the California utilities' prior proposal to recover their costs via very high, flat fixed charges, using a fixed charge to recover utility costs remains controversial, regardless of income focus.

Regardless, new approaches may be necessary. The situation in California is unique in that it is the state’s very high volumetric rates that are driving this new approach. Most states thus far have been spared such high volumetric rates, thereby limiting their need to adopt such an approach. Nonetheless, observers in other states are monitoring the approach as they anticipate utility rates being used to fund more social and environmental policy efforts in their states. Finding equitable and sustainable ways of paying for the costs of climate change is a new dimension that utility regulators will be increasingly called upon to resolve. Doing so will require that they develop a menu of rate options that can provide bill affordability and capture the benefits of efficient building electrification.

The examples we have offered here are not intended as solutions that can or should be readily imported to other states. Rather, they serve to illustrate the types of complex issues that states can reasonably expect to encounter as they attempt to balance building electrification efforts and economically equitable outcomes in the somewhat narrow confines of utility rate designs. These examples also show how regulators, advocates, and utility professionals are attempting to develop new solutions or to revisit old ones that fit their specific needs. Finally, our examples indicate that solving the intertwined problems of building electrification and equity for the long term may take more than a single rate-design solution.

References

APPA (American Public Power Association). 2019. *Leadership in Rate Design: A Compendium of Rates Essays.* Arlington, VA: APPA. www.publicpower.org/system/files/documents/Leadership-in-Rate-Design.pdf.

Ashford, S., and M. Chhabra. 2023. "Reforming CA's Electric Rates for Decarbonization and Equity." *NRDC Expert Blog*, April 14. nrdc.org/bio/sylvie-ashford/reforming-cas-electric-rates-decarbonization-and-equity.

Baatz, B. 2017. *Rate Design Matters: The Intersection of Residential Rate Design and Energy Efficiency.* Washington, DC: ACEEE (American Council for an Energy-Efficient Economy). aceee.org/research-report/u1703.

Borenstein, S. 2023. "Rebalancing Rates for Electrification and Equity." *Energy Institute Blog*, May 1. energyathaas.wordpress.com/2023/05/01/rebalancing-rates-for-electrification-and-equity/.

Borenstein, S., M. Fowlie, and J. Sallee. 2021. *Designing Electricity Rates for An Equitable Energy Transition.* Berkeley: Energy Institute at Haas, University of California, Berkeley and Next 10. next10.org/sites/default/files/2021-02/Next10-electricity-rates-v2.pdf.

Bushnell, J. 2023. "(More) Breaking News! California Electricity Prices Are Still High!" *Energy Institute Blog*, January 17. energyathaas.wordpress.com/2023/01/17/more-breaking-news-california-electricity-prices-are-still-high/.

California Joint IOUs. 2023. *Joint Testimony of Southern California Edison Company, Pacific Gas and Electric Company, and San Diego Gas & Electric Company (the Joint IOUs) Describing Income-Graduated Fixed Charge Proposals*. R.22-07-005, April 7. San Francisco: CPUC (California Public Utilities Commission). cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/demand-response/demand-response-workshops/advanced-der---demand-flexibility-management/joint-ious-opening-testimony-exhibit-1.pdf.

California State Legislature. 2022. *Assembly Bill No. 205: Chapter 61*. Sacramento: California State Legislature. leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220AB205.

Chhabra, M. 2022. *Analyzing (some) Policy Levers for Affordable Decarbonization*. New York: NRDC (Natural Resources Defense Council). cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/en-banc/chhabra-v2-with-alt-image-link-text.pdf.

Chhabra, M., and S. Ashford. 2023. *Opening Testimony of Mohit Chhabra and Sylvie Ashford, Sponsored by the Natural Resources Defense Council and The Utility Reform Network: Addressing Options for An Income-Graduated Fixed Charge*. R.22-07-005, April 7. San

Francisco: CPUC. cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/demand-response/demand-response-workshops/advanced-der---demand-flexibility-management/turn-and-nrdc-opening-testimony.pdf.

Code of Virginia. 2020. "§ 56-585.6. Universal Service Fee; Percentage of Income Payment Program and Fund." law.lis.virginia.gov/vacode/title56/chapter23/section56-585.6/.

Colorado PUC (Public Utilities Commission). 2023. "Energy Bill Assistance Programs." puc.colorado.gov/LIprograms.

CPUC. 2021. *Utility Costs and Affordability of the Grid of the Future: An Evaluation of Electric Costs, Rates, and Equity Issues Pursuant to P.U. Code Section 913.1.* San Francisco: CPUC. cpuc.ca.gov/-/media/cpuc-website/divisions/office-of-governmental-affairs-division/reports/2021/senate-bill-695-report-2021-and-en-banc-whitepaper_final_04302021.pdf.

———. 2022. *Assigned Commissioner's Phase 1 Scoping Memo and Ruling.* R.22-07-005, November 2. San Francisco: CPUC. docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M498/K072/498072273.PDF.

———. 2023a. "Demand Flexibility Rulemaking (R.22-07-005)." cpuc.ca.gov/industries-and-topics/electrical-energy/electric-costs/demand-response-dr/demand-flexibility-rulemaking.

———. 2023b. *E3 Fixed Charge Tool and Income Verification Follow-Up Workshop: R.22 07 005, Phase 1, Track A*. San Francisco: CPUC. cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/demand-response/demand-response-workshops/advanced-der---demand-flexibility-management/fixed-charge-rate-design-tool-and-income-verification-0212023.pdf.

Drehobl, A., L. Ross, and R. Ayala. 2020. *How High Are Household Energy Burdens?* Washington, DC: ACEEE. aceee.org/research-report/u2006.

EIA (Energy Information Administration). 2022. "U.S. Electricity Profile 2021." www.eia.gov/electricity/state/.

———. 2023. "Electricity Data Browser: Average Retail Price of Electricity." Accessed June. eia.gov/electricity/data/browser/.

Farley, C., J. Howat, J. Bosco, N. Thakar, J. Wise, and J. Su. 2021. *Advancing Equity in Utility Regulation: Future Electric Utility Regulation Report No. 12*. Prepared by Berkeley Lab. Washington, DC: DOE. eta-publications.lbl.gov/sites/default/files/feur_12_-_advancing_equity_in_utility_regulation.pdf.

Farnsworth, D., J. Shipley, J. Lazar, and N. Seidman. 2018. *Beneficial Electrification: Ensuring Electrification in the Public Interest.* Montpelier, VT: RAP (Regulatory Assistance Project).

raponline.org/knowledge-center/beneficial-electrification-ensuring-electrification-public-interest/.

Faruqui, A. 2021. *Electricity Ratemaking and Equitable Rate Design: A Survey of Best Practices*. Boston: The Brattle Group. www.brattle.com/wp-content/uploads/2021/08/Electricity-Ratemaking-and-Equitable-Rate-Design-A-Survey-of-Best-Practices.pdf.

———. 2023. "How Will the Income-Graduated Fixed Charges (IGFC) Proposed by California's Investor-Owned Utilities Affect Customer Bills?" *Energy Central*, April 17. energycentral.com/c/um/how-will-income-graduated-fixed-charges-igfc-proposed-california%E2%80%99s-investor-owned.

Hayes, S., M. MacPherson, C. Gerbode, and L. Ross. 2022. *Pathways to Healthy, Affordable, Decarbonized Housing: A State Scorecard*. Washington, DC: ACEEE. aceee.org/research-report/h2201.

Howat, J., K. Lusson, and O. Wein. 2020. *Utility Bill Affordability in Colorado: Reforms to Protect Low-Income Consumers from Increasing Rates.* Boston: NCLC (National Consumer Law Center). www2.ed.gov/policy/highered/reg/hearulemaking/2021/codoraholdharmreportfin.pdf.

Lazar, J. 2013. *Rate Design Where Advanced Metering Infrastructure Has Not Been Fully Deployed.* Montpelier, VT: RAP. raponline.org/wp-content/uploads/2016/05/rap-lazar-ratedesignconventionalmeters-2013-apr-8.pdf.

———. 2015. "Appendix D: The Specter of Straight Fixed/Variable Rate Designs and the Exercise of Monopoly Power." *Smart Rate Design for a Smart Future.* Montpelier, VT: RAP. raponline.org/wp-content/uploads/2016/05/appendix-d-smart-rate-design-2015-aug-31.pdf.

———. 2023. "The California 'Income-Graduated Fixed Charge' Proposal Is Probably Impossible to Implement. There Are Better Options Available." Energy Central, April 25. energycentral.com/c/pip/california-%E2%80%9Cincome-graduated-fixed-charge%E2%80%9D-proposal-probably-impossible-implement.

Lazar, J., and W. Gonzalez. 2015. *Smart Rate Design for a Smart Future Webinar.* Montpelier, VT: RAP. www.raponline.org/wp-content/uploads/2016/05/rap-lazargonzalez-smartrates-2015-08-04.pdf.

LIHEAP Clearinghouse. 2014. *Overview of Percentage of Income Payment Plans (PIPP) Compiled by the LIHEAP Clearinghouse.* Butte, MT: LIHEAP Clearinghouse. liheapch.acf.hhs.gov/docs/PIPPupdate.pdf.

Littell, D., and J. Sliger. 2020. *Time-Varying Rates in New England: Opportunities for Reform.* Montpelier, VT: RAP. raponline.org/wp-content/uploads/2020/10/rap-littell-sliger-time-varying-rates-in-new-england-opportunities-for-reform-2020-october.pdf.

Lukanov, B., A. Makhijani, K. Shetty, Y. Kinkhabwala, A. Smith, and E. Krieger. 2022. *Pathways to Energy Affordability in Colorado*. Prepared by PSE (Physicians, Scientists, and Engineers for Healthy Energy) and IEER (Institute for Energy and Environmental Research). Denver: Colorado Energy Office. psehealthyenergy.org/wp-content/uploads/2022/01/Colorado-Energy-Affordability-Study_Full-Report.pdf.

Michaels, H., and R. Nachtrieb. 2022. "Transitioning to Heat Pumps in Cold Climates: a Systems Dynamics Analysis." *Proceedings of the 2022 ACEEE Summer Study on Energy Efficiency in Buildings* 9: 391-405. Washington, DC: ACEEE. aceee2022.conferencespot.org/event-data/pdf/catalyst_activity_32605/catalyst_activity_paper_20220810191635007_66d91a56_7fbc_41af_9a66_5f9e7a76093b

Morales, D., and S. Nadel. 2022. *Meeting the Challenge: A Review of Energy Efficiency Program Offerings for Low-Income Households*. Washington, DC: ACEEE. aceee.org/research-report/u2205.

Nadel, S. 2023. *Impact of Electrification and Decarbonization on Gas Distribution Costs*. Washington, DC: ACEEE. aceee.org/research-report/u2302.

Nadel, S., and L. Fadali. 2022. *Analysis of Electric and Gas Decarbonization Options for Homes and Apartments*. Washington, DC: ACEEE. aceee.org/sites/default/files/pdfs/electric_and_gas_decarb_for_homes_and_apartments_7.21.pdf.

Nevada DWSS (Division of Welfare and Supportive Services). 2022. *Nevada Fund for Energy Assistance and Conservation State Plan.* Carson City: Nevada DWSS. dwss.nv.gov/uploadedFiles/dwssnvgov/content/Energy/The%20Nevada%20Fund%20for%20Energy%20Assistance%20and%20Conservation%20State%20Plan%202023%20Final_Signed.pdf.

New York PSC (Public Service Commission). 2021. *Order Adopting Energy Affordability Policy Modifications and Directing Utility Filings*. Cases 14-M-0565 and 20-M-0266, August 12. Albany: New York PSC. documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7b1CFD4CE2-AB87-4A8C-B56B-F123366B1520%7d.

Offenstein, J., C. Johnson., T. Bohannan., and A. Thomas. 2020. *Evaluation of the Percentage of Income Payment Plans*. Prepared by ADM Associates, Inc. Denver: Colorado Energy Office. admenergy.com/colorado-energy-office-process-evaluation/.

PG&E (Pacific Gas and Electric Company). 2023. "Electric Home Rate Plan (E-ELEC)." pge.com/en_US/residential/rate-plans/rate-plan-options/electric-home-rate-plan.page.

PUCO (Public Utilities Commission of Ohio). 2023. "PIPP Plus." Accessed June. puco.ohio.gov/utilities/gas/resources/pipp-plus.

Sergici, S., A. Faruqui, and S. Tang. 2023. *Do Customers Respond to Time-Varying Rates: A Preview of Arcturus 3.0.* Boston: The Brattle Group. brattle.com/wp-content/uploads/2023/02/Do-Customers-Respond-to-Time-Varying-Rates-A-Preview-of-Arcturus-3.0.pdf.

Sergici, S., A. Ramakrishnan, G. Kavlak, A. Bigelow, and M. Diehl. 2023. *Heat Pump-Friendly Cost-Based Rate Designs*. Reston, VA: Energy Systems Integration Group. esig.energy/wp-content/uploads/2023/01/Heat-Pump%E2%80%93Friendly-Cost-Based-Rate-Designs.pdf.

White, L., and N. Sintov. 2020. "Varied Health and Financial Impacts of Time-of-Use Energy Rates across Sociodemographic Groups Raise Equity Concerns." *Nature Energy* 5, 16–17. doi.org/10.1038/s41560-019-0515-y.