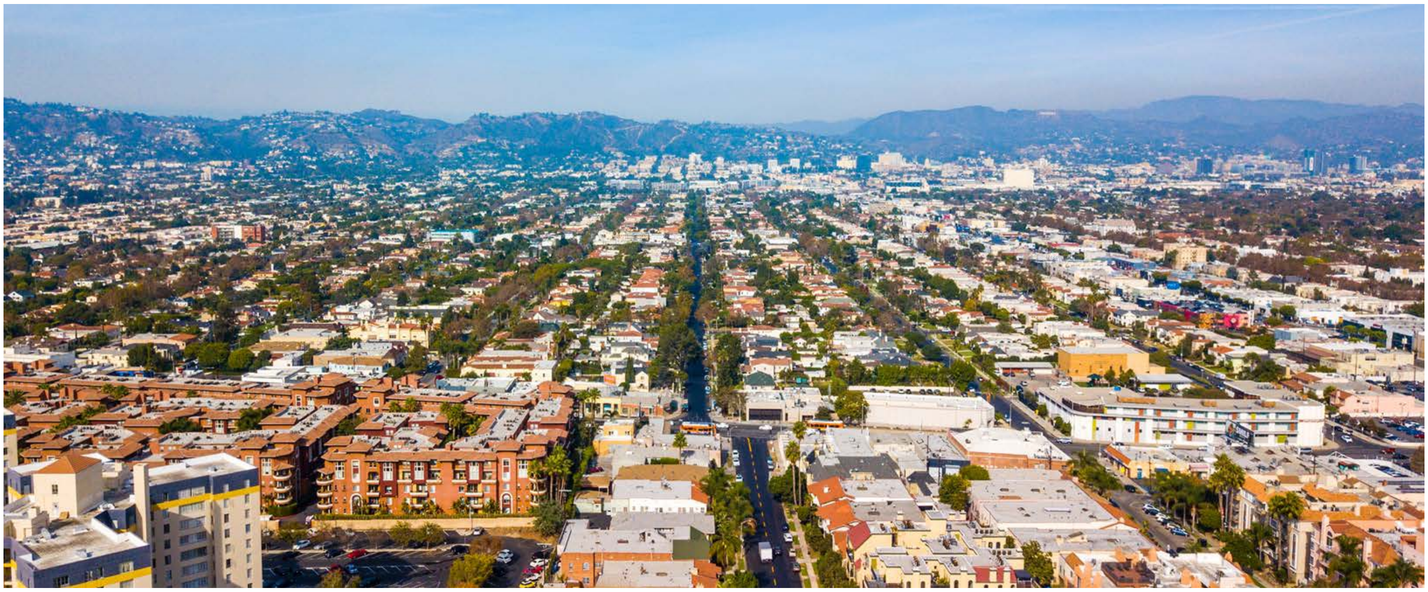
LA100 EQUITY STRATEGIES



Chapter 5. Low-Income Energy Bill Equity and Affordability

FINAL REPORT: LA100 Equity Strategies

Thomas Bowen, Christina Simeone, Katelyn Stenger, Lixi Liu, Megan Day, Noah Sandoval, Kinshuk Panda, Daniel Zimny-Schmitt, and Janet Reyna

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NREL Transforming ENERGY

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LA100 EQUITY STRATEGIES

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Preface

The Los Angeles 100% Renewable Energy Study, or LA100, revealed that although all communities in Los Angeles will share in the air quality and public health benefits of the clean energy transition, increasing equity in participation and outcomes will require intentionally designed policies and programs. The LA100 Equity Strategies project was specifically designed to help Los Angeles identify pathways to such policies and programs in the form of equity strategies. The project aimed to do this by incorporating research and analysis to chart a course toward specific, community-prioritized, and equitable outcomes from the clean energy transition outlined in the LA100 study.

The Project Partners

The Los Angeles Department of Water and Power (LADWP), the National Renewable Energy Laboratory (NREL), and the University of California Los Angeles (UCLA) partnered on the LA100 Equity Strategies project to develop strategies for engaging communities, funding equitable technology and infrastructure investments, expanding existing programs, and designing new programs and policies to improve equity by incorporating what community members themselves know is needed to achieve a more equitable energy future.

The Project Approach

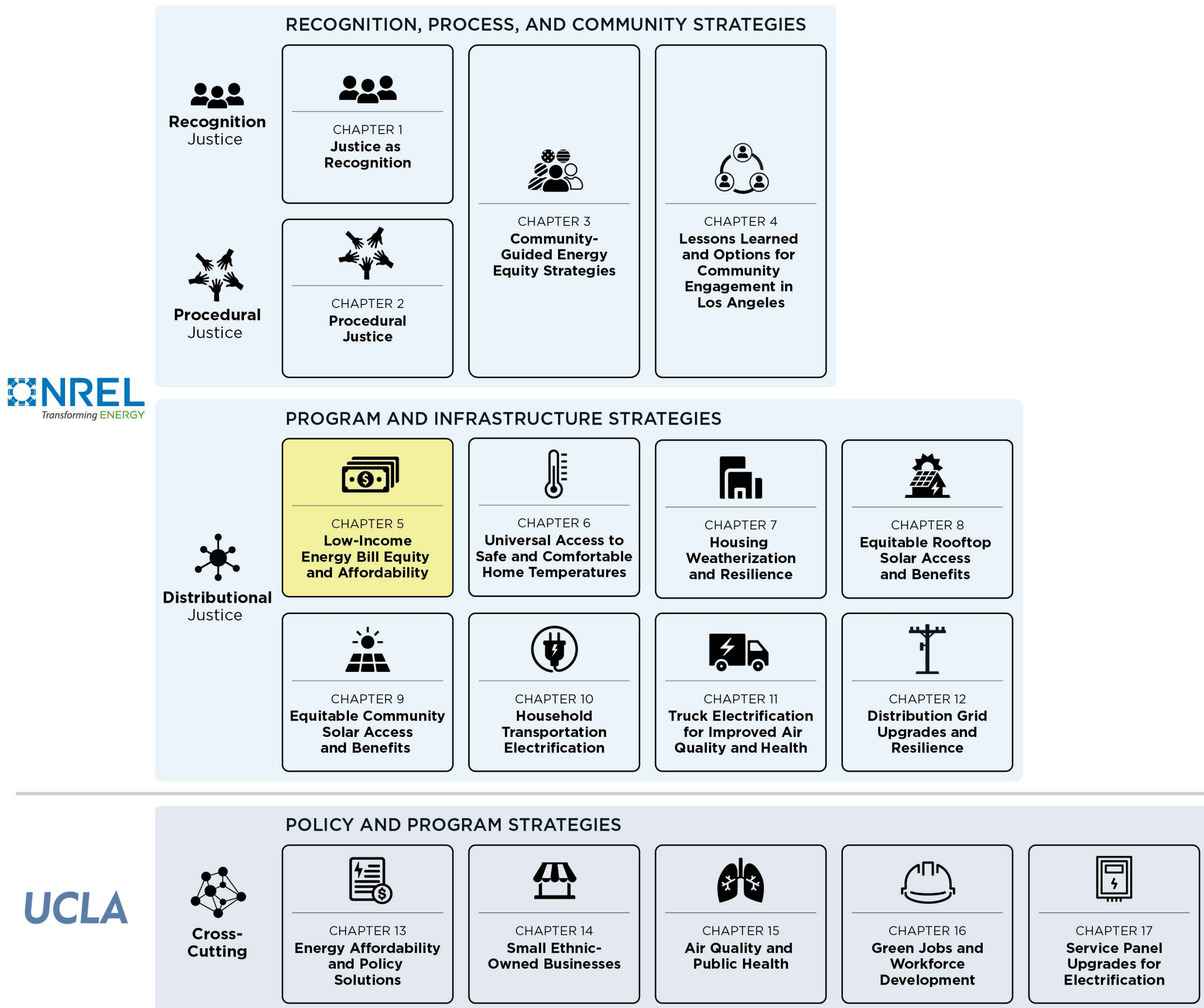
LA100 Equity Strategies employs a unique mixed-methodological approach utilizing three distinct—but connected—research efforts. Through these efforts, NREL and UCLA developed a range of strategy options for increasing equity in LA's transition to 100% clean energy.

A Project Summary

To get a high-level overview of the project, you can dive into the executive summary, interactive data visualizations, and more on the LA100 Equity Strategies website at maps.nrel.gov/la100/equity-strategies.

The Full Report

NREL's final full report for the LA100 Equity Strategies project encompasses seventeen chapters. The first twelve chapters, authored by NREL, are organized around the three tenets of justice. Chapters 1–4 address recognition and procedural justice, while Chapters 5–12 address distributional justice. The final five chapters, authored by UCLA, provide crosscutting policy and program strategies. Each chapter provides data, methods, insights, and strategies to help LADWP make data-driven, community-informed decisions for equitable investments and program development.



NREL Chapters

UCLA Chapters

List of Abbreviations and Acronyms

ACC	Avoided Cost Calculator
AMI	area median income
AMY	actual meteorological year
BAU	business as usual
CAIRO	Customer Affordability, Incentives, and Rates Optimization
CARE	California Alternate Rates for Energy
CPUC	California Public Utilities Commission
dGen	Distributed Generation Market Demand
ESA	Energy Subsidy Adjustment
FERA	Family Electric Rate Assistance
HMW	hours at minimum wage
HOMES	Home Owner Managing Energy Savings
HSPF	heating seasonal performance factor
IBFC	income-based fixed charges
IOU	investor-owned utility
LADWP	Los Angeles Department of Water and Power
LBNL	Lawrence Berkeley National Laboratory
LMI	low and moderate income
MW_{DC}	megawatts-direct current
NER	net energy return
NREL	National Renewable Energy Laboratory
PV	photovoltaics
REPLICA	Rooftop Energy Potential of Low Income Communities in America
SB 100	California Senate Bill 100: The 100 Percent Clean Energy Act of 2018
SCE	Southern California Edison
SEER	seasonal energy efficiency ratio
SLTRP	Strategic Long-Term Resource Plan
TOU	time of use

Executive Summary

The LA100 Equity Strategies project integrates community guidance with robust research, modeling, and analysis to identify strategy options that can increase equitable outcomes in Los Angeles' clean energy transition. This chapter focuses on utility rates and low-income bill assistance programs as means to improve energy affordability, which is one of the community's highest priorities.

Specifically, NREL developed a model using Los Angeles Department of Water and Power (LADWP)-specific inputs to test 2035 rate design and low-income assistance program scenarios.

Utility bills were modeled based on the hourly household energy usage (electricity and gas) of each of the 50,000 prototypical LADWP residential households NREL developed with unique combinations of housing types (single-family, multifamily), climate zones, insulation levels, appliances, heating and cooling systems, solar adoption and generation, renter or owner occupancy, and income levels. We evaluated the results to assess the relative efficacy of each approach in reducing bills for LADWP's low-income households using customer affordability and equity metrics including energy burden and hours worked at minimum wage.

NREL modeling and results are bounded by LADWP-provided projected revenue requirements as of March 2023. Revenue forecasts were not validated due to lack of data and thus may overstate or understate actual future costs. Also, because we focused solely on affordability and equity impacts to low-income households, this work does not represent a holistic analysis of rate design.

Research was guided by input from the community engagement process, and associated equity strategies are presented in alignment with that guidance.

Community Guidance

Guidance from the LA100 Equity Strategies Steering Committee, listening sessions with community-based organizations and community members, and community meetings yielded the following:

- Energy affordability is one of the highest priorities.
- Low-income ratepayers and seniors suggested subsidies, free aid, and other support instruments to address communities' inability to pay electricity bills.

Steering Committee Member:

"Split incentives for affordable housing owners and operators must be addressed. They aren't able to recuperate costs of solar and other upgrades, electrification. Use the rate structure to make sure low-income households receive financial benefits from upgrades."

Community Member:

"Households in hotter areas of the city can't afford new technologies like solar and are hit with time-of-use charges. This is inequitable."

Steering Committee Member/Community-Based Organization Representative:

"Our constituents are concerned about utility debt."

- Participants suggested reassessing eligibility for LADWP programs, which could include:
    - Reassessing how to measure eligibility and burden.
    - Basing the criteria on an understanding of affordability and burden as context-specific.
    - Examining how energy burden affects household access to benefits such as homeownership.
    - Expanding access to moderate-income households.
- Participants suggested expanding eligibility for LADWP programs to renters.
- Participants suggested expanding programs to help low- and moderate-income (LMI) disadvantaged community residents maintain and upgrade their homes affordably, which also improves access to homeownership.

Baseline Affordability

Household energy burden—the percentage of household income spent on energy bills—is a common energy affordability metric. An energy burden of 6% or less is a common threshold for affordable utility costs, based on affordability thresholds of utility costs not exceeding 20% of housing costs and housing costs not exceeding 30% of income (Colton, Roger D. 2011; Brown et al. 2019). The U.S. West Census Region (which includes the Pacific and Mountain divisions) has the lowest average energy burden in the United States for low-income populations (≈8.5%, as measured by households eligible for the federal Weatherization Assistance Program)[1] (Rose and Hawkins 2020). Estimates for the same income group living in metropolitan areas of California suggest the low-income energy burden in Los Angeles (6.0%) has historically been lower than in San Francisco (6.1%), San Jose (6.5%), and Riverside (8.7%) (Drehobl, Ross, and Ayala 2020).

Though energy burden can be a useful metric, it alone is an incomplete measure of both affordability and overall need. County-level data on federal low-income energy assistance indicates the concentration of need is far greater in Los Angeles County than in other California counties. For example, low-income households in Los Angeles County received almost 30% of total 2016 need-based statewide weatherization program funding, followed by Sacramento County at 5.1% (California Department of Community Services and Development 2016). This is consistent with the fact that Los Angeles County is home to about 30% (about 1.3 million in 2020) of the state's population living in poverty, which is more than in any other California county (USDA Economic Research Service 2020).

Over a 15-year period, LADWP spent more than $173 million in low-income program assistance[2] and more than $313 million in Lifeline program assistance.[3] Our analysis of program equity indicates assistance programs appropriately benefitted households in disadvantaged

[1] Federal Weatherization Assistance Program-eligible households are those living at or below 200% of U.S. federal poverty guidelines.
[2] These funds were spent as part of the EZ-SAVE program.
[3] Lifeline program eligibility is based on income qualification for customers who are 62 years of age or older or who are permanently disabled.

communities,[4] and mostly non-White, Hispanic, renter, and lower-income census tracts. Despite these significant program investments, the same demographic groups have the most utility disconnections stemming from bill payment failures. In 2022, LADWP ended its practice of disconnects for a limited set of customers (primarily EZ-SAVE enrollees and Lifeline customers) as a debt collection tool (Haley Smith 2022). Although long-term low-income assistance investments have been significant, LADWP's January 2022 Rates and Equity Metrics Board Package noted the low-income assistance program has "minimal outreach efforts by LADWP to customers," "no targeted communications to customers," "no formal engagement with community-based organizations," and has experienced a "reduction in customers recertifying for the program" (Santilli, Ann and Adams, Martin 2022).

Key Findings

Continuing LADWP's current rate design and low-income assistance programs through 2035 is estimated to result in low-income[5] households experiencing disproportionately higher bill increases. Under the existing LADWP rate design and low-income assistance programs, modeling indicates average electricity bills will increase by $83/month across all households between 2019 and 2035 (a 79% increase), while low-income households see an average expected increase of $110/month (a 131% increase).[6]

Electricity bill affordability metrics modeled for 2035 include:

- Average electricity burdens, or the percentage of income spent on electricity bills, by income level.
- Average monthly electricity bills by income level.
- Average hours worked at minimum wage required to pay for monthly electricity bills, per income level.

LADWP's ability to revise rate design is inhibited by California Proposition 218 and Proposition 26, which classify municipal utility rates as taxes and restrict certain government tax increases unless approved by voters. Beyond existing programs grandfathered in at current funding levels, the propositions also functionally prohibit the practice of supporting low-income assistance programs through funds recovered from non-low-income customers (League of California Cities 2021). These regulatory constraints prevent LADWP from increasing the budget for low-income bill assistance.

Leveraging federal funding through the Inflation Reduction Act, LADWP could potentially implement an on-bill tariff program (e.g., Pay-As-You-Save) for heat pump water heaters or

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[4] Disadvantaged communities as defined by SB 535 and the California Office of Environmental Health Hazard Assessment, oehha.ca.gov/calenviroscreen/sb535.

[5] Throughout this report, low-income households are defined as those 0%–50% of area median income (AMI), which includes the "extremely low" (0%–30% AMI) and "low" (30%–50% AMI) income bins.

[6] Unless otherwise indicated, all dollar results are based in 2021 dollars, assuming an average annual inflation of 2.5% to 2035. While this is not in keeping with actual inflation observed, it aligns with LADWP Strategic Long-Term Resource Plan forecasts, which were used to inform the analysis.

enhanced insulation that has the technical potential to provide energy bill (gas and electricity) savings to 154,000 or 72,000 low-income customers, respectively.

Modeling results indicate that for 2035, converting from LADWP's current complex multiperiod rate structure[7] to a simplified tiered rate,[8] or a default time-of-use (TOU)[9] rate structure that does not apply to certain low-income customers—as well as replacing net metering solar compensation with net billing compensation and establishing a policy to modestly boost low-income solar adoption—modestly improves low-income bill affordability and significantly improves equity between solar adopters (who tend to have higher incomes) and non-adopters (who tend to have lower incomes). This applies *even without* EZ-SAVE or Lifeline low-income assistance programs. For affordability, average low-income bills are also reduced by about $14-15 per month. For equity, the cost spread between average monthly bills for a solar photovoltaics (PV) adopter and non-adopter in 2035 drops from $162 under business as usual (BAU) to $55 and $65 under the simplified tiers and TOU models, respectively. This scenario is useful to understand the impact of rate design changes, as well as the loss of the EZ-SAVE and Lifeline discount programs that may not survive a proposition challenge. Potential administrative and system cost reductions (e.g., peak load reductions) from more understandable and cost-reflective rates and customer responsiveness are not quantified.

Low-income affordability would be significantly improved by replacing EZ-SAVE and Lifeline programs with robust low-income assistance programs modeled after the California Public Utilities Commission's (CPUC's) California Alternate Rates for Energy (CARE) and Family Electric Rate Assistance Program (FERA) programs. These programs have larger monthly discounts and higher enrollment rates compared to the EZ-SAVE and Lifeline programs. As a result, compared to a BAU rate approach, in 2035, the combination of updated rate design, revised solar compensation, and robust low-income assistance reduces average low-income monthly bills by $55 per month. Equity is also improved as the cost spread between solar PV adopter and non-adopter average monthly bills drops to between $29 and $39. However, these robust assistance programs have program costs of between 9.6% and 10% of the residential requirement, or between $307 million and $335 million. These revenues are transferred from customers not participating in CARE and FERA to participating customers, violating Proposition 26 and Proposition 218.[10]

Income-based fixed charges (IBFC), where certain utility costs are assigned to customers scaled to their income, achieve the greatest affordability for low-income customers and reduce energy

[7] The 15 rate periods are based on the intersection of (1) a three-tier, two-season set of tiered rates and (2) a four-season set of incremental ordinances (see Appendix C).
[8] NREL modeled a tiered "inclining block rate" structure recommended by the California Public Utilities Commission, which charges customers more per kilowatt-hour as their usage increases past certain thresholds (or blocks).
[9] LADWP does not currently have the smart meter infrastructure required to implement default TOU rates, but it is assumed that by 2035 sufficient metering infrastructure is in place.
[10] Note that even customers *eligible* for CARE and FERA that are not ultimately enrolled shoulder the transfer costs associated with participating customers.

burdens below the 6% affordable threshold for all customers.[11] IBFC require customer-level income verification, a substantial implementation challenge. In addition, IBFC require increasing higher-income average bills for reasons not related to the energy consumption of these customers, which likely violates Proposition 26 and Proposition 218. IBFC design tends to increase solar adopter average monthly bills because solar adopters tend to have higher incomes (thus higher fixed costs driving up the average). Solar adopters in all income bins continue to see lower bills than non-adopters under IBFC. IBFC are currently being investigated for implementation in California by the CPUC.

Equity Strategies

Our modeling indicates equity and affordability outcomes could be improved through rate design and programmatic reforms.

- *On-bill tariffs for efficiency can deliver bill savings*. LADWP could use Inflation Reduction Act funds to establish an on-bill tariff program for heat pump water heaters or enhanced insulation that has the technical potential to deliver energy bills savings to about 154,000 or 72,000 low-income customers, respectively. This strategy may not require a rate case and may not violate Proposition 26 and Proposition 218, as it is supported by federal funds and only participating customers are assessed bill riders.[12]
- *Revised rate design and solar compensation mechanisms improve equity*. Converting LADWP's complex rate structure to a simplified tiered rate or TOU rate structure, replacing net metering with net billing for solar compensation, and implementing a modest program to boost low-income solar adoption would provide modest low-income bill savings (approximately $14-15/month) and drastically improve equity between solar adopters and non-adopters. Low-income bill affordability improvements occur even in the absence of LADWP's EZ-SAVE and Lifeline low-income assistance programs.
- *Robust low-income assistance programs improve affordability*. Establishing robust low-income assistance strategies with larger discounts and higher enrollment rates compared to EZ-SAVE and Lifeline could significantly improve low-income affordability.
- *Income-based fixed charges can achieve affordability*. IBFC most effectively reduce the affordability disparity between high- and low-income households and ensure customers in all income levels remain below the 6% affordability threshold.

[11] Six percent is a common affordability threshold for total energy burden. Here we use the 6% affordability threshold with the electricity burden, which slightly overstates affordability for these warm-weather climate households.

[12] Note that this study models an on-bill tariff program leveraging federal funds in 2035 to facilitate comparisons to other scenarios. An on-bill tariff program implemented sooner could see different results or focus on other technologies.

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1 Introduction

In this report, the National Renewable Energy Laboratory (NREL) explores whether and how California-relevant rate design practices and more robust low-income assistance strategies could improve affordability for the Los Angeles Department of Water and Power's (LADWP's) low-income customers. As LADWP pursues its clean energy goals, state policy constraints inhibiting the utility from pursuing alternative rate designs could result in inequitable outcomes for low-income customers.

Modeling and Analysis Approach

NREL modeled customer bills in 2019 baseline and 2035 rate and low-income assistance program scenarios to compare affordability and other equity metrics. Bills were modeled based on the hourly household energy usage (electricity and gas) of each of the 50,000 prototypical LADWP residential households developed by NREL with unique combinations of housing types (single-family, multifamily), climate zones, insulation levels, appliances, heating and cooling systems, solar adoption and generation, renter or owner occupancy, and—most importantly for this analysis—income levels. Figure 1 presents a graphical overview of the rate scenarios and program strategies modeled for this study.

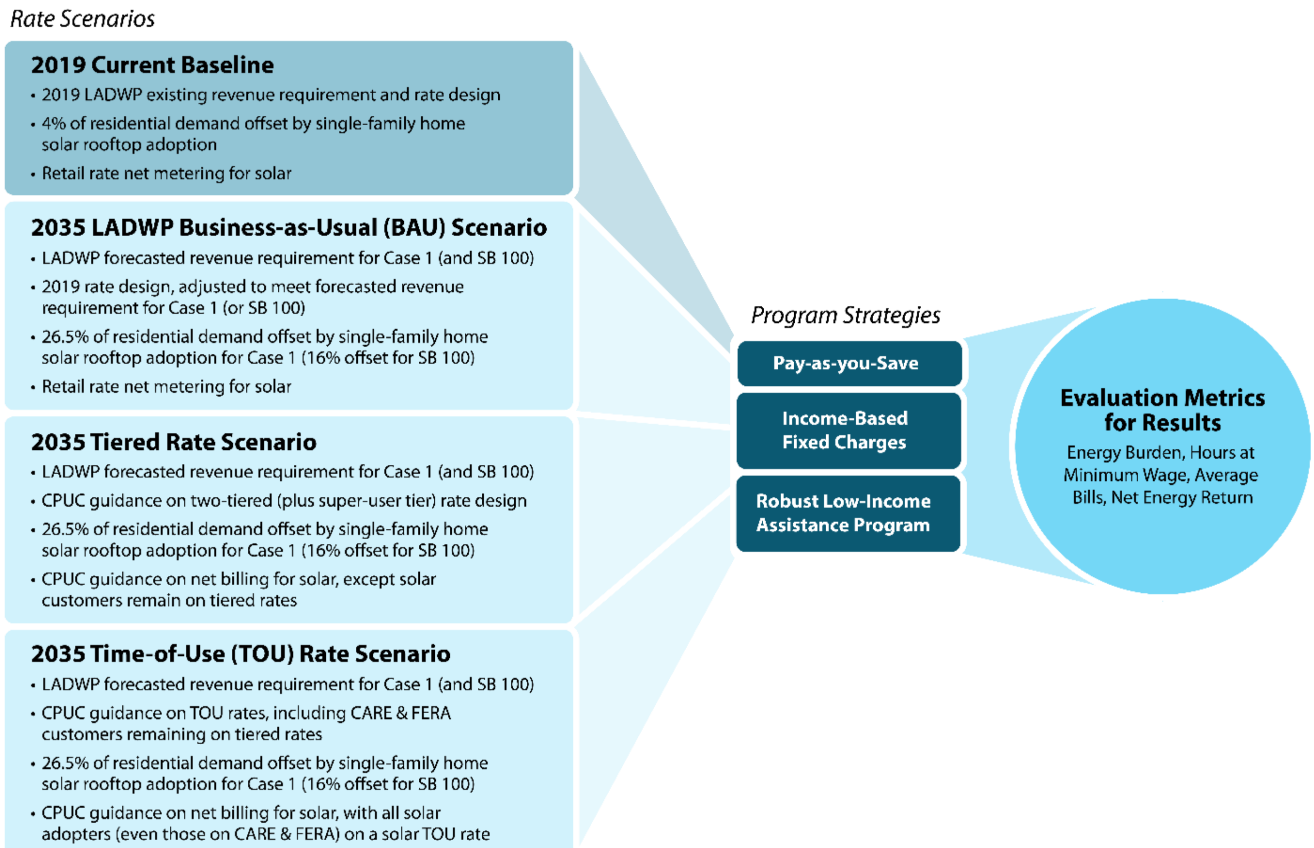

Figure 1. Rate scenarios, program strategies, and evaluation metrics modeled

Three future rate design scenarios are modeled to meet LADWP's Strategic Long-Term Resource Plan (SLTRP) 2022 revenue requirements and rate increase projections for Case 1 and California Senate Bill 100 (SB 100).[13] Rate design scenarios compare LADWP's existing rates approach to rate design strategies recommended by the California Public Utilities Commission (CPUC) and implemented by California investor-owned utilities. Rate design scenarios include:

- **2019 LADWP Baseline:** This scenario provides a baseline against which to compare evaluation metrics from forecast scenarios. The scenario uses LADWP's 2019 revenue requirement and respective energy-year tariff, including residential tiered rate schedules for Jan. 1–June 30, 2019, and July 1–Dec. 31, 2019 (see Appendix C).
- **2035 LADWP Business-as-Usual (BAU) Forecast:** Under this scenario, using the Case 1 revenue requirement, we model LADWP's 2035 rates by extending its existing tariff design and rate schedule in place in 2019. We incorporate LADWP's existing EZ-SAVE and Lifeline low-income assistance program enrollment and discounts at percentage levels consistent with average nominal levels between 2016 and 2019.[14] More recent data on enrollment are not used due to potential anomalies experienced from the COVID-19 pandemic.
- **2035 Simplified Tiered Rates:** Using the Case 1 revenue requirement, we design a two-tiered inclining block rate design where rates increase once a consumption threshold is met, with a third super-user tier, consistent with the CPUC 2015 rate reform order (California Public Utilities Commission 2015) (see Appendix C). This scenario does not include any low-income bill assistance programs.
- **2035 Default Time-of-Use (TOU) Rates:** Under this scenario, using the Case 1 revenue requirement and proxy marginal system costs, we design a default TOU rate consistent with CPUC guidance (California Public Utilities Commission 2017; 2019; 2020) (see Appendix C). This approach prevents certain low-income customers from being defaulted into TOU rates, and they therefore remain on the tiered rate structure. We model this rate structure even though LADWP currently does not have the smart meter infrastructure required to implement default TOU rates. This scenario does not include any low-income bill assistance programs.

This rate analysis uses projected LADWP customer energy demand in 2035 calibrated against historical customer load data (see Chapters 6 and 7). To inform how distributed solar rooftop photovoltaics (PV) and associated compensation policies impact rates and customer bills, we use customer-sited solar offsets about 4% of residential load in 2019, 16.2% in 2035 under SB 100, and 26.5% in 2035 under Case 1 based on LA100 study models (Jacquelin Cochran and Paul Denholm 2021). We assume net metering for LADWP baseline and BAU rate scenarios and net

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[13] SB 100 requires renewable energy and zero-carbon resources to supply 100% of electric retail sales to end-use customers by 2045. See "SB 100 Joint Agency Report," California Energy Commission, https://www.energy.ca.gov/sb100.

[14] Participation in EZ-SAVE across the entire residential customer class (not just eligible population) was 7.1572% in 2019 with discounts of $8.17/month. Enrollment for 2035 is 9.2993% with a nominal discount of $8.17/month. The discount does not change given it is held constant at this nominal value in the current LADWP tariff. This is because the funding mechanisms for EZ-SAVE and Lifeline have reached their cap and would require a rate case to increase funding.

billing compensation for CPUC simplified tiered and TOU rate scenarios.[15] We use historic data on solar adopter household income distributions to randomly assign solar to individual households, as well as to model the impacts of increasing solar adoption in LMI households by 20% (compared to 2035 forecasts). The solar analysis aimed to identify residential intra-class transfers and resultant equity and affordability metrics that occur when we vary the level of solar penetration and solar compensation strategies. Our solar analysis does not aim to precisely predict aggregate future solar penetration levels, household adoption probability (e.g., logit model), or likely future adopter household income distributions.

We analyze the potential impacts of certain low-income strategies, including establishing robust low-income assistance programs modeled after the California Alternate Rates for Energy (CARE) and Family Electric Rate Assistance (FERA) programs,[16] on-bill efficiency tariff programs (e.g., Pay As You Save), and income-based fixed charges (IBFC). These strategies are chosen to represent a range of options from contemporary California utility practice (i.e., CARE and FERA) to strategies that could leverage federal Inflation Reduction Act funding (on-bill tariff) and innovative rate design approaches currently under consideration such as IBFC.

To enable this analysis, we develop a new Customer Affordability, Incentives, and Rates Optimization (CAIRO) model to calculate and analyze residential retail electricity rates based on a set of user-defined criteria on tariff design elements, input data requirements, low-income assistance strategy design, and output evaluation metrics. Required data inputs include:

- **8760 Load Patterns:** A sample of 50,000 prototypical LADWP residential customers developed by NREL is used to model hourly household energy usage (electricity and gas) patterns for both the 2019 baseline and 2035 scenarios. The load patterns incorporate household solar adoption consistent with the criteria previously discussed, as well as household-level solar resource availability data from the Distributed Generation Market Demand (dGen) model and ResStock.
- **Customer Metadata:** These demographic data include income, persons per household, housing type and tenure, and other parameters.
- **Utility Revenue Requirement:** The 2035 revenue requirement associated with the SLTRP Case 1 scenario for 2035 is $4.552 billion in 2035$.[17] The 2035 revenue requirement associated with the SLTRP SB 100 scenario, and specifically compliance for the residential sector, is $3.341 billion in 2035$.
- **Marginal System Costs:** LADWP's marginal system costs for 2035 were not available, so marginal system cost estimates from CPUC's Avoided Cost Calculator are used for the

[15] In basic terms, net metering provides retail rate compensation for customer-generated solar exported to the grid, while net billing provides avoided cost compensation for solar exports to the grid. Net billing compensation tends to be lower than net metering compensation.
[16] California investor-owned utilities are required to offer 30%–35% discounts to eligible low-income customers under the CARE program and 18% discounts for eligible middle-income families under the FERA program.
[17] LADWP's residential revenue requirement for Case 1 and SB 100 are from a March 2023 forecast.

investor-owned utility (IOU) service territory surrounding LADWP, Southern California Edison (SCE).[18] These costs are used for the TOU rates and IBFC modeling.

- **Fixed and Adjustable Tariff Design Elements:** Inputs including the number and timing of rate periods, rate price differentials, and tariff schedule distribution guide the model's optimization engine ("Model Run" in Figure 2).

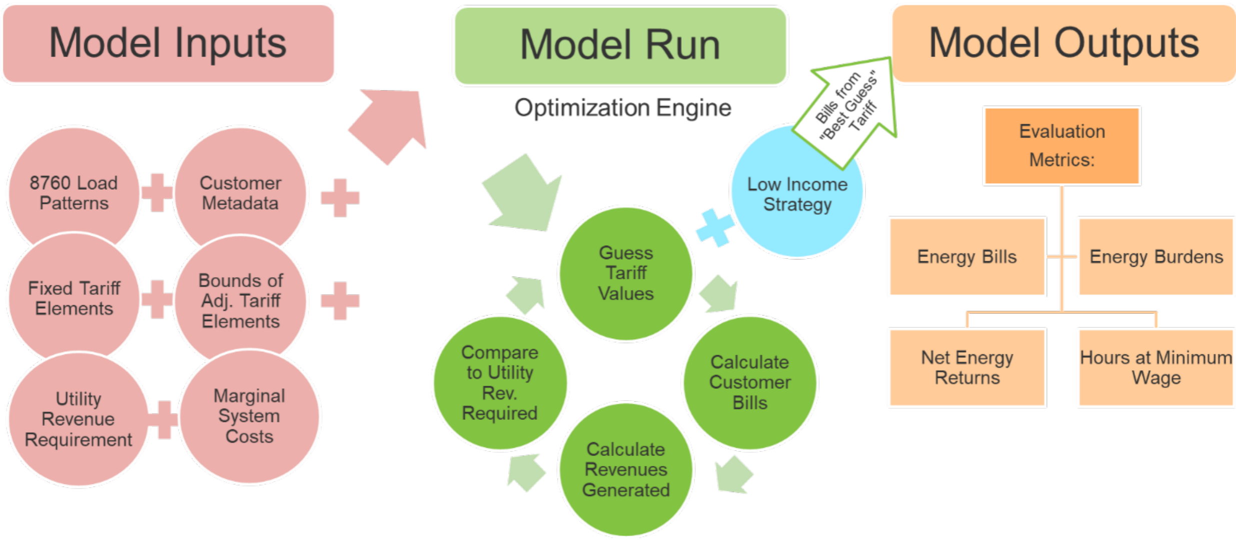

Figure 2. CAIRO model workflow summary

Using regulatory criteria on rate design, CAIRO identifies the optimal rate values that recover the utility's required revenues (i.e., the residential revenue requirement). These rates are then used to calculate customer bills based on individual household electricity usage. Low-income strategies are applied to customer bills based on criteria (e.g., customer location and income) mapped to individual customers. This step often requires customer bills to be recalculated, depending on the source of low-income assistance strategy funding. For example, low-income customer discount program costs may be recovered in rates charged to non-low-income customers through a volumetric line-item charge. The final customer-level bill outputs are evaluated by a series of equity and affordability metrics that help identify affordability trade-offs among rate design and assistance program strategies. The evaluation of the final electricity bills is performed by comparing four metrics:

- **Average Monthly Electricity Bills by Income Bin:** Here, we separate households by income bin, then calculate average monthly bill data (annual bill, divided by 12 months).
- **Energy Burden (electricity only):** This is a widely used metric to describe energy affordability. It is derived by dividing annual household-level income by annual household energy expense. If income is zero or bills are greater than income, energy burden metrics become infinite or negative.

[18] For SB 100, 2035 values were used directly as both LADWP and SCE are forecasted to have the same approximate share of renewable energy on their systems. For Case 1, 2045 values for SCE were used and adjusted to 2035$ as LADWP would have 100% renewable energy on its system in 2035, which SCE does not reach until 2045.

- **Hours at Minimum Wage (HMW):** This is a version of an affordability metric used by the CPUC that describes how many hours a person working at minimum wage would need to work to pay for an essential quantity of energy. We modify this metric by replacing essential energy quantity with the customer's average monthly electricity bill. The metric is calculated by dividing the monthly bill by the prevailing (and projected in the 2035 case) minimum wage rate.
- **Net Energy Return (NER):** This unitless metric describes the ratio of income dollars earned by a household for every dollar spent on energy (here, electricity only). It is calculated by subtracting annual electricity costs from annual income and then dividing by electricity costs. Higher NER values are more desirable than lower values. Compared to energy burden, this metric provides more useful treatment of income extremes such as households with zero or negative incomes, energy expenditures that exceed incomes, or higher incomes (Scheier and Kittner 2022).

These evaluation metrics are intended to contextualize bill costs in terms of affordability, equity, and disparate impacts, and to facilitate comparison and rank ordering. Where applicable, we contextualize the cost of a program strategy through the intra-class transfer cost metric. This transfer metric represents the low-income program costs that must be recovered from noneligible residential customers. For example, the transfer cost included in Table 2 (page 13) 13is the low-income assistance strategy cost as a percentage of the residential class revenue requirement.

Modeled evaluation metrics are included in Table 213, where all dollar values and metrics are in 2021 terms. The following are the scenario-strategy model combinations we evaluate. More information on these model scenarios can be found in Appendix A:

- **Model Run A: 2019 Baseline LADWP Rates** serves as a baseline to compare against future projections. It includes LADWP's 2019 calendar year tariff (see Appendix C), existing EZ-SAVE and Lifeline program, and 2019 residential revenue requirement. Residential single-family home rooftop solar PV generation offsets 4% of residential load, and net metering compensation is applied.
- **Model Run B: 2035 LADWP BAU Forecast** uses LADWP's projected Case 1 revenue requirement for 2035 and extrapolates tariff rates based on LADWP's current tariff rate design pattern and EZ-SAVE and Lifeline program enrollment levels. Residential single-family home rooftop solar PV generation offsets 26.5% of residential load, and net metering compensation is applied.
- **Model Run C: 2035 CPUC Tiered Rates** uses LADWP's 2035 Case 1 revenue requirement, CPUC guidance on tiered inclining block rate structure, and no low-income assistance program. Residential single-family home rooftop solar PV generation offsets 26.5% of residential load, net billing compensation is applied, and solar customers remain on tiered rates.
- **Model Run D: 2035 CPUC TOU Rates** uses LADWP's 2035 Case 1 revenue requirement, CPUC guidance on TOU rate structure and participation, and no low-income assistance program. Residential single-family home rooftop solar PV generation offsets 26.5% of

residential load, net billing compensation is applied, and all solar customers are put on a special TOU rate.

- **Model Run E: 2035 LADWP BAU with CARE and FERA** is the same as Model B, but it replaces the EZ-SAVE program with low-income bill assistance modeled after CARE and FERA programs offered by California IOUs and models similar discount and enrollment levels as the IOUs.
- **Model Run F: 2035 Tiered Rates with CARE and FERA** is the same as Model C, but it adds CARE and FERA bill assistance programs.
- **Model Run G: 2035 Tiered Rates with IBFC** uses the same rate design as Model C for recovery of marginal costs, but recovers residual cost[19] through fixed charges assigned to customers based on their income levels.
- **Model Run H: 2035 Tiered Rates with CARE and FERA and IBFC** is the same as Model G except it includes the CARE and FERA programs.
- **Model Run I: 2035 TOU Rates with CARE and FERA** is the same as Model D with CARE and FERA programs.
- **Model Run J: 2035 TOU Rates with IBFC** recovers marginal costs through TOU rates and recovers residual costs through fixed charges assigned to customers based on their income levels.
- **Model Run K: 2035 TOU Rates with CARE and FERA and IBFC** is the same as Model J with CARE and FERA programs.

The following models incorporate electrification of natural gas end-use technologies and therefore incorporate both gas and electricity bill cost data:

- **Model Run N2: 2035 LADWP BAU with On-Bill Tariff for Heat Pump Water Heaters** is the same as Model B but enrolls eligible customers in an on-bill tariff program for installing an energy-efficient heat pump water heater.
- **Model Run N5: 2035 LADWP BAU with On-Bill Tariff for Enhanced Insulation** is the same as Model B but enrolls eligible customers in an on-bill tariff program for installing enhanced insulation.

[19] Residual costs equal the total residential revenue requirement minus total system marginal costs. The residential revenue requirement is the amount of revenue the utility is permitted by regulators to collect from customers. Total system marginal costs are economic costs associated with serving customers.

2 Modeling and Analysis Results

A selection of equity metrics for most of the models explored is included in Table 2. These metrics summarize the following modeling and analysis results:

- If BAU continues, under the SLTRP Case 1's 233% (nominal) or 124% (real) residential revenue requirement increase, average monthly customer bills for the residential class will increase by 79% between 2019 and 2035.
- Under a continued net metering solar compensation structure, the inequity that exists in 2019 between solar adopters (who on average have much lower bills than non-adopters) is significantly exacerbated by 2035. Modeling indicates solar adopter average monthly bills were $69 lower than non-adopters in 2019 and will be $162 lower than non-adopters in 2035.
- The net metering-induced intra-class transfer from non-adopters, who are predominantly lower-income, to solar adopters, who tend to have higher income, is one contributor to the finding that in 2035 average monthly bills for the low-income customer are higher than average bills for the rest of the residential class. The average percent of household income spent on electricity bills for low-income customers increases from 7.8% in 2019 to 16.1% in 2035, and the number of households over 100% electricity burden increases from 4,760 to 23,000.

LMI Bill Savings Within the Existing Rate Structure

- On-bill tariff could reduce energy bills for some LMI households. Six technologies were tested within an on-bill tariff framework, partially subsidized through Inflation Reduction Act funds, to determine if bill savings could be achieved without requiring up-front investment from capital-constrained customers or cross-subsidization from other customers. Only LMI customers were considered eligible, the bill rider was limited to less than $50/month,[20] and threshold bill savings was defined as savings on total energy (power and gas) 25% higher than the bill rider applied. It is important to clarify that we identify technical potential for total potential customers served assuming the most cost-efficient use of funds. We do not consider implementation challenges, lack of customer awareness or interest, or other factors (e.g., larger portion of high-cost projects served) that would reduce the reach of this program. The technologies tested include:
  - Heat pumps (air-source or mini-split).
  - Heat pump water heaters.
  - Whole-home electrification: heat pumps, heat pump water heaters, induction ranges, electric clothes dryers, ENERGY STAR refrigerators.
  - Heat pumps and basic insulation.
  - Enhanced insulation.

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[20] The $50/month threshold was based on an approximate non-weighted average of bill riders from on-bill tariffs implemented by electric utilities; see Deason, Murphy, and Leventis (2022).

- LEDs, as a test case (see details in Appendix A).

The only technologies that delivered sufficient bill savings at a reasonable monthly bill rider were LED lighting, heat pump water heaters, and enhanced insulation. For heat pump water heaters, the participant-wide monthly bill rider was $17/month with the potential to serve 154,000 LMI on-bill tariff customers; see electricity bill and total energy bill (gas and electricity) savings shown in Figure 3. For enhanced insulation, the monthly rider was $17/month and the number of customers potentially served was 72,000 (see Figure 4). On-bill tariff-eligible customers are in the LMI groups and tend to have higher energy bills than customers who are not eligible for the on-bill tariff program due to income ineligibility or lower energy bills.

The on-bill tariff approach recovers costs over time from the customers receiving benefits, and the efficiency technologies modeled receive Inflation Reduction Act funding. Additionally, bill riders only apply to enrolled customers. Because this program approach may not trigger a ballot action or violate Proposition 26 and Proposition 218, we model the on-bill tariff program with heat pump water heaters and enhanced insulation using the 2035 LADWP BAU rate strategy.

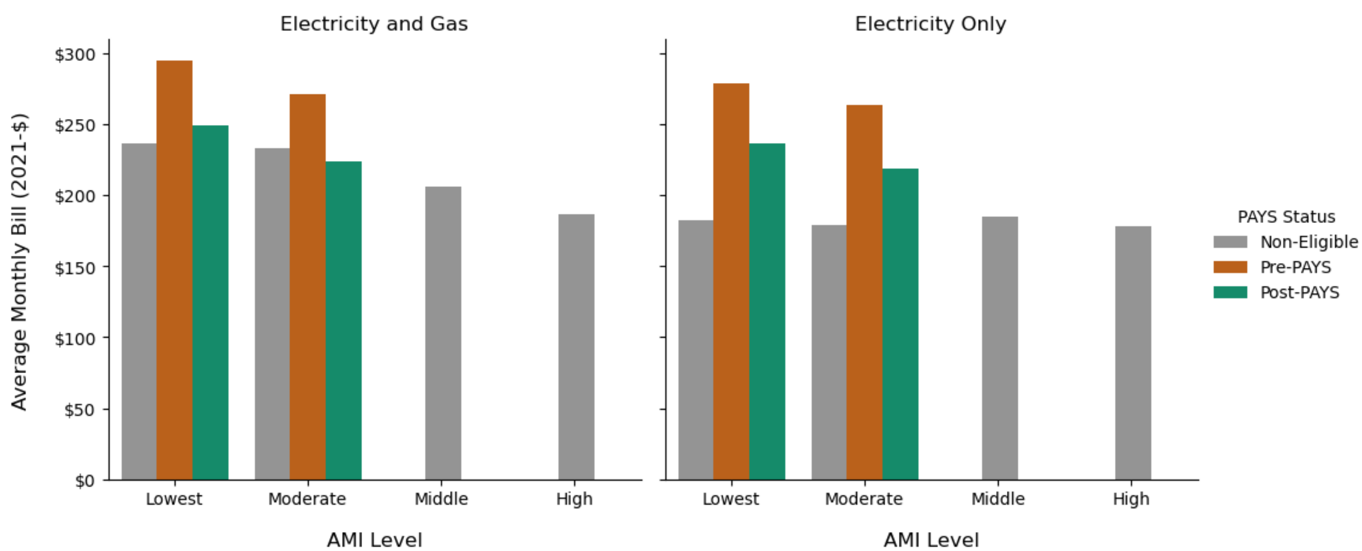

Figure 3. Average monthly bills for on-bill tariff with heat pump water heater customers and noneligible customers using LADWP BAU rates in 2035

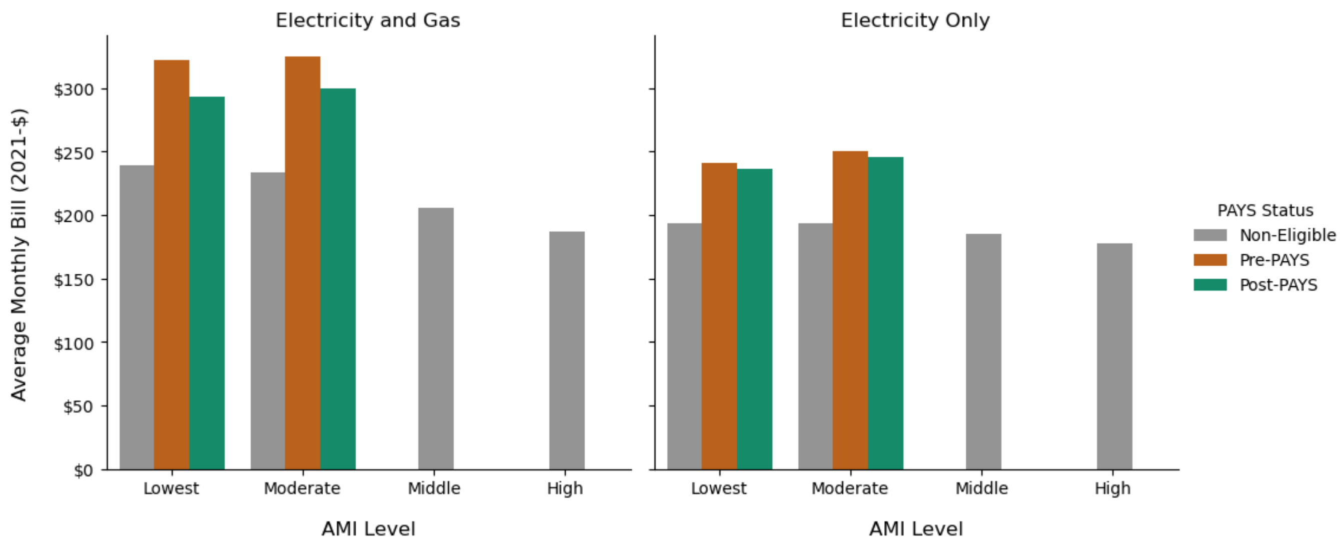

Figure 4. Average monthly bills for on-bill tariff with enhanced insulation customers and noneligible customers using LADWP BAU rates in 2035

As shown in Figures 3 and 4, total energy bills of higher-income customers are expected to decline by 2035 (left panels), as these customers are projected to electrify end uses with high-efficiency appliances, reducing natural gas use and costs and increasing the efficiency of electricity usage (right panels). See Appendix F for additional details.

Only LMI households were enrolled for the on-bill tariff program. Of the households that achieved bill savings from an on-bill tariff-funded heat pump water heater, 68% of the dwellings were built before 1980 and had electric water heating. In addition, 65% of these households had cooling. Heat pump water heaters can provide a co-benefit of cooling by removing heat from conditioned spaces.

Of the households that achieved bill savings from on-bill tariff-funded enhanced insulation, more than 67% have natural gas heating fuel and live in dwellings built before 1980. Of the household enrolled for enhanced insulation, 81% of the household have access to whole-home or partial cooling. For more information, please see Appendix G.

Changes to Rate Design and Solar Compensation Policy Improve Equity

Even without the EZ-SAVE and Lifeline programs, outcomes for low-income customers improve by changing rate design to simplified tiers or a TOU rate, switching from net metering to net billing for solar compensation, and adding a program to incrementally boost LMI solar adoption.[21,22] These reforms decrease inequity between solar adopters and non-adopters and incrementally improve affordability for low-income customers.

[21] See Appendix A for a description of the low-income solar adoption program modeled.
[22] Our focus with changing solar compensation strategies is limited to determining if more equitable and affordable outcomes may exist for low-income customers. We do not evaluate how the change in compensation strategies may impact total solar penetration; rather, we hold these penetration levels constant at target levels.

- Inequity is reduced as the cost spread between solar adopter and non-adopter average monthly bills shrinks from $162 in the BAU scenario to $55 for the simplified tiers and $65 for TOU rates. Compared to tiered rates, solar adopters see lower bills with TOU rates, as the timing of solar generation allows these customers to avoid grid electricity use during certain high-price periods. The improvement in equity between solar adopters and non-adopters can be seen in Figure 5, where moving to net billing with simplified tiers or TOU rates results in a narrower spread between adopter and non-adopter average monthly bills, in all income bins.
- Affordability improves as average monthly bills for low-income households fall about $10 below the average monthly bills for the entire residential class. However, average electricity burdens are still high for low-income households at approximately 15% for both simplified tier and TOU, and there are at least 19,500 households with electricity burdens over 100%.

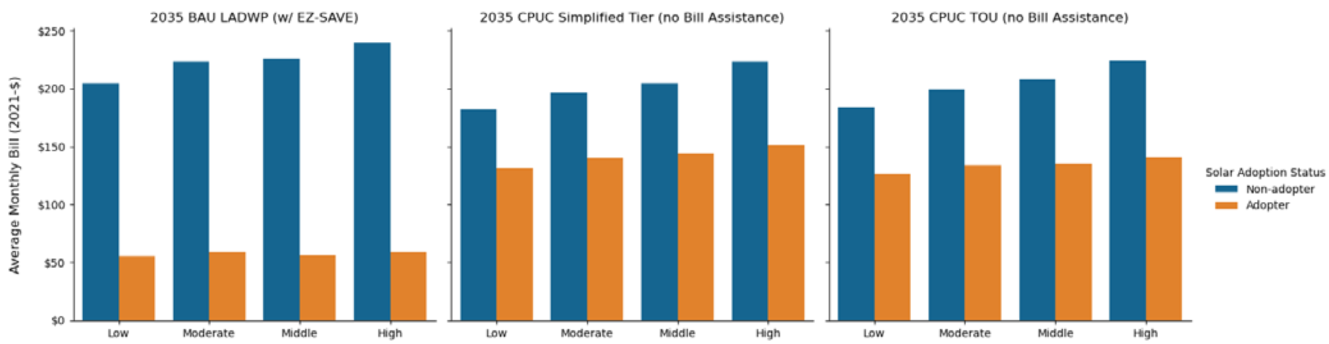

Figure 5. Average monthly bills by scenario and area median income group for solar adopters and non-adopters in 2035

For the 2035 BAU LADWP (with EZ-SAVE), solar PV is compensated under a net metering scheme, while for the other two scenarios solar PV is compensated under a net billing scheme.

Robust Low-Income Assistance Programs Improve Affordability

The addition of robust low-income assistance programs to updated rate design and reformed solar compensation mechanisms results in significant improvements to low-income energy bill affordability. Establishing robust assistance programs modeled after CARE and FERA results in higher bill savings and enrollment rates than LADWP's existing EZ-SAVE and Lifeline programs.

Equity further improves as the spread between solar adopter and non-adopter average monthly bills decreases to $29 (simplified tiers) and $39 (TOU).

- Compared to only updating rate design and solar compensation, affordability improves significantly as low-income average monthly bills drop by $40, electricity burdens are reduced from 15.2% to 12.2% (simplified tiers) and 15.4% to 12.4% (TOU), and households over 100% electricity burdens decrease by at least 8,300 households.

Establishing robust low-income assistance programs requires a significant subsidy ranging from $307 million to $335 million, or 9.5%–10.4% of the residential revenue requirement. We model this cross-subsidy coming from non-enrolled residential customers. In practice, this program would also be supported by customers from the commercial, industrial, and other classes.

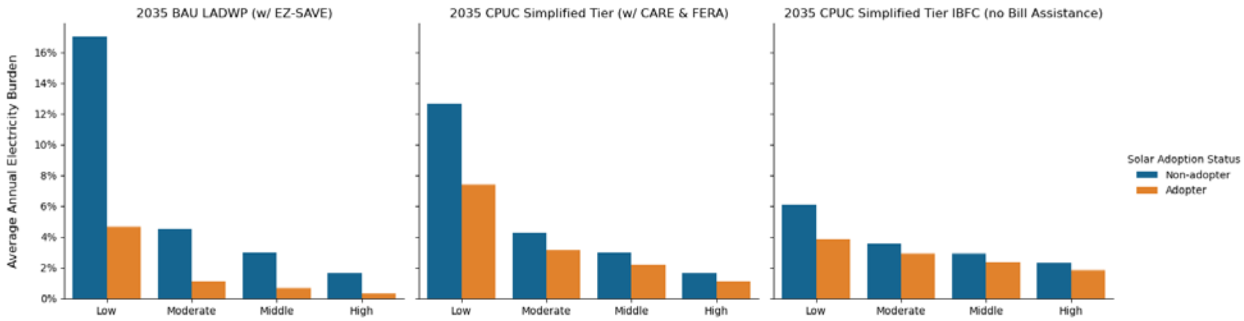

Figure 6. Annual electricity burden by scenario and area median income group for solar adopters and non-adopters in 2035

For the 2035 BAU LADWP (with EZ-SAVE), solar PV is compensated under a net metering scheme, while for the other two scenarios solar PV is compensated under a net billing scheme.

Income-Based Fixed Charges Achieve Affordability

The strategies discussed thus far *improve* equity and affordability for low-income households; however, affordability is *achieved* through IBFC. Here, we define affordability as an electricity-only burden under 6%.[23] Even as higher-income energy burdens are slightly increased, the IBFC strategy brings average electricity burdens for all customers under 6% (Figure 5 and Appendix E). As shown in Figure 6, IBFC narrows the energy burden disparity across income groups more than other approaches modeled.

- Although affordability is achieved, higher-income customers are charged a larger portion of fixed costs based on their ability to pay, and not related to their actions (e.g., usage). Furthermore, higher fixed charges could conflict with other energy policy priorities such as incentivizing energy efficiency investments. IBFC in this regard will require consideration for the trade-offs in policy priorities, between equity and affordability on the one hand and energy conservation priorities on the other.
- Also in this scenario, on average, solar adopters tend to have higher average monthly bills than non-adopters, which could impact residential rooftop solar adoption. However, these higher average bills are a function of weighted averages. Table 1 shows the solar adopter and non-adopter customer counts for each income group, along with their average monthly bills. The table confirms that solar adopters on average are saving money, and the majority of solar adopters have higher incomes and higher average bills, therefore driving up the adopter-wide average monthly bill.

[23] The 6% affordability threshold is typically associated with energy burden (i.e., all household energy use, including electricity and natural gas). In the absence of a threshold for electricity-only burden, we use the 6% threshold as an approximation for an affordable level.

Table 1. Customer Counts and Average Bills by Solar Adopter and Non-Adopter Status Using TOU Rates with IBFC and with CARE and FERA programs (2035)

TOU Rates with IBFC, CARE, and FERA				
Area Median Income (AMI) Bin	**Solar Non-Adopter**		**Solar Adopter**	
	Count	**Avg. Bill ($2021)**	**Count**	**Avg. Bill ($2021)**
Very Low	327,700	$30.93	26,000	$21.29
Low	192,400	$113.98	27,300	$99.38
Moderate	218,600	$175.42	54,400	$161.83
Middle	207,600	$224.61	60,100	$208.06
High	316,100	$342.58	141,400	$322.11

As shown in Table 2 (and Appendix E), electricity affordability decreases for moderate-income households between the 2019 baseline and 2035 BAU model forecasts. Most strategies explored in this analysis do not meaningfully improve affordability for moderate-income households. We ran sensitivity analyses to determine if increasing the FERA program participation rate from 14.6% to 89% of eligible households would improve moderate-income affordability. The results indicate enrollment expansion alone would not lead to significant bill savings or improved affordability metrics for moderate-income households. More research is required to identify strategies to target this income group and could include raising the eligible income threshold or increasing discounts.

This analysis is not a comprehensive review of all rate and program design options available to LADWP, nor does the analysis attempt to categorize all the costs, benefits, and trade-offs that occur among design choices. The analysis focuses on impacts to low-income households, defined here as including households with annual income of 0%–50% area median income (AMI). The rate and program design approaches modeled are currently or soon to be implemented by other California utilities based on CPUC guidance. A more holistic analysis of rate design would include metrics to identify intra-class cross-subsidies, deadweight loss,[24] and other trade-offs.

Table 2 summarizes the rate affordability and equity modeling results, excluding on-bill tariff results, which are shown in Table 3. Results were reported separately for the on-bill tariff program, as both gas and electricity costs to the customer must be accounted for when comparing the bill impacts of electrifying end uses.

[24] Deadweight loss is a metric that describes how efficiently (zero or no deadweight loss) or inefficiently (high deadweight loss) a resource such as electricity was utilized. In simple terms, deadweight loss typically occurs through a mismatch of supply-and-demand market forces. For example, if a pizza store bakes 50 pizzas for an event but only sells 45 pizzas, and the remaining 5 pizzas go unsold and rot, these 5 unsold, rotten pizzas are considered deadweight loss.

Table 2. Rate Affordability and Equity Modeling Results

Rate Equity Metric	2019 LADWP Baseline w. EZ-SAVE	2035 LADWP BAU w. EZ-SAVE	Simplified Tiers	TOU Rates	LADWP BAU w. CARE & FERA	Simplified Tiers w. CARE & FERA	TOU Rates w. CARE & FERA	Simplified Tiers w. IBFC	TOU Rates w. IBFC	Simplified Tiers w. IBFC, CARE & FERA	TOU Rates w. IBFC, CARE & FERA
Avg. Monthly Bill (All Households)	$105	$188	$188	$188	$188	$188	$188	$188.00	$188	$188	$188
Avg. Monthly Bill (Low-Income, 0-50% AMI)	$83	$193	$178	$179	$151	$138	$138	$81	$81	$62	$62
Avg. Monthly Bill (Solar PV Adopters, all incomes)	$38	$58	$144	$136	$86	$165	$157	$215	$217	$225	$227
Avg. Monthly Bill (Non-adopters, All Incomes)	$107	$220	$199	$201	$213	$194	$196	$181	$181	$179	$179
Transfer Cost ($)*	$10.3M**	$10.4M**	–	–	$335M	$307M	$309M	–	–	$153M	$153M
Transfer Cost (% – Share of Revenue Requirement)*	0.7%**	0.3%**	–	–	10%	9.5%	9.6%	–	–	4.8%	4.8%
Average Annual Electricity Burden for:											
All Households	3.7%	7.2%	6.9%	7.0%	6.4%	6.0%	6.1%	3.8%	3.8%	3.3%	3.3%
Low-Income, 0-50% AMI	7.8%	16%	15%	15%	13%	12%	12%	5.9%	5.8%	4.1%	4.1%
Moderate-Income, 50-80% AMI	2.1%	4.0%	3.7%	3.8%	4.3%	4.1%	4.1%	3.4%	3.4%	3.6%	3.6%
Number of Households Over 100% Electricity Burden	4,800	23,000	20,000	20,000	13,000	11,000	11,000	4,400	4,400	4,000	4,000
Average Monthly Hours Worked at Minimum Wage for:											
Avg. Hours (All Households)	7	14	14	14	14	14	14	14	14	14	14
Avg. Hours (Moderate-Income, 50-80% AMI)	6.9	14	13	13	15	15	15	12	12	12	12
Avg. Hours (Low-Income, 0-50% AMI)	5.5	14	13	13	11	9.9	9.9	5.8	5.8	4.4	4.4
Average Annual Net Energy Return (Electricity Only) for:											
All Households	121	88	62	59	65	56	53	39	38	41	40
Low-Income, 0-50% AMI	55	16	16	16	18	21	20	32	31	40	39
Moderate-Income, 50-80% AMI	82	48	43	40	37	37	35	30	30	29	29

Baseline

More Affordable

Less Affordable

No Change

* for EZ-SAVE & Lifeline or CARE & FERA

**The model did not recover Lifeline program expenses from the residential revenue requirement, which makes transfer costs lower than if these program expenses were recovered solely from the residential class.

Dollar values are adjusted to 2021$. Each row is color-coded relative to other values in the row: green signifies more affordable outcomes for low-income customers, red represents less affordable outcomes, and yellow denotes values midway between green and red. Gray indicates functionally equal results. Results for all income groups are available in Appendix E.

Table 3. Heat Pump Water Heater On-Bill Tariff (e.g., Pay-As-You-Save) Energy Bill Impacts	2035 BAU LADWP (with EZ-SAVE)	2035 LADWP BAU On-Bill Tariff Heat Pump Water Heaters (No Bill Assistance)		2035 LADWP BAU On-Bill Tariff Enhanced Insulation (No Bill Assistance)	
	All Customers	Participating Customers Only		Participating Customers Only	
		Pre-Installation	Post Installation	Pre-Installation	Post Installation
Average monthly combined electricity and gas bill (all households)	$222	$285	$238	$323	$296
Average monthly combined electricity and gas bill (low income)	$245	$295	$249	$322	$293
Average monthly combined electricity and gas bill (solar adopters, all incomes)	$90	$128	$101	$177	$145
Average monthly combined electricity and gas bill (non-adopters, all incomes)	$254	$291	244	$341	$315
Transfer costs ($)	$10,400,000	$0	$0	$0	$0
Transfer costs (share of revenue requirement)	0.3%	0%	0%	0%	0%
Average combined electricity and gas burden (all households)	8.3%	14.2%	13.3%	15.1%	14.4%
Average combined electricity and gas burden (low income)	18.7%	21.3%	20.2%	20.3%	19.3%
Average combined electricity and gas burden (moderate income)	4.9%	5.6%	4.7%	6.6%	6.1%
Households over 100% combined electricity and gas burden (all households)	32,900	8,350	6,180	3,120	2,580
Average month HMW (all households)	15	19	16	22	20
Average month HMW (moderate income)	16	18	15	22	20
Low-cost month HMW (low income)	12	16	13	15	15
Average month HMW (low income)	16	20	17	22	20
High-cost month HMW (low income)	23	25	21	33	27
Average annual NER (all households)	108	19	23	17	19
Average annual NER (low income)	15	10	12	11	12
Average annual NER (moderate income)	43	31	38	27	30

3 Equity Strategies Discussion

As LADWP pursues clean energy goals, model results indicate continuing the current rate and bill assistance program approaches with the existing complex rate design will lead to more inequitable and unaffordable outcomes for low-income households. Though LADWP is constrained from pursuing solutions available to most utilities under current state statutes, if these barriers were removed, several approaches would increase electricity rate equity and affordability in LA's transition to 100% clean energy. In addition, an on-bill tariff program for at least two efficiency technologies could reduce bills within the existing rate approach. Strategies include:

- **Update rate design and solar compensation method:** Low-income average electricity bills would decrease by $14–$15/month, and the disparity in the share of system costs paid by solar adopters and non-adopters would decrease by revising rate design from LADWP's existing multiperiod, complex rates with the EZ-SAVE and Lifeline programs and net metering policy to (1) either a simplified tiered inclining block rate structure or a default TOU rate structure, both as recommended by the CPUC, and (2) shifting from net metering to net billing customer-sited solar compensation. A change in rate design strategy would likely result in loss of the annual transfer to the city's General Fund (Carmen A. Trutanich 2012).[25] Eliminating the transfer requirement from customers to the city of Los Angeles would reduce rates for all customers while reducing the city's General Fund. Such a rate design change might also lead to challenges maintaining existing low-income bill assistance programs like EZ-SAVE and Lifeline.
- **Enhance low-income assistance programs:** Replacing the EZ-SAVE and Lifeline programs with a more robust low-income energy assistance program approach modeled after the CARE and FERA programs results in 22% lower monthly electricity bills for low-income customers, even if BAU rate design remains. This low-income assistance program approach requires funding from non-low-income customers, which is explicitly prohibited by California Proposition 26 and California Proposition 218 (League of California Cities 2021). It is unclear how LADWP could fund a robust low-income program without triggering a proposition challenge.
- **Explore innovative IBFC to achieve affordability:** IBFC would reduce low-income electricity bills by nearly $100/month and improve affordability more than all other approaches modeled. California passed Assembly Bill 205 in June 2022, allowing for implementation of IBFC for IOUs in the state. The CPUC is currently considering design and implementation approaches. Implementation presents practical challenges, particularly related to income verification (Severin Borenstein, Meredith Fowlie, and James Sallee 2022).

[25] The city of Los Angeles receives money through electricity bills via two mechanisms: the Utility User Tax and the annual transfer (known as the Power Revenue Transfer). The former appears as an explicit line item of 10% in nonexempt customers' bills. The latter is integrated into LADWP rates, as it must recover its revenue requirements and the city transfer costs. The Utility User Tax would be unaffected by a rate design change. In the 2022–2023 city budget, the Utility User Tax represented $614.1 million in revenue (8.25% of the General Fund) and the Power Revenue Transfer represented $229.7 million in revenue (3.09% of the General Fund) (City of Los Angeles 2022).

Implementing IBFC would likely violate the California propositions because residual costs would be assigned to customers based on income and not costs.

- **Leverage federal Inflation Reduction Act funding through an on-bill-tariff program for LMI customers:** Modeling indicates a heat pump water heater or enhanced insulation on-bill tariff program could reduce energy bills for nearly 154,000 or 74,000 LMI customers, respectively. This strategy could potentially be implemented without violating Proposition 26 and Proposition 218.

Most options to improve low-income equity and affordability are not currently available for LADWP given its unique constraints as a municipal utility subject to the restrictions of California Proposition 26 and California Proposition 218. In addition, as a municipal utility, LADWP is not subject to CPUC jurisdiction. Compared to 2019, modeling indicates a BAU approach with the existing, complicated rate design practices with layered cost-based adjustment factors and line-item bill riders would increase inequity and result in decreased electricity bill affordability for low-income households by 2035. The clean energy transition does not need to be inequitable; however, electric utilities could evolve their approach to rates and rate-making to ensure affordable outcomes for low-income populations.

Table 4. Equity Strategy Options: Benefit, Cost, Timeline, Responsibility, and Evaluation Metrics

NREL modeled the impacts of rate design changes, an on-bill tariff program for energy efficiency technologies, and low-income assistance strategies. Implementation of some strategies is likely to conflict with California Proposition 26 and California Proposition 218.

Equity Strategy	Benefit/Impact	Cost[a]	Timeline	Responsible Party	Metric
Implement an on-bill tariff program leveraging Inflation Reduction Act funds, to support heat pump water heater or enhanced insulation installation for low-income customers	Technical potential for nearly 154,000 and 74,000 LMI customers to save on energy bills through on-bill financed heat pump water heaters and enhanced insulation, respectively.	Leverages Inflation Reduction Act funds. Only participating customers are assessed monthly bill riders	Possible rate case or other action to establish on-bill tariff, then identify program implementor and launch program	LADWP could initiate the program. May or may not need rate case to establish the on-bill tariff.	Income-eligible customers who qualify for the program will see energy (gas and electricity) bill savings 25% higher than the program bill rider. Number of participating households
Update rate design to simplified tiers or default TOU, switch from net metering to net billing solar compensation, and moderately boost low-income solar adoption	Low-income electricity bills would decrease by $14–$15/month. Reduces disparity between solar adopter and non-adopter contributions toward system costs. 3,300–3,500 fewer customers with >100% energy burdens than BAU	Uncalculated cost of moderate low-income solar adoption program. Improved price signals could promote cost savings if customers respond by avoiding consumption in higher-priced periods	Referendum or legislative change and rate case with rate redesign required	Government entity, citizen, or LADWP initiates, and LADWP's board and city council approve results of rate case.	Average monthly electricity bill savings. Reduced intra-class cross-subsidization for solar compensation. Reduced number of customers over 100% energy burden. Customer satisfaction and customer understanding surveys preapproved and post-approved rate design changes[b]

Equity Strategy	Benefit/Impact	Cost[a]	Timeline	Responsible Party	Metric
Implement robust CARE/FERA-type low-income assistance program	22% lower electricity bills for low-income customers Monthly assistance increases from $5.78/month under EZ-SAVE to ~$54/month under CARE and ~$37/month under FERA. Increase in assistance recipients from 150,000 under EZ-SAVE to 436,000 under CARE and FERA Larger cross-subsidy from nonparticipating to participating customers[c]	On average, $307–$335 million/year in reallocated funds (compared to $35 million for EZ-SAVE, Lifeline, and two smaller assistance programs in 2020)	Referendum or legislative change and rate case with rate redesign required	Government entity, citizen, or LADWP initiates, and LADWP's board and city council approve results of rate case.	Equitable access to bill discount programs can be measured in reference to California utility averages of 30%–35% discount on electric bills for enrollees. Eligible enrollment rates of 89% for CARE and 15% for FERA
Explore IBFC	58% (nearly $100) lower average monthly electricity bills for low-income customers With IBFC, all customers are under the 6% energy burden affordability threshold.	No direct low-income program budget required. Costs for income verification. Higher fixed costs and bills for higher-income customers. Potential for weaker price signals to reduce incentive to conserve, which may incentivize electrification	Referendum or legislative change and rate case with rate redesign	Government entity, citizen, or LADWP initiates, and LADWP's board and city council approve results of rate case.	Change in energy burden by different income bins

[a] Any strategy that requires a rate case with departure from LADWP's BAU rate design is likely to result in cessation of the ≈$220-million annual transfer to the city of Los Angeles, which in turn would reduce customer rates.

[b] For example, see Hiner & Partners "Residential Rate OIR Customer Survey Key Findings," April 16, 2013, available in Appendix A.1 of Pacific Gas and Electric Company's 2013 rate design proposal (Christopher Warner and Gail L. Slocum 2013).

[c] Under BAU, customers save on average $5.78/month (7.5% of their monthly bill) with approximately 150,000 participating customers in 2035 for a total program cost of $10 million (0.3% of revenue requirement). Under CARE/FERA and renter's discount programs, customers save on average $14–$55/month (10%–33% of their monthly bill), depending on the program; a total of approximately 520,000 customers participate across all programs, and the total program cost ranges from $310 million to $340 million (9.5%–10% of revenue requirement).

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Appendix A. Low-Income Bill Equity and Affordability Detailed Methodology

A.1 Basic Model Inputs

The Customer Affordability, Incentives, and Rates Optimization (CAIRO) tool developed by the National Renewable Energy Laboratory (NREL) and used for this analysis leverages data inputs for customer loads and demographics, utility revenue requirement, hourly system marginal costs, and information on tariff design to estimate how retail tariffs and associated energy bills and burdens will evolve under different scenarios. These data include:

- **Customer Loads:** Hourly load profiles for electricity and natural gas consumption generated for 50,000 representative Los Angeles households using the ResStock model (see Chapters 6 and 7) are used in the model to calculate customer bills based on modeled tariff design and rates. Solar generation is assigned to single-family homes based on historical income-differentiated household adoption patterns and maximum aggregate solar penetration.
- **Customer Metadata:** Demographic metadata associated with each representative customer are used to determine energy burden (e.g., income estimates), eligibility for certain rates and/or bill assistance programs (e.g., income estimates, renter or owner occupancy status, and location), and to analyze trends across customer types.
- **Revenue Requirement:** Revenue targets are used within the optimization process to set rate values by adjusting rates until the target revenue for the utility is reached. Revenue targets are provided, exogenously, by the Los Angeles Department of Water and Power (LADWP).
- **Hourly System Marginal Costs:** Marginal costs are used to inform the development of rates based on recommended rate-making principles and guidance from the California Public Utilities Commission (CPUC), as well as the development of income-based fixed charges (IBFC) for low-income strategies.
- **Customer Mapping:** The CAIRO model requires the user to indicate how information such as load profiles and retail tariffs should be mapped to prototypical customers. These model mapping files connect building and customer data in the prototypes to key model inputs.
- **User-Determined Tariff Guidance:** The model requires the user to distinguish between fixed and variable tariff elements, with the former being held constant across a given scenario and the latter being adjusted to meet the revenue requirement.[26] For variable tariff elements, the user also supplies the bounds within which the model can explore.

A.2 Customer Loads and Metadata

For this analysis, 50,000 8760 hourly energy use (electricity and natural gas) profiles were generated from ResStock using a combination of 100 housing characteristics to form a representative sample of prototypical LADWP residential customers. Each prototypical customer was associated with a weight capturing how prevalent the customer "type" was in LADWP's territory. This weight was used to scale the prototypical customers to represent hourly energy usage and associated bills for LADWP's more than 1.57 million estimated residential customers

[26] An example of fixed tariff elements includes the number and associated consumption limits of each rate tier. An example of variable elements includes the charge ($/kWh) associated with each rate tier.

in 2035. In addition to generating energy use profiles, the ResStock model associates metadata with each prototypical customer, including information such as housing tenure, vintage, number of occupants, household income estimates, and climate zone. These metadata were used to determine eligibility for low-income bill assistance programs such as California Alternate Rates for Energy (CARE), Family Electric Rate Assistance (FERA), and EZ-SAVE; produce estimates for energy burden and net energy return (NER) metrics; and organize results along different defining characteristics (e.g., multifamily homes versus single-family homes and low-income families versus high-income families). Detailed income assumptions based on 2019 American Community Survey data were used for each prototypical customer in 2019$ for 2019. These income levels were assumed to stay constant in real dollar values (i.e., income grew at the pace of inflation such that real wages remained constant), and they were converted to 2021$ before determining eligibility criteria for bill assistance programs or for calculating energy burden. For additional information on how these demand profiles were generated, see Chapter 6.

Weather Differences for 2012, 2019, and 2035

Weather is an essential element of residential building energy usage, as more than half of energy use in average U.S. residential buildings is due to space heating and cooling (U.S. Energy Information Administration 2022). We used weather forecasted in 2035 by weighting 2012 actual meteorological year (AMY) weather data using the methodology described in Chapter 3 of the LA100 study (Hale et al. 2021). In contrast, the rate analysis used 2019 AMY to calibrate the rate models and align modeled customer demand with actual customer demand for LADWP.

We compared 2012 and 2019 AMY weather files to estimate the potential impacts on residential building loads. Using 2012 AMY as a substitute for 2019 weather year increases cooling demand by about 4.7% and increases heating demand by 8.8% for most LA households (i.e., households in Climate Zone 9). Therefore, using 2012 AMY results in a slight overestimation of residential building loads.

A.3 Revenue Requirements

LADWP supplied actual and projected revenue targets by customer class for historical and future years (LADWP uses a fiscal year that runs from July 1 to June 30). For future years, these revenue targets were based on results of LADWP's Strategic Long-Term Resource Plan (SLTRP). The model and results relied on two SLTRP scenarios:

- California Senate Bill 100 (SB 100) assumes LADWP reaches 100% clean energy by 2045 and 80% clean energy by 2035.
- Case 1 assumes LADWP reaches 100% clean energy by 2035.

The residential revenue requirement for the fiscal year ending June 30, 2019, was $1.369 billion. The SLTRP SB 100 scenario projects a residential sector revenue requirement of $3.341 billion and SLTRP Case 1 projects $4.552 billion for 2035 (all in nominal dollar-year terms). These revenue requirement projections were developed by LADWP in March 2023.[27]

The revenue requirement is the main driver of rate and bill increases in this analysis. Validating LADWP's revenue requirement forecasts was not in NREL's scope of work. If LADWP's revenue requirement overstates or understates required LADWP costs, then the rates identified in this report will be higher or lower than what is needed to achieve compliance.

Certain customer-level activities have the potential to reduce costs to LADWP, in turn reducing the revenue requirement. In our analysis, these activities include energy efficiency and conservation from the on-bill tariff program, and on-site solar generation that offsets customer loads. These activities lead to "avoided costs" to LADWP, which we do not separately quantify. While LADWP's revenue requirement forecasts do incorporate certain on-site solar-related avoided costs, we do not validate these projections against the solar penetration levels in the rates analysis, which were informed by LA100 study estimates.

Note: Results for select rate scenarios under the SB 100 revenue requirement are available in Appendix D. These results provide an indication for the sensitivity of the analysis' results to assumptions around revenue requirements.

Hourly Marginal Costs

LADWP-specific marginal cost projections were unavailable to NREL, which results in a significant shortcoming of this analysis. As an alternative, we relied on the CPUC's Avoided Cost Calculator's (ACC's) annual hourly marginal costs for the Southern California Edison (SCE) service territory that surrounds the LADWP territory (California Public Utilities Commission 2022a). LADWP's marginal costs are likely different from SCE's marginal costs. Therefore, use of the SCE ACC for LADWP likely result in certain misrepresentations. For example, inaccurate intra-daily supply cost patterns and inaccurate total residual costs (total revenue requirement minus marginal costs) potentially distort metrics associated with IBFC. The marginal cost data are also required for calculation of the TOU rates and the IBFC. For SB 100, we used the SCE marginal costs in 2035 because the utility must also comply with SB 100. For Case 1, we use SCE's marginals costs in 2045, when the utility is expected to meet the 100% clean energy requirement,[28] and adjust dollar values from 2045$ to 2035$. This allows us to keep the marginal cost patterns consistent with 100% clean energy compliance while eliminating the 2% rate of annual inflation incorporated by the ACC. There are several climate zones within SCE that are present in the ACC. This model "blends" 8760 hourly marginal cost estimates for the four climate zones that overlap LADWP and SCE territories (6, 8, 9, and 16) to arrive at a

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[27] Bill and burden results in this analysis are extremely sensitive to assumptions around the revenue requirements for future years. The estimated revenue requirements used for this analysis were taken exogenously from LADWP and there was no opportunity to independently verify or confirm these estimates. As part of its planning exercises, LADWP will be constantly adjusting these estimates, and in future years the revenue requirements may ultimately be significantly higher or lower than what was used here. Regardless, the authors believe that the general directionality of the results will remain, even under different assumptions for revenue requirements.

[28] In 2045 the ACC assumes SCE meets a certain portion of the 100% clean energy requirement through use of "greenhouse gas adders" or offsets.

single set of LADWP-representative hourly marginal costs. Hourly load by each zone is used to weight the corresponding marginal cost estimates and then averaged.

A.4 Customer Mapping

Prototypical LADWP customers from ResStock were mapped to additional data as needed to inform the modeling exercise. This included:

- **Tiered Rate Zones:** Customers were mapped to either Climate Zone 1 or Zone 2 based on geospatial data supplied by LADWP. This is consistent with LADWP's current rate structures, which set higher consumption limits for customers in Zone 2 for the tiered rates (R1-A) to accommodate higher loads due to hotter climate conditions. These zones were also used when allocating tier consumption levels under the tiered rate structure, based on guidance from the CPUC. Zones were not relevant for time-of-use (TOU) rates.
- **Tariffs:** Customers were mapped to tariffs based on the modeling scenario and unique customer attributes. For most model runs A, B, C, E, F, G, H, L, and M, all customers within a given model run shared the same residential retail tariff structure (although the tariffs differed across model runs).[29] Model runs A, B, E, and N relied on tiered rates aligned with LADWP's current residential tariffs. Model runs C, F, G, H, and L relied on simplified tiered rates matching CPUC guidance. For model runs D, I, J, K, and M, however, customers were assigned to *either* TOU rates (if eligible) *or* tiered rates based on assumed customer income and monthly demand, in line with CPUC guidance to investor-owned utilities (IOUs) and resulting in approximately 73% of residential customers assigned to TOU rates and 27% on inclining block rates. For model runs with TOU rates, the same inclining block energy charge rates were used from scenarios where all customers were assigned inclining block rates. In other words, the TOU energy charges were optimized in isolation to recover the remaining revenue requirement after revenues from customers on the already-optimized inclining block rates had been removed.
- **Loads:** Customers were mapped to specific load profiles by a combination of weather, climate, occupancy, behavioral patterns, and technology adoption. While most of these variables were held constant across all model runs, for certain runs (e.g., on-bill tariff), different technology adoption patterns were implemented to measure the impact of energy efficiency and electrification measures on affordability. Specifically, customer loads were decreased or increased in certain hours consistent with the use patterns for the relevant efficiency or electrification technology or technologies. In addition, certain ResStock building load profiles were adjusted to incorporate generation from rooftop solar systems on single-family homes. Solar was randomly assigned to single-family homeowners based on the adopter household income distribution and total aggregate solar generation targets. Maximum solar generation for each household was based on load and Distributed Generation Market Demand (dGen) data for developable rooftop space and system capacity factor.

[29] See Section 1 for a list of the models.

A.5 User-Defined Tariff Inputs

In addition to the above input data, the model requires the user to identify tariff design constraints for fixed and variable elements of the optimization. Fixed tariff elements are inputs not eligible for adjustment by the optimization. Variable elements serve as bounds for values within which the model can select when running through the optimization process. Generally, only volumetric energy charges were allowed to be optimized within the model to meet (1) forecasted revenue collected through specific rate components from LADWP or (2) guidance for the California IOUs from the CPUC.

Fixed charges, minimum bills, and demand charges (if applicable) were not considered optimizable within the model, because either (1) the CPUC discouraged their use, (2) they were calculated based on fixed values (e.g., residual costs and number of customers), or (3) LADWP forecasts indicated these values would not change by 2035. The timing of TOU periods and the consumption levels associated with tiered (inclining block rates) were also not considered optimizable. TOU periods were set to reflect the cost of serving load in particular periods, which were considered set by the CPUC within this framework (see Section A.11: Limitations). Tiered consumption levels were either set by CPUC guidance or based on LADWP input; both approaches are oriented toward the concept of "baseline usage," which would not change in response to tariff structures.

A.6 Model Optimization

The model leverages the Bayesian optimization open-source Python package (Fernando Nogueira 2014) to determine the retail rate values needed to achieve revenue sufficiency given information on tariff value bounds and customer consumption, among other constraints. Bayesian optimization is a valuable way to find near-optimal solutions to problems (functions) that may be computationally intensive to sample. The Bayesian optimization process takes the function to be optimized (in this case, the absolute difference between the revenues collected and the revenue requirement) and user-defined bounds for parameters that the model can adjust when sampling (solving) the function. An example of such a bound might be setting the energy charge associated with the lowest tier of consumption to be between $0.05/kWh and $0.25/kWh.

In determining an optimal set of rate values, the model samples (guesses) values between these bounds for the variable parameters. It then applies these rates to the individual customer loads, which are aggregated to reflect which load would receive a particular rate, and it calculates the customer's monthly bills. The model then aggregates the bills across all customers and months (scaling the bills by the appropriate prototype weight) to arrive at a "revenue collected" value, which is compared to the revenue requirement. The model was given 65 guesses to return an optimal solution,[30] defined as one that respects all user-provided bounds and returns a total revenue collected from customers within ±0.1% of the revenue requirement.

[30] The model (based on the Bayesian optimization package) differentiates an "exploration" phase and an "exploitation" phase, with the former randomly sampling the bounds provided to help map out and diversify the potential solution space and the latter designed to find the best solution.

One exception to this process was the Model A run, which used only known historical LADWP rate values to both serve as a calibration for the model and provide a baseline of evaluation metrics for future years.

A.7 Residential Solar Rooftop PV Assumptions

Incorporating residential customer-sited generation enables estimation of impacts (e.g., affordability, intra-class transfers) that occur from rate design options, solar compensation strategies, and low-income solar strategies.

Aggregate Solar Penetration

This analysis considers three levels of residential solar penetration on single-family home rooftops based on the revenue requirement scenario explored. We exclude consideration of renters and multifamily homes, as these customers were considered more likely to participate in community solar or other alternatives to rooftop solar investments (Chapter 9). Solar penetration levels are based on Chapter 4 of the LA100 report and electricity demand projections based on Chapter 3 of the LA100 report (Jacquelin Cochran and Paul Denholm 2021):

- **2019 Baseline:** Includes 216 MW_{DC} of cumulative single-family rooftop solar photovoltaics (PV), which equates to offsetting about 4% of total annual residential electricity demand in the relevant year.[31]
- **2035 Case 1:** Includes 1,826 MW_{DC} cumulative single-family rooftop solar PV, which equates to offsetting about 26.5% of residential load in the relevant year.[32]
- **2035 SB 100:** Includes 1,118 MW_{DC} cumulative single-family rooftop solar PV, which equates to offsetting about 16.2% of residential load in the relevant year.[33]

Solar Compensation Strategy

For solar compensation, we assume the 2019 baseline and 2035 LADWP business-as-usual (BAU) rate design scenarios use net metering consistent with LADWP's current practice.

For the tiered rate and TOU rate design scenarios, we use net billing informed by CPUC guidance. CPUC issued its net billing order in December 2022 establishing a replacement for net metering compensation that was found to negatively impact nonparticipating ratepayers, disproportionately harming low-income ratepayers, and not cost-effective (California Public Utilities Commission 2022d). After a 5-year glide path (that we ignore given our focus on 2035), net billing retail export compensation will be based on a 576 period of average monthly values for each hour, differentiated by weekend and weekday, and the most recently passed annual

[31] 216.21 MW_{DC} (in 2020) × 96% inverter efficiency × 20% capacity factor × 8,760 hours per year = 363,648 MWh per year, or about 4% of annual residential demand in the 2020 high electrification SB 100 scenario of 9,129,853 MWh (excluding losses).
[32] 1,826.02 MW_{DC} (in 2035) × 96% inverter efficiency × 20% capacity factor × 8,760 hours per year = 3,071,220 MWh per year, or about 26.5% of annual residential demand in the 2035 early, no biofuels, high electrification scenario of 11,578,692 MWh (excluding losses).
[33] 1,117.74 MW_{DC} (in 2035) × 96% inverter efficiency × 20% capacity factor × 8,760 hours per year = 1,879,949 MWh per year, or about 16.2% of annual residential demand in the 2035 SB 100 high electrification scenario of 11,578,692 MWh (excluding losses).

ACC. The net billing order requires all net billing customers to use a specific form of TOU rates (e.g., excludes baseline credit). For the tiered rate design scenario, we keep all solar customers on tiered rates. For the TOU rate design scenario, all solar customers are switched to a net-billing-compliant TOU rate, even if they are CARE- or FERA-eligible customers.

Solar Adopter Income Distribution

For this analysis, we preserve existing income distributions of residential solar adopters to baseline the analysis and identify impacts of intra-class transfers and low-income solar adoption strategies. We use historical (2010–2021) rooftop solar adopter data for Los Angeles County by AMI bin from Lawrence Berkeley National Laboratory (LBNL) (Sydney Forrester et al. 2022), which are slightly different than the Rooftop Energy Potential of Low Income Communities in America (REPLICA) income bins used in the LA100 Equity Strategies study.[34] The initial distribution for the 2019 baseline is based on the 2019 LBNL adopter income distribution. The 2035 projections use the most recent adopter income distribution from LBNL, for 2021. These distributions are shown in Table A-1. We did not have access to data that would otherwise guide us toward establishing a different adopter income distribution. We did not use the solar adopter income distributions from Chapter 4 of the LA100 study (Jacquelin Cochran and Paul Denholm 2021), as those projections assume strong solar uptake from low-income households—specifically that low-income households adopt solar at equal measures as high-income households and that low-income households have equal access to financing. Here, we take a constrained approach recognizing low-income households may have less disposable income, unequal access to financing, inability to take on additional debt, a time preference for immediate consumption, and other barriers to solar adoption This also led us to adopting a strategy aimed at increasing solar adoption in low- and moderate-income (LMI) households.

Table A-1. Solar Adopter Income Distributions by AMI Bin for 2019 and 2035

	0%–60% AMI	60%–80% AMI	80%–100% AMI	100%–120% AMI	>120% AMI
2019 baseline	16.4%	10.6%	9.8%	10.2%	53%
2035 projections (2021 distribution)	18.6%	11%	10.2%	10.4%	49.9%

Low-Income Solar Adoption Initiative

We model a hypothetical policy aimed at increasing LMI household (defined here as <80% AMI) solar adoption by 20%, while holding aggregate solar penetration constant. We do not specify the policy design, only achieving a 20% increase in LMI solar adoption compared to the 2035 BAU projections (shown in Table A-2). To increase LMI solar adoption and keep total aggregate solar constant, the percentages of adopters in other AMI bins are reduced

[34] REPLICA income bins: (high >120%, middle 80%–120%, moderate 50%–80%, low 30%–50%, very low 0%–30%); LBNL income bins: (>120%, 100%–120%, 80%–100%, 60%–80%, <60%). ResStock provides estimates for customer prototype incomes (in 2019$), making it possible to calculate into which AMI bin a customer would fall in, regardless of which set of bins is used. The model assumed that both sets of AMI bins relied on the same AMI estimate from the U.S. Department of Housing and Urban Development.

proportionately. A 20% increase in LMI solar adoption boosts the lowest AMI bin (0%–60% AMI) from 18.6% to 22.3%, and the second lowest AMI bin (60%–80%) from 11% to 13.2%.

Table A-2. Solar Adoption Income Distribution for 20% Increase in LMI Household Adoption

	0%–60% AMI	60%–80% AMI	80%–100% AMI	100%–120% AMI	>120% AMI
2035 increase LMI adoption by 20%	22.3%	13.2%	9.3%	9.5%	45.7%

Solar Data and Methods

To calculate customer-sited solar generation, this analysis draws upon certain solar data from dGen, building data from ResStock, and various simplifying assumptions. dGen data on household developable rooftop space per building and system-specific annual average capacity factors were determined for 2035.[35] The specific data were developable rooftop space per building, associated maximum solar system size (MW_{DC}), and system-specific capacity factor. Where multiple dGen agents were represented by the same ResStock agent, the weighted average of mean values was used, based on the number of customers represented by each dGen agent associated with the ResStock agent. The system size was taken to be the smaller of either a "consumption limit" (such that annual PV generation did not exceed annual consumption) or a "rooftop limit" such that the PV system would not exceed the maximum developable rooftop space, while no minimum system size constraints were applied. Annual hourly solar generation for each adopter household was calculated based on the maximum allowable system size,[36] 96% DC-to-AC inverter conversion efficiency, and an hourly capacity factor from dGen that was unique to each census tract. While net energy metering compensated systems would be constrained to be no larger than the annual consumption, net billing systems would not face such a constraint. To simplify comparisons across scenarios, the same system size is deployed for adopting customers regardless of whether they are compensated under net metering or net billing (i.e., at no larger than 100% annual consumption). In practice, the compensation mechanism employed could have a significant impact on the system sizes deployed, the distribution of systems across LADWP's customer class, and the total capacity deployed, as customers see different value from investing in solar PV.

A.8 Residential Natural Gas Bill Assumptions

Customers are impacted by their overall obligations (e.g., electricity, gas, water, trash, rent/mortgage payments) rather than any individual component in isolation. Given the limitations around accurately forecasting gas or water bills, however, this analysis focuses on electricity bills in particular. For certain low-income strategies (discussed in the next section) it was necessary to estimate both electricity *and* gas bills. For instance, for energy efficiency upgrades that involve the electrification of end uses like heating, capturing the overall bill savings to

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[35] dGen generates data for even-numbered years. To arrive at 2035 values, the average values for 2034 and 2036 were taken as appropriate.

[36] In reality, a customer might choose to site a system that is smaller than the maximum allowable system, either because they are financially constrained from investing in a larger system or because a larger system would provide a poorer return on investment.

customers requires appropriately accounting for the changes of both electricity and gas bills. For these cases, gas bills were calculated using hourly gas consumption as forecasted by ResStock and the latest tariff for SoCal Gas,[37] which serves LADWP customers (see Appendix C). Regardless of the year the model was run, bills were first calculated using the latest available tariff in 2023$, then scaled to account for changes in natural gas prices between 2023 and the model year run (either 2019 or 2035) using the California Energy Commission's "Form 2.3: California Energy Demand 2021–2035 Baseline Forecast for the Mid Demand Case Natural Gas Rates by Sector" for SoCalGas (California Energy Commission 2021).[38] Finally, the bills were adjusted again to update the dollar year into either 2035$ or 2019$ so that they matched the dollar year from the electricity bills (all results presented in this report are converted a final time into 2021$ across all model runs). This analysis, while capturing individual changes to natural gas consumption, does not consider how a larger push for electrification concentrated in higher-income homes could lead to increased natural gas prices for low-income customers. Given the analysis' focus on electricity bills, no sensitivities around natural gas price forecasts were used.

A.9 Equity and Affordability Scenarios and Strategies

The model first determines the best-guess tariff based on the rate design scenario inputs. Then, low-income strategies are applied to customer bills based on criteria (e.g., location and income) mapped to individual customers. The details of the rate design scenarios and low-income assistance strategies are discussed in this section.

Rate Design Scenarios

This section details the specific rate designs or rate design inputs designated for each scenario.

Model A: 2019 LADWP Rates—A Baseline

The 2019 LADWP baseline uses historical rates and serves as a benchmark for comparing evaluation metrics to forecast scenarios. Historical tariff values for calendar year 2019 were used for the 2019 LADWP model run (see Appendix C). The optimization model relied on revenue requirements from LADWP, which for 2019 were provided for the fiscal year of July 1, 2018, to June 30, 2019. A different set of rates was used for the first and second half of the fiscal year.[39] EZ-SAVE discounts were applied to qualifying customer bills, as outlined in the EZ-SAVE section (page 34). Modeled 2019 loads were used when calculating customer bills.

2035 LADWP BAU Forecast

Based on guidance from LADWP and leveraging data from the SLTRP scenarios, the 2035 LADWP BAU case used the same general rate design from calendar year 2019. The only values that were allowed to increase over time to collect additional revenue were incremental

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[37] The applicable SoCalGas tariff Schedule No. GR for Residential Service effective July 10, 2023, is available at https://tariff.socalgas.com/regulatory/tariffs/tm2/pdf/tariffs/GAS_G-SCHEDS_GR.pdf (accessed July 13, 2023), where there is a customer charge of $0.16439 per meter per day, non-baseline rate of $0.177923/therm, and a public purpose charge of $0.06681/therm.

[38] The rates provided in California Energy Commission's Mid Demand Case forecast for SoCalGas rates are given in 2020$, but are converted into a unitless price escalator that results in a forecasted 1.402× increase in natural gas prices for the residential sector in real terms between 2023 and 2035.

[39] 2018 rate values (2018–2019 rates) and 2019 rate values (2019–2020 rates) can be found on LADWP's website: https://rates.ladwp.com/Contentpage.aspx?SubCatID=1040 (accessed 2023).

ordinances, which are volumetric energy charges applied to all residential customer consumption and that vary by season. Based on data provided by LADWP, the model considers four incremental ordinances (i-base, i-itca, i-eca, and i-rca) that are set independently of one another and in 3-month increments. The range for the values was set to approximately recover the anticipated revenues from each incremental ordinance based on data provided by LADWP. Seasonal patterns in the values were based on historical changes in today's incremental ordinances, taken from LADWP rates for 2019–2020.

2035 CPUC Simplified Tiered Rates

Relevant CPUC guidance on tiered rates (or inclining block rates) to the California IOUs is shown in the following list. These directions from the CPUC were incorporated into the model by adjusting the tariff fixed and variable elements to ensure the model's optimal solution for the CPUC tier run would reflect CPUC guidance.

- **Simplified Tiered Residential Rate Structure:** A two-tiered structure with a third super-user tier using an inclining block rate structure was preferred because, for example, the CPUC found customers prefer simple rate structures, customers do not understand structures with more tiers, and a two-tiered structure makes it easier to adjust other rate components to achieve energy efficiency and other policy goals (California Public Utilities Commission 2015, sec. 5.2).
- **Reasonable Tier Differential:** The tier differential is the percentage difference in price between the two tiers. A 10% differential means the price of the second tier is 110% of the first-tier price. The CPUC settled on a 25% differential (California Public Utilities Commission 2015).
- **Baseline Quantities and Usage Amount per Tier:** By law, the baseline quantities must be 50%–60% of the average residential consumption in each geographic area, set for the appropriate climate zone and adjusted for seasonal variation. The CPUC allowed the baseline quantities to be determined in individual rate proceedings of the IOUs (California Public Utilities Commission 2015, sec. 5.5). For LADWP, baseline quantities are differentiated between "zones," with Zone 1's baseline quantity being set at 225 kWh/month and Zone 2's being set at 260 kWh/month, based on a fraction of the average monthly consumption by zone, in line with CPUC guidance. Zone 2 is in a warmer climate, and the higher baseline quantity reflects the additional cooling energy required in this zone to ensure the same comfort levels under Zone 1's baseline quantity.
- **Seasonal Rates:** The CPUC initially indicated that tiered rates should include seasonal components to reflect differences in costs across the year (California Public Utilities Commission 2015, sec. 5.6). However, CPUC Decision 19-07-004 subsequently found seasonally differentiated tiered rates not to be in the public interest, and they were therefore excluded from this scenario.
- **Super-User Electric Surcharge:** To send price signals to high-usage customers who would otherwise benefit from tier consolidation, the CPUC required implementation of a super-user electric surcharge on customers with usage over 400% of the baseline. The differential between the Tier 1 price and the super-user electric surcharge was targeted at 119%. This surcharge was modeled after the CARE program, which notifies high-usage customers of the

need to reduce usage to remain on the assistance program (California Public Utilities Commission 2015, sec. 5.7).

- **Minimum Bill:** The CPUC rejected new or increased fixed charges proposed by the IOUs and instead allowed the alternative of a minimum bill. Doing so allowed all customers, even those with little or no usage, to contribute to fixed cost recovery. The minimum bill would only apply to customers below baseline tier usage. The minimum bill amount was set at $10/month for non-CARE customers and $5/month for CARE customers (California Public Utilities Commission 2015, sec. 7.6).
- **Discount Programs:** Assembly Bill 327 required the average effective CARE program per-unit rate discount to be between 30% and 35%. The CPUC settled on a 12% discount for all FERA customers,[40] who include LMI customers with larger households (California Public Utilities Commission 2015, sec. 8).

2035 CPUC Default TOU Rates

We modeled this scenario even though LADWP does not currently have the smart meter infrastructure required to implement default TOU rates. The default TOU rate design is informed by CPUC's Phase 2B TOU order for SCE (California Public Utilities Commission 2019), which generally followed the CPUC's 2017 policy guidelines applicable to TOU rate design and implementation (California Public Utilities Commission 2017). We assumed by 2035, default TOU implementation was fully implemented and no longer in the TOU-lite or glide path phase-in period. Per the 2019 CPUC order, CARE/FERA-eligible and/or enrolled customers in hot climate zones, medical baseline, and certain other customers are not to be defaulted into TOU rates and therefore remain on the tiered rate plan.

- **Peak Periods:** We used SCE's 4–9 p.m. peak period, as it matches better with LADWP's system than the 5–8 p.m. peak period option. These periods define times when system costs are higher (peak) and lower (super off-peak), so system cost-reflective rates can be developed.
- **Rate Period Price Ratios:** The ratios determine how costs should escalate between the base (lowest cost) period and higher cost periods. Table A-3 shows the rate period ratios used to develop the TOU prices.
- **Seasonal Rate Differential:** The TOU rate includes a $0.01/kWh differential between summer and winter seasons within the TOU rate period ratios (we assumed this is $0.01 higher for the summer off-peak period than the winter super off-peak period). Summer is June through September and winter is October through May.
- **Minimum Charge:** For default TOU rates, the CPUC did not allow for new or increased fixed charges but permitted inflation adjustments to minimum bills (California Public Utilities Commission 2020). For SCE, the minimum charge applies when the delivery service charges plus the applicable basic charge are less than the minimum charge. We did not model SCE's grandfathered basic charge, and we used a bundled generation and delivery charge as we did not break down the split between generation, transmission, and delivery costs or

[40] It was subsequently raised to an 18% discount, effective January 2019.

charges in our optimization model. This modification likely results in under-application of minimum charges. A minimum daily charge of approximately \$0.346/day or about \$10/month was taken from SCE's residential TOU-D schedule effective January 1, 2023 (Southern California Edison 2023).

- **Baseline Credit:** A baseline credit was provided as a consumer protection mechanism. This is a credit for each kilowatt-hour of baseline energy usage and is applied against TOU rate charges. We used the credit of \$0.09759/kWh that was in place for SCE in January 2023 (Southern California Edison 2023). Baseline energy usage is defined in the SCE tariff by region (e.g., 17 kWh/day in Region 5 during the summer) and applied to LADWP customer TOU bills. For example, assume a 31-day month of July in Region 5 using 800 kWh. First calculate the bill using the TOU rate schedule. Then subtract \$51.44 (31 days × 17 kWh/day × \$0.0976/kWh) for the monthly baseline credit from the total TOU rate charges.

The model leverages hourly marginal cost data for SCE's territory in the CPUC ACC to develop TOU rates in line with CPUC guidance on default TOU rate design. The CAIRO model currently does not attempt to calculate how TOU rates impact consumer usage, a shortcoming we discuss in Section A.11: Limitations.

Table A-3. Periods and Period Ratios Used for TOU Rate Prices

Rate Type	Period		Period Ratios
Energy charge (\$/kWh)	Summer on-peak	(4–9 p.m., weekdays)	1.6
	Summer mid-peak	(4–9 p.m., weekends)	1.3
	Summer off-peak	(all other hours)	1.0
	Winter mid-peak	(4–9 p.m., all days)	1.45
	Winter off-peak	(9 p.m.–8 a.m., all days)	1.1
	Winter super off-peak	(8 a.m.–4 p.m., all days)	1.0

Low-Income Assistance Strategies

This section describes the details of the various low-income assistance strategies modeled, including the EZ-SAVE and Lifeline programs, CARE and FERA programs and associated renter's discount program, IBFC, and the on-bill tariff program.

LADWP EZ-SAVE and Lifeline Programs

LADWP's EZ-SAVE program offers qualifying low-income customers a fixed discount on their bills. Table A-4 shows the household income eligibility requirements for EZ-SAVE assumed in the model. These values are based on 2022 eligibility requirements, whereas the prototypical customer household income levels provided by ResStock were provided in 2019 \$ values for 2019. The same eligibility requirements were used for model runs based in 2019 and in 2035 assuming both eligibility requirements and incomes would increase at the same rate.

Table A-4. Household Income Requirements for LADWP's EZ-SAVE

Members in Household	Maximum Annual Gross Income
1	$36,620
2	$36,620
3	$46,060
4	$55,500
5	$64,940
6	$74,380
7	$83,820
8	$93,260
Each additional member	+$9,440

Source: LADWP (2023)

Discounts under EZ-SAVE for 2019 were determined to be $8.17/month (nominal) for qualifying customers.[41] Monthly discounts under EZ-SAVE were assumed to be fixed in nominal terms, as the rider that funds EZ-SAVE has reached its maximum threshold. In the absence of a new or modified funding source, we assumed (1) the total budget available for EZ-SAVE does not grow to account for inflation or increased energy charges, and (2) the corresponding real discount that low-income customers receive decreases over time, arriving at $5.78/month in 2035 (in 2021$).

The model uses census-level program enrollment data provided by LADWP to model the EZ-SAVE program. A systemwide "participation target" (calculated as the total number of EZ-SAVE participating customers divided by the total number of residential customers within LADWP in 2019) was established based on average EZ-SAVE enrollment rates between 2016 and 2019 and assuming 1,349,209 total residential customers (Table A-5). The resultant average enrollment rate across this period was 9.2993%, which is used for 2035 (but applied to the estimated 1.57 million customers anticipated in 2035), and the actual EZ-SAVE enrollment rate of 7.1572% was used for 2019. LADWP's "Energy Subsidy Adjustment" (ESA) funds the EZ-SAVE, Lifeline, and other smaller assistance programs. ESA revenues ranged from $35 million to $36 million between 2016 and 2019, with about 74% of ESA revenues collected from LADWP's commercial class and 26% collected from the residential class.[42] For this analysis, we assume an $8.17/month subsidy (nominal, established in 2009) and hold this nominal value constant (i.e., unadjusted) through 2035.[43] As a simplifying assumption, to avoid the

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[41] As of June 2023, in the "LL/LI" residential rate tariff, LADWP's website advertised an EZ-SAVE subsidy of $16.34 every 2 months. Although some LADWP customers in 2019 were eligible to apply their water discounts toward their electricity bills, if they did not pay their water bills, the discounts were not incorporated in the model, and they were discontinued in 2019.

[42] LADWP provided these program enrollment and ESA revenue data directly to NREL.

[43] See the LADWP Electric Rate Ordinance established on July 1, 2008, where the Residential R-1 Rate D Low Income Service discount of $8.17/month was established effective July 1, 2009: https://www.ladwp.com/cs/idcplg?IdcService=GET_FILE&dDocName=OPLADWP009439&RevisionSelectionMethod=LatestReleased (accessed June 29, 2023).

complexities of modeling inter-class cross-subsidization, we collect all revenues required to support EZ-SAVE expenses from the residential class.

Table A-5. Bill Subsidy Program Enrollment Data

Fiscal Year End	EZ-SAVE Enrollment	Lifeline Enrollment
2016	153,273	93,432
2017	135,173	95,644
2018	116,858	96,902
2019	96,566	98,300

To better capture geographic patterns in participation, the model uses historical participation rates by census tract for 2016 and scales those rates to ensure the total participation target is reached. Doing so ensures the model accurately captures the magnitude and spread of EZ-SAVE participation.

EZ-SAVE discounts were applied after the tariff values had been set by the model in the optimization process and the customer bills had been calculated. Eligible customers (based on household income) were selected to receive the monthly discounts (based on participation rates), which were subtracted from their bills. The model funds the program through a time-invariant volumetric energy charge (i.e., a nonvarying rate in $/kWh) that is applied to all *non*participating customers' consumption. Total discounts for participating customers were aggregated throughout the year to arrive at a program cost, and it was divided by aggregated annual nonparticipating load to arrive at the energy charge, which was then applied to each nonparticipating customer's bills based on consumption within each billing cycle.

The Lifeline program is available to LADWP customers who are either senior citizens or disabled citizens and have a combined adjusted gross income of all household members of less than $47,650 (in the past calendar year, 2023$). The Lifeline program offers a combination of a nominal $17.71/month subsidy[44] plus an exemption from paying the 10% utility user tax. The direct subsidy is funded by LADWP residential and commercial customers, and the municipality foregoes collection of the tax revenues. The municipality processes applications for program qualification and enrollment.[45] We use the actual Lifeline 2019 enrollment rate of 7.2858% for Model Run A (baseline 2019) and the average enrollment rate from the 4 years of data in Table A-5 (i.e., 7.1204%) for Model Run B (2035 LADWP BAU). We randomly assign eligible customers to the Lifeline program based on historic census-tract-level patterns of enrollment until we reach the target level. In the limited instances where the Lifeline program reduces a monthly bill below $10/month, the $10/month minimum bill is instead charged. We recover

[44] See the LADWP Electric Rate Ordinance established on July 1, 2008, where the Residential R-1 Rate E Lifeline Service discount of $17.17/month was established effective July 1, 2009: https://www.ladwp.com/cs/idcplg?IdcService=GET_FILE&dDocName=OPLADWP009439&RevisionSelectionMethod=LatestReleased (accessed June 29, 2023)

[45] An example of the Lifeline program application is available at https://finance.lacity.gov/sites/g/files/wph1721/files/2023-04/Lifeline%20Application%20English%20revised%20040623.pdf (accessed June 26, 2023).

Lifeline program expenses outside of the residential revenue requirement through a post-processing step. In practice, the majority of EZ-SAVE and Lifeline expenses are recovered from LADWP's commercial class. For simplicity, and given the approximate program budgets, we recover EZ-SAVE program costs through the residential revenue requirement and Lifeline program costs through a theoretical commercial class that is not financially accounted for in our model. This results in incremental improvements to affordability metrics from the Lifeline program without factoring in incremental additional required revenues.

CARE and FERA Low-Income Assistance Programs

Under the CARE program, the CPUC requires California IOUs and electrical corporations with 100,000 or more customer accounts to offer eligible and enrolled customers a 30%–35% discount on electric bills and a 20% discount on natural gas bills. Eligibility is based on total household income, scaled for persons per household.[46] The CPUC also requires the three large IOUs (SCE, San Diego Gas & Electric, and Pacific Gas and Electric Company) to offer 18% discounts through the FERA program to families whose household incomes are slightly higher than the CARE limits but less than 250% of the federal poverty guideline.[47]

The model applies 32.5% CARE and 18% FERA discounts to eligible participating customers. Customer participation is established in a similar fashion as with EZ-SAVE with three modifications:

- "Participation targets" for CARE and FERA are based on the average annual IOU-wide participation targets for California's IOUs for the pre-COVID-19 pandemic period of 2017–2019 (see Table A-6), which result in average targets of 89.4% for CARE and 14.6% for FERA.
- The geographic distribution of CARE and FERA participation by census tract is held to be approximately the same as the geographic distribution of participation for EZ-SAVE by census tract while observing the above overall targets.
- "Participation targets" are calculated as "participating customers" divided by "eligible customers" instead of "total residential customers."

[46] For more information on household income and eligibility criteria, see https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-costs/care-fera-program (accessed Jan. 6, 2023).
[47] Several other programs—including but not limited to the Energy Savings Assistance Program—provide no-cost weatherization services to CARE-eligible customers, utility company emergency assistance programs, and medical baseline programs. These are in addition to federally funded programs such as California's Low-Income Weatherization Program and the federal Low-Income Home Energy Assistance Program. For the purposes of our analysis, we will limit modeling to programs structured like the CARE and FERA programs implemented by the IOUs.

Table A-6. CARE and FERA Participation Rates, Counts, and Budgets by IOU and Year

		SCE				San Diego Gas & Electric				Pacific Gas and Electric Company			
Program	Year	Enrolled (% of eligible)	Subsidy Expense (millions)[a]	Participants Enrolled	Subsidy per Participant	Enrolled (% of eligible)	Subsidy Expense (millions)*	Participants Enrolled	Subsidy per Participant	Enrolled (% of eligible)	Subsidy Expense (millions)*	Participants Enrolled	Subsidy per Participant
CARE	2017	84%	$458	1,222,526	$375	85%	$114	281,274	$405	89%	$644	1,406,396	$458
	2018	85%	$376	1,205,539	$312	92%	$126	297,103	$425	90%	$611	1,376,003	$444
	2019	89%	$365	1,185,146	$308	95%	$118	301,810	$391	96%	$639	1,382,663	$462
FERA	2017	9%	$5	19,184	$276	18%	$1	7,853	$164	17%	$6	29,072	$218
	2018	9%	$3	19,344	$160	17%	$1	8,229	$175	15%	$5	25,257	$208
	2019	9%	$9	19,734	$454	25%	$2	9,577	$234	13%	$7	21,815	$314

[a] Subsidy expense is limited to the direct subsidy to participants and does not include programmatic or administrative expenses that are a much smaller portion of total CARE and FERA implementation costs. Sources: For CARE programs in the applicable years 2017, 2018, and 2019 for SCE, [48,49,50] San Diego Gas & Electric,[51,52,53] and Pacific Gas and Electric Company.[54,55,56] For FERA programs in the applicable years 2017, 2018, and 2019 for SCE, [14,17,20] San Diego Gas & Electric, [57,58,59] and Pacific Gas and Electric Company[60,61,62]

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[48] Southern California Edison Company's 2018 Annual Report for 2017 Low Income Programs, filed with CPUC May 1, 2018, https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M220/K593/220593857.PDF

[49] Southern California Edison Company's 2019 Annual Report for 2018 Low Income Programs, filed with the CPUC May 1, 2019, https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M290/K365/290365295.PDF

[50] Southern California Edison Company's 2020 Annual Report for 2019 Low Income Programs, filed with the CPUC May 1, 2020, https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M335/K511/335511400.PDF

[51] Annual Report Activity of San Diego Gas and Electric Company on Low-Income Assistance Programs for 2017, filed with the CPUC May 1, 2018, https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M220/K564/220564108.PDF

[52] Annual Report Activity of San Diego Gas and Electric Company on Low-Income Assistance Programs for 2018, filed with the CPUC May 1, 2019, https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M292/K932/292932678.PDF

[53] Annual Report Activity of San Diego Gas and Electric Company on Low-Income Assistance Programs for 2019, filed with the CPUC May 1, 2020, https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M335/K511/335511405.PDF

[54] Annual Report of Pacific Gas and Electric Company on the Results of its Energy Savings Assistance and California Alternate Rates for Energy Programs, filed with the CPUC May 1, 2018, https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M220/K116/220116913.PDF

[55] Annual Report of Pacific Gas and Electric Company on the Results of its Energy Savings Assistance and California Alternate Rates for Energy Programs, filed with the CPUC on May 1, 2019, https://liob.cpuc.ca.gov/wp-content/uploads/sites/14/2020/12/PGE-2019-PY2018-ESA-CARE-Annual-Report.pdf

[56] Annual Report of Pacific Gas and Electric Company on the Results of its Energy Savings Assistance and California Alternate Rates for Energy Programs, filed with the CPUC May 1, 2020, https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M335/K526/335526334.PDF

[57] Annual Report for Family Electric Rate Assistance (FERA) Program of San Diego Gas and Electric Company for Program Year 2017, filed with the CPUC May 1, 2018, https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M220/K755/220755069.PDF

[58] Annual Report for Family Electric Rate Assistance (FERA) Program of San Diego Gas and Electric Company for Program Year 2018, filed with the CPUC May 1, 2019, https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M292/K289/292289096.PDF

[59] Annual Report for Family Electric Rate Assistance (FERA) Program of San Diego Gas and Electric Company for Program Year 2019, filed with the CPUC May 1, 2020, https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M335/K710/335710570.PDF

[60] Annual Progress Report of Pacific Gas and Electric Company of the Family Energy Rate Assistance (FERA) Program, 2017, filed with the CPUC May 1, 2018, located at https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M219/K473/219473976.PDF

[61] Annual Progress Report of Pacific Gas and Electric Company of the Family Energy Rate Assistance (FERA) Program, 2018, filed with the CPUC May 1, 2019, located at https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M309/K591/309591690.PDF

[62] Annual Progress Report of Pacific Gas and Electric Company of the Family Energy Rate Assistance (FERA) Program, 2019, filed with the CPUC May 1, 2020, located at https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M335/K832/335832720.PDF

Similar to the EZ-SAVE program, within the model, the bills are first calculated for all customers using the model-determined retail tariff values. Then, eligible and participating customers receive the CARE and FERA discounts. The total program costs for CARE and FERA are calculated to be the total discounts received over the year of analysis. The program costs are recovered through a time-invariant volumetric energy charge ($/kWh) applied to all nonparticipating load.[63] The final bills are the initial bills minus discounts and plus program costs applied to participating and nonparticipating customers as appropriate.

CARE and FERA Renters Discount Program

This strategy aims to provide targeted discounts to income-qualified households that are renters and may not qualify for CARE and FERA programs because they are not submetered. In the absence of submeters, LADWP cannot confirm the household is an actual LADWP customer and cannot understand the household's energy usage. The NREL load data set from ResStock does not include information on which percentage of renters are submetered. We therefore conservatively assume all renters are not submetered and therefore are not qualified for the CARE and FERA programs. Instead, we offer renters that meet the CARE and FERA income qualifications a flat monthly discount based on the average dollar value of the CARE or FERA program, minus a small reduction. The value reduction applied given monthly energy usage cannot be verified. We assume $24.77/month for CARE and $14.15/month for FERA in 2021$. The renters program would require a verification process, perhaps involving landlord validation, to confirm the household receiving the monthly discount is living in a building that is an LADWP-metered customer. Models indicate participation in the CARE renters program to be high and in line with participation for CARE (>85%), but FERA renters program participation is low due to the limited number of households that meet the qualification criteria. The results of the renters program are integrated into the larger CARE and FERA program model results.

Income-Based Fixed Charges (IBFC)

Concurrent with this study, the CPUC is actively deliberating implementation of IBFC for California IOUs. This effort was enabled by the passage of California Assembly Bill 205 in June 2022, which, among other things, allows for fixed charges to be established on an income-graduated basis.[64] The CPUC began exploring income-graduated fixed charges with its July 2022 rulemaking that included fixed charge reforms (California Public Utilities Commission 2022b). In November 2022, the CPUC instituted a separate track of the rulemaking, dedicated to income-graduated fixed charges, and it is actively deliberating design principles (California Public Utilities Commission 2022c). Given the active nature of the CPUC's deliberations, this study could not rely on CPUC regulatory guidance to inform IBFC design. Rather, this strategy is modeled after Borenstein, Fowlie, and Sallee's recommendation for California IOUs (Severin Borenstein, Meredith Fowlie, and James Sallee 2022). A complete discussion of the benefits and drawbacks of IBFC is beyond the scope of this report, but they can be explored in the relevant

[63] California IOUs recover costs for the CARE and FERA programs from all noneligible customers, including customers from other classes (e.g., commercial, industrial).
[64] Assembly Bill No. 205, Legislature Information, https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220AB205, accessed April 19, 2023.

CPUC proceeding.[65] In general, proponents argue the high residual costs of many California utilities are more equitably recovered through income-sensitive methods. Opponents argue IBFC may distort marginal cost price signals to consumers with negative implications for distributed resources such as energy efficiency and will increase costs to high-income customers.

For our IBFC model, all customers are charged such that the marginal system costs are recovered based on customer usage and the applicable rate design (e.g., tiered, TOU). All residual costs (i.e., revenue requirement minus total marginal system costs) are charged to customers based on an income-scaled fixed rate. IBFC could only be explored under CPUC guidance rates, where economic and residual costs could be calculated and separately apportioned. In other words, IBFC could not be added to the existing LADWP rate design without fundamentally altering the existing LADWP approach to rates.

Marginal system costs are derived from CPUC's ACC for SCE's territory for 2035 (SB 100) or for 2045 adjusted to 2035 $ (Case 1). The hourly total levelized marginal cost[66] was preserved for every climate zone in both LADWP's and SCE's territory (California Energy Commission Climate Zones 6, 8, 9, and 16). Hourly load data were then aggregated by hour and climate zone and scaled to provide an hourly estimate of all residential load in each hour of 2035. This hourly climate-zone-specific load was then multiplied by the appropriate hourly marginal cost estimate and aggregated across all hours and climate zones to provide an estimate of the marginal systems cost for usage for all of LADWP's residential customers. Using the same guidance as provided for the CPUC tiered and TOU rates, this new marginal system cost was set to be the new revenue requirement, and the model optimized the energy charges to recover the marginal system costs.

To set the IBFC to recover the residual cost, customers were binned into fractions of the AMI (0%–30%, 30%–50%, 50%–80%, 80%–120%, and 120% and above). Based on the approach in Borenstein, Fowlie, and Sallee (2022), the IBFC were set so that the lowest bin paid no fixed charge, the second lowest bin paid a fixed charge of "X" per month, the third lowest paid a fixed charge of 1.23 × X per month, the fourth lowest a charge of 1.66 × X, and the highest bin a charge of 2.8 × X.[67] For Case 1, these resulted in the fixed charges in Table A-7.

Table A-7. Modeled Monthly IBFC Results for Case 1

AMI Bin	1 (0%–30% AMI)	2 (30%–50% AMI)	3 (50%–80% AMI)	4 (80%–120% AMI)	5 (>120% AMI)
IBFC $/month (2035$)	$0.00	$127	$156	$211	$355

[65] Income-graduated fixed charges (a form of IBFC) are explored in Track A of the CPUC's Demand Flexibility Rulemaking (R.22-07-005). More information, including a link to the docket, can be found at https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-costs/demand-response-dr/demand-flexibility-rulemaking (accessed May 18, 2023)

[66] Assuming a 10-year levelized period and a weighted average cost of capital of 7.52%, the default in the ACC.

[67] In Borenstein, Fowlie, and Sallee (2022), these relative values were set to achieve a distribution of burdens across the richest four quintiles that is equal to the burden of raising the revenue through the sales tax.

AMI Bin	1 (0%–30% AMI)	2 (30%–50% AMI)	3 (50%–80% AMI)	4 (80%–120% AMI)	5 (>120% AMI)
IBFC $/month (2021$)	$0.00	$90	$110	$149	$251

Although these fixed charges are higher for all but the first quintile, some higher fixed costs are offset by a reduction in energy rates. For example, marginal cost-based rates are not upwardly adjusted to recover residual costs, as residual costs are solely recovered through fixed charges. The joint proposal for income-graduated fixed charge design submitted to the CPUC by California IOUs in April 2023 included just four household income brackets, with the lowest-income bracket (household income up to 100% of the federal poverty level) receiving "extra discounted" fixed charges but not zero fixed charges (Joint IOUs 2023).

On-Bill Tariff for Energy Efficiency Deployment

Low-income households often do not have the luxury of investing in energy efficiency measures due to lack of homeownership, discretionary income, and up-front costs. Under an on-bill tariff energy efficiency program, the utility or another third party deploys energy efficiency measures and appliances with reduced or no up-front costs and recovers the costs of those deployments by applying a rider (i.e., extra charge) on participating customer bills. Though on-bill tariff cannot address all the barriers to low-income energy efficiency adoption, it is one avenue jurisdictions are exploring for equitable efficiency programs. On-bill tariff is different from traditional on-bill financing because it is not considered debt to the customer.

As a customer protection measure, on-bill monthly riders are calculated to be less than the expected monthly savings from the efficiency measures/appliances deployed (for both electricity and gas bills; see above methodology for discussion on gas bill estimations), and the payments are designed to last less than the anticipated lifetime of the appliance. Therefore, the customer is expected to benefit from a slightly reduced bill and financing-based access to the new appliance or measure. On-bill tariff programs should be designed so that the bill rider is less than 80% of the projected bill savings and the payments last less than 80% of the shortest-lived component of the appliance or measure. On-bill tariff programs are designed to address low-income barriers to efficiency finance by being structured to be cash-flow positive, and designed as a utility investment attached to the utility meter rather than a loan to a customer (Leventis, Kramer, and Schwartz 2017). This design reduces customer concerns about taking on new debt or discouraging participation associated with renting or moving.

Within this analysis, the on-bill tariff strategy assumes Inflation Reduction Act funding can contribute to lowering on-bill tariff program costs for low-income consumers. Specifically, based on the fiscal year 2022 budget for the U.S. Department of Energy allocated to California through formula grants compared to the total fiscal year 2022 budget from the U.S. Department of Energy, we estimate approximately 6.78% of the U.S. 50122 Electric Program (U.S. 50122 High-Efficiency Electric Home) and the U.S. 50121 Home Owner Managing Energy Savings (HOMES) program budgets will be available to California. We further assume the city of Los Angeles will be able to secure 10% of the total state budget for each of these programs and that the municipal utility LADWP will be able to secure 75% of the city's funds for a total of $43.58

million across the High-Efficiency Electric Home and HOMES programs. We estimate 20% of this will be allocated for administrative, outreach, and technical assistance costs and 80% will be allocated to customers in the on-bill tariff program as rebates to reduce the required bill riders.

As a result of these bill rider values, we excluded certain technologies based on the assumption of limited discretionary income, and independent of whether the overall investment was economically rational. We only include Technology 2 (heat pump water heaters) and Technology 5 (enhanced insulation) in the final report, given their low monthly bill rider costs. It should be noted that some technologies were assumed to already have achieved significant penetration of the housing stock by 2035, thereby limiting the number of eligible dwellings that could benefit from the on-bill tariff program. See Chapter 6 for additional information on how technologies were assumed to diffuse through the housing stock in the ResStock model.

It should be noted that the bill riders and potential eligible customer counts identified below for the heat pump water heaters and enhanced insulation represent the technical potential of an LADWP on-bill tariff program assuming maximum economic efficiency (i.e., only enrolling the most cost-effective projects). In practice, there are multiple barriers to customer participation, program implementation challenges, and economic inefficiencies that would likely result in far fewer customers being served (National Association of Regulatory Utility Commissioners 2022). For example, a review of utility on-bill tariff programs implemented over multiple years shows a range of 75–2,475 total projects per program (Deason, Murphy, and Leventis 2022).

For both sets of Inflation Reduction Act programs, the following technologies were modeled under an on-bill tariff program:

- **Technology 1: Heat Pumps:** Air-source heat pump (seasonal energy efficiency ratio [SEER] 26) or mini-split heat pump (SEER 31).
- **Technology 2: Heat Pump Water Heaters:** Individual heat pump water heaters.
    - Bill rider: $17/month. Participating customer count: 154,010.
- **Technology 3: Whole-Home Electrification:** Heat pumps, heat pump water heaters, induction ranges, electric clothes dryer, ENERGY STAR refrigerators.
- **Technology 4: Heat Pumps and Basic Insulation:** Heat pump (minimum efficiency) with attic and roof insulation and duct sealing.
- **Technology 5: Enhanced Insulation:** Attic and roof insulation, air sealing, duct sealing, and drill and fill insulation.
    - Bill rider: $17/month. Participating customer count: 72,403.
- **Technology 6: LEDs (used as a test case):** 100% LED usage in the home.

For the U.S. 50121 HOMES program, for all technologies above, the rebates were contingent on the estimated energy savings and the AMI level, as outlined in Table A-8, with both a fraction of project costs covered as well as a maximum rebate available.

Table A-8. Modeled HOMES Rebates Available Under the Inflation Reduction Act

	Fraction of Project Costs (maximum rebate)		
Energy Savings	**<80% AMI**	**80%–120% AMI**	**>120% AMI**
>35% modeled	80% ($8,000)	50% ($4,000)	50% ($4,000)
20%–35% modeled	80% ($4,000)	50% ($2,000)	50% ($2,000)
15%–20% measured	80% ($4,000)	50% ($2,000)	50% ($2,000)

For the U.S. 50122 High-Efficiency Electric Home program, for all technologies above, the rebates were contingent on the AMI level, as outlined in Table A-9, with both a fraction of project costs covered as well as a maximum rebate available. Rebates were not available for LEDs or households above 120% of the AMI.

Table A-9. Modeled High-Efficiency Electric Home Rebates Available Under the Inflation Reduction Act

	Fraction of Project Costs (Maximum Rebate)		
Energy Savings	**<80% AMI**	**80%–120% AMI**	**>120% AMI**
Heat pumps	100% ($8,500)	50% ($8,500)	0% ($ -)
Heat pump water heater	100% ($2,250)	50% ($2,250)	0% ($ -)
Heat pump and basic insulation	100% ($10,100)	50% ($10,100)	0% ($ -)
Enhanced insulation	100% ($2,100)	50% ($2,100)	0% ($ -)
Whole-home electrification	100% ($14,500)	50% ($14,500)	0% ($ -)

For incorporating the on-bill tariff equity strategy, the model first compares *baseline* energy usage and bills (electricity and natural gas) before a particular technology (e.g., heat pumps) is deployed against a set of *upgrade* usages and bills for each prototypical customer, where the technology has been deployed wherever physically possible. These energy savings, combined with metadata on customer incomes, indicate the level of rebates for which each customer is eligible. Technology costs for capital costs and installation and technology lifetimes are also tracked by customer prototype. Then, the model initiates an optimization routine (similar to how the rates model functions as outlined above) to determine the bill rider that fully recovers the cost of the program to LADWP. First, the model guesses a bill rider for the on-bill tariff technology program, and it then determines which customers (with rebates applied) would see bill savings 25% higher than the guessed bill rider (the 80% rule outlined above). All customers who pass this constraint are enrolled in the on-bill tariff program, subject to limits on the number of customers LADWP could feasibly enroll in a given year and the total number of customers LADWP could enroll over the life of the on-bill tariff program. The limit on new annual customers was based on estimates for the number of installations a contractor could install per day, the number of contractors LADWP would hire over a given year, and the number of working days in the year.

For each program year, the number of new customers enrolled, the total number of customers enrolled, total annual bills savings for customers (modeled as a loss of revenue to LADWP), total capital costs per year, total rebates applied, and total costs to LADWP (assuming that all capital costs not covered by rebates would be financed by LADWP through debt) are tracked. Administrative and outreach costs are assumed to be 30% of the capital expenditure costs of the technology deployed in years where new customers are added and 1% in years where no new customers are added to the program. Admin and outreach costs are offset by the portion of the Inflation Reduction Act funding set aside for LADWP for such costs until the budget is exhausted. The net present value of the program costs (capital and administrative) is then compared against the net present value of the revenues from the bill rider, and the model optimizes to minimize this difference.

We recognize any strategy that involves energy efficiency or conservation measures has the potential to reduce LADWP's projected revenue requirement and reduce system costs with the potential to lower costs for all customers. We calculate the potential avoided marginal system costs associated with the on-bill tariff program, but we do not adjust rates accordingly. We do not calculate potential system peak reductions associated with this program. We track avoided sales from energy efficiency measures, but we also do not try to capture this impact on rates for nonparticipating customers.

A.10 Evaluation Metrics

The city of Los Angeles' 10% residential "electricity users tax" (without exemptions) [68] and California's electric energy resources surcharge of $0.0003/kWh are applied to customer bills as a last step.[69] All bills are calculated in nominal terms, and the evaluation metrics are then calculated. Evaluation metrics in dollar values (e.g., average monthly bill) are converted to 2021$, whereas evaluation metrics that calculated by percentage, calculated by hours worked, or are unitless (e.g., NER) are unadjusted. Inflation assumptions were used to convert future bills into 2021$, and the U.S. Bureau of Labor Statistics' average annual Consumer Price Index was used to convert historical dollars into 2021$. Inflation for future years was assumed to be a constant 2.5% starting in 2022, which is in line with guidance from LADWP on assumptions used in the SLTRP. For converting dollar values from past years, the Consumer Price Index annual average was used (Bureau of Labor and Statistics n.d.).

The following affordability and equity metrics were calculated to help rank order scenarios and strategies and identify trade-offs between various approaches. The metrics included:

- **Energy Burden (electricity only):** This is a widely used metric to describe energy affordability. It is derived by dividing annual income by annual household electric energy expense.

[68] The City of Los Angeles' Electricity Users Tax is codified in Section 21.1.4 of the Los Angeles Municipal Code (https://codelibrary.amlegal.com/codes/los_angeles/latest/lamc/0-0-0-125957, accessed Feb. 3, 2023) with exemptions at Section 21.1.12 for older adults, disabled individuals, and very-low-income customers who complete applications. These exemptions were ignored in this model due to a lack of granular data on exemption eligibility.
[69] "Energy Resources (Electrical Energy) Surcharge Guide," California Department of Tax and Fee Administration, https://www.cdtfa.ca.gov/taxes-and-fees/energy-res-surcharge-electrical.htm

- **Hours at Minimum Wage (HMW):** HMW are the hours at minimum wage required to pay for an essential quantity of utility services. To make this more applicable to our analysis, we used the customer's average monthly electric bill instead of essential quantity. The HMW metric was calculated by dividing the household's average monthly bill by the minimum wage for the household's area. As of July 1, 2022, the city of Los Angeles had a minimum wage of $16.04, which increases every July 1 based on inflation adjustments using the U.S. Bureau of Labor Statistics' Consumer Price Index for urban wage earners and clerical workers for the LA metropolitan area (U.S. Bureau of Labor and Statistics n.d.). For example, a $200 monthly electricity bill in an area with a $16.04 minimum wage would equate to an HMW of 12.46 hours, meaning a customer would have to work 12.46 hours at minimum wage to pay the monthly bill.
- **Net Energy Return (NER):** This metric describes how many dollars are earned by a household for every dollar spent on energy (here, electric only). It is calculated by subtracting annual electricity costs from annual income and then dividing it by electricity costs. Compared to energy burden, this metric provides more useful treatment of income extremes—for example, households with zero/negative incomes, with energy expenditures that exceed incomes, and with higher incomes (Scheier and Kittner 2022).

A.11 Limitations

Customer load data are approximated for LADWP customers, not actual customer data. Solar on-site rooftop generation was estimated to provide the flexibility needed to identify intra-class transfers. These solar projections were developed solely for the rates analysis and are unlikely to comport to more detailed solar projections identified in other chapters of this report.

This rates analysis does not incorporate consideration of electric vehicle residential home-based charging and associated rate design. This is a meaningful omission because California has significant electric vehicle incentives (e.g., zero-emissions sales mandate) and has banned the sale of new internal combustion engine vehicles after 2035. The potential effect of incorporating residential electric vehicle charging could include incrementally increased loads for customers adopting electric vehicles who are likely to have higher incomes. This has the potential to increase LADWP system costs. Intra-class transfers could be impacted based on electric vehicle charging rate design, net effect on system costs, and incentive and compensation policy choices.

Our analysis holds electricity demand steady across all the model runs except for the on-bill tariff energy efficiency scenarios (where load is reduced based on high-efficiency appliance deployment). The reality is electricity consumption will change based on how customers respond to price changes (i.e., price elasticity of demand). Rate design changes that are easier for customers to understand (i.e., CPUC two-tier rates) or that more accurately reflect the inter-daily fluctuation in energy system costs (i.e., CPUC TOU rates) may incentivize beneficial consumer behavior. Specifically, rates that accurately reflect system costs that consumers understand may help reduce consumption in peak hours when costs are high. Such beneficial behavior has the potential to result in reduced energy consumption that could lower costs for all consumers. By holding demand constant, our analysis fails to capture an important, iterative relationship between rate design change and consumer behavior change in the face of price signals. We do not iteratively reduce the utility's revenue requirement when we avoid system costs, such as through energy efficiency or distributed generation. Avoided system costs would reduce the revenue requirement and therefore reduce customer rates. Here, we hold LADWP's revenue requirement constant. However, we do calculate total avoided costs in certain scenarios (e.g., on-bill tariff program).

Another limitation is this study used proxy system marginal costs for LADWP's system rather than utility-specific system marginal costs. This may lead to imprecise results associated with calculation of total marginal costs and total residual costs, as well as aligning rates to actual system cost patterns. This primarily impacts TOU rates and IBFC rates. For TOU rates, more accurate local marginal cost data could inform the development of more cost-reflective price periods that better align customer behavior with power system needs. For IBFC rates, more accurate local marginal cost data could provide more accurate assumptions for how much revenue should be recovered from energy charges versus through (income-based) fixed charges.

These model runs look explicitly and exclusively at the residential class alone; they do not consider the behavior or impacts of other customer classes. Though rates are designed to recover costs by customer classes, certain elements (e.g., the funding of low-income bill assistance programs) occur across multiple classes, which this study was unable to incorporate.

These model runs are exceptionally sensitive to utility revenue requirement assumptions. For this analysis the revenue requirements were taken exogenously, directly from the utility, and were not assessed. Actual revenue requirement in 2035 will be different than what was assumed here or within the SLTRP, as technology prices change, load forecasts are updated, and new federal, state, and local policies are implemented, among many factors. While these will change the actual bills and burdens seen in 2035, the findings here indicate the *directionality* of changes under various scenarios.

Appendix B. Data Sources and Assumptions

Table B-1. Summary of Low-Income Bill Affordability Modeling Data Sources

Data	Source	Description	Resolution	Vintage
Residential electrical loads	NREL buildings team; ResStock	8760 hour building loads (no electric vehicles or solar) for 50,000 prototypical customers in LADWP service territory	Census tract	2019, 2035
SB 100 residential class revenue requirement	LADWP, March 2023 forecast	$3,341,331,261	Utility-wide, residential class only	2035
Case 1 residential class revenue requirement	LADWP, March 2023 forecast	$4,552,052,517	Utility-wide, residential class only	2035
2019 LADWP residential class revenue requirement	LADWP	$1,369,329,000	Utility-wide, residential class only	2019
CPUC two-tier rate design guidance	CPUC (California Public Utilities Commission 2015)			
CPUC default TOU guidance	CPUC (California Public Utilities Commission 2019)			
Marginal cost projections	CPUC ACC for SCE territory (California Public Utilities Commission 2022a)	8760 hour marginal cost projections	Climate zone and utility territory for the CA IOUs	2035, 2045
Solar PV projections as a fraction of residential load	LA100 Report, Ch. 3 and 4. (Jacquelin Cochran and Paul Denholm 2021)	2019: 4.0% 2035 – SB 100: 16.2% 2035 – Case 1: 26.5%	Annually per scenario for all of LADWP	2019, 2035
Distribution of solar projects by income bin	LBNL (Sydney Forrester et al. 2022)	Solar rooftop PV adopter data by income	Annually by AMI bin for Los Angeles County	2010–2021
Natural gas price forecasts	CEC (California Energy Commission 2021)	Natural gas rate projections for 2035 for SoCalGas territory	Annual	2035

Appendix C. Tariffs Overview

Tariffs used for this analysis can be found in the NREL Data Catalog at https://data.nrel.gov/submissions/218.

The LADWP FY2019 Residential Rates file shows the LADWP rates used for fiscal year 2019 for Model Run A (2019 baseline). These rates are a combination of the residential R-1 (A) tariff for fiscal year 2018–2019 (effective July 1, 2018) and the R-1 (A) tariff for fiscal year 2019–2020 (effective July 1, 2019). Both historic tariffs are available on the LADWP website.[70] In addition to the rates listed below, there is a minimum bill of $10/month.

The LADWP 2035 Residential Tariff (Case 1) file shows the rate used for 2035 LADWP BAU (Model Run B). All results are in 2035 $. Note that only the incremental ordinances change between the 2019 tariff values (effective July 1, 2019) and the 2035 values.

The CPUC 2035 Simplified Tier Rate 2035 file shows the rate values for the CPUC simplified tier rate for Model Run C, in 2035$, and the tiered consumption limits.

The CPUC TOU Rate for 2035 file shows the results for the CPUC TOU rate for Model Run D. This does not include the baseline credit that is described in the methods section above.

The CPUC Simplified Tier Rate with IBFC for 2035 file shows the results for the CPUC simplified tier rate with IBFC that is used for Model Run G.

The CPUC TOU Rate with IBFC for 2035 file shows the results for the CPUC TOU rate with IBFC used for Model Run J.

The SoCalGas Residential Natural Gas Tariff file provides an overview of the tariff used for calculating natural gas bills across all applicable model runs, in 2023$.

[70] LADWP's archive of electric rate and adjustment factor summaries is available at https://rates.ladwp.com/Contentpage.aspx?SubCatID=1040 (accessed June 28, 2023)

Appendix D. SB 100 Results

This section details the results from the sensitivity analysis exploring how rates evolve under a significantly lower revenue requirement, in line with LADWP complying with SB 100. Under these scenarios, LADWP is forecasted to achieve 80% clean energy by 2035 before reaching 100% clean energy in 2045. As with the SLTRP Case 1 results detailed in the body of this report, the following results are based on the SB 100 forecasted revenue requirements taken exogenously from LADWP totaling $3.341 billion in 2035 $. In addition to the new revenue requirement, there are two key differences between SB 100 and Case 1 results. In the following SB 100 results, total rooftop solar PV generation from single-family residences was forecasted to offset 16.2% of total residential load (compared to 26.5% under Case 1). Additionally, whenever marginal cost estimates from the CPUC ACC were used, for SB 100 the 2045 results for SCE were used and the dollar year converted to 2035$, assuming a 2.5% annual inflation rate.

Table D-1. Sample Results Comparing Case 1 and SB 100 Revenue Requirements

	2035 BAU LADWP (w/ EZ-SAVE)		2035 CPUC Simplified Tier (no Bill Assistance)		2035 CPUC TOU (no Bill Assistance)	
Revenue Requirement	**Case 1**	**SB100**	**Case 1**	**SB100**	**Case 1**	**SB100**
Avg. Monthly Bill (All Households)	$ 188	$ 136	$ 188	$ 138	$ 188	$ 138
Avg. Monthly Bill (Lowest-Income)	$ 193	$ 127	$ 178	$ 126	$ 179	$ 127
Avg. Monthly Bill (Solar PV adopters, all incomes)	$ 58.0	$ 39.7	$ 144	$ 90.8	$ 136	$ 87.3
Avg. Monthly Bill (Nonadopters, all incomes)	$ 220	$ 149	$ 199	$ 144	$ 201	$ 145
Transfer Costs ($)	$ 10,400,000	$ 10,400,000	$ -	$ -	$ -	$ -
Transfer Costs (share of revenue requirement	0.323	0.44	0	0	0	0
Avg. Electricity Burden (All Households)	7.18	5.37	6.89	5.39	6.96	5.42
Avg. Electricity Burden (Lowest-income)	16.1	11.9	15.2	11.9	15.4	12
Avg. Electricity Burden (Moderate-income)	3.96	2.81	3.73	2.73	3.77	2.75
Households over 100-percent Eletricity Burden (All Households)	23,000	9,580	19,500	9,710	19,700	9,740
Avg. Month HMW (All Households)	13.5	9.77	13.5	9.9	13.5	9.9
Avg. Month HMW (Moderate-Income)	14	10	13.3	9.76	13.4	9.8
Low-cost Month HMW (Lowest-Income)	10.2	6.84	9.24	6.58	9.45	6.69
Avg. Month HMW (Lowest-Income)	13.9	9.09	12.7	9.05	12.8	9.09
High-cost Month HMW (Lowest-Income)	19.2	12.7	19.1	13.7	18.9	13.5
Avg. Annual NER (All Households)	87.5	107	61.7	85	58.7	81.4
Avg. Annual NER (Lowest-Income)	16	32.2	16.3	23.4	15.6	22.7
Avg. Annual NER (Moderate-Income)	47.8	63.5	42.5	59.5	39.8	56.3

Across the three rate scenarios, average household electricity bills decreased by approximately $50/month, or a 26% reduction. Lowest-income household bills decreased by $66/month (34%) in the BAU case, $52/month (29%) under a simplified tier rate and TOU rate. Solar adopter bills under net energy metering frameworks (2035 BAU LADWP) saw the smallest change between the Case 1 and SB 100 revenue requirement scenarios, reflecting the fact that solar adopters under net metering are mostly insulated from energy prices. As stated before, the model used for this analysis is very sensitive to assumptions around the revenue requirement. The revenue requirement under SB 100 ($3.341 billion) is approximately 73% of the revenue requirement under Case 1 ($4.552 billion), and the average bills across the scenarios reflect a similar reduction in magnitude. *Aside from changes in absolute values, the general trends observed under the Case 1 revenue requirement hold for the SB 100 revenue requirement.*

The model was run with SB 100 revenue requirements to determine how sensitive the trends observed under Case 1 were to assumptions around the costs of operating and building the power system of the future. These results are not a complete picture of the differences between meeting LADWP's current policies and target (100% by 2035) versus under California state mandates (100% by 2045). For instance, the model does not capture benefits or costs associated with reduced air pollution, job impacts, or mitigating the worst effects of climate change. Given the results above, however, we should note that (1) the general trends around equity and affordability seem to hold, and LADWP should have more confidence in our recommendations; and (2) as LADWP continues to improve its forecasts for revenue requirements in line with its SLTRP process, it should consider re-evaluating in detail the impacts to lowest-income customers as done in this analysis.

Appendix E. Complete IBFC Model Results

This appendix contains a more detailed breakdown of certain IBFC model results, showing both the average and median electricity bills and electricity burdens. The focus on these results is to highlight how high-income customers would be impacted by the transition to IBFC tariff design. The median results are included here to illustrate what would happen to a typical customer as the average was skewed by customers with exceptionally high or low bills and burdens. Bill and burden results are broken down by AMI bin and solar PV adoption status.

Table E-1. Average and Median Annual Electricity Bills by Scenario for Solar PV Adopters and Non-Adopters for Income-Based Fixed Charge Model Runs

		Average		Median	
	AMI Bin	**Non-adopter**	**PV Adopter**	**Non-adopter**	**PV Adopter**
2035 CPUC Simplified Tier IBFC (no Bill Assistance)	*Lowest*	$ 980	$ 912	$ 712	$ 1,320
	Moderate	$ 2,040	$ 1,780	$ 1,940	$ 1,720
	Middle	$ 2,570	$ 2,290	$ 2,480	$ 2,250
	High	$ 3,980	$ 3,650	$ 3,850	$ 3,610
2035 CPUC Simplified Tier IBFC (w/ CARE & FERA)	*Lowest*	$ 744	$ 709	$ 498	$ 891
	Moderate	$ 2,110	$ 1,910	$ 2,020	$ 1,870
	Middle	$ 2,700	$ 2,480	$ 2,600	$ 2,430
	High	$ 4,120	$ 3,850	$ 3,970	$ 3,790
2035 CPUC TOU IBFC (no Bill Assistance)	*Lowest*	$ 975	$ 946	$ 712	$ 1,370
	Moderate	$ 2,030	$ 1,810	$ 1,900	$ 1,740
	Middle	$ 2,570	$ 2,300	$ 2,440	$ 2,260
	High	$ 3,970	$ 3,670	$ 3,810	$ 3,620
2035 CPUC TOU IBFC (w/ CARE & FERA)	*Lowest*	$ 740	$ 735	$ 498	$ 931
	Moderate	$ 2,100	$ 1,940	$ 1,980	$ 1,890
	Middle	$ 2,700	$ 2,500	$ 2,550	$ 2,440
	High	$ 4,110	$ 3,870	$ 3,920	$ 3,800

Appendix F. 2035 Housing Stock

The residential loads were simulated using a projected 2035 housing stock. The 2035 housing stock is projected off the 2019 housing stock used in other housing analysis in this report (Stenger et al. 2023). Projections were done under a BAU frame where more-intensive residential energy efficiency investments are done by wealthier homeowners than lower-income, renting households (Solà et al. 2020). AMI and tenure were used to sort the housing characteristics, where higher-income households were ordered before lower-income, and then owners were ordered before renters. After ordering the housing stock, housing technology packages were applied in percentages shown in Table F-1.

Table F-1. Housing Stock Package Saturation

Package #	Package Description	Package Saturation
1	• 100% LED lighting • 25% reduced infiltration (minimum at 1 ACH50) • Induction cooking range • Wall insulation (R-19) • Double-pane windows • Heat pump clothes dryer • Attic insulation (R-49; only applicable to single-family dwellings with vented attics) • Heat pump water heater • Heat pump (air-source heat pump SEER 26.1, 11 heating seasonal performance factor [HSPF] for dwellings with ducts; mini-split heat pump SEER 33.1, 13.5 HSPF for dwellings without ducts)	25%
2	• 100% LED lighting • 25% reduced infiltration • Induction cooking range • Wall insulation (R-19) • Double-pane windows • Heat pump clothes dryer • Attic insulation (R-49; only applicable to single-family dwellings with vented attics) • Heat pump water heater	10%
3	• 100% LED lighting • 25% reduced infiltration • Induction cooking range • Wall insulation (R-19) • Double-pane windows • Heat pump clothes dryer • Attic insulation (R-49; only applicable to single-family dwellings with vented attics)	15%

Package #	Package Description	Package Saturation
4	• 100% LED lighting • 25% reduced infiltration • Induction cooking range • Heat pump clothes dryer • Attic insulation (R-49; only applicable to single-family dwellings with vented attics)	10%
5	• 100% LED lighting • 25% reduced infiltration • Heat pump clothes dryer • Attic insulation (R-49; only applicable to single-family dwellings with vented attics)	15%

The 2035 housing stock has a different profile of energy use than the 2019 housing stock. The average household energy use is shown in Figure F-1 disaggregated by AMI. On average, electricity and natural gas use decrease from 2019 (shown in Figure F-1) to 2035 (shown in Figure F-2) for higher-income households (>120% AMI). The decrease in natural gas usage and electricity usage is attributed to the larger percentage of energy efficiency and decarbonizing technologies to higher-income households. In comparison, extremely low-income (0%–30% AMI) households do not see a notable difference between 2019 and 2035 for electricity or natural gas use, largely because these households did not receive energy efficiency or decarbonizing technologies in the BAU case.

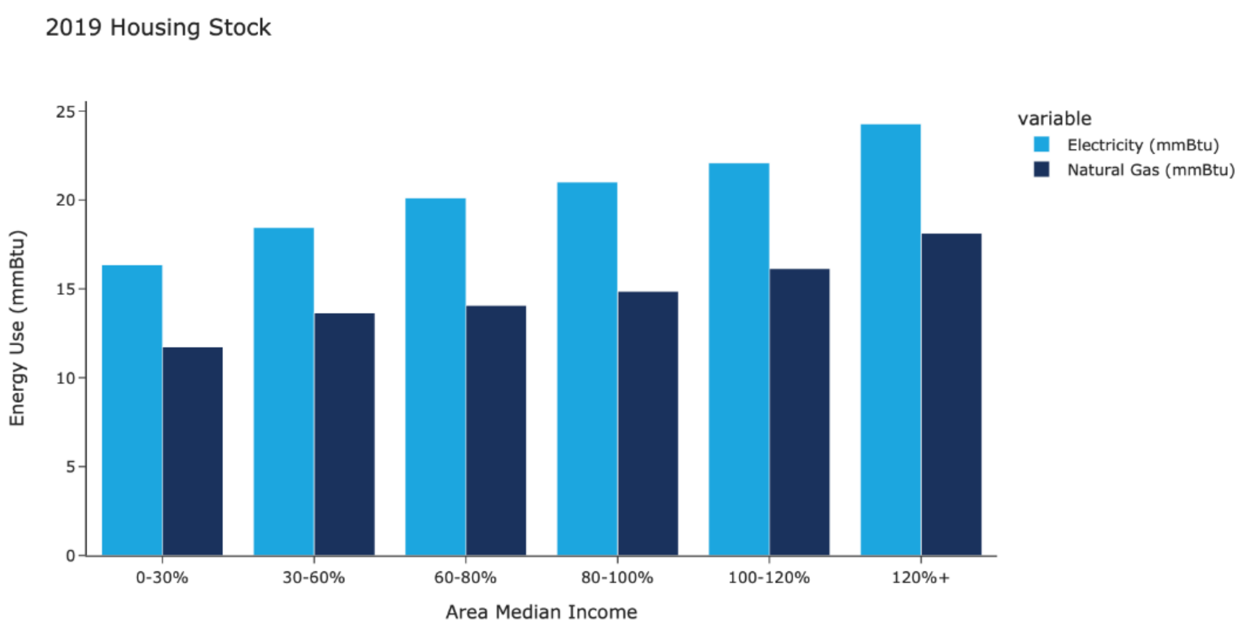

Figure F-1. Average dwelling energy use in 2019 housing stock

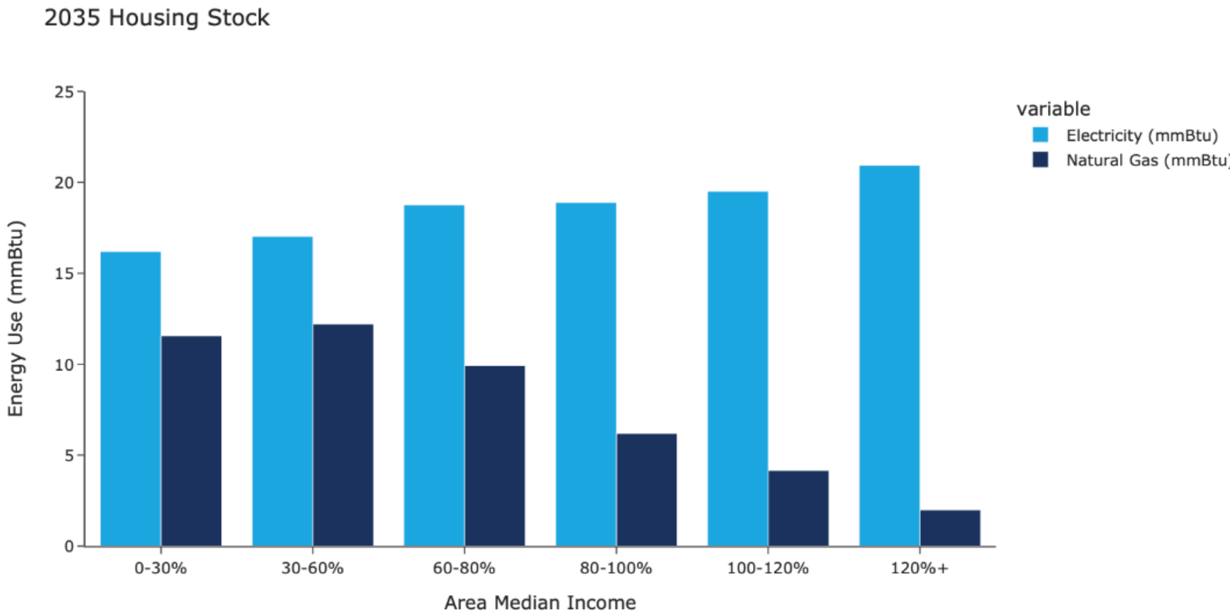

Figure F-2. Average dwelling energy use in 2035 housing stock

Appendix G. On-Bill Tariff Technical Potential Enrollment Demographics

The on-bill tariff program examined viable technologies to decrease energy use. Of the technologies examined, heat pump water heaters and enhanced insulation proved to be most economically viable. For our technical potential analysis, Figure G-1 and Figure G-2 show the demographics of the potentially served households in an on-bill tariff program to receive heat pump water heaters. Figure G-3 and Figure G-4 show the demographics of the potentially served households to receive enhanced insulation.

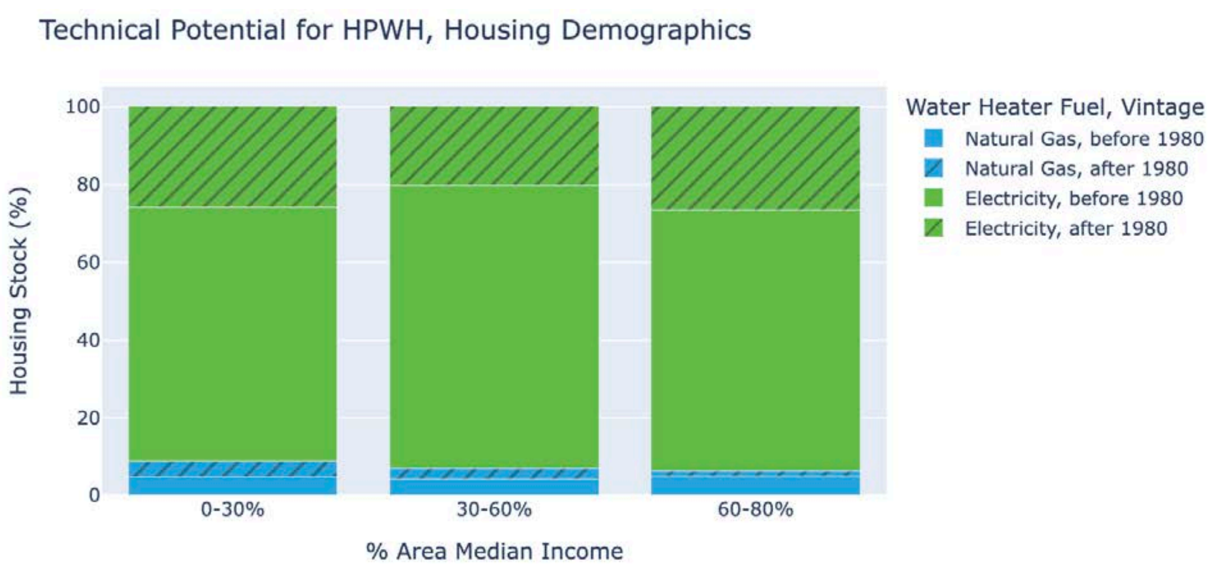

Figure G-1. Building characteristics of households achieving bill savings from on-bill, tariff-funded heat pump water heaters

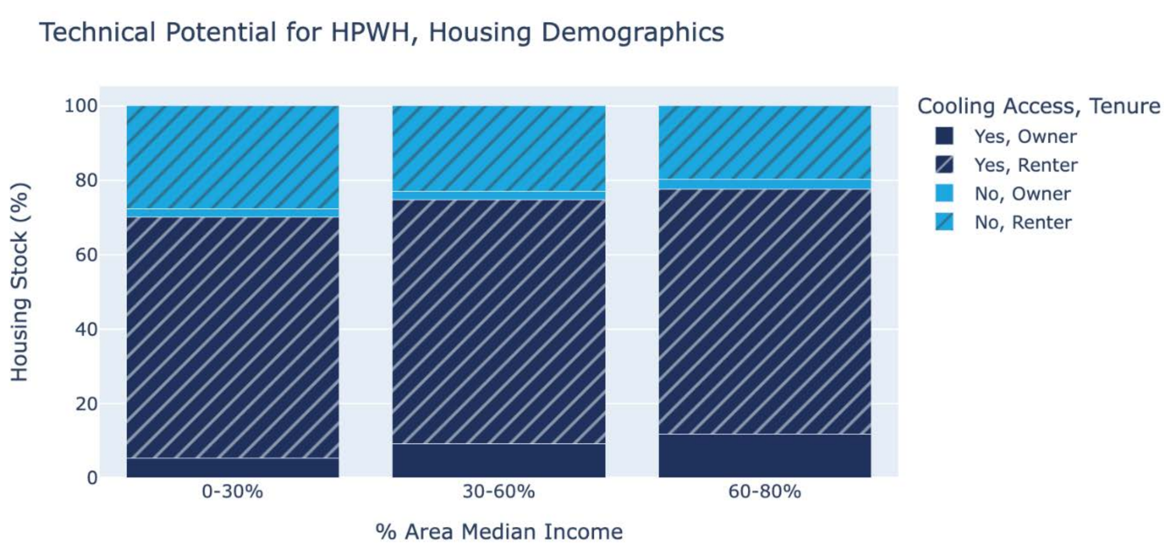

Figure G-2. Demographics of households achieving bill savings from on-bill, tariff-funded heat pump water heaters

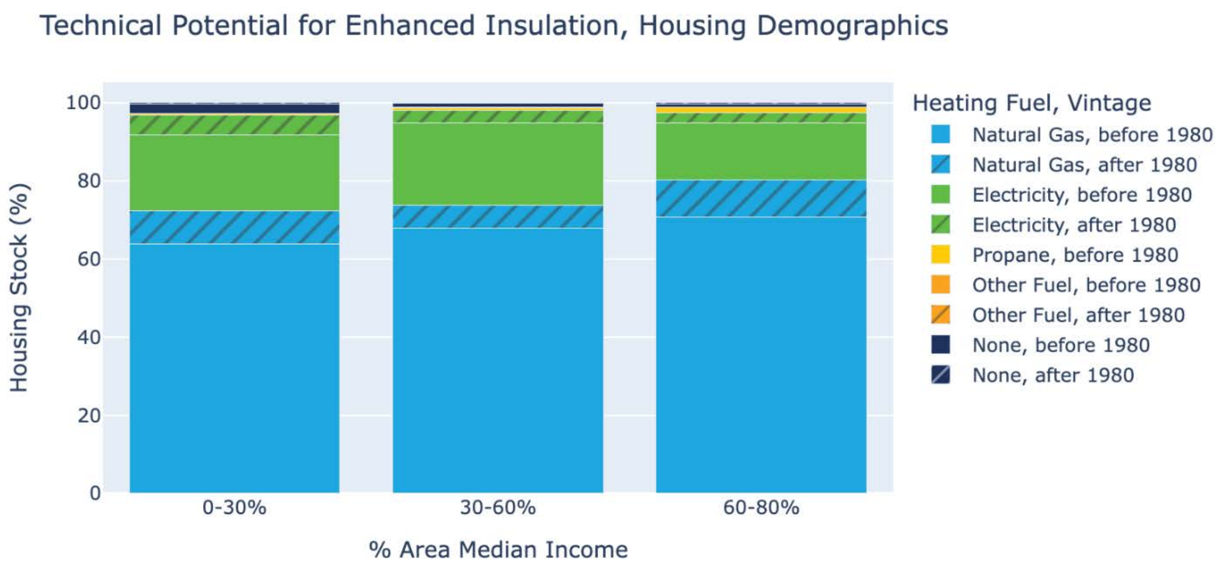

Figure G-3. Building characteristics of households achieving bill savings from on-bill, tariff-funded enhanced insulation

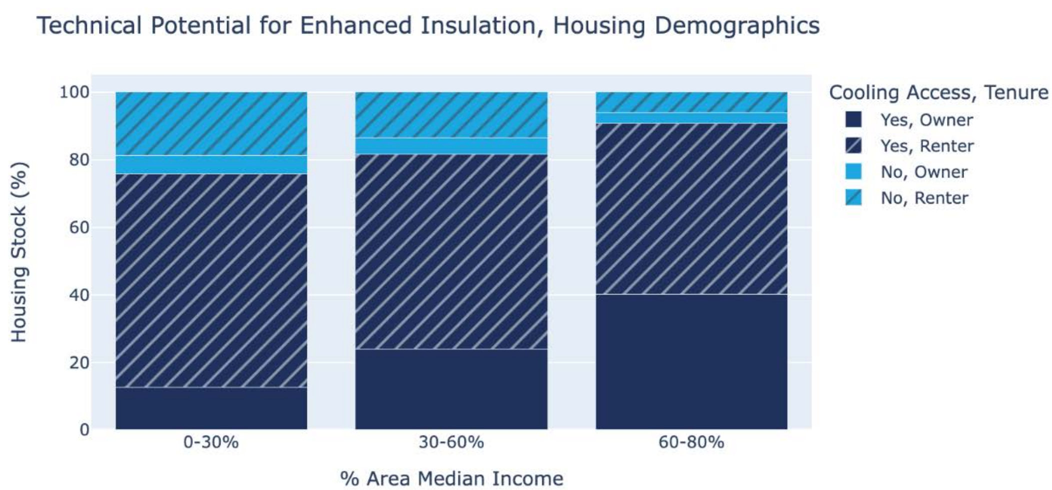

Figure G-4. Demographics of households achieving bill savings from on-bill, tariff-funded enhanced insulation

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