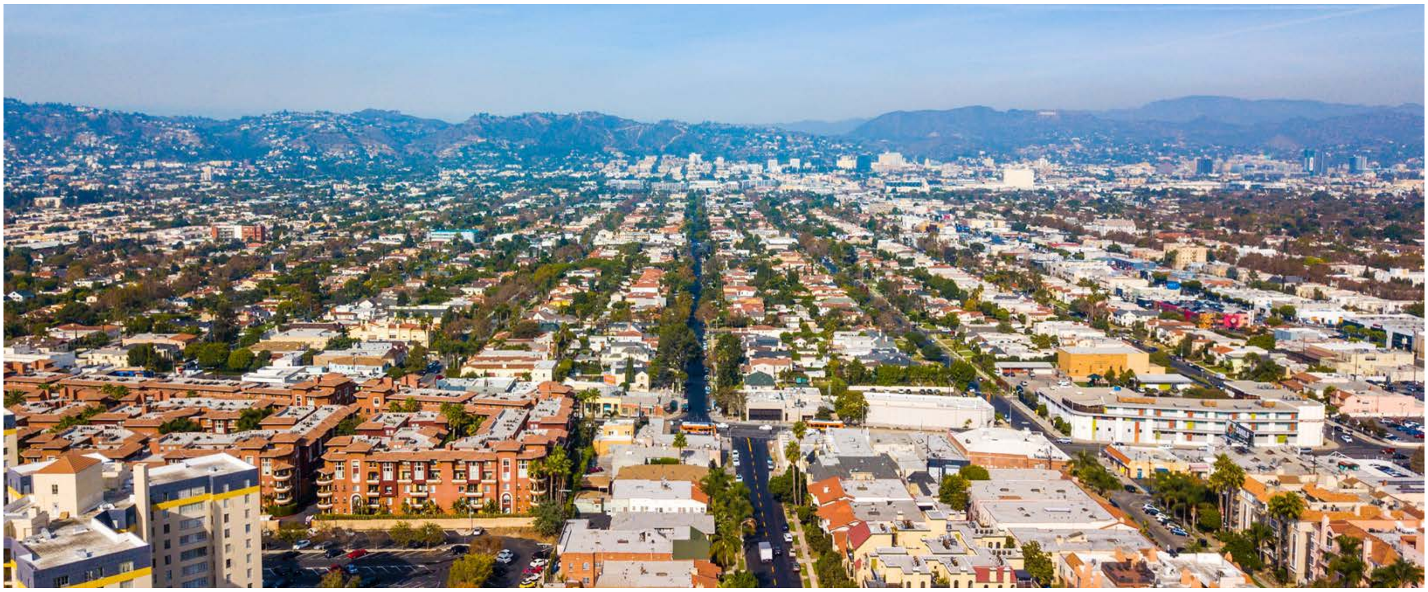

Chapter 8: Equitable Rooftop Solar Access and Benefits

FINAL REPORT: LA100 Equity Strategies

Ashok Sekar, Ashreeta Prasanna, Paritosh Das, Megan Day, and Kate Anderson

LA100 EQUITY STRATEGIES

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November 2023

LA DWP NREL Transforming ENERGY

LA100 EQUITY STRATEGIES

Produced under direction of the Los Angeles Department of Water and Power by the National Renewable Energy Laboratory (NREL) under Work for Others Agreement number ACT-18-00039.

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

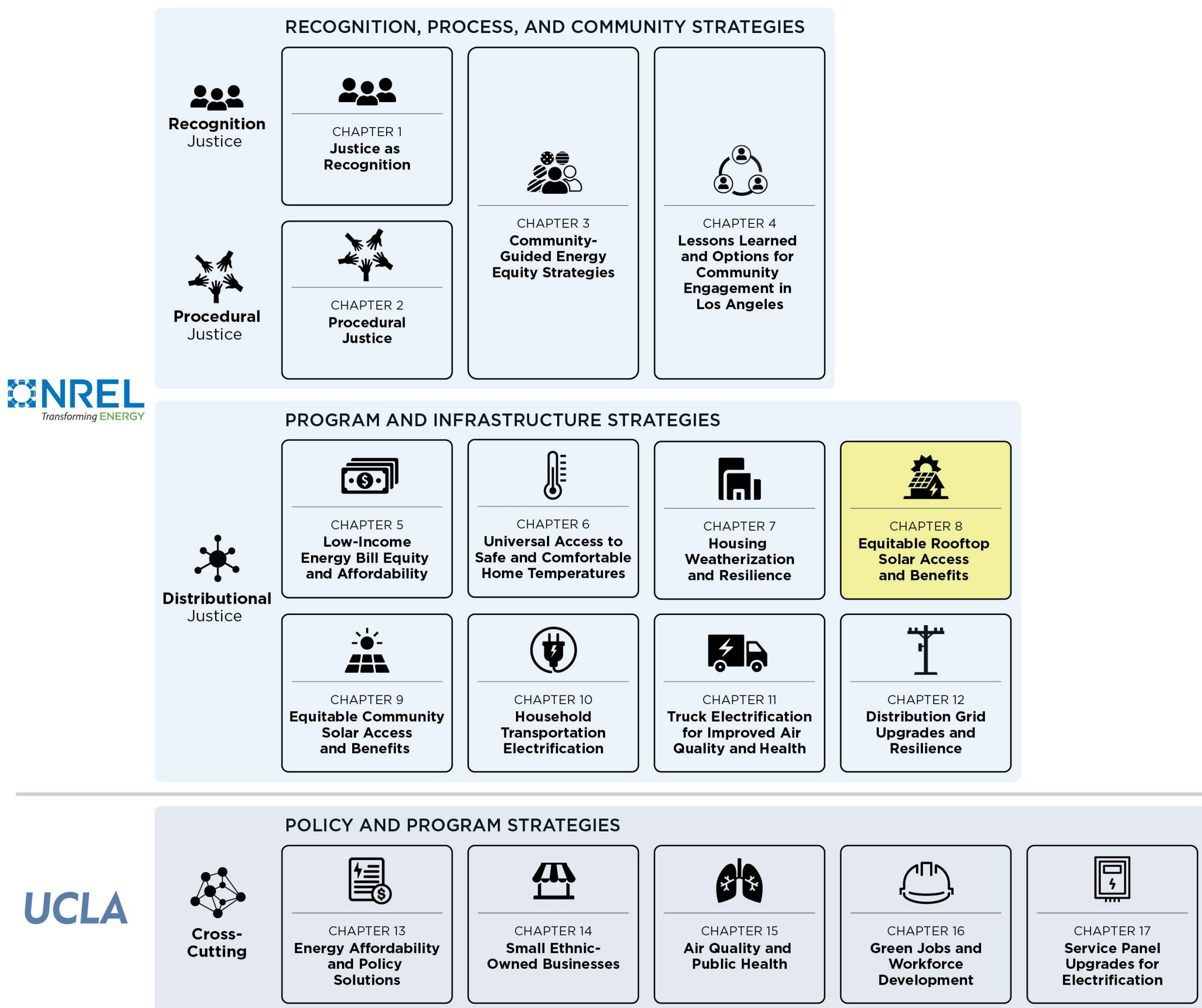
LA100 Equity Strategies employs a unique mixed-methodological approach utilizing three distinct—but connected—research efforts. Through these efforts, NREL and UCLA developed a range of strategy options for increasing equity in LA's transition to 100% clean energy.

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

Chapter 1: Justice as Recognition

Chapter 2: Procedural Justice

Chapter 3: Community-Guided Energy Equity Strategies

Chapter 4: Lessons Learned and Options for Community Engagement in Los Angeles

Chapter 5: Low-Income Energy Bill Equity and Affordability

Chapter 6: Universal Access to Safe and Comfortable Home Temperatures

Chapter 7: Housing Weatherization and Resilience

Chapter 8: Equitable Rooftop Solar Access and Benefits

Chapter 9: Equitable Community Solar Access and Benefits

Chapter 10: Household Transportation Electrification

Chapter 11: Truck Electrification for Improved Air Quality and Health

Chapter 12: Distribution Grid Upgrades for Equitable Resilience and Solar, Storage, and Electric Vehicle Access

UCLA Chapters

Chapter 13: Energy Affordability and Policy Solutions Analysis

Chapter 14: Small Ethnic-Owned Businesses Study

Chapter 15: Air Quality and Public Health

Chapter 16: Green Jobs Workforce Development

Chapter 17: Service Panel Upgrade Needs for Future Residential Electrification

List of Abbreviations and Acronyms

AMI	area median income
DAC	disadvantaged community
dGen	Distributed Generation Market Demand (model)
DI	direct-install
EE	energy efficiency
GW	gigawatts
hr	hour
ITC	investment tax credit
kW	kilowatt
kWh	kilowatt-hour
LADWP	Los Angeles Department of Water and Power
LMI	low- and moderate-income
MW	megawatts
MWh	megawatt-hours
NEM	net energy metering
NREL	National Renewable Energy Laboratory
PV	photovoltaic
REPLICA	Rooftop Energy Potential of Low Income Communities in America
SB	Senate Bill (California)
SI	split incentive
W	watt
WACC	weighted average cost of capital
yr	year

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 analysis of customer-sited rooftop solar and storage as a means to reduce electricity bills for low- and moderate-income (LMI) households, multifamily building residents, and renters, who traditionally lack access to bill savings from rooftop solar.

Specifically, NREL modeled customer-sited solar and storage adoption using the Distributed Generation Market Demand (dGen™)[1] model through 2035 and developed scenarios to identify programs or policies that could support equitable access to bill savings from rooftop solar or solar-plus-storage. Scenarios tested include a direct-install program for LMI customers, net metering for LMI customers, and equitable distribution of benefits from installing solar between owners and renters of renter-occupied buildings.

Research was guided by input from the community engagement process, and 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 includes the following:

- Address the cost of rooftop solar
- Provide community solar access
- Deliver customized information on investments and payback periods to address skepticism about the value of solar
- Protect residents from predatory solar developers.

Wilmington, LA Harbor Resident

"I'm a homeowner. And I have a duplex, so I rent out … And we're trying to get solar from the Department of Water and Power, it's difficult. Yes, you have subsidies and stuff. But you gotta put up almost 20 grand just to get the solar power. Who's going to take on all that with my tenants?"

Steering Committee Member

"More outreach in low- and moderate-income communities and communities of color is needed on options for solar and storage."

South LA Public Housing Resident

"… they were trying to put solar panels on the roof, on the projects. But some people from the community gathered around and then they were telling me to vote no for them to put it [solar on the roof]. Because they were like, what's the point of them putting solar panels on the roof when they're going to start charging us or you may never know even if they're going to work or how long they're going to last. So, a lot of people rejected that offer, so ... they still tried to convince us to get it. But mostly all of us voted no."

[1] "Distributed Generation Market Demand Model," NREL, https://www.nrel.gov/analysis/dgen

Distributional Equity Baseline

Analysis of Los Angeles Department of Water and Power (LADWP) residential net energy metering programs (Figure ES-1) indicates 62% of LADWP net energy metering program incentives delivered between 1999 and 2021 went to households in non-disadvantaged communities. In addition, the $341 million in LADWP net energy metering incentives over these 22 years disproportionately benefited predominantly White, non-Hispanic, home-owning, and wealthier neighborhoods.

Figure ES-1. Statistical analysis of LADWP residential solar investments by disadvantaged community status (1999–2021)

Geospatial analysis of the distribution of LADWP solar incentives finds that disadvantaged communities (DACs), particularly in South LA and the Harbor region, did not receive solar incentives proportional to their populations (Figure ES-2).

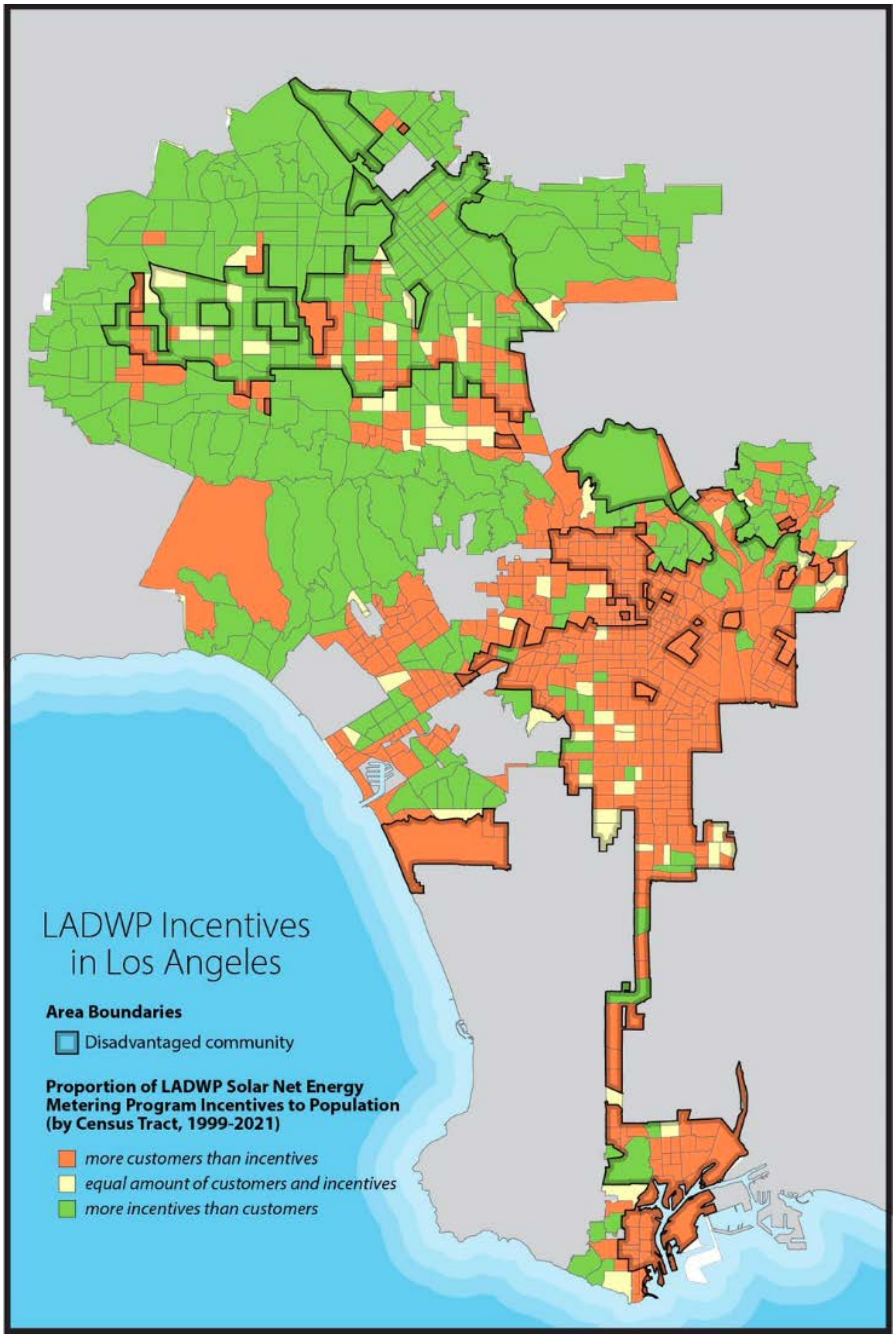


Figure ES-2. Distributional equity analysis of LADWP residential solar net energy metering incentive programs (1999–2021)

Key Findings

- A substantial portion of suitable rooftop solar area lies outside of the types of households who have received most incentives to date. LMI households occupy buildings representing

57% of all solar photovoltaic (PV)-suitable roof area in Los Angeles. Multifamily households represent 60%, and 55% of suitable rooftop area is occupied by renters.
- Baseline scenario modeling indicates 1.4 gigawatts (GW) of cumulative rooftop solar adoption by 2035 in Los Angeles. With current incentives extended into the future, single-family, owner-occupied, non-LMI households will account for approximately 70% of that adoption.

Rooftop solar equity metrics include:

- Annual electricity bill savings
- By income, housing type, disadvantaged community status, and renter/owner status.

- Rooftop PV adoption among LMI customers could increase by 85% (up to 530 megawatts [MW] of solar and 520 MW of storage) under a direct-install program for LMI customers funded by LADWP, combined with strategies to convey solar savings to renters and resolve the split incentive challenge. LMI rooftop PV adoption could increase by 40% (up to 280 MW of solar and 0 MW of storage) under a net metering program for LMI customers combined with strategies to convey solar savings to renters.
- New solar capacity adoption in DACs is lower than in non-disadvantaged tracts in most scenarios in the initial years. Analysis shows that implementing LADWP direct-install programs, combined with strategies to convey solar savings to renters, substantially increases solar capacity additions in DACs as compared to non-DACs as we approach 2035.
- Under a net metering for LMI households scenario, moderate-, low-, and very low-income households see additional average electricity bill savings of 30%, 30%, and 34%, respectively, compared to the Baseline scenario. Under a net billing with direct-install and renter solar bill savings scenario, average electricity bill savings increase by 16%, 17%, and 18% for moderate-, low-, and very low-income customers, respectively, compared to the Baseline scenario.
- The total program costs over 16 years for direct-install of 530 MW of solar and 520 MW of storage for LMI households is $2.2 billion or $140 million/year. Total program costs for 280 MW of net metered solar (with no storage) for LMI households is $2.7 billion or $170 million/year. These costs would be recovered from rate increases, leading to higher bills for households without access to solar bill savings.

Equity Strategies

- Offering net energy metering to LMI customers enables these customers to achieve an average of 30% additional electricity bill savings ($460/year [yr]) if they install solar compared to the Baseline scenario.
- Implementing direct-install programs results in higher-capacity deployment, which could benefit the LADWP distribution grid if the program is targeted to specific geographic regions. Net metering programs result in higher bill savings for low-income customers.
- Resolving renter-owner split incentives through programs such as virtual net energy metering, community solar, green leases, on-bill financing, or property-assessed clean energy programs can increase solar electricity bill savings by up to 84% for renters.

- A discounted LMI Shared Solar rate delivers similar savings to rooftop solar approaches modeled here, is easily accessible to multifamily building residents and renters, and is essentially cost-neutral for LADWP (see Chapter 9, Prassana et al. 2023).

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1 Introduction

This analysis focuses on improved access to bill savings from solar and storage for low-income households, multifamily building residents, and renters. NREL modeled adoption of customer-sited rooftop solar (with storage, where it was economic) using the Distributed Generation Market Demand (dGen™) model under multiple scenarios. Scenarios consider electrification, targeted incentives, and future utility rates and are simulated in dGen from 2020 to 2035 to inform incentive and program design and investment prioritization.

Rooftop solar historically has had limited reach in these communities because of barriers like financing challenges, monetization of investment tax credits, costs to upgrade electrical panels or replace roofs, and split incentives. Split incentives refer to situations where upgrades like solar would be paid for by a building owner, yet savings would accrue to renters, disincentivizing the investment. Policies including solar leasing, property-assessed clean energy financing, and LMI-specific incentives may increase access to bill savings among lower-income households and renters. In addition to addressing split incentives, direct-install programs where solar and storage systems are installed at no cost or net metering programs are also methods to increase access to solar bill savings among low-income households. Such programs would also allow the Los Angeles Department of Water and Power (LADWP) to provide resiliency services or monetize aggregated distributed energy resources under Federal Energy Regulatory Commission Order 2222.

1.1 Modeling and Analysis Approach

Census tract-level information about LADWP's residential customers were input into the dGen model to identify strategies to achieve increased equity in access to bill savings from rooftop solar (and storage where it was economic).

The dGen model is a geospatially rich, bottom-up, market-penetration model that simulates the potential adoption of distributed energy resources, such as rooftop solar photovoltaics (PV), for residential, commercial, and industrial customers at high spatial and temporal resolutions. For Chapter 4 of the completed Los Angeles 100% Renewable Energy Study (Sigrin et al 2021), the dGen model was used to simulate solar adoption at a premise level and the model incorporated several characteristics to estimate the probability of adoption, including socioeconomic characteristics such as income, sensitivity to prices, and parameters to capture the social diffusion of technology (Sigrin et al. 2021). The LA100 Equity Strategies project builds on that analysis by using the same characteristics to further identify the probability of adoption based on income, building type, and ownership status, specifically in the residential sector.

Figure 1 outlines the main dGen adoption modeling steps, and Figure 2 provides an overview of the spatial layers in dGen used to characterize representative customers. Results from dGen include several financial output metrics, such as the net present value of solar and storage systems that are sited at customer premises, electricity bills of customers with and without solar and storage systems, excess electricity exported to the grid, and payback periods of solar and storage systems. Energy burden, calculated as annual utility bills divided by annual household income, is calculated for each customer demographic before and after the adoption of solar and storage technologies. Thus, the impact on energy burden for low-income customers from access to solar and storage can also be determined. In addition to financial output metrics, results include the modeled cumulative capacity of solar and storage systems at high spatial resolution for future years by income class, building type, and household ownership status under multiple scenarios. By modeling representative customers across all income levels and calibrating the model to account for differences in the propensity to adopt, the results from the model reflect the differences in adoption patterns by customer type and location.

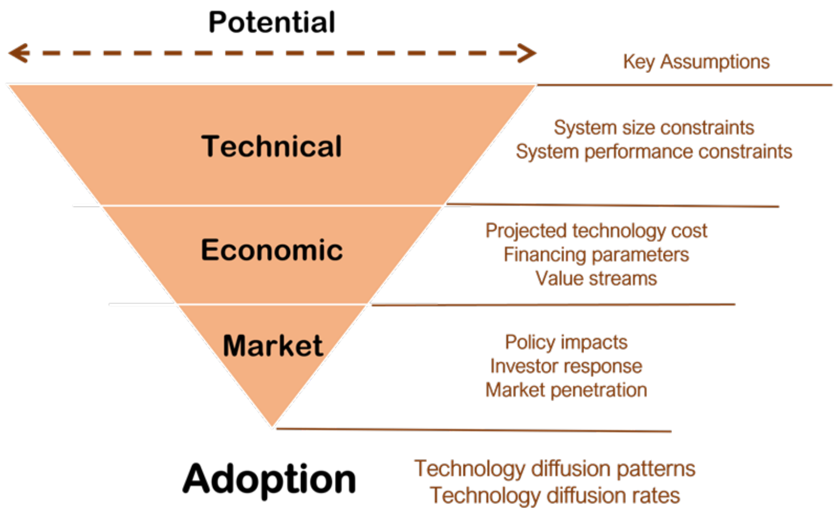

Figure 1. Overview of the dGen model used for rooftop solar and storage analysis

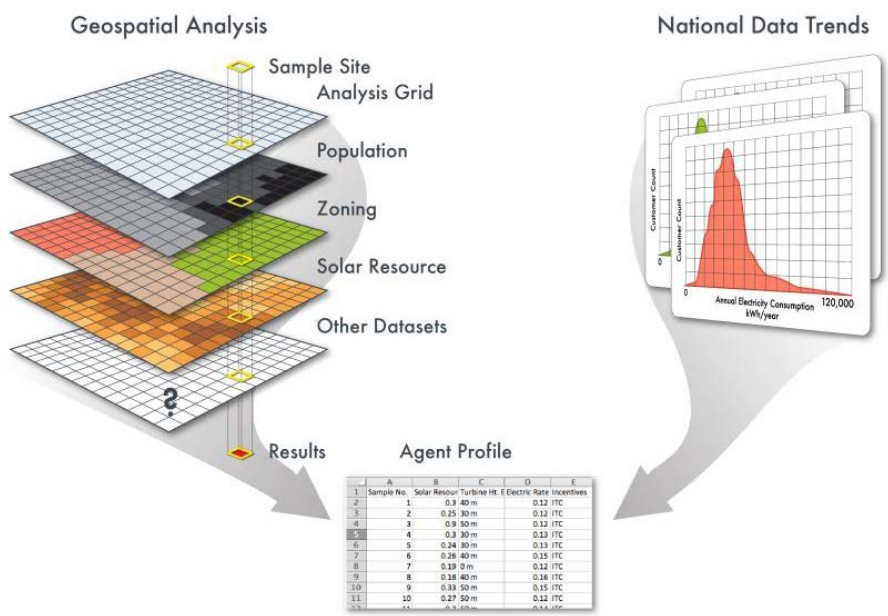

Figure 2. Schematic of spatial layers in dGen

Historically, dGen has modeled single-family, owner-occupied households only. Preparing the dGen model for the LA100 Equity Strategies project involved first updating customer characteristics, such as:

- Electricity consumption
- Load profile
- Total PV-suitable roof area
- Economic and financial parameters that include—but are not limited to—incentives, tariff rates, and inflation rates, as well as the future outlooks of these parameters.

Next, new representations of customers were developed to model non-single-family, owner-occupied households. Representative customers modeled in dGen include LADWP households by five income classes:

- Very low (0%–30% area median income [AMI])
- Low (30%–60 % AMI)
- Moderate (60%–80% AMI)
- Mid (80%–120% AMI)
- High (120%+ AMI).

These households are further categorized by eight building classifications:

- 2 Unit (multifamily)
- 3 or 4 Unit (multifamily)
- 5 to 9 Unit (multifamily)
- 10 to 19 Unit (multifamily)
- 20 to 49 Unit (multifamily)
- 50 or more Unit (multifamily)
- Single-Family Attached
- Single-Family Detached.

Households are also classified by ownership status: owner and renter.

Appendix A provides details on the data sets and methods used to develop representative customers.

1.2 Scenarios

Several scenarios were developed to guide equity strategy development. These scenarios were selected to model benefits for low- and moderate-income (LMI) multifamily building residents and renters from solar and storage access or adoption. Modeled scenarios include the following.

1.2.1 Baseline Scenario

Under the Baseline scenario, we assume customers have baseline electricity consumption modeled using ResStock as described in Chapter 5 (Prasanna et al. 2023). Tiered rates are assigned to customers based on their zone and average monthly consumption.[2] Retail rate escalation is based on LADWP Strategic Long-Term Resource Plan projections under the California Senate Bill (SB) 100 scenario. The federal investment tax credit (ITC) is applied based on the Inflation Reduction Act of 2022. We assume the existing LADWP net metering program will be discontinued and transitioned to a program modeled after Net Energy Metering (NEM) 3.0, which was passed by the California State Legislature and enforced for investor-owned utilities in the state. NEM 3.0 provides lower compensation for excess electricity reduction than NEM 2.0. Therefore, export rates are set to be comparable to wholesale electricity prices, or net billing. Wholesale prices are flat rates that increase yearly from 2.6 cents/kilowatt-hour (kWh) in 2020 to 4.3 cents/kWh in 2035. All other financial parameters are modeled based on NREL's 2022 Annual Technology Baseline projection data (NREL 2022).

1.2.2 Direct-Install for LMI (DI for LMI) Scenario

Under this scenario, solar and storage systems are installed at zero cost for LMI households between 2020 and 2035. The cost of the systems is assumed to be borne by LADWP. We assume LADWP can claim the 30% ITC for these systems and that costs are recovered through state funds or through rate recovery. We do not model the impact of recovering program costs through retail rate increases. Also, despite systems being offered at no cost, not all LMI households adopt the systems because of several barriers, such as distrust (Reames 2016) or general lack of interest in installing solar (Wolske 2020). A recent analysis of adoption data for California's low-income solar programs, managed by GRID Alternatives, showed that between 2009 and 2018, only 10% of all households contacted adopted solar despite being offered a solar system at no cost; although this was often due to ineligibility, many lost interest despite being qualified leads (Sigrin, Sekar, and Tome 2022).

1.2.3 Split Incentives Resolved (No SI) Scenario

Renters and multifamily households face a split incentive problem where residents of the housing units do not have agency over the rooftop and building owners pay for upgrades, but bill savings accrue to tenants who pay utility bills. To model the impact of split incentives in this scenario, two edge cases are considered: split incentives being fully resolved and split incentives being partially resolved. There is no existing work to mathematically characterize split incentive phenomena at fine spatial resolution. Therefore, we fully resolve split incentives by assuming the weighted average cost of capital (WACC) is the same for tenants who are renters and tenants who are owners of their units. In the Baseline scenario, we assume WACC for tenants who are renters is significantly higher than for tenants who are owners. The assumptions are based on updated WACC cost estimates from NREL's 2022 Annual Technology Baseline (NREL 2022) and Heeter et al. (2021) as part of the Solar Futures Study.[3] The effect of this assumption impacts all multifamily households and renters irrespective of their income class or the building type in which they reside. In practice, solutions to split incentives between owners and tenants

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[2] "Customer Service: Electric Rates," LADWP, https://www.ladwp.com/ladwp/faces/ladwp/residential/r-customerservices/r-cs-understandingyourrates/r-cs-ur-electricrates.
[3] "Solar Futures Study," U.S Department of Energy, https://www.energy.gov/eere/solar/solar-futures-study.

include programs such as property-assessed clean energy,[4] green leases, and other strategies (Castellazzi, Bertoldi, and Economidou 2017). Such programs aim to formalize and realign the financial incentives from energy measures between the owner and the renter. Because these programs are new, the propensity of adopting these measures is unavailable. The case of split incentives being fully resolved assumes such programs are 100% effective, such that multifamily renters behave similarly to single-family owners.

1.2.4 Net Metering for LMI (NEM for LMI) Scenario

In this scenario, LMI customers are assumed to benefit from net energy metering where the excess generation is compensated at retail rates (greater than 20 cents/kWh). The net metering for LMI customers cost is assumed to be borne by LADWP. Net metering for LMI is modeled in combination with resolving split incentives because resolving split incentives is a necessary precursor to renters accessing net metering benefits.

1.2.5 High Energy Efficiency (High EE) Scenario

This scenario is modeled based on Chapter 7 (Stenger et al. 2023), where a high uptake of energy efficiency measures, such as weatherization and end-use technology upgrades, is modeled as an equity strategy. High uptake of energy efficiency measures reduces the annual electricity consumption of LADWP customers in this scenario, which in turn impacts the cost savings from—and, therefore, the adoption propensity for—solar and storage systems.

We develop five combinations of the above equity scenarios in addition to the Baseline scenario to investigate equity strategies (Table 1). Additional assumptions, inputs, and financial assumptions are described in Appendix A.

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[4] "Commercial Property Assessed Clean Energy (C-PACE)," October 2017, DOE/EE-1697, https://www.energy.gov/scep/slsc/articles/commercial-property-assessed-clean-energy-fact-sheet-state-and-local-governments

Table 1. Summary of Scenarios Modeled in dGen

Scenario Name	Scenario Short Name	Load Profile	Split Incentives	External Incentives	Compensation Style
Baseline	Baseline	Baseline	Partially resolved	ITC only	Net billing
High Adoption of Energy Efficiency Measures	High EE	Equity	Resolved	ITC only	Net billing
Split Incentives Resolved	No SI	Baseline	resolved	ITC only	Net billing
Direct-Install for LMI	DI for LMI	Baseline	Partially resolved	ITC and no system cost for LMI customers	Net billing
Split Incentives Resolved and Direct-Install for LMI	No SI and DI for LMI	Baseline	Resolved	ITC and no system cost for LMI customers	Net billing
Split Incentives Resolved and Net Metering for LMI	No SI and NEM for LMI	Baseline	Resolved	ITC only	Net metering for LMI customers and net billing for others

2 Modeling and Analysis Results

2.1 Rooftop Solar Technical Potential

Table 2 shows the demographic characteristics and technical rooftop PV potential of residential customers by income, tenure, and building type. The number of households represents the 1.55 million rate payers in the LADWP service territory. Of LADWP customers, 57% are LMI households, 60% are multifamily households, and 55% are renters (Mooney and Sigrin 2018; Sigrin et al. 2021; U.S. Census Bureau, 2021).

PV-suitable roof area is defined as the portion of the roof that is viable for solar installation based on shading and roof orientation analysis (Gagnon et al. 2016). LMI households, multifamily households, and renters have substantially less PV-suitable roof area and lower average electricity consumption than non-LMI households, single-family households, and owners (Table 2).

Table 2. Characteristics of LADWP Customers by Income, Building Type, and Tenure

Category	Number of Households	Average PV-Suitable Roof Area per Household (ft^2)	Average Annual Household Consumption (kWh)	Aggregate Rooftop PV Technical Potential (GW)
Income Level				
LMI	880,000	230	5,100	3.5 (48%)
Non-LMI (mid- and high-income)	670,000	340	6,400	3.9 (52%)
Building Type				
Multifamily	940,000	150	4,400	2.3 (32%)
Single-family	610,000	480	7,600	5.0 (68%)
Tenure				
Renter	860,000	210	4,800	3.1 (42%)
Owner	690,000	360	6,800	4.3 (58%)

Number of households and rooftop PV technical potential under each category sums to the total for all LADWP customers, and PV-suitable roof area and annual consumption are average values at the household level. The percentage values for number of households and aggregate rooftop PV technical potential should be interpreted as a percentage of that category to the total; for example, 48% of all rooftop PV technical potential is from LMI customers. The same statistic is not applicable for average suitable roof area or average annual consumption.

2.2 Overview of Modeled PV and Storage Adoption in Los Angeles

Cumulative rooftop PV adoption in the Baseline scenario is 1.4 gigawatts (GW) by 2035. The High EE scenario does not change adoption compared to the Baseline scenario. Resolving renter-owner split incentives (No SI) increases cumulative PV adoption to 1.7 GW by 2035. Combining resolution of split incentives with NEM for LMI customers (No SI & NEM for LMI) further increases adoption to 1.8 GW of cumulative PV adoption by 2035. Providing direct installs for LMI customers (DI for LMI) alone results in adoption of 1.9 GW of cumulative PV adoption by 2035. Combining resolution of split incentives with direct-install (No SI & DI for LMI) results in the highest adoption with 2.0 GW of cumulative PV adoption by 2035—a 41% increase in cumulative adoption compared to the Baseline scenario and 28% of total technical potential adopted by 2035.

In the Baseline scenario, a total of 5.3 megawatts (MW) of storage capacity is adopted in conjunction with residential rooftop installations by 2035; this is an additional 0.3 MW compared to 2020. Direct-install scenarios with no system costs for LMI customers result in significant increase in storage co-adopted with PV, and around 520 MW (1,000 megawatt-hours [MWh]) of storage is adopted by 2035 as battery costs are paid for by LADWP. In the Baseline, High EE, No SI/No SI & NEM for LMI scenarios, customers do not adopt solar and storage because the combined costs are uneconomic. Note dGen assumes all storage systems adopted have a 2-hour (hr) duration.

Figure 3 shows the cumulative adoption of rooftop PV and storage, and Table 3 summarizes key adoption statistics for 2035.

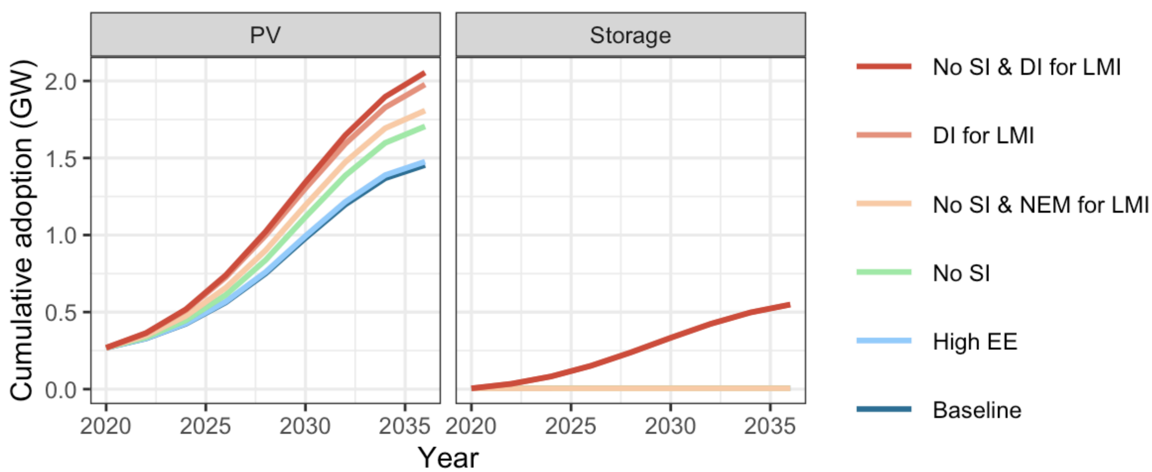

Figure 3. Cumulative rooftop solar adoption in Los Angeles by scenario

Table 3. Modeled PV and Storage Adoption by Scenario (2035)

Scenario	PV Market Potential (GW)	PV Economic Potential (GW)	Number of PV Adopters (millions)	PV Adoption (GW)	Storage Adoption (MW)
Baseline	2.4	1.7	0.80	1.4	5.3
High EE	2.4	1.8	0.80	1.4	5.3
No SI	2.9	2.1	0.80	1.7	5.3
No SI & NEM for LMI	2.9	2.2	0.85	1.8	5.3
DI for LMI	2.8	2.4	0.95	1.9	520
No SI & DI for LMI	3.0	2.5	0.96	2.0	520

2.3 PV and Battery Adoption by Demographic Segments

Combining direct-install for LMI households with the resolution of split incentives (No SI & DI for LMI) results in the highest PV adoption, followed by resolving split incentives plus net energy metering for LMI customers (No SI & NEM for LMI). Resolving split incentives alone has the least impact. See Figure 4 (page 11).

The increase in rooftop solar adoption for LMI households could vary between 26% and 83%, which translates to total adoption of 0.8 GW to 1.2 GW, depending on the scenario implemented. The increase in adoption for renters could vary between 48% and 94%, which translates to total adoption of 0.6 GW to 0.79 GW. Increases in adoption of multifamily households could vary between 37% and 80%, which translates to total adoption of 0.63 GW to 0.83 GW. In all categories, the High EE scenario leads to a slight decrease in uptake (about -1% to -2%) because high energy efficiency leads to a decrease in total load and therefore smaller PV system sizes.

The No SI scenario increases adoption the most for renters because it specifically targets renters. Direct-install and NEM programs impact only LMI households. There are LMI households within multifamily and renter populations; therefore, combining LMI-targeted programs (DI or NEM) with the No SI program results in higher adoption. In other words, program design targeting multiple population groups increases adoption.

Adoption potential is a high upper bound that does not take into consideration constraints such as that LMI households may have time scarcity, language issues, and lack of internet and phone access (Sigrin, Sekar, and Tome 2022). Multifamily building residents and renters have constraints such as split incentives.

LMI multifamily renters represent 30% of the total households in Los Angeles and have a technical rooftop PV capacity of 1.4 GW (19% of total technical capacity). Multifamily building renters represent 53% of the total LMI population, 50% of all multifamily building residents, and 55% of all renters in Los Angeles; in technical capacity terms, they are 39%, 59%, and 45% respectively. Technical capacity does not scale with the share of the population due to reduced

PV-suitable area. Table 4 (page 12) summarizes the population characteristics of these hard-to-reach LMI, multifamily, and renter households. Large portions of these households also live in disadvantaged communities. Figure 5 (page 13) shows the percentage of LMI, multifamily, and renter populations living in disadvantaged communities (DACs).

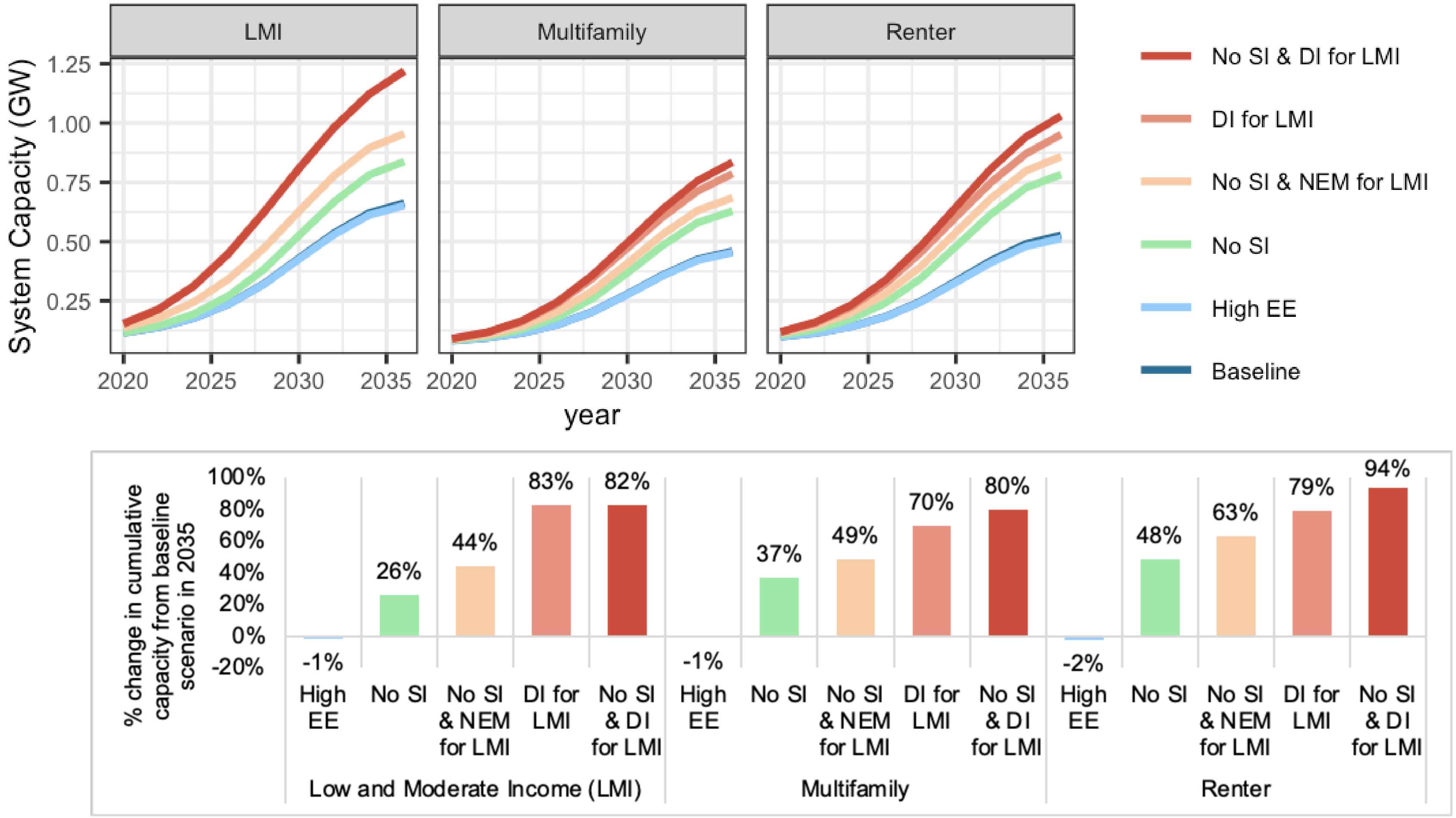

Figure 4. Cumulative system capacity changes, 2020–2035, by scenario for LMI, multifamily, and renter households (top panel) and percentage increase across the scenarios compared to the baseline in the year 2035 (bottom panel)

Table 4. Rooftop PV Characteristics of LMI Households, Multifamily Building Residents, and Renters in Los Angeles

Sources: Mooney and Sigrin 2018; Sigrin et al. 2021; U.S. Census Bureau, 2021

Category	Number of Households	Average PV-Suitable Roof Area per Household (ft^2)	Average Annual Household Consumption (kWh)	Aggregate Rooftop PV Technical Potential (GW)
LMI and multifamily and renter	470,000	170	4,300	1.4
All LMI households	880,000	230	5,100	3.5
All multifamily households	940,000	150	4,400	2.3
All renter households	860,000	210	4,800	3.1
All LADWP households	1,600,000	280	5,700	7.3

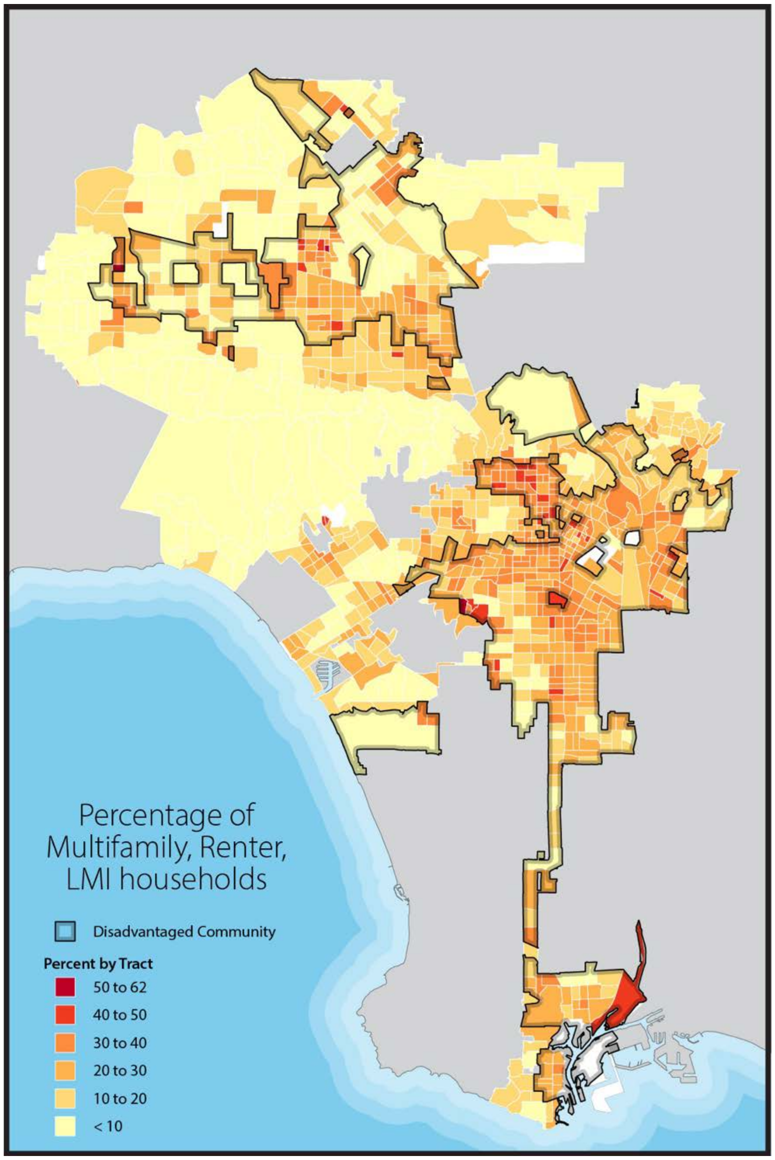

Figure 5. Percentage of combined multifamily, renter, and LMI households in DACs

In Figure 6, we show the percent increase in PV adoption in difficult-to-reach populations along with other subsets to compare scenario impacts. For example, the category "renter" includes subsets of both LMI and non-LMI renters as well as those living in single-family or multifamily households. We compare renters who are low income and living in multifamily buildings with all other renter populations. Results show that the highest-percentage increase in rooftop capacity across all the scenarios was the difficult-to-reach population. Again, this indicates the importance of targeting multiple population groups.

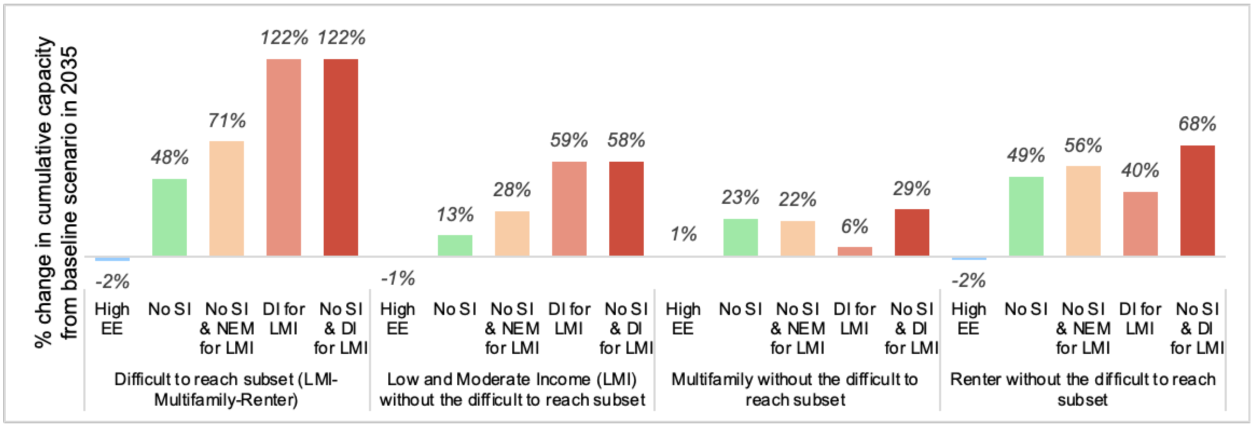

Figure 6. Percentage increase in PV adoption in difficult-to-reach populations compared to other subsets within the LMI, multifamily, and renter categories (2035)

Figure 7 shows the distribution of rooftop solar adoption by DAC status (SB 535[5]) under the considered scenarios. New solar capacity adoption in DACs is lower compared to non-disadvantaged tracts in most of the considered scenarios, with adoption in DAC communities ranging from 0.67 GW to 1.0 GW by 2035 and adoption in non-DACs ranging from 0.78 GW to 1.0 GW by 2035. The split incentive resolved and direct-install for LMI households scenario (No SI & DI for LMI) and the direct-install for LMI households scenario (DI for LMI) increase solar capacity additions in DACs the most by 2035.

[5] "SB 535 Disadvantaged Communities," California Office of Environmental Health Hazard Assessment, oehha.ca.gov/calenviroscreen/sb535.

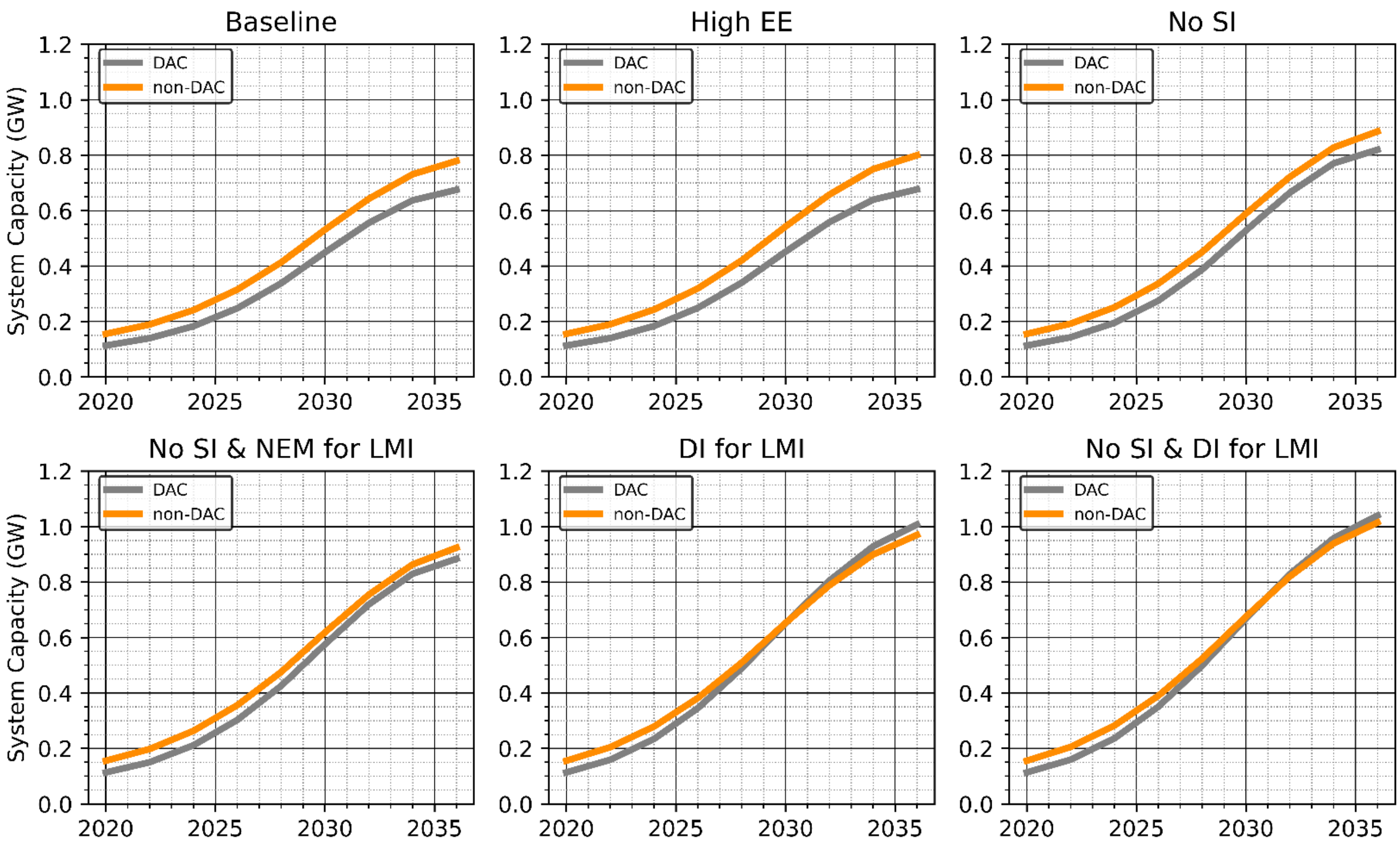

Figure 7. Cumulative solar adoption by scenario modeled for DAC and non-DAC communities

2.4 Electricity Bill Savings from Solar and Storage Adoption

One benefit of installing rooftop solar and storage systems is the electricity bill savings resulting from offsetting electricity use. For this analysis, we estimate electricity bill savings across modeled scenarios to determine whether modeled incentives can provide bill savings to customer segments that have historically not benefited from solar programs offered by LADWP, including LMI, multifamily, and renter households. Modeled average electricity bills without solar and storage adoption for LMI, multifamily, and renter households in 2022 are $1,300, $1,100, and $1,300 respectively.

Figure 8 shows annual electricity bill savings by scenario. The box plots summarize the minimum, first quartile, median, third quartile, and maximum electricity bill savings under each scenario. The High EE and No SI scenarios have lower average annual electricity bill savings ($390/year). This is because compensation for excess electricity generated by adopted solar and storage systems is lower under these scenarios, which assume LADWP transitions to NEM 3.0. Similarly, the No SI & DI for LMI and the DI for LMI (with no system cost) scenarios also have lower average annual electricity bill savings ($420/year [yr]), because these scenarios also assume a transition to NEM 3.0. Average electricity bill savings across all customers are highest under the No SI & NEM for LMI scenario, with average electricity bill savings of $450/yr. Savings are higher due to the higher compensation for excess electricity generated under these scenarios, which assume LADWP continues its current NEM program for LMI customers rather than transitioning to NEM 3.0 for all customers.

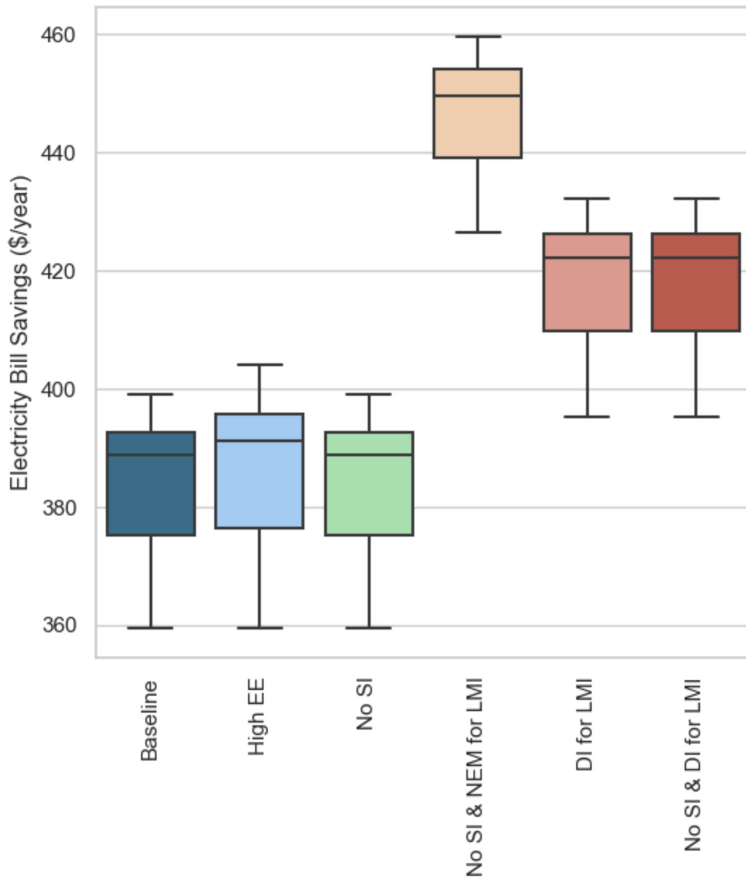

Figure 8. Annual electricity bill savings by scenario

Figure 9 shows electricity bill savings by income and scenario. The No SI & NEM for LMI scenario results in the highest bill savings for LMI customers, with an average savings of $460/yr. Under this scenario, moderate-, low-, and very low-income households see average savings of 30%, 30%, and 34%, respectively, compared to the Baseline scenario. Modeling indicates net metering (as compared to net billing, also known as NEM 3.0) increases bill savings available to LMI customers. High-income customers continue to have high average electricity bill savings ($460/yr) due to their high electricity consumption, which can be offset by installing solar and storage regardless of scenario, while mid-income customers have an average electricity bill savings of $380/yr.

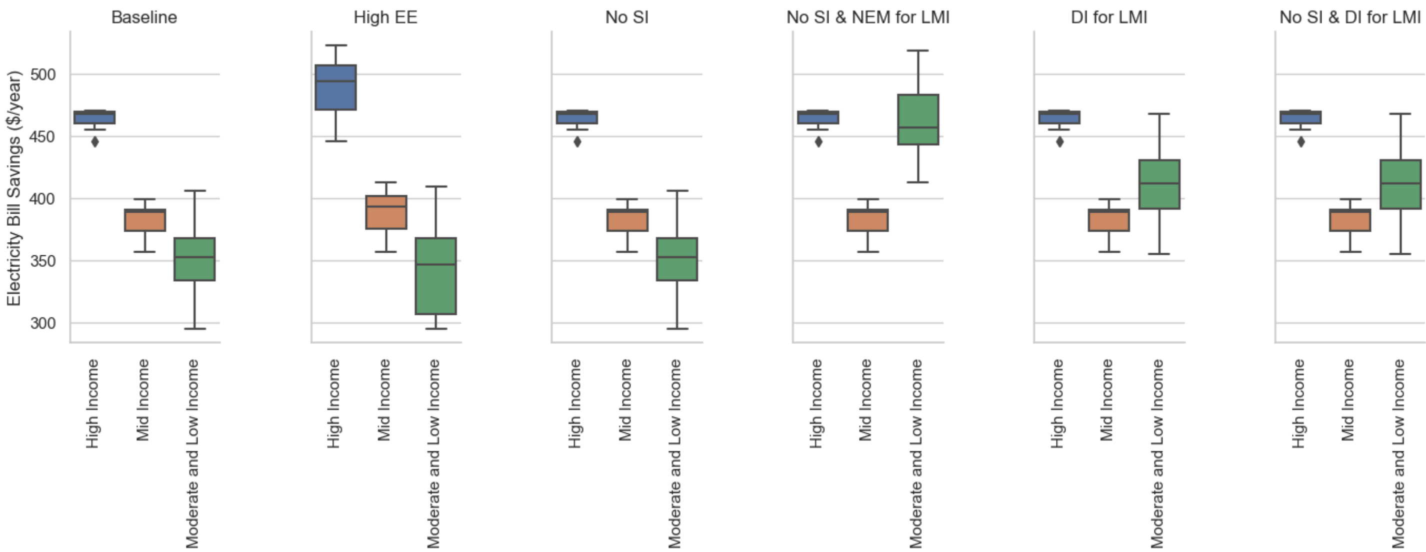

Figure 9. Electricity bill savings by income and scenario

Figure 10 shows electricity bill savings by scenario based on building type and tenure. Across all building types, single-family homes have higher average electricity bill savings. This is likely due to (1) their larger roof areas, which can host more solar panels, and (2) higher electricity consumption for this building type. Larger multifamily buildings have the lowest average electricity bill savings ($250/yr). Across the building types, resolving split incentives combined with net metering for LMI households (No SI & NEM for LMI) provides the highest bill savings, with average savings of 19% for smaller multifamily homes, 20% for larger multifamily homes, and 15% for single-family homes. A direct-install program with net billing (NEM 3.0) (No SI & DI for LMI) can provide an increase in average savings of 11% for smaller multifamily homes, 14% for larger multifamily homes, and 7% for single-family homes.

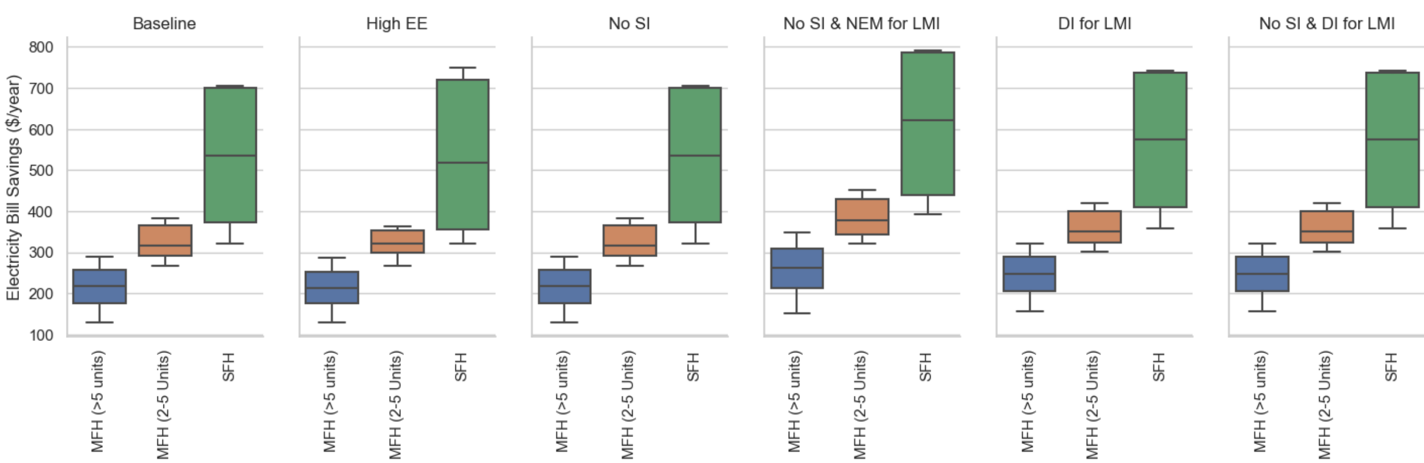

Figure 10. Electricity bill savings by scenario and building type

MFH = multifamily home, SFH = single-family home

Renters have lower electricity bill savings compared to owners across all scenarios. Combining resolved split incentives with net metering for LMI households provides the highest average electricity bill savings ($410/yr) for renters (an increase of 20% from Baseline) and $480/yr for owners (an increase of 13% from Baseline). Note that actual bill savings can vary compared to the modeled bill savings. Fikru (2019) suggests actual bill savings can be 20% higher than modeled bill savings.

2.5 Electricity Burden

Electricity burden is defined as the percentage of household income spent on electricity bills. We calculate electricity burden two ways: (1) without including solar and storage installation costs and (2) including the cost paid by the customer for the installed technology. Solar and storage costs are assumed to be paid by the household through on-bill financing for the life of the system (30 years).

Figure 11 shows the percentage change in electricity burden for LMI, multifamily, and renter households for the No SI scenario and the No SI & NEM for LMI scenario. The No SI and DI for LMI scenario assumes capital costs are not borne by the customer leading to a reduction of electricity burden for customers of more than 25%. In the No SI & NEM for LMI scenario, the electricity burden increases 10%–65% depending on the adoption year when including the cost of the technology.

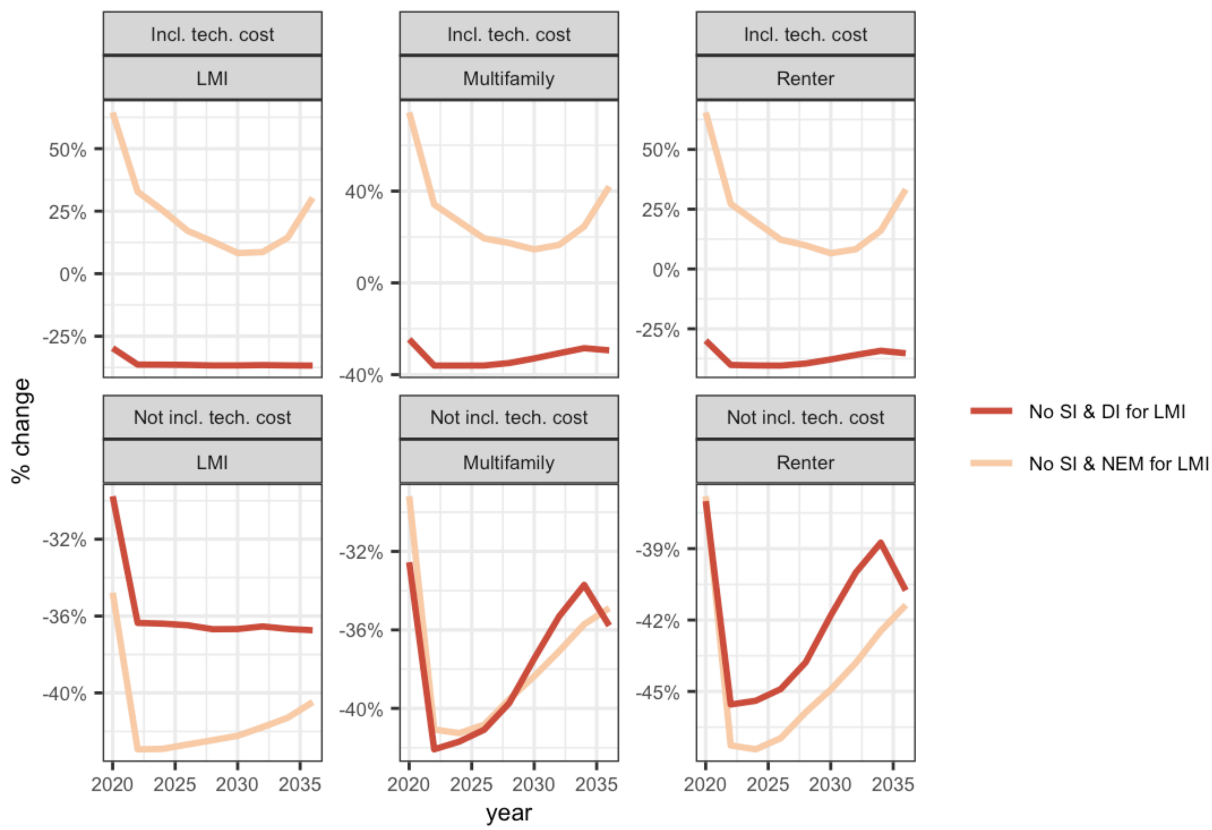

Figure 11. Percentage change in electricity burden when customer segments adopt solar and storage under No SI & DI for LMI and No SI & NEM for LMI scenarios

The top row shows electricity burden when technology cost of solar and storage systems is included. The bottom row shows change in electricity burden when technology costs of solar and storage systems are *not* included.

2.6 Incentive Program Costs

In this section, we compare the program costs of two incentive program scenarios for LMI households: (1) direct-install for LMI and (2) split incentives resolved and net metering.

DI for LMI Scenario

The total program cost for the direct-install program is calculated as the total kilowatts installed (for both solar and storage) multiplied by the cost ($/kW) of systems installed minus the credits from the 30% ITC schedule based on the Inflation Reduction Act of 2022, plus the operation and maintenance cost for the life of the system. The ITC Low-Income Communities Bonus Credit of an additional 20% is not considered because not all LMI households live in multifamily buildings or in low-income communities.

Formulas used to calculate program cost for direct-install of solar and battery are shown in Equations 1 and 2, respectively, where:[6]

- K_{pv}, K_{batt}, k_{batt} are the capital cost of the PV system, power and energy components of the battery system, respectively, and are depreciated over the system lifetime.
- S_{pv}, S_{batt}, s_{batt} are the system sizes quantified by dGen for LMI adopter *i* in year *y* of PV, power, and energy capacity of the batteries, respectively.
- f_{ITC} is the non-ITC fraction of capital cost.
- M_{pv}, M_{batt}, and m_{batt} are the operation and maintenance cost in $/unit-year of PV, power component, and energy component of the battery, respectively.
- L is the life of the PV and battery system.
- C is the linear constant in dollars used to adjust the battery cost.

$$\boldsymbol{PC_{pv}} = \sum_{\boldsymbol{i,y}} \left(\boldsymbol{K_{pv,y}} \times \boldsymbol{f_{ITC}} + (\boldsymbol{M_{pv,y}} \times \boldsymbol{L_{pv}})\right) \times \boldsymbol{S_{pv,i}} \qquad (1)$$

$$\begin{aligned} PC_{batt} = \sum_{i} &\left(K_{batt,y} \times S_{batt,i} + k_{batt,y} \times s_{batt,i}\right) \times f_{ITC} \\ &+ (M_{batt,y} \times S_{batt,i} + m_{batt,y} \times S_{batt,i}) \times L_{batt} \\ &+ C \end{aligned} \qquad (2)$$

No SI & NEM for LMI Scenario

The total program cost for the NEM program is calculated as the sum of the total bill savings through the life of solar and storage systems (30 years) for LMI customers purchasing a system

[6] More information on these calculations can be found in NREL's 2022 Annual Technology Baseline (NREL 2022).

due to the incentives during the analysis period (2020–2035), where P_{elec} is electricity price and Gen_{PV} is solar generation in Equation 3:

$$\boldsymbol{Bill\ Savings}_{\boldsymbol{No\ SI\ \&\ NEM\ for\ LMI}} = \sum_{i} \boldsymbol{P}_{\boldsymbol{elec,i}} \times \boldsymbol{Gen}_{\boldsymbol{PV,i}} \quad (3)$$

Table 5 includes modeled outcomes for two scenarios.

Table 5. Modeled Outcomes for the Direct-Install (No SI & DI for LMI) and Net Metering (No SI & NEM for LMI) Scenarios that Target Only LMI Customers

Systems are installed 2020–2035 until their end of life

Scenario	PV Capacity Added (MW)	Battery Capacity Added (MW)	Additional LMI Customers with PV or Storage	Total Program Cost for LADWP (billion $)	Incentive Spent per Additional Capacity ($/W)
No SI & DI for LMI	530	520	160,000	2.2	2.10
No SI & NEM for LMI	283	0	52,000	2.7	9.70

Under the DI for LMI scenario, which models a direct-install program for LMI customers, an additional 530 MW of solar and an additional 520 MW of storage are adopted by 2035 at a cost of approximately $2.2 billion. Approximately 160,000 additional LMI customers adopt solar and storage over the program lifetime. The total program cost for this additional adoption is $2.06/watt (W) of combined solar and storage capacity. Note that this calculation does not consider any additional operation and maintenance costs, the costs of electric panel upgrades or of other upgrades required to install solar and storage systems, or program administration costs. Additionally, despite providing systems at no cost under a direct-install program, other factors might prevent these systems from being adopted, as projected in the model and described in Section 1.2 (page 3).

Under the No SI & NEM for LMI scenario, total bill savings for LMI customers, and therefore program costs, assuming NEM for the entire system lifetime of 30 years amounts to $2.7 billion, or $170 million/year. This scenario adds 52,000 additional adopters and 280 MW at a cost of $9.7/W of additional capacity. This scenario has significantly higher costs than LADWP's existing net metering program. The program cost calculated for the scenario:

- Considers only the total bill savings by the customer that is assumed to be paid by LADWP and does not include any grid impacts or programmatic costs
- Is applicable only for LMI customers who adopt solar, whereas, in the old program, NEM was applied for all customers who owned solar
- Assumes net metering continues until the end of life for the system

- Considers Strategic Long-Term Resource Plan SB 100 year-on-year retail rate increases, which are approximately 10% each year.

For customers who adopt in 2035 the program is expected to run until 2060.

Due to LADWP's projected increases in retail rates, future net metering compensation cost increases and increases in solar capacity adopted in later years are high. The direct-install program leads to more adopters at lower cost per adopter while the net metering for LMI program provides higher electricity bill savings to LMI customers.

2.7 Caveats

Model input caveats include the following:

1. The dGen model is run in 2-year increments between 2020 and 2036. Results for 2035 are calculated as an average of 2034 and 2036 results.
2. Historical data are calibrated until the year 2020.
3. We do not explore a storage-only scenario because the historical data available to calibrate storage adoption are insufficient. In the case of solar + storage adoption, the model assumes storage systems are adopted if they add additional monetary value to the customer who adopts PV. In this model formulation, customers who want to install storage systems that are uneconomic (i.e., have a negative net present value) are not considered.

2.8 Equity Strategies Discussion

In this section, we synthesize modeling, analysis, and community guidance to identify potential strategies for achieving more-equitable outcomes in the distribution of benefits and burdens in Los Angeles' transition to clean energy.

Analysis of baseline distributional equity indicates the $340 million in LADWP residential solar incentives and NEM compensation distributed over the 22 years analyzed and paid for by all ratepayers, disproportionately benefited non-disadvantaged, predominantly White, non-Hispanic, home-owning, and wealthier communities. Disadvantaged communities, particularly in South LA and the Harbor region, did not receive solar incentives proportional to their populations. This inequitable investment resulted in 39% more capacity installed per customer in non-disadvantaged communities than disadvantaged communities, and inequitable access to bill savings for adopters and contributions toward total electric system costs from non-adopters.

Continued residential solar investment through the same programmatic approaches will continue to inequitably shift funds from lower-income customers, renters, and multifamily building residents who cannot install rooftop PV to higher-income residential customers who can make the co-investment and then benefit from the bill savings. To redress these inequities and the disproportionate impact on low-income households from anticipated rate increases, we conducted solar and storage modeling and analysis to explore the following potential strategies:

- One potential strategy is to restrict NEM compensation to the 57% of LA households that are LMI customers.
    - This strategy or program approach is projected to result in an additional 52,000 additional LMI customers benefiting from rooftop PV and storage compared to the Baseline scenario.
    - The approach provides average annual electricity bill savings of $460 for low- to moderate-income customers, which equates to average annual savings of 30%–34% compared to the Baseline scenario.
    - If strategies are implemented to enable NEM benefits to accrue to the 55% of LA households that rent and the 60% of households that live in multifamily buildings as renters, LMI NEM could provide average annual electricity bill savings to renters of $410, or average savings of 15%–20% depending on building type.
    - Though this strategy leads to the highest LMI bill savings, it costs $2.7 billion over 16 years (with NEM being applicable through 2060 for systems installed in 2035). And, though the strategy is modified to benefit LMI customers, it continues net energy metering, which analysis indicates has been highly inequitably distributed.
- An alternative and lower cost option than NEM for LMI customers that delivers comparable bill savings is a direct-install program in which LADWP funds rooftop PV installations for LMI households.
    - This program approach is projected to result in 160,000 additional LMI households adopting solar.
    - The approach provides average annual electricity bill savings for LMI households of $420.
    - If bill savings can accrue to renters, the approach provides average annual electricity bill savings for renters of $380.
    - The approach could be targeted to specific regions where solar and storage capacity would benefit the distribution grid.
    - Though direct installations for LMI households and enabling of benefits to accrue to renters results in more LMI solar adoption than NEM for LMI households, a direct-install program for 160,000 LMI households is projected to cost $2.2 billion over 16 years.
- Implementing strategies to deliver rooftop solar bill savings to renters can dramatically increase rooftop PV adoption, open up the 42% of rooftop PV technical potential on renter-occupied buildings, and enable bill savings of $380/yr–$410/yr for the 470,000 LMI households that are also renters living in multifamily buildings. Potential strategies include on-bill financing, equipment leasing, property-assessed clean energy, green leases, and LMI renter enrollment in a discounted community or shared solar rate.

- Additional opportunities for LADWP to provide resiliency services or monetize aggregated distributed energy resources under Federal Energy Regulatory Commission Order 2222 are possible under both the modeled programs in the No SI & NEM for LMI scenario and the DI for LMI scenario. LADWP could specify additional program conditions that allow these systems to be controlled by LADWP to participate in wholesale markets or to provide resiliency services in the event of grid outages. Doing so would allow for multiple benefits including additional monetary benefit to LADWP accruing from providing resiliency services or from aggregation of distributed energy resources not modeled here.
- Another potential strategy is to deliver solar bill savings to LMI renters and multifamily building residents through community solar or virtual-net-metering enrollment. Community solar or virtual net energy metering is estimated to deliver LMI electricity bill savings of $480/yr with net present value-positive solar costs (i.e., essentially costs are recuperated) (see Chapter 9) compared to the net metering scenario (No SI & NEM for LMI) savings of $460/yr with program costs in the billions. Community solar enrollment also enables renters to take this benefit with them if they move.

Table 6 summarizes these options and associated metrics.

Table 6. Equity Strategy Option Benefits, Costs, Timeline, Responsible Party, and Evaluation Metrics

Equity Strategy	Benefit/Impact	Cost	Timeline[a]	Responsible Party	Metric
Implement an NEM rooftop solar program for LMI customers with strategies to deliver bill savings to renters and multifamily building residents (No SI & NEM for LMI scenario)	LMI electricity bill savings of $460/yr, 10%–65% energy burden reduction 280 MW additional PV adoption potential	$2.7 billion total LADWP program cost for 0.7 GW installed $2.95/W installed	2024–2035	LADWP	Targeted portion of the 52,000 potential households
Implement a direct-install solar program for LMI customers with strategies to deliver bill savings to renters and multifamily building residents (No SI & DI for LMI scenario)	LMI electricity bill savings of $420/yr, 25% energy burden reduction 530 MW additional PV adoption potential	$2.2 billion total LADWP program cost for 0.5 GW installed $1.8/W installed plus operation and maintenance	2024–2035	LADWP with Inflation Reduction Act funding support	Targeted portion of the 160,000 potential households Targeted portion of the 520 MW battery storage potential
Implement strategies to deliver solar bill savings to LMI renters	55% of LADWP customers are renters Enabling access to solar bill savings for renters can increase their electricity bill savings ≈84%.	Primarily administrative costs	2024–2025	LADWP	Participation in and annual bill savings from on-bill financing, equipment leasing, green leases, virtual-net-metering, or enrollment in a discounted LMI shared solar rate
Deliver solar bill savings to LMI renters and multifamily building residents through community solar or virtual-net-metering enrollment	LMI electricity bill savings of $480/yr	NREL identified >4,000 suitable community solar sites 30 kW or more with positive net present value	2024–2035	LADWP	20% of LMI renters enrolled by 2030, 30% by 2035

[a] The timeline indicates the program covers all systems installed between 2024 and 2035. For systems installed in 2035, the program covers NEM until the end of life of the system, which is assumed to be 2060.

Baseline equity conditions, community solutions guidance, and modeling and analysis key findings were synthesized into equity strategies (see Figure 12). These figures were shared with the LA100 Equity Strategies Steering Committee and Advisory Committee and were revised based on their feedback and guidance.

Baseline Equity

- 62% of LADWP net energy metering program incentives went to households in non-disadvantaged communities
- The $341 million in LADWP solar incentives analyzed disproportionately benefited predominantly White, non-Hispanic, home-owning, and wealthier neighborhoods.

Community Solutions Guidance

- Address the cost of rooftop solar.
- Provide community solar access.
- Deliver customized information on investments and payback periods to address skepticism about the value of solar.
- Protect residents from predatory solar developers.

Modeling & Analysis Key Findings

- LADWP renter, multifamily, and low- and moderate-income households make up 64% of all solar-suitable roof area
- 1.45 GW of solar adoption is expected by 2035 with no co-location of batteries in the baseline model. Without targeted equity approaches, ~70% of that adoption will be from single family, owner-occupied, non-LMI households
- When high adoption of energy efficiency measures are considered, adoption is expected to slow due to reduction in energy consumption
- When the renter/owner split incentive is resolved and solar benefits also flow to renters, solar adoption is increased up to ~84%.

Equity Strategy

- Designing solar programs to benefit low- and moderate-income customers through direct install or net energy metering programs for LMI customers enables these customers to achieve between 25% and 50% electricity bill savings
- Designing solar programs to enable renters to benefit from rooftop solar will increase adoption substantially for the 55% of LADWP customers who are renters
- Delivering solar bill savings to LMI renters and multifamily building residents through community solar or virtual-net-metering can save these customers $480 per year on electricity bills at lower costs than rooftop PV programs.

Figure 12. Strategies for equitable access to solar bill savings

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Appendix A. Methodology

This appendix describes the methodology used to develop the agent data file, which is an input to the dGen model. The agent data file contains the characteristics of buildings and households within the LADWP territory, including roof area, energy consumption, utility tariff information, and financial parameters.

An agent is a statistical representation of a household in each census tract, classified by income class, ownership type/tenure, and building type. Approximately 1,059 census tracts are in the LADWP service area, listed by their six-digit code. There are eight different agent building types. Households are classified based on American Community Survey income data and U.S. Department of Housing and Urban Development area median income (AMI) bins. For each census tract, 80 agents are created, based on building type, ownership status, and income class. Table A-1 describes the agent classes considered in the model. For each agent type, household characteristics such as energy consumption, number of customers in that agent class, total PV-suitable roof area, financial parameters, and other decision parameters are assigned.

Table A-1. Descriptions of Agent Classes

Agent Classes	Descriptions
Tract	Census tract, each with a six-digit code
Building Type	2 Unit (multifamily) 3 or 4 Unit (multifamily) 5 to 9 Unit (multifamily) 10 to 19 Unit (multifamily) 20 to 49 Unit (multifamily) 50 or more Unit (multifamily) Single-Family Attached Single-Family Detached
Ownership Status or Tenure	Owner Renter
Income Class	Very low (0–30% AMI) Low (30–60 % AMI) Moderate (60–80% AMI) Mid (80–120% AMI) High (120%+ AMI)

The starting point in the agent generation process is an agents file (herein referred to as "base agents") from a previous study (Sigrin et al. 2021) that has agents characterized by tract ID and load subclass. This agent file also has only two of the core attributes of an agent to enable adoption of rooftop solar: the PV-suitable roof area and the number of customers in bin lacking electricity demand. PV-suitable roof area refers to available roof space onto which solar panels could be mounted. Customers in bin refers to the number of buildings of a particular type available in a geospatial grid that defines an agent. Electricity demand refers to annual electricity demand per household within a geospatial grid that defines an agent.

For the aforementioned reasons, we need ways to convert these agents from tract ID and load subclass characterization so they include further subcategories of tenure and income class. We also need to allocate electricity demand to agents. To achieve these two goals, we use data from other sources, as described in Appendix B, to convert the base agents from characterization by tract ID and load subclass to characterization by tract ID, load subclass, tenure, and income class.

A.1 Converting the Base Agents

To convert a base agent to the desired characterization, we use the Rooftop Energy Potential of Low Income Communities in America REPLICA (REPLICA) (Mooney and Sigrin 2018) data to create weights that help us disaggregate the PV-suitable roof area and number of customers in bin from a characterization comprising tract ID and load subclass to one that has tract ID, load subclass, tenure, and income class.

A.2 Weights Creation and Application

The weights are evaluated as products of ratios evaluated in REPLICA and ratios evaluated using the baseline agents data set. For the baseline agents, the ratios are tract ID, load subclass, and family type level values of PV-suitable roof area and customers in bin divided by tract ID, family type level totals. On the REPLICA data set, the ratios are tract ID, family type, tenure, and income class level values of PV-suitable roof area and customers in bin divided by the tract ID, family type level totals. Multiplying these ratios generates the fractions of these attributes at a desired agent characterization level. To get agent level customers in bin and PV-suitable roof area, the respective weights or fractions are multiplied by the baseline agents values. Areas in the base data are in square feet, and areas in REPLICA are in square meters; however, we assume this unit misalignment does not impact the calculations because the ratios are essentially unitless.

A.3 Conversion Issues and Solutions

When the REPLICA data imply there is PV-suitable roof area and/or customers in bin for a specific tract and family type but the corresponding tract in the base data imply those data do not exist, we base the final PV-suitable roof area and/or customers in the bin on the base data. Thus, for all the agents in that tract and building types, the final values are assigned zero (0) values.

When the REPLICA data imply there are no PV-suitable roof area or customers in bin for a specific tract and building type but the base data show those data do exist, we assign the REPLICA weights in a controlled and randomized manner by solving an optimization problem that constrains the sum of the weights to equal 1.

A.4 Allocating Electricity Demand to Agents

The building agents, together with the accompanying electricity demand data, are used to assign the electricity demand to the agents through the following steps:

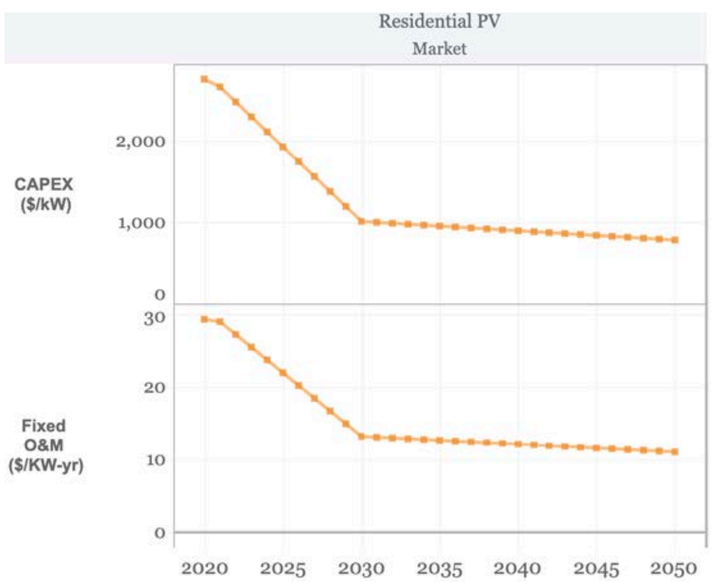
- Aggregate the building agents to tract ID, load subclass, income class, and tenure resolution by taking averages of the building ID-level data.
- For all matching agents in the newly created agents data set, allocate the electricity demand.
- For tracts in newly created agents but absent in the aggregated buildings agents, assign the average of the neighboring tracts' values.

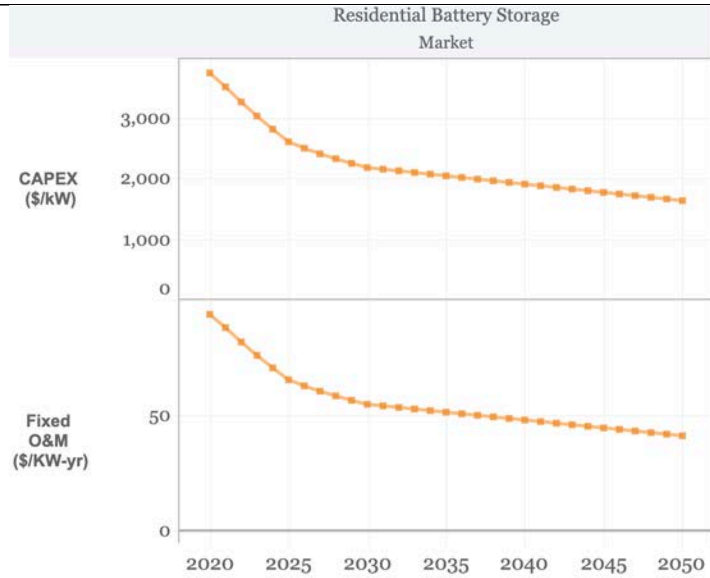
A.5 Allocating Load Profiles

The load profile data are provided at a building ID-level resolution. These load profiles are combined into groups of tract ID, load subclass, income class, and tenure using the building agents. For each agent, a load profile is allocated from a random selection in the load profiles from a corresponding group. For agents that do not have corresponding groups, a random load profile is allocated from groups with similar load subclass, income class, and tenure.

A.6 Other Modeling Assumptions

Table A-2. Summary of Additional Modeling Assumption Values and Sources

Variables	Description	Source
Tariff	Tariffs are assigned based on location of the households by zone and monthly energy consumption: • Residential Service (R1A): Zone 1 (<350 kWh) • Residential Service (R1A): Zone 1 (350–1,050 kWh) • Residential Service (R1A): Zone 1 (>1,050 kWh) • Residential Service (R1A): Zone 2 (<500 kWh) • Residential Service (R1A): Zone 2 (500–1,500 kWh) • Residential Service (R1A): Zone 2 (>1,500 kWh).	LADWP Summarized descriptions of the rates can be found in the associated hyperlinks in the Utility Rate Database.
Electricity price escalation	Strategic Long-Term Resource Plan SB 100 rate projections Compound annual growth rate of 2.56% between 2022 and 2035	LADWP
Load escalation	Yearly load escalation is derived from ResStock data. The load escalation varies by each household.	ResStock data
Model years	2020–2036 (dGen works with 2-year increments.)	
System costs	Modeling is based on NREL's 2022 Annual Technology Baseline projections (NREL 2022).  Solar PV cost trend are shown above.	NREL 2022

Variables	Description	Source
	 Residential battery storage costs are shown for a 5kW, 12.5kWh system.	
Wholesale electricity price	Varied between 2.6 cents/kWh in 2020 to 4.3 cents/kWh in 2035. Modeled based on projection data from NREL's 2022 Annual Technology Baseline (NREL2022). (Used for net billing compensation.)	NREL 2022
ITC	30% for the installation of which was between 2022 and 2032. 26% for systems installed in 2033. 22% for systems installed in 2034. 0% for system installed in 2035 and after.	Inflation Reduction Act of 2022

Appendix B. Data Sources and Assumptions

This appendix details the outsourced data used in the analysis for this chapter. The descriptions in Table B-1 cover data sources, attributes within the data set, and their granularity, spatial resolution, and vintage.

Table B-1. Solar and Storage Data: Sources and Descriptions

Data	Source	Description of Attributes Available	Resolution/ Characterization	Vintage
REPLICA	NREL Data Catalog: data.nrel.gov/submissions/81 (Mooney and Sigrin 2018)	PV-suitable roof area and customers in bin	Tract ID, income class, load subclass, and family type	2018
Building agents	ResStock[a]-customized modeling for the LA100 Equity Strategies project	Electricity demand and electricity demand profiles	Tract ID, building ID, load subclass, family type, income class, and tenure	2020, 2035
DACs	SB 535	DACs are identified as tracts with the highest 25% CalEnviroScreen scores.	Census tract	2021

[a] ResStock is NREL's large-scale residential energy analysis tool: "ResStock Analysis Tool," NREL, https://www.nrel.gov/buildings/resstock.html.

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