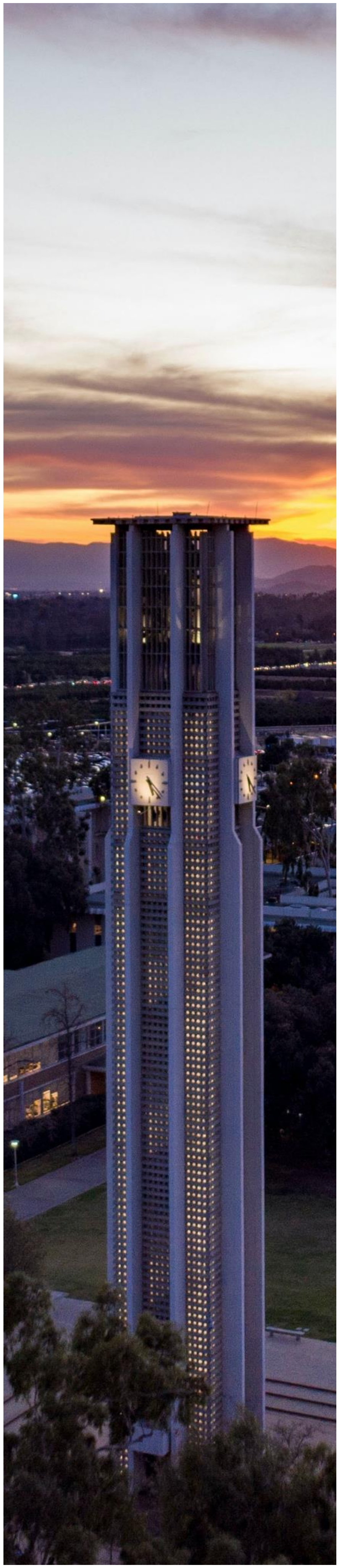

An Analysis of California's Net Energy Metering Policy Proposals and Impacts

Prepared by
Ryan Drover and Chris Rudnicki

UC RIVERSIDE
Science to Policy

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Introduction

The University of California Riverside's Science to Policy (S2P) Initiative and the College of Engineering Center for Environmental Research & Technology (CE-CERT) seek to inform the public and decision makers on the background, context, and environmental, social, and grid management issues surrounding Net Energy Metering (NEM) policies and how current proposals might affect ratepayers, the solar industry, and the state of California and its goals. Additionally, we provide considerations for policymakers when formulating their positions on NEM-related issues.

Executive Summary

NEM is the tariff structure that sets the rules of interconnection between a utility company and a ratepayer, including compensation for excess energy exported to the grid. California has a strong record of increasing the deployment of solar in the renewable energy sector using NEM policies. NEM 2.0 (in effect since 2016-17) was designed as an interim structure by the California Public Utilities Commission (CPUC), giving the CPUC time to better study the impacts of NEM on the electric grid and ratepayers. As that interim period concluded, the CPUC requested proposals from interest groups, issued a preliminary decision on NEM 3.0 (December 13, 2021), and will announce a final decision in early 2022. The decision will have significant impacts on climate change, the environment, social equity, and grid management.

> The decision on NEM 3.0 will impact all Californians. The CPUC aims to enable a more equitable distribution of energy costs, more reliable and affordable energy, and a more sustainable energy grid. We will not know the full implications of NEM 3.0 until the final decision is released by the CPUC.

California regularly implements policies to reduce greenhouse gas (GHG) emissions that contribute to global warming and create pollutants harmful to public health and the environment. Historically, NEM policy incentivized ratepayers to install solar systems and compensated them for sending excess solar energy back to the grid. Higher-income ratepayers are more capable of affording solar systems and therefore benefitting from NEM incentives, which has created a social equity issue referred to as the "cost shift." A portion of the utility rates that customers pay supports the utility's necessary fixed costs such as grid operation, maintenance, and improvement. These fixed costs naturally increase as grid maintenance is required to reduce the risk of wildfires caused by the grid, to update the grid for resilience, to accommodate renewable energy sources, and to meet changing energy demand. As solar owners have lower electricity bills, these fixed costs shift towards the rest of the rate base at an estimated $100-$230 annually per household. However, the increasing prevalence of solar energy production contributed to lowering greenhouse gas emissions, expanded the renewable energy industry, and helped to defer costly utility energy transmission and distribution projects.

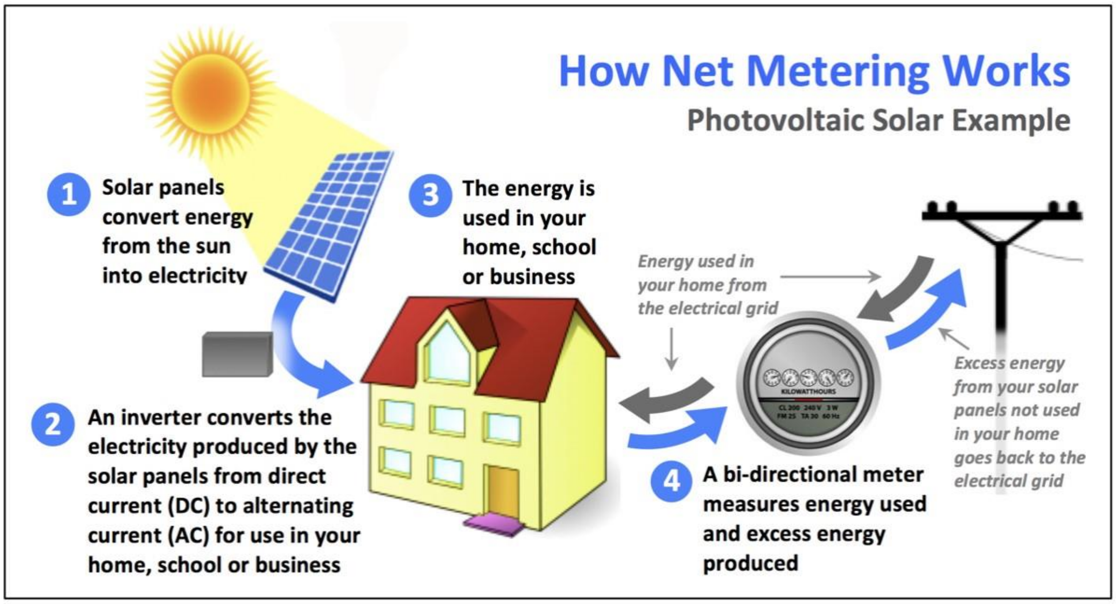

Figure 1. How NEM functions with rooftop solar photovoltaic (PV) systems (Solaflect Energy)

NEM 3.0 will impact all Californians, and aims to achieve a more equitable distribution of energy costs, more reliable and affordable energy, and a more sustainable energy grid. The CPUC stated in its NEM 3.0 guiding principles that the current decision-making process ensures equity among customers, maximizes the value of customer-sited renewable generation, ensures transparency to all customers, and is in line with California's energy policies. Broadly, interest groups agree that the current NEM structure requires a re-alignment of benefits, and this has led to a variety of NEM 3.0 proposals. A balanced NEM 3.0 policy produced by the CPUC will be guided by their and the state's focus on the 2045 goal of 100% renewable energy, will create incentives to equitably increase solar adoption where it's most needed, and will provide for needed grid improvements.

NEM policies that have been successful so far are not the only mechanisms than can be used to achieve any of the goals surrounding energy and the grid, environmental issues, and social equity in California. State policy from regulatory agencies and the legislature could take a more active role alongside corporate commitments, changes in infrastructure, technological advancements, and the role of utilities to pursue these ends and direct specific goals. Energy technology and its related sectors will continue to advance, leading to an increasingly diverse mix of generation, storage, and uses at increased efficiency and reduced cost. The path forward following NEM 3.0 will remain unclear until the final decision is released by the CPUC, but it is clear that NEM 3.0 alone will not ensure that California meets its climate goals.

1. NEM background and role

> Net Energy Metering (NEM) is a compensation structure that determines a ratepayer's bill when they install rooftop solar or another eligible generation system based on the amount of electricity they import from and export to the grid.

NEM creates an agreement between a utility and a person or organization with on-site generation facilities, such as rooftop solar, that interconnect (including a permission to operate agreement) with the grid through a two-way electricity meter (Figure 1). NEM exists in 45 US states and 4 territories, but these policies vary between states and between utility companies.

Table 1. Comparison of NEM 1.0 and NEM 2.0

	NEM 1.0	NEM 2.0
Interconnection Fee	None	$75-$145
Time of use (TOU) charges	Not required	Required
Installation size limit	1 MW	No limit
IOU Program Cap	5% of IOU's aggregate peak demand	No cap
Grandfathering	NEM 1.0 rates will remain for 20 years	NEM 2.0 rates will remain for 20 years

California has two types of utility companies, investor owned utilities, and municipally operated utilities. Municipal Utilities (Munis) are not-for-profit, locally controlled publicly owned entities formed to serve a city or region. Munis serve approximately 25-30% of California residents. California's Investor Owned Utilities (IOUs), Pacific Gas & Electric (PG&E), San Diego Gas & Electric (SDG&E), and Southern California Edison (SCE) are private, for-profit enterprises regulated by the CPUC. Munis are regulated instead by local boards, and determine their own NEM policies. Examples include the Imperial Irrigation District's (IID) transition to a net-billing system in 2016, and Sacramento Municipal Utility District's (SMUD) approved update for March 2022 that reduces the solar NEM credit for interconnected customers and adds interconnection fees. While Munis and their customers are not directly affected by CPUC NEM policymaking, they face similar issues.

California NEM was introduced by Senate Bill (SB) 656 (Alquist, 1995), and AB 920 (Huffman, 2009) and SB 32 (McLeod, 2009). This formalized California's NEM policy, requiring the CPUC to establish a feed-in-tariff program (providing a guaranteed rate for solar energy producers) for utilities to purchase excess solar at a fixed rate for a period of up to 20 years. The goal was to encourage private investment in renewable energy, stimulate in-state economic growth, diversify California's energy production, and reduce utility administrative and interconnection costs.

California's NEM 1.0 policy transitioned to NEM 2.0 through AB 327 (Perea, 2013), which directed the CPUC to develop a successor tariff ("NEM 2.0") with the changes listed in Table 1. The required TOU rates change the price of electricity based on the demand from consumers with a higher rate during peak demand, between 4-9 p.m. Systems under NEM 1.0 would maintain their rates for 20 years from the date of their interconnection, (a procedure commonly known as grandfathering). After NEM 2.0 was approved by the CPUC, each

IOU transitioned to NEM 2.0 between June 2016 and July 2017.

To date, California generates 33.1% of its energy from renewable sources, specifically 13.2% from solar with almost one-third of this generation from NEM-governed solar systems. Solar systems have decreased in cost by 54% from 2015 to 2021 with decreases expected to be 5% annually. Over the last decade ratepayer generation has grown dramatically due to support from NEM structures and federal incentives such as the Investment Tax Credit (ITC) (Figure 2A). As of 2021, there are over 1.3 million rooftop solar systems in California with 67.7% being ratepayer-owned, 25% under power purchase agreements (PPAs), and 6% under lease agreements with solar installers. However, solar ownership is mostly tied to higher-income households and zip codes (Figure 2B).

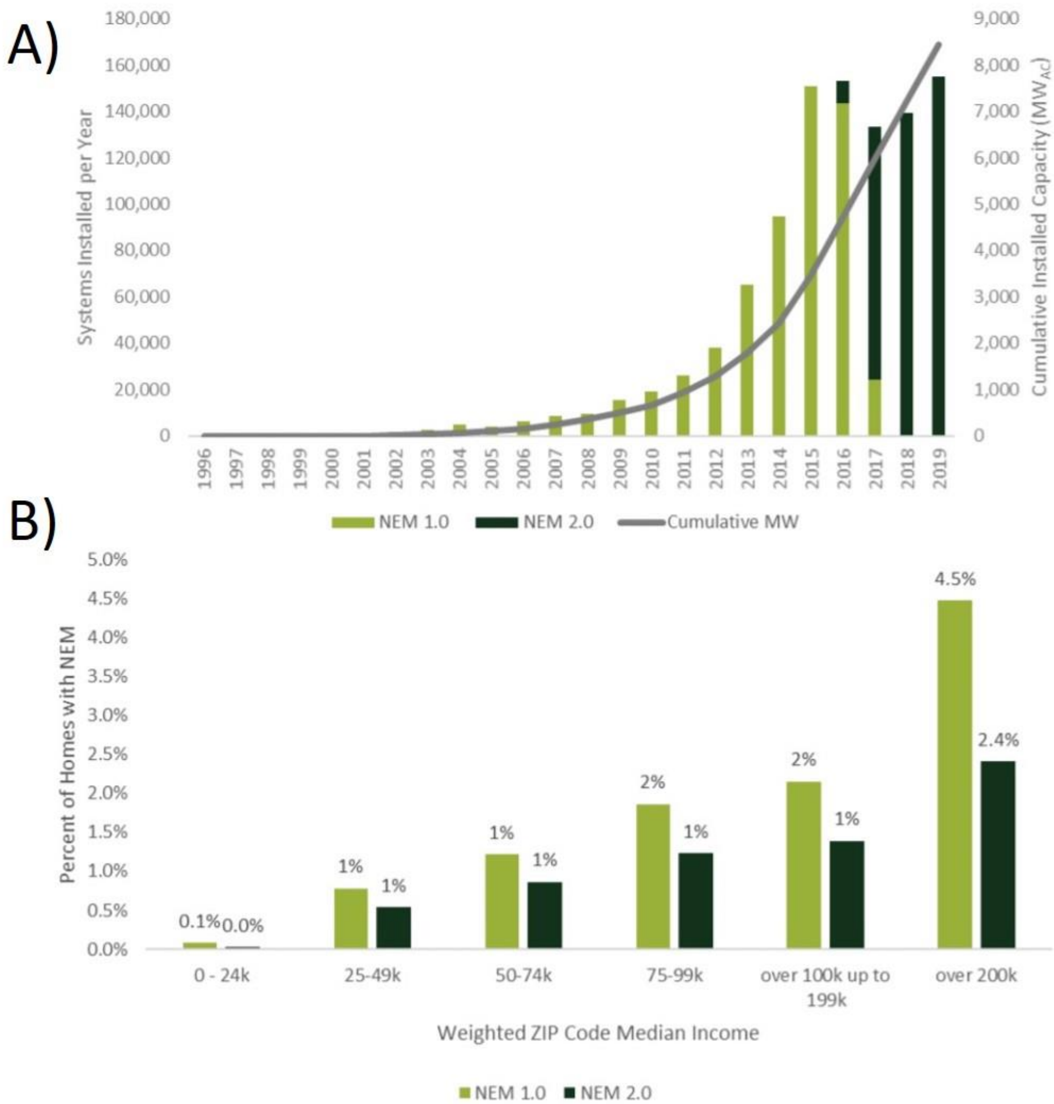

Figure 2. The distribution of systems under NEM 1.0 and 2.0 (Verdant Associates, Net-Energy Metering 2.0 Lookback Study, 2021)

2. Why is NEM being discussed now?

The CPUC issued a preliminary NEM 3.0 structure December 13, 2021, with a final decision coming in the first quarter of 2022, and expected to apply 4-6 months after the ruling. Urgent issues include:

- Environmental: reducing carbon emissions contributing to climate change
- Social: fixed utility costs are distributed to fewer, disproportionally lower-income ratepayers
- Grid reliability, safety, and management

NEM 2.0 was designed as an interim structure to give the CPUC time to study and publish in January 2021 the impacts of NEM on the electric grid and ratepayers. Now, the CPUC has taken proposals and arguments for possible NEM 3.0 structures from stakeholders, including the IOUs, coalitions of private solar companies, and environmental and low-income advocacy groups.

Climate Change. Emissions, such as those from burning fossil fuels, have contributed to increasing global average temperatures creating instability in the climate and ecosystems worldwide. The energy sector produced 25% of U.S. GHG emissions in 2019 creating an impetus for cleaner energy generation in order to reduce emissions. California has pursued climate policies and programs to increase the use and availability of renewable energy, including for disadvantaged and low-income residents. SB 100 (De León, 2018) mandating renewable energy and zero-carbon resources to supply 100% of California retail electricity by 2045. Energy efficiency and structural changes led to significant GHG reductions from California's energy sector of 44% from the peak in 2001 even as energy consumption remained constant. The beneficial role of rooftop solar in this renewable energy transition has fostered support for NEM benefits from environmental and pro-solar organizations.

To achieve California's renewable energy goals, IOUs plan to build large-scale solar systems that can provide energy at one-third to one-half the cost of residential solar systems per kWh of energy[1] (Figure 3). However, due to the amount of land that solar farms occupy, utility-scale projects are

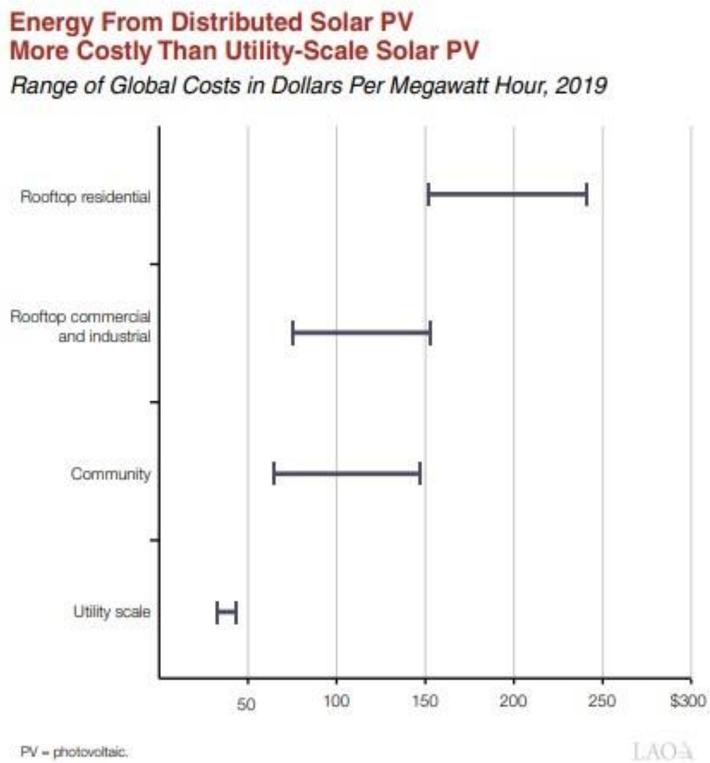

Figure 3. Comparison of unit costs ($ per MWh) of generation capacity for different solar PV system scales (Legislative Analyst's Office)

[1] For reference, a dishwasher may use 1.2 kWh per run, or a central air conditioner may use 1450 kWh per month.

often protested by local residents, environmental groups, and indigenous interests that might prefer to maintain natural space or to support already-fragile ecosystems. Environmental groups are advocating for distributed solar projects like on rooftops or parking lots rather than requiring as much as 148,000 new acres for utility-scale projects that is criticized as incompatible with land conservation initiatives such as Governor Newsom's 2020 executive order pledging to conserve 30% of California's land and water by 2030.

Cost-shifting. Utility fixed costs include new energy generation projects, grid infrastructure improvements, wildfire prevention, and public programs for low-income customers that can reduce electricity bills by 30-35% like California Alternate Rates for Energy (CARE). In California, these fixed costs, (not electricity generation or transmission), are responsible for as much as 77% of the ratepayer's bill. California IOU electricity rates are rising faster than inflation (2021-2030 rate increases projected at 37% for PG&E, 35% for SCE, and 45% for SDG&E) and currently stand 45-100% higher than national averages, a situation that is especially burdensome on lower income ratepayers. Beyond the direct affordability of rates, the Legislative Analyst's Office (LAO) has noted that California's increasingly high electricity costs may be a barrier to electrification, so rate increases are of concern.

As customers add solar systems, they reduce their energy needs from the grid and their utility. Consequently, utilities are distributing their costs over a shrinking number of customers, disproportionally affecting lower-income customers and/or renters, leading to annual household energy bills $100-$230 ($67-$128 for CARE customers) higher than those of ratepayers with solar (Figure 4). These costs and benefits vary in magnitude as a small number of households installing solar results in their avoided costs being shifted across the whole of the much larger rate base. As more ratepayers install solar panels, this cost shift increases, placing further burden on people who can't afford solar. Pro-solar organizations such as the California Solar and Storage Association (CALSSA) emphasize that ratepayers are not obligated to purchase a certain amount of energy from the utilities and so their use of solar to reduce their energy demand should not result in other charges to recoup the reduced energy rate, but IOUs argue ratepayers with solar still use energy from the grid and should contribute to fixed costs.

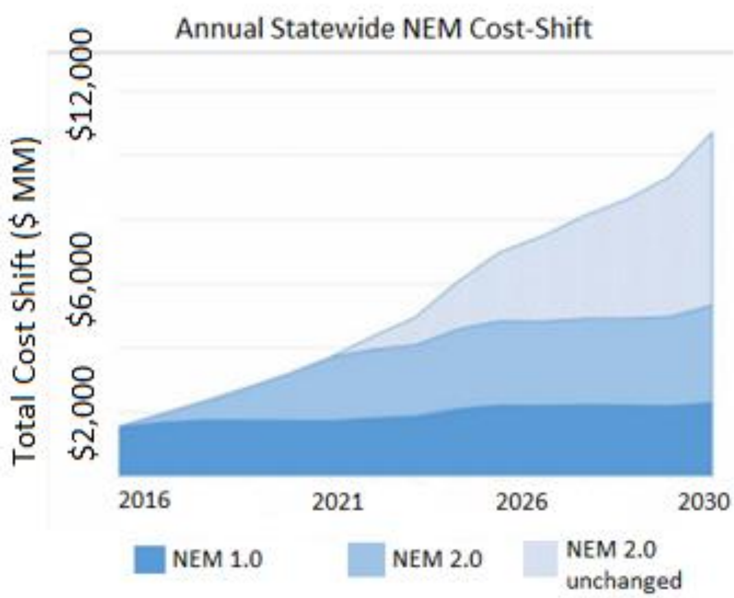

Figure 4. Annual historic and projected utility-measured cost shift due to NEM 1.0, NEM 2.0 under current parameters (installation rates, export compensation, etc.), and NEM 2.0 if it continues unchanged (CALSSA)

In the NEM 2.0 Lookback Study, the Total Resource Cost (TRC) measures the net cost of the program based on its total costs, including the customer and utility's costs. A TRC value of 1.0 or greater indicates that the program is cost-effective, while a TRC below 1.0 indicates that the program is not cost-effective. Across all three IOUs, the non-residential customer segments (agricultural, commercial, and industrial) are all cost effective, while the residential segment is not (Table 2).

Table 2. Cost-effectiveness (through TRC) of NEM 2.0 for each customer sector (Verdant Associates, Net-Energy Metering 2.0 Lookback Study)

Utility	Customer sector	NEM 2.0 TRC
PG&E	Agricultural	1.19
	Commercial	1.12
	Industrial	1.17
	Residential	0.69
SDG&E	Agricultural	1.43
	Commercial	1.35
	Industrial	1.34
	Residential	0.80
SCE	Agricultural	1.25
	Commercial	1.18
	Industrial	1.21
	Residential	0.76

Other sources have estimated the overall and longer-term benefits of rooftop solar to be as high as $295 annually by household, with solar and electrification together having greater potential benefits. The growth of rooftop solar (based on installation targets projected by the California Energy Commission (CEC)) could further lead to savings of $4 billion per year, or over $120 billion by 2050 for California (approximately $310 per household annually, or $9,230 cumulatively by 2050). These potential benefits contrasted against the cost effectiveness (TRC) of rooftop solar highlight the controversy around how to value solar, and the metrics used to do so.

Grid Reliability, Safety and Management. The average California electricity transmission line is over 86 years old, leaving parts of the state uniquely fire-prone, limiting additions of rooftop solar systems, and requiring costly transmission and generation investments by the IOUs. Grid hardening costs such as replacing transmission towers with new, fire-resistant ones, insulating lines, adding remote sensing capabilities to monitor problems, and properly clearing the areas around lines to limit wildfire risk are included in bundled utility rates. SB 901 (Dodd, 2018) and more recently the CPUC issued a decision aimed at improving oversight and enforcement of the IOUs proposed cost of up to $15 billion with regard to maintaining and modernizing the grid.

Utilities are increasingly resorting to Public Safety Power Shutoffs (PSPSs), during which power is shut off during high wind events that create wildfire risks from downed power lines that remain energized. This has resulted in the state and critical services such as hospitals relying on gas and diesel generators to mitigate power loss. While NEM 3.0 discussions have centered on social equity with regards to solar accessibility and the cost-shift, enabling safe and reliable energy access to all Californians is a critical equity issue as power outages disproportionately impact vulnerable, lower-income households, businesses, and communities. Energy unreliability additionally incentivizes ratepayer solar and storage options to minimize or avoid these impacts. Solar advocacy groups have proposed programs to install one million batteries, echoing the success of the Million Solar Roofs initiative.

The difference between electricity demand and supply throughout the day (net energy load) is an important factor in grid management. When all energy was entirely utility moderated, supply generation could be ramped up or down to match demand. However, as solar and wind contributions have increased, their intermittent contribution makes the net load on the grid more challenging to manage as large utility-scale plants (e.g., coal and nuclear) are difficult and costly to start and stop. Large swings in demand (Figure 5) due to renewable generation such as solar have made utilities rely on more easily controlled generation from natural gas to provide energy when the renewable sources cannot.

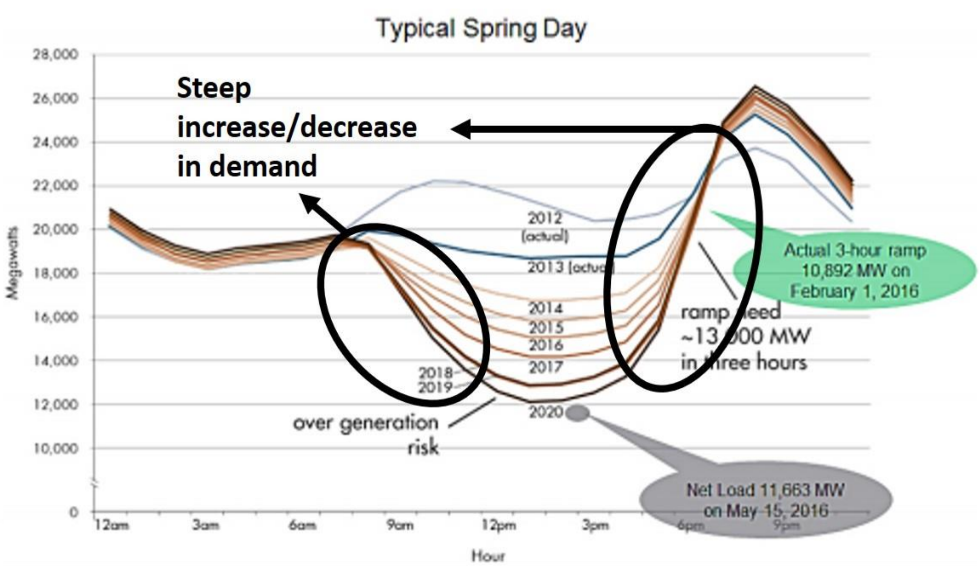

Figure 5. Typical Net Energy Load of the Grid (difference in electricity demand and supply) often referred to as a "duck curve." (CAISO)

Overgeneration of solar energy beyond the capacity of what is immediately usable reduces the benefits and poses risks to the grid. This forces operators to resort to exporting the energy and curtailing solar generation. The need for curtailment has increased as the energy solar participants generate continues to grow, with the California Independent System Operator (CAISO) curtailing 1.5 million MWh (5% of its capacity) of utility-scale solar production in 2020 and solar accounting for 94% of curtailed energy.

Solar industry advocates have proposed making real-time TOU rates available to all customers so they can make informed decisions on their energy usage and optimally use their solar production to reduce overgeneration. Without TOU structures, energy rates do not accurately reflect the value of electricity production or the cost of consumption, disincentivizing flexible loads and storage devices. Making real-time TOU rates available has been promoted as potentially providing better information on the location and scale of solar needs, and would enable customers to better integrate energy storage for their needs.

The CPUC stated in a May 2021 report on Utility Costs and Affordability, "IOUs are inherently incentivized to make investments to drive an increase in their rate base and therefore, their profitability." In 2018, the expanded distributed generation led by rooftop solar contributed to the CPUC modifying projects to avoid $2.6 billion in fixed costs that would be distributed among ratepayers. However, interest groups disagree on how to fully quantify the benefit against needs for grid improvements and the Legislative Analyst's Office has recommended further study of the cost-reduction benefits of distributed solar.

3. Who has a stake in the decision-making?

The decision on NEM 3.0 will impact the energy rates of all Californians, with the IOUs, the solar industry, and customers expected to be most impacted by any policy changes.

The broad-reaching impacts of NEM 3.0 led environmental groups, housing advocacy groups, organized labor, and others to issue proposals and statements, but the most significant and well-funded voices are from the IOUs and solar industry groups. California's NEM decisions will impact the larger solar market, with effects in other states that are looking to rapidly grow distributed renewable generation or begin to reduce subsidies in strong solar markets.

The IOUs have an interest in building more utility-scale renewable energy projects and limiting solar distributed generation. A less financially attractive NEM structure helps maintain the number of ratepayers.

The rooftop solar industry's future will be impacted by the NEM structure as its business is based on the benefits and affordability of solar systems. For example, the IID experienced an approximately 60% drop in new solar installations from the prior three-year period when they shifted to net billing (an alternative approach to NEM in valuing grid energy exports and imports) in 2016.

Consumers with solar will be impacted depending on the grandfathering rules that are adopted that sunset for NEM 1.0 and 2.0 in 2022 and 2037 respectively (20 years from individual customer system interconnection). Similarly, customers that expand their system size and all future customers that enter NEM 3.0 agreements would receive the proposed reduced benefits.

Consumers considering installing solar will be most interested in the updated NEM 3.0 structure and benefits, as it will make rooftop solar either more or less financially viable.

Consumers without current or future solar systems will be most impacted by how much the cost-shift will continue to grow, stay the same, or be reduced by NEM 3.0.

Nonunionized solar workers typically install rooftop solar systems. The rooftop solar industry currently employs 68,000 Californians possibly reaching as many as 100,000 new jobs added by 2030, and 374,000 new jobs added by 2050. Any reduction in solar demand will decrease the economic benefits and the number of new jobs.

Labor Unions whose workers fix and upgrade transmission lines and grid infrastructure, and install large scale solar farms for the IOUs have been vocal in the NEM 3.0 proceedings and have supported AB 1139 (Gonzalez, 2021) that proposed to reduce the benefits of NEM. Representatives of other electrical workers and utility employees echoed similar concerns around the cost-shift necessitating a transition in NEM policy.

Regulators and the State of California will implement the NEM 3.0 changes. Residential and commercial/industrial systems have amounted to nearly half of the renewable (or solar) annual installations, and reducing the NEM benefits for distributed solar could slow installations and make California's clean energy goals more difficult to attain.

4. What is currently known about NEM 3.0?

The CPUC preliminary decision reduces the ratepayer generation benefit to solar customers and adds monthly fees for rooftop solar owners. Grandfathering NEM 1.0 and 2.0 customers as proposed would be reduced to a 15-year period from their date of interconnection. A final decision will be released in the first quarter of 2022.

The CPUC released a preliminary NEM 3.0 decision (referred to as the Proposed Net Billing Tariff) on December 13, 2021, and will finalize NEM 3.0 in early 2022. Broadly, interest groups agree to a reduction in benefits from the current NEM structure but differing interests and approaches have led to numerous NEM 3.0 proposals. The CPUC is obligated to follow its guiding principles from SB 100 and AB 327 to allow rooftop solar to continue growing "sustainably" (a line criticized as unclear). Following the reduction in benefits under NEM 2.0, the annual rate of new solar interconnections recovered within 3 years (Figure 2A). Similarly, a potential reduction of installations following NEM 3.0 is anticipated to rebound over time as PV system costs continue to decrease. With a reduction in NEM benefits, other price mechanisms including the total PV system cost and incentives like the federal ITC will be relied on to ensure solar is cost-effective for owners.

Solar industry and customer-aligned groups support continued grandfathering or a gradual tariff step down, such as lowering rates 25-50% by 2027. Solar-aligned interests criticized AB 1139 as breaking the trust of ratepayers that installed solar systems under a known NEM benefit structure since it ended the grandfathering plan. The CPUC's preliminary NEM 3.0 decision would reduce the grandfathering period for existing NEM 1.0 and 2.0 projects to 15 years (low-income solar customers would remain on the 20 year grandfathering period). A grandfathering system would freeze the cost-shifting effect at its current size from NEM 1.0 and 2.0, however, every reduction in NEM benefits reduces the further cost-shifting effect (Figure 6).

Table 3. Comparison of NEM 2.0 and the CPUC Preliminary Decision NEM 2.0

	NEM 2.0	NEM 3.0
Time of use (TOU) charges	Required	Required; high-differential TOU
Installation size limit	No limit	Sized to cover 150% of customer's historical load
Monthly charges	No cap	Grid Participation Charge: $22.05-$40.00 for a 5-kW system
Grandfa-thering	NEM 2.0 rates will remain for 20 years	Reduction of NEM 2.0 grandfathering to 15 years

A critical aspect for the sustainability of solar is the "payback period," or how long it takes until owners break even on their solar systems. Under NEM 2.0, the payback period is approximately 5-8 years. Reducing NEM benefits could cause solar to be financially further out of reach for many lower and middle-income households and small businesses depending on the benefit reduction. Proposals favoring NEM benefits have shorter payback periods and a greater cost shift, while reductions to the NEM benefits have longer payback periods and a smaller cost shift (Figure 6).

NEM 3.0 could involve net billing or a feed-in-tariff (FIT) combined with system-based grid charges. Net billing and a FIT provide differing value systems and have been implemented within California (e.g. by the IID in 2016) and other states. Net billing acts similarly to NEM, with electricity consumption and excess generation credited at set rates (no TOU) and with the "net cost" billed to the ratepayer rather than being used to offset future usage in the billing cycle. FITs differ in that they act as a "buy all, sell all" tariff. All electricity generated from a customer's solar system is purchased by the utility company, and all electricity used by the customer is purchased from the utility company.

Additional proposals have included shifting the burden of NEM and fixed costs from the IOUs to the state in order to distribute the burden of costs more progressively through taxes while ensuring funds to maintain and harden the grid. Some proposals address environmental and social justice issues by offering lower retail energy rates to low-income or CARE customers, but keeping standard-rate compensation for energy produced and exported to the grid. Due to the prohibitive upfront cost of solar systems, these recommendations also include adding zero- or low-interest-rate loans for these systems to assist low and middle-income customers.

Community solar is an alternatively proposed method enabling local residents or businesses to own or lease offsite solar systems not on their own rooftops to receive the benefits of solar that they otherwise may not have access to. Although these projects can be utility-owned, community solar provides energy and generation credit to that community. A major advantage of community solar is that it allows for solar systems to be placed strategically, potentially on unused local land, to improve energy reliability and reduce energy costs. Other proposals have included a "net value billing tariff" that would allow for community solar projects to provide electricity credits for customers that can't participate in typical NEM systems.

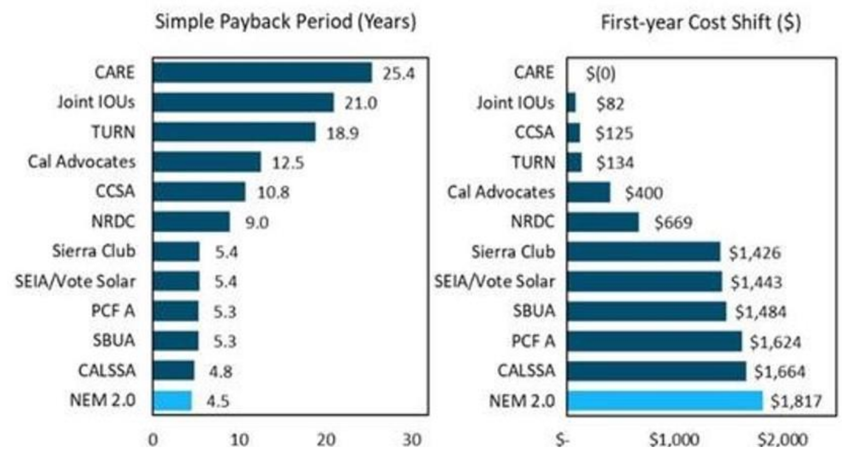

Figure 6. Analysis prepared by E3 for the CPUC showing the payback period of major NEM 3.0 Proposals. CCSA: Coalition for Community Solar Access; TURN: The Utility Reform Network; NRDC: Natural Resources Defense Council; SEIA: Solar Energy Industries Association; SBUA: Small Business Utility Advocates; PCF: Protect Our Communities Foundation (Energy and Environmental Economics, Inc., Alternative Ratemaking Mechanisms for Distributed Energy Resources in California, January 28, 2021).

The IOUs proposed in the NEM 2.0 proceedings multiple redesigns of the fixed monthly fees including a fixed charge designated for customer support and service ($12.02-24.10 / month), and a solar-only fee for "maintaining, operating and improving the grid" ($7.39-11.09 / kW), but these were not included in NEM 2.0. For larger systems commonly installed by schools, small businesses, or other organizations, fixed fees could range from $950 to $3,400 monthly, reducing the benefit of NEM solar systems by up to 77-80%. This would impact large and small non-residential customers to a significant degree; Walmart has recently filed with the CPUC raising concerns that utilities already over-recover their costs by $118 million annually for non-residential customers under NEM 2.0. For a 500 kW non-residential system, the IOU-proposed Grid Benefits Charge fee structure would result in $43,440-$62,280 annually in added costs. The CPUC NEM 3.0 preliminary decision includes a Grid Participation Charge of $6.38/kW for PG&E, $4.41/kW for SCE, and $8.00/kW for SDG&E (ranging from -$5.25 to $0/kW for low-income customers) of system size. For a 5 kW residential solar system, this would result in $22.05-$40.00 (ranging from -$26.25 to $0.00 for low-income customers) as a monthly charge.

Current customers with solar systems face operating costs as solar panels require cleaning and maintenance to continue operating optimally, as well as eventual disposal and replacement costs at the end of the system's lifecycle. Any degradation of generation capacity may increase their utility costs after grandfathering, especially if the NEM 3.0 structure includes fixed monthly fees. However, ongoing solar research is working to develop more robust systems with improved generation capacity, and this is coupled with an increasing length in manufacturers warranties. The California building code requires new residential construction up to 3 stories as of January 2020, and larger residential and commercial buildings in 2023, to have solar and be compatible with energy storage, working towards "net-zero" homes. This mandate was criticized for increasing home costs by the $10,000-20,000 cost of the solar/storage system, further increasing California's housing affordability issues. This will result in additional new NEM 3.0 ratepayers as those systems are interconnected.

5. What should be considered moving forward?

Future focus on plans to further decarbonize California with an affordable and reliable grid need to include

- Both distributed and large-scale generation
- An increased role of energy storage systems

As solar and energy storage technologies are expected to increase in efficiency and decrease in cost, determining how best to engineer a reliable grid from mostly variable renewable energy sources will be an ongoing challenge composed of complex balances of energy, infrastructure, and policy.

Technology is available for a sustainable grid using renewable energy sources with storage, but California currently faces an expected energy system capacity shortfall of 4% in 2021 and 6% in 2022. Energy storage is touted as the "true bridge" to clean energy, but only 4% of California residential solar systems are equipped with batteries. This may change as the solar industry estimates 13% of new residential solar installations and in total as high as two-thirds of existing rooftop solar installations will include storage due to a decrease in battery cost. If NEM 3.0 reduces energy buyback rates, energy storage could become more popular (battery-storage attachment rates have reached 80% following reduced NEM policies in Hawaii) granting solar owners more flexibility on when they use self-generated energy. The needs of electrification and storage have influenced the CPUC's preliminary decision to include solar systems allowed to cover

150% of a customer's historical load to support electrification, as well as high differential TOU rates. The larger difference in TOU rates for peak and off-peak prices are designed to incentivize storage while lower off-peak prices make electric vehicles and household appliances more affordable.

Additionally, utility scale storage of varied size and methodology (e.g., battery, pumped, thermal) should be a focus of future investment and efforts by the state in order to match demand with supply to best fit energy needs, and minimize the impacts of rising energy prices and the cost shift itself. Due to its mountainous geography and both ocean and in-land bodies of water, California could be ideally suited for methods such as pumped storage to fill in the gaps of variable renewable energy production.

Nuclear power and other carbon-free sources significantly contribute to California's energy generation. They are currently limited as ongoing drought conditions have limited hydroelectric production, with the Edward Hyatt Power Plant at Lake Oroville being shut down for the first time due to low water levels, and the Diablo Canyon Nuclear Generating Station scheduled to be shut down. Wind generation projects, such as those proposed and underway offshore, could support California's energy needs, although wind comes with variable generation challenges similar to solar.

Managing intermittent energy requires policy makers and regulators to consider maintaining nuclear power as a constant and reliable energy supply supplemented with renewable sources and storage to meet fluctuating demand periods. Focusing on grid and energy stability and reliability will also support the reduction of the most heavily polluting energy resources, such as emergency diesel generators, which can lead to environmental and public health benefits.

Microgrids, or connected "islands" with onsite generation and storage are becoming more common, enabling an area to disconnect from the grid and remain energized during grid outages to avoid the impacts of blackouts. The CPUC has recently announced new programs to better meet California's energy needs during crises, including new microgrid projects, among other consumer and utility-side programs. Meeting the demands of wide-scale electrification[2] while avoiding increases in electricity costs will depend on comparisons to natural gas prices for residential, commercial, and industrial use, and gasoline and diesel prices for electric vehicle and other transportation (e.g., trucking, maritime) transitions. If the price of oil and gas increases, renewable energy becomes comparatively more desirable.

The need to continue to reduce fossil fuel emissions remains important and is expected to result in strong solar growth in the coming years, including new buildings being required to include rooftop solar. Phasing out fossil fuel-based energy generation and its pollution will continue to provide benefits in reducing emissions and public health problems that disproportionally affect lower-income areas.

[2] Electric vehicles alone are projected to increase California's electricity needs by 25% (72 TWh) over the next 15 years

6. Conclusions

The utilities, solar industry, and ratepayers will need to adjust accordingly when NEM 3.0 goes into effect.

- Utility grid management work is costly but critical
- The cost shift must be assessed and weighed against the benefits of NEM
- Energy technology developments will continue to change the landscape
- There are other policy and decision-making mechanisms that can be used

As addressed in the NEM 3.0 preliminary decision, numerous interest groups have acknowledged that a change in benefits to the current NEM subsidy structure over time is needed, and this is reflected in their proposals. The notable differences come in their approaches and priorities, structuring reduced benefits under NEM 3.0 with differing methods and to varying degrees. NEM 3.0 could take attributes from these wide-ranging proposals, balancing and weighing the benefits of both rooftop and larger-scale solar, the size and impact of the cost-shift, the accessibility of rooftop solar, and the capacity of the grid to provide energy access safely and reliably to all Californians in an equitable and growth-oriented manner.

Prioritizing land preservation favors expanding rooftop solar on currently unused space and by expanding consumer-safe low-interest loans, or by enabling the expansion of solar investment mechanisms that could include utility or privately owned microgrids or generation. A forward-looking energy policy should take a comprehensive approach to achieve California's decarbonization goals. This could involve learning from other jurisdictions' experience in designing sustainable, innovative policy solutions to support the future grid while ensuring equitable energy access.

There is a fundamental conflict in NEM policies between the cost shift and the payback period, as lowering the NEM benefits to reduce the cost shift leads to an increased payback period that might slow rooftop adoption. Since the cost shift and payback period cannot both be reduced within the NEM structure, effective balancing of these interests could be accomplished by subsidizing the upfront costs of solar systems to increase the accessibility of rooftop solar while also implementing reduced NEM export benefits in order to reduce the cost shift. Making solar more expensive through reducing the incentives under NEM or other methods risks only further entrenching current inequities in ownership.

NEM policies that have been successful so far are not the only mechanisms than can be used to achieve any of the goals surrounding energy and the grid, environmental issues, and social equity in California. State policy from regulatory agencies and the legislature could take a more active role alongside corporate commitments, infrastructure changes, technological advancements, and the role of utilities to pursue these ends and direct specific goals. Further efforts should continue to study the impacts of NEM (2.0 and as 3.0 takes effect) on solar and non-solar customers, as well as study utility resource, generation, and other project costs, the rate of increase of electricity rates, and the rate changed composition based on these and other factors.

California's long-term grid development should encourage both rooftop solar and utility-scale projects. While NEM 3.0 in the context of decarbonizing California's energy resources seems to cast subsidies for rooftop solar against utility-scale projects, mechanisms within and outside of NEM can be used to provide more intelligent land use, financing, and ownership structures. Solar provides a valuable addition to California's energy mix, and will be critically supported by storage to make solar energy storable and dispatchable. Moving forward, as non-utility generation increases and energy generation becomes more distributed due to the growing proportion of renewables on the grid, the role of the utility company may shift in its involvement with energy generation, transmission, distribution and storage with all of these elements supported by reduced costs and increased efficiency of current and new technologies.

The numerous challenges of solar and NEM policy are complex and not easily summarized. However, NEM in a particular form was not meant to be permanent: it was intended to catalyze the adoption of renewable energy, and it will continue to evolve as goals are met and priorities shift. The variability in perspectives and desired goals of interest groups for NEM 3.0, and the direction the municipal utilities take are complex topics requiring careful analysis. The CPUC's mandate is to create a tariff that maintains "sustainable growth" in equitable and affordable solar power for California. The path forward following NEM 3.0 will remain unclear until the final decision is released by the CPUC, but it is clear that NEM 3.0 alone will not ensure that California meets its climate goals.

Key Takeaways

- Grid management and modernizing is high cost but critical work. IOUs and grid regulators allocate fixed costs to prepare a grid that makes energy reliable, accessible, and affordable to all Californians. The state's goals of decarbonizing energy resources include policy mechanisms to ensure those goals are met, but disaster-prevention goals must be emphasized to ensure the grid's resiliency.

- The cost shift of fixed utility costs to ratepayers without solar is a challenge facing California's goal of accessible energy for all residents. The tension between the cost shift and the affordability of solar (through the payback period of solar systems) must be balanced with the benefits of rooftop solar in structuring NEM 3.0 and future policy. Making solar more expensive through reducing the incentives risks only further entrenching current inequities in ownership.

- Energy technology and its related sectors will continue to advance, leading to increased efficiency and reductions in cost. This will make a diverse mix of solar, storage, electric vehicles, and more all more available and fulfill a greater role in the grid. Even under a reduction in NEM benefits, these developments will continue to support the sector and further high-level applications such as microgrids and expanded energy storage.

- NEM has numerous components and covers a breadth of sectors and applications. Discussed as complementary policies with respect to NEM, federal incentives, state policy through legislative goals, and regulatory agencies each have mechanisms to drive specific goals. These, alongside options such as corporate commitments and consumer behavior can target specific goals in order to work in a complementary fashion with NEM or support aims for which NEM is less effective.

Peer Review. This report was reviewed by colleagues holding positions in industry, policy, academia, and research respectively. We would like to acknowledge and thank our peer reviewers for providing their time, technical knowledge, scientific insights, and their help in understanding the relevant policy and social consequences of new NEM policies

Addendum: Summarized findings from customer interviews

While ratepayers with and without rooftop solar care about the environmental benefits of solar, their priorities are financial; they adopted solar to offset high electricity bills but aren't buying storage options because they aren't worth the benefit of having power during outages. Ratepayers disagreed with the principle of cost shifting but understood why the IOUs, as for-profit businesses, implement cost-shifting to protect their bottom line. Non-ratepayers agreed that storage should be prioritized alongside solar to meet the variability challenges of renewable energy. They also agreed solar should be subsidized, but disagreed on who should do the subsidizing and who it should primarily benefit.

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Ryan Drover, Chemical and Environmental Engineering
Thomas Dugger, Ph.D., Materials Science and Engineering
Melanie Kushida, Sociology
Stephanie Piper, Botany & Plant Sciences
Chris Rudnicki, Mechanical Engineering
Yun Xie, Electrical Engineering
Hao Xin, Ph.D., Electrical Engineering

Authors
Ryan Drover and Chris Rudnicki completed the Science to Policy Certificate course in the Winter of 2021 and continued to contribute to the organization afterwards. Both students are Ph.D. candidates in the Environmental and Chemical, and Mechanical Engineering departments respectively. Thomas Dugger, Ph.D. Material Science and Engineering, was the primary editor of this white paper.

Paper Preparation
Doug Brown
Susan Hackwood, Ph.D.
Alfredo Martinez-Morales, Ph.D.
William Ota

Interviews
Thomas Dugger, Ph.D.

Project Review
Doug Brown
Susan Hackwood, Ph.D.
Alfredo Martinez-Morales, Ph.D.
Fred Schwartz

Glossary

Investor-Owned Utility (IOU): Large distributors that serve the majority of California ratepayers. IOUs issue stock to shareholders and operate as private, for-profit enterprises. In California: Pacific Gas & Electric (PG&E), San Diego Gas & Electric (SDG&E), Southern California Edison (SCE)

Municipal Owned Utility (MOUs): local public utilities formed to serve a city or region and account for approximately 25-30% of California residents. Municipal utilities are based on local control and public ownership structured as not-for-profit. MOUs have independent processes and are not regulated by public utility commissions (the CPUC).

The California Public Utilities Commission (CPUC): A regulatory agency that oversees privately owned utilities in California. The five CPUC commissioners approve final decisions on many aspects of utility functions, including regular rate increases, or larger policy shifts such as NEM 3.0 as discussed here.

The California Energy Commission (CEC): The primary energy policy and planning agency for California. The CEC plays a significant role in planning the energy system and its management, advancing state energy policy, pursuing energy efficiency, investing in energy innovation, overseeing infrastructure, and preparing for energy emergencies, among other responsibilities.

California Independent System Operator (CAISO): The non-profit independent system operator in California, which "manages the flow of electricity on high-voltage power lines, operates a wholesale energy market, and oversees infrastructure planning." The primary mission is to "operate the grid reliably and efficiently, provide fair and open transmission access, promote environmental stewardship, and facilitate effective markets and promote infrastructure development."

Distributed Generation, or Distributed Energy Resources (DG, or DER): Distributed generation or on-site forms of energy generation are electrical generation and storage components performed by small, grid-connected devices referred to as distributed energy resources. DG/DERs are generally referred to regarding renewables like small-scale solar PV and wind, but they are not necessarily decarbonized energy: e.g., portable diesel generators also fall under the definition of DG/DERs.

Decarbonized [energy sources]: Carbon-emitting energy sources are fossil fuels (such as oil, coal, and natural gas) that release carbon dioxide (CO_2, or other greenhouse gases). Decarbonizing aims to replace these resources with minimal or carbon-free emissions sources, such as wind, solar, and nuclear energy.

Net Energy Metering (NEM): Net energy metering policies determine the way and price in which individuals who produce their own power are compensated for electricity returned to the electrical grid.

Payback period: How long until the benefits of the solar system reach a breakeven point for the owner. With high upfront costs (purchasing the system, permitting, and installation costs), solar PV systems benefit from NEM policies to make them financially viable in a shorter period as the energy generated is able to offset the initial costs.

Time of Use (TOU): Electric rates that change during the day or season, as renewables like solar and wind do not produce constant energy throughout the day or year there is a fluctuation in available energy to the grid. This causes utilities to need to increase more costly generation forms to supply energy.

Cost Shift: As ratepayers install solar or other DERs, the fixed costs of the utilities are then distributed over a shrinking base of ratepayers. This “cost shift” is the increased costs on those ratepayers due to solar ratepayers reducing their contribution to the utility costs.

Solar or Photovoltaic (PV) systems: Electrical power system that convert solar energy into electricity

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Science to Policy (S2P) at the University of California, Riverside, is founded on the idea that scientists can and should play a critical role in public policy. By hosting and supporting a number of professional development opportunities on and off campus, S2P's vision is to empower UCR STEM graduate students to participate in science policy by providing a suite of experiential opportunities to learn from public policy experts.

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