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GROWTH OF BEHIND-THE-METER ELECTRICITY GENERATION: IMPACTS TO STATE BUDGET REVENUE

This report investigates the long-term impacts that growth of behind-the-meter (BTM) electricity generation could have on state budget revenue from electricity consumption charges. While there are numerous surcharges and fees that electricity customers pay utilities to support numerous programs, this report focuses on two specific electricity consumption fees used to fund the operations of the California Energy Commission (CEC) and the California Public Utilities Commission (CPUC). Electricity generated behind the meter is exempt from state consumption charges, which results in a combination of revenue erosion and cost shifting. Key findings and legislative considerations from this investigation include:

> **Revenue erosion and cost shifting likely will accelerate as BTM electricity generation is expected to become a more significant part of total electricity consumption.** Between 2015 and 2030, BTM electricity is forecast to grow from about 7 percent to 17 percent of total electricity consumed.

> **BTM electricity generation creates equity concerns by shifting cost burdens for state consumption charges.** When BTM electricity consumers avoid paying a state consumption charge, the costs likely will shift into higher electricity rates paid by a smaller remaining pool with a higher proportion of lower- to middle-income utility customers.

> **Options for imposing charges on BTM electricity generation contain various issues and trade-offs and could range from using a simple fixed fee to estimation formulas to meters.** Trade-offs and issues to consider include costs, accuracy, administrative feasibility, equity, privacy, and co-benefits of acquiring actual generation data.

> **To avoid inflationary erosion and maintain a state agency's ability to provide services over time from a fixed or capped charge, the Legislature could consider tying that charge to an inflationary measure.**

This report also (1) provides background on BTM electricity generation technologies, (2) identifies potential drivers that could accelerate BTM generation growth, (3) presents a forecast of BTM generation growth in California, and (4) discusses in more detail how state budget revenue that funds the operations of CEC and CPUC are affected by BTM electricity generation.

BTM ELECTRICITY GENERATION TECHNOLOGIES

Electricity generated by a power source typically passes through a utility-owned electric meter before reaching an end user. The difference between behind-the-meter and front-of-meter energy systems comes down to a system's position in relation to the electric meter. Generating electricity from a BTM system means electricity can be used on-site without passing through a utility-owned meter and interacting with the electric grid. Numerous activities conducted by an end user are technically considered to be behind the meter, including energy generation, storage, demand response, and efficiency measures. This report focuses on BTM electricity generation.

Several types of technologies can be employed to generate electricity behind the meter. These include solar, wind, natural gas, fuel cell, and diesel. Table 1 provides a short description of each of these electricity-generating technologies.

POTENTIAL DRIVERS INCENTIVIZING BTM GENERATION GROWTH

Costs

Costs are likely the most significant factor for consumers choosing to generate electricity behind the meter. Cost reductions for BTM generation can come through federal or state subsidy programs, natural market trends from technology breakthroughs and commercialization, or the avoidance of existing costs.

State Efforts to Support BTM Generation

California has taken significant steps to help reduce the costs of BTM electricity generation through numerous programs and policies. One of the largest of these efforts is known as Go Solar California. SB 1 (Murray), Chapter 132, Statutes of 2006, authorized CEC and CPUC to establish programs to achieve

Table 1: Technologies Used to Generate Electricity Behind the Meter

Technology	Description
Solar Photovoltaic (PV)	The photovoltaic effect is the process of converting light to electricity. Solar cells used for BTM generation typically are made from silicon and usually are assembled into larger modules that can be installed on the roofs of residential or commercial buildings.
Wind Turbines	Wind turbines use propeller-like blades to capture wind energy and convert it into electricity by turning a rotor. Multiple gears are used to increase the rotor's rotation by a hundredfold to generate enough speed for the turbine's generator to produce electricity.
Natural Gas Turbines	Natural gas turbines generate electricity by combusting and expanding natural gas through a turbine, causing a generator to spin a magnet. The high-temperature exhaust from the turbines also can be used to generate heat, a process known as combined heat and power, or cogeneration.
Fuel Cell	Fuel cells use an electrochemical process to convert the chemical energy in a fuel (such as hydrogen) to electricity. Fuel cells generate electricity without combusting the fuel and can be stacked to provide more power.
Diesel Generator	Diesel generators use a combination of an electric generator and a diesel engine to generate electricity by combusting diesel fuel to rotate a crank that moves a wire through a magnetic field, inducing electrical charges.

Table 2: Current State Programs and Policies Supporting BTM Electricity Generation

Program/Policy	Description of BTM Generation Support	Administrator	Lead Agency
Self-Generation Incentive Program (SGIP)[2]	Financial incentives for BTM generation from wind, waste heat to power, pressure reduction turbines, internal combustion engines, microturbines, gas turbines, and fuel cells[3]	IOUs and CSE	CPUC
Net Energy Metering (NEM)[4]	Provides a financial credit on electric bills for customers who install BTM solar photovoltaic (PV), wind, fuel cell, biogas, biomass, digester gas, geothermal, small hydroelectric, landfill gas, municipal solid waste conversion, ocean thermal, ocean wave, solar thermal, and tidal current generation facilities and supplies any surplus energy back to their utility	IOUs	CPUC
Solar Building Energy Efficiency Standard (BEES)[5]	A new standard that requires PV systems on every house that receives a building permit	N/A	CEC
Electric Program Investment Charge (EPIC)[6]	Funds scientific and technological research in clean energy, including microgrid demonstration projects	CEC	CPUC
Renewable Energy for Agriculture Program (REAP)[7]	Funding to assist agriculture operations with the installation of on-site renewable energy technologies	CEC	CEC
Property Assessed Clean Energy (PACE) Loss Reserve Program[8]	Increases availability of residential PACE financing to install PV by making first mortgage lenders whole for direct losses as a result of a PACE lien in a foreclosure or forced sale	CAEATFA	CAEATFA
Low-Income Weatherization and Solar[9]	Funding for PV in low-income single-family and multifamily dwellings	CSD	CSD
SB 1339 (Stern), Chapter 566, Statutes of 2018	Requires CPUC to facilitate the commercialization of microgrids	IOUs	CPUC
Energy Conservation Assistance Act (ECAA)[10]	Zero- and low-interest loan programs for energy generation projects	CEC	CEC

* CAEATFA = California Alternative Energy and Advanced Transportation Financing Authority, CSD = California Department of Community Services and Development, CSE = Center for Sustainable Energy, IOUs = Investor-Owned-Utilities.

the goal of installing 3,000 megawatts (MW) of solar energy systems on homes and businesses by the end of 2016. Funded primarily through a surcharge on electricity bills, the statewide budget for subsidies to achieve this goal was more than $3.3 billion. By the end of 2018, California had installed approximately 8,001 MW of solar capacity at 926,986 customer sites.[1]

Although the Go Solar California effort has concluded, California continues to support and incentivize electricity generation behind the meter. Table 2 on the previous page provides information about current state programs and policies that support BTM electricity generation.

Market Trends

Cost reductions for BTM generation also can occur through changing market trends such as improved supply chains, technology innovations, and economies of scale. For example, the installed cost of solar PV has fallen rapidly in recent years. Led by steep declines in the price of PV modules, residential solar PV costs declined by almost 70 percent nationally from 2000 to 2018.[11] In California, the average cost of installed small solar PV systems decreased by more than 50 percent between 2007 and 2018.[12] At the federal level, the U.S. Department of Energy has an explicitly stated goal of continuing to support these market trends by reaching a 2030 levelized cost of energy target of $0.05 per kilowatt-hour (kWh) for residential solar PV, currently estimated to be about $0.15 to $0.24 per kWh.[13]

Avoiding High Retail Electricity Rates

Avoiding existing costs, such as the high retail electricity rates consumers normally have to pay to utilities, also can be a factor in incentivizing BTM generation adoption. In 2017, California's average retail electricity rates were about 50 percent higher than the national average.[14] California utilities also have historically charged much higher rates as electricity consumption increases through block or tiered pricing rate designs. Even when combining the declining costs of residential solar with state incentives, residential solar PV largely has not been economical for most customers. However, the incentive to avoid California's very high electricity tiered prices by high-consuming households has significantly helped drive the adoption of residential BTM solar PV in the state.[15] A similar result was found in Hawaii, which has both the highest electricity costs and the highest penetration of distributed solar PV in the nation.[16]

Support for Clean Energy

One nonfinancial driver for the growth of BTM electricity generation could be Californians' support for clean energy. In a July 2019 Public Policy Institute of California survey, 71 percent of Californians stated they ". . . favor the state law that requires 100 percent of the state's electricity to come from renewable energy sources by the year 2045."[17] One indicator of Californians' interest in supporting clean energy is the recent growth of community choice aggregators (CCAs). CCAs are governmental entities formed by cities and counties to serve the energy requirements of their local residents and businesses, and communities served by CCAs have cited clean energy as one of the primary benefits.[18] In 2020, 19 CCA programs were serving more than 10 million customers in California.[19]

Self-Reliance and Mitigating Blackouts

California has experienced recent catastrophic wildfires. To protect public safety, investor-owned utilities (IOUs) may shut off electric power to customers, an action referred to as "de-energization" or public safety power shutoff (PSPS) events.[20] In October 2019, 12 PSPS events took place in IOU territories. Each event affected between one to 38 counties and approximately 442 to 975,000 customers.[21] In all of 2020, there were 33 PSPS events in IOU territories. Additionally, historic heat storms in August 2020 caused energy supply shortages that led to two rotating power outages. One of these power outages affected more than 300,000 customers and lasted for approximately 150 minutes.[23]

Mitigating the adverse impacts of blackouts could be a driver for increased adoption of BTM electricity generation. During a power shutoff, most solar systems automatically power down to ensure the safety of repair crews and first responders. However, some systems have the ability to "island" themselves from the grid during outages and provide power. Many solar inverters are designed to continue operating during grid outages, such that solar systems can provide limited backup power. Backup power from solar systems during power outages can be extended beyond daylight hours when paired with a battery storage system. BTM diesel generators are most frequently used during power shutoffs and can provide backup power for as long as fuel is available to the customer.

At a larger scale, microgrids can provide backup power using BTM electricity generation by functioning essentially as a localized energy grid. By islanding from the traditional grid, microgrids can operate autonomously using local energy generation—potentially indefinitely depending on how they are fueled and managed. Many large university campuses, medical centers, military bases, and public safety operations already use microgrids.

In conjunction with the requirements of SB 1339, CPUC has begun crafting a policy framework to facilitate the commercialization of microgrids for distribution customers of large electrical corporations to maintain access to essential services during PSPS events and other outages. CEC's Electric Program Investment Charge (EPIC) program has invested $90 million in 39 microgrid projects to increase resiliency and drive down costs. EPIC research has shown that PSPS events are a major factor in California's increased interest in microgrids.[24]

One example of the growth of microgrids in California is a microgrid developed by the Blue Lake Rancheria tribe. Supported in part by CEC's EPIC program, the microgrid is a complex of solar panels, storage batteries, and distribution lines that can operate independently of the grid. During one of the worst PSPS events in October 2019 that cut power to more than 2 million people across Northern California, the Blue Lake Rancheria microgrid islanded itself and served the electricity needs of an estimated 10,000 people locally. The tribe's hotel, gas station, and mini-mart were able to provide services to the surrounding communities, which included taking in eight critically ill patients from the county Department of Health and Human Services.[25]

Blockchain and Growth of 'Prosumers'

Developed as the underlying technology that supports Bitcoin, blockchain has attracted attention for its potential in energy applications. A blockchain is a growing list of records stored digitally using cryptography, which is virtually impossible to modify while being transparently accessible to network users.[26] Some experts have argued that the development of blockchain technology could provide innovative peer-to-peer energy trading that will drive the growth of BTM electricity generation.[27] The primary reason for this thinking is the smart contract capabilities in blockchain, which are immutable, transparent, and tamper-proof.[28]

In addition to consuming BTM electricity, adopters could function as local energy producers by selling their electricity on energy marketplaces, becoming a "prosumer." Small prosumers typically have challenges accessing energy markets due to high associated costs; however, blockchain has the potential to decentralize these markets and provide access to prosumers through smart contracts and reduced transaction costs.[29] By enabling the growth of consumer-based energy trading marketplaces, technologies such as blockchain could provide a profit incentive to drive the adoption of BTM generation.

CALIFORNIA BTM GENERATION FORECAST

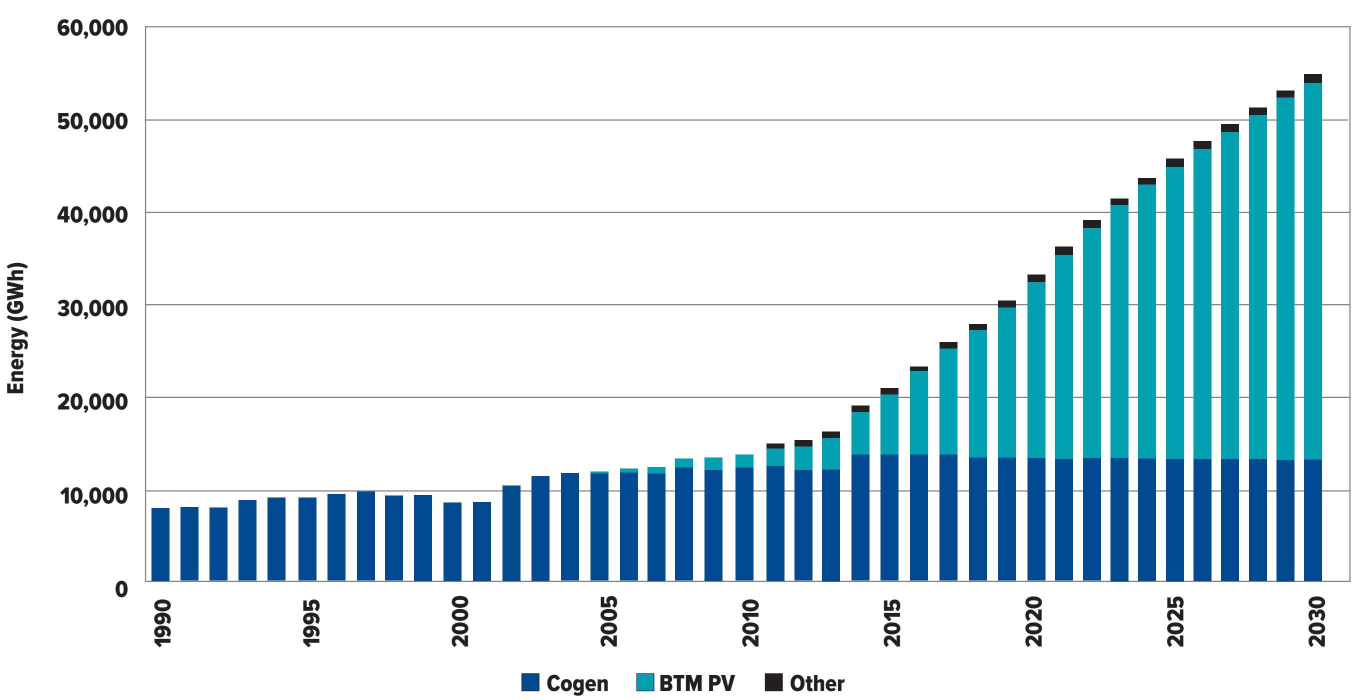
CEC forecasts electricity demand as part of the Integrated Energy Policy Report (IEPR) process. The forecast incorporates numerous variables that could impact electricity demand, such as the economy, population, electricity retail rates, energy efficiency, incentive programs, mandates, and climate change impacts.[30] The 2019 IEPR forecast also includes estimated electricity generation behind the meter.

Figure 1 shows CEC's estimates for electricity produced behind the meter between 1990 and 2030. As the figure shows, BTM solar PV is forecast to grow significantly between 2020 and 2030.

CEC estimates BTM generation from solar PV by using a formula that includes actual capacities of installed solar systems from interconnection data collected from utilities and estimated capacity factors.[31] An electricity generator's capacity factor is the ratio (or percentage) of its actual energy produced in a given period to the theoretical maximum possible. For example, consider a 1-kilowatt solar PV system capable of producing a kWh of electricity every hour, or 8,760 kWh in a year. If this system actually produces 876 kWh during a year, then its capacity factor would be 10 percent. CEC estimates capacity factors for solar PV by taking into account numerous factors, including geographic location, historical weather conditions, hours of sunlight, and actual electricity production measurements from a sample of PV solar systems statewide.[32]

Electricity produced by combined heat and power systems in CEC's forecast primarily is based on actual data as most BTM cogenerators are required to report their generation data to CEC in compliance with AB 1613 (Blakeslee), Chapter 713, Statutes of 2007. In 2018, at least 88 percent of BTM cogenerators used natural gas as their fuel source to generate electricity.[33]

Figure 1: CEC Forecast of BTM Generation in California



Source: California Energy Commission. Cogen = cogeneration, BTM PV = behind-the-meter photovoltaic.

BTM GENERATION IMPACTS ON STATE BUDGET REVENUE

Electricity Consumption Surcharge and Fee

CEC and CPUC both are funded primarily by a surcharge or fee on electricity consumption. The Energy Resources Surcharge Law levied a tax on the consumption of electrical energy purchased from a utility.[34] The surcharge is currently at its statutory cap of $0.0003 per kWh, and the law explicitly excludes electricity generated behind the meter if used on-site.[35] Revenue from this surcharge is transferred into the Energy Resources Program Account (ERPA) to provide funds for ongoing energy programs and projects, including CEC's operations.[36] In fiscal year 2020–21, the surcharge was estimated to generate about $63 million.[37]

CPUC has the authority to annually determine user fees, one of which is paid in part by electrical corporations regulated by CPUC to produce the authorized revenue required for its regulatory activities.[38] The 2020 electrical user fee is $0.0013 per kWh, and the revenue is deposited into the Public Utilities Commission Utilities Reimbursement Account (PUCURA), which is used to fund CPUC's operations.[39] The statutes authorizing PUCURA allow CPUC to assess a fee on electricity sold by an IOU to a customer.[40] Therefore, the CPUC electricity consumption user fee does not apply to electricity generated behind the meter because it is not sold and delivered by electrical corporations. In 2020, CPUC's electricity user fee was expected to generate about $218 million.

Budget Revenue Impacts From BTM Growth

The recent growth of electricity produced behind the meter, as shown in Figure 1, has had an impact on both the ERPA and PUCURA. As more electricity consumption moves to behind the meter, the base of electricity sales from utilities subject to the consumption surcharge and fee has been gradually reduced, resulting in a combination of revenue erosion and cost shifting.

Estimated Impact on ERPA

Since the surcharge funding ERPA is capped, BTM electricity generation likely has caused a small cost shift but more significantly has eroded revenue

available for ERPA since those sources of electricity are exempt from the surcharge. According to CEC, in 2017, BTM electricity generation reduced ERPA revenue by about $7.5 million, estimated to be about a 10 percent reduction in revenue.[41] The growth of BTM electricity generation, along with other factors, has contributed to ERPA being in a structural deficit.

Estimated Impact on PUCURA

While the ERPA surcharge is capped, the PUCURA electricity user fee is not, so the primary impact of the growth of BTM electricity generation on CPUC's revenue has been cost shifting. To compensate for eroded revenue from a smaller base of electricity sales from utilities, higher PUCURA rates are necessary to generate equivalent revenue needed for CPUC's regulatory activities. Table 3 contains cost shift estimates over the last five years for the PUCURA electricity user fee. As the table shows, the magnitude of the cost shift has increased slightly over the previous five years.

Similar Challenges in Other States

California is likely not the only state to experience revenue impacts from the growth of BTM electricity generation. Other states that have seen high adoption rates for rooftop solar PV also could be experiencing similar revenue impacts if their utility regulator and energy policy entity have funding mechanisms similar to CPUC and CEC. Specifically, any other state that has seen significant growth in BTM electricity generation—while at the same time generating revenue from a surcharge or fee on utility electricity sales—also are likely to experience similar challenges of revenue erosion and potential cost shifting.

Table 4 on the next page contains a summary of the top 10 states with rooftop solar capacity per capita as of November 2019.[43] The table lists the states in order from highest to lowest rooftop solar capacity per capita, provides the name of the utility regulator (similar to CPUC) and energy policy entity (similar to CEC), describes their authorized surcharge or fee if applicable, and identifies whether the entities could be experiencing a cost shift.[44] Any fee or assessment on utility electricity sales (consumption, income, or operating revenue) can assume to have revenue erosion for the entity as the growth of rooftop solar PV would decrease utility electricity sales. However, only uncapped assessments are likely to result in a full cost shift, as observed with PUCURA. Capped assessments likely will experience a limited cost shift up until the rate hits the cap. In contrast, fixed assessments are not assumed to experience a cost shift as the entity does not have the statutory authority to raise rates to compensate for eroded revenue.

Table 3: Estimated PUCURA Cost Shift Due to BTM Generation

Year	PUCURA Electricity Rate ($/kWh)	Estimated PUCURA Electricity Rate With BTM Included[42] ($/kWh)	Estimated Cost Shift Due to BTM ($/kWh)	Percentage of Rate Due to Cost Shift
2020	0.0013	0.00111	0.00019	14%
2019	0.00058	0.00051	0.00007	12%
2018	0.00046	0.00041	0.00005	11%
2017	0.00043	0.00038	0.00005	11%
2016	0.00033	0.00030	0.00003	9%

Table 4: Summary of Assessments for States With High Levels of Rooftop Solar

State	Energy Entity	Entity Purpose	Surcharge or Fee Description	Possible Cost Shift?
Hawaii	Hawaii Public Utilities Commission	Utility Regulator	Fixed fee on utility's gross income	No
	Hawaii State Energy Office	Energy Policy	Fixed tax on petroleum	No
Massachusetts	Massachusetts Department of Public Utilities	Utility Regulator	Capped fee on utility's operating revenue	Yes–Limited
	Massachusetts Department of Energy Resources	Energy Policy	Capped assessment on nonmunicipally owned utilities	Yes–Limited
California	California Public Utilities Commission	Utility Regulator	Uncapped fee on utility's electricity sales	Yes
	California Energy Commission	Energy Policy	Capped surcharge on electricity consumption	Yes—Limited
Arizona	Arizona Corporation Commission	Utility Regulator and Energy Policy	Capped fee on utility's gross operating revenue	Yes—Limited
Vermont	Vermont Public Utility Commission	Utility Regulator	Fixed tax on utility's gross operating revenue	No
	Vermont Department of Public Services–Planning and Energy Resources Division	Energy Policy	Fixed tax on utility's gross operating revenue	No
New Jersey	New Jersey Board of Public Utilities	Utility Regulator and Energy Policy	Capped fee on utility's gross operating revenue	Yes—Limited
Connecticut	Connecticut Public Utilities Regulatory Authority	Utility Regulator	Uncapped assessment on utility's gross revenue	Yes
	Connecticut Department of Energy and Environmental Protection	Energy Policy	Uncapped assessment on utility's gross revenue	Yes
Nevada	Public Utilities Commission of Nevada	Utility Regulator	Capped assessment on utility's gross operating revenue	Yes—Limited
	Nevada Governor's Office of Energy	Energy Policy	No fees	No
Rhode Island	Rhode Island Public Utilities Commission	Utility Regulator	Uncapped assessment on utility's gross operating revenue	Yes
	Rhode Island Office of Energy Resources	Energy Policy	No fees	No
Maryland	Maryland Public Service Commission	Utility Regulator	Capped assessment on utility's gross operating revenue	Yes—Limited
	Maryland Energy Administration	Energy Policy	No fees	No

LEGISLATIVE CONSIDERATIONS

Revenue Impacts From BTM Generation Likely Will Accelerate

The revenue erosion for ERPA and the resulting cost shift for PUCURA likely will not only continue but also accelerate as BTM electricity generation becomes a more substantial part of total electricity consumption over time. Figure 2 shows the proportion of total electricity consumption forecast to be consumed behind the meter between 2015 and 2030. In 2015, electricity consumed behind the meter was estimated at about 7 percent of the total electricity consumed, while that proportion is forecast to increase to a little more than 17 percent in 2030.

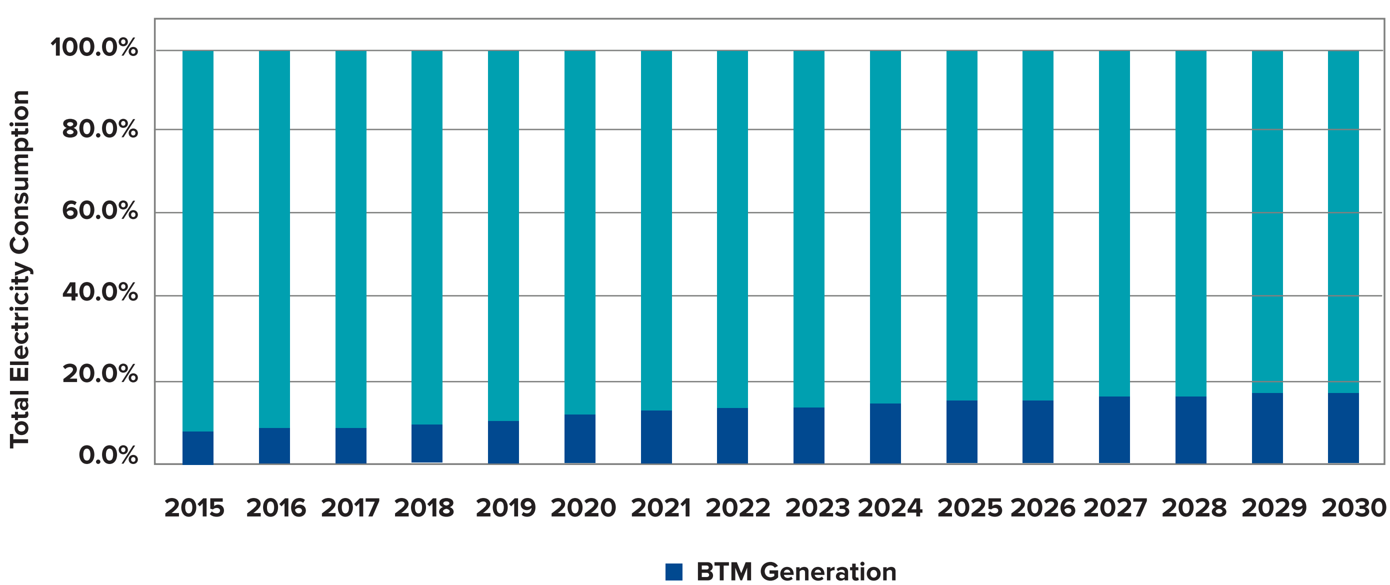
BTM Generation Creates Equity Concerns by Shifting Cost Burdens

As shown in Table 3, when BTM electricity consumers avoid paying the consumption surcharge or fee for electricity sold by electrical corporations, the costs shift into higher electricity rates paid mostly by the remaining utility customers. This can be considered a multilayered perverse cost shift as ratepayers typically fund financial incentive programs that support BTM generation such as Go Solar California and the Self-Generation Incentive Program. In turn, research has shown that some of the benefits of these incentive programs, particularly those supporting residential rooftop solar, have largely accrued to higher-consuming and higher-income customers.[46] This leaves the higher consumption rates to be absorbed by the smaller remaining pool with a higher proportion of lower- to middle-income utility customers.

Options for Imposing BTM Generation Surcharges

If the Legislature is interested in including BTM generation in the state's surcharge and fee, there are a few options with various trade-offs and issues to consider. CEC already collects generation data on most electricity produced by BTM cogenerators and could assess a charge on the reported data. The major challenge is imposing a surcharge or fee on electricity generated from BTM solar PV. Options for imposing assessments on BTM generation from solar PV range from a simple fixed fee to using estimation formulas or meters to measure electricity generation, each containing their own trade-offs.

Figure 2: Forecast BTM Generation as a Proportion of Total Electricity Consumption[45]



Fixed Fee

The most administratively simple and least costly option for imposing a BTM generation assessment would be a fixed fee. The flat fee could be based off the average amount paid by each household without estimating BTM electricity generation from solar PV. For example, in 2017, CEC estimated the ERPA surcharge cost the average household about $2 annually, and this method could be used to set a flat fee on households consuming electricity behind the meter.[47] One trade-off for this approach is accuracy as essentially all households consuming electricity from BTM solar PV would be charged the same fee regardless of actual electricity consumption. Another trade-off would be equity concerns, as fixed fees are considered regressive because they take a larger percentage of income from low-income households than from higher-income ones.

Estimation Formulas

A surcharge or fee on BTM electricity consumption could be imposed more accurately than a fixed fee by estimating the amount of BTM electricity generated from solar PV. CEC currently uses a formula to estimate BTM electricity generation from solar PV for the electricity demand forecast in its IEPR process. A similar formula that could be used to calculate BTM solar PV generation consumed on-site is:

> *Electricity Consumed On-Site = (Capacity Factor x Capacity x 8,760)—(Exports)*

where *Exports* is a known quantity of BTM electricity generated from solar PV that is exported back to the grid, *8,760* are the number of hours in a year, *Capacity* is the known capacity of installed solar systems, and the *Capacity Factor* is estimated as previously discussed.[48] This formula estimates the amount of BTM electricity consumed by subtracting the exports from a solar PV system from its estimated annual generation.

The main trade-off with using this estimation formula is the uncertainty within the estimated capacity factors. CEC has estimated a range of capacity factors specific to 20 regions within California and could use a regionally specific capacity factor for households consuming BTM electricity generated from solar PV.[49] However, although using these estimates would be a significant improvement in accuracy over imposing a fixed fee, these estimates still do not represent actual electricity production. The estimated regional capacity factors throughout the state typically range from about 17 percent to 20 percent. Given that the ranges of these estimates are accurate, choosing the midpoint within the range of each estimated regional capacity factor likely would keep accuracy within +/- 10 percent.

Revenue-Grade Meters

The most accurate but also costly option to impose an assessment on BTM electricity generation from solar PV is to meter the actual production from the installed system. While a BTM system means electricity can be used on-site without passing through a utility-owned meter, there are numerous options for metering generation behind the utility-owned meter. In fact, many solar PV systems already have some type of metering capability available to the owner.

To assess a fee or comply with a state program, a meter specified as being revenue-grade typically is recommended or required. Revenue-grade meters (RGMs) are accurate to within +/- 2 percent and offer many technical options from which to choose. Basic RGMs require the meter to be read by a person physically standing in front of the meter, while remote RGMs have "smart" communication capabilities of accessing data remotely. RGMs also can contain numerous technological upgrades, such as improved accuracy and providing real-time data. Basic RGMs typically cost about $100, while remote RGMs can cost more than $1,000, depending on what technological upgrades are included. Installation costs for external stand-alone BTM RGMs could reach $1,000.

Solar PV systems in California that participate in Net Energy Metering (NEM) are required to have an approved solar inverter. The vast majority (about 97 percent of systems interconnected to the grid) of California's BTM solar PV capacity in the large IOU territories is enrolled in NEM.[50] A solar inverter converts the output of a PV solar panel into a current that can be fed into the electrical grid. Some solar inverters have built-in RGMs, while others have lower-quality meters or none at all. CEC maintains a list of approved inverters for NEM participants that includes inverters, both with and without built-in RGMs.[51] According to CEC, all eligible inverters for the next iteration of NEM will have built-in basic RGMs; however, this will apply only to rooftop solar in IOU territories and not for those in publicly owned utility areas.

In addition to the meter costs, assessing a surcharge or fee on a metered solar PV system likely will have administrative challenges. Remote RGMs would be the most straightforward option for assessing a fee as the data could be sent over a communication network to be accessed remotely. Other options could include physically inspecting a basic RGM or requiring the owners of PV solar systems to self-report their generation data from a basic RGM to an entity such as CEC. Any one of these options could present privacy concerns as the BTM meter is considered private property rather than utility-owned property.

In addition to metering solar PV to impose a consumption surcharge or fee, requiring BTM solar PV to be metered could have significant statewide co-benefits to consider, including:

> **Improving CEC's Demand Forecast.** CEC's forecasts are important for numerous statewide planning processes, including CPUC's integrated resource planning process and the California Independent System Operator's transmission planning process.[52] Rather than estimating BTM electricity generation from solar PV as CEC currently does, having actual data would significantly improve the accuracy of CEC's forecasts. Accurately accounting for solar PV generation will become more important in planning processes as electricity generation from these sources continues to grow in the future.

> **Grid Management Benefits.** Distributed energy resources such as BTM solar PV present challenges for traditional distribution systems and grid management due to their variable and non-dispatchable nature that lacks visibility and monitoring.[53] Historical planning and operation practices for the traditional distribution system likely will need to be reassessed as BTM generation continues to grow. Data from RGMs can be beneficial for these necessary planning processes and also can work with smart inverters to provide immediate grid support functions.

> **Consumer Awareness.** While some solar inverters provide metered data for the solar PV system owner, that data does not provide information about how the production efficiency of their solar panels compares with others. In general, customers are unaware of how the actual productivity of solar panels made by different manufacturers compares with one another. Collecting actual production data from solar PV systems across the state could provide significant consumer awareness benefits by allowing a comparison of the efficiency of solar panels produced by different manufacturers.

Inflationary Erosion of Fixed Charges

Over time, the value of a dollar erodes due to inflation and therefore decreases its purchasing power as goods and services become more expensive. One way to ensure a fixed or capped surcharge or fee can fund the same level of operations and activities of a state agency over time is to tie that surcharge with an inflationary measure such as the consumer price index. For example, the ERPA surcharge was originally set at $0.0001 per kWh in 1974 for CEC to conduct its operations. Table 5 shows the inflation-adjusted ERPA rate in January 2020, which would allow that surcharge to have the same purchasing power for CEC to support the same level of operations as it did in 1974.

Table 5: ERPA Surcharge Adjusted for Inflation

Original ERPA Surcharge ($/kWh)	Current ERPA Surcharge ($/kWh)	Inflation Adjusted ERPA Surcharge ($/kWh)[54]
0.0001	0.0003	0.00055

ENDNOTES

1 California Public Utilities Commission, "2019 California Solar Initiative," annual program assessment, https://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/Utilities_and_Industries/Energy/Energy_Programs/Demand_Side_Management/2019-CSI-APA.pdf.

2 Public Utilities Code §399.15(b).

3 While the Self-Generation Incentive Program in the past has funded all of these technologies, and to a limited extent continues to provide funding for these technologies, the vast majority of current funding and support has gone to energy storage projects.

4 Public Utilities Code §2827.

5 Section 150.1(b)1 of Title 24, California Code of Regulations, Part 6.

6 Established by California Public Utilities Commission Decision 12–05–037.

7 AB 109 (Ting, Budget Act of 2017), Chapter 249, Statutes of 2017, and SB 856 (Senate Budget and Fiscal Review Committee), Chapter 30, Statutes of 2018.

8 SB 96 (Senate Budget and Fiscal Review Committee), Chapter 356, Statutes of 2013.

9 Established under the California Air Resources Board's California Climate Investments.

10 Public Resources Code §§25410–25422.

11 Galen Barbose and N. Darghouth, "Tracking the Sun: Pricing and Design Trends for Distributed Photovoltaic Systems in the United States," Lawrence Berkeley National Laboratory, October 2019, https://emp.lbl.gov/sites/default/files/tracking_the_sun_2019_report.pdf.

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Paul Jacobs at the California Senate Office of Research (SOR) prepared this report at the request of Sen. Bob Wieckowski, chair of the Senate Budget and Fiscal Review Subcommittee 2 on Resources, Environmental Protection and Energy. The California Senate Office of Research is a nonpartisan office charged with serving the research needs of the California State Senate and assisting Senate members and committees with the development of effective public policy. The office was established by the Senate Rules Committee in 1969. For more information, please visit **http://sor.senate.ca.gov** or call **(916) 651-1500**.