Frequently Asked Questions
2019 Building Energy Efficiency Standards

Question Topics

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Question 1: On the average, the new PV requirements will add about $8,400 to the cost of a single-family home. Wouldn't that make homeownership less affordable at a time where California's home prices are already out of reach?

Answer: No. A home with solar costs less to own than one without. Put another way, the benefits of solar outweigh its costs, such that the new homeowner is saving money from day one in the home. That family will save thousands of dollars over the first decade of ownership.

Home affordability includes both the first cost and operating costs, which include utility bills. The PV requirement actually makes homeownership more affordable: the reduction in energy bills exceeds the corresponding increase in mortgage payment by around $35 per month on average.

If first cost is a primary concern – as it is for many including young families and first-time home buyers – the cost of PV need not be covered by the home price or mortgage principal. PV options are already today routinely leased instead of purchased outright. Leased PV systems have little or no upfront costs, and offer up to 20 percent electric bill savings; thus the same logic as above applies. In the future, community-shared solar options may also be available as an alternative to onsite PV systems, with little or no upfront costs.

Question 2: What is the basis for the Energy Commission's $3.10 photovoltaic (PV) installed cost by 2020, and what is the evidence that the PV prices are continuing to drop?

Answer: The Energy Commission used three sources to establish the cost for newly constructed residential PV system installations. The primary source of cost information was the National Renewable Energy Laboratory (NREL) report titled *U.S. Solar Photovoltaic System Cost Benchmark: Q1 2017*. NREL estimated an installation cost of $2.80 in Q1 2017. The complete report is located at: https://www.nrel.gov/docs/fy17osti/68925.pdf.

To corroborate these cost estimates, the Energy Commission also examined cost data from the Solar Energy Industries Association (SEIA). SEIA data track installed PV costs in all 50 states, including California. SEIA estimated an installation cost of $2.94 in Q4 2017.

Finally, the Energy Commission considered the California New Solar Home Partnership (NSHP) program data, which include thousands of California new construction installations since 2015. The table below summarizes the findings based on the most recent NSHP data.

2015-2018 NSHP PV Installation Costs for New Buildings

Year	Number of Systems Installed	Median PV Size, kilowatt (kW)	Average PV Size, kW	Median Cost/Watt	% Reduction, Median	Average Cost/Watt	% Reduction, Average
2015	7,150	2.6	3.0	$4.85	0%	$4.82	0%
2016	5,924	2.7	3.3	$4.31	11%	$4.30	11%
2017	7,973	2.7	3.2	$3.58	26%	$3.98	17%
2018	2,922	2.7	2.9	$3.00	38%	$3.66	24%

The NSHP data also indicate that the downward trend for PV prices is continuing at a strong pace through mid-2018. These data also show that the Energy Commission's assumed $3-per-watt average for the installed cost of PV systems in newly constructed buildings is in keeping with the current PV price trends.

The Energy Commission projections are conservative. The PV requirement will remove many of the "soft costs" of the PV market, such as customer acquisition costs and customer-specific design, which can be significant. Bulk equipment procurement and factory-like installation (similar to windows and roofing) in a "production build" housing development are highly likely to reduce costs to well below Commission estimates by 2020.

Question 3: Did the Energy Commission's PV cost-effectiveness study consider the system maintenance costs and replacement costs for inverters and battery storage systems?

Answer: Yes, the Energy Commission included maintenance and inverter replacement costs in its life-cycle costing analysis. PV panels do not require much maintenance; however, the Commission assumed $0.02 per kilowatt-hour (kWh) for maintenance cost and assumed two inverter replacements at the beginning of years 11 and 21. The present value of these costs were added to the upfront cost of the PV system, yielding a total system present value of $3.10 per watt for 2020.

The Energy Commission did not consider battery storage replacement costs because these devices are not prescriptive requirements and are optional under the 2019 Standards.

Question 4: The 2019 PV requirements are often referred to as the "PV mandate." Is this requirement truly a mandate?

Answer: The word "mandate" does not precisely describe the 2019 Standards PV requirement, as it implies a rigid and inflexible set of requirements. Builder and homeowner choice and flexibility are essential parts of the building energy efficiency standards approach. Builders can use more energy efficiency, demand-responsive measures, thermal storage, and battery storage technologies to reduce the PV size by 40 percent or more, while maximizing the benefits to the homeowners, the grid, and the environment. If first costs are the main concern, PV lease arrangements with little or no upfront cost may be used to comply with the energy standards PV requirements. In the future, when approved by the Energy Commission, community-shared solar options may be an alternative to onsite PV systems. Exceptions to the PV requirement exist for specific instances in which a house may be built in an area of insufficient solar availability or where electricity rates are uncommonly low.

Question 5: The larger utility-scale PV systems cost about half as much as onsite PV systems. Would it be more cost-effective to achieve the state's policy goals with the less expensive utility-scale PV systems?

Answer: The state is pursuing a diverse set of energy and environmental policies to simultaneously save energy and reduce greenhouse gas emissions, including:

- Reducing greenhouse gas emissions from all sectors, including buildings and transportation.
- Maintaining grid reliability and resilience.
- Achieving cost-effective energy savings in buildings.

To achieve these policy goals, the state must use all available options, including utility-scale and onsite PV systems. These approaches are complementary and not mutually exclusive. Both options reduce carbon dioxide (CO2) emissions, and present unique opportunities, challenges, and environmental benefits:

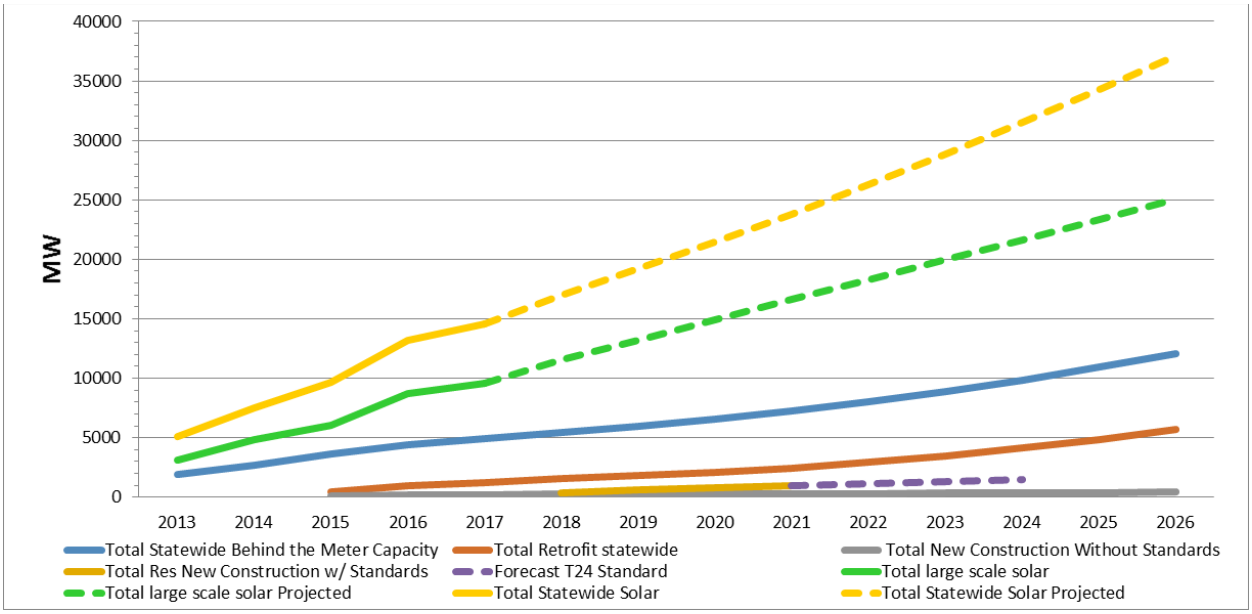
- **Utility-scale PV systems** may be up to 500 megawatts (MW) or larger. The benefits include installed equipment costs that are less expensive per watt ($1.05 to $1.20 per watt) than an onsite rooftop system, and reduced system-wide CO2 emissions. The challenges include acquiring large plots of land, long transmission, distribution, and transformer infrastructure; and time consuming, and expensive environmental impact reports. The systems can also negatively impact sensitive wildlife habitats. It is important to include all costs and challenges when comparing a utility-scale PV system to onsite solar.

- **Onsite or rooftop PV systems** are generally only a few kW. The installed equipment costs are around $3 per watt. The benefits of these systems are that they do contribute to CO2 reduction from building loads, they do not require land acquisition (the roof is existing and available for PV deployment at no additional cost) or additional transmission and distribution infrastructure because the system is close to the load it serves. As part of a local distributed energy resource (DER) system and because of the proximity to the loads it serves, an onsite PV system, once coupled with smart inverters, demand response, and a battery storage system, can enhance grid reliability and resilience. The benefits of a DER system include providing ancillary services (frequency and voltage regulation) and improved reliability during grid failures, natural disasters, and wildfires. Further, the distributed nature of small generation systems reduces the grid's overall vulnerability to cyberattacks. Onsite efficiency and PV systems allow building occupants to save each month on their utility bills, making home ownership more affordable.

Importantly, the 2019 Standards allow community-scale PV as an alternative renewable resource to onsite PV systems, when approved by the Energy Commission. Community-scale PV systems can range from a few kW to a few MW. The equipment costs for these systems are even lower than rooftop, in the $2-per-watt range. Plans for community solar may face unique barriers such as limitations of the compensation model. Some community solar options may also require land acquisition, and distribution infrastructure development.

Question 6: Would the 2019 Standards PV requirement create or exacerbate a market where California has too much solar capacity on mild and sunny days?

Answer: The expected increase in PV installations due to the 2019 Standards PV requirement is equal to only 1.1 percent of total existing statewide PV capacity. The other 98.9 percent of the PV capacity installed in the state–including utility-scale PV systems, nonresidential buildings installations, and PV installed on existing homes–is unaffected by the new requirements. Further, because the rate of growth for utility-scale and voluntary, behind-the-meter capacities is steeper than the residential new construction rate, residential new construction will make up a smaller percentage of total statewide PV capacity in the future.



Moreover, the 2019 Standards require PV systems sized to offset just the annual electricity consumption of a highly efficient dual-fuel home. The result is a modest PV size (2.8 kW for a typical single-family house) when compared to the average PV size installed on existing homes (about 7.2 kW for a typical single-family home). PV for existing homes is unaffected by the 2019 Standards. Overgeneration that causes a homeowner to sell electricity back to the grid is discouraged by both net energy metering rules and by the 2019 Standards.

The 2019 Standards include compliance incentives for demand response and grid-harmonization measures, such as precooling[1], thermal storage, and battery storage systems. These complementary technologies maximize self-utilization[2] of PV electricity generated onsite and minimize hourly exports back to the grid, and as they come into common use, they will benefit distribution systems and enhance local reliability.

Question 7: The Energy Commission assumed an average statewide residential retail rate of 18 cents per kWh to calculate the monthly energy bill savings of $80. What assumptions did the Energy Commission make to reach this number?

Answer: The Energy Commission conservatively chose 18 cents per kWh by considering the residential rates of several utilities, including Pacific Gas & Electric (PG&E), Southern California Edison (SCE), San Diego Gas & Electric (SDG&E), and Los Angeles Department of Water and Power (LADWP). Together, these utilities cover about 90 percent of the state's ratepayers. The following table summarizes these rates for each utility.

[1] *Precooling* is the practice of cooling the house by 3 to 5 degrees in early afternoon when the electricity rates are relatively low and then turning off the air conditioning between 4 and 9 p.m., when the electricity rates are highest. This practice saves money for the building occupants and results in lower CO2 emissions from the grid.
[2] *Self-utilization* refers to the practice of using demand response and battery storage strategies to maximize using the PV output to serve the house loads, rather than exporting the electricity back to the grid; this practice harmonizes the PV system with the grid.

2018 Residential Flat Rates. Cents per kWh

Tier	PG&E - Schedule E1, EM	SCE - Schedule D	SDG&E - Summer, Schedule DR	LADWP - June, Schedule R1
Base	21.1	17.5	27	15.5
Mid-Tier	27.9	24.7	47	19.6
High-Tier	43.3	34.5	55	26.4
Average	**25.3**	**20.9**	**33.5**	**17.7**

Given these data, it appears that the Energy Commission's estimate of statewide average electricity cost of 18 cents/kWh is on the low side. If the actual rates are higher than 18 cents per kWh, then savings will be even greater for the utility customer.

Question 8: Why did the Energy Commission use a lifespan of 30 years for PV panels instead of 25 years?

Answer: The National Renewable Energy Laboratory (NREL), SunPower, Solar City, and other manufacturers support a 30-year or longer lifespan for PV panels. Although most panel warranties through the manufacturers are 20 to 25 years, the expected lifespan is longer. A warranty and the lifespan of a panel are not the same thing.

Question 9: How did the Energy Commission calculate the emissions reduction benefits of the 2019 Standards and the PV requirements? Did Energy Commission consider the impact of midday "renewable curtailment" on CO2 emissions? California's long-term policies require the energy grid to use more renewable resources, essentially making the grid greener. Do the new onsite PV requirements reduce CO2 emissions despite these policies?

Answer: Yes. The Energy Commission uses a detailed hourly simulation model, known as CBECC-Res, to determine energy savings and emission impacts of the 2019 Standards. For every hour of the year, the software tracks all house loads (HVAC, water heating, plug loads, appliances, lighting, and so forth) and PV generation. Based on these hourly calculations, the software calculates PV-generated kWh that serve the house loads (which reduces the kWh that is purchased from the grid), and the hourly exports back to the grid. Next, the software applies California hourly long-term marginal emission rates[3] to the hourly kWh balances to calculate the CO2 generation impact for each hour of the year. Finally, the software adds all the hourly results to yield the annual CO2 reduction benefits.

Overabundance of PV resources can occasionally cause the grid operators to "curtail renewables" midday on some mild and sunny days; the California long-term marginal emission rates consider the impacts of "renewable curtailment" on the grid.

The 2019 Standards PV requirements will reduce building-based CO2 emissions significantly, even considering the Renewables Portfolio Standard (RPS) goal of 50 percent by 2020 for

[3] *Long-term marginal emission rates* represent the change in CO2 emissions for a group of generating resources relating to a unit change in electricity load (a kWh or MWh), where long-term structural changes in the electric infrastructure are characterized in the simulation model.

California grid, as indicated in the table below. Over the longer term, the PV requirement will help California reach the newly-established 100 percent clean energy goal.

Prototype home: 2,700 sf, Climate Zone 12 – Sacramento, CA

CO2 Impact of Housing Choices		**Metric Tons of CO2 Generated/Year**
Mixed-fuel	1997 Standards, no PV	**6.5**
Mixed-fuel	2019 Standards, no PV	**3.1**
Mixed-fuel	2019 Standards, with 3.1 kW PV	**2.3**
All-electric	2019 Standards, 3.1 kW PV, no battery	**1.1**
All-electric	2019 Standards, 6 kW PV, with battery	**0.2**

During the three-year cycle of the 2019 Residential Standards, CO2 emissions will be reduced by 700,000 metric tons, equivalent to taking 115,000 18-miles-per-gallon gas cars off the roads.

Further, the 2019 Standards compliance incentives for demand response and grid harmonization measures, such as precooling, thermal storage, and battery storage systems, can make the house invisible to the grid during most hours of the day, resulting in little or no CO2 emissions.

Question 10: The Energy Commission used only the current net energy metering, known as NEM2, rules to determine cost effectiveness for the onsite PV systems. NEM2 will be up for review by the California Public Utilities Commission (CPUC) in 2019. Did the Energy Commission consider alternatives to the current NEM2 policy?

Answer: Yes, the Energy Commission examined three net energy metering scenarios: (1) the current NEM 2.0 systems; (2) an alternative that significantly reduces bill savings for PV hourly exports to the grid (avoided cost instead of retail cost); and (3) a case where all generation is credited only with avoided costs – a highly unlikely scenario. Under the first two scenarios, all systems were cost effective by large margins. Under the third scenario, PV passed the cost test in 5 of 16 climate zones and narrowly failed in the others.

Question 11: When batteries are used, there is a loss of electricity associated with the roundtrip charge and discharge, resulting in fewer generated kWh. Why does the Commission provide a compliance credit for a battery storage system that is coupled with a PV system if there is a loss of energy?

Answer: Battery storage systems store the PV generated electricity in the middle of the day when solar resources are generally plentiful and electricity prices are low. The system discharges the stored electricity later in the day, during peak hours when solar resources are diminished and electricity prices are high. Battery storage systems have a roundtrip charge and discharge loss of 5 to 15 percent, depending on the type of battery technology and the inverter efficiencies. A compliance credit is available because the electricity price differential between the middle of the day and peak hours is greater than the battery charge and discharge losses. This means that even with the relatively small loss of electricity, it is still cost effective for a

consumer to store electricity generated onsite around midday and use it later on instead of purchasing additional electricity from the grid.

To calculate the compliance credit of a battery storage system coupled with a PV system, the Energy Commission's compliance software on an hourly-basis accounts for the PV generation, losses, storage capacity remaining, charge and discharge rates, cost of electricity, house loads, and hourly exports. Similar calculations are also performed to calculate the benefits of storage for CO2 emissions.

Not all battery storage systems are eligible for compliance credit; the system must comply with the requirements of Reference Joint Appendix 12 (See References). These requirements ensure that the battery storage system operates in a way that allows residents to take advantage of variable electricity costs associated with periods of clean energy availability throughout the day. Static batteries that remain mostly in backup mode have little to no value to the homeowner, the grid, or the environment.

Question 12: Did the Energy Commission receive any stakeholder input on these requirements? Were stakeholders aware of the Energy Commission's proposal?

Answer: Zero-net-energy goals have been part of California's *Energy Efficiency Strategic Plan*[4] since 2008; the 2013, 2016, and 2019 updates to Part 6 have consistently and transparently worked toward these goals. The 2019 rulemaking was preceded by 10 utility-hosted and 14 Energy Commission-hosted workshops and public hearings over 15 months. Hundreds of participants provided thousands of comments, to each of which the Energy Commission responded during the 2019 rulemaking process. Participants included California Building Industry Association (CBIA), Solar Energy Industries Association (SEIA), California Energy Storage Alliance (CESA), Bay Area Regional Energy Network (BayREN) representing local jurisdictions, investor-owned utilities, municipal utilities, community-shared solar and renewables advocates, environmental advocates, solar PV and battery storage manufacturers, the California Public Utilities Commission (CPUC), the California Air Resources Board (CARB), and members of the public, among others. All events were publicly noticed weeks in advance, and relevant information was emailed to thousands of subscribers on the Energy Commission's Building Standards listserv.

[4] http://www.cpuc.ca.gov/General.aspx?id=4125

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California New Solar Home Partnership Program (NSHP) 2015-2018 Data:
https://www.newsolarhomes.org/WebPages/Public/Reports.aspx

Energy Commission Energy Efficiency Listservs - Self-Subscribing/Unsubscribing:
https://www.energy.ca.gov/efficiency/listservers.html

Pacific Gas & Electric 2018 Residential Rates:
https://www.pge.com/tariffs/electric.shtml

Southern California Edison 2018 Residential Rates:
https://www.sce.com/wps/portal/home/residential/rates/Standard-Residential-Rate-Plan

San Diego Gas & Electric 2018 Residential Rates:
https://www.sdge.com/total-electric-rates

Los Angeles Department of Water and Power 2018 Residential Rates:
https://www.ladwp.com/ladwp/faces/wcnav_externalId/a-fr-elecrate-schel

SMUD 2018 Residential Rates:
https://www.smud.org/en/Rate-Information/Residential-rates

2019 CBECC-Res, Residential Building Simulation Software:
http://www.bwilcox.com/BEES/BEES.html

2019 Reference Appendices – JA11, JA12, and Others:
http://www.energy.ca.gov/title24/2019standards/rulemaking/documents/2018-05-09_hearing/2019_Reference_Appendices.php

California Public Utilities Commission (CPUC) Energy Efficiency Strategic Plan:
http://www.cpuc.ca.gov/General.aspx?id=4125