

# Rooftop Solar and Energy Storage

*A Review of Existing Statutes, Proceedings,  
Initiatives and Issues in California*

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# 1 Introduction

This report is funded by the Department of Energy Rooftop Solar Challenge Program. California's Rooftop Solar Challenge program, called the Golden State Solar Impact, supports the goals of the Department of Energy (DOE) Solar Energy Technologies Program and the SunShot Initiative, which seek to make solar electricity cost competitive without subsidies by the end of the decade by seeking to address and lower system costs for photovoltaics (PV). The Center for Sustainable Energy (CSE) is working as part of a statewide team to encourage market transformation through expanding financing options for residential and commercial customers, streamlining permitting processes, and standardizing net metering and interconnection standards across investor-owned and municipally owned utilities in the region. The project goals are supported by cross-jurisdictional collaboration and information sharing.

## 1.1 About this Report

This report focuses on the deployment of energy storage systems with rooftop solar PV panels. While it addresses the many applications of energy storage at all levels of the grid to provide information on current and potential deployments of this technology, the emphasis is on behind-the-meter applications of energy storage and PV. The report also focuses on the major statutory, regulatory, and policy drivers behind the deployment of energy storage systems in California. Behind-the-meter applications of energy storage are expected to continue to grow in California as the price of systems decreases and as major installers bundle PV and storage systems together, creating the market for these types of consumer energy applications.

The report will provide the reader with necessary background information on energy storage systems in terms of their use and some of the technologies involved in Section 2. The report then focuses on the state statutory and regulatory framework driving applications of energy storage and PV behind-the-meter and at the distribution grid level in Section 3. These sections draw the reader's attention to procurement, distribution planning, incentives, interconnection, and rate structures shaping energy storage. The report next addresses permitting, inspection, and safety before concluding with information on the wholesale bulk energy market in Section 3.2. Federal Energy Regulatory Commission (FERC) orders as well as existing or pending California Independent System Operator (CAISO) actions and related California Public Utilities Commission (CPUC) proceedings are included in Section 4 because large individual PV and energy storage systems as well as the aggregation of large numbers of smaller systems will be allowed to participate in the wholesale bulk electric market and transmission system under CAISO's current [Energy Storage and Distributed Energy Resource Initiative](#). This initiative resulted in approval of the [Energy Storage and Distributed Energy Resources \(ESDER\) Stakeholder Initiative Revised Draft Proposal](#), and corresponded with the approval of the [Expanded Metering and Telemetry Options Phase 2 for Distributed Energy Resource Providers](#) rule. The reader can also link to the Current [Supplement](#) and proposed tariff to the Expanded Metering and Telemetry Options from the [stakeholder webpage](#).

Finally, the reader should keep in mind that energy storage is an evolving multi-dimension technology with broad, interrelated applications across regulatory, market, and policy areas. The regulations and market signals for energy storage continue to evolve with the growing number of installations and changing needs of the grid. This will remain an ever-changing area for years to come.

## 1.2 Glossary of Terms

**Behind-the-Meter:** This refers to systems that are on the customer side of the meter as opposed to the utility side of the meter. Often, behind-the-meter systems serve the on-site load of the property owner.

**Demand Charge:** A charge based on the maximum load (expressed in kilowatts, or kW) placed on the utilities system by a customer's equipment at any interval during the billing period.

**Demand Response:** The ability of an individual electric customer to reduce or shift usage or demand in response to a financial incentive or reliability need.

**Dispatch:** A broadcast signaling the initiation of a control strategy or price adjustment.

**Fixed Charges:** monthly charge (e.g., \$5/month) applicable to all customers regardless of usage intended to reflect costs that do not change with usage and are necessary to ensure constant availability of service.

**Net-Energy Metering:** A billing mechanism that credits solar energy system owners for the electricity they add to the grid.

**Time-Of-Use Rate:** Retail rate structures that set different prices for electricity based on demand and supply throughout the day.

**Use Case:** Categorization of customer or market needs and uses to distinguish how storage systems may be used at the wholesale and retail level.

**Volumetric Charges:** Charges: per kWh charges based on electricity usage during the billing cycle (e.g., \$0.15/kWh) intended to reflect costs that change with usage (e.g., variable generation charges), but typically includes generation, distribution, transmission, and public purpose program costs.

## 2 Background on Energy Storage and Rooftop Solar PV in California

Combining rooftop solar PV with energy storage systems is part of a larger trend of developing end user capacity, distribution system resources and flexibility, and wholesale transmission market opportunities. The use of storage systems moves electricity from a service to a storable commodity, which fundamentally changes how individual end-users can interact with the electric grid as well as how system operators can manage the grid. Many commercial, industrial, and agricultural ratepayers currently have the most viable use cases for storage systems because time-of-use (TOU) rates and demand charges<sup>1</sup> provide a clear market signal to use stored power for onsite loads to offset electric use from the grid as well as the potential opportunity to sell stored power to the grid subject to present retail and wholesale market rules. Residential ratepayers are not presently subject to default TOU rates (TOU rates will be phased in by 2019 for all residential customers) and largely use storage for emergency back-up purposes. However, energy storage systems combined with PV can provide power quality and reliability services (See Section 2) for all PV systems regardless of whether the system is six kilowatts

(kW) or one megawatt (MW) or more. This allows a system owner to manage the variability of its PV system output in a way that avoids production spikes or drops that create voltage, frequency, power factor, or harmonic issues on the distribution grid or with onsite equipment.

The use of rooftop solar PV with storage systems is a small but growing part of the energy sector. Most, if not all, energy storage systems previously paired with solar PV were installed by the system owner with the intent of disconnecting from the distribution grid. However, energy policy has shifted its focus to creating a viable and affordable energy storage system marketplace that seeks to provide benefits to storage system owners and the electric grid at the distribution and transmission levels. The shift ranges in effect from discussions of rate reform, statutorily mandated storage procurement, state incentive programs, regulatory rule development and implementation, and technology research and development.

This report will look at these developments to help readers understand the goals, issues, and opportunities of rooftop solar PV and energy storage systems.

## 2.1 Energy Storage Defined

At any point in time, electric generation must equal consumption unless there is a means of storing the energy. Storage offers the ability to preserve electricity generated at one point in time and use it at another point in time to balance variable generation sources and variable loads.<sup>2</sup> Energy storage is also one of the only grid resources that can be both load when a system is charging (storing) and generation when the system is discharging (consuming stored energy).

Energy storage systems are described, measured, and evaluated in the following ways:

- Nameplate capacity (kilowatts or megawatts);
- The amount of energy delivered over a period of time (generally kilowatt-hour or megawatt-hour<sup>3</sup>);
- Target discharge duration range (from seconds to multiple hours); and
- Minimum cycles per year.

For example, a 10 kilowatt (kW) system that discharges over an hour period will produce 10 kilowatt-hours (kWh) of electricity (kWh= kW x period of time (hours)). The minimum cycles per year is determined by how many times the system is expected to charge and discharge over its lifetime depending on how it will be used. The target discharge duration is the amount of time the system is expected to discharge depending on its application or the services it is providing.

The State of California defines energy storage systems broadly under California Public Utilities Code Section 2835(a). The section states:

(a) (1) “Energy storage system” means commercially available technology that is capable of absorbing energy, storing it for a period of time, and thereafter dispatching the energy. An “energy storage system” may have any of the characteristics in paragraph (2), shall accomplish one of the purposes in paragraph (3), and shall meet at least one of the characteristics in paragraph (4).

(2) An “energy storage system” may have any of the following characteristics:

(A) Be either centralized or distributed.

(B) Be either owned by a load-serving entity or local publicly owned electric utility, a customer of a load-serving entity or local publicly owned electric utility, or a third party, or is jointly owned by two or more of the above.

(3) An “energy storage system” shall be cost effective and either reduce emissions of greenhouse gases, reduce demand for peak electrical generation, defer or substitute for an investment in generation, transmission, or distribution assets, or improve the reliable operation of the electrical transmission or distribution grid.

(4) An “energy storage system” shall do one or more of the following:

(A) Use mechanical, chemical, or thermal processes to store energy that was generated at one time for use at a later time.

(B) Store thermal energy for direct use for heating or cooling at a later time in a manner that avoids the need to use electricity at that later time.

(C) Use mechanical, chemical, or thermal processes to store energy generated from renewable resources for use at a later time.

(D) Use mechanical, chemical, or thermal processes to store energy generated from mechanical processes that would otherwise be wasted for delivery at a later time.

California Public Utilities Code Section 2835(a) (2) & (4) provide broad characteristics that define where the system will exist in the electric system, who can own the system, and from where the energy to be stored can be generated. California Public Utilities Code Section 2835(a)(3) narrows the definition with the requirement that each system must be cost effective and meet the express policy purposes that serve as the backbone of storage deployment in the state. While this definition goes beyond storage systems that can be coupled with rooftop solar, it is nonetheless helpful to understand the complete realm of how California defines storage.

## 2.2 Use Cases for Storage

Energy storage systems can provide services and benefits at the transmission level, at the distribution level, and behind-the-meter to both customers and the grid. The services and benefits of energy storage can be described in the following use cases,<sup>4</sup> based on the operation of the existing electric system<sup>5</sup>:

**Table 1 Storage System Services and Benefits**

<b>Transmission</b>	
Bulk Energy Services	Electric Energy Time-Shift (Arbitrage)
	Electric Supply Capacity
Ancillary Services	Regulation
	Spinning, Non-Spinning, and Supplemental Reserves
	Voltage Support
	Black Start
	Other Related Uses: <ul style="list-style-type: none"> <li>• Load Following/Ramping Support for Renewables</li> </ul> Frequency Response
Transmission Infrastructure Services	Transmission Upgrade Deferral
	Transmission Congestion Relief
	Other Related Uses: <ul style="list-style-type: none"> <li>• Transmission Stability Dumping</li> <li>• Sub-synchronous Resonance Dumping</li> </ul>
<b>Distribution</b>	
Distribution Infrastructure Services	Distribution Upgrade Deferral and Voltage Support
<b>Behind-the-Meter</b>	
Power Quality	
Power Reliability	
Retail Energy Time-Shift	
Demand Charge Management	
<b>Use Case Combinations for Stacked Services (see Section 2.2.5)</b>	

Further explanation of behind-the-meter use cases is provided below to help readers better understand possible use cases for energy systems paired with solar PV. It is also important to understand that behind-the-meter resources may operate under transmission and distribution use cases when these systems are aggregated at the wholesale level (See Section 4) or as part of distribution level planning dispatch (See Section 3.1.3).

**2.2.1 Power Quality**

Short duration events—such as a power interruption—can degrade the quality of power delivered to a customer to serve on-site load.<sup>6</sup> Battery energy systems can provide protection from poor power

quality by discharging to smooth out the disturbance for a few seconds to a few minutes.<sup>7</sup> Hospitals, data centers, research facilities, and other large industrial or manufacturer customers use battery back up systems to ensure power quality to support their operations. The following provides conditions for which the attributes of storage can offer a solution:

- Variations in voltage magnitude (e.g., short-term spikes or dips, longer term surges, or sags).
- Variations in the primary 60-hertz (Hz) frequency at which power is delivered.
- Low power factor (voltage and current excessively out of phase with each other).
- Harmonics (i.e., the presence of currents or voltages at frequencies other than the primary frequency).
- Interruptions in service, of any duration, ranging from a fraction of a second to several seconds.<sup>8</sup>

This use case generally requires technical considerations that:

- Provide a storage system size range between 100 kW and 10 MW;
- Provide a target discharge duration range between 10 seconds and 15 minutes; and
- Provide a minimum cycle per year of 10 to 200.<sup>9</sup>

### 2.2.2 Power Reliability

Power reliability refers to the duration of unbroken electrical service. Back-up systems that effectively supply power for onsite customer load during total power loss from the grid, including energy storage systems, can improve power reliability by eliminating or decreasing the duration of outages. Certain energy storage systems, such as those included in a microgrid, can allow customers to “island” by using controls that disconnect the customer from the grid and resynchronize the customer once power is restored to the grid.<sup>10</sup> The size of the energy storage system relative to the size of the customer load determines the duration that the system can serve the on-site load.<sup>11</sup> These systems may be combined with onsite diesel or gas generator to extend power reliability beyond the duration of the energy storage system depending on customer need.<sup>12</sup>

### 2.2.3 Retail Energy Time-Shift

Retail energy time-shift describes the practice of charging storage systems during one time period and discharging (consuming) the stored energy at another time. This practice is used to reduce overall costs of electricity because customers store energy during off-peak time periods and discharge the stored energy during on-peak time periods when higher time-of-use (TOU) charges apply.<sup>13</sup> The cost effectiveness of this type of shifting depends on the customer’s retail tariff.<sup>14</sup> The duration of on-peak time periods determines the maximum discharge duration.<sup>15</sup>

This use case requires technical considerations that:

- Provide a storage system size range between one kW and one MW;
- Provide target discharge durations between one and six hours; and
- Provide minimum cycles per year of 50 to 250.<sup>16</sup>

## 2.2.4 Demand Charge Management

Customers can also use energy storage to reduce the overall costs for electric service by reducing their demand during peak periods.<sup>17</sup> Generally, load must be reduced during all hours of the demand period to lower a demand charge.<sup>18</sup> Storage systems are charged when there are no or low demand charges and presumably lower rates.<sup>19</sup> Stored energy is discharged over a period of five to six hours to serve load when demand charges apply.<sup>20</sup> California operates with both coincident demand charges (within the peak period) and non-coincident<sup>21</sup> demand charges (highest demand within a specific period regardless of time of occurrence) that result in different rate costs. Storage can prevent demand charges by avoiding additional costs created by an end-user’s spike in demand. For example, an end use customer may have a demand of 100 kW at peak time and spike to 150 kW for one second triggering a demand charge at the 150 kW rate. Storage can provide the capacity to meet the one second increased demand, avoiding the increased electric demand on the system and the demand charge.

This use case requires technical considerations that:

- Provide a storage system size range between 50 kW and 10 MW (Note: California’s SGIP program data show the use of systems as small as 15 kW for demand charge management);
- Provide target discharge duration range of one to four hours; and
- Provide a minimum cycle per year of 50 to 500.<sup>22</sup>

## 2.2.5 Stacked Services: Use Case Combinations

Storage provides the flexibility for electricity to be used in multiple or stacked services or use cases. Theoretically, use case combinations allow an energy storage system to provide multiple benefits to the grid and for system owners to capture multiple revenue streams driving economic viability.<sup>23</sup> Stacked services represent a more complicated option than a single use case because of regulations, operational constraints, and planning processes. The California Public Utilities Commission (CPUC)—with stakeholders—created three general use cases with multiple applications based on the location of the storage system on the grid in its rulemaking, R.10-12-007.

**Table 2 CPUC Use Cases**

Use Case	Categories
Transmission-Connected Energy Storage	Bulk Storage System
	Ancillary Services
	On-Site Generation Storage
	On-site Variable Energy Resource Storage
Distributed-Level Energy Storage	Distributed Peaker
	Distributed Storage Sited at Utility Substation
	Community Energy Storage
Demand-Side (Customer-Sited) Energy Storage	Customer Bill Management
	Customer Bill Management w/ Market Participation
	Behind the Meter Utility Controlled

	Permanent Load Shifting
	EV Charging

Storage can perform multiple services at the same time and across use cases depending on the system size, location, and ability to be dispatched. The CPUC has further defined these types of use cases under its Assembly Bill (AB) 2514 rulemaking (See Section 3.1.1). Work continues at both the California Independent System Operator (CAISO) and CPUC to evaluate, define, authorize, and limit multiple use cases.

## 2.3 Technologies and Typical Storage Systems for Rooftop Solar PV

Mechanical, chemical, and thermal processes are all used to store energy. This section focuses on the technologies deployed or most likely to be deployed with residential rooftop solar PV systems ranging from one to 10 kW and commercial, industrial, and agricultural rooftop solar PV systems ranging from 10 kW to over one MW.<sup>24</sup>

The following is not an exhaustive list; however, the sections try to account for the broadest range of deployable technology based on anticipated technological advancements and decreases in installed cost.

### 2.3.1 Lead-Acid (Advanced Lead-Acid and Lead-Acid Carbon) Batteries

Lead-acid batteries are the oldest and most developed rechargeable battery technology. All lead-acid batteries share the same basic chemistry with the positive electrode composed of lead-dioxide and the negative electrode composed of metallic lead.<sup>25</sup> Both electrodes are highly porous to maximize surface area with a sulfuric acid solution serving as the electrolyte.<sup>26</sup> Two types of lead-acid batteries are evaluated in this section: advanced lead-acid technologies and lead-acid carbon technologies.

Lead-acid carbon technologies use carbon to improve power characteristics of the battery and mitigate effects of partial states of charge.<sup>27</sup> This technology can deliver and accept high current rates equal to that of higher cost nickel metal-hydride and Lithium-ion batteries with no apparent detrimental effects.<sup>28</sup> Advanced lead acid technologies focus on enhancements of conventional lead-acid technologies including carbon-doped cathodes, granular silica electrolyte retentions systems, high density-positive active material, and silica based electrolytes.<sup>29</sup>

The life cycle of lead-acid systems depends on the depth of the discharge from a particular application. Historically, systems that have shallow discharges will last longer than systems with deep discharges.<sup>30</sup> Current research and development of advanced lead-acid and lead-acid carbon batteries seek to resolve this limitation and have made significant strides in cycle lives.<sup>31</sup> Additionally, some advanced lead-acid technologies exhibit fast response characteristics similar to lithium-ion batteries.<sup>32</sup> Lead-acid systems provide ample installation flexibility and are built to project specifications with a general size range from one kW to one MW.

### 2.3.2 Sodium-Nickel-Chloride Batteries (NaNiCl<sub>2</sub>)

Sodium-nickel-chloride batteries operate at high temperatures (270°C - 350°C) with system deployments in the 50 kW- one MW range.<sup>33</sup> When charging, salt and nickel are transformed into nickel-chloride and molten sodium and reversed at discharge.<sup>34</sup> The Department of Energy Electricity Storage Handbook describes the process in this way:

When charging a Sodium-nickel-chloride battery at normal operating temperatures, salt (NaCl) and nickel (Ni) are transformed into nickel-chloride (NiCl<sub>2</sub>) and molten sodium (Na). The chemical reactions are reversed during discharge, and there are no chemical side reactions. The electrodes are separated by a ceramic wall (electrolyte) that is conductive for sodium ions but an isolator for electrons. Therefore, the cell reaction can only occur if an external circuit allows electron flow equal to the sodium ion current. The porous solid NiCl<sub>2</sub> cathode is impregnated with a sodium ion conductive salt (NaAlCl<sub>4</sub>) that provides a conductive path between the inside wall of the separator and the reaction zone. Cells are hermetically sealed and packaged into modules of about 20 kWh each.<sup>35</sup>

These batteries are deployed for utility grid support and renewable integration, which is why they are included in this report.

### 2.3.3 Lithium-Ion Batteries

Lithium-ion batteries use two reactive materials that allow for an electron transfer chemical reaction.<sup>36</sup> The reaction is dependent on the two materials contacting each other electrically – either directly or through a wire – and the exchange of charged ions to maintain overall charge neutrality via an electrolyte to transfer electrons via an external circuit.<sup>37</sup> The Department of Energy Electricity Storage Handbook explains the chemical reaction to produce power in this way: “When the external terminals of the battery are connected to each other through a load, electrons are given a pathway between the reactive materials, and the chemical reaction proceeds with a characteristic electrochemical potential difference or voltage. Thus there is a current and voltage (i.e., power) applied to the load.” This technology has seen vast investments in scaling production to serve the power market, electric vehicle market, and many pilot and market deployments across the United States and the world. Deployed lithium-ion batteries range in size from five to 10 kW behind-the-meter nationally (five kw to 3 MW under SGIP) to one to two MW systems for large distribution grid or transmission services, such as frequency regulation or peak-shaving.

### 2.3.4 Vanadium Redox Batteries (Flow Battery Example)

Vanadium reduction and oxidation (redox) batteries are a type of “flow batter[y], in which one or both active materials is in an electrolyte solution at all times.<sup>38</sup> Vanadium ions are contained in an “aqueous acidic solution throughout the entire process” with electrolytes pumped in as needed to each cell.<sup>39</sup> The process is described in the following way:

The vanadium redox flow battery is a flow battery based on redox reactions of different ionic forms of vanadium. During battery charge, V<sup>3+</sup> ions are converted to V<sup>2+</sup> ions at the negative electrode through the acceptance of electrons. Meanwhile, at the positive electrode, V<sup>4+</sup> ions are converted to V<sup>5+</sup> ions through the release of electrons. Both of these reactions absorb the electrical energy put into the system and store it chemically. During discharge, the reactions run in the opposite direction, resulting in the release of the chemical energy as electrical energy.<sup>40</sup>

Cells are generally connected in a series to produce a stack to increase voltage. Additionally, the two electrolytes composing this type of flow battery are identical when fully discharged, making shipment and storage simple and cost-effective.<sup>41</sup> Vanadium redox batteries are expected to have an estimated life cycle of 10 years with an average life cycle rate of 10,000 cycles.<sup>42</sup> These batteries can discharge their full output in milliseconds if the systems are primed with reactant providing short-duration discharge for services such as voltage support.<sup>43</sup> These batteries are expected to range from one MW-20 MW in size, depending on application and commercial viability.

### 2.3.5 Additional Technologies

Nickel-cadmium (NiCd) and nickel metal hydride (NiMH) are additional battery systems that are mature and deserve mention for their suitability for niche applications.<sup>44</sup> There are many other technologies that are mature or in the R&D phase of development. With continued investment in storage technology it is expected that existing and new technologies will continue to improve and be developed.

## 2.4 Research and Commercialization of Storage Technologies

The Department of Energy has developed cost and performance goals for energy storage technologies.<sup>45</sup> These goals serve as major drivers for research and commercialization in the energy storage sector. The Department of Energy published near and long term cost and performance goals for energy storage in 2013:

### Near-term

- Demonstrate alternating current (AC) energy storage systems involving redox flow batteries, sodium-based batteries, lead-carbon batteries, lithium-ion batteries and other technologies to meet the following electric grid performance and cost targets:
  - System capital cost: under \$250/kWh
  - Levelized cost: under \$0.20/kWh/cycle
  - System efficiency: over 75%
  - Cycle life: more than 4,000 cycles
- Develop and optimize power technologies to meet AC energy storage system capital cost targets under \$1,750/kW

### Long-term

- Research and develop new technologies based on advanced materials and chemistries to meet the following AC energy storage system targets:
  - System capital cost: under \$150/kWh
  - Levelized cost: under \$0.10/kWh/cycle (i.e., economically scalable without subsidies)
  - System efficiency: over 80%
  - Cycle life: more than 5,000 cycles
- Develop and optimize power technologies to meet AC energy storage system capital cost targets under \$1,250/kW
- For Concentrated Solar Power (CSP)-storage systems:
  - System capital cost: under \$15/kWh
  - System efficiency: 95%
  - Cycle Life: 10,000 cycles<sup>46</sup>

Presently, it is difficult to compare costs between systems due to a lack of reliable costs information for both capital and installed costs. However, several analyses on current costs comparisons exist, including cost comparison for [residential and utility scale systems](#) and [lifetime costs comparisons](#).<sup>47</sup> These provide a present picture of costs as well as estimates on continued declines in cost as the industry matures.

### 3 California Legislative and Regulatory Framework

California’s policies are helping to shape and advance the energy storage industry. State policy—coupled with public and private investment—drive the technological research and development that aims to produce cost-effective systems that meet the needs of end-users, utilities, independent power producers, and regulators. These actions will encourage the use of mechanical, chemical, or thermal processes to store energy generated from renewable resources, such as solar PV, for use at a later time.

AB 2514 and its related procurement as well as the Self-Generation Incentive Program (SGIP) serve as two of the greatest drivers for storage. Battery storage implementation is also driven and shaped by policies that drive procurement, planning, rates, interconnection, and market participation at the wholesale, distribution, and behind-the-meter customer sited level. The following sections will examine these drivers as they relate to the integration of PV and energy storage systems:

#### STATE

- CPUC:
  - AB 2514: Energy Storage System Procurement
  - Self-Generation Incentive Program (SGIP)
  - Distribution Planning Rulemaking, R.14-08-013
  - Net Energy Metering and Energy Storage Systems
  - Rule 21: Interconnection and Smart Inverters
  - Retail Rates

#### LOCAL

- Permitting
- Inspection
- Safety

Relevant federal policies under the federal jurisdiction of the Federal Energy Regulatory Commission, including those relating to the California Independent System Operator are discussed in Section 4.

## 3.1 State Policy and Regulation Related to Energy Storage

### 3.1.1 AB 2514: Energy Storage Systems

[AB 2514](#) (Chapter 469, Statutes 2010)<sup>48</sup> required the CPUC to open a proceeding by March 1, 2012 to determine appropriate targets for each load-serving entity (LSE) to procure viable and cost-effective energy storage systems and to adopt energy storage procurement targets for each LSE by October 1, 2013, if determined appropriate. The Legislature mandated that the storage procurement targets be achieved by December 31, 2015 for the first target (see details below) and by December 31, 2020 for the second target, if deemed appropriate. AB 2514 also required the governing board of a local publicly owned electric utility to open a proceeding to determine appropriate targets, if any, for the utility to procure viable and cost-effective energy storage systems and to adopt an energy storage system procurement target, if determined to be appropriate. Based on the law, adopted targets would have to be achieved by the utility by December 31, 2016, and a second target to be achieved by December 31, 2021.

On October 17, 2013, the CPUC adopted Decision 13-10-040, creating an energy storage procurement framework and program that established a target of 1,325 megawatts (MW) of energy storage to be procured by Pacific Gas & Electric (PG&E), Southern California Edison (SCE), and San Diego Gas & Electric (SDG&E) by 2020 with installment no later than 2024.<sup>49</sup> The decision directed each utility to file separate procurement applications containing a proposal for the first energy storage procurement period by March 1, 2014 to meet specified use case requirements for each IOU.<sup>50</sup> The decision further established targets for community choice aggregators and electric service providers to procure energy storage equal to 1% of their annual 2020 peak load by 2020 with installation no later than 2024.<sup>51</sup> Importantly, the CPUC determined that AB 2514 was silent as to whether to apply a system needs determination as a basis for storage procurement targets finding it reasonable to set procurement targets based on precedent, policy, and market need, as defined.<sup>52</sup> This means that procurement targets are not based on system need, as would be case for other procurements, but on other factors.

The decision adopted the following guidance principles for the storage procurement policy:

- 1) The optimization of the grid, including peak reduction, contribution to reliability needs, or deferral of transmission and distribution upgrade investments;
- 2) The integration of renewable energy; and
- 3) The reduction of greenhouse gas (GHG) emissions to 80 percent below 1990 levels by 2050, per California goals.

Guidance principles 2 and 3 are the most important for integration of rooftop solar PV with energy storage systems as the market and regulations evolve.

Similar to the DOE categorization, the CPUC created three categories or “use case buckets” for allocating the procurement targets: Transmission Connected, Distribution Connected, and Behind-The-Meter.<sup>53</sup> The use case buckets are based on interconnection points and are designed to develop market participation without technology or application preferences.<sup>54</sup> Additionally, the CPUC found that it was unnecessary to revise the existing Energy Action Plan “Loading Order”<sup>55</sup> to expressly include energy storage as a “preferred resource” consistent with the *Assigned Commissioner’s Ruling Proposing Storage Targets and Mechanisms and Noticing All-Party Meeting* (ACR) issued on June 10, 2013.<sup>56</sup> The Behind-The-Meter use case bucket represents the major driver for rooftop solar systems integrated with battery storage under AB 2514. The use case buckets can be found in Table 3:

**Table 3 CPUC Use Case defined by Storage Grid Domain and Regulatory Function**

STORAGE GRID DOMAINS (Grid Interconnection Point)	REGULATORY FUNCTION	USE-CASE EXAMPLES
<b>Transmission-Connected</b>	Generation/Market	<b>(Co-Located Energy Storage)</b> Concentrated Solar Power, Wind + Energy Storage, Gas Fired Generation + Thermal Energy Storage
		<b>(Stand-Alone Energy Storage)</b> Ancillary Services, Peaker, Load Following
	Transmission Reliability (FERC)	Voltage Support
<b>Distribution-Connected</b>	Distribution Reliability	Substation Energy Storage (Deferral)
	Generation/Market	Distributed Generation + Energy Storage
	Dual-Use (Reliability & Market)	Distributed Peaker
<b>Behind-the-Meter</b>	Customer-Sited Storage	Bill Mgt/Permanent Load Shifting, Power Quality, Electric Vehicle Charging

The CPUC defined two-year procurement targets by use case bucket or storage grid domains for each IOU out to 2020. These targets are flexible to allow each IOU to defer procurement targets from one solicitation period to the next to maximize and balance both developer and ratepayer value.<sup>57</sup> IOUs can

shift up to 80% of their target MW between Transmission and Distribution domains (use case buckets) but cannot shift any MWs between the Customer domain and Transmission or Distribution domains.<sup>58</sup> The total Customer or Behind-The-Meter procurement totals 200 MW for all three IOUs. The Procurement targets can be found below:

**Table 4 Energy Storage Procurement Targets (in Megawatts (MW))<sup>59</sup>**

<b>Storage Grid Domain (Point of Interconnection)</b>	<b>2014</b>	<b>2016</b>	<b>2018</b>	<b>2020</b>	<b>Total</b>
<b>Southern California Edison</b>					
Transmission	50	65	85	110	310
Distribution	30	40	50	65	185
Customer	10	15	25	35	85
<b>Subtotal SCE</b>	<b>90</b>	<b>120</b>	<b>160</b>	<b>210</b>	<b>580</b>
<b>Pacific Gas and Electric</b>					
Transmission	50	65	85	110	310
Distribution	30	40	50	65	185
Customer	10	15	25	35	85
<b>Subtotal PG&amp;E</b>	<b>90</b>	<b>120</b>	<b>160</b>	<b>210</b>	<b>580</b>
<b>San Diego Gas &amp; Electric</b>					
Transmission	10	15	22	33	80
Distribution	7	10	15	23	55
Customer	3	5	8	14	30
<b>Subtotal SDG&amp;E</b>	<b>20</b>	<b>30</b>	<b>45</b>	<b>70</b>	<b>165</b>
<b>Total - all 3 IOUs</b>	<b>200</b>	<b>270</b>	<b>365</b>	<b>490</b>	<b>1,325</b>

The IOUs are limited to owning a maximum of 50% of all storage for all three grid domains and must procure energy systems through established competitive solicitations.<sup>60</sup> The CPUC also established that customer-side storage targets can be met as a result of energy storage systems installed under existing proceedings, such as the 2015 demand response application, the distributed generation/California Solar Initiative rulemaking, the alternative-fueled vehicle rulemaking, and the Self-Generation Incentives Program.<sup>61</sup> The Commission expressly acknowledges the benefits of utility ownership or contracts of customer-side storage projects behind-the-meter and noted that rate design, net energy metering (NEM), and storage interconnection processes (such as Rule 21) may help develop innovative strategies on the customer side of the meter.<sup>62</sup>

The IOUs submitted their Storage Procurement and Program Applications for the 2014 Biennial Procurement Period to the CPUC on February 28, 2014. The CPUC approved the procurements in D.14-10-045 on October 16, 2014, making adjustment to the original procurement targets to maintain flexibility in a new process and to take advantage of existing projects and planning processes or incentive programs such as the Long Term Procurement Plan (LTPP) that includes Local Capacity Requirement proceedings, the Self-Generation Incentive Program, and Permanent Load Shifting (PLS) Program.<sup>63</sup> A breakdown of the 2014 procurement can be found below:

**Table 5 Energy Storage Procurement Targets for First Request for Offer (RFO) (MW)<sup>64</sup>**

Storage Grid Domain (Point of Interconnection)	CPUC Initial Storage Decision Targets	Procurement Targets Proposed in IOU Applications	Final CPUC Energy Storage Procurement Targets	Final IOU Energy Storage Procurement Targets
<b>Southern California Edison</b>				
Transmission	50	0	0	0-16.3
Distribution	30	16.3	16.3	0-16.3
Customer	10	0	0	0
<b>Subtotal SCE</b>	<b>90</b>	<b>16.3</b>	<b>16.3</b>	<b>16.3</b>
<b>Pacific Gas and Electric</b>				
Transmission	50	50	50	50
Distribution	30	21.5	24	24
Customer	10	6.5	6.5	0
<b>Subtotal PG&amp;E</b>	<b>90</b>	<b>78</b>	<b>80.5</b>	<b>74</b>
<b>San Diego Gas &amp; Electric</b>				
Transmission	10	10	10	0-25
Distribution	7	6	6	4-29
Customer	3	0	0	0
<b>Subtotal SDG&amp;E</b>	<b>20</b>	<b>16</b>	<b>16</b>	<b>29</b>
<b>Total - all 3 utilities</b>	<b>200</b>	<b>110.3</b>	<b>112.8</b>	<b>119.3</b>

The revised procurement targets reduced the original targets for the customer domain use case bucket with only PG&E still needing to procure additional storage for this domain. SCE’s procurement was greatly reduced due to its procurement of storage in its Local Capacity Reliability RFO as part of its LTTP proceeding.<sup>65</sup> PG&E has satisfied 9 MW of its 10 MW requirement through existing projects with the additional 1 MW coming from other programs. SDG&E will procure its targets through transmission and distribution connected storage under its All Source RFO and Distribution Reliability/Power Quality Program RFO.<sup>66</sup> SDG&E procured 20 MW of storage in the first quarter of 2016 through this process.<sup>67</sup> It is clear from the CPUC’s approval of existing IOU procurement processes that each IOU can meet its obligation through existing processes; the CPUC considers the AB 2514 procurement targets to be part of current procurement need and not a separate or additional procurement requirement. This is why the final targets differ from the initial targets and why the final CPUC targets differ from the final IOU proposed targets when accounting for existing or proposed procurement processes.

### 3.1.2 Self-Generation Incentive Program (SGIP)

The CPUC's Self-Generation Incentive Program (SGIP) provides rebates for qualifying distributed energy systems installed on the customer's side of the utility meter. Advanced energy storage systems are one of several qualifying technologies under the program. Currently the program offers \$ 1.46 per watt<sup>68</sup> under the emerging technologies category. The program offers a tiered incentive where the first 0-1 MW systems receive a 100% incentive rate, the next 1 MW-2 MW systems receive a 50% incentive rate, and final 2-3 MW systems receive a 25% incentive rate.<sup>69</sup> For example, a 2 MW system would receive an incentive of \$1.46 x 1 MW + \$0.73 x 1 MW. Incentives for advanced energy storage began to decline at 10% annually beginning on January 1, 2013.<sup>70</sup> Incentive calculations and capacity limits are treated separately for advanced energy storage and generation storage.<sup>71</sup> An additional 20% incentive is also provided for the installation of advanced energy storage supplied from a California Supplier, as defined.<sup>72</sup>

SB 861 (Chapter 35, Statutes 2014) and AB 1478 (Chapter 664, Statutes 2014) amended Public Utilities Code Section 379.6, and among other things, authorized collection of funds for SGIP of \$83 million annually through 2019 and restricted eligibility to distributed energy resources (DERs) technologies that:

- Reduce demand from the grid by offsetting customer onsite energy load;
- Are commercially available;
- Safely utilize the grid; and
- Improve air quality by reducing criteria air pollutants.<sup>73</sup>

Advanced energy storage systems integrated with solar PV strongly exhibit these characteristics by offsetting customer onsite load, being commercially available, interconnecting with the grid, and improving air quality by reducing GHG production. Storage systems must meet the following criteria to be eligible:

- Be connected to local Electric Utility's distribution system and be on the customer's side of the meter;
- Be configured to run in parallel with the grid;
- Be a permanent installation for the useful life of the system; and
- Have the capability to discharge its rated capacity for a minimum of two hours and discharge fully at least once per day.

Systems that meet this eligibility criteria and participate in the SGIP greatly reduce the installed cost of the system. Presently, many systems would not be economically viable without the SGIP incentive because of high costs.

The SGIP releases quarterly and weekly statewide data on the status and stages of SGIP applications. For example, the weekly Report from July 6, 2015<sup>74</sup> provides the following information for advanced energy storage (AES) paired with solar PV:

**Table 6 SGIP Projects by Stages for Combined AES. and PV only from July 6, 2015**

Stage and Status	Number of Projects/Applicants
Total in Review Process	501
Review Completed with Payment Completed/In Progress	15
Applications Cancelled	244

Finally, CPUC Chief Administrative Law Judge Karen Clopton issued a proposed decision under R. 12-11-005 in May 2016. The proposed decision seeks continued implementation of SB 861 and AB 1478 in addition to program improvements. The proposed decision would, among other things, make the following major changes to SGIP;

- Modify SGIP to be administered on a continues basis (as opposed to allocating additional funding every year) with incentive levels declining based on the capacity reserved in the program, similar to the California Solar Initiative;
- Divide the incentive budget between energy storage and generation with energy storage receiving 75% of program funds and 25% allocated to generation. Of the allocated storage budget, 15% would be used for projects less than or equal to 10 kW. Of the allocated generation budget, 10% would be used for renewable generation projects;
- New Incentive levels shown below:

**Table 7 Adopted Incentives for Generation Technologies**

	Step 1		Step 2		Step 3	
	Incentive Per kW Capacity	Max. Incentive w/ Biogas Adder	Incentive Per kW Capacity	Incentive Per kW Capacity	Incentive Per kW Capacity	Max. Incentive w/ Biogas Adder
	\$0.90	N/A	\$0.80	N/A	\$0.70	N/A
Wind	\$0.60	N/A	\$0.50	N/A	\$0.40	N/A
Waste heat to Power	\$0.60	\$1.20	\$0.50	\$1.10	\$0.40	\$1
Pressure reduction turbine	\$0.60	\$1.20	\$0.50	\$1.10	\$0.40	\$1
Internal combustion CHP	\$0.60	\$1.20	\$0.50	\$1.10	\$0.40	\$1
Microturbine CHP	\$0.60	\$1.20	\$0.50	\$1.10	\$0.40	\$1
Gas turbine CHP	\$0.60	\$1.20	\$0.50	\$1.10	\$0.40	\$1
Fuel cell CHP	\$0.60	\$1.20	\$0.50	\$1.10	\$0.40	\$1
Fuel cell electricity only	\$0.60	\$1.20	\$0.50	\$1.10	\$0.40	\$1

**Table 8 Adopted Incentives For Energy Storage Technologies**

	Step 1	Step 2	Step 3	Step 4	Step 5
Large Scale Energy Storage (>10kW)	\$0.50/Wh	\$0.45/Wh	\$0.40/Wh	\$0.35/ Wh	\$0.30/ Wh
Small Scale Energy Storage (<=10 kW)	\$0.60/ Wh	\$0.55 /Wh	\$0.50/ Wh	\$0.45/Wh	\$0.40/Wh

- Beginning in program year 2017, require generation projects consuming natural gas to use a minimum of 10% biogas to receive SGIP funding. This minimum requirement would increase to 25% in 2018, 50% in 2019, and 100% in 2020;
- Use of a lottery to replace the first-come, first serve system when application received on the same day requires more incentives than the remaining budget at the current incentive step. Projects which have additional greenhouse gas/grid benefits will be given priority;
- Each participating project developer will be capped at a total of 20% of the incentive budget on a statewide basis replacing the existing cap of 40% applied to equipment manufacturers; and
- Require third-party certification to show that at least 50% of value added occurs in California for California Supplier adder eligibility.

While this is a proposed decision, it is expected that the CPUC will act to further modify the SGIP program in the near term. The CPUC may adopt some or part of this proposed decision with modification. This may occur at the CPUC’s June 2016 meeting or a subsequent meeting.

### 3.1.3 Distribution Grid Planning for Distributed Resources: AB 327 (2013)

Integrated planning that incorporates the bi-directional benefits of customer sited distributed resources is becoming a more important aspect of distribution level grid management. This type of planning represents a shift away from traditional models of distribution level grid management to a networked grid model that sites distributed resources to benefit the distribution grid and ensure cost-effective deployments. AB 327 is the first action in California to create this type of distribution network.

The Governor signed AB 327 (Chapter 611, Statutes 2013) into law on October 7, 2013. Among other things, the law added California Public Utilities Code Section 769 that mandates electric corporations (i.e., PG&E, SCE, SDG&E, PacifiCorp, Liberty Utilities, and Bear Valley Electric Service) to submit a distribution resource plan (DRP) proposal to the CPUC by July 1, 2015. The DRPs must identify optimal locations for distributed resources, such as solar PV and energy storage systems. Section 769 requires that each DRP proposal:

- (1) Evaluate locational benefits and costs of distributed resources located on the distribution system. This evaluation shall be based on reductions or increases in local generation capacity needs, avoided or increased investments in distribution infrastructure, safety benefits, reliability benefits, and any other savings the distributed resources provides to the electric grid or costs to ratepayers of the electrical corporation.

(2) Propose or identify standard tariffs, contracts, or other mechanisms for the deployment of cost-effective distributed resources that satisfy distribution planning objectives.

(3) Propose cost-effective methods of effectively coordinating existing commission-approved programs, incentives, and tariffs to maximize the locational benefits and minimize the incremental costs of distributed resources.

(4) Identify any additional utility spending necessary to integrate cost-effective distributed resources into distribution planning consistent with the goal of yielding net benefits to ratepayers.<sup>75</sup>

The CPUC opened rulemaking R.14-08-013 to establish policies, procedures, and rules to guide the DRP proposals. The CPUC has noted that other open CPUC proceedings may address issues related to this proceeding, including:

- R.13-09-011 (Demand Response and Advanced Metering);
- R.13-11-005 (Energy Efficiency);
- R.13-12-010 (Long-Term Procurement Rulemaking);
- R.13-11-007 (Electric Vehicles);
- R.11-10-023 (Resource Adequacy Rulemaking);
- R.08-12-009 (Smart Grid Deployment Rulemaking);
- R.12-11-005 (California Solar Initiative and Distributed Generation Rulemaking);
- R.11-09-011 (Rule 21 Interconnection Rulemaking);
- R.12-06-013 (Comprehensive Examination of Investor Owned Electric Utilities' Residential Rate Structures, the Transition to Time Varying and Dynamic Rates, and Other Statutory Obligations); and
- Application A.14-02-006, et seq., (Energy Storage Procurement Applications pursuant to Decision 13-10-040).

On July 1, 2015, [SDG&E](#), [PG&E](#), and [SCE](#) as well as the other required utilities submitted their Electric Distribution Resource plan to the CPUC for review. The CPUC is reviewing each DRP and approve or modify and approve a DRP to minimize overall system costs and maximize ratepayer benefit from investments in distributed resources.<sup>76</sup> PG&E, SCE, and SDG&E may also propose any spending on distribution infrastructure necessary to implement a DRP for CPUC consideration under their next general rate case.<sup>77</sup>

The CPUC provides links to many of these proceedings on its [Distributed Resources Plan webpage](#).

### 3.1.4 Net Energy Metering (NEM)

Customers who install eligible systems one MW or less to serve onsite load are eligible for net energy metering (NEM). NEM systems are sized to meet annual load – as opposed to peak demand – to account for seasonal variation in demand and solar production. NEM uses an electricity billing mechanism to provide customers retail-rate billing credits for energy exported to the grid when onsite generation exceeds onsite load. Energy storage systems paired with solar systems can export excess energy to the grid under the CPUC's NEM D.14-04-003.

The CPUC adopted D.14-05-003 on May 24, 2014 to clarify that energy storage devices paired with NEM-eligible generation facilities that meet the California Energy Commission’s Renewable Portfolio Guidebook<sup>78</sup> are “addition or enhancement” to NEM-eligible systems and therefore exempt from interconnection application fees, supplemental review fees, costs for distribution upgrades, and standby charges when interconnecting under current NEM tariffs.<sup>79</sup> This Decision also determined storage system sizing limits, among other things. The CPUC determined that:

- All NEM-paired storage systems with storage devices sized at 10 kW or smaller shall have no requirement to be sized to the customer demand or the NEM generator; and
- NEM-paired storage systems with storage devices larger than 10 kW should have a maximum output power no larger than 150% of the NEM generator’s maximum output capacity.<sup>80</sup>

The Decision addressed a methodology for NEM credits, metering requirements, and modifying the NEM tariff for NEM-eligible generators paired with storage. These issues are being adjudicated under the open proceeding, R.12-11-005.

On July 10, 2014, the CPUC opened a successor rulemaking to the existing NEM tariff, R.14-07-002, to implement AB 327 (Chapter 611, Statutes 2013), which added California Public Utilities Code Section 2871.1 requiring a successor tariff/standard contract to the NEM tariff by December 31, 2015. The CPUC issued a scoping memo on January 23, 2015, setting the issues and timeline for the completion of the rulemaking. The proceeding addressed:

- Develop one or more tariffs/standard contracts as the successor to the NEM program that:
  - Account for growth among residential customers in disadvantaged communities;
  - Develop common methodology for evaluating proposals under the successor tariff/standard contract; and
  - Ensure that application of the tariff/standard contract to community choice aggregator and direct access customers is investigated and determined; and
  - Ensure that the application of the tariff/standard contract to projects greater than one MW is investigated and determined.
- Determine whether various program elements related to existing NEM programs that are variations within the NEM tariffs themselves (virtual net metering; NEM aggregation, etc.) should be continued, clarified, modified, or ended.
- Determine whether various secondary customer benefits associated with the current NEM program (e.g., exemptions from interconnection fees, standby charges, and departing load charges; faster interconnection processing; and net surplus compensation) should be continued, clarified, modified, or ended in the development of the successor tariff/standard contract(s).
- Consider the development of measurement and evaluation plans, program evaluation budgets, and similar tools for the program under the successor tariff/standard contract(s), to align with the administration of other Commission programs on customer-sited distributed energy resources (DER).
- Consider consumer protection issues associated with customer-sited renewable electrical generation facilities as structured under the successor tariff/standard contract(s), including whether any new provisions would apply to customers transitioning under the current NEM tariff.

- Identify and address any safety issues related to the program of customer-sited renewable electrical generation facilities under the successor tariff/standard contract(s). Examples include but are not limited to:
  - Issues associated with allowing “projects greater than one megawatt that do not have significant impacts on the distribution grid,” in accordance with the terms of Section 2827.1(b)(5);
  - Compliance with the requirements of the Rule 21 interconnection process.
- Consider the integration of energy storage devices and other distributed energy resources into one or more of the NEM successor tariff/standard contract(s).<sup>81</sup>

The CPUC issued a final decision on January 28, 2016. The decision ([D.16-01-044](#)) does all of the following:

- Ensures that customer-sited renewable distributed generation continues to grow sustainably by creating a successor to the existing NEM tariff that includes a new NEM tariff, with modifications;
- Follows the fundamental approach to residential rate reform expressed in Decision D. 15-07-001, by:
  - Declining to impose any demand charges, grid access charges, installed capacity fees, standby fees, or similar fixed charges on NEM residential customers while the Commission is working on how, if at all, any such fees should be developed for residential customers;
  - Continuing to rely on the minimum bill established in D.15-07-001 as a mechanism for ensuring that customers using the NEM successor tariff contribute through their bill payments to the costs of maintaining the services of the electric grid for all customers;
  - Maintaining the requirement that non-residential NEM customers pay any demand charges, standby fees, or similar fixed charges that are part of the underlying rate for their customer class, regardless of the requirements of the NEM tariff under which they receive service.
- Continues the basic features of the current NEM tariff transition to the successor NEM tariff, but makes changes that:
  - Require customers installing customer-sited renewable DG systems to pay a reasonable interconnection fee to the interconnecting investor-owned utility (IOU), with an exception for customers participating in the Single-Family Affordable Solar Homes program;
  - Require customers on the NEM successor tariff to pay nonbypassable charges that are levied on each kilowatt-hour (kWh) of electricity the customer obtains from the IOU in each metered time interval, regardless of the monthly netting of the kWh obtained from the IOU and exported to the grid by the customer;
  - Require all residential customers interconnecting under the NEM successor tariff prior to the institution of default residential any time-of-use (TOU) rates to take service on any TOU rate available to them, as a condition of using the NEM successor tariff, except that residential customers of San Diego Gas & Electric Company (SDG&E) will not be required to take service on a TOU rate until after the TOU rates being developed in Application A. 15-04-012 are in effect;

- Provide NEM successor tariff customers who take service on TOU rates prior to the effective date of default TOU rates for all residential customers with the opportunity to remain on the TOU rate they have chosen for up to five years;
- Allow residential customers of SDG&E who complete their interconnection applications for the NEM successor tariff prior to the time the TOU rates for SDG&E residential customers being developed in SDG&E's General Rate Case Phase 2, A.15-04-012, are in effect, to participate in the NEM successor tariff while taking service on SDG&E's existing tiered rates, with the option to maintain their tiered rate for up to five years;
- After the implementation of default TOU rates for residential customers, require all residential NEM successor tariff customers, regardless of their date of interconnection, to be on any applicable TOU rate as a condition of taking service under the NEM successor tariff, with a limited exception for certain SDG&E residential customers.
- Extends eligibility for the NEM successor tariff to customer-sited facilities larger than one megawatt in size, so long as the customer pays all Rule 21 interconnection study and distribution system upgrade fees for the facility;
- Establishes minimum warranty and equipment safety requirements for installations for customers taking service under the NEM successor tariff;
- Determines that the Virtual Net Metering (VNM) tariff and net metering aggregation (NEMA) sub-schedule of the NEM tariff should be maintained and updated consistent with the provisions of the NEM successor tariff established by this decision;
- Provides that customer-generators may continue to take service under the NEM successor tariff established by this decision for 20 years from the year of interconnection of the customer's system;
- Determines that a better understanding of the impact of customer-sited distributed resources on the electric system will be developed from work currently under way but not yet completed in other Commission proceedings, including but not limited to the distribution resources plan proceeding (Rulemaking R. 14-08-031), the integrated distributed energy resources proceeding (R.14-10-003), and the recently opened rulemaking to consider technical issues for future TOU rates (R.15-12-012);
- Identifies the year 2019, which the Commission has selected as the target for beginning default TOU rates for residential customers, as the appropriate time to review the NEM successor tariff established by this decision, with a view to considering adjustments to the successor tariff that include an export compensation rate for NEM successor tariff customers that takes into account locational and time-differentiated values;
- Authorizes the Director of Energy Division to direct the development, in consultation with the parties, of a method of evaluating whether the NEM successor tariff results in growth of customer-sited renewable distributed generation, consistent with the methodology established by this decision;
- Authorizes the Director of Energy Division to take appropriate steps to prepare for further work in this proceeding, including but not limited to, convening workshops led by Energy Division staff, producing staff reports, developing information for potential NEM successor tariff customers, and similar work;
- Requires Pacific Gas and Electric Company, Southern California Edison Company, and SDG&E, each to submit a Tier 2 advice letter, with its NEM successor tariff, including NEMA, and VNM tariff, in conformity with the provisions set out in this decision, within 30 days after the effective date of this decision; and

- Determines that in order to develop the alternatives for residential customers in disadvantaged communities, and more fully develop the means for effectuating consumer protection and evaluation measures for the NEM successor tariff, a second phase of this proceeding should be initiated.<sup>82</sup>

The NEM Successor Tariff rulemaking is still an open proceeding.

### 3.1.5 Electric Tariff Rule 21 Interconnection and Smart Inverters

Rule 21 governs interconnection, operation, and metering requirements for generating facilities that interconnect to the IOU distribution system and transmission system over which the CPUC has jurisdiction. This includes NEM systems and non-exporting generating systems. Exporting generating systems that connect to the transmission system must apply to the California Independent System Operator (CAISO) for interconnection and are subject to CAISO tariffs. Exporting generation systems apply to CAISO under the Wholesale Distribution Access Tariff (WDAT).<sup>83</sup> Rule 21 and WDAT interconnections are substantially similar by design to ensure compatibility between federal and state interconnection processes.<sup>84</sup>

The IOUs successfully interconnect large number of distributed generation NEM and non-exporting systems under Rule 21. However, Rule 21 is under continuous review to account for the dynamic changes in grid operation created by new technologies, including energy storage. The CPUC opened an interconnection proceeding, R.11-09-011, that continues the ongoing review process. Over the last five years, the CPUC revised Rule 21 to better accommodate the large number of distributed generation interconnections to reduce deployment and integration barriers.

The CPUC opened R.11-09-011 on September 13, 2011 and revised Rule 21 under a settlement agreement with the IOUs per D.12-09-018. CPUC D.12-09-018 required each IOU to assign all interconnection requests to either the “Fast Track”, which uses a screen based, streamlined process for NEM, non-export, and small exporting facilities,<sup>85</sup> or the “Detailed” study with three study processes for more complicated generation facilities. More recently, D.14-04-003 focused on streamlining the application process for interconnection services in the same electrical area by developing a Distribution Group Study Process.<sup>86</sup> This Decision allows projects to share grid study and upgrade costs among the group and mirrors the cluster study under the WDAT.

The CPUC also recently adopted Rule 21 revisions for smart inverters under D.14-12-035. This Decision is particularly important for solar PV systems paired with storage to ensure safety and reliability because smart inverters allow solar to deliver DC power to an AC grid and the AC grid to charge DC batteries and thus provide real and reactive power and voltage and frequency support to the distribution grid.<sup>87</sup> This Decision set a fixed effective date for mandatory smart inverter requirements as the later of either December 31, 2015, or 12 months after the Supplement SA of UL-1741 is approved by the full UL-18741 Standards Panel<sup>88</sup> and requested that load shedding, voltage support, ramp-down specifications, and other issues be brought back to the CPUC within one year for further revisions.<sup>89</sup> The proceeding remains open to address communication protocols and appropriate levels of compensation, if any, for grid support provided by inverter owners.<sup>90</sup>

Ongoing Rule 21 proceedings seek to address specific issues that the CPUC and its staff have identified regarding energy storage. In R.10-12-007, the CPUC identified that a lack of appropriate interconnection policies presents a major barrier to the deployment of storage after the CPUC created storage procurement targets for the IOUs under AB 2514.<sup>91</sup> The CPUC also directed SCE and SDG&E to procure a minimum of 50 MW and 25 MW of storage, respectively, under the LTPP proceeding for Local Capacity Reliability, making these issues more pressing. CPUC staff created an Issues, Priorities and Recommendations for Energy Storage Interconnection Staff Proposal on July 18, 2014, which includes the following:

- Safety Planning: Staff proposed that the Interconnection Agreement should contain a custom Safety Plan that should be submitted to IOUs and reviewed and updated biannually. Staff also proposed that a safety disclosure clause be added to Rule 21, as a requirement during the Interconnection Agreement phase.<sup>92</sup>
- Pre-Interconnection Consultation Process: Staff proposed that IOUs develop and adopt an optional Advance Interconnection Consulting Process to help eliminate issues arising in the middle of the interconnection process.<sup>93</sup>
- Define Storage Interconnection Terms and Concepts in the Definition Section of Rule 21: Staff proposed that a standardized definition for storage under Rule 21 Section C be developed to account for the particular attributes of storage and harmonize with the CAISO definition.<sup>94</sup>
- Identify Fast Track Threshold and Study Screens for Storage Projects: Staff proposed a threshold for storage to qualify for Fast Track interconnection based on the grid conditions of each IOU. Currently, the thresholds for generators are 3 MW in PG&E's and SCE's territory and 1.5 MW in SDG&E's territory. Staff also proposed that Fast Track study screens be identified and delineated for load-side/charging functions of storage devices for Engineering Review, Initial review, and Supplemental review (if required). Staff also questioned whether storage facilities located behind-the-meter should be subject to the interconnection process at all because these systems modify load and do not export power to the grid. Finally, staff addressed the need for standardized data and system characteristics to be entered into algorithms to reduce load flow analysis timeframes.<sup>95</sup>
- Update the Interconnection Agreement to Account for Storage Attributes: Staff proposed that the Generator Interconnection Agreement be retitled to "Interconnection Agreement" and updated to account for the attributes of storage including its ability to charge and discharge, its ability to be controlled via functions that optimize grid need and system use, the need to account for cost responsibility and use restriction, and the ability to contract for use restrictions.<sup>96</sup>
- Update the Interconnection Application to Accommodate Storage Attributes: Staff proposed standardization of the Interconnection Application to include collection of relevant information based on storage attributes upfront. Staff proposed that all documents and forms be received and easily accessed via internet-based submission channels to ensure integrity of data and maximum process efficiency. Staff also proposed that applicants be able to check their application electronically and the application be posted on each IOU's website.<sup>97</sup>
- Utility Consideration of Alternative Interconnection Metering and Protection Schemes: Staff proposed that the IOUs determine a process for testing the capabilities of alternative protection schemes brought forth by applications. This accounts for the continued changes in technology and uses, such as the integration of generation and storage systems, in an effort to standardize protection schemes to reduce overall project costs.<sup>98</sup>

These proposals will help to drive the continued reform of Rule 21 to account for the attributes and needs of energy storage interconnection. This is another important step towards driving down costs and decreasing interconnection times.

### 3.1.6 Retail Rates

Retail rates regulated by the CPUC are divided between residential, agricultural, industrial, and commercial rate structures, among others. The rate structures are service territory dependent because each IOU regulated by the CPUC uses a slightly different rate structure.

Time-of-Use (TOU) rate structures provide the greatest benefit to energy storage installations. Presently, many commercial, agricultural, and industrial rates require default time-of-use or time-variant rates that allow those customers with storage systems to charge their systems during off-peak hours and discharge their system at on-peak hours to load shift. Residential customers can benefit from this type of rate structure by voluntarily participating in TOU rates.<sup>99</sup> Few residential customers participate in TOU schedules and therefore receive no financial benefit for any load shifting. However, it is possible for customers that have PV systems combined with storage to charge their storage systems from their PV systems during the day and run their load with the storage systems later in the day. Examples of TOU rate structures can be found in Figure 1 and Figure 2. This will become more common as the CPUC phases in residential TOU with full implementation targeted for 2019.

Figure 1 Example of Summer Time-of-Use Rate Structure<sup>100</sup>

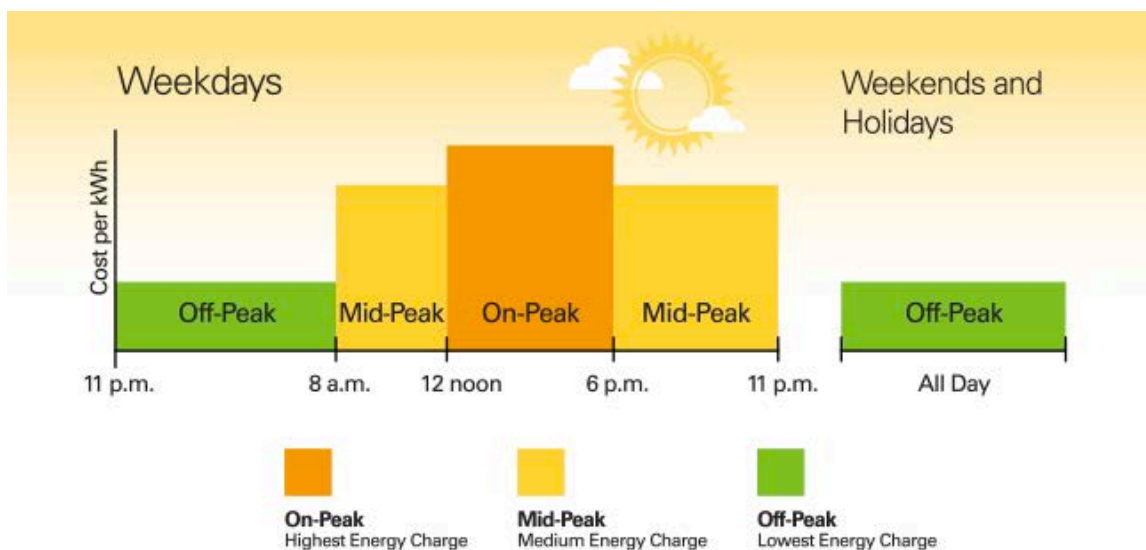
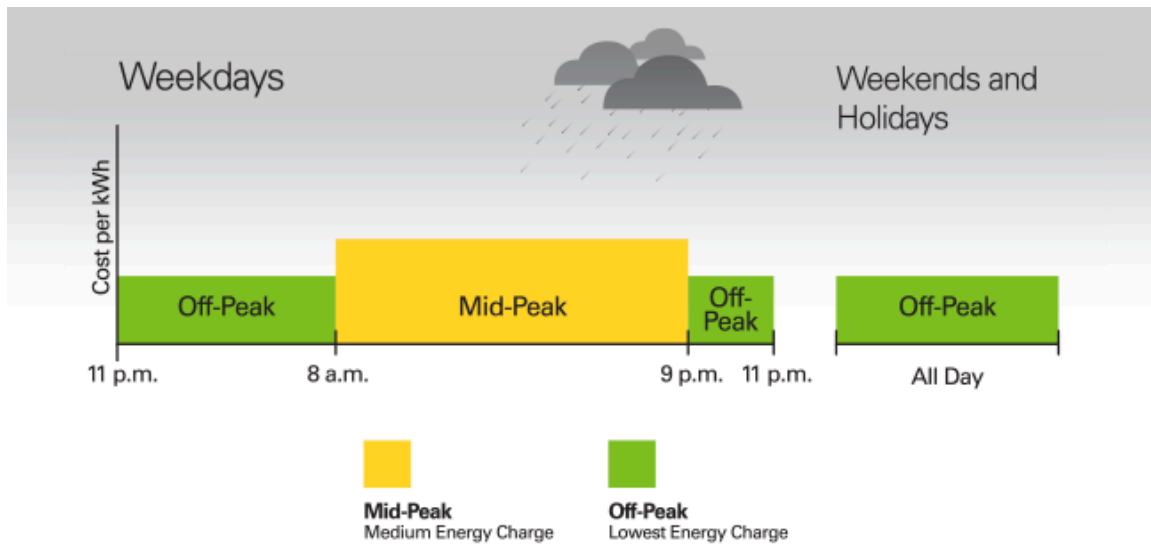


Figure 2 Example of Winter Time-of-Use Rate Structure



There remains unresolved issues around rates and NEM customers with storage systems. Current electric rate tariffs provide NEM incentives to electric customers with energy storage systems that are subject to TOU or time-varying rates (almost exclusively commercial, agricultural, and industrial customers only at this time). A financial incentive is produced only when energy consumed by a storage system during a lower priced time period is later used to export electricity at a higher priced time period to generate a bill credit.<sup>101</sup> Customers on standard non-time-varying rates would receive no benefit for either a storage device dispatched at a different time of day to peak load shift or to export power to the grid during peak demand. Without rate modification, only commercial, industrial, and agricultural customers can currently use their storage systems to benefit from varying TOU rates. Notably, residential rate reform will shift residential customers to TOU schedules over the coming years creating this type of financial incentive. The increasing number of electric vehicles is also expected to speed TOU adoption.

## 3.2 Considerations at the Local Level: Permitting, Inspection, and Safety

The following sections address considerations at the local level for permitting, inspecting, and maintaining public safety as these systems are installed in and around residential, multifamily, commercial, and industrial structures.

### 3.2.1 Safety

All systems must meet applicable building, electrical, mechanical, and fire code regulations. The following paragraphs are specific to energy storage regulation and updated standards for PV panels.

Safety requirements for stationary energy storage depend on several factors. The physical location of a stationary energy storage system and whether the system has a capacity of more than 50 gallons (189 L) for flooded lead-acid, nickel cadmium (Ni-Cd) and valve-regulated lead-acid (VRLA), or 1,000 pounds (454 kg) for lithium-ion and lithium metal polymer triggering California Fire Code Section 608.1 are important considerations. Systems subject to Section 608.1 that are indoors or located in cabinets are subject to [California Fire Code Section 608.2-608.9](#). These code sections require specific:

- Safety venting caps;
- Devices to detect and control thermal run away;
- Room design stack requirements, and methods to prevent unauthorized access to equipment;
- Spill control and neutralization of electrolytes;
- Room or cabinet ventilation;
- Supervision by remote or on-site monitoring service;
- Signage;
- Seismic protection; and
- Smoke detection.

Additionally, the energy storage system should receive certification by a nationally recognized testing laboratory (NRTL). These certifications are required for many programs including SGIP. Under the SGIP, systems must be commercially available, have one year of documented commercial availability or have obtained or be in the process of obtaining NRTL certification indicating that it meets national recognized standards for safety and performance requirements.<sup>102</sup>

In terms of PV systems, the most recent 2013 California Building Code (CBS), specifically Section 1505.9 and California Residential Code (CRC) Section R902.4, were updated to comply with the most recent edition of the Underwriters Laboratories Inc. (UL) 1703 *Standard for Flat-Plate Photovoltaic Modules and Panels* published in October 2013.<sup>103</sup> Implementation of these requirements was delayed until January 1, 2015, and the California State Fire Marshal further clarified on November 25, 2014 that in areas that require minimum Class C roofing under California Health and Safety Code Section 13132.7, the use of panels and modules that have Class C rating under UL 1703(2002 edition with revision through April 2008), have Class C ratings that comply with UL 790 (2004 edition with revisions through October 2008), or have a minimum C Rating under the most current version of UL 1703 (2002 edition with revisions through October 2013) may be installed.<sup>104</sup>

Finally, the U.S. Department of Energy's Energy Storage section created and released several reports on [Energy Storage Safety](#). The U.S. Department of Energy's [Energy Storage Safety Strategic Plan](#) sets forth the current state of technology and safety for energy storage with a focus on the development of:

1. Validation Techniques
2. Incident Preparedness
3. Safety Documentation
4. Implementation

The importance of these processes grows with the introduction of new chemistries and technologies at all levels of the transmission grid, distribution grid, and behind-the-meter deployments.

The DOE also developed an [Overview of Development and Deployment of Codes, Standards, and Regulations Affecting Energy Storage System Safety in the United States](#), as well as an [Inventory of Safety-Related Codes and Standards for Energy Storage Systems](#). These documents identify current and future issues and address code revisions and technical and policy initiatives to resolve these issues.

### 3.2.2 Permitting

Solar PV systems combined with energy storage systems follow the same permitting processes as all applications for solar PV systems. Jurisdictions reviewing these applications require the same information and plans. From a review standpoint, an energy storage system on a residential or commercial building is generally seen as an addition to the solar PV system that does not add complexity or cost to the review. Energy systems sized for PV systems are generally small when compared to utility scale systems and use technology with a multi-year track record (e.g., lithium-ion and lead acid batteries) across other applications, such as backup power on telecommunication sites.

Energy storage systems may also need a hazmat/fire review depending on the size of the system. Stationary battery storage systems are subject to [California Fire Code Section 608](#). This code section applies to systems with an electrolyte capacity of more than 50 gallons (189 L) for flooded lead-acid, nickel cadmium (Ni-Cd), and valve-regulated lead-acid (VRLA) or 1,000 pounds (454 kg) for lithium-ion and lithium metal polymer used for facility standby power, emergency power or uninterrupted power supply.<sup>105</sup> This generally does not apply to residential systems but may apply to large commercial or multi-family systems. If a system is subject to Section 608, triggering an additional review, an additional fee for the hazmat/fire review may be charged.

Many jurisdictions provide a more streamlined review process for PV systems on residential single or two-family dwellings. These processes generally use checklists and/or plan templates to decrease review times. However, not all jurisdictions allow these applications to use the streamlined process when a battery system is added to a PV system application. For example, the City of San Diego Development Services process allows any qualifying system for residential to use its plan template for a more streamlined review regardless of whether an energy system is added.<sup>106</sup> However, the Los Angeles Department of Building and Safety removes qualifying PV applications for residential single and two-family dwellings from its express permit process if a battery system is installed.<sup>107</sup> Removal from the express permit process requires applicants to proceed through a plan review process that would not otherwise be required but for the addition of the battery system to the application.

On commercial buildings or multifamily residential buildings, applicants may be required to submit additional documents, such as site plans, framing plans, and single line diagrams, and must proceed through an electrical plan check and/or building plan check.

Additionally, it is unclear whether small residential solar PV systems that include energy storage remain eligible for AB 2188 (2014) streamlined permitting.<sup>108</sup> The law does not explicitly address the addition of storage systems, but it is possible that jurisdictions may still include these configurations in their streamlined process.

### 3.2.3 Inspection

Inspections for solar PV systems combined with energy storage can include: electrical rough, electrical final, structural-foundation, structural rough, structural final, and fire requirements. Issues often arise at the inspection stage of the process when compared to other phases of the process. Inspections evaluate the installation and safety of systems to enforce mandatory state building code requirements from the state building, mechanical, electrical, and fire code.

Inspection issues revolve around labeling, certification of equipment, proper identification and execution of grounding methods, and proper rail system installation. Inspectors will evaluate equipment to see whether each system is certified and labeled by a NRTL. Inspectors will also evaluate installations for proper grounding and rail system install pursuant to manufacturer requirements. Systems that are installed without proper labeling and certification will fail inspection and require applicants to resubmit for a permit with properly certified equipment costing time and money. It is essential for installers to only use systems with labels and certifications to pass inspection and avoid resubmission of an application costing additional time and money. It is also important that installers follow all state codes and proper grounding and manufacturer installation requirements to avoid re-inspection. As the storage industry matures, it is expected that single inspections will become standard in line with current streamlined inspection for solar systems.

## 4 Federal Framework: CAISO Action and FERC Framework

With the growing number of individual large PV deployments of 500 kW or larger and the ability to aggregate smaller behind-the-meter systems as a 500 kW or larger resource, energy storage systems are becoming a powerful resource at the wholesale level to balance supply and demand during ramping and to shift on-site load when PV is not producing. While most relevant to larger energy storage systems, it is important to understand how the evolving federal framework can provide opportunity for aggregated small behind-the-meter systems to participate in wholesale markets.

At the federal level, the Federal Energy Regulatory Commission (FERC) regulates the transmission and sale of electricity in interstate markets. The federal agency issues orders that prevent undue discrimination in the sale and transmission of electricity, provide market rules for various services that operate in ISO and RTO systems, create rules for transmission planning, and regulate interconnection procedures, among other things. The California Independent System Operator (CAISO) manages one such market subject to FERC regulation.

In the CAISO market,<sup>109</sup> storage accounted for 46% of all projects in the CAISO's Queue Cluster 7 interconnection study, with submissions for 34 interconnection requests totaling over 2,000 MW.<sup>110</sup> CAISO received approximately 1,043 MW of stand-alone storage (23 projects) and approximately 1,016 MW of storage combined with generation (11 projects).<sup>111</sup> In this cluster, three of the 11 storage projects were combined with PV ranging in size from 15 to 153.4 MW for PV and from 5 to 200 MW for battery storage.<sup>112</sup> Participating transmission owners made additional requests for energy storage interconnection through the distribution interconnection process.<sup>113</sup> Distribution interconnection

requests for full or partial capacity deliverability status will be studied for deliverability purposes under the CAISO's Generator Interconnection and Deliverability Allocation Procedures (GIDAP).<sup>114</sup> The ability of aggregated PV combined with storage to access the wholesale market is expected to follow the advances of these types of interconnection cluster studies, GIDAP, and FERC and CAISO procedure changes that accommodate and utilize storage systems. Presently, developers and regulators are moving towards standardizing the processes necessary to aggregate distribution level resources to meet the CAISO's 500 kW minimum requirements for generator resource identification that allows participation in the wholesale transmission system.

The following sections will summarize the CAISO Energy Storage Roadmap (Roadmap), which was developed jointly by the CAISO, the CPUC, and the Energy Commission. The Roadmap serves as a bridge between stakeholders, regulators, the wholesale transmission market, and the distributed transmission system. It identifies issues and assigns each entity tasks based on priority to resolve issues to continue the development of energy storage in California. The last sections provide a summary of existing FERC Orders related to energy storage as well as the CAISO actions. This represents the evolving pathway for integration of energy storage system at the wholesale level.

## 4.1 California Independent System Operator (CAISO): Advancing and Maximizing the Value of Energy Storage Technology- A California Roadmap

The [CAISO California Roadmap](#) (Roadmap) was developed through a CAISO, CPUC, Energy Commission, and stakeholder collaboration to identify necessary policy, technology, and process changes to address challenges faced by the storage sector. This process began on July 31, 2014, and ended with the publication of the Roadmap on December 31, 2014, after multiple workshops and stakeholder input.

The California Roadmap identified three general categories of challenges faced by the energy storage sector:

- The ability to realize the full revenue opportunities consistent with the value energy storage can provide;
- The need to reduce cost of interconnection and ongoing operations; and
- The need to increase certainty regarding processes and timelines.<sup>115</sup>

Stakeholders also identified additional issues including:

- The inability to accurately value energy storage for all the services it can provide;
- The need to clearly identify the need for flexible capacity and valuation of the capability in the CPUC resource adequacy program; and
- The need to clarify tariff treatment for energy storage facilities.<sup>116</sup>

The Roadmap organizes actions into five topic areas that identify the specific process in the electric sector where issues can be addressed. Each action is also ranked by priority and assigned to the responsible regulatory organization. The actions are provided below with additional information relating to each process.

### 4.1.1 Planning

The Roadmap calls for close planning and operations coordination between the CAISO transmission grid and the distribution grid to account for the different regulatory frameworks, rules, architecture, and needs to reliably operate each system. The Roadmap emphasizes the need for CAISO and distribution utilities to understand the operation characteristics of storage to effectively utilize and resolve issues.<sup>117</sup> This will require changes at the distribution level to account for an ever increasing number of resources that can operate as bi-directional power flows in a radial system where power flows in one direction from the transmission grid to the end user.<sup>118</sup>

At the transmission level, the annual Transmission Planning Process (TPP) and other studies identify transmission level needs for system, local, and flexible capacity.<sup>119</sup> Adequate system capacity need ensures that there is enough resources on the grid to meet the peak forecast demand.<sup>120</sup> Adequate local capacity need ensures that additional capacity exists in specific regional locations to prevent outages from unanticipated generation or transmission outages.<sup>121</sup> Flexible capacity need refers to the ramping capability to quickly increase or decrease output as needed.<sup>122</sup> CAISO staff evaluates the benefits of anticipated energy storage resources in addressing the needs identified by the TPP and may recommend the use of energy storage to the CAISO board to meet identified need when energy storage is found to be effective.<sup>123</sup>

The TPP process informs the CPUC’s Long-Term Procurement Planning (LTTP) process to match the needed operational characteristic with the resource authorized for IOU procurement.<sup>124</sup> Additionally, the CPUC directed California’s IOUs to develop Distribution Resource Plans pursuant to AB 327 (See Section 3.1.3) to identify optimal locations for resources such as storage.<sup>125</sup> There is also a “More than Smart” working group that serves as a companion to the CPUC proceedings to facilitate technical discussions and topics outside of current proceedings.<sup>126</sup> Planning action items can be found below listed by priority:

**Table 9 Planning Action Items<sup>127</sup>**

Category	Action Item	Agency	Priority
Planning	Describe distribution grid operational needs and required resources characteristics.	CPUC	High
	Facilitate clarification by IOUs of operational constraints that can limit the ability to accommodate interconnection on the distribution system.	CPUC	High
	Examine and clarify opportunities for storage to defer or displace distribution upgrades.	CPUC	High
	Describe ISO grid operational needs and required resource characteristics.	CAISO	Medium
	Develop coordination process for transmission and distribution system planning.	CPUC, CAISO	Medium
	Clarity assessment of energy storage resources classified as transmission assets to defer or displace transmission upgrades.	CAISO	Low

### 4.1.2 Procurement

There is no established common methodology or tool to evaluate and define the product, services, and need for storage in procurement proceedings.<sup>128</sup> The CPUC identified several areas of value to be considered in the IOUs' procurement filings in D.13-10-040 (See AB 2514 in Section 3.1.1) but did not define a specific methodology or tool for procurement cycles. This Decision gave the IOUs flexibility "to use proprietary protocols for actual project selection."<sup>129</sup> The Energy Commission has funded research to develop storage methodologies and tools to determine the value of storage under the Public Interest Energy Research (PIER) program and Electric Program Investment Charge (EPIC) program.<sup>130</sup> These methodologies and tools may be used to determine need and value for procurement.

Additionally, because many energy storage systems are new products and services, it is necessary to define and quantify the benefits of energy storage through a tariff or procurement process.<sup>131</sup> The CPUC's Long Term Procurement Process (LTTP) and other proceedings require load serving entities to "demonstrate that their procured resource portfolio meets system, local, and flexible capacity needs according to its rules and eligibility requirements."<sup>132</sup> The CPUC annually takes up this assessment to evaluate modifications to rules and eligibility requirements under its Resource Adequacy (RA) proceedings (the current CPUC RA proceeding is R.14-10-010).<sup>133</sup>

One such requirement is deliverability. Deliverability is one part of eligibility for RA capacity and may need reform to better integrate storage. Deliverability refers to the requirement that the transmission system be able to deliver the output of the resource —along with all other resources—to meet planning reserve margin across peak timeframes (usually 15% over normal demand).<sup>134</sup> Deliverability status is determined in a study process and is consistent with requirements for system and local RA resources "as these needs are based on meeting resource shortage conditions during peak load."<sup>135</sup> Energy storage, on the other hand, is considered flexible capacity and is used to meet ramping need, not system or local RA resource shortage conditions during peak load requirements.<sup>136</sup> However, resource adequacy counting qualifies each resource as either a system or local resource with some local resources also counted as system resources.<sup>137</sup> Flexible capacity is subject to the deliverability assessment because it is considered a system resource.<sup>138</sup> This creates a potential issue for storage because flexible capacity must meet resource shortage condition deliverability requirements despite only being used for ramping need. The Roadmap points out that the potential "unbundling" of flexible capacity and clarification of counting rules can remove energy storage resources that provide flexible capacity from deliverability assessments benefitting energy storage developers.<sup>139</sup>

**Table 10 Procurement Action Items**<sup>140</sup>

Category	Action Item	Agency	Priority
Procurement	Consider refinements to the valuation methodologies used by IOUs to support CPUC decisions on storage procurement and make models publicly available	CPUC, Energy Commission	High
	Clarify rules for energy storage qualification and counting in an evolving Resource Adequacy (RA) framework	CPUC	High
	Consider “unbundling” flexible capacity RA counting	CPUC	High
	Prepare summary of efforts underway focused on developing models for energy storage valuation and plans [for] public distribution	Energy Commission	Medium

### 4.1.3 Rate Treatment

Many questions arise around wholesale and retail rate treatment for energy storage in light of the fact that storage acts as a generator and consumer of electricity.<sup>141</sup> The Roadmap highlights two types of storage applications:

1. Energy that is stored for later injection back to the grid to provide grid services; and
2. Energy stored and injected at different times of the day to change consumption patterns (generally customer-sited).<sup>142</sup>

In the first type of application, grid services can be provided at both the wholesale and distribution level. At the wholesale level, the rate treatment is consistent with that of a generation resource.<sup>143</sup> CAISO clarified this treatment in its recent [energy storage interconnection stakeholder initiative](#). Wholesale market activities for positive (discharging) and negative (charging) are settled at the locational marginal price (LMP).<sup>144</sup> CAISO does not consider the charging of storage systems for later resale in the markets to be consumption.<sup>145</sup> At the distribution level, an energy storage resource can participate in the wholesale market by filing a FERC jurisdiction tariff called a Wholesale Distribution Access Tariff (WDAT). There is a need for the CPUC to determine additional rate treatment for “customer sites with a mix of resources that help meet local consumption needs and do not result in the net export of energy that want to provide wholesale grid services.”<sup>146</sup> The CPUC currently evaluates this type of rate treatment on a case-by-case basis.<sup>147</sup> Distribution grid services are not fully defined, nor are products available to monetize these services.<sup>148</sup> As energy storage develops, these issues will be addressed in terms of products and tariffs as needed.<sup>149</sup>

In the second type of application, CPUC retail rates are applied. Issues abound and include the need to optimize the value of energy storage sited with renewable generation, such as solar PV.<sup>150</sup> For example, current rules limit the use of storage devices to store electricity from renewable resources for use at

different times of day without affecting the host customer’s ability to receive net energy metering (NEM) credit.<sup>151</sup> The CPUC approved a NEM successor tariff in February 2016 (See Section 3.1.4). Other issues revolve around whether certain charges will be applied to energy storage. CAISO clarified the application of infrastructure charges for transmission access charge (TAC), wheeling charges, and uplifts to energy storage in a recent energy storage interconnection initiative but still needs to address the treatment of station power and round trip efficiency loss needs.<sup>152</sup>

**Table 11 Rate Treatment Action Items**<sup>153</sup>

Category	Action Item	Agency	Priority
Rate Treatment	Clarify wholesale rate treatment and ensure that the ISO tariff and applicable business practices manuals and other documentation provide sufficient information	CAISO	High
	Clarify and potentially modify net energy metering tariffs applicable to cases where energy storage is paired with renewable generators	CPUC	High
	Clarify rate treatment for customer sites with a mix of resource that help meet local consumption needs and do not result in the net export of energy, and want to provide wholesale grid services	CPUC	Medium
	Evaluate the need and potential to define distribution level grid services and products	CPUC	Medium
	Consider a new proceeding to develop distribution grid services provided by distributed energy resources to the utility or other entities	CPUC	Low

#### 4.1.4 Interconnection

Interconnection tariffs provide the standards and processes required to connect to the utility or CAISO-managed grid. Interconnection processes generally include applications and studies to determine if upgrades are needed. Interconnection also has technical requirements for data, equipment, telemetry, and metering. A resource seeking to connect can utilize three different tariffs depending on its intended use. The CPUC’s Rule 21 is used to connect distributed generation systems that do not intend to participate at the wholesale level as well as to connect behind-the-meter systems that may or may not net export electricity.<sup>154</sup> Resources connecting to the distribution system that will participate in the wholesale market use the FERC jurisdictional Wholesale Distributed Access Tariff (WDAT). Resources that interconnect to the transmission system use the CAISO interconnection tariff governed by the Generator Interconnection and Deliverability Allocation Procedures (GIDAP).

Stakeholders expressed the need for clarity in understanding the processes, costs, and timeframes, especially the differences between Rule 21 and WDAT.<sup>155</sup> This includes streamlining the processes and improving the transition between Rule 21 and WDAT when a resource’s use changes.<sup>156</sup> Stakeholders also proposed a “fast track” for systems to interconnect to the distribution system with little impact on the system (reducing load without exporting) as well as a new fee structure for non-exporting resources.<sup>157</sup> There is also an unresolved issue with how to treat a customer-sited resource that is not a net energy exporter but that can provide services in the wholesale market (e.g., demand response).<sup>158</sup>

CAISO determined that existing interconnection processes could accommodate storage by treating storage as a generator resource.<sup>159</sup> This means that storage resources must respond to CAISO dispatch instructions. CAISO will update these processes as the market place evolves.

In terms of metering and telemetry, stakeholders expressed concern over duplicative metering required to participate in the wholesale and distribution systems.<sup>160</sup> This issue is ever evolving with the introduction of new products, but the utilities and CAISO require accurate telemetry and metering to aggregate resources, dispatch, and respond to outages. CAISO continues to evaluate and address this issue through its Expanded Metering and Telemetry Options action.<sup>161</sup> This will remain an ongoing issue.

Safety issues were raised over the lack of fire protection standards and codes applicable to energy storage.<sup>162</sup> Continued actions are required to examine requirements and identify practices to ensure safety with the deployment of these systems. Finally, existing certification and tests required to bring a facility on-line designed for generators need to be refined to address the fact that storage operates by shifting from supply to consumption.<sup>163</sup>

**Table 12 Interconnection Action Items**<sup>164</sup>

Category	Action Item	Agency	Priority
Interconnection	Clarify existing transmission and distribution interconnection processes, including development of integrated process flow charts and check lists	CPUC, CAISO	High
	Evaluate opportunities to coordinate between Rule 21 and Wholesale Distribution Access Tariff (WDAT) to streamline interconnection processes and ability to efficiently move between processes	CPUC, CAISO	High
	Evaluate the potential for a streamlined or ‘fast track’ distribution interconnection process for storage resources that meet certain use-case criteria	CPUC, CAISO	High
	Evaluate, define and establish a fee structure to interconnect non-exporting resources	CPUC	High
	Define and support entities collecting telemetry data from multiple facilities, to allow bulk submission of data	CAISO	High

	Review and potentially modify utility WDAT to incorporate applicable modifications consistent with the ISO interconnection tariff including adjustments that streamline requirements	CAISO (FERC)	Medium
	Review ISO's procedure for testing and certifying resources for ancillary services	CAISO	Medium
	Evaluate expanding technology options for providing resource telemetry	CAISO	Medium
	Initiate and administer a working group to evaluate common telemetry framework and recommend actions to standardize resource telemetry requirements	Energy Commission	Medium
	Evaluate and consider refinements to ISO telemetry requirements	CAISO	Medium
	Research and evaluate refinements to IOU telemetry requirements	Energy Commission	Medium
	Initiate and administer a working group to research and recommend a certification process for integrated device metering that can be used in place of the ISO or utility meter	Energy Commission	Medium
	Evaluate the rule for certifying sub-metering and third-party meter data collection and consider a process to validate, estimate and edit meter data to expand options for sourcing revenue quality meter data	CPUC, Energy Commission	Medium
	Establish the value and develop a framework under which the ISO and Utility can share metering and meter data	CPUC, Energy Commission, CAISO	Medium
	Initiate and administer a working group to review existing fire protection codes and materials handling guidelines for various energy storage technologies and applications and identify best practices	CPUC, Energy Commission	Medium
	Initiate and administer a working group to review and determine applicability, scope, and consistency of UL and other certification requirements for energy storage systems	Energy Commission	Medium
	Evaluate establishing rules for utility subtractive metering for behind-the-meter whole-sale resources to improve resource granularity, visibility, and clarity in retail billing	CPUC	Low

#### 4.1.5 Market Participation

Energy storage resources seek to participate in both the wholesale and retail markets to maximize revenue streams. There are many challenges including metering, telemetry, rate treatment, and FERC approval.<sup>165</sup> Many stakeholders seek to develop multiple-use or stacked applications. For example, an energy storage resource may seek to serve as a transmission asset and participate in the wholesale market.<sup>166</sup> In this example, there is currently no FERC approval for this type of arrangement, and it creates a conflict for CAISO because "the ISO cannot be responsible for determining the operation of a resource that it would compensate as it could affect market price."<sup>167</sup> Where an energy storage resource seeks to participate at the distribution level and in the wholesale market, there are still unresolved issues with rate treatment, product categorization, and valuation of the benefits.<sup>168</sup>

The CAISO continues to take incremental action in this area. On February 3, 2016, the CAISO Board of Governor's approved proposed changes to the existing 2012 market participation model for storage.<sup>169</sup> The Board approved two enhancements. First, the Board approved that a storage resource participating as a non-generator resource to submit a daily state of charge bidding parameter in the day-ahead market (as opposed to using the ending state of charge from the previous day-ahead award or fifty percent assumption of maximum energy limit).<sup>170</sup> Second, the Board approved the proposal that non-generator resources have an option to self-manage their energy limits and state of charge instead of co-optimization by the CAISO.<sup>171</sup> These changes may help non-generator resources participate in both wholesale and retail markets.

Finally, the need to clearly communicate existing products and modeling at the wholesale level concludes the Roadmap's discussion of market participation. These initial discussions identified gaps in the ability of resources to be modeled as part of an aggregation with other resources (e.g., storage and solar).<sup>172</sup> This effects both wholesale and distribution participation by energy storage resources and requires continued efforts by CAISO and the CPUC to resolve identified and future issues.<sup>173</sup>

**Table 13 Market Participation**<sup>174</sup>

Category	Action Item	Agency	Priority
Market Participation	Clarify existing ISO requirements, rules and market products for energy storage to participate in the ISO market	ISO	High
	Identify gaps and potential changes or additions to existing ISO requirements, rules, market products and models	ISO	High
	Where appropriate, expand options to current ISO requirements and rules for aggregations of distributed storage resources	ISO	High
	Define and develop models and rules for multiple-use applications of storage	CPUC, ISO	Medium

	Identify and develop models of hybrid storage configurations for wholesale market participation	ISO	Medium
	For configurations of greatest interest or likelihood of near-term development, clarify the requirements and rules for participation	CPUC, ISO	Medium

#### 4.1.6 Continued Actions

The CPUC and CAISO continue to address the outlined issues from the Roadmap through proceedings and joint workshops. Specifically, the CPUC’s [R.15-03-011](#) Track 2 focuses on multi-use energy storage applications and Station Power. Additionally, the CAISO ongoing Energy Storage and Distributed Energy Resources (ESDER) stakeholder initiative completed its first phase. The scope of ESDER 1 included: 1) enhancements to the CAISO non-generator resources (NGR) model; 2) enhancement to demand response performance measures and statistical sampling for the CAISO proxy demand resource (PDR) and reliability demand resource (RDR) market participation models; and 3) clarifications to rules for non-resource adequacy multi-use applications. Changes to the NGR model enhancement and demand response performance measures require CAISO tariff amendments. The CAISO Board of Governor’s approved the proposals in February of 2016. The stakeholder process to implement these changes is underway.

The CAISO began [ESDER 2](#) in March of 2016. The scope of this initiative includes the following proposed topics:

- **NGR Enhancement Considerations:** (a) represent use limits in the NGR model; and (b) represent multiple configurations in the NGR model.
- **Demand Response Enhancement Considerations:** (a) ability for PDR to dispatch to both curtail and increase load and provide regulation service; and (b) alternative baselines to evaluate PDR performance. Both are to be developed through stakeholder processes.
- **Multiple- Use Applications:** The CAISO will continue to work on this issue through the CPUC’s R.15-03-011 Track 2 proceeding.
- **Distinction issue between wholesale charging energy and station power:** CAISO will contribute to CPUC’s R.15-03-011 Track 2 proceeding on this issue and also address it under ESDER 2 because station power is addressed in the CAISO tariff.
- **Allocation of Transmission access charge to load served by DER:** This issue was previously raised but will not be part of the ESDER 2 initiative.<sup>175</sup>

This initiative continues to grapple with the challenges of multiple-use applications (MUA) of storage. The CAISO invited stakeholder responses to evaluate current and near-term future applications of storage. The CAISO combined these responses with the DOE’s Challenges of Valuing Energy Storage (2011) and Rocky Mountain Institutes “The Economics of Battery Energy Storage.”<sup>176</sup> From this, the CAISO ESDER 2 initiative narrowed MUA to five use cases. The use cases are below:

1. In-front-of-meter distributed energy resources providing services to the distribution system and participating in the CAISO market;
2. Behind-the-meter distributed energy resources providing services to end-use customers and the distribution grid;
3. Behind-the-meter distributed energy resources providing services to end-use customers and participating in the CAISO market;
4. Behind-the-meter distributed energy resources providing services to the distribution system and the CAISO market; and
5. Behind-the-meter distributed energy resources providing services to end-use customers, the distribution system and the CAISO market.

These use cases as well as the remaining issues identified in the Roadmap are the current and future issues evaluated under R. 15-03-011 and ESDER 2. Ultimately, these proceeding and initiatives will determine the actual value and application of combined PV and storage systems for end-users, the distribution system, and the CAISO market.

## 4.2 Non-Generator Resources in Ancillary Services: FERC Order Nos. 890, 719, and 745

### 4.2.1 FERC Order No. 890 (2007): Preventing Undue Discrimination and Preference in Transmission Service

Order No. 890 requires that non-generation resources – such as demand response – be evaluated on a comparable non-discriminatory basis to services provided by generation resources in meeting mandatory reliability standards, providing ancillary services, and planning grid expansion. Energy storage can provide demand response by supplying onsite load in turn resulting in a decrease of system demand.

### 4.2.2 FERC Order No. 719 (2008): Wholesale Competition in Regions with Organized Electric Markets

Order No. 719 directs independent system operators (ISOs) and regional transmission organizations (RTO) to accept bids from demand response resources for certain ancillary services on a basis comparable to other resources. This makes it possible to meet commercial and industrial customers' critical load using storage by enabling frequent demand response participation.<sup>177</sup>

The CAISO Board of Governors approved proposals to implement these orders in March 2010.<sup>178</sup> Information about non-generator resources in ancillary markets can be found [here](#).

### **4.2.3 FERC Order No. 745 (2011): Demand Response Compensation in Organized Wholesale Energy Markets [The U.S. Supreme Court upheld this order in January 2016 reversing the D.C. Circuit Opinion overturning it]**

Order No. 745 created a market-based demand response (DR) compensation rule. Under this order, electric utilities and retail market operators are required to pay wholesale resources - such as energy storage – the market price for energy or locational marginal price (LMP) when load reductions avoid the need for additional generation sources by balancing supply and demand. This may allow energy storage to bid in larger customer loads for DR participation.<sup>179</sup>

The D.C. Circuit overturned this rule, finding that FERC exceeded its statutory authority in promulgating this rule. The U.S. Supreme Court overturned the D.C. Circuit finding that:

- (1) FERC had authority to require wholesale electric market operators to pay the same price to demand response providers for conserving energy as to generators for producing it, so long as consumers actually saved money, since the rule directly affected the wholesale rate which was reduced by displacing higher-priced generation bids;
- (2) Although transactions occurring on the wholesale market affected retail rates, the regulatory plan did not invade the states' authority to regulate retail rates since every aspect of the plan happened exclusively on the wholesale market and governed exclusively the wholesale market's rules; and
- (3) The decision to pay demand response providers at the same price paid to generators was reasonable since FERC engaged in reasoned decision making, weighed competing views, and intelligibly explained the decision.<sup>180</sup>

This ruling creates both support for the use of other aggregated products in wholesale markets, such as rooftop solar combined with storage, and uncertainty regarding where the state and federal lines of jurisdiction end and begin.

## **4.3 Pay for Performance Regulation and Ancillary Services Participation: FERC Order No. 755 and Order No. 784**

### **4.3.1 FERC Order No. 755 (2011): Frequency Regulation Compensation in the Organized Wholesale Power Markets**

Order No. 755 directed ISOs to pay compensation to regulation resources based on actual service(s) provided. This comprises capacity payments that include the marginal unit's opportunity costs and a payment for performance based on accuracy and speed of response to requested capacity for frequency regulation. This order allows higher compensation for fast responding energy storage that provides faster and more accurate level of power to the ISO than conventional generation.<sup>181</sup>

CAISO modified its compensation mechanism regulation to include a performance payment with an accuracy adjustment.<sup>182</sup> CAISO received FERC approval for this tariff modification and is currently, during a one-year period, in the process of evaluating the methodology for calculating mileage accuracy

and assessing whether the minimum performance standard and any additional items should be amended.<sup>183</sup> Additional information about CAISO’s Pay for Performance Regulation can be found [here](#).

#### **4.3.2 FERC Order No. 784 (2013): Third Party Provision of Ancillary Services; Accounting and Financial Reporting for new Electric Storage Technologies**

Order No. 784 allows battery storage to compete with other resources in ancillary services market. It also expands Order No. 755 pay-for-performance requirements by requiring public utility transmission providers to account for the speed and accuracy of regulation resources for Regulation and Frequency Response services when determining reserve requirements and accounting and reporting rules to aid rate recovery for energy storage systems by utilities.

#### **4.4 Regional Transmission Planning Under FERC Order No. 1000 (2011): Transmission Planning and Cost Allocation**

Order No. 1000 requires public utility transmission providers to participate in transmission planning at the regional level that includes comprehensive evaluation of transmission solutions in coordination with neighboring region transmission providers to ensure cost effectiveness and account for public policy requirements. The requirement that alternatives in transmission planning be evaluated means that non-transmission alternatives – such as energy storage – may see greater deployment as a potentially more cost-effective solution.<sup>184</sup>

#### **4.5 Small Generator Interconnection Agreements and Procedures under FERC Order No. 792 (2013)**

Order No. 792 updated the Small Generator Interconnection Procedures and Small Generator Interconnection Agreement (SGIA) rules to include energy storage. FERC included energy storage under the definition of “small Generating Facility” and affirmed that energy storage is within the scope of the Small Generator Interconnection Procedures and SGIA. This allows energy storage to access fast track interconnection processes for generators that use inverters (such as solar PV).<sup>185</sup>

#### **4.6 15-Minute Scheduling & Settlement under FERC Order No. 764 (2012): Integration of Variable Energy Resources**

FERC issued Order No. 764 amending the *pro forma* Open Access Transmission Tariff (OATT) to remove unduly discriminatory practices and ensure just and reasonable rates for services. The order removes barriers to the integration of variable energy resources (VERs) by “requiring each public transmission provider to: (1) offer inter-hourly transmission scheduling; and, (2) incorporate provisions into the *pro*

*forma* Large Generator Interconnection Agreement requiring interconnection customers whose generating facilities are variable energy resources to provide meteorological and forced outage data to the public utility transmission provider for the purpose of power production forecasting.”<sup>186</sup> Order No. 764 allows a 15-minute interval as the default scheduling process.<sup>187</sup>

On May 1, 2014, CAISO implemented a new 15-minute market option in the real-time market with “financially binding energy and ancillary services awards for internal generators, imports and exports and participating loads.”<sup>188</sup> Additional information regarding 15-Minute Scheduling & Settlement can be found [here](#).

## 4.7 CAISO Renewable Integration Market and Product Review Phase 1:

### 4.7.1 CAISO Regulation Energy Management (new resource model)

The California Renewable Portfolio Standard (RPS) requires CAISO to integrate more renewable energy in the wholesale energy market while at the same time protecting system reliability. The variable nature of renewables requires the creation of additional operational capabilities, such as ramping support, ancillary services, and increased ability to manage over-generation conditions.<sup>189</sup> This further imposes additional operational requirements, including more frequent starts and stops and cycling of existing generation units. CAISO implemented non-generator resource and regulation energy management functionality as part of its 2012 market redesign under its renewable integration market and product phase 1 initiative.<sup>190</sup> This allows batteries, flywheels, and other resources to participate in energy and ancillary services as either generation or load.<sup>191</sup> The CAISO redesign provides the capability to support 20% renewable integration but will require additional redesign with higher percentages of renewable generation.<sup>192</sup> More information about the CAISO renewable integration market and product review can be found [here](#).

### 4.7.2 CAISO Lower Bid Floor for Downward Dispatch Capacity

As part of the renewable integration market and product review phase 1 initiative, CAISO lowered the bid price floor from a soft bid floor of \$30/MWh to a hard bid floor of \$150/MWh.<sup>193</sup> This action provides an additional incentive to offer downward dispatch capacity by paying suppliers to reduce output during an overproduction period and charges over-producing suppliers as a disincentive to over-supply.<sup>194</sup> Examples of how bid cost recovery works in the CAISO market can be accessed [here](#). More information about the CAISO renewable integration market and product review can be found [here](#).

## 4.8 Flexible Ramping Constraints and Ramping Products in the CAISO Market

### 4.8.1 CAISO Flexible Ramping Constraints

Flexible ramping constraint in the CAISO market helps to ensure that sufficient ramping capability is available to meet conditions in the five-minute market interval when conditions change from assumptions of the prior procurement procedures.<sup>195</sup> Enforcement of the constraint can produce opportunity costs for resources that resolve the constraint, such as energy storage.<sup>196</sup> CAISO implemented a new flexible ramping constraint in its five-minute market optimization.<sup>197</sup> This is an interim measure until market bid-based products are developed under the Flexible Ramping Product initiative to address how to appropriately compensate resources that resolve the constraint.<sup>198</sup> Resources that resolve the constraint are compensated at the shadow price (the marginal unit's resource specific opportunity cost).<sup>199</sup> Additional information on Flexible Ramping Constraint can be found [here](#).

### 4.8.2 CAISO Flexible Ramping Product

The CAISO Board of Governors approved a flexible ramping constraint interim compensation methodology.<sup>200</sup> CAISO will develop and evaluate, through a stakeholder initiative, the creation of a flexible ramping product that allows procurement of sufficient ramping capability through economic bids.<sup>201</sup> Cost causation principles will be used to evaluate how to allocate costs to generation and load.<sup>202</sup> Both tariff and policy development are pending at this time.<sup>203</sup> Additional information about the development of the CAISO Flexible Ramping Product can be accessed [here](#).

## 4.9 CAISO Reliability Services

CAISO is leading an initiative to create an efficient and durable market mechanism for the procurement of backstop capacity, develop necessary conforming changes to various resource adequacy processes, and enhance rules specific to Resource Adequacy resources.<sup>204</sup> This initiative is currently in process and additional information can be accessed [here](#).

## 4.10 CAISO Flexible Resource Adequacy Criteria and Must Offer Obligations

In a joint effort between CAISO, the CPUC, and local regulatory authorities, an effort is underway to ensure flexible capacity resources are available to reliably operate the grid while meeting state energy mandates.<sup>205</sup> CAISO must develop tariff changes to accommodate resource adequacy flexible capacity requirements adopted by regulators, including establishing availability, must offer obligations, and

default provisions for entities that fail to procure flexible capacity allocations.<sup>206</sup> CAISO filed a tariff amendment and awaits FERC approval. Additional information on this issue can be found [here](#).

## 4.11 Energy Storage Interconnection

CAISO developed an initiative to accommodate interconnection of storage without changing existing interconnection tariffs.<sup>207</sup> CAISO and the CPUC have also worked to ensure that the CPUC Rule 21 and CAISO interconnection procedures are similar to make it simpler for applicants to interconnect at either the distribution or transmission grid level. The CAISO initiative also addressed rate treatment issues, processes for modifying existing projects to add storage, resource adequacy issues, and other stakeholder issues. CAISO issued a draft Energy Storage Interconnection proposal on November 18, 2014. Additional information on interconnection can be accessed [here](#).

## 5 Conclusion

This document seeks to provide a snapshot of current and proposed legislative, regulatory, and policy drivers for energy storage in California and how these drivers affect the use of PV systems combined with energy storage.

For updates and more information on the Southern California Rooftop Solar Challenge, visit [www.energycenter.org/sunshot](http://www.energycenter.org/sunshot)

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<sup>1</sup> Generally defined as the price paid by a retail ratepayer for each unit of power consumed from the electric grid. Typically demand charges are applied to the maximum demand during a given month (\$/kW-month).

<sup>2</sup> DOE/EPRI 2013 Electricity Storage Handbook in Collaboration with NREC, Akhil et al., SANDIA Report SAND2013-5131 July 2013, p. XXX.

<sup>3</sup> Kilowatt-hour is defined as: a unit of work or energy equal to that expended by one kilowatt in one hour or to 3.6 million joules by Merriam-Webster Dictionary; A megawatt-hour is one thousand Kilowatt-hours or one million-watt hours.

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<sup>4</sup> Use cases generally describe the benefit that a system may provide to an end use customer or wholesale market participant. It also may refer to the service that the system can provide to a load serving entity at the distribution level, an end use customer, a regulator such as CAISO, or a market participant at the wholesale level.

<sup>5</sup> DOE/EPRI 2013 Electricity Storage Handbook in Collaboration with NREC, Akhil et al., SANDIA Report SAND2013-5131 July 2013, p. 1-28.

<sup>6</sup> *Ibid.* at 21.

<sup>7</sup> *Ibid.*

<sup>8</sup> *Ibid.*

<sup>9</sup> *Ibid.*

<sup>10</sup> *Ibid.* at 22.

<sup>11</sup> *Ibid.*

<sup>12</sup> *Ibid.*

<sup>13</sup> *Ibid.* at 23.

<sup>14</sup> *Ibid.*

<sup>15</sup> *Ibid.* at 24.

<sup>16</sup> *Ibid.* at 24.

<sup>17</sup> *Ibid.*

<sup>18</sup> *Ibid.*

<sup>19</sup> *Ibid.* at 24.

<sup>20</sup> *Ibid.* at 24-25.

<sup>21</sup> Non-Coincident peak demand is defined specifically by each load serving entity or IOU. For example, SDG&E's definition states: Non-Coincident Demand: The sum of the individual peak demands of the components of the customer/group/class or system within a specific period (day, week, month, year) regardless of time of occurrence. For electric TOU accounts, the greater of the highest kW demand for the billing period or 50% of the highest kW demand from the previous 12 months.

<sup>22</sup> DOE/EPRI 2013 Electricity Storage Handbook in Collaboration with NREC, Akhil et al., SANDIA Report SAND2013-5131 July 2013, at 26.

<sup>23</sup> *Ibid.*

<sup>24</sup> Most analysis assumes that cost effective solar systems range between 1 kW and 100 kW depending on load; however, large systems that are larger than 1 MW are deployed and are subject to this analysis. See Cost-Effectiveness of Rooftop Photovoltaics Systems for Consideration in California's Building Energy Efficiency Standards, Draft, May 2013, pp. 4 & 11.

<sup>25</sup> DOE/EPRI 2013 Electricity Storage Handbook in Collaboration with NREC, Akhil et al., SANDIA Report SAND2013-5131 July 2013, p. 75.

<sup>26</sup> *Ibid.*

<sup>27</sup> *Ibid.*

<sup>28</sup> *Ibid.*

<sup>29</sup> *Ibid.* at 76.

<sup>30</sup> *Ibid.* at 76-77.

<sup>31</sup> *Ibid.*

<sup>32</sup> *Ibid.*

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<sup>33</sup> DOE/EPRI 2013 Electricity Storage Handbook in Collaboration with NREC, Akhil et al., SANDIA Report SAND2013-5131 July 2013, p. 49.

<sup>34</sup> *Ibid.*

<sup>35</sup> *Ibid.*

<sup>36</sup> *Ibid.* at 96.

<sup>37</sup> *Ibid.* at 96-97.

<sup>38</sup> *Ibid.* at 53.

<sup>39</sup> *Ibid.*

<sup>40</sup> *Ibid.*

<sup>41</sup> *Ibid.* at 54.

<sup>42</sup> *Ibid.*

<sup>43</sup> *Ibid.*

<sup>44</sup> *Ibid.* at 109.

<sup>45</sup> Grid Energy Storage, U.S. Department of Energy, December 2013, pp. 33-34.

<sup>46</sup> *Ibid.*

<sup>47</sup> Shaw, Z., *Tesla Powerwall & Powerpacks Per-kWh Lifetime Prices vs Aquion Energy, Eos Energy, & Imergy*, May 9, 2015, Found at: <http://cleantechnica.com/2015/05/09/tesla-powerwall-powerblocks-per-kwh-lifetime-prices-vs-aquion-energy-eos-energy-imergy/> ; Shaw, Z., *Tesla Powerwall Price vs Battery Storage Competitor Prices (Residential & Utility-Scale)*, May 7, 2015, Found at: <http://cleantechnica.com/2015/05/07/tesla-powerwall-price-vs-battery-storage-competitor-prices-residential-utility-scale/> .

<sup>48</sup> 2514 was codified in the California Public Utilities Code Section 2835-2839.

<sup>49</sup> CPUC D.13-10-040 (October 17, 2013), p. 2.

<sup>50</sup> *Ibid.*

<sup>51</sup> *Ibid.*

<sup>52</sup> *Ibid.* at 19-21.

<sup>53</sup> *Ibid.* at 10-12.

<sup>54</sup> *Ibid.* at 10.

<sup>55</sup> The Energy Action Plan, created in 2003 and subsequently updated in 2005 and 2008 by the Commission and California Energy Commission, lays out a single, unified approach to meeting California's energy needs by focusing on energy efficiency, demand response, and renewable energy.

<sup>56</sup> *Assigned Commissioner's Ruling Proposing Storage Targets and Mechanisms and Noticing All-Party Meeting* (ACR) issued on June 10, 2013, at p. 21.

<sup>57</sup> CPUC D.13-10-040, pp. 14 & 34.

<sup>58</sup> *Ibid.* at 34.

<sup>59</sup> *Ibid.* at 15.

<sup>60</sup> *Ibid.* at 45-46.

<sup>61</sup> *Ibid.* at 51-52 & 59-60

<sup>62</sup> *Ibid.* at 52.

<sup>63</sup> D.14-02-006 at 10-12.

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- <sup>64</sup> Energy Storage Update: 2014 California, Orrick, accessed, 1/8/14:  
<http://cleanenergypipeline.com/Resources/CE/ResearchReports/Energy%20Storage%20Update%20-%202014%20California%20Storage%20RFO.pdf> .
- <sup>65</sup> See CPUC A.14-02-006.
- <sup>66</sup> *Ibid.*; Energy Storage Update: 2014 California, Orrick, accessed, 1/8/14:  
<http://cleanenergypipeline.com/Resources/CE/ResearchReports/Energy%20Storage%20Update%20-%202014%20California%20Storage%20RFO.pdf> .
- <sup>67</sup> See CPUC A. 16-03-003 Application of San Diego Gas and Electric Company (U 902 M) For Approval of its Energy Storage Procurement Framework as Required by D. 13-10-040 (Filed Mark 1, 2016).
- <sup>68</sup> Note: Incentives change year to year.
- <sup>69</sup> 2014 Self-Generation Incentive Program Handbook, pp. 32-33.
- <sup>70</sup> *Ibid.* at 33.
- <sup>71</sup> *Ibid.* at 38.
- <sup>72</sup> *Ibid.* at 32.
- <sup>73</sup> CPUC D. 15-11-027 implemented California Public Utilities Code Section 379.6(b)(2), which set new GHG emission factor for avoided GHG emission under SGIP.
- <sup>74</sup> SGIP Statewide Report 7-06-15.
- <sup>75</sup> California Public Utilities Code Section 769(b)(1)-(4).
- <sup>76</sup> California Public Utilities Code Section 769(c).
- <sup>77</sup> California Public Utilities Code Section 769(d).
- <sup>78</sup> The Seventh Addition of the RPS Guidebook Section III.G states that a storage device may be considered an addition or enhancement to a renewable generation facility so long as it can be classified as integrated or directly connected energy storage, pp. 64-65; See CPUC D.14-05-033, pp. 10 & 35.
- <sup>79</sup> CPUC D.14-05-033, p. 2.
- <sup>80</sup> *Ibid.* at 14-15.
- <sup>81</sup> CPUC R. 14-07-022, 1/23/15, *Scoping Memo and Ruling of Assigned Commissioner*, pp. 3-4.
- <sup>82</sup> CPUC D.16-01-044, p. 2-5 (January 28, 2016)
- <sup>83</sup> Electric Rule No. 21 Generation Interconnections, Sheet 11, accessed 1/7/15 at:  
[http://www.pge.com/tariffs/tm2/pdf/ELEC\\_RULES\\_21.pdf](http://www.pge.com/tariffs/tm2/pdf/ELEC_RULES_21.pdf) .
- <sup>84</sup> CPUC D.14-04-003, April 10, 2014, p. 31; D.12-09-018, Sept. 13, 2012, pp. 35-36 & Col #4 p. 59.
- <sup>85</sup> Rule 21, Section F.1-2 and Section E.2.b.i.
- <sup>86</sup> See CPUC D.14-04-003, April 10, 2014.
- <sup>87</sup> CPUC D.14-12-035, pp. 2-3.
- <sup>88</sup> *Ibid.* at 9.
- <sup>89</sup> *Ibid.* at 10-13.
- <sup>90</sup> *Ibid.* at 17.
- <sup>91</sup> Staff Phase 2 Report and Proposals in R. 10-12-007, p. 25.
- <sup>92</sup> Energy Storage Interconnection Staff Proposal, July 18, 2014, p. 6.
- <sup>93</sup> *Ibid.* at 7.
- <sup>94</sup> *Ibid.* at 7-8.
- <sup>95</sup> *Ibid.* at 8-9.

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- <sup>96</sup> *Ibid.* at 9-10.
- <sup>97</sup> *Ibid.* at 10-11.
- <sup>98</sup> *Ibid.* at 11.
- <sup>99</sup> See PG&E's Electric Schedule E-6: Residential Time-of-Use Service: [http://www.pge.com/tariffs/tm2/pdf/ELEC\\_SCHEDS\\_E-6.pdf](http://www.pge.com/tariffs/tm2/pdf/ELEC_SCHEDS_E-6.pdf) .
- <sup>100</sup> Southern California Edison, Time-Of-Use Rates FAQ. Available at <https://www.sce.com/wps/portal/home/business/tools/time-of-use>.
- <sup>101</sup> See CPUC R.12-11-005, Attachment A p. 1.
- <sup>102</sup> 2014 Self-Generation Incentive Program Handbook, p. 42.
- <sup>103</sup> California State Fire Marshal- Information Bulletin 14-002: Fire Classification for Roof Mounted Solar Photovoltaic Panels/Modules [Systems] and Application of the 2013 Building Standards Code, p. 1: <http://osfm.fire.ca.gov/informationbulletin/pdf/2014/IB14002PVFireClassification.pdf> .
- <sup>104</sup> California State Fire Marshal- Information Bulletin 14-002: Fire Classification for Roof Mounted Solar Photovoltaic Panels/Modules- 2013 California Building Standards Code Supplement Effective January 1, 2015, p. 1: <http://osfm.fire.ca.gov/informationbulletin/pdf/2014/IB14011FireClassificationPV.pdf> .
- <sup>105</sup> Systems that meet these requirements must comply with Table 608.1 of the Fire Code Section 608: [http://publicecodes.cyberregs.com/st/ca/st/b300v10/st\\_ca\\_st\\_b300v10\\_6\\_sec008.htm](http://publicecodes.cyberregs.com/st/ca/st/b300v10/st_ca_st_b300v10_6_sec008.htm) .
- <sup>106</sup> City of San Diego Development Services: How to Obtain a Permit for Installation of Solar Photovoltaic Systems, Bulletin 301 (September 2014): <http://www.sandiego.gov/development-services/pdf/industry/infobulletin/ib301.pdf> .
- <sup>107</sup> City of Los Angeles Department of Building and Safety- Express Permit Information Sheet For Photovoltaic Installations in 1 & 2 Family Dwellings (June 30, 2014): [http://ladbs.org/LADBSWeb/LADBS\\_Forms/PlanCheck/PV-Install-Wrkshts.pdf](http://ladbs.org/LADBSWeb/LADBS_Forms/PlanCheck/PV-Install-Wrkshts.pdf) .
- <sup>108</sup> California Government Code Section 65850.5(j)(3)(A) defines small residential solar energy system to mean a solar energy system that is no larger than 10 kW alternating current nameplate rating.
- <sup>109</sup> The CAISO market and service territory can be found here: <http://www.caiso.com/about/Pages/OurBusiness/UnderstandingtheISO/The-ISO-grid.aspx> .
- <sup>110</sup> CAISO Energy Storage Interconnection: Draft Final Proposal, November 18, 2014, p. 3.
- <sup>111</sup> *Ibid.* at 5.
- <sup>112</sup> The CAISO Master Controlled Grid Generation Queue-CISO Active Capability List, January 13, 2015.
- <sup>113</sup> CAISO Energy Storage Interconnection: Draft Final Proposal, November 18, 2014,
- <sup>114</sup> *Ibid.*
- <sup>115</sup> Advancing and Maximizing the Value of Energy Storage Technology: A California Roadmap, December 2014, p. 3.
- <sup>116</sup> *Ibid.*
- <sup>117</sup> *Ibid.* at 6.
- <sup>118</sup> *Ibid.*
- <sup>119</sup> *Ibid.*
- <sup>120</sup> *Ibid.*
- <sup>121</sup> *Ibid.*
- <sup>122</sup> *Ibid.*

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<sup>123</sup> *ibid.*

<sup>124</sup> *ibid.*

<sup>125</sup> *ibid.* at 7.

<sup>126</sup> *ibid.*

<sup>127</sup> *ibid.*

<sup>128</sup> *ibid.*

<sup>129</sup> *ibid.*

<sup>130</sup> *ibid.*

<sup>131</sup> *ibid.* at 8.

<sup>132</sup> *ibid.*

<sup>133</sup> *ibid.*

<sup>134</sup> *ibid.*

<sup>135</sup> *ibid.*

<sup>136</sup> *ibid.*

<sup>137</sup> *ibid.*

<sup>138</sup> *ibid.*

<sup>139</sup> *ibid.*

<sup>140</sup> Advancing and Maximizing the Value of Energy Storage Technology: A California Roadmap, December 2014, p. 8.

<sup>141</sup> *ibid.* at 9.

<sup>142</sup> *ibid.*

<sup>143</sup> *ibid.* (FERC addressed the issue of storage charging under a PJM filing by stating that electricity “stored for later delivery” is not “end-use” consumption and is therefore not subject to the jurisdiction of regulatory authorities over retail costs. Docket ER10-1717-000.)

<sup>144</sup> *ibid.*

<sup>145</sup> *ibid.*

<sup>146</sup> *ibid.*

<sup>147</sup> *ibid.*

<sup>148</sup> *ibid.* at 10.

<sup>149</sup> *ibid.*

<sup>150</sup> *ibid.*

<sup>151</sup> *ibid.* (Net energy metering is a tariff established to allow one meter at a customer site that measures the net of the renewable generation production against the customer’s electricity use. The customer is then charged or paid on the net amount according to the tariff. Storage devices paired with net energy metering-eligible generation facilities are governed by CPUC’s net energy metering tariff established through proceeding R.12-11-005 provided in Decision D.14-05-033, issued May 2014.)

<sup>152</sup> *ibid.*

<sup>153</sup> Advancing and Maximizing the Value of Energy Storage Technology: A California Roadmap, December 2014, p. 10.

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<sup>154</sup> *ibid.* at 11.  
<sup>155</sup> *ibid.*  
<sup>156</sup> *ibid.*  
<sup>157</sup> *ibid.*  
<sup>158</sup> *ibid.* at 11-12.  
<sup>159</sup> *ibid.* at 12.  
<sup>160</sup> *ibid.*  
<sup>161</sup> See Expanded Metering and Telemetry Options Phase 2: Distributed Energy Resource Provider (DERP) Draft Final Proposal, June 10, 2015.  
<sup>162</sup> Advancing and Maximizing the Value of Energy Storage Technology: A California Roadmap, December 2014, p. 12.  
<sup>163</sup> *ibid.*  
<sup>164</sup> Advancing and Maximizing the Value of Energy Storage Technology: A California Roadmap, December 2014, p. 13.  
<sup>165</sup> *ibid.*  
<sup>166</sup> *ibid.*  
<sup>167</sup> *ibid.* at 14.  
<sup>168</sup> *ibid.* at 14-15.  
<sup>169</sup> California ISO Management Memorandum To ISO Board of Governors, Decision on Energy Storage and Distributed Energy Resource Proposal, January 27, 2016 (Approved February 2, 2016), p. 2.  
<sup>170</sup> *ibid.*  
<sup>171</sup> *ibid.*  
<sup>172</sup> *ibid.* at 15.  
<sup>173</sup> *ibid.*  
<sup>174</sup> Advancing and Maximizing the Value of Energy Storage Technology: A California Roadmap, December 2014, p. 15.  
<sup>175</sup> Joint Workshop on Multiple-Use Applications and Station Power for Energy Storage: CPUC Rulemaking 15-03-011 and CAISO ESDER 2 Stakeholder Initiative, May 2-3, 2016, p. 5-6.  
<sup>176</sup> *ibid.* p. 19.  
<sup>177</sup> DOE/EPRI 2013 Electricity Storage Handbook in Collaboration with NREC, Akhil et al., SANDIA Report SAND2013-5131 July 2013, p. 133.  
<sup>178</sup> Relevant CPUC, Energy Commission, and ISO Proceedings & Initiatives: CAISO Energy Storage Roadmap: Companion Document, p. 13.  
<sup>179</sup> DOE/EPRI 2013 Electricity Storage Handbook in Collaboration with NREC, Akhil et al., SANDIA Report SAND2013-5131 July 2013, p. 133.  
<sup>180</sup> Federal Electric Regulatory Commission v. Electric Power Supply Association et al., 577 U.S. \_\_\_\_\_ (2006) (Reporter publication pending).  
<sup>181</sup> DOE/EPRI 2013 Electricity Storage Handbook in Collaboration with NREC, Akhil et al., SANDIA Report SAND2013-5131 July 2013, p. 133.  
<sup>182</sup> Relevant CPUC, Energy Commission, and ISO Proceedings & Initiatives: CAISO Energy Storage Roadmap: Companion Document, p. 14.

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<sup>183</sup> *ibid.* at 14.

<sup>184</sup> DOE/EPRI 2013 Electricity Storage Handbook in Collaboration with NREC, Akhil et al., SANDIA Report SAND2013-5131 July 2013, p. 133.

<sup>185</sup> FERC Order No. 792 (Part 2 of 3): Benefits for Energy Storage December 31, 2013, accessed January 20, 2014: <http://lklaw.com/ferc-order-no-792-part-2-of-3-benefits-for-energy-storage/>.

<sup>186</sup> 139 FERC 139 FERC ¶ 61,246, United States of America Federal Energy Regulatory Commission, 18 CFR Part 35, [Docket No. RM10-11-000; Order No. 764], Integration of Variable Energy Resources (Issued June 22, 2012), p. 1

<sup>187</sup> *ibid.* at 43 & 114-115.

<sup>188</sup> Relevant CPUC, Energy Commission, and ISO Proceedings & Initiatives: CAISO Energy Storage Roadmap: Companion Document, p. 15.

<sup>189</sup> CAISO: Renewable Integration Market and Product Review Phase 1: <http://www.caiso.com/27be/27beb7931d800.html>.

<sup>190</sup> Relevant CPUC, Energy Commission, and ISO Proceedings & Initiatives: CAISO Energy Storage Roadmap: Companion Document, p. 13.

<sup>191</sup> *ibid.*

<sup>192</sup> CAISO: Renewable Integration Market and Product Review Phase 1: <http://www.caiso.com/27be/27beb7931d800.html>.

<sup>193</sup> Relevant CPUC, Energy Commission, and ISO Proceedings & Initiatives: CAISO Energy Storage Roadmap: Companion Document, p. 14.

<sup>194</sup> *ibid.*

<sup>195</sup> *ibid.*

<sup>196</sup> *ibid.*

<sup>197</sup> *ibid.*

<sup>198</sup> *ibid.*

<sup>199</sup> *ibid.*

<sup>200</sup> *ibid.* at 15

<sup>201</sup> *ibid.*

<sup>202</sup> *ibid.*

<sup>203</sup> *ibid.*

<sup>204</sup> *ibid.*

<sup>205</sup> *ibid.* at 16.

<sup>206</sup> *ibid.*

<sup>207</sup> *ibid.*



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