# ADVANCING AND MAXIMIZING THE VALUE OF ENERGY STORAGE TECHNOLOGY

## A CALIFORNIA ROADMAP

California ISO
Shaping a Renewed Future

December 2014

*This roadmap is a product of collaboration among three organizations – the California Independent System Operator (ISO), the California Public Utilities Commission (CPUC), and the California Energy Commission. It culminates years of work and input from more than 400 interested parties, including utilities, energy storage developers, generators, environmental groups and other industry stakeholders. DNV GL and Olivine, Inc. provided facilitation and consulting to support the development of the roadmap. While identified actions, venues and priorities will be used by each organization to inform future regulatory proceedings, initiatives and policies, it is not a commitment by any of the organizations to perform the actions. The team is deeply grateful for the time, effort and insight provided by stakeholders to shape the roadmap and looks forward to continuing this interaction as each organization embarks on the actions identified in this roadmap.*

Cover photos from left to right:
Yerba Buena battery energy storage pilot in east San Jose courtesy of PG&E
Interface in garage, customer side of Residential Energy Storage project courtesy of SMUD
Tehachapi Storage Project courtesy of SCE
Pad-mounted battery, utility side of Community Energy Storage project courtesy of SMUD

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# EXECUTIVE SUMMARY

California is a worldwide leader in shifting to sustainable and renewable energy sources, including solar, wind and geothermal power, with the goal to reduce greenhouse gas emissions. But by its nature, electricity must be used the instant it is generated, which makes solar and wind resources challenging to manage on the power grid. Power from these renewable generation sources is produced at different times of the day, and often does not align with the instantaneous demand for electricity.

Ground-breaking energy storage technology is changing all that. This technology harnesses energy generated by the sun during the day, wind gusts late in the afternoon, and energy from sources across the West. It stores it when consumption is low and puts it back onto the grid when needed at peak demand times or to compensate for unanticipated changes in renewable energy output. It is beginning to revolutionize the electric system by enabling increased renewables integration, increasing grid optimization, and reducing greenhouse gas emissions.

Maximizing energy storage in the marketplace will take a network of policies, incentives, and processes to support innovation and manage risk over the next several years. While many organizations are testing energy storage technologies and systems, a comprehensive plan is needed to incorporate storage projects into the state's grid at scale. In a fast-changing technological environment, it is important to have a clear vision of priorities and needed actions to realize the full benefits of energy storage. This document, the Energy Storage Roadmap, identifies actions that can help create a path to a sound marketplace for energy storage resources.

The roadmap focuses on actions that address three categories of challenges expressed by stakeholders:

- Expanding revenue opportunities
- Reducing costs of integrating and connecting to the grid
- Streamlining and spelling out policies and processes to increase certainty

It analyzes the current state to identify needed actions, sets priorities for the next steps and defines the responsibilities of each organization to address the issues. The document highlights actions and will act as a platform to inform future regulatory proceedings, initiatives and policies, however, it does not lay out a plan to perform them. Work on many of those actions is already underway or planned.

In general, high-priority concerns that need to be addressed include refining existing products and driving new ones to market; clarifying operational constraints to connecting energy storage to the grid; reducing costs of metering and connection; and creating a predictable and transparent process for commercializing and connecting storage projects. Deliberate collaboration in the execution of this roadmap will advance energy storage technology to better enable a more efficient, reliable and greener grid.

# INTRODUCTION

## Guidance to advance energy storage

California has been a dynamic force for transitioning to sustainable, renewable energy sources. The state has seen explosive growth in renewable energy in the past several years, particularly with solar installations more than doubling in recent years. The next step in this fast-moving shift towards a more sustainable grid is energy storage technology. Incorporating variable resources requires an accompanying portfolio of resources and contract provisions that provide operational flexibility to quickly change electricity production and consumption and maintain needed output levels for the time required. Energy storage resources are by their nature flexible resources and therefore beneficial to reliable, low-carbon grid operations. The purpose of this roadmap is to support the advancement of energy storage as a grid resource by identifying actions, their priority and the appropriate venue for implementing them.

## State actions to advance energy storage

The state has taken action to advance energy storage, including the passage of Assembly Bill 2514 and the resulting California Public Utilities Commission (CPUC) decision for energy storage procurement targets for each of the Investor Owned Utilities (IOUs) totaling 1,325 MW to be completed by the end of 2020 and implemented by 2024.[1] Additionally, the CPUC provides funding programs including Permanent Load Shifting and the Self Generation Incentive Program that provide incentives for adoption of customer-side energy storage.[2] The California Energy Commission continues to fund critical research to further the effectiveness of energy storage as a viable grid resource through the Electric Program Investment Charge (EPIC).[3] At the national level, the Federal Energy Regulatory Commission (FERC) Order No. 792, provides clarity through its direction to transmission providers to define electric storage devices as generating facilities enabling these resources to take advantage of generator interconnection procedures. Federal incentives such as the Business Energy Investment Tax Credit and the U.S. Department of Agriculture High Energy Cost Grant Program also provides support for energy storage.[4] The United States Department of Energy provides grants to fund research and demonstration of new technologies including storage through their Advanced Research Projects Agency – Energy and Energy Efficiency and Renewable Energy offices.[5]

With this foundation in place, energy storage resources are beginning to enter the California market. As the three California IOUs prepared and carried out resource procurement to satisfy authorizations under the CPUC long-term procurement plan as well as fulfillment of the energy storage targets, stakeholders raised a number of questions that were either not addressed by current policy or unclear. This situation as well as a surge in energy storage projects seeking interconnection to the ISO grid also with questions needing clarification, propelled the CPUC, Energy Commission, and ISO to partner to develop this roadmap.

[1] AB2514 was approved on September 29, 2010 and was entered into California Public Utilities Code, Chapter 7.7, Sections 2835-2839; CPUC decision D14-10-045, October 16, 2014.

[2] CPUC decision on permanent load shifting, D 12-04-045, implemented through resolution E-4586; http://www.cpuc.ca.gov/PUC/energy/DistGen/sgip/aboutsgip.htm

[3] See for example PON-13-302 Developing Advanced Energy Storage Technology Solutions to Lower Costs and Achieve Policy Goals (http://www.energy.ca.gov/contracts/epic.html#PON-13-302)

[4] Business Energy Investment Tax Credit (ITC), 26 USC § 48 and IRS Notice 2013-29; USDA - High Energy Cost Grant Program, 7 CFR 1709

[5] https://eere-exchange.energy.gov/and http://www.arpa-e.energy.gov/?q=arpa-e-programs/range

## Stakeholders voice challenges

In crafting the roadmap, the team worked closely with interested stakeholders, including utilities, energy storage developers, generators, environmental groups, and others to identify challenges facing energy storage and propose actions to address them. Through stakeholder workshops and written comments, three general categories of challenges emerged:

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

Of the issues communicated, stakeholders most frequently expressed the inability to accurately value energy storage for all the services it can provide, especially as evaluated by utilities in their procurement processes. Two additional issues stand out with strong consensus for action. First, to clearly identify the need for flexible capacity and valuation of that capability in the CPUC resource adequacy program, and second, to clarify tariff treatment of storage facilities, in particular between charging and discharging of electricity. Energy storage stakeholders also expressed the need for clarity of wholesale market treatment including the application of the transmission access charge (TAC), available products, models, and rules to support their ability to build a business case. Stakeholders expressed less concern with the technical aspects of storage, such as standardized design and metering and telemetry requirements.

# ROADMAP ACTIONS

The roadmap identifies actions to address the three categories of challenges described above. The venue for each action was also identified along with an assigned priority. The team organized the actions into five topic areas: planning, procurement, rate treatment, interconnection, and market participation.[6] The following table contains the highest priority actions by topic area.

Energy Storage Roadmap: highest priority actions

| | | | |
|---|---|---|---|
| Planning | **CPUC** Describe distribution grid operational needs and required resources characteristics. | **CPUC** Facilitate clarification by IOUs of operational constraints that can limit the ability to accommodate interconnection on the distribution system. | **CPUC** Examine and clarify opportunities for storage to defer or displace distribution upgrades. |
| Procurement | **CPUC & Energy Commission** Consider refinements to the valuation methodologies used by IOUs to support CPUC decisions on storage procurement and make models publicly available. | **CPUC** Clarify rules for energy storage qualification and counting in an evolving Resource Adequacy (RA) framework. | **CPUC** Consider "unbundling" flexible capacity RA counting. |
| Rate treatment | **ISO** Clarify wholesale rate treatment and ensure that the ISO tariff and applicable business practices manuals and other documentation provide sufficient information. | **CPUC** Clarify and potentially modify net energy metering tariffs applicable to cases where energy storage is paired with renewable generators. | |

[6] The appendix provides a table that organized actions according to the category of challenge it addresses.

| | | | |
|---|---|---|---|
| Interconnection | **CPUC & ISO**<br>Clarify existing transmission and distribution interconnection processes, including developing integrated process flow charts and check lists. | **CPUC & ISO**<br>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 & ISO**<br>Evaluate the potential for a streamlined or 'fast track' distribution interconnection process for storage resources that meet certain use-case criteria. |
| Market participation | **ISO**<br>Clarify existing ISO requirements, rules and market products for energy storage to participate in the ISO market. | **ISO**<br>Identify gaps and potential changes or additions to existing ISO requirements, rules, market products and models. | **ISO**<br>Where appropriate, expand options to current ISO requirements and rules for aggregations of distributed storage resources. |

Together, the actions form a roadmap toward potential solutions to advance the use of energy storage in California. It is beyond the scope to offer specific solutions. Instead, solutions will be developed through stakeholder participation at the appropriate venue. The ISO, CPUC, and Energy Commission each have their own processes for allocating resources and developing work plans, which will affect how and when each individual action item is addressed. Note the actions may be carried out differently than the identified priority. This may be due to actions already underway, complexity of a particular action, or through combining actions.[7]

[7] A companion document to this roadmap captures actions taken or underway by each organization: http://www.caiso.com/informed/Pages/CleanGrid/EnergyStorageRoadmap.aspx

## Planning

Planning and operation of the transmission and distribution grids need to be closely coordinated, however there are important differences in the regulatory framework, rules, and architecture. The ISO operates the high-voltage transmission grid and the wholesale energy markets, under the jurisdiction of the FERC. The lower voltage distribution grid is operated by IOUs, municipalities, and other regional entities under the oversight of a local regulatory authority.[8]

The architecture of the transmission and distribution grids differ. The transmission grid is a network where power flows can frequently change directions across the system, while the distribution system is a radial system typically with a single connection to the transmission system where power flows in one direction from the transmission grid to the end-user. As distribution-connected energy resources, including energy storage, become more prevalent, distribution system planning must evolve considering new requirements and capabilities brought by these resources to ensure grid reliability and safety. When performing grid planning, both the ISO and distribution utilities must have a complete understanding of the operational characteristics of storage resources connecting to their systems to assess and address their impact and contribution, including displacing or deferring infrastructure upgrades.

Electric system planning requires clearly defining grid needs to reliably operate the transmission and distribution grids. In the case of the ISO, these needs can be addressed through transmission projects and resources located in specific areas that possess particular operating capabilities. The ISO identifies expected amounts of different types of capacity needed through studies executed in the annual Transmission Planning Process (TPP) and other published studies.[9] The types of needs include system, local, and flexible capacity. System capacity reflects the amount of additional capacity needed to ensure the portfolio of resources is capable of meeting the peak forecast electricity demand. Local capacity needs indicate additional capacity required in a particular regional location to ensure the system can continue to operate when unanticipated generation or transmission outages occur. Flexible capacity refers to the need for resources that can provide ramping capability by increasing or decreasing output quickly. Since ramping capability is required to address needs across the entire ISO grid, flexible capacity is considered a system resource. These ISO studies are used to inform the CPUC's Long-Term Procurement Planning (LTPP) process.[10] This allows for the resulting resources authorized for IOU procurement to embody the needed operational characteristics.

The ISO currently assesses the benefits of anticipated energy storage market resources coming on the system in addressing transmission needs identified in the annual TPP. When energy storage is found to be effective, ISO staff may recommend to the ISO Board that energy storage is the best way to address the need, rather than approving a transmission project. Stakeholders expressed that when energy storage was presented as a transmission asset rather than a market resource, more clarity was needed as to how that is done. This is included in the action items table at the end of this section.

*The Pacific Gas & Electric Helms Pumped Storage Plant represents the most well-known and oldest form of utility scale energy storage. Using two reservoirs at different elevations, water is released to produce electricity and then pumped back up to be stored as energy for use at a different time. The facility has been operational since 1984 and acts as a valuable market resource contributing to the reliable operation of the ISO grid.*

[8] The CPUC is a local regulatory authority that has oversight over the energy service providers including the IOUs and community choice aggregators. Rules for the interconnection of generation resources on the distribution grid that intend to engage in wholesale transactions are under the jurisdiction of the FERC.

[9] http://www.caiso.com/planning/Pages/TransmissionPlanning/Default.aspx. The Flexible Capacity study is known as the "Flexible Capacity Needs Assessment" and can be found at http://www.caiso.com/informed/Pages/StakeholderProcesses/FlexibleCapacityRequirements.aspx

[10] http://www.cpuc.ca.gov/PUC/energy/Procurement/LTPP/

The IOUs are currently developing Distribution Resource Plans as directed by the CPUC to fulfill a requirement of Assembly Bill 327.[11] These plans will identify the optimal locations for distributed energy resources, including energy storage, on the distribution system. A working group called "More than Smart" is a companion effort to the CPUC proceeding to facilitate technical discussions and includes topics outside the current proceeding. One such topic is the need to define coordination between utility and ISO planning. This will ensure that assumptions made in the transmission planning process of the types, amounts, and locations of distributed energy resources are included in distribution planning. Conversely, as resources begin to materialize on the distribution system, assumptions in transmission planning can be adjusted.

### Planning action items

| | | |
|---|---|---|
| 1 Describe distribution grid operational needs and required resources characteristics. | CPUC | High |
| 2 Facilitate clarification by IOUs of operational constraints that can limit the ability to accommodate interconnection on the distribution system. | CPUC | High |
| 3 Examine and clarify opportunities for storage to defer or displace distribution upgrades. | CPUC | High |
| 4 Describe ISO grid operational needs and required resource characteristics. | ISO | Medium |
| 5 Develop coordination process for transmission and distribution system planning. | CPUC, ISO | Medium |
| 6 Clarify assessment of energy storage resources classified as transmission assets to defer or displace transmission upgrades. | ISO | Low |

## Procurement

Several stakeholders expressed the need for a common methodology and tools for evaluating storage for use by utilities and the CPUC in making procurement decisions. In its 2013 decision on storage, the CPUC identified several areas of value that should be considered in the IOU procurement filings.[12] The decision also identified available tools to support valuation but stopped short of defining a specific methodology or tool to be used in future storage procurement cycles. In the decision, the CPUC concluded that each "utility should be allowed to propose its own methodology to evaluate the costs and benefits of bids and evaluate the full range of benefits and costs identified for energy storage in the use-case." The decision further acknowledged that this approach gives IOUs wide latitude to use proprietary protocols for actual project selection.

Under the Public Interest Energy Research (PIER) program, the Energy Commission funded research and development of storage evaluation tools and methodologies to address at least some of the needs in determining the value of storage for the California grid and for energy storage developers. Similarly, under the EPIC program, the Energy Commission also aims to fund the development of storage valuation methodologies and tools with the purpose of making such tools and methodologies transparent and publicly available.

This valuation includes defining products and services that can provide revenue to energy storage and other flexible resources suppliers. These products and services need to be grounded in the operational needs of the transmission and distribution systems. That means clearly defining grid

[11] Public Utilities Code Section 769 was instituted by Assembly Bill 327, Sec. 8 (Perea, 2013). This new code section requires the electrical corporations to file distribution resources plan proposals by July 1, 2015. According to the Code, these plan proposals will "identify optimal locations for the deployment of distributed resources." It defines "distributed energy resources" as "distributed renewable generation resources, energy efficiency, energy storage, electric vehicles, and demand response technologies." The Code also requires the CPUC to "review each distribution resources plan proposal submitted by an electrical corporation and approve, or modify and approve, a distribution resources plan for the corporation. The commission may modify any plan as appropriate to minimize overall system costs and maximize ratepayer benefit from investments in distributed resources." Pursuant to Section 769, the CPUC instituted a rulemaking on August 13, 2014 (R. 14-08-013).

[12] CPUC energy storage proceeding R.10-12-007, Decision D.13-10-040

*Thermal energy storage represents another type of energy storage that can contribute to customer demand management as well as provide grid benefits. This type of storage technology reserves energy produced in the form of heat or cold for use at a different time. While thermal energy storage has historically been used mainly for customer demand management, recent procurement of 25.6 MW from Ice Energy by Southern California Edison (SCE) illustrates its value as a grid resource. The Ice Energy Ice Bear installations like this one at Kohl's facility in Redding, CA will be used by SCE to reduce the demand on distribution infrastructure during peak periods.*

needs through planning processes as described in the previous section, prior to developing products or instituting tariff or procurement mechanisms.

From the distribution perspective, developers contend that energy storage provides benefits to the distribution system, but tariffs are not in place to value these capabilities and procurement does not recognize these additional values. To date, there has not yet been sufficient experience to define and quantify these benefits and establish how these capabilities can be monetized.

Load serving entities under CPUC jurisdiction receive guidance and procurement authorization through the CPUC LTPP and other proceedings. The CPUC requires the load serving entities under its jurisdiction to annually demonstrate that their procured resource portfolio meets system, local, and flexible capacity needs according to its rules and eligibility requirements. This assessment as well as modifications to rules and eligibility requirements are taken up annually in the CPUC Resource Adequacy (RA) proceeding.[13]

Under current RA rules, one component for a resource to be eligible to qualify as RA capacity, it must be found to be deliverable. This deliverability assessment is performed by the ISO and requires that the transmission system can deliver the output of the resource, along with all other resources, to meet planning reserve margin requirements, across the peak timeframe. The current study process for determining deliverability status is consistent with requirements for system and local RA resources as these needs are based on meeting resource shortage conditions during peak load. Flexible capacity, however, addresses ramping needs not resource shortage conditions during peak load. The current RA counting qualifies each resource as a system or local resource, with local resources also counting as system resources. Because flexible capacity is considered a system resource, this counting rule results in all resources being subject to the deliverability assessment. The potential "unbundling" of flexible capacity and clarification of counting rules will benefit energy storage developers by removing the deliverability assessment for those resources providing only flexible capacity.

## Procurement action items

| | | |
|---|---|---|
| 7 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 |
| 8 Clarify rules for energy storage qualification and counting in an evolving RA framework. | CPUC | High |
| 9 Consider "unbundling" for flexible capacity RA counting. | CPUC | High |
| 10 Prepare summary of efforts underway focused on developing models for energy storage valuation and plans public distribution. | Energy Commission | Medium |

13 The current CPUC RA proceeding is R.14-10-010

## Rate treatment

Since energy storage acts as both a generator and consumer of electricity, stakeholders questioned what rates, wholesale or retail, will apply when consuming electricity to charge the storage device as well as whether other charges that traditionally apply to consumption will be levied.

There are many ways that energy storage can be used. The CPUC in its recent energy storage proceeding defined a number of use cases to inform the determination of the procurement target as well as other ongoing and future policy initiatives. In general, as it pertains to rate treatment, it is important to distinguish 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. The second case typically occurs at a customer facility to help mitigate demand charges and minimize consumption during higher rate periods.

To provide context for the needed actions, for the first case, grid services can be provided to the wholesale market or to the utilities for distribution system management. In the case that the energy reserved using storage technology is providing grid services to the wholesale market, the rate treatment is consistent with that of a generation resource.[14] This treatment was clarified as part of the ISO's recent energy storage interconnection stakeholder initiative.[15] The energy storage resource wholesale market activities for positive (discharging) or negative (charging) energy dispatches will be settled at the wholesale market locational marginal price. The ISO considers storage resources in the charging mode as storing electricity for later resale in the markets, rather than consumption of this electricity.

When the energy storage resource is located on the distribution system or on the customer site behind the utility meter, and seeks participation in the wholesale market, the resource can use the FERC jurisdictional tariff governing access to the wholesale market called the WDAT.[16] Stakeholders also questioned 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 service. For this case, the CPUC needs to determine rate treatment. Currently, utilities must file an application with the CPUC on a case-by-case basis to determine the rate treatment.[17]

*As part of the Irvine Smart Grid Demonstration Project, Southern California Edison, instrumented a neighborhood with smart grid technology including energy storage. This project benefited from funding from the DOE and the Energy Commission to bring a variety of technologies, communication and control systems to the distribution system and the customer. Instrumentation at the customer's homes included energy management systems, smart appliances, thermostats, electric vehicles, rooftop solar and energy storage. The project also included community energy storage, shown here, to provide capabilities across a larger area. This smart grid technology establishes the foundation that enables customers to provide automated responses to calls for changes in consumption. Taken together these responses can be a significant resource to help manage the electric grid. It will be important to clarify rate treatment to ensure these capabilities can be leveraged by the utility and the wholesale market.*

[14] 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

[15] http://www.caiso.com/informed/Pages/StakeholderProcesses/EnergyStorageInterconnection.aspx

[16] Each utility has a separate Wholesale Distribution Access Tariff (WDAT) and can be found on their respective websites
http://www.pge.com/en/b2b/newgenerator/index.page
https://www.sce.com/wps/portal/home/regulatory/open-access-information
http://www.sdge.com/generation-interconnections/wholesale-generator-transmission-interconnections

[17] One example is the requirement for SCE to file applications to determine rate treatment of the energy storage devices selected through the recent local capacity requirement procurement. This procurement focused on replacing the capacity lost because of the retirement of the San Onofre Generating Station.

As previously described, distribution grid services that energy storage technology could provide are not yet fully defined, nor are products available to monetize these services. Development of specific products and tariffs may need to be considered as distribution utility services emerge.

For the second case, when energy storage is used by the customer to manage their energy costs, the CPUC jurisdictional retail rate is applied. However, stakeholders communicate the need to optimize the value of the energy storage sited with renewable generation such as rooftop solar. Stakeholders express that the current rules limit the ability to use a storage device to save electricity produced by a renewable resource for use at different times of day without affecting the ability of the host customer to receive net energy metering credit for those exports.[18,19]

Another component of rate treatment is whether other charges that traditionally apply to electricity consumption will be levied. For wholesale market participation, the ISO clarified the application of infrastructure charges including the transmission access charge (TAC), wheeling charges, and uplifts to energy storage in its recent energy storage interconnection initiative.[20,21] In addition, the treatment of station power and round trip efficiency loss needs to be clarified and potentially refined.[22,23] The ISO needs to ensure its documentation provides sufficient information and is updated as policies evolve.

### Rate treatment action items

| | | | |
|---|---|---|---|
| 11 | Clarify wholesale rate treatment and ensure that the ISO tariff and applicable business practices manuals and other documentation provide sufficient information. | ISO | High |
| 12 | Clarify and potentially modify net energy metering tariffs applicable to cases where energy storage is paired with renewable generators. | CPUC | High |
| 13 | Clarify 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, and want to provide wholesale grid services. | CPUC | Medium |
| 14 | Evaluate the need and potential to define distribution level grid services and products. | CPUC | Medium |
| 15 | Consider a new proceeding to develop distribution grid services provided by distributed energy resources to the utility or other entities. | CPUC | Low |

[18] 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.

[19] The CPUC recently opened proceeding R.14-07-002 to address net energy metering successor tariffs by December 31, 2015.

[20] The transmission access charge is a charge paid by all utility distribution companies and metered sub-system operators with gross load in a participating transmission owner service territory. The access charge recovers the participating transmission owner's transmission revenue requirement.

[21] The wheeling access charge is the charge assessed by the ISO that is paid by a scheduling coordinator for the use of the ISO controlled grid for the transmission of energy from the ISO controlled grid for delivery to a point outside the transmission and distribution system of a participating transmission owner.

[22] Station power is energy for operating electric equipment, or portions thereof, located on the generating unit site owned by the same entity that owns the generating unit, which electrical equipment is used exclusively for the production of energy and any useful thermal energy associated with the production of energy by the generating unit

[23] Round trip efficiency losses refers to energy lost in the conversion between charging and discharging.

## Interconnection

Most physical energy storage resources connecting to the utility or the ISO-managed electric grid must adhere to the established interconnection standards and processes. Interconnection tariffs outline the rules for installing or modifying the installation of an energy storage project. The interconnection process includes application and study phases that determine whether and what types of electric grid upgrades are needed to accommodate the project. Technical requirements include data, equipment, telemetry, and metering and can vary based on the type, location, size, and intended operation of the facility. The method for apportioning the costs of grid and facility upgrades as well as cost recovery differs based on the use of the resource and the interconnection tariff.

There are three available interconnection tariffs that can apply. Generally, facilities connecting to the distribution system not intended for wholesale market participation, and facilities connecting behind a customer's meter that may or may not result in a net export of energy, interconnect using the CPUC jurisdictional tariff Rule 21. Resources connecting to the distribution system planning to participate in the wholesale market use the FERC jurisdictional WDAT. Finally, energy storage resources interconnecting to the transmission system are governed by the ISO interconnection tariff.[24]

Stakeholders expressed the importance of having a clear and predictable interconnection process to support the ability to make accurate estimates of project cost as well as the time to bring a facility on line and begin providing services. Suggestions included developing an integrated process flowchart especially between Rule 21 and the utility WDAT, differentiating between interconnection levels, project configurations, and the project's intended operating behavior based on the market products and services it will provide. Energy storage developers also stated the need to streamline the processes as well as develop a smooth transition process to move a project from Rule 21 to WDAT as business requirements change.

In addition to interconnection process clarity, stakeholders communicated candidate areas for process streamlining, modification, or additions to address operational characteristics not currently considered. In particular, energy storage developers desire a "fast track" distribution interconnection process for those projects that have little impact on the distribution system. Several stakeholders view the addition of energy storage that reduces load without creating electricity export to be a candidate for a fast track process. Furthermore, the screens applied to determine eligibility to current fast track interconnection processes under Rule 21 and WDAT need to be reviewed and potentially revised.

Additionally, questions remain about the interconnection options available to a customer-sited resource that does

*Several interesting configurations involving energy storage are emerging on customer sites. The Powertree installation shown here is located at a residential multi-unit dwelling and includes electric vehicle charging infrastructure as well as energy storage. Rooftop solar provides energy to the building tenants as well as for use to charge the battery. In addition to providing service to the building, Powertree is preparing to provide grid services to the wholesale market. This installation is one of the first of its type seeking to directly participate in the wholesale market and is exposing gaps and needs for interpretation in the current distribution interconnection process. The process has taken significantly more time than expected and has resulted in extensive studies, equipment reviews, duplicative metering and other equipment required by the existing processes. Powertree continues to work with the utility to resolve issues and fill gaps. This experience helped identify several roadmap actions that focus on bringing clarity as well as improvements to the interconnection process, installation and operational requirements, rate treatment and other areas.*

[24] New interconnection requests to the ISO grid are governed by the Generator Interconnection and Deliverability Allocation Procedures (GIDAP) approved by FERC in 2012. The GIDAP rules are contained in ISO Tariff Appendix DD.
http://www.caiso.com/Documents/AppendixDD_GeneratorInterconnectionAndDeliverabiltyAllocationProcess_Dec19_2014.pdf

not result in net energy export electricity but could be offered in the wholesale market. As previously described in the rate treatment section, stakeholders also communicate the desire to define and establish a new fee structure for the interconnection of non-exporting resources. The CPUC continues to work through Rule 21 policy issues where these topics may be considered.[25]

The ISO recently conducted a stakeholder process on energy storage interconnection and found that the ISO's current rules can accommodate the interconnection of storage projects to the ISO grid consistent with the treatment of generators.[26] To be treated consistently with generation means that it must respond to ISO dispatch instructions, including curtailment, to manage power flow on the transmission system during both charging and discharging operations. The ISO will consider updates to the energy storage interconnection rules based on its learning and experience with the energy storage interconnection requests currently being processed.

Measuring electricity output and the ability to communicate information using standard methods is essential for all resource types and not unique to energy storage. Additionally, it is important to have standards for installations to ensure safety and reliability as well as streamlining installations.

Telemetry refers to the measurement of real-time electricity production or consumption of an energy storage installation or other resource. Electric grid operators rely on this critical information to ensure reliability. Stakeholders conveyed concerns with the ISO telemetry requirements as well as the obligations imposed by the utility. Accuracy for telemetry is less strict than for metering used for settlement, however, because of its operational function, network connectivity must be available around the clock with low latency. Resource aggregations require an additional system function to determine the total real-time measurement of aggregate resource production or consumption. This telemetry aggregation function may directly combine the individual telemetry feeds from the individual resources to the aggregate level or may use a sampling of individual feeds to statistically create the aggregated total.[27]

Metering refers to the measurement of generation and consumption with strict standards for accuracy, security, and safety used to determine customer bills as well as payments and charges to all types of resources participating in the wholesale market.[28]

Stakeholders communicated that duplicative metering requirements increase installation as well as ongoing costs. Stakeholders cited instances when both a utility meter and ISO meter are required. This occurs when the energy storage resource is providing services to the wholesale market as well as to the distribution grid and potentially a utility customer.

As technology continues to evolve, most standard energy storage installations will include embedded, integrated meters or other low cost solutions that are not yet acceptable by the utility or ISO as metering or telemetry solutions. Utilizing these on-board measurement devices, once proven as accurate and tamper-resistant, could significantly reduce cost for telemetry and metering.

Both telemetry and metering require network connectivity to transport the measurement data to the utility and the ISO. For the ISO, this is typically provided over a leased line referred to in ISO documentation as the Energy Communication Network (ECN). The ISO has taken recent steps to allow communication over the internet in specific cases as means to reduce costs.

Finally, stakeholders expressed concern over the lack of fire protection standards and codes applicable to energy storage. It was noted by stakeholders that "one-size-fits-all" ordinances may not always be feasible given the range of circumstances of various municipal and city regulations and codes. Needed actions could include examination of the current requirements and identification of best practices for consideration in statewide regulations or development of standards by developers such as Underwriters Laboratories (UL).

Verification of interconnection to bring a facility on-line includes various tests and certifications. Stakeholders conveyed the need to review and revise the certification process for testing and certifying energy resources, especially in preparation for provision of ancillary services to the wholesale market. The existing approach designed for generators is not well suited for energy storage. Generators have mostly static expectations for output capabilities, while energy storage differs in its operation shifting from supply to consumption.

[25] Order Instituting Rulemaking on the Commission's Own Motion to improve distribution level interconnection rules and regulations for certain classes of electric generators and electric storage resources, R.11-09-011

[26] http://www.caiso.com/informed/Pages/StakeholderProcesses/EnergyStorageInterconnection.aspx

[27] Depending on the market services provided, the ISO requires 4-second to 1-minute telemetry.

[28] Depending on the market services provided, the ISO requires five-minute to hourly meter data reporting.

### Interconnection action items

| | | |
|---|---|---|
| 16 Clarify existing transmission and distribution interconnection processes, including developing integrated process flow charts and check lists. | CPUC, ISO | High |
| 17 Evaluate opportunities to coordinate between Rule 21 and WDAT to streamline interconnection processes and ability to efficiently move between processes. | CPUC, ISO | High |
| 18 Evaluate the potential for a streamlined or 'fast track' distribution interconnection process for storage resources that meet certain use-case criteria. | CPUC, ISO | High |
| 19 Evaluate defining and establishing a fee structure to interconnect non-exporting resources. | CPUC | High |
| 20 Define and support entities collecting telemetry data from multiple facilities, to allow bulk submission of this data. | ISO | High |
| 21 Review and potentially modify utility WDAT to incorporate applicable modifications consistent with the ISO interconnection tariff including adjustments that streamline requirements | ISO, (FERC) | Medium |
| 22 Review ISO's procedure for testing and certifying resources for ancillary services. | ISO | Medium |
| 23 Evaluate expanding technology options for providing resource telemetry. | ISO | Medium |
| 24 Initiate and administer a working group to evaluate common telemetry framework and recommend actions to standardize resource telemetry requirements. | Energy Commission | Medium |
| 25 Evaluate and consider refinements to ISO telemetry requirements. | ISO | Medium |
| 26 Research and evaluate refinements to IOU telemetry requirements. | Energy Commission | Medium |
| 27 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 |
| 28 Evaluate the rules 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 |
| 29 Establish the value and develop a framework under which the ISO and utility can share metering and meter data. | CPUC, Energy Commission, ISO | Medium |
| 30 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. | Energy Commission, CPUC | Medium |
| 31 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 |
| 32 Evaluate establishing rules for utility subtractive metering for behind-the-meter wholesale resources to improve resource granularity, visibility, and clarity in retail billing. | CPUC | Low |

## Market participation

Market participation primarily refers to the participation of energy storage resources in the established ISO wholesale market. It also refers to the ability of these resources to provide additional services to the distribution utilities or the end-use customer whether the service is contracted for through a market or not. Stakeholders identified several challenges to market participation surrounding the specific requirements to provide metering and telemetry. Actions to address these challenges are included in the interconnection section above.

Energy storage developers articulated that one of the biggest challenges to realizing the full value of energy storage is the ability for a single installation to provide multiple services to several entities with compensation provided through different revenue streams. Stakeholders provided several examples of multiple-use applications of interest for energy storage.

One such example involves the storage device serving as a transmission asset while also participating in the markets. This affords the energy storage developer greater certainty of revenues in that it could recover part of its costs through the TAC and also earn market revenues. FERC has not approved such an arrangement to the best of the ISO's knowledge, and prior FERC orders identify the challenges and hurdles associated with classifying storage facilities.[29] One critical concern, addressed in the Nevada Hydro order, is that the ISO cannot be responsible for determining the operation of a resource that it would compensate as it could affect market prices.

Stakeholders also highlight an emerging scenario where the energy storage facility provides reliability services to the distribution grid and services to the wholesale market. Even though energy storage may provide benefits to the distribution system, tariffs and rules are not in place to value these capabilities and procurement does not recognize these additional values. As the utilities solidify distribution grid needs that may be satisfied by energy storage and the CPUC begins to consider supporting policy, it will be important to include the rules that enable this multiple-use scenario.

The most frequently provided example involves the energy storage device providing demand management  at the customer site while also participating in the wholesale

*The sodium sulfur battery located at the Pacific Gas and Electric facility in Vaca-Dixon, CA was the first to provide services to the ISO market. Utility scale energy storage such as this one offers significant flexibility in balancing the grid under a variety of conditions. The potential operational benefits include:*

- *reliability and flexible energy management – offsetting the variability of preferred resources such as wind and solar power*
- *voltage support – helping maintain local grid voltage, which supports grid stability by providing a steady push of electrons across long-distance power lines*
- *reserves – providing replacement reserves called upon when the grid is under stress*
- *demand response and load management – flatting spikes in high consumer energy use, which helps bring down wholesale energy prices during peak periods, and increasing consumption during times of abundant low-cost supply*

[29] See Western Grid Development, LLC., 130 FERC ¶61,056, reh'g denied, 133 FERC ¶61,029 (2010); The Nevada Hydro Company, 122 FERC ¶61,272 (2008). See also Third Party Provision of Ancillary Services; Accounting and Financial Reporting for New Electric Storage Technologies, 135 FERC ¶61,240 (2011).

market. Stakeholders articulate that demand management actions, especially for peak-load occurs during a predictable range of time. The storage device could be reserved for this use during this time and participate in the ISO market the remainder of the time.

Also, in the interest of maximizing revenue, stakeholders hold a perception that there are insufficient wholesale market products available to fully realize the value energy storage can provide. This perspective highlights the need for the ISO to communicate existing products and modeling options for market participation.[30] Market products and models are developed to facilitate wholesale market procurement of needed services and capabilities. The ISO is engaging stakeholders in an initiative to develop a flexible ramping product to ensure sufficient amounts of ramping capability can be procured through economic bids. Preparing and discussing this information with stakeholders may result in the identification of gaps and opportunities to make changes to current requirements, rules, or market products.

A gap that began to emerge during the roadmap effort involved the ability for a resource to be modeled as part of an aggregation with other resources. For example, developers are pursuing siting energy storage together with renewable generation resources. This has been referred to as a hybrid configuration and includes a broader set of combinations, including combinations with demand response. Beyond ISO market modeling, the CPUC should assess how each utility considers hybrid configurations based on its procurement targets and needs. In addition, where appropriate, the ISO should consider expanding options to current ISO requirement and rules for aggregations of distributed storage resources. Because the scope of possible multiple use and hybrid configurations is potentially quite large, stakeholders suggested that it would be useful to identify and prioritize storage configurations. For the higher priority configurations, the ISO or CPUC can identify key requirements and drivers and determine how best to support these configurations.

## Market participation action items

| | | |
|---|---|---|
| 33 Clarify existing ISO requirements, rules and market products for energy storage to participate in the ISO market. | ISO | High |
| 34 Identify gaps and potential changes or additions to existing ISO requirements, rules, market products and models. | ISO | High |
| 35 Where appropriate, expand options to current ISO requirements and rules for aggregations of distributed storage resources. | ISO | High |
| 36 Define and develop models and rules for multiple-use applications of storage. | CPUC, ISO | Medium |
| 37 Identify and develop models of hybrid storage configurations for wholesale market participation. | ISO | Medium |
| 38 For configurations of greatest interest or likelihood of near-term development, clarify the requirements and rules for participation. | CPUC, ISO | Medium |

[30] The various market models provide options for how the resource will be characterized and operated in the market. The Non-Generating Resource (NGR) model is the primary model used for energy storage, however, the proxy demand resource model, pumped storage, and NGR – Regulation Energy Management model are other options.

# NEXT STEPS

The roadmap effort fulfilled its objective to enhance the team's understanding of challenges articulated by stakeholders and identified actions that can be taken to address these challenges. It was not the goal to create a timeline to carry out the actions, rather to assign priorities and identify appropriate venues to address them.[31] This roadmap will be used by the CPUC, Energy Commission and the ISO to inform future regulatory proceedings, initiatives and policies.

Although CPUC staff participated actively in the roadmap development, staff cannot dictate future CPUC actions. Parties are encouraged to actively participate in CPUC proceedings to raise issues and work in collaboration with utilities and other stakeholder to affect desired policies. The best way for individuals and companies to follow these developments and track progress toward meeting goals is to become parties or to subscribe to relevant CPUC proceedings.

[31] A companion document to this roadmap captures actions taken or underway by each organization: http://www.caiso.com/informed/Pages/CleanGrid/EnergyStorageRoadmap.aspx.

Appendix: Actions mapped to revenue opportunities, cost reduction, and increased certainty

| Actions to increase revenue opportunities | Venue | Priority | Section # |
|---|---|---|---|
| **Define grid needs to identify gaps in existing markets and identify new products** | | | |
| • Describe distribution grid operational needs and required resources characteristics. | CPUC | High | Planning 1 |
| • Facilitate clarification by IOUs of operational constraints that can limit the ability to accommodate interconnection on the distribution system. | CPUC | High | Planning 2 |
| • Describe ISO grid operational needs and required resources characteristics. | ISO | Medium | Planning 4 |
| • Develop coordination process for transmission and distribution system planning. | CPUC, ISO | Medium | Planning 5 |
| **Clarify existing wholesale market product and models available for energy storage** | | | |
| • Clarify existing ISO requirements, rules and market products for energy storage to participate in the ISO market. | ISO | High | Market Participation 33 |
| **Refine existing and add new wholesale and retail market products to meet grid needs** | | | |
| • Examine and clarify opportunities for storage to defer or displace distribution upgrades. | CPUC | High | Planning 3 |
| • Identify gaps and potential changes or additions to existing ISO requirements, rules, market products and models. | ISO | High | Market Participation 34 |
| • Evaluate the need and potential to define distribution level grid services and products. | CPUC | Medium | Rate Treatment 14 |
| • Clarify assessment of energy storage resources classified as transmission assets to defer or displace transmission upgrades. | ISO | Low | Planning 6 |
| **Identify gaps in rate treatment and clarify if existing rules address gaps** | | | |
| • Clarify wholesale rate treatment and ensure that the ISO tariff and applicable business practices manuals and other documentation provide sufficient information. | ISO | High | Rate Treatment 11 |
| • Clarify and potentially modify net energy metering tariffs applicable to cases where energy storage is paired with renewable generators. | CPUC | High | Rate Treatment 12 |
| • Clarify 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, and want to provide wholesale grid service. | CPUC | Medium | Rate Treatment 13 |
| • Consider a new proceeding to develop distribution grid services provided by distributed energy resources to the utility or other entities. | CPUC | Low | Rate Treatment 15 |
| **Determine storage configurations and multiple use applications to enable prioritization and development of requirements** | | | |
| • Define and develop models and rules for multiple-use applications of storage. | CPUC, ISO | Medium | Market Participation 36 |
| • Identify and develop models of hybrid storage configurations for wholesale market participation. | ISO | Medium | Market Participation 37 |
| • For configurations of greatest interest or likelihood of near-term development, clarify the requirements and rules for participation. | CPUC, ISO | Medium | Market Participation 38 |

| Actions to increase revenue opportunities, *continued* | Venue | Priority | Section # |
|---|---|---|---|
| **Assess existing methodologies for valuing energy storage and develop a common methodology.** | | | |
| • 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 | Procurement 7 |
| • Clarify rules for energy storage qualification and counting in an evolving RA framework. | CPUC | High | Procurement 8 |
| • Consider "unbundling" for flexible capacity RA counting. | CPUC | High | Procurement 9 |
| • Prepare summary of efforts underway focused on developing models for energy storage valuation and plans for public distribution. | Energy Commission | Medium | Procurement 10 |

| Actions to reduce cost | Venue | Priority | Section # |
|---|---|---|---|
| **Review interconnection process for distribution-connected resources to reduce costs** | | | |
| • Evaluate defining and establishing a fee structure to interconnect non-exporting resources. | CPUC | High | Interconnection 19 |
| • Review and potentially modify utility WDAT to incorporate applicable modifications consistent with the ISO interconnection tariff including adjustments that streamline requirements. | ISO, (FERC) | Medium | Interconnection 21 |
| • Review ISO's procedure for testing and certifying resources for ancillary services. | ISO | Medium | Interconnection 22 |
| **Review and modify telemetry requirements** | | | |
| • Define and support entities collecting telemetry data from multiple facilities, to allow bulk submission of this data. | ISO | High | Interconnection 20 |
| • Where appropriate, expand options to current ISO requirements and rules for aggregations of distributed storage resources. | ISO | High | Market Participation 35 |
| • Evaluate expanding technology options for providing resource telemetry. | ISO | Medium | Interconnection 23 |
| • Initiate and administer a working group to evaluate common telemetry framework and recommend actions to standardize resource telemetry requirements. | Energy Commission | Medium | Interconnection 24 |
| • Evaluate and consider refinements to ISO telemetry requirements. | ISO | Medium | Interconnection 25 |
| • Research and evaluate refinements to IOU telemetry requirements. | Energy Commission | Medium | Interconnection 26 |
| **Review and modify metering requirements** | | | |
| • 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 | Interconnection 27 |
| • Evaluate the rules 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 | Interconnection 28 |
| • Establish the value and develop a framework under which the ISO and utility can share metering and meter data. | CPUC, Energy Commission, ISO | Medium | Interconnection 29 |
| • 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. | Energy Commission, CPUC | Medium | Interconnection 30 |
| • Evaluate establishing rules for utility subtractive metering for behind-the-meter wholesale resources to improve resource granularity, visibility, and clarity in retail billing. | CPUC | Low | Interconnection 32 |
| **Assess codes and standards to identify gaps and best practices** | | | |
| • 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 | Interconnection 31 |

| Actions to increase certainty | Venue | Priority | Section # |
|---|---|---|---|
| **Clarify interconnection processes to make it predictable and transparent** | | | |
| • Clarify existing transmission and distribution interconnection processes, including developing integrated process flow charts and check lists. | CPUC, ISO | High | Interconnection 16 |
| • Evaluate opportunities to coordinate between Rule 21 and WDAT to streamline interconnection processes and ability to efficiently move between processes. | CPUC, ISO | High | Interconnection 17 |
| • Evaluate the potential for a streamlined or 'fast track' distribution interconnection process for storage resources that meet certain use-case criteria. | CPUC, ISO | High | Interconnection 18 |

*This roadmap and material generated in support of the roadmap can be found on the California ISO website:*

*http://www.caiso.com/informed/Pages/CleanGrid/EnergyStorageRoadmap.aspx.*

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California ISO

Shaping a Renewed Future