BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking to Develop an Electricity Integrated Resource Planning Framework and to Coordinate and Refine Long-Term Procurement Planning Requirements.	Rulemaking 16-02-007 (Filed February 11, 2016)

INFORMAL COMMENTS OF THE CALIFORNIA ENERGY STORAGE ALLIANCE ON THE STAFF CONCEPT PAPER ON INTEGRATED RESOURCE PLANNING

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Pursuant to an August 11, 2016 request by the California Public Utilities Commission ("Commission") Energy Division Staff, the California Energy Storage Alliance ("CESA")[1] hereby submits these informal written comments on the questions embedded in the *Staff Concept Paper on Integrated Resource Planning*, published on August 11, 2016 ("Staff Concept Paper").

I. INTRODUCTION.

CESA generally supports the Staff Concept Paper as a balanced, high-level concept piece that will effectively inform the development of a draft Staff Proposal expected to be released in

[1] 1 Energy Systems Inc., Adara Power, Advanced Microgrid Solutions, AES Energy Storage, Amber Kinetics, Aquion Energy, Bright Energy Storage Technologies, Brookfield, California Environmental Associates, Consolidated Edison Development, Inc., Cumulus Energy Storage, Customized Energy Solutions, Demand Energy, Eagle Crest Energy Company, East Penn Manufacturing Company, Ecoult, Electric Motor Werks, Inc., ElectrIQ Power, ELSYS Inc., Enphase Energy, GE Energy Storage, Geli, Gordon & Rees, Green Charge Networks, Greensmith Energy, Gridscape Solutions, Gridtential Energy, Inc., Hitachi Chemical Co., Ice Energy, Innovation Core SEI, Inc. (A Sumitomo Electric Company), Invenergy LLC, Johnson Controls, K&L Gates, LG Chem Power, Inc., Lockheed Martin Advanced Energy Storage LLC, LS Power Development, LLC, Mercedes-Benz Research & Development North America, Nature & PeopleFirst, NEC Energy Solutions, Inc., NextEra Energy Resources, NGK Insulators, Ltd., NRG Energy LLC, OutBack Power Technologies, Parker Hannifin Corporation, Powertree Services Inc., Qnovo, Recurrent Energy, RES Americas Inc., Saft America Inc., Samsung SDI, Sharp Electronics Corporation, Skylar Capital Management, SolarCity, Sovereign Energy, Stem, SunPower Corporation, Sunrun, Swell Energy, Trina Energy Storage, Tri-Technic, UniEnergy Technologies, Wellhead Electric, Younicos. The views expressed in these Comments are those of CESA, and do not necessarily reflect the views of all of the individual CESA member companies. (http://storagealliance.org).

December 2016. In these informal comments, CESA offers its recommendations to further clarify and improve the Energy Division Staff's proposed Integrated Resource Planning ("IRP") process to achieve state policy objectives, grant some flexibility to load-serving entities ("LSEs") to procure for their specific needs, and facilitate a fair, transparent, and efficient process. CESA also provides its response to selective questions.

II. GUIDING PRINCIPLES FOR PROCESS DEVELOPMENT.

Question 1: Are any of the guiding principles inconsistent with any statutory, Commission, or other requirements? If so, please identify the principle, explain the inconsistency, and suggest how the inconsistency should be resolved.

CESA believes that the six guiding principles for IRP process development are appropriate and are generally consistent with statutory and Commission requirements of Public Utilities ("P.U.") Code Section 454.52. To be fully consistent with P.U. Code Section 454.52(a)(1), however, CESA recommends that the Commission expand the first principle to read: "The structure and design of the IRP process should prioritize minimizing long-term customer costs *through 2030* while meeting the state's other policy goals, *which includes appropriately accounting for the full range of benefits of various supply and demand-side resources* [emphasis added]." As proposed in the Staff Concept Paper, the Commission would run the risk of focusing exclusively on cost rather than expanding the focus to account for the environmental, reliability, and economic benefits that different resources can provide.

CESA recommends the above revision to the first principle for multiple reasons. First, CESA believes that the planning horizon of the IRP process should align with state policy objectives, which stipulate that the state must reduce greenhouse gas ("GHG") emission levels to 40% from 1990 levels by 2030, and must procure at least 50% of eligible renewable resources by 2030. Each of these requirements have targets through 2030. The IRP process must therefore move beyond continuing the 10-year resource planning horizon from the Long-Term Procurement Planning ("LTPP") process and evaluate the full costs and benefits of resources across a longer time frame. Distributed energy resources, for example, provide long-term benefits to the grid and to customers by avoiding or deferring infrastructure investments, by diversifying the resource mix, and by reducing rates through avoided generation costs – benefits which may not be fully accounted for in a traditional 10-year planning horizon.[2] Meanwhile, for bulk storage projects in particular, benefits may persist beyond typical contract terms for smaller resources, which puts bulk storage projects at a disadvantage compared to shorter-lived assets when it comes to cost recovery over a shorter contract term. Given long-term state policy objectives, CESA finds it appropriate to also set a guiding principle that aligns with these objectives and establishes an IRP process that looks to 2030 and beyond.

Second, the first principle should be expanded to elaborate on what is meant by 'meeting the state's policy objectives'. As provided in P.U. Code Section 454.52(a)(1), these include strengthening the diversity, sustainability, and resilience of the grid, enhancing distribution systems and demand-side energy management, minimizing localized air pollutants, and supporting disadvantaged communities. In many cases, resources that best meet these other policy objectives are not necessarily the lowest cost in the strictest sense. In other words, optimizing procurement for the most reliable and least cost resources may not optimize for the cleanest resources, or for the resources that diversify the resource mix, or support customer choice and disadvantaged communities. When the benefits are fully accounted for and quantified, then CESA believes that the IRP process can appropriately procure for the resources

[2] Tim Woolf, et al. *Benefit-Cost Analysis for Distributed Energy Resources: A Framework for Accounting for All Relevant Costs and Benefits*, Advanced Energy Economy Institute, published on September 22, 2014. pp. 15, 54.

that minimize customer costs. The first principle as currently written could cause higher-cost resources to not be procured in the IRP process because the full range of benefits is not accounted for.

III. CONCEPTUAL INTEGRATED RESOURCE PLANNING FRAMEWORK.

Question 5: Which Option do parties prefer: A, B, or C? If not Option C, please provide your rationale and include consideration of any potential drawbacks or adverse impacts.

CESA prefers Option C, the 'Hybrid Approach,' that involves the Commission producing a multi-LSE optimized portfolio that is used as a benchmark for individual LSEs generating their own LSE-specific portfolios CESA agrees that this approach allows the LSEs to customize portfolios to meet their individual needs and provides sufficient guidance for the LSEs to meet other statutory and Commission requirements. The Commission has a 'bird's eye' view of state policy objectives and overall grid needs that the LSEs do not have. Under Option A, LSEs would be procuring for their specific needs rather than taking a system-level approach of creating an optimal portfolio that meets state policy objectives while accounting for the portfolios of other LSEs in California. Under Option B, the Commission would be taking an overly top-down approach that is a resource intensive process and does not fully account for or understand LSE-specific needs. CESA therefore agrees with the Energy Division Staff that Option C is the best approach that balances flexibility and sufficient guidance and accountability pursuant to statutory and Commission requirements.

Even as Option C is more efficient of staff resources and time, CESA envisions the process of developing multi-LSE portfolios as a baseline to be a challenging task that will require significant resources due to the need for substantial modeling and continuous stakeholder engagement and vetting. As proposed in the Staff Concept Paper, this baseline is intended to determine compliance of the IRPs filed by the LSEs, particularly if the IRPs deviate significantly from the baseline portfolio. CESA believes that this process of setting an appropriate baseline portfolio will require significant resources and time to ensure an efficient regulatory approval process for resulting IRPs.

> **<u>Question 6</u>: What electricity market, regulatory, and/or operational implementation issues may emerge under Option C? Please identify potential solutions to the implementation issues identified.**

As highlighted in Table 7 of the Staff Concept Paper, there are key electricity market and regulatory issues related to coordination and integration of resource-specific proceedings into the IRP proceeding. As the Commission conducts multi-LSE preferred portfolio development, it will need to incorporate the outputs of the resource-specific proceedings. A challenge will be in aligning the procedural timelines of different proceedings. For example, the Energy Storage Rulemaking (R.15-03-011) conducts biennial solicitation cycles where solicitations are conducted in even years (*i.e.*, 2014, 2016) and applications are approved in odd years (*i.e.*, 2015, 2017), barring any legal and/or regulatory delays. In this case, the most up-to-date energy storage procurements can be incorporated into IRP modeling scenarios. However, for other resource-specific proceedings, there may need to be some work to align procurement cycles with that of the IRP proceeding to ensure that the most accurate inputs are being incorporated into IRP modeling scenarios.

Furthermore, Table 7 highlighted key electricity market and regulatory issues related to the procurement and cost recovery of long-lead-time resources. The challenge for long-lead-time resources such as bulk storage is in the cost allocation of these projects given the system-wide benefits of these resources to multiple LSEs. Currently, there is no adequate multi-LSE procurement mechanism. Under Option C, with the Commission developing a multi-LSE preferred portfolio, bulk storage procurement therefore could be authorized through the "CPUC Guidance for LSEs" if the Commission identifies the potential need for bulk storage resources in its modeling exercises. If so authorized, the Commission could explicitly direct the LSEs to determine a procurement framework to share the benefits and costs of bulk storage resources, and given the long lead time, the expected bulk storage procurement could be incorporated as an input in future biennial IRP planning scenarios.

> **<u>Question 9</u>: Please provide recommendations for the IRP filing frequency, contract period, and process for submitting updates or modifications in the IRP-LTPP 2016-2017 proceeding. Where appropriate, distinguish between any near-term recommendations (i.e., for IRP 2017) and longer-term recommendations (i.e., for cycles beyond IRP 2017).**

Given the time and resources required to develop multi-LSE preferred portfolios and to conduct solicitations and contract negotiations, CESA believes a biennial IRP filing frequency is appropriate. Especially with the rapid growth of renewable and/or distributed energy resources in California, the resource mix on the grid changes rapidly over short periods of time and therefore requires proactive and relatively frequent grid planning.

> **<u>Question 11</u>: Are there any categories or types of guidance for filing entities that are not addressed above, but should be? If so, explain why and include a reference to the relevant guiding principles for IRP process development.**

CESA recommends that the Commission consider a pre-filing review by the Energy Division of all Applications to ensure compliance with all procurement authorization requirements. To minimize delays due to appeals, the Commission could conduct a limited pre-filing review prior to the filing of the final Application. This change to the IRP process would support the third principle of providing "clear and consistent market signals to facilitate sufficient, *timely*, and cost-effective technology and infrastructure investments [emphasis added]."

Furthermore, in support of the third principle, CESA recommends that the Commission be open to making multiple decisions in response to an Application for contract approval. Often, multiple projects are included in a single Application, as authorized previously in the LTPP proceeding, but the merits and/or fairness of a single project or contract may unduly delay other projects in the same Application that warrant expeditious Commission approval. The Commission should institute flexibility into the IRP filing process and allow the LSEs an option to request more than one decision.

Question 13: What filing process would be appropriate for IRPs (e.g., advice letter, application)? Please refer to the procedural steps in Table 3 in your response. Please include as much detail as possible, including whether the process should be confidential or public, posted to a website or served on a proceeding, etc.

CESA recommends that the Commission require an Application filing process for the IRPs. Just as with the LTPP proceeding, IRP procurements require close public scrutiny and vetting to ensure compliance with the Commission's guidance, which includes important cost, reliability, and other state policy-related requirements. The Advice Letter process does not allow for the appropriate level of stakeholder review.

Question 14: What consequences/incentives would be appropriate for submitting non-compliant/compliant IRPs? What criteria should be used?

CESA does not recommend that there should be incentives for submitting compliant IRPs. LSEs should be expected to meet the guidance set forth by the Commission. However, CESA believes that there could be incentives provided for LSEs that submit IRPs that exceed the requirements of the Commission's guidance, for example, by including resource procurements in its Application for disadvantaged communities. CESA does not recommend any specific incentive mechanism at this time but such ideas should be explored in this proceeding.

On the other hand, while CESA favors the idea of having consequences for submitting non-compliant IRPs, it may be difficult to set the criteria to determine if and when IRPs are non-compliant given the multiple dimensions and objectives of the Commission's guidance. CESA views consequences for non-compliant IRPs to be difficult to demonstrate and implement in practice. CESA, however, is open to the Commission's or other parties' suggestions on this subject.

Question 20: Are there any other options for how the IRP process should address deviations between actual procurement and approved IRPs? What is the preferred approach to handling these deviations? Please explain your answer.

CESA does not have specific alternatives to offer how the IRP process should address deviations between actual procurement and approved IRPs at this time. The best option may be to evaluate these deviations for reasonableness during the Commission review period for IRPs and Applications.

Question 21: Should the quantity or assumed cost of a particular resource type included in the CPUC-preferred portfolio define the amount of that resource that is cost-effective to procure? If so, should it be used to limit procurement below pre-established targets (such as 50% RPS) pursuant to statutory language that requires the CPUC to maintain low rates and avoid disproportionate rate impacts? Alternatively, should the IRP process have authority to raise procurement targets but not to lower them? Why or why not?

In developing the multi-LSE preferred portfolio, the Commission should have looked at current cost levels and trends as well as referenced past procurements to define the amount of a resource that is cost-effective to procure. As long as the LSE is able to demonstrate reasonableness for under-procuring or over-procuring the quantity of a particular resource type in the multi-LSE preferred portfolio, CESA believes that it is unnecessary to artificially limit procurement in any way.

IV. <u>KEY ISSUES FOR IRP GUIDANCE: SCENARIOS, MODELING, GHG PLANNING TARGETS, AND PROCESS ALIGNMENT.</u>

<u>Question 25</u>: What types of future uncertainties should be included among the candidate portfolios generated in IRP 2017? Please provide a prioritized list of uncertainties that should be represented, along with an explanation for the priority level assigned to each uncertainty. Please indicate which uncertainties may be appropriate to represent together and which should be represented separately, and why. For example, it may be reasonable to represent the impact of multiple GHG-reduction activities that all increase electric sector load together to create a single "high load" future in order to represent the maximum load stress on the electric system?

CESA recommends that the Commission include a 'high energy storage' scenario as it conducts its modeling and develops multi-LSE preferred portfolios. CESA notes that the 2016 LTPP Assumptions and Scenarios did not evaluate alternative portfolios that include high levels of energy storage beyond the 1.325 GW as authorized in the Storage Rulemaking. Track 2 within R.15-03-011 is in the process of considering revised procurement targets and CESA therefore believes that the IRP assumptions and scenarios should examine a 'high energy storage' scenario to measure the benefits in terms of reduced curtailments, emissions, and production costs as compared to a 'standard energy storage' baseline scenario.

V. <u>POTENTIAL ELECTRICITY MARKET AND REGULATORY ISSUES.</u>

<u>Question 33</u>: For each of the identified issues: (a) Indicate the priority on a scale of 1 to 3, with 1 being the highest priority; and (b) Identify critical path items and associated dependencies that need to be addressed.

CESA identifies four issues in Table 7 as the highest priority market and regulatory issues in this proceeding – *i.e.*, deserving of a "3" on the priority scale. First, pre-existing statutory requirements associated with particular resources and utilization of outputs from other resource specific proceedings of the Commission are critical as the IRP proceeding is positioned as an umbrella proceeding that optimizes the state's resource mix. CESA believes it is important to maintain these resource-specific procurement authorization vehicles, especially in situations where proceedings are intended to serve a unique purpose - such as market transformation. In R.15-03-011, for example, procurement targets have been set for energy storage to develop an understanding of energy storage benefits, procurement, and operations. In maintaining these resource-specific proceedings, the Commission will need to align regulatory approval cycles to ensure that the most recent outputs from these proceedings are aligned with those of the IRP in order to determine the resource procurements needed beyond those already authorized in these resource-specific proceedings. This will involve coordinating with stakeholders from each of the individual resource-specific proceedings.

Second, long-lead-time resources and cost allocation between multiple LSEs requires evaluation in this proceeding. Bulk storage resources, for example, provide significant benefits to the grid in the form of reduced curtailment, emissions, and production costs, especially in a solar-dominant renewables portfolio.[3] However, bulk storage face barriers to procurement such as extensive licensing requirements, geotechnical and engineering studies, and cost allocation of new transmission lines.[4] These challenges are not unique to bulk storage and are similar to general development issues affecting utility-scale development. In fact, bulk storage is also known to be proven, efficient and reliable. What is most challenging for bulk storage is the lack of a clear procurement framework and authorization for LSEs, and that in turn is partly a function of longer lead times beyond planning horizons, and multi-LSE portfolio benefits. Major challenges and barriers to bulk storage procurement are discussed in further detail in a California

[3] Shucheng Liu. "A Bulk Energy Storage Resource Case Study with 40% RPS in 2024," presented at the 2015-2016 Transmission Planning Process Stakeholder Meeting on February 18, 2016.

[4] Collin Doughty, et al. "Bulk Energy Storage in California," California Energy Commission Staff Paper, published in July 2016. pp. 18-19. http://www.energy.ca.gov/2016publications/CEC-200-2016-006/CEC-200-2016-006.pdf

Energy Commission ("CEC") Staff Paper published in July 2016 and provided as Attachment A to these informal comments.

As highlighted in CESA's response to Question 6, the Commission could direct the LSEs to develop a procurement framework to share the benefits and costs of bulk storage resources across multiple LSE off-takers if a need for bulk storage resources is identified. One such procurement framework may be the 'contingent procurement concept' proposed by Southern California Edison ("SCE") and cited by Eagle Crest Energy at a Bulk Energy Storage Workshop held at the California Energy Commission ("CEC") in November 2015, which involves building a pipeline of projects under development that would provide a backstop in case bulk energy storage projects under negotiation or contract fail to deliver.

Question 34: Identify the top six issues in the final list.

CESA identifies the following as the top six issues in the list in order of importance:

- Long-lead-time resources (*e.g.*, pumped hydroelectric storage and transmission beyond California borders)
- Cost sharing and/or cost allocation among multiple LSEs
- Pre-existing statutory requirements associated with particular resources (*e.g.*, energy efficiency, storage, renewables, distributed generation, demand response)
- Utilization of outputs from other resource specific proceedings of the Commission
- Potential widespread adoption of DERs
- Potential regionalization of the CAISO's jurisdiction

VI. CONCLUSION.

CESA appreciates the opportunity to submit these informal comments on the Staff Concept Paper and looks forward to working with the Commission and the parties in this proceeding going forward. CESA hopes that these informal comments will help inform a deeper discussion of the more detailed aspects of the IRP process during the planned September 26, 2016, workshop as well as the anticipated December 2016 Staff Proposal.

Respectfully submitted,

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Date: August 31, 2016

ATTACHMENT A:
CEC Staff Paper on Bulk Energy Storage in California

STAFF PAPER

Bulk Energy Storage in California

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July 2016 CEC-200-2016 -006

DISCLAIMER

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"*Joint California Energy Commission and California Public Utilities Commission Long-Term Procurement Plan Workshop on Bulk Energy Storage"* November 20, 2015.
http://www.energy.ca.gov/research/notices/#11202015

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ABSTRACT

This report summarizes the issues discussed at a November 20, 2015, workshop held at the California Energy Commission on bulk energy storage in California. The workshop included discussions of opportunities for bulk energy storage to contribute to California's renewable energy goals and challenges facing new bulk energy storage projects in California.

Keywords: Energy storage; pumped hydro; compressed air energy storage; greenhouse gas emissions; renewable energy; distributed generation, AB 2514

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EXECUTIVE SUMMARY

As California moves toward meeting its greenhouse gas reduction and renewable energy goals, the state's electric grid is expected to evolve rapidly. Increased renewable energy on the grid will present grid operators with new challenges, such as short, steep electricity demand ramps and fewer conventional resources that maintain electric grid stability. Bulk energy storage, which includes pumped hydroelectric energy storage and other large-scale energy storage methods, is seen as a key resource to help meet the challenges of renewable energy integration onto California's electric grid.

In November 2015, California Energy Commission Chair Robert Weisenmiller and California Public Utilities Commission President Michael Picker conducted a workshop to discuss bulk energy storage in California. The workshop included speakers from California's energy agencies, utilities, energy storage developers, and other stakeholders. Workshop speakers presented on several topics, including the challenges of planning the electric grid and developing future bulk energy storage projects, the potential for bulk energy storage to address grid challenges, and the operations of existing bulk energy storage projects in California.

This paper summarizes the presentations and public comments from the bulk energy storage workshop, as well as the written comments submitted after the workshop.

Introduction

California has led the country in the reduction of fossil fuel consumption and energy and transportation greenhouse gas (GHG) emissions through numerous initiatives over the past decade. In 2006, the California Global Warming Solutions Act of 2006, Assembly Bill (AB) 32 (Núñez, Chapter 488, Statutes of 2006), was signed by Governor Arnold Schwarzenegger with the goal to reduce California's GHG emissions to 1990 levels by 2020. With California progressing toward AB 32 targets,[1] Governor Edmund G. Brown, Jr. signed Executive Order B-30-15 on April 29, 2015, which increased California's GHG reduction target to 40 percent below 1990 levels by 2030. Six months later, the Governor signed the Clean Energy and Pollution Reduction Act of 2015, Senate Bill 350 (De León, Chapter 547, Statutes of 2015), which requires the state to generate at least half of its electricity from qualified clean, renewable resources and double energy efficiency in all existing, vital end uses throughout the state by 2030.

As the amount of renewable energy on the electric grid increases toward 50 percent, new challenges arise to manage these variable resources safely, reliably, and affordably. Challenges include short, steep electricity demand ramps, overgeneration[2] risk, and fewer conventional resources that can provide frequency response. The California Independent System Operator (California ISO) forecasts show that by 2020, the California ISO balancing authority area[3] could experience a 13,000 megawatt (MW) ramp within a three-hour period as increasing amounts of solar and other variable energy sources come on-line.[4]

Additionally, the announcement of the Diablo Canyon nuclear plant retirement in 2025 could drive even higher penetration of renewable energy in southern California. The Diablo Canyon shutdown will prompt the replacement of the 2 GW of capacity that will be lost, and renewable energy will be integral to replace the lost capacity.

Energy storage is widely acknowledged as one option available to support grid flexibility and reliability. In some circumstances, energy storage can reduce the cost of renewable resource intermittency and help manage the physical grid constraints that limit high

1 "California Greenhouse Gas Emission Inventory – 2015 Edition," California Air Resources Board, accessed March 2, 2016. http://www.arb.ca.gov/cc/inventory/data/data.htm.

2 Overgeneration occurs when total demand is less than or equal to the sum of regulatory must-take generation, regulatory must-run generation, and reliability must-run generation Regulatory must-take generation refers to generating facilities that are allowed to generate electricity without being subject to competition. Regulatory must-run generation refers to facilities that are allowed to generate electricity when hydro resources are spilled for fish releases, irrigation, and agricultural purposes, and to generate power that is required by federal or state laws, regulations, or jurisdictional authorities. Reliability must-run refers to generating facilities that generate power that is needed to ensure system reliability.

3 The collection of generation, transmission, and loads within the metered boundaries of the balancing authority in which the balancing authority maintains load-resource balance.

4 California ISO (2013). "What the Duck Curve Tells Us About Managing a Green Grid." https://www.caiso.com/Documents/FlexibleResourcesHelpRenewables_FastFacts.pdf.

penetration of renewable resources. California is procuring energy storage as it implements Assembly Bill 2514 (Skinner, Chapter 469, Statutes of 2010), the energy storage legislation under which the California Public Utilities Commission (CPUC) is prompting a 1,325 MW energy storage target for California's investor-owned utilities (IOU). However, pumped storage projects larger than 50 MW are not eligible toward the 1,325 MW target. Although the smaller-scale energy storage projects that will help meet the 1,325 MW target can provide important benefits to the grid, long-duration bulk energy storage projects larger than 50 MW, such as pumped hydroelectric storage and compressed air energy storage, will play a very important role in meeting future grid needs in California, including the 13,000 MW ramp expected by California ISO by 2020. Bulk energy storage, also known as *grid-scale energy storage*, can include any technology used to store energy on a large scale within a power grid.

On November 20, 2015, Chair Robert Weisenmiller, the California Energy Commission lead commissioner for electricity and natural gas, and CPUC President Michael Picker conducted a workshop to discuss bulk energy storage in California. California ISO President and CEO Stephen Berberich and CPUC Commissioner Carla Peterman, the lead commissioner for the CPUC's Energy Storage Procurement proceeding (R.15-03-011), also attended the workshop.[5]

This paper summarizes issues discussed at the November 20, 2015, workshop, including the ways in which operations of existing pumped storage projects are meeting changing grid needs. Presentations on new and emerging technologies and projects highlight the technical, financial, and regulatory barriers that developers of new bulk storage projects face. The paper concludes with suggestions for next steps to enhance the use of existing bulk energy storage and remove barriers to develop new bulk energy storage projects.

Chair Weisenmiller encapsulated the opportunity by stating:

> California obviously has a massive water infrastructure, including pumped storage…as we have more and more renewables, how do we… optimize that? So one of the things I'm looking for is how do people use their existing pumped storage facilities, and are there ways we can do more with that?[6]

President Picker added that California has a challenge to quantify the benefits of energy storage "in relationship to other technologies so that we can really get at those criteria for least cost/best fit, and especially in terms of greenhouse gas emissions, but also the system reliability and overall costs[7]."

Summing up the problem, California ISO President and CEO Stephen Berberich said,

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5 The workshop agenda is accessible at http://docketpublic.energy.ca.gov/PublicDocuments/15-MISC-05/TN206690_20151119T101531_Bulk_Storage_Workshop_Agenda.pdf.

6 Transcript of 11/20/15 Joint Workshop with the California Energy Commission and the California Public Utilities Commission, California Energy Commission, November 20, 2015, pg. 2.

7 Transcript of 11/20/15 Joint Workshop with the California Energy Commission and the California Public Utilities Commission, California Energy Commission, November 20, 2015, pg. 53.

> Clearly as the system continues to evolve here in California and we aspire to show the world how all this can fit together, storage is going to be a critical element of that. And we certainly have the opportunity for distributed storage. But I think bulk storage will provide a great opportunity to offset conventional generation in a number of ways, one, from a contingency perspective, two, from a ramping perspective, and three, just from a load management perspective. So we need to certainly explore bulk storage in earnest as an opportunity to help kind of fit all the pieces together.[8]

8 Transcript of 11/20/15 Joint Workshop with the California Energy Commission and the California Public Utilities Commission, California Energy Commission, November 20, 2015, p. 4.

Planning Context

A variety of legislation, policies, and programs in California affect energy storage, two of which are the CPUC's Long-Term Procurement Planning Proceeding (LTPP) (R.13-12-10) and AB 2514. The LTPP proceeding is the CPUC's "umbrella" proceeding that ensures system reliability by looking ahead 10 years from the perspective of system needs, local needs, grid integration, and flexible resources. AB 2514 encourages California to incorporate energy storage into the electricity grid. This section will discuss how bulk energy storage is handled in these two areas.

Long-Term Procurement Planning

Analysis in the LTPP starts with the Energy Commission's *Integrated Energy Policy Report* electricity demand forecast as a primary input. LTPP analysis incorporates forecasts of load, distributed generation, energy storage, energy efficiency, demand response, combined heat and power, resource retirements, and generation flexibility. The LTPP proceedings generally operate on a two-year cycle. If a procurement need is identified through the LTPP, an investor-owned utility (IOU) is authorized to hold a request for offers to fill the need using least-cost, best-fit principles.

The most recent 2014 LTPP evaluates the electric system and determined that there was insufficient evidence to authorize procurement of resources for flexible capacity. The LTPP capacity assumptions show relatively flat future demand and declining supply due to retirement of once-through cooling power plants. Bulk storage may have the capability to provide value to the system in the future, but other methods, including demand response, greater regional coordination, time-of-use rates, flexible loads, and flexible generation resources, can provide benefits as well.

With competition from other valuable methods, bulk storage opportunities may be overlooked. Bulk storage projects are generally large projects that have substantial capital costs and very long project lifetimes, often 50 years or more. These high upfront costs and long project timelines make it difficult for bulk storage projects to compete in the LTPP process with projects that have much shorter time frames and fewer uncertainties.

Additional barriers to bulk storage projects in the LTPP process include site requirements and environmental screenings. To bid into the LTPP request for offers, site control must be established, which is generally more costly for larger bulk storage projects and puts these projects at a competitive disadvantage compared to other types of projects. Bulk storage projects, such as pumped hydro and compressed air energy storage, are restricted in terms of project location due to their site-specific nature. The best sites for bulk storage projects may not be within the local capacity areas in which they are needed.

Other barriers to bulk storage projects include studies over a 10-year or longer time frame. There are too many uncertainties related to project financing and economics to go forward with a project without a clear indication of need, especially in comparison to competing projects, such as battery energy storage projects, that often have much shorter time frames and less development risk. Uncertainty surrounding cost allocation and the lack of institutional knowledge are additional barriers to successful bulk energy storage development.

As LTPP proceedings move forward, consideration of bulk energy storage as a potential solution to meet system needs will be important, especially with more renewable energy on-line in California.

Assembly Bill 2514

AB 2514 requires the CPUC to determine appropriate targets, if any, for the state's IOUs to procure viable and cost-effective energy storage systems. AB 2514 also requires the state's publicly owned utilities to consider adopting energy storage targets.

The CPUC created an energy storage framework and established energy storage procurement targets for the state's IOUs to implement this bill. The combined IOU target is 1,325 MW of energy storage procurement by 2020. These energy storage projects must address integration of renewable energy sources, grid optimization (including peak-load reduction, reliability needs, or deferment of transmission or distribution upgrades), or GHG emissions reductions. This energy storage target will be a major driver of energy storage installations in California through 2020.

Battery energy storage projects have been the primary energy storage technology procured during the initial stages of this program. Although bulk energy storage has not been included in the CPUC's implementation of AB 2514 to date, some stakeholders have filed comments encouraging the CPUC to expand its energy storage procurement proceeding to include targets for new bulk energy storage projects.[9] Pumped storage projects greater than 50 MW are not eligible under the CPUC's target in order to avoid a single large project fulfilling an IOU's entire energy storage procurement goal. Encouraging installation of a variety of energy storage technologies is one goal of the CPUC's energy storage targets, and the installation of a single large project to meet the target would negate that goal.

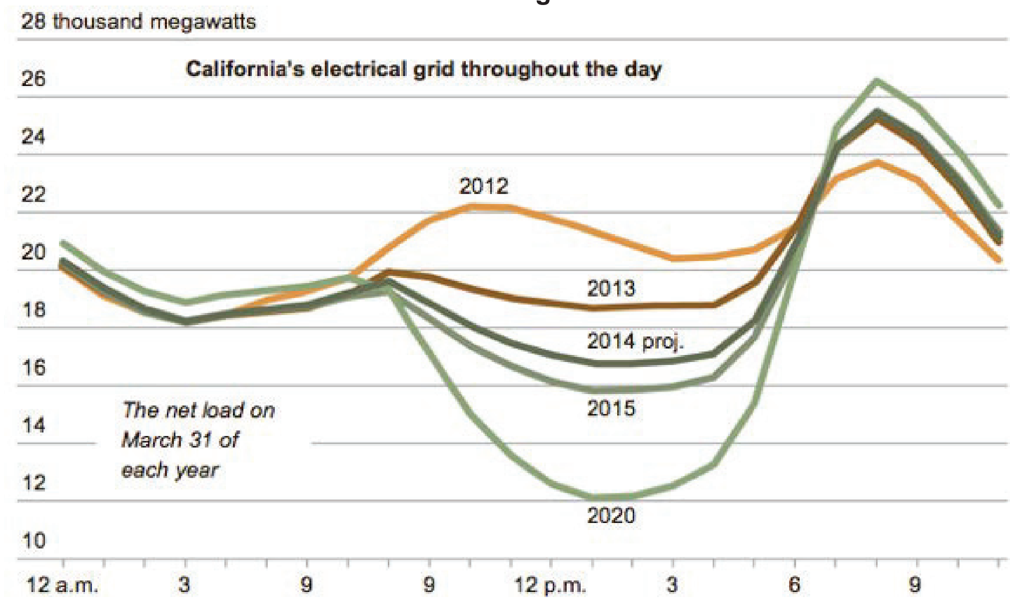
Projects must be on-line by 2024 to qualify for current AB 2514 energy storage target requirements. As discussed, project timelines for bulk energy storage are often on the order of 10 years or more; therefore significant changes would be necessary for bulk energy storage projects to qualify for this program.

9 Comments submitted to "Order Instituting Rulemaking to consider policy and implementation refinements to the Energy Storage Procurement Framework and Design Program (D.13-10-040, D.14-10-045) and related Action Plan of the California Energy Storage Roadmap," accessed March 2, 1016. http://delaps1.cpuc.ca.gov/CPUCProceedingLookup/f?p=401:56:1832503084198::NO.

Bulk Storage Role in Meeting a 50 Percent Renewables Portfolio Standard

California has experienced significant changes in the operating characteristics of the electric grid as higher amounts of renewable energy come on-line. **Figure 1** illustrates these changes, which are often referred to as "the duck curve."[10] The *duck curve* refers to the net load on the system, or total electric demand on the system minus wind and solar generation. As renewable energy capacity increases, particularly from solar, the shape of the curve changes significantly. Because solar energy peaks in the middle of the day, but peak demand generally occurs in the late afternoon to early evening, net demand increases very sharply in the afternoon hours. These conditions will create a variety of challenges on the grid, including steep demand ramps over a short period of time in which generation must be brought on-line or ramp down quickly to avoid the risk of overgeneration. *Overgeneration* refers to conditions in which electricity supply exceeds demand, leading to the need to reduce generation.

Figure 1: California ISO Net Load 2012 Through 2020



Source: California ISO

10 California ISO (2013). "What the Duck Curve Tells Us About Managing a Green Grid." https://www.caiso.com/Documents/FlexibleResourcesHelpRenewables_FastFacts.pdf

Role of Bulk Energy Storage

At the bulk energy storage workshop, Mark Rothleder of California ISO and Arne Olson of Energy and Environmental Economics (E3) reported the results of recent research that investigates the challenges expected to arise as California moves toward a 50 percent Renewables Portfolio Standard (RPS).

With roughly 25 percent renewable penetration today,[11] California is already experiencing excess generation and curtailment at certain times of the day and year. As California moves toward 50 percent renewables, projections by E3, the National Renewable Energy Laboratory, and others indicate that 10 to 25 percent of total renewable production may be curtailed.[12,13] As renewable generation is curtailed, less renewable energy can count toward the RPS goal. To meet the RPS goal, additional renewable capacity must be installed, which would increase costs. Storage, including bulk energy storage, is one potential solution to this problem.

Using the new RESOLVE model,[14] E3 demonstrated that energy storage can provide two types of services: long duration services, for example energy storage during times of overgeneration, and short duration services, such as ancillary services.[15] Preliminary results from the model show that in cases with high solar penetration, significant quantities of storage are needed. This need, however, can be reduced or delayed if other strategies such as renewable portfolio diversity, time of use rates, demand response, and improved regional coordination are implemented. The quantity, type, and duration of storage will depend on the relative costs of the different storage technologies.

California ISO Bulk Energy Storage Case Study

Dr. Shucheng Liu presented results of a study California ISO conducted for the 2014 LTPP proceeding to look at bulk storage.[16] California ISO studied several scenarios to assess bulk storage as a solution to renewable curtailment, assessing the ability for bulk storage to reduce production costs and carbon dioxide emissions, as well as the renewable energy capacity needed to reach a 40 percent RPS goal.

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11 "Tracking Progress – Renewable Energy," California Energy Commission, accessed March 23, 2016. http://www.energy.ca.gov/renewables/tracking_progress/documents/renewable.pdf.

12 Transcript of 11/20/15 Joint Workshop with the California Energy Commission and the California Public Utilities Commission, California Energy Commission, November 20, 2015, p. 6.

13 Denholm, Paul et. al., *Overgeneration From Solar Energy in California: A Field Guide to the Duck Chart.* National Renewable Energy Laboratory, Golden, Colorado: November, 2015.

14 *Resolve Model Documentation,* available at https://www.caiso.com/Documents/RESOLVEModelDocumentation.pdf.

15 Transcript of 11/20/15 Joint Workshop with the California Energy Commission and the California Public Utilities Commission, California Energy Commission, November 20, 2015, p. 12.

16 Review of the ISO LTPP System Flexibility Study, California ISO. http://www.caiso.com/Documents/Presentation_2014LTPPSystemFlexibilityStudy_SHcall.pdf.

The scenarios included various levels of overbuilding wind energy or solar energy to meet a 40 percent RPS and compared the role of bulk storage in determining the solar or wind capacity needed. Across several scenarios studied for meeting the 40 percent RPS by 2024, significant curtailment of renewable energy occurred, and bulk storage provided benefits in all the scenarios studied. However, bulk storage provides greater benefits to an RPS portfolio with higher levels of solar energy as opposed to wind energy due to the high ramp rates and midday peak of solar energy.

These studies confirm that bulk energy storage projects should be considered as part of planning for future grid needs. Further work is needed to determine not only the cost of bulk energy storage in comparison with other potential solutions, but the operational effectiveness and contribution to GHG emission reductions.

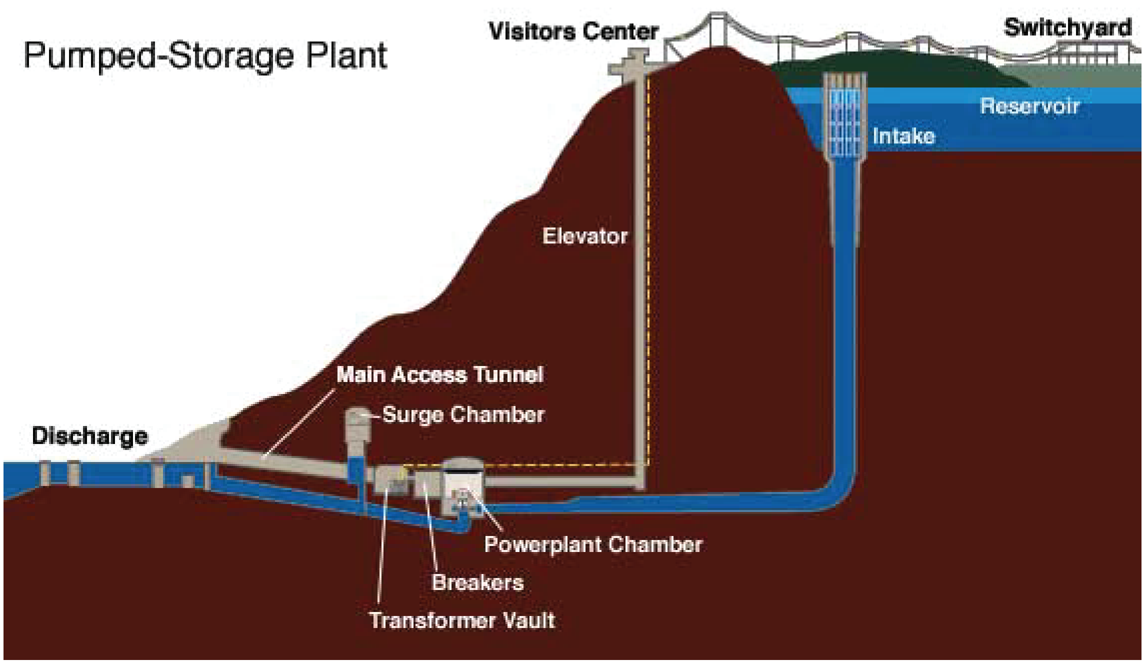
Bulk Energy Storage Technologies

Pumped hydroelectric energy systems are the primary bulk energy technology deployed in California. However, other technologies, including compressed air energy systems and advanced rail energy systems, have potential as bulk energy storage options as well.

Pumped Hydro

Commercially deployed since the 1890s, pumped hydroelectric energy is the dominant utility-scale electricity storage technology in California and worldwide. A typical pumped hydro facility uses pumps and generators to move water between an upper and lower reservoir (**Figure 2**). When electricity is cheap during times of low demand, water is pumped from the lower reservoir to the upper reservoir. During periods of high demand, water is released from the upper reservoir through a generator to produce electricity that can be sold at higher prices. As a peak-loading technology, pumped generally competes with natural gas peaking power plants, meaning that the viability of pumped hydro depends on the price of natural gas. The round-trip efficiency of pumped storage facilities varies significantly, from lower than 60 percent for some older systems to more than 80 percent for newer state-of-the-art systems. Round-trip efficiency refers to the percentage of electricity used to charge an energy storage system that can later be discharged to provide electricity.

Figure 2: Schematic of Typical Pumped Storage Plant



Source: Tennessee Valley Authority

Pumped storage can stabilize the grid through peak shaving, load balancing, frequency control, and reserve generation; it can also reduce harmonic distortions and eliminate voltage sags and surges. Ninety-eight percent of installed energy storage in California is pumped hydro. The state has seven existing pumped storage facilities with a total capacity of 3,967 MW, including projects at Lake Hodges, Castaic Lake, Helms, San Luis Reservoir, O'Neill Forebay, Big Creek, and Oroville.

At the bulk energy storage workshop, Mike Jones of PG&E discussed the operations of the Helms Pumped Storage Plant, one of the larger pumped storage facilities in California. Built in the late 1970s, Helms began operation in 1984 as an underground power plant below the reservoirs. Capable of both short- and long-term storage, the plant can go from stopped to operational in eight minutes and has the ability to pump or generate continuously for days at a time. Helms has proved useful for maintaining grid stability but in 2015 was called on only about 75 days by the California ISO. With 1,200 MW of generating capability and 930 MW of pumping capability, Helms has been called on to use excess electricity to pump water into storage for 13 of the last 19 overgeneration events as of November 20, 2015, but equipment operation and transmission constraints limit the operations of the plant.[17] Overgeneration events typically occur when high amounts of renewable energy production cause electricity supply to exceed demand. During these times, energy storage can enter charging mode to consume some of the excess supply of electricity.

Following the Helms presentation, John Dennis of Los Angeles Department of Power and Water (LADWP) presented on the Castaic Pumped Storage Plant, a facility that began operations in 1978. The Castaic plant underwent significant repairs and refurbishing from 2004 to 2013 but remained operational throughout the refurbishment. with a net dependable output of 1,175 MW, this plant has served as a powerful resource for peaking, regulation, and reserves. Kelly Rodgers of the San Diego County Water Authority spoke about the 40 MW Lake Hodges Pumped Storage Facility operated by San Diego County Water Authority. Although Lake Hodges was not originally planned as a pumped storage facility, it has proven to be a highly flexible resource that can alleviate overgeneration and provides GHG reductions.

At the workshop, operators of several of California's existing pumped storage projects discussed how they are changing their operational profiles as renewable energy production increases. Traditionally, pumped storage has been operated in pumping mode, in which electricity is consumed to pump water to the upper reservoir during overnight hours when demand is low, and in generating mode during afternoon hours. In recent years, these projects have often been called upon to operate in pumping mode during the midday hours when solar energy generation is peaking. As more renewables come on-line, pumped storage projects will likely continue to modify the operating profiles to the extent allowed by project permits and operational constraints. With almost 4,000 MW of pumped storage in

17 Transcript of 11/20/15 Joint Workshop with the California Energy Commission and the California Public Utilities Commission, California Energy Commission, November 20, 2015, pg. 58.

the state, the ability for these projects to adjust operating profiles provides tremendous benefits to the state's grid, but competing uses, such as reservoir recreational use, can limit operational flexibility.

Since many pumped storage plants in California are several decades old, there is potential to increase pumped hydro capacity through retrofitting existing facilities, which was discussed during the bulk storage workshop.[18] Retrofitting is one way to create more efficient and effective pumped storage, with potentially lower cost and time investments compared to building a new facility. PG&E and LADWP studied upgrades to their plants with variable-speed pumps to replace existing pumps, but cost and space requirements made the retrofits prohibitive.

Pumped storage requires specific terrain requirements, and many good locations for pumped storage projects in California have already been developed. In addition, due to environmental regulations and land-use concerns, developing pumped storage is long and arduous. Although operations and maintenance costs for pumped storage are low, upfront capital costs are very high. Several pumped storage facilities have been proposed in California, and the Eagle Mountain Pumped Storage Project is far along in the planning process. This project plans on commencing construction in 2019 and coming on-line by 2023. At the bulk storage workshop, Eagle Crest CEO Doug Divine reported that when the facility is done, it should be able to provide "anywhere from 12 to 18 hours of continuous…output storage at up to 1,300 MW."[19] In addition, the project is being designed with the ability to provide the California ISO with up or down ramps of up to 20 MW per second in either energy generation or energy storage mode.

Eagle Mountain illustrates the importance of early planning for pumped storage projects. Mr. Divine explained, "We appreciate time is of the essence…we have about two years of engineering and about four years of construction ahead of us. So we're at a minimum of six to six-and-a-half years from being in operation. Some of the modeling we've done suggests that in mid-2022, 2025 would be a good time for a storage asset like this to come…on-line."[20]

The six- to six-and-a-half-year time frame does not take into account any previous planning or the permits required to start construction. Obtaining a Federal Energy Regulatory Commission (FERC) license took Eagle Crest five years. This exemplifies the urgency needed to start new projects; anything that is begun today can take a decade or more to come on-line.

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18 "Pumped Hydroelectric Storage," Chi-Jen Yang, Center on Global Change, Duke University; http://people.duke.edu/~cy42/PHS.pdf.

19 Transcript of 11/20/15 Joint Workshop with the California Energy Commission and the California Public Utilities Commission, California Energy Commission, November 20, 2015, p. 83.

20 Transcript of 11/20/15 Joint Workshop with the California Energy Commission and the California Public Utilities Commission, California Energy Commission, November 20, 2015, p. 86.

Compressed Air Energy Storage

Compressed air energy storage (CAES) is a bulk energy storage alternative to pumped hydro. In CAES systems, air is compressed and stored under pressure in an underground cavern. When electricity is required, the pressurized air is heated and expanded to drive a generator for power production (**Figure 3**). CAES systems have not been widely developed, with only two systems operational worldwide, a 290 MW project in Germany that has operated since 1978 and a 110 MW project in Alabama that has operated since 1991. The Huntorf CAES plant in Germany provides black-start power[21] to nearby nuclear units, levels and reduces the prices of peak power demand, backs up local power systems, fills the energy gap of slow responding coal plants, and buffers intermittent wind energy production.[22] The McIntosh CAES plant in Alabama charges at night using excess nuclear energy and discharges during the daytime when demand is higher.[23] Extended project lead times and siting challenges are significant barriers to CAES projects, but several utilities in California have investigated and continue to investigate CAES.

Fred Fletcher from Burbank Water and Power presented on a CAES project called Pathfinder, which would use underground salt domes in Utah as a cavern. Pathfinder is proposed as a low GHG emission replacement to the Intermountain Power Plant (IPP), a 1,900 MW coal-fired plant, set to retire in 2025. The Pathfinder CAES project would use a geologic feature consisting of up to 90 underground caverns with energy storage potential in excess of 25,000 MW. The initial Pathfinder project would be a 300 MW project, with a second phase that would add 1,200 MW, for a total of 1,500 MW of storage. This project is in the early planning stages and has numerous hurdles to overcome, including the retirement of the IPP, permit acquisition, regulatory question marks, and barriers related to the multistate nature of the project. As Mr. Fletcher said during the workshop, “Compressed air energy storage is generally not part of policy discussions. It’s not very well understood.”[24]

PG&E has also been investigating CAES for several years. In 2009, PG&E was awarded American Recovery and Reinvestment Act funding to analyze how CAES might provide ancillary services to the California ISO grid to help California meet its renewable energy goals. Through this analysis, PG&E has identified a depleted natural gas reservoir in San Joaquin County as a site with technical potential, and the utility issued a request for offers (RFO) in October 2015 to determine the economic and commercial potential of the project.

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21 A black start is the process of restoring an electric power station or a part of an electric grid to operation without relying on the external transmission network.

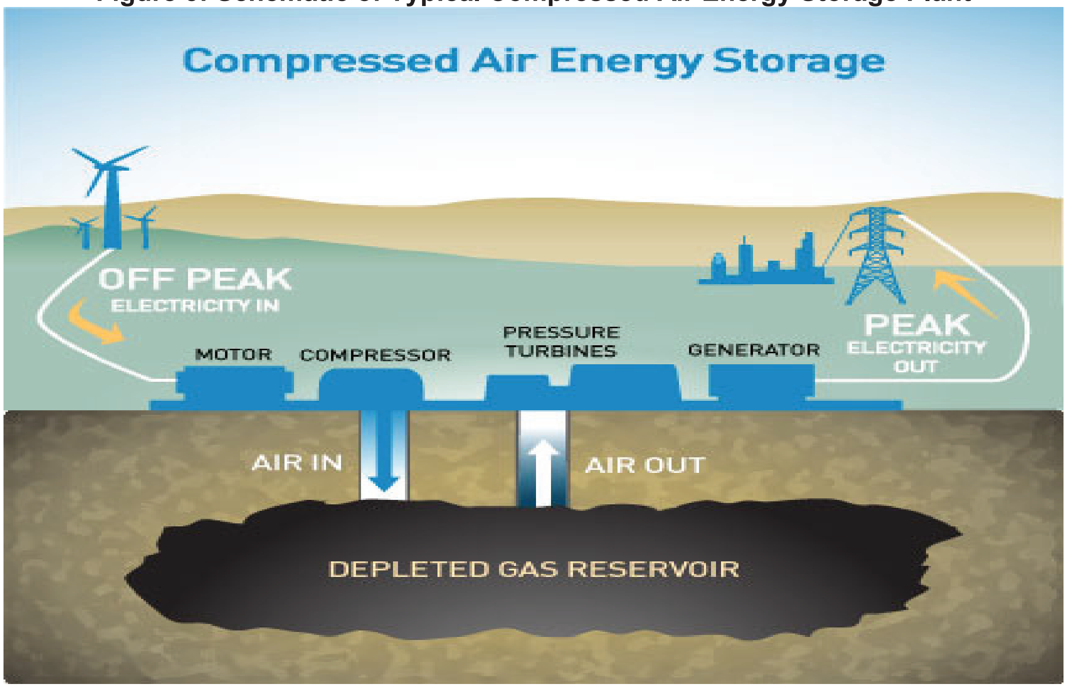
22 Luo, Xing and Jihong Wang, *Overview of Current Development on Compressed Air Energy Storage – Technical Report*, University of Warwick, Coventry, United Kingdom: December 2013.

23 Enipedia, http://enipedia.tudelft.nl/wiki/McIntosh_(CAES)_Plant; accessed June 14, 2016.

24 Transcript of 11/20/15 Joint Workshop with the California Energy Commission and the California Public Utilities Commission, California Energy Commission, November 20, 2015, p. 94.

The RFO specified that the project would be between 100 MW and 350 MW, would have at least a four-hour discharge time, and would be able to provide ancillary services.[25]

Figure 3: Schematic of Typical Compressed Air Energy Storage Plant



Source: PG&E

Advanced Rail Energy Storage

Advanced Rail Energy Storage (ARES) is a startup company that has proposed a new type of bulk storage technology for California, which it refers to as "pumped storage on rails." Michael Katz of ARES discussed the technology at the bulk energy storage workshop. The process would move weighted train cars up and down a hillside to store large amounts of energy. This technology is emission-free, using no water or environmentally hazardous materials. Efficient and scalable, it could help with small and large loads, reducing curtailment and GHG emissions, but the lack of existing rail energy projects makes the viability of this technology highly uncertain. ARES has tested its technology on grades of 6 percent to 8 percent in the Tehachapi Pass, and the company has recently received approval to build a 50 MW project in Southern Nevada.

Other Storage Technologies

Other energy storage technologies exist, such as various types of batteries, vehicle-to-grid energy storage, and thermal energy storage. These technologies provide energy storage on a smaller scale, but as costs of these technologies decrease and related long-term

25 "Smart Grid Compressed Air Energy Storage Demonstration Project Request for Offers," PG&E, October 2015.

performance expectations improve, they could become economically viable to deploy on larger scales.

Barriers to New Energy Storage

A roadmap developed jointly by the CPUC, California ISO, and the Energy Commission in December 2014, *Advancing and Maximizing the Value of Energy Storage Technology*,[26] identified three broad categories of barriers for energy storage: the inability to realize the full revenue opportunities consistent with the value that energy storage can provide, interconnection and operations costs, and uncertainty about processes and timelines. Discussions during the bulk storage workshop revolved around these and related barriers.

The extended planning time frames of bulk energy storage projects trigger many barriers. Many of the state's energy planning processes are not well-suited to plan on these extended time frames. For example, the LTPP operates on a 10-year planning time frame, but bulk storage projects often take more than 10 years to become operational.

The need for numerous permits and licenses from both state and federal agencies is a major hurdle in developing pumped storage projects. In particular, when it comes to FERC licenses, Mr. Divine from Eagle Crest indicated it took five years to obtain a FERC license from filing to the final license approval. He indicated that is "on the quick side for FERC to act."[27] In addition to the FERC permit, the project was required to obtain a Section 401 water quality certification from the State Water Quality Control Board and right-of-way approval from the Bureau of Land Management. The Eagle Crest project has made significant progress toward construction, but the project still requires several years of geotechnical and engineering studies before beginning construction. These will take another 4–5 years, with the earliest operational date in 2023. A complicating factor is that the FERC permit must be extended if construction is not started within two years of the permit being issued.

Transmission line congestion is another issue bulk storage projects face in California. In particular, the Helms pumped storage facility is limited in pumping operations by transmission congestion in the Fresno area.[28] PG&E submitted comments indicating that transmission upgrades could eliminate the operational constraints caused by transmission congestion, but the question of who will pay whom for the upgrades is an ongoing discussion. Whether new transmission will need to be built for every storage project remains an open question.

The operators of the Helms and Castaic projects both investigated retrofitting their facilities with variable-speed pumps, which would allow for greater flexibility for these

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26 "Advancing and Maximizing the Value of Energy Storage Technology – a California Roadmap," California ISO, December 2014.

27 Transcript of 11/20/15 Joint Workshop with the California Energy Commission and the California Public Utilities Commission, California Energy Commission, November 20, 2015, p. 88

28 PG&E Comments on the Joint Bulk Energy Storage Workshop (11/20/15), California Energy Commission Docket15-MISC-05, December 18, 2015.

projects, but physical and economic constraints proved retrofitting unfeasible. Variable-speed pumps allow a project to pump at almost any capacity up to the maximum capacity of the project, instead of in fixed increments that are tied to the capacity of each pump. For the Helms and Castaic projects, however, the analyses indicated that the costs of retrofitting would outweigh the benefits.

ARES is facing difficulties in obtaining financing for a demonstration project. Uncertainties surrounding an unproven technology, along with other barriers that affect bulk storage projects in general, provide challenges to this technology moving forward. In addition, the land-use and permitting requirements that would be necessary to scale this technology up to larger sizes are additional impediments.

The Pathfinder CAES project is still in the planning stages and is unlikely to move forward until there is more certainty surrounding the closure of the IPP. This project is just one possibility to replace Intermountain; questions surrounding regulatory treatment and market conditions add to the uncertainty and barriers to the Pathfinder CAES moving forward.

Storage costs are expected to decline as technology improves, but for now, most projects face barriers to development or optimal use. As California agencies develop guidelines for the integrated resource plans (IRP) required by Senate Bill 350,[29] the question of which storage technologies will provide the most efficient solutions from an operational and cost perspective remains uncertain. Identifying and addressing the barriers to energy storage will be an important aspect in the development of the SB 350 IRPs.

29 SB 350 is the Clean Energy and Pollution Reduction Act of 2015. https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB350

Recommendations

Bulk energy storage can have a larger role in reaching California's goal of 50 percent renewable energy; however, significant barriers exist for its development. In order for bulk storage projects to be included in solutions to achieving renewable energy and GHG reduction goals, California must better use existing bulk storage projects and remove their permitting and procurement barriers.

This paper focuses on highlighting the various bulk storage technologies that are being used, evaluated, and, in some cases, developed by parties in California and the West. Statewide, existing bulk storage projects are increasingly used to meet ramping needs as more intermittent renewable power is added to the grid. As California moves forward to implement SB 350 goals and increase renewable generation, the ways in which bulk storage will fit into this new integrated resource portfolio are unknown. The following recommendations are intended to improve information that will help system operators, policy makers, and project developers understand the role and value of bulk storage in an integrated resource plan that supports a least-cost, clean, reliable, and flexible grid.

Valuation of Pumped Storage

Of all the bulk storage technologies discussed, pumped storage is a proven, efficient, and reliable technology. However, justifying investments to upgrade existing facilities or build new pumped storage projects remains very challenging under current regulatory structures and electricity market economics. Given that pumped storage systems, depending on whether they have variable pumping capabilities, can provide both generation and grid support services, the Energy Commission, CPUC, and California ISO should undertake investigations to better understand and quantify the value of this resource:

- How does it compete with least-cost/best-fit requirements that are used to measure benefits of traditional technologies?
- What new functionalities will the integrated grid require, and which ones pumped storage provide (for example, fast ramping, response to decremental needs such as significant wind ramping)?
- One role pumped storage fills that is often overlooked is the ability to provide energy security within a given control or balancing area (for example, black start capability). If there is a major transmission line failure or other event, the pumped storage black start capability or spinning reserves can be called on to restart or stabilize the grid quickly. Because of the size of pumped storage projects, full generation can be accomplished to cover the energy deficit for longer periods of time. What are other options to meet these emergencies and how do they compare with regard to performance, especially on a highly dynamic regional grid?

- As part of the SB 350 integrated grid, what should the cost versus the benefits equation for pumped storage include? What value streams are not currently included and, if included, would provide a different cost benefit balance, potentially tipping the analysis in favor of pumped storage.
- How does the state's planning process need to evolve and feed into the existing regulatory process so new innovative solutions like pumped storage can be considered?
- Pumped storage projects can only be built in certain locations. How do you allocate these locational benefits and costs to various ratepayers? Could the benefits extend to more than one utility?
- How does pumped storage investment support GHG emission reductions?
- How does pumped storage compare to battery energy storage?

Bulk Storage User Committee

The Energy Commission and CPUC should consider organizing a statewide Bulk Storage User Committee where owners and operators of pumped storage facilities share evolving challenges they face trying to maximize the use of their equipment. This group could also serve as experienced technology experts and assist each other and state officials and planners.

Streamline Licensing

The Energy Commission, CPUC, and California ISO should look into implementing an alternative and streamlined licensing and permitting process for low-impact pumped storage, such as closed-loop projects.[30] The state should interface and work with FERC on a simplified permitting process for these types of projects.

Cost-Benefit Study

The Energy Commission and CPUC should evaluate and analyze the potential for bulk energy storage to help integrate renewable generation into the electric system. The potential costs and benefits of location-specific bulk energy storage resources should be assessed, including impacts to the transmission and distribution system.

Facilitate Joint Ventures

The complexity of bulk energy storage can be prohibitive for a single organization to develop a bulk energy storage project. Joint ventures between two or more entities may increase the likelihood of successful development of bulk storage projects. The Energy Commission should investigate ways in which bulk energy storage joint ventures can be facilitated.

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30 A *closed-loop pumped storage project* is not continuously connected to a naturally flowing water feature, as compared to an *open-loop pumped storage project* that is continuously connected to a naturally flowing water feature.

LIST OF ACRONYMS

Acronym/Abbreviation	Original Term
AB	Assembly Bill
ARES	Advanced Rail Energy Storage
CAES	compressed air energy storage
California ISO	California Independent System Operator
CPUC	California Public Utilities Commission
Energy Commission	California Energy Commission
FERC	Federal Energy Regulatory Commission
GHG	greenhouse gas
IOU	investor-owned utility
LADWP	Los Angeles Department of Power and Water
LTPP	Long Term Procurement Planning
MW	megawatt
PG&E	Pacific Gas and Electric
RPS	Renewables Portfolio Standard
SB	Senate Bill

Appendix: Summary of Workshop Comments

The following are excerpts of comments submitted for the Bulk Storage Workshop. The complete comments are available at:
https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=15-MISC-05

PG&E

- PG&E works continuously to improve its hydroelectric generating capabilities.
- Helms is frequently used, with midday pumping increasing with more renewables on the grid.
- Retrofitting Helms offers limited benefits with high risks.

Pathfinder CAES I LLC

- Bulk storage must be part of planning as California approaches 50 percent renewables.
- Successful procurement of high-quality, cost-effective energy storage will require an integrated, long-term understanding of the benefits of bulk storage for California and the West.
- Future agency assessments and decisions should include multiple bulk storage technologies.
- Bulk storage projects should be evaluated in the context of regional needs and opportunities; direct comparisons between technologies outside of this context may be misleading.
- The Energy Commission should provide specific direction on how it expects the POUs to evaluate and potentially procure bulk storage resources.

AES

- AES encourages further consideration of battery energy storage for bulk storage purposes.
- Battery energy storage provides the advantages of modular architecture, fast deployment, cost-competitiveness, and flexible siting.

San Diego County Water Authority (SDCWA)

- SDCWA operates two hydroelectric facilities, the Lake Hodges Pumped Storage Facility and Rancho Penasquitos hydroelectric facility.

Nate Sandvig, Clean Power Development LLC

- Clean Power Development will develop a new closed-loop pumped storage project near the Columbia River to meet the challenge of integrating renewable energy.
- The maximum potential capacity of the project is 1,200 MW.
- The project will use variable-speed pump-turbine units.

Eagle Crest Energy Company

- Large pumped hydro should be an integral part of the solution to achieving 50 percent RPS in California.
- The Eagle Mountain project is well-suited to meet California's needs, but a new procurement paradigm is needed.
- California's energy agencies should look at ways to spread costs among all beneficiaries of potential pumped hydro projects.

Brookfield Renewable Energy Partners L.P.

- The potential need for long-duration storage supports near-term action to procure bulk storage.
- The valuation of, and contracts for, large-scale pumped hydro storage should consider the long-term nature of the asset and benefits expected throughout. Extending valuation methods and contracting terms to 30-40 years would generally align with the contract length typical for long-term hydroelectric projects.
- California should develop a procurement framework specific to long-duration storage.

Bison Peak Pumped Storage

- Bison Peak is a 1,000 MW pumped storage project being developed in Kern County.
- Focus is needed to achieve SB 350 goals at lowest cost and highest reliability.
- Procurement should be based on demonstration of system benefits.
- To spur development and investment in bulk energy storage, there must be a cost-allocation mechanism and procurement process in place and a technology-neutral procurement framework suitable for bulk energy storage must be established.

Edward Cazalet on Behalf of NGK Insulators and MegaWatt Storage Farms

- Chemical batteries can competitively provide bulk storage with shorter lead times and more flexible deployment and sizing.
- Sodium-sulfur is the most-used and proven large-scale battery technology in the world, with 3 GWh of capacity deployed at more than 190 projects.

CESA

- CPUC should take the lead in directing methods for procurement of bulk storage
- Renewable energy-related planning should identify synergies with bulk storage solutions.
- Next steps should be developed for consideration of alternative methods for procurement of bulk storage.

SCE

- SCE operates a 1 MW, 7.2 MWH sodium-sulfur battery on Catalina Island, which is an islanded system with no connection to the mainland grid.
- Catalina's generation system includes six diesel-generating units and 23 microturbines.
- The sodium-sulfur battery is used to provide flexibility and reliability and enables the Pebbly Beach Generating Station to operate at optimal pollution control and efficiency parameters.
- SCE is investigating opportunities to use the battery as a fast-acting power/frequency conditioner to reduce the occurrence of system disturbances.

David Kates, The Nevada Hydro Company

- Lake Elsinore Advanced Pump Storage is a proposed 500 MW project located midway between Los Angeles and San Diego.
- Because LEAPS can store off-peak power, it will be vital to the state's alternative energy goals.
- Securing a financeable revenue stream is key to developing the project.

Steve Uhler

- A paradigm shift is required as we move to storage as a solution to overgeneration, as it applies to where storage is placed and how it is sized to produce a better value stream.