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 DRAFT SOURCES FOR 2019-2020 IRP SUPPLY-SIDE RESOURCES DOCUMENT

Alex J. Morris
Sr. Director, Policy & Regulatory Affairs

Jin Noh
Policy Manager

CALIFORNIA ENERGY STORAGE ALLIANCE
2150 Allston Way, Suite 210
Berkeley, California 94704
Telephone: (310) 617-3441
Email: amorris@storagealliance.org

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As follow-up to the Modeling Advisory Group ("MAG") webinar on March 1, 2018 and in response to the March 27, 2018 email from the California Public Utilities Commission ("Commission") staff soliciting comment on the draft *Sources for 2019-2020 IRP Supply-side Resources* ("Draft Sources") document, the California Energy Storage Alliance ("CESA")[1] hereby submits these informal comments.

[1] 8minutenergy Renewables, Able Grid Energy Solutions, Advanced Microgrid Solutions, AltaGas Services, Amber Kinetics, American Honda Motor Company, Inc., Axiom Exergy, Brenmiller Energy, Bright Energy Storage Technologies, BrightSource Energy, Brookfield Renewables, Centrica Business Solutions, Consolidated Edison Development, Inc., Customized Energy Solutions, Demand Energy, Doosan GridTech, Eagle Crest Energy Company, East Penn Manufacturing Company, Ecoult, EDF Renewable Energy, ElectrIQ Power, eMotorWerks, Inc., Energport, Energy Storage Systems Inc., EnerNOC, ENGIE Energy Storage, E.ON Climate & Renewables North America, Fluence Energy, GAF, Geli, Greensmith Energy, Gridscape Solutions, IE Softworks, Ingersoll Rand, Innovation Core SEI, Inc. (A Sumitomo Electric Company), Iteros, Johnson Controls, Lendlease Energy Development, LG Chem Power, Inc., Lockheed Martin Advanced Energy Storage LLC, LS Power Development, LLC, Magnum CAES, Mercedes-Benz Energy, NantEnergy, National Grid, NEC Energy Solutions, Inc., NextEra Energy Resources, NEXTracker, NGK Insulators, Ltd., NRG Energy, Inc., Ormat Technologies, Parker Hannifin Corporation, Pintail Power, Qnovo, Range Energy Storage Systems, Recurrent Energy, Renewable Energy Systems (RES), Sempra Renewables, Sharp Electronics Corporation, SNC Lavalin, Southwest Generation, Sovereign Energy, Stem, STOREME, Inc., Sunrun, Swell Energy, True North Venture Partners, Viridity Energy, Wellhead Electric, and 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).

I. INTRODUCTION.

CESA appreciates the opportunity to provide informal input to the MAG as it works in parallel tracks to enhance the production cost modeling in the 2017-2018 Integrated Resource Planning ("IRP") cycle and to update assumptions for initial modeling for the 2019-2020 IRP cycle. CESA agrees that this is a prudent and wise use of the Commission's time to prepare for the next round of RESOLVE modeling beginning in January 2019 while the load-serving entities ("LSEs") prepare their IRP filings for the 2017-2018 IRP cycle based on Decision ("D.") 18-02-018. CESA plans to continue its active participation in this important proceeding.

In these informal comments, CESA provides responses to the questions posed in the Draft Sources document but first offers its comments on the data source criteria, which requires that data sources to be used in IRP modeling must be publicly available, technically credible, reflective of future costs, usable to develop all-in technology costs, and geographically specific, if needed.[2] CESA generally agrees with this criteria, but adds that certain credible proprietary data and actual cost data from real-world competitive solicitations may be used to inform which publicly-available data sources and ranges to use. CESA understands the challenge for any public proceeding is around the ability to use publicly available data, which eliminates the use of perhaps more informative confidential data from competitive solicitations and/or the use of proprietary data due to licensing barriers. However, such datasets that are unusable for citing in public proceedings may still be useful to benchmark the publicly available data sources and inform the adoption of low-end or high-end cost ranges from the publicly available data source for different resources. Overall, we should not use inaccurate data knowingly, and should find a way to use realistic going-forward cost data.

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[2] Draft Sources document, p. 11.

Furthermore, CESA believes that there should be some criteria around the process or triggers for updating resource cost inputs. Especially for energy storage, where costs are on a rapid downward trajectory, the use of one primary data source at this stage of the IRP modeling process may soon become stale by the time that the actual modeling efforts are underway in early 2019 and the modeling results are completed by late 2019, possibly early 2020. In instances where the primary data source is not updated annually or frequently enough, it may be reasonable to utilize certain proprietary data sources and/or actual costs from recent competitive solicitations to inform whether the high-, mid-, or low-end costs of the resource is reasonable for adoption in the 2019 or 2020 Reference System Plan. The Commission already proposes a criteria to justify changes to model functionality and run-time, where the magnitude of potential impact on future portfolio costs and composition must be sufficient. However, in this case, CESA believes that cost assumption updates as CESA proposes above do not require a significant re-work of the model functionality or create extra run-time, and thus a consideration of some threshold criteria or a streamlined process by which to update cost assumptions may be reasonable and prudent to ensure more accurate model outputs.

II. RESPONSE TO QUESTIONS.

Below, CESA provides our select responses to the questions posed by Commission staff from the Draft Sources document.

Question 4: Do parties have recommendations on how to distinguish between specific battery technologies in an emerging market?

CESA appreciates the Commission's consideration of emerging battery storage technologies. There are a number of battery storage technologies on the market today or are in the early stages of commercialization that each offer its own unique advantages and disadvantages in terms of power/energy density, lifetime, performance, safety, recyclability, among other traits. New advancements are frequently occurring, but rather than modeling every specific battery technology, CESA believes it may be more reasonable to model and price the different capabilities of battery (and other energy storage) technologies, with some differentiation across the major sub-classes of battery storage technologies – *i.e.*, lithium-ion, flow, advanced lead-acid, and flywheel battery storage – as it has been done in the IRP modeling to date and as it is usually reported in publicly-available industry sources. Ultimately, CESA views the role of the procurement process to select the specific battery technology, whereas the IRP modeling should identify the higher-level capabilities needed from energy storage resources to meet identified grid needs. For example, energy storage costs can be differentiated by duration levels to guide the authorization of procurement for specific energy storage capabilities.

Question 5: What sources should be considered in developing recommended battery costs for use in IRP?

CESA supports the Commission's approach of using Lazard's *Levelized Cost of Storage 3.0* (or whatever subsequent version of the study comes out)[3] as a primary data source that can be benchmarked or revised with a literature review of other proprietary industry market research from

[3] *Lazard's Levelized Cost of Storage Analysis – Version 3.0*, published in November 2017. https://www.lazard.com/media/450338/lazard-levelized-cost-of-storage-version-30.pdf

sources such as Bloomberg New Energy Finance ("BNEF"),[4] GTM Research,[5] Navigant Research,[6] IHS,[7] and potentially others.[8] CESA finds Lazard to be a generally credible and technically sound public industry data source that breaks out the various cost drivers of different energy storage technologies and takes a use-case perspective to determine costs that take into account the operational parameters of different energy storage technologies.

Lazard as a primary data source also has the advantage of representing a broader range of technologies, which many other data sources lack. In addition to Lazard's study, CESA points to

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[4] BNEF conducts an annual *Lithium-Ion Battery Price Survey* that provides valuable insights into the trajectory of lithium-ion cell and pack prices, primarily those used for electric vehicles and stationary storage. This proprietary resource is limited for focusing on the storage module costs and not incorporating the balance of system, power conversion, or engineering, procurement, and construction costs of a grid-connected energy storage system. However, this resource is useful in tracking recent cell/pack capital cost trajectories as well as forward trajectories based on their calculated learning rates, though this is only useful for lithium-ion-based batteries. https://data.bloomberglp.com/bnef/sites/14/2017/07/BNEF-Lithium-ion-battery-costs-and-market.pdf

[5] See, for example, *Grid-Scale Energy Storage Balance of Systems 2015-2020*, published in January 2016. https://www.greentechmedia.com/research/report/grid-scale-energy-storage-balance-of-systems-2015-2020 or see *U.S. Front-of-the-Meter Energy Storage System Prices 2018-2022*, published February 2018. https://www.greentechmedia.com/research/report/us-front-of-the-meter-energy-storage-system-prices-2018-2022#gs.VhyGBzc

GTM Research conducts battery hardware and balance of system costs over a three- to four-year look-ahead period and is thus limited to its applications when looking out to 2030. Furthermore, GTM Research does not provide a cost model for alternative energy storage technologies, limiting its application to short-term lithium-ion battery prices and forecasts, but given its more project-by-project tracking of energy storage costs, it may serve as a useful benchmark for current and short-term cost assumptions for lithium-ion battery storage projects. https://www.greentechmedia.com/research/storage

[6] Navigant is a major industry market research firm, but this source may be less reliable for IRP modeling purposes given the lack of detail and infrequency of its energy storage cost reports. When these reports do come out, it may be useful to at least benchmark and review.

[7] The same points for Navigant apply to IHS as a data source. The latest IHS report that CESA could find was limited in scope to lithium-ion battery projects of a specific configuration with short-term look-aheads. https://www.utilitydive.com/news/ihs-grid-scale-lithium-ion-battery-storage-prices-will-decline-by-half-by/409822/

[8] There are a number of other services firms that may produce energy storage cost reports, including one from McKinsey. However, these reports are usually one-off reports and may not track industry cost trends as closely, though it may still be informative as part of the literature review. https://www.mckinsey.com/business-functions/sustainability-and-resource-productivity/our-insights/the-new-economics-of-energy-storage

a peer-reviewed, publicly-available analysis of current energy storage costs as well as projections through 2030 from the International Renewable Energy Agency ("IRENA").[9] Using a methodology that identified economic and materials-based factors that could drive down costs with scale and innovation, the IRENA report provided a comprehensive report on not just classes of energy storage technologies (*e.g.*, lithium-ion, flow batteries) but also specific chemistries and sub-classes of each type of technology. The report also covers a range of alternative energy storage technologies such as compressed air energy storage ("CAES") and flywheel energy storage that many industry data sources do not provide. The IRENA report may be helpful in benchmarking the Lazard's current and forecasted cost estimates.

Additionally, CESA recommends that the Commission consider the approach used by the New York State Energy Research and Development Authority ("NYSERA") in developing its *NYS Energy Storage Roadmap*, which aims to conduct an energy storage study to determine the energy storage deployment potential that would deliver net positive ratepayer benefits for the state of New York. As part of that study, NYSERDA generated 2018-2030 energy storage cost projections as inputs into their modeling runs by conducting a literature review of data from Lazard, GTM Research, Navigant Research, BNEF, and energy storage developers and creating a 'blended' cost number to calculate the installed cost per kW and per kWh of different durations of energy storage (see below table).[10] This is an approach that could be explored in lieu of modeling each and every energy storage technology (see response to Question 4) and that could be replicated in some manner here in California. It may be useful to coordinate between NYSERDA and the

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[9] IRENA, *Electricity Storage and Renewables: Costs and Markets to 2030*, October 2017. http://www.irena.org/menu/index.aspx?mnu=Subcat&PriMenuID=36&CatID=141&SubcatID=3879

[10] NYSERDA and New York Department of Public Service, *NYS Energy Storage Roadmap*, presented on March 16, 2018, p. 11. https://www.nyserda.ny.gov/-/media/Files/Programs/Energy-Storage/2018-03-09-energy-Storage-Roadmap-base-case-webinar.pptx

Commission to share their approach to using industry data sources. If this approach is used, it will also be important to make transparent to stakeholders how the Commission determined these blended cost numbers.

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Energy Storage Technologies and Cost Declines

Duration and Installed Cost	2018	2020	2025	2030
Long (6 hrs)				
per kW	$2,270	$1,800	$1,200	$1,000
per kWh	$380	$300	$200	$165
Medium long (4 hrs)				
per kW	$1,600	$1,280	$840	$700
per kWh	$400	$320	$210	$175
Medium short (2 hrs)				
per kW	$1,080	$875	$600	$500
per kWh	$540	$435	$300	$250
Short (half hour)				
per kW	$630	$510	$350	$290
per kWh	$1,260	$1,020	$700	$580

All costs are in 2018 dollars and reflect bulk distribution or transmission system installed cost including a basic estimate for land lease cost and interconnection.

Add 1.25 multiplier for NYC Zone J installations and 1.10 multiplier for Long Island Zone K installations.

Add 40% multiplier for customer sited storage located behind a customer's utility meter.

Blended cost of technologies and sources including Lazard Levelized Cost of Storage 2017, GTM Research, Bloomberg, Navigant Research and storage developers

acelerex NYSERDA

Furthermore, in addition to Lazard and other industry data sources, CESA encourages the Commission to, with appropriate controls and protections for confidentiality, also look at confidential cost numbers reported as part of rate proceedings and applications for contract/project approval.[11] The use of actual cost data can serve as a very useful benchmark on the current or near-term costs used for energy storage assumptions, which can then be extrapolated using forecasts from industry data and forecasting reports. While CESA does not have access to these numbers, the Commission does have access and has the ability to adjust and adopt high-, mid-, or low-end cost estimates based on this actual cost data. The Commission has the discretion to select among the cost ranges from the publicly-available data sources, which can be guided by solicitation data from any number of energy storage applications in California – *e.g.*, biennial

[11] Comparative projects should be used. Importantly, CESA recommends *not* using projects that may not be reflective of normal development times, such as, for example, the 2016 Aliso Canyon Energy Storage (ACES) RFO projects. Such projects were needed and procured due to an emergency order stemming from the Aliso Canyon natural gas facility leak and subsequent moratorium on injections and withdrawals.

energy storage applications, local capacity requirement ("LCR") applications that selected energy storage contracts, etc. As an example, CESA points to Xcel Energy's all-source solicitation report that aggregated bid information by resource type and found surprisingly low cost data for standalone and paired energy storage resources.[12] A similar approach could be used to aggregate cost data across actual solicitations in California if possible – *i.e.*, sufficient number of bids to be able to aggregate bid prices and protect confidentiality – and be reported into the IRP. CESA encourages the Commission to explore this possibility given that we have seen reports of hundreds of bids submitted into energy-storage-related solicitations that could be used for IRP purposes.[13] In sum, this actual cost data can serve as a baseline against cost forecasts for energy storage resources as well as for other supply-side resources.

Another important consideration for supply-side energy storage assumptions is to reflect the investment costs for energy storage resources paired with generation assets. Hybrid energy storage resources have a significant advantage in potentially reducing the balance of plant and engineering, procurement, and construction ("EPC") costs, which factor into the capital costs reported by Lazard and will be used for supply-side cost assumptions of energy storage in the IRP modeling. One of the serious limitations of the 2017-2018 IRP modeling is that RESOLVE did not factor in the reduced cost impacts of coupling energy storage with solar resources, generating potential cost savings in terms of shared land, shared inverters (in the case of DC-coupled solar-plus-storage systems), and the Federal Investment Tax Credit ("ITC") when charging the energy storage resource by at least 75% from the paired ITC-eligible solar generator. In the next IRP

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[12] Xcel Energy, *2016 Electric Resource Plan: 2017 All Source Solicitation 30-Day Report*, submitted on December 28, 2017. https://www.documentcloud.org/documents/4340162-Xcel-Solicitation-Report.html

[13] St. John, Jeff. "California Dreaming: 5,000MW of Applications for 74MW of Energy Storage at PG&E." Greentech Media, May 28, 2015. https://www.greentechmedia.com/articles/read/california-dreaming-5000mw-of-applications-for-74mw-of-energy-storage-at-pg#gs.em6QU2k

cycle, CESA believes it is important to properly model these potential capital cost savings as well as to get this functionality into RESOLVE where energy storage resources are not just selected independently but also coupled with either existing or new resources.

Understandably, this added functionality will require modeling generation and energy storage charge/discharge correctly, but robust modeling that accurately reflects the tools available for the grid should be the backbone to the IRP process. The National Renewable Energy Laboratory ("NREL") produced a study that could be referenced by the Commission on how pairing energy storage resources with solar plants can impact the costs and benefits of these hybrid assets, depending on the configuration and the charge profile of the resource. Notably, the study found significant balance of system and inverter cost savings as well as a major benefit in the ITC that boosted the viability of DC-coupled solar-plus-storage systems.[14] Similar type of work can be conducted in this IRP cycle, and in many ways, CESA believes that this functionality must be done since the Reference System Plan results demonstrated how the ITC has significant impacts on the resulting optimal resource portfolio, as evidenced by the more than 9,000 MW of utility-scale solar selected before 2026. To simplify modeling efforts, CESA suggests that the Commission consider modeling energy storage resources that can either charge 75% or 100% from the on-site solar resource as separate candidate resources, which can claim 75% or 100% of the ITC, respectively, against its investment costs.[15] For the 75% energy storage case, it may require further discussion on how the energy storage charging from the grid should be modeled, including

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[14] Denholm, Paul, Josh Eichman, and Robert Margolis. *Evaluating the Technical and Economic Performance of PV Plus Storage Power Plants*, National Renewable Energy Laboratory, published on August 2017. https://www.nrel.gov/docs/fy17osti/68737.pdf

[15] Though there is a range of energy storage charging cases between 75% and 100%, testing these two polar ends of ITC-eligible paired energy storage may be informative on the types of paired energy storage selected as well as the potential grid impacts of PV-only versus PV-majority charging.

how it should be sized in terms of capacity and durations and how it may be operationally constrained due to the 75% charge requirement.

In addition to storage paired with solar, CESA also recommends that the Commission consider other hybrid configurations where energy storage resources are paired with gas generation projects. For example, gas-plus-storage projects may also have similar capital cost benefits while providing the added benefit of reducing gas turbine starts and run time, thereby reducing the GHG emissions profile of the otherwise standalone gas plant. In both of these cases, adjustments to the capital and investment costs of the energy storage resource is needed when added to an existing or new generation resource in addition to adjustments to the modeled operating profile of the generation asset. Likewise, wind-plus-storage projects may have similar capital cost benefits as solar-plus-storage projects but have a different benefit where energy storage can firm generation, which reduces forecast uncertainty and/or load following requirements, generating cost and potential indirect greenhouse ("GHG") emission savings from not have to have other resources on standby to address those issues.

Understandably, the modeling of hybrid energy storage resources is a complex task, but CESA believes this is reasonable, if not essential, for the Commission to adapt its models to incorporate this functionality because of the potential ratepayer savings that could be generated by investing in new energy storage resources that can be paired with new or existing generation assets, rather than having the model make separate and potentially costlier investment decisions of generation and energy storage assets. Gas-hybrid resources may also have special applicability to address longer-term contingency conditions or local conditions, so they especially warrant representation in IRP models in this period of gas-plant attrition.

<u>Question 6</u>: How should Multiple Use Applications of battery storage by modeled?

CESA appreciates the Commission's consideration of multiple-use applications ("MUAs") of energy storage resources to be modeled in the IRP. In line with R.15-03-011 and ongoing work to effectuate MUAs in energy storage contracts and operations, CESA recommends exploration of MUA cost models that could be both prudent and reflective of real-word MUA capabilities. These resources can be modeled as new MUA storage resources into RESOLVE or other tools. Controls are needed to ensure MUAs are appropriately incremental to other resources, but the general concept here would be to model MUAs as resources that can be dispatched but that may have lower costs. Ultimately, modeling results should highlight system or grid needs and should be able to direct competitive solicitations wherein MUAs may be best evaluated via a procurement process using bids by third-party energy storage operators, who have the project- or fleet-specific optimization model for the energy storage resource to optimize revenues while managing financial risk, and by the distribution utility and the California Independent System Operator ("CAISO"), who have the visibility to key grid constraints and needs to ensure whether MUAs are viable from a single resource.

Additionally or alternatively, CESA recommends that the Commission adopt low-end cost assumptions for energy storage resources as an input into the model. CESA believes this is a minimally reasonable proxy for the MUA capabilities, which measures the added benefits of energy storage resources when evaluated for cost-effectiveness. In other words, if cost-effectiveness is a measurement of benefits over costs and the benefits are difficult to model in the context of MUAs, it is reasonable to assume lower costs for energy storage resources, with the intent to eventually tap into the MUA benefits of energy storage when these resources are procured and contracted.

<u>Question 7</u>: How should high- and low-cost trajectories for future battery costs be developed?

See CESA's response to Question 5-6. In general, CESA believes that it is reasonable to use low-end energy storage cost numbers from Lazard, supported by benchmarking from other industry resources. If actual cost data can be used as a basline for the current year, the aggregate average of the actual cost information should be used as the mid-point estimate. If actual aggregated and anonymized cost data cannot be reported publicly in the model, it could inform whether the Commission should use the high-, mid-, or low-end estimates from public industry data sources for use as the mid-point estimate in 2020-2030. Low- and high-cost trajectories for battery costs can be informed by literature reviews as well as learning rate estimates of cost reductions based on the scale of MW deployment.

<u>Question 8</u>: How should pumped storage costs be represented given that they are highly site-specific and difficult to estimate on a generic basis?

Given that pumped storage projects are site specific and fewer in number and are thus difficult to estimate on a generic basis, CESA recommends that differentiated categories of pumped storage projects could be used to model their costs. For example, "PHS 1" could represent pumped storage sites on brownfield sites while "PHS 2" could represent pumped storage projects on greenfield sites. Due to the confidentiality of site-specific information, CESA believes that a PHS 1, PHS 2, PHS 3, etc. type of approach is needed, similar to how the 2017-2018 RESOLVE model represented different gas generation units. Categories of specific capabilities, size, and project characteristics may be used to model pumped storage in this way.

CESA also suggests IRP staff have conversations with pumped storage developers to explore cost structures for specific sites. The goal of these conversations would be to have a more accurate and informed IRP outcome. Large pumped storage solutions should be available to the

IRP model for selection. IRP should also recommend how cost-sharing for resources larger than any single LSE's procurement appetites can be supported, if it is in the interests of ratepayers.

<u>Question 9</u>: To what extent are new pumped hydroelectric facilities able to contribute to primary frequency response?

In addition to having significant total inertia, ternary pumped storage facilities have the ability to contribute to primary frequency response ("PFR") due to the ability of the pumped storage plant to pump and generate at the same time. In other words, ternary pumped storage facilities are capable of acting like a fast-acting system that can transition quickly from pumping to generating in response to frequency deviations. There are a number of studies highlighting the capabilities of ternary pumped storage units, including one from Argonne National Laboratory on how these systems should be modeled in production cost and revenue analyses.[16]

CESA recommends the RESOLVE model or alternative IRP model also solve for grid needs such as PFR. A constraint such as this may highlight how resources with actual or synthetic inertia and PFR capability are needed in the grid of the future. The provision of PFR from any resource requires headroom, so model inputs should reflect this real-world operational requirement.

<u>Question 10</u>: Are there any new resource types (not described in Questions 1-9) that Energy Division should prioritize including as a candidate resource in the 2019 IRP? Describe how the new resource type satisfies the new candidate resource criteria listed above. List the data sources available for quantifying the cost and potential of the proposed resource type and describe how the data sources satisfy the data source criteria listed above.

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[16] *Modeling Ternary Pumped Storage Units*, Argonne National Laboratory, published in August 2013. https://ceeesa.es.anl.gov/projects/psh/ANL_DIS-13_07_Modeling_Ternary_Units.pdf

Yes, CESA believes that there are several new resource types that should be prioritized for inclusion in the 2019-2020 RESOLVE model as candidate resources. Using the criteria set forth by the Commission to justify their inclusion as well as some recommended data sources, CESA has outlined the case for each in the below table.

Resource	CAES	Gas + Storage
Criteria 1: Resource must have plausible trajectory to commercial availability within planning time horizon	Yes, there are two CAES plants in operation today in Germany[17] and one CAES plant in Alabama[18] that has been in operation for decades.	Yes, SCE contracted with Wellhead Electric and GE to procure energy storage integrated with a simple-cycle combustion turbine – *i.e.*, the new Hybrid EGT technology.[19]
Criteria 2: Magnitude of potential impact on future portfolio costs and composition must be sufficient to justify changes to model functionality and run-time	Yes, RESOLVE model economically selected approximately 1,200 MW of PHS as being optimal in the 30 MMT scenario and economically selected significant levels of PHS in 2034 to achieve the 2038 GHG emissions target in the limited post-2030 sensitivity for the 42 MMT scenario. D.18-02-018 then added that PHS benefits can be generalized to other bulk storage types, which includes CAES.	Yes, SCE reported to the Commission on the GHG emission reduction benefits from higher capacity factor, lower fuel usage, and fewer gas turbine starts and runs by having the paired energy storage resource optimize gas turbine operations.[20]
Potential Public Data Sources	Lazard's LCOS 2.0[21] and PacifiCorp's 2017 IRP Study Report[22]	Informed estimates based on informational interviews and data reported from SCE's procurement with GE and Wellhead

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[17] See E.ON's Huntorf CAES Plant: http://www.solarplan.org/Research/BBC_Huntorf_engl.pdf

[18] See the McIntosh Plant from PowerSouth Energy Cooperative: http://www.powersouth.com/wp-content/uploads/2017/07/CAES-Brochure-FINAL.pdf

[19] "GE and Southern California Edison Debut World's First Battery-Gas Turbine Hybrid." BusinessWire, published on April 17, 2017. https://www.businesswire.com/news/home/20170417005741/en/GE-Southern-California-Edison-Debut-World%E2%80%99s-Battery-Gas

[20] Application of Southern California Edison (U 338-E) for Approval of its 2018 Energy Storage Procurement and Investment Plan, filed on April 13, 2018. http://www3.sce.com/sscc/law/dis/dbattach5e.nsf/0/E02F51B6FDDADE36882582430079252O/$FILE/A1803XXX-SCE-Various-2018%20Energy%20Storage%20Procurement%20and%20Investment%20Plan%20Testimony-SCE-01.pdf

[21] *Lazard's Levelized Cost of Storage Analysis – Version 2.0*, published in December 2016. https://www.lazard.com/media/438042/lazard-levelized-cost-of-storage-v20.pdf

[22] Black & Veatch, *Bulk Storage Study for the 2017 Integrated Resource Plan*, prepared for PacifiCorp, August 19, 2016. http://www.pacificorp.com/content/dam/pacificorp/doc/Energy_Sources/Integrated_Resource_Plan/2017_IRP/Black_Veatch_PacifiCorp_Bulk_Storage_IRP_Study_Report-final_20160819.pdf

For each of the above, CESA believes that they are already commercially available and present significant potential to support the state's renewable and GHG goals at least cost. CESA recommends the Commission explore these candidate resources.

III. <u>CONCLUSION</u>.

CESA appreciates the opportunity to submit these comments to the Ruling and looks forward to working with the Commission going forward in this proceeding.

Respectfully submitted,

Alex J. Morris
Sr. Director, Policy & Regulatory Affairs
CALIFORNIA ENERGY STORAGE ALLIANCE
2150 Allston Way, Suite 210
Berkeley, California 94704
Telephone: (310) 617-3441
Email: amorris@storagealliance.org

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