

**UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION**

Hybrid Resources

Docket No. AD20-9-000

**INFORMATIONAL REPORT OF THE CALIFORNIA INDEPENDENT SYSTEM
OPERATOR CORPORATION**

The California Independent System Operator Corporation (CAISO) files this informational report in compliance with the Commission’s Order Directing Reports.¹

I. Background

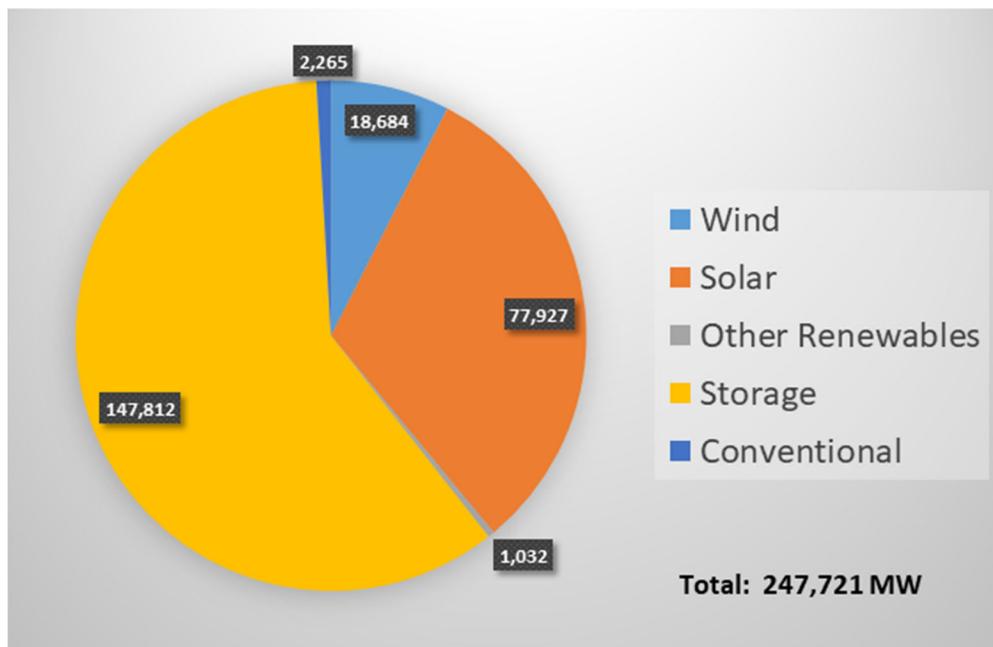
On January 19, 2021, the Commission issued its Order Directing Reports requiring each regional transmission operator (RTO) and independent system operator (ISO) to file informational reports regarding four hybrid resource issues: (1) terminology; (2) interconnection; (3) market participation; and (4) capacity valuation. The Commission directed each RTO/ISO to describe its current practices related to each of these four issues, provide an update on the status of any ongoing efforts to develop reforms related to each of the four issues, and respond to the specific requests for information. The CAISO expects significant deployment of hybrid and co-located resources in its balancing authority area and balancing authority areas participating in the Western Energy Imbalance Market over the next several years, comprised primarily of solar photovoltaic and battery energy storage or wind and battery energy storage.

¹ *Hybrid Resources*, 174 FERC ¶ 61,034 (2021) (*Order Directing Reports*).

II. Hybrid and Co-located Resources are participating in the CAISO’s wholesale markets and represent a significant amount of capacity in its interconnection queue

As of July 1, 2021, the CAISO had one hybrid resource operating within its balancing authority area and participating in its market. The CAISO had twelve co-located resources comprised of solar photovoltaic or battery energy storage participating in its market. The CAISO now has 284 projects in its interconnection queue that have proposed hybrid or co-located projects. Figure 1 reflects the CAISO’s current interconnection queue by project type. Storage interconnection requests include both hybrid and co-located projects.

Figure 1 – Current CAISO Interconnection Queue by Project Type



III. CAISO Response to Reporting Directives

A. Terminology

The Commission directs each RTO/ISO to explain whether it has a definition of hybrid resources in its tariff or in a business practice manual and, if so, to provide the definition and citation in its response.² The Commission also directs that, if the RTO/ISO has already provided this information to the Commission, the RTO/ISO should confirm the information that remains relevant and describe any updates that have occurred.

The CAISO's tariff contains a definition for hybrid resource as well as a definition for co-located resource. The distinction between co-located and hybrid resources is that co-located resources operate in the CAISO's markets as separate and independent resources. Co-located resources are located at the same generating facility from an interconnection perspective, but the CAISO treats them as separate market resources. Co-located resources have separate Resource IDs.³ Co-located resources submit separate bids and receive separate market dispatch instructions from other resources with which they are co-located. They submit separate outages and have separate metering arrangements.

In contrast, hybrid resources combine different components at a generating unit location and are modeled as a single resource. The most prominent example is a resource with an energy storage component and a variable energy component, such as wind or solar, operating and modeled as one generator. A hybrid resource has one bid curve that applies to all of its component parts. A hybrid resource

² Order Directing Reports at P 5.

³ A Resource ID is a set of "[i]dentification characters assigned by the CAISO to Generating Units, Loads, Participating Loads, Proxy Demand Resources, Reliability Demand Response Resources, System Units, System Resources, and Physical Scheduling Plants." Master Definitions Supplement, Appendix A to the CAISO tariff. The CAISO uses Resource IDs to identify separate market resources.

receives one dispatch instruction from the CAISO. The hybrid resource operator self-optimizes the components of its resource to meet that dispatch instruction. The CAISO settles the aggregate output of each hybrid resource under its single Resource ID.

Through a tariff amendment filed earlier this year, the CAISO revised the definition of hybrid resource and added a new definition for mixed-fuel resource.⁴ The CAISO offered this clarification to mitigate potential confusion between references to hybrid resources generically as opposed to the defined term. The CAISO also incorporated the definition of mixed-fuel resource into the existing definition of hybrid resource. Each of the definitions reprinted below from the Master Definitions Supplement, Appendix A of the CAISO tariff reflect the current terminology used by the CAISO.

Mixed-fuel Resource

A Generating Facility with components that use different fuel sources or technologies, participating as a Hybrid Resource or Co-located Resources.

Hybrid Resource

A Mixed-fuel Resource with a single Resource ID at a single Point of Interconnection.

Co-located Resource

A Generating Unit with a unique Resource ID that is part of a Generating Facility with other Generating Units. An EIM Participating Resource with a unique Resource ID that is part of a single resource with other EIM Participating Resources

⁴ See CAISO tariff amendment dated January 8, 2021 in ER21-843. The Commission accepted these terminology clarifications through a Letter Order dated March 9, 2021 in ER21-843.

B. Interconnection

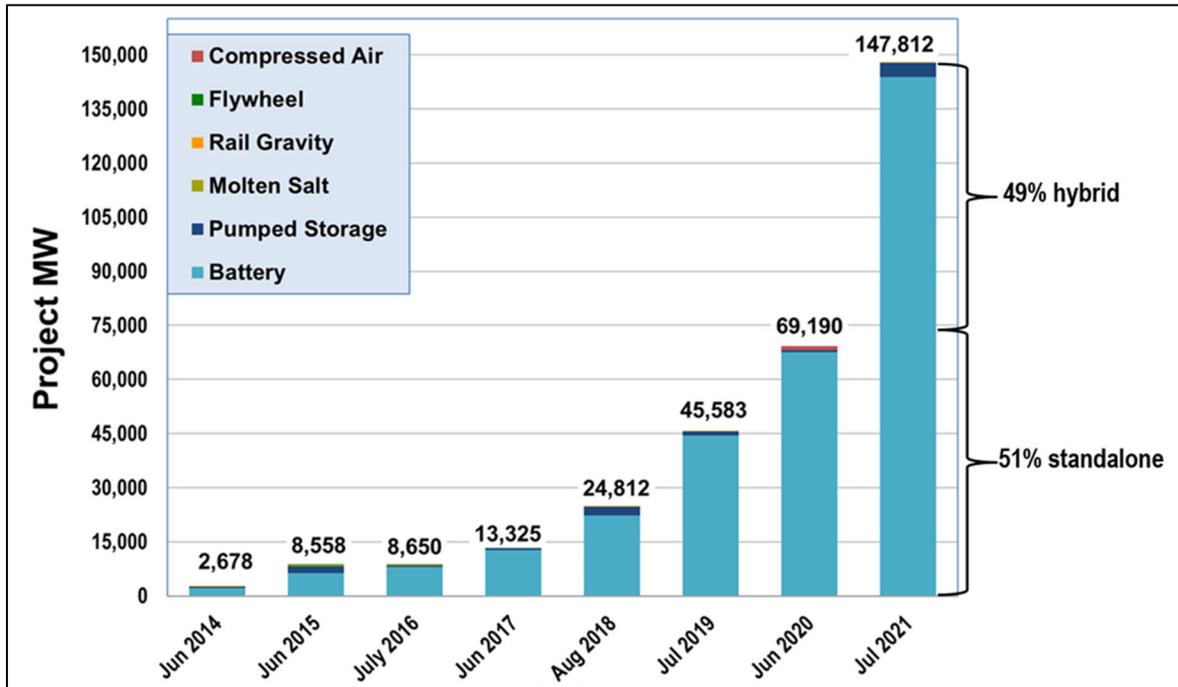
The Commission directs each RTO/ISO to describe the interconnection process for both a hybrid resource newly entering the interconnection queue and a resource adding a storage component to an existing interconnection request.⁵ The description should include details of interconnection request requirements that are specific to hybrid resources (such as parameters necessary for transmission providers to adequately model hybrid resources), how the RTO/ISO models these types of resources both for reliability and market participation, and how an RTO/ISO would treat a request for the addition of storage to an existing interconnection request. The Commission also directs each RTO/ISO to describe any changes to the tariff or business practice manual that would directly affect the interconnection of hybrid resources and that the RTO/ISO is planning or discussing with stakeholders. Finally, if the RTO/ISO has previously provided such information, the Commission directs that the RTO/ISO confirm the information that remains relevant and describe any updates that have occurred.

i. Interconnection process for new hybrid and co-located resources

The CAISO generator interconnection process received its first battery energy storage project in 2014. Figure 2 provides the current and historical levels of energy storage capacity of active projects in the CAISO interconnection queue. Currently, nearly all of the storage capacity totaling 147,812 MW are battery energy storage systems, which include stand-alone projects (51 percent) and capacity associated with hybrid or co-located projects (49 percent).

⁵ Order Directing Reports at P 9.

Figure 2 – Active Energy Storage Capacity in CAISO Interconnection Queue



The CAISO treats mixed-fuel projects submitting an interconnection request similar to other projects.⁶ Because the distinction does not impact the CAISO’s interconnection studies, the CAISO does not require mixed-fuel projects to specify whether they will participate as co-located resources or hybrid resources until very close to commercial operation. Mixed-fuel projects are required to provide technical data information related to their project in the same manner as all projects seeking to interconnect. The CAISO requires technical data for each specific generating technology. In addition, mixed-fuel projects are required to specify the source of their charging energy, either from the transmission grid or from an on-site generator.

⁶ The CAISO provides a significant amount of information about its generator interconnection process on its resource interconnection guide website: <http://www.caiso.com/participate/Pages/ResourceInterconnectionGuide/default.aspx>

Given that mixed-fuel resources typically reflect inverter-based technologies, modeling hybrid interconnection requests generally follows the same guideline as other inverter-based resources. The CAISO aggregates inverters as equivalent generators behind respective equivalent pad-mounted transformers and equivalent collector circuits. However, there are unique considerations for mixed-fuel interconnection requests to enforce plant level control limits and coordination. Depending on coupling of different technologies in the same plant, the power flow representation will vary. The CAISO models DC-coupled components as a one generator. AC-coupled components are represented by separate generators subject to common plant level limitations.

Another unique aspect of modeling mixed-fuel interconnection requests is the charging source. The maximum charging power requested by the interconnection customer is reflected in the power flow and dynamic models as the PMin of the generator. If the storage resource plans to charge from the on-site generation only, the plant level minimum power is set to 0; otherwise, the plant level minimum power is the sum of individual generators' minimum power levels.

For AC-coupled components, the CAISO requires that the interconnection customer enforce the plant level maximum and minimum active power in both the power flow and the dynamic models. The power plant controller model in the power flow has been developed and approved by the WECC Model Validation Subcommittee and is being implemented by the software vendors. Currently, interconnection customers maintain the plant level limits for an AC-coupled hybrid plant outside the power flow model in a separate database. The dynamic models

that can properly model the active power limits and reactive power capability at the plant level and coordination controls among different components are already available. The CAISO works with interconnection customers to ensure they are using the correct dynamic models, enforcing the plant level limits, and coordinating the controls for all mixed-fuel interconnection requests.

ii. Addition of energy storage to existing interconnection projects

In the CAISO's generator interconnection process, interconnection customers may add energy storage resource to an existing generator interconnection request or to a generating facility already in operation. Adding storage to an existing interconnection request or existing generating facility follows the same process as all other modifications. Over the last two years, the CAISO has observed significant interest in adding energy storage to interconnection requests and existing facilities.

If the storage addition requires additional interconnection service capacity or would materially change the electrical characteristics of the interconnection request, the developer must submit a separate interconnection request for the CAISO to study the storage addition.⁷ More often, the addition of energy storage can occur through a modification request.⁸ The CAISO and the participating transmission owner study the modification to ensure there is no material change in electrical characteristics, and that the modification would not negatively impact the cost or timing of other interconnection requests. Even where one occurs, the CAISO allows the

⁷ CAISO tariff section 25.1.

⁸ See CAISO tariff section 25.5 and Section 9 of CAISO Business Practice Manual for Generation Interconnection Procedures.

interconnection customer to mitigate the impact (where mitigation is possible) and to modify the modification request to try to avoid any issue.

At this time, the CAISO is not contemplating specific changes to its tariff governing the generator interconnection processes in order to interconnect mixed fuel resources. Energy storage projects, mixed-fuel projects, and storage additions have been pervasive in the CAISO's interconnection queue for the last several years, and the CAISO has implemented business process enhancements to process them efficiently. Nevertheless, the CAISO regularly considers enhancements to its interconnection processes and will leverage those efforts to consider necessary and appropriate changes based on stakeholder input.

iii. The CAISO's new resource implementation process requires additional information for the CAISO to model hybrid and co-located resources in its markets

The CAISO's "new resource implementation" process on-boards new resources approaching commercial operation, including hybrid and co-located resources. This process includes guidelines, deliverables, and activities the CAISO and interconnection customers undertake during the final three months before interconnection projects to ensure successful synchronization and operation.⁹ Through the project details form submitted into Resource Interconnection Management System (RIMS), a mixed-fuel resource can elect to participate as a hybrid resource or co-located resources. In addition, there are requirements for any resource submitting a generation project in RIMS that has a fuel type of solar or wind

⁹ More information about the CAISO's new resource implementation process is available on its new resource implementation website:
<http://www.caiso.com/participate/Pages/NewResourceImplementation/Default.aspx>

to provide site information and topographic maps to facilitate the development of production forecast for those technologies. The requirements of the CAISO eligible intermittent resource protocol extend to hybrid resources with a wind generation or solar generation component.¹⁰

C. Market Participation

The Commission directs each RTO/ISO to describe how hybrid resources are currently participating in its wholesale energy, ancillary services, and capacity markets.¹¹ The report should include the services that hybrid resources are eligible to provide and how modeling and bidding for such resources occurs, including modeling and bidding provisions unique to hybrid resources. If no specific provisions exist, the RTO/ISO should explain whether and how hybrid resources have participated in its markets to date. If hybrid resources are not able to provide certain services, the RTO/ISO should explain why they are not able to provide such services. The Commission also directs each RTO/ISO to describe any changes to its tariff or business practice manuals that relate to the market participation of hybrid resources and that the RTO/ISO is planning or discussing through its stakeholder process. Finally, the Commission directs that if RTOs/ISOs have submitted this information to the Commission previously, each RTO/ISO should confirm the information remains relevant and include any updates that have occurred.

- i. Hybrid and co-located resources may participate in energy and ancillary services markets as well as offer resource adequacy capacity**

¹⁰ See CAISO tariff, Appendix Q.

¹¹ Order Directing Reports at P 12.

Market participants may participate in the CAISO's energy and ancillary services markets as either hybrid or co-located resources, so long as they meet technical requirements for those services. As discussed above, the CAISO models the various components of a hybrid resource under one Resource ID. The CAISO models co-located resources at a single generating facility under separate Resource IDs.

Under the hybrid model, a scheduling coordinator submits one bid curve that applies to all of the hybrid resource's component parts. For a hybrid resource with a solar or wind component, the CAISO requires meteorological and other data to develop a production forecast for that component of the resource. A hybrid resource receives one dispatch instruction from the CAISO. The hybrid resource operator self-optimizes the components of its resource to meet that dispatch instruction. The CAISO settles the aggregate output of each hybrid resource under its single Resource ID.

Scheduling coordinators for co-located resources submit separate bids and receive separate market dispatch instructions for each co-located resource. In fact, co-located resources may have distinct scheduling coordinators. In any case, co-located resources submit separate outages and have separate metering arrangements. For a co-located resource that is an eligible intermittent resource, *i.e.* principally solar photovoltaic and wind resources, the CAISO requires meteorological and other data to develop a production forecast for that resource. When an eligible intermittent resource's dispatch operating target equals its forecast, the CAISO tariff allows the resource to generate to its capability. Based on its bid curves or operating

needs, the CAISO may dispatch co-located eligible intermittent resources to reduce output to remain at or below its forecast levels.

Earlier this year, the CAISO enhanced its market rules to clarify that co-located resources may deviate from dispatch instructions under certain conditions. Specifically, the CAISO clarified that when an eligible intermittent resource produces energy above its dispatch instruction because meteorological conditions differ from what was forecast a co-located energy storage resource may produce less energy than its dispatch instruction to ensure the combined resources' output does not exceed their shared interconnection service capacity.¹² This market rule recognizes that the energy storage resource may reduce output to compensate for the over-performing eligible intermittent resource based on control technologies installed to ensure safety and reliability at resources' the point of interconnection.

The CAISO models co-located energy storage resources in the same way it models energy storage resources that are not co-located. Scheduling coordinators for these resources bid into the market and follow dispatch instructions like other conventional resources. The market model for storage includes a charging (negative) and discharging (positive) dispatch range and the CAISO may dispatch a storage resource anywhere within this range. Furthermore, the CAISO market software tracks state of charge and ensures these values do not exceed registered upper and lower thresholds.

¹² See CAISO tariff section 34.13.3.

ii. The CAISO has implemented a market constraint to support the optimization of co-located resources

In 2020, the CAISO implemented an aggregate capability constraint for co-located resources that are “oversized” relative to their approved interconnection service capability. For example, a 100 MW solar resource co-located with a 50 MW storage resource may have a combined interconnection service capacity of 100 MW. This configuration reduces costs for physical interconnection equipment, which may be unnecessary because the solar and storage typically will generate at different times. The CAISO’s aggregate capability constraint allows the CAISO’s market optimization to issue awards and dispatches such that the capability of co-located units at a single generating facility does not exceed the generating facility’s interconnection service capacity or charging capacity.¹³

Although both hybrid and co-located resources are eligible to provide ancillary services in CAISO markets, the CAISO has limited co-located resources utilizing an aggregate capability constraint to provide only energy. The CAISO plans to lift this restriction in fall 2021 so that co-located resources utilizing an aggregate capability constraint may provide both energy and ancillary services.

In addition, the CAISO plans to amend its tariff in August 2021 to allow multiple sets of co-located resources to use distinct aggregate capability constraints simultaneously within a single generating facility. At present, the CAISO only allows for the use of a single aggregate capability constraint at a generating facility comprised of co-located resources. The use of multiple aggregate capability

¹³ Exceeding the interconnection service capacity would violate the interconnection customer’s generator interconnection agreement and could threaten reliability and safety.

constraints at a single generating facility will allow the CAISO to nest a set of constraints that are subordinate to the master aggregate capability constraint that observes the generating facility's total interconnection service capacity limit. These subordinate aggregate capability constraints will support multiple resources and off-takers at a generating facility by allowing the CAISO to model each set of co-located resources to their maximum contractual operating levels, but limit the awards and dispatch instructions to the portion of the interconnection service capacity represented by the subordinate aggregate capability constraint.¹⁴

iii. The CAISO plans to enhance its hybrid resource model and will continue to work with stakeholders to explore additional enhancements

Under the CAISO's current market rules, hybrid resources must convey information to the CAISO about how much energy they can actually provide to the market during any given interval. This can be challenging because resources seeking to use a hybrid resource model may have underlying wind or solar components. The CAISO allows these resources to submit outage cards through the outage management system to reflect the unavailability of fuel, but this submission is a manual process and is relatively labor intensive to maintain if the actual output changes often. The CAISO is proposing two enhancements to its hybrid model to help address this issue. The first enhancement will require each wind or solar component of a hybrid resource to provide the CAISO with its high sustainable limit on an ongoing basis. This data will reflect the instantaneous generating capability of

¹⁴ See Memorandum from Anna McKenna, CAISO Vice President of Market Policy and Performance to CAISO Board of Governors regarding Decision on Hybrid Resource Aggregate Capability Constraint dated July 7, 2021 <http://www.aiso.com/Documents/Decision-Hybrid-Resources-Aggregate-Capability-Constraint-Implementation-Memo-July-2021.pdf>

each variable or intermittent component of the hybrid resource provided to the CAISO through telemetry.¹⁵ The CAISO plans to amend its tariff in August 2021 to implement this requirement in the fall of 2021.

The second enhancement will implement a bid parameter that will allow scheduling coordinators to represent the real-time capabilities of hybrid resources and thereby support the issuance of feasible dispatch instructions. The bid parameter will allow scheduling coordinators for hybrid resources to submit three hours of expected resource availability—with 5-minute granularity—to the CAISO through an automated process. The CAISO market software will use the data submitted to inform upper and lower bounds for dispatch of hybrid resources. The CAISO plans to amend its tariff in August 2021 to implement this enhancement in the spring of 2022.

As part of the CAISO's three-year policy roadmap, the CAISO has planned a stakeholder process in 2022 to address "Hybrid Resource Evolution."¹⁶ The Hybrid Resource Evolution initiative will review the market rules in place for hybrid and co-located resources, and may consider new market functionality to allow them to operate more effectively in the market. This stakeholder initiative will review operations and market data from actual experience with hybrid and co-located resource operation to inform any new market rules.

¹⁵ The CAISO also plans to extend the requirement to eligible intermittent resources, which will facilitate the real-time provision of ancillary services by these resources.

¹⁶ See July 15, 2021 Briefing to CAISO Board of Governors on 2021 Three-Year Policy Initiatives Roadmap and Annual Plan by Greg Cook, CAISO Executive Director, Market and Infrastructure Policy at slides 2 and 5. <http://www.aiso.com/Documents/Briefing-2021-Three-Year-Policy-Initiatives-Roadmap-Annual-Plan-Presentation-July-2021.pdf>

D. Capacity Valuation

The Commission directs each RTO/ISO to explain how the capacity value of hybrid resources is currently determined in its markets. Each RTO/ISO should describe the method used and any changes to how it calculates capacity values for hybrid resources it is planning or that it is discussing with stakeholders. The Commission directs that If RTOs/ISOs have submitted this information to the Commission previously, each RTO/ISO should confirm the information remains relevant and include any updates that have occurred.

i. Within the CAISO balancing authority area local regulatory authorities determine qualifying capacity for resource adequacy purposes

In the CAISO's balancing authority area, local regulatory authorities such as the California Public Utilities Commission determine qualifying capacity for resource adequacy resources. Currently, the CPUC uses an electric load carrying capability (ELCC) methodology to assign resource adequacy values to solar and wind resources. This methodology applies an "effectiveness factor" to the nameplate value of the resource to determine the resource adequacy capacity value for which the renewable resources counts. The CPUC determines qualifying capacity for storage resources by how much energy the storage resource is capable of continuously discharging for four hours. Resources with a longer discharge duration do not receive a different amount of credit for resource adequacy capacity than those that can only provide energy for four hours.

The CPUC calculates capacity for hybrid and co-located resources differently than stand-alone solar, wind and storage resources. The CPUC has adopted a

methodology that reduces the qualifying capacity of the solar or wind component by an amount of energy that the CPUC expects to charge the on-site storage resource. As a result, hybrid and co-located resources receive slightly less qualifying capacity than identically sized stand-alone resources. Under this methodology, the CPUC determines a resource's qualifying capacity by adding the effective qualifying capacity of each component of the hybrid resource or each co-located resource. However, the qualifying capacity for the renewable component or renewable co-located resource reflects the nameplate capacity of the resource multiplied by the production profile of the resource less the necessary MWh to charge the storage component. The CPUC then divides the remaining MWh by the production profile to reach the effective qualifying capacity of the renewable component or resource. The CPUC then multiplies this value by the relevant ELCC value for the month in question. The effective qualifying capacity for the storage component or co-located resources reflects the resource's nameplate capacity if the resource can be fully charged by renewable component or co-located resource. Otherwise, the resource is limited to the MWh the renewable component is capable of producing divided by four hours.

The CAISO actively engages with the CPUC and other local regulatory authorities on resource adequacy counting rules. The CAISO anticipates the issue of how local regulatory authorities count these resources for qualifying capacity will evolve as we gain experience with their operation.

ii. The CAISO is working with stakeholder to refine resource adequacy counting rules

Through its resource adequacy enhancements stakeholder initiative, the CAISO is working to refine how hybrid and co-located resources qualify to offer

resource adequacy capacity.¹⁷ One primary component of this policy is to adopt an “unforced capacity” (UCAP) counting methodology, that would incorporate historic outage rates into resource adequacy capacity values for specific resources. This will incentivize resources to be available more often and will help inform procurement of more effective resource adequacy resources.

In this initiative, the CAISO also proposes that co-located resources receive identical treatment as stand-alone resources for resource adequacy purposes. The expected performance of storage resources that are independent of solar or wind resources is identical to electrically similar resources that are co-located and should therefore be eligible for the same amount of resource adequacy capacity. The same is true for co-located solar and wind resources. The CAISO is also proposing changes for how hybrid resources qualify for resource adequacy. Hybrid resources participate as a single resource, and manage state of charge internally. These resources should receive resource adequacy credits based on their availability, via a methodology similar to the proposed UCAP methodology, based on historic availability. The proposed methodology is similar to what the CPUC uses for hydroelectric resources today. Hydroelectric resources, like hybrid resources also have a significant amount of control over when they can bid into the market. Adopting such a methodology will incentivize hybrid resources to be available more often and align resource adequacy accreditation with availability.

¹⁷ More information about the CAISO’s stakeholder initiative is available on its stakeholder initiative website: <https://stakeholdercenter.caiso.com/StakeholderInitiatives/Resource-adequacy-enhancements>

IV. Conclusion

The CAISO expects significant deployment of hybrid and co-located resources in its balancing authority area over the next several years. As described in this informational report, the CAISO will continue its efforts to integrate these resources into its markets.

Respectfully submitted,

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