
# Hybrid Resources White Paper

**A STAFF PAPER: FEDERAL ENERGY REGULATORY COMMISSION**

**DOCKET NO. AD20-9-000**

MAY 2021

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## I. Introduction

This staff white paper examines hybrid resources. The information in this white paper was developed through the Commission's July 2020 Hybrid Resources technical conference in Docket No. AD20-9-000[1] and the post-conference comments. The technical conference focused on the growth of co-located hybrid and integrated hybrid resources and the current approaches to interconnecting such resources and allowing for their participation in the Regional Transmission Organization (RTO) and Independent System Operator (ISO) markets, as well as outside of RTO/ISO markets. In particular, the conference focused on generation paired with electric storage. This white paper includes excerpts from the record, also reflecting additional staff research and updates from RTO/ISO proceedings.

The terms hybrid resource, co-located resource, and mixed technology resources, among others, are all commonly used by industry to refer to resources that share a point of interconnection and incorporate at least two different resource types. As discussed below, the installation of these resources has been increasing rapidly over recent years, prompting a discussion of how they are interconnected across the country, and incorporated into wholesale markets in particular. These resources are often broken into two general categories: (1) co-located hybrid resources, generally referring to sets of resources that are modeled and dispatched as two (or more) separate resources that share a single point of interconnection; and (2) integrated hybrid resources (also referred to as co-controlled or integrated control hybrid resources), generally referring to sets of resources that share a single point of interconnection, and are modeled and dispatched as a single integrated resource.[2] While diverse terminology exists, this white paper refers to such resources as "co-located hybrid resources" and "integrated hybrid resources," respectively. The expansion of co-located hybrid resources and integrated hybrid resources is so new that various regions have different definitions of what constitutes a

[1] *Notice of Technical Conference re Hybrid Resources*, Docket No. AD20-9-000 (Apr. 7, 2020), https://www.ferc.gov/sites/default/files/2020-06/20200407120752-AD20-9-000.pdf (Notice of Technical Conference); *Supplemental Notice of Technical Conference re Hybrid Resources*, Docket No. AD20-9-000 (June 16, 2020), https://elibrary.ferc.gov/eLibrary/filelist?document_id=14869484&accessionnumber=20200616-3067; *Supplemental Notice of Technical Conference re Hybrid Resources*, Docket No. AD20-9-000 (July 13, 2020), https://www.ferc.gov/sites/default/files/2020-07/AD20-9-000-Supp-Tech-Conf.pdf.

[2] *Hybrid Resources*, 174 FERC ¶ 61,034, at P 4 (2021) (Order Directing Reports). In January 2021, the Commission issued an Order Directing Reports requiring each RTO/ISO to provide certain information to the Commission regarding co-located hybrid and integrated hybrid resource participation in their markets.

co-located hybrid or integrated hybrid resource, and many are currently undertaking stakeholder processes to better assess how to categorize such resources.

This white paper provides an analysis of selected issues including co-located hybrid and integrated hybrid resource terminology, interconnection, market participation, and capacity accreditation. The white paper also highlights some policy issues of continued interest regarding increases in co-located hybrid and integrated hybrid resource participation in organized wholesale electric markets, as well as in non-RTO/ISO regions. While this white paper is not an exhaustive list of considerations for co-located hybrid and integrated hybrid resources, it focuses on a number of issues to summarize and build upon the information gained in the technical conference proceeding.

## II. Background

Interest in co-located hybrid and integrated hybrid resources has accelerated in recent years. Because current co-located hybrid and integrated hybrid resources frequently include battery storage paired with intermittent generation, the increased interest in co-located hybrid resources and integrated hybrid resources is at least in part attributable to the recent growth in electric storage resources.[3] Co-located and integrated hybrid resource deployment has increased in both RTO/ISO and non-RTO/ISO regions, with growth concentrated in certain RTOs/ISOs, most notably in the California Independent System Operator Corporation (CAISO).[4]

The vast majority of publicly announced co-located hybrid or integrated hybrid projects are solar photovoltaic (PV) combined with battery electric storage, but project developers have also announced wind combined with electric storage, natural gas

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[3] *See* Gramlich, Rob et al., *Enabling Versatility: Allowing Hybrid Resources to Deliver Their Full Value to Customers*, at 5 (Sep. 2019), https://energystorage.org/thought-leadership/enabling-versatility-allowing-hybrid-resources-to-deliver-their-full-value-to-customers/#:~:text=Become%20a%20Member-,Enabling%20Versatility%3A%20Allowing%20Hybrid%20Resources%20to%20Deliver%20Their%20Full%20Value,differently%20than%20traditional%20generator%20resources; CAISO Hybrid Resources Issue Paper at 3, http://www.caiso.com/Documents/IssuePaper-HybridResources.pdf.

[4] In American Wind Energy Association's (AWEA) prepared remarks for the Hybrid Resources Technical Conference, Adam Stern notes that 10% of resources in RTO/ISO interconnection queues nationwide are co-located or hybrid projects (i.e., co-located hybrid or integrated hybrid projects, respectively). Speaker Materials of Adam Stern at 1. In its post-conference comments, CAISO notes that, of all active interconnection requests in its queue, 47.6% are co-located or hybrid, and, of those submitted in 2020, 58% are co-located or hybrid. CAISO Comments at 2.

combined with electric storage, and even solar combined with wind and electric storage projects.[5] One driver of the increase in co-located hybrid and integrated hybrid resources is that some configurations allow the electric storage component of the resource to qualify for increased financial incentives, including the federal Investment Tax Credit and certain state incentives for electric storage resources that charge from renewable resources.[6] These financial benefits, in addition to the opportunity for wholesale market revenues, could attract further investment in hybrid technologies and projects, potentially leading to increased competition and market efficiency. At the beginning of 2020, the six Commission-jurisdictional RTOs/ISOs reported collectively greater than 62 gigawatts of co-located hybrid and integrated hybrid projects in their interconnection queues.[7]

## A. Technical Conference and Comments

### 1. July 2020 Technical Conference

Commission staff held a technical conference to discuss co-located hybrid resources and integrated hybrid resources on July 23, 2020.[8] During the technical conference, participants discussed issues related to the terminology, interconnection,

[5] Research by Lawrence Berkeley National Laboratory found that solar/storage hybrids made up approximately 85 percent of the capacity of hybrid resources in the interconnection queues nationwide at the beginning of 2020. *See* Berkley Lab Electricity Markets & Policy, *Generation, Storage, and Hybrid Capacity in Interconnection Queues*, https://emp.lbl.gov/generation-storage-and-hybrid-capacity. *See also*, AWEA Comments at 8, which contains a chart of current hybrid resource types by region.

[6] *See, e.g.*, AWEA Comments at 9-10; Savion Comment at 3; R Street Comments at 3; ACORE Comments at 2; MISO Comments at 5; Enel North America, Inc. (Enel) Comments at 4. The Further Consolidated Appropriations Act of 2020 delayed the phasedown of the Investment Tax Credit. The credit is currently 26 percent for all projects (residential and commercial) that begin construction in 2021 and 2022, 22 percent for all projects that begin construction in 2023, and zero percent for residential projects and 10 percent for commercial projects that begin construction after 2023. *See* Further Consolidated Appropriations Act, 2020, Pub. L. No, 116–94, 133 Stat. 2535 (2019).

[7] *See* Berkley Lab Electricity Markets & Policy, *Generation, Storage, and Hybrid Capacity in Interconnection Queues*, https://emp.lbl.gov/generation-storage-and-hybrid-capacity.

[8] *Supplemental Notice of Technical Conference re Hybrid Resources*, Docket No. AD20-9-000 (July 13, 2020), https://www.ferc.gov/sites/default/files/2020-07/AD20-9-000-Supp-Tech-Conf.pdf.

market rules, and capacity valuation for co-located hybrid and integrated hybrid resources, among other issues. The technical conference provided an opportunity for staff and industry representatives to discuss the benefits and challenges of integrating co-located and integrated hybrid resources, as well as the status of the ongoing efforts to address these challenges.

In these discussions, experts in industry, academia, and at RTOs/ISOs all emphasize how quickly co-located hybrid and integrated hybrid resources have been added to interconnection queues, and the relative lack of operational experience with these resources in many regions. Various panelists note that, as recently as two years ago, there were virtually no co-located hybrid or integrated hybrid resources in interconnection queues, and today there are 102 gigawatts of solar paired with storage, and 11 gigawatts of wind paired with storage in interconnection queues across the country, including both RTO/ISO regions and non-RTO/ISO regions.[9]

Factors driving the increase in co-located hybrid and integrated hybrid resources include lower costs for battery, wind, and solar resources, and the federal Investment Tax Credit.[10] Various participants note the work ahead to accommodate co-located hybrid and integrated hybrid resources, but it is evident from discussions during the technical conference that RTOs/ISOs, other industry stakeholders, and the academic community are all invested in addressing terminology, defining a path for interconnection, and reviewing energy, capacity, and ancillary services market rules to determine what changes may be required to address the growing number of these hybrid resources. While not a focus of the technical conference, participants also reference the need to consider and discuss market power issues in relation to co-located hybrid and integrated hybrid resources.

### 2. Post-Conference Comments

The Commission received post-conference comments from five RTOs/ISOs: CAISO, PJM Interconnection, L.L.C. (PJM), New York Independent System Operator, Inc. (NYISO), Midcontinent Independent System Operator, Inc. (MISO), and ISO New England Inc. (ISO-NE). The Commission also received comments from a number of stakeholders from industry and academia. Some commenters recommend that the Commission allow regional stakeholder processes to address co-located hybrid and integrated hybrid resource integration issues and that the Commission should not act generically at this time.[11] These commenters maintain that allowing the various regions to continue their ongoing stakeholder processes would accommodate differences in

[9] Tr. 17-18 (Will Gorman).

[10] Tr. 18 (Will Gorman).

[11] Edison Electric Institute (EEI) Comments at 2, 6; NYISO Comments at 2.

penetration of co-located hybrid and integrated hybrid resources and would allow for needed flexibility in accommodating regional differences.[12] Other commenters request that the Commission ask market operators to identify and address potential limitations to co-located hybrid and integrated hybrid resource participation in organized wholesale markets.[13] Commenters note that a large number of co-located hybrid and integrated hybrid resources are located outside of RTO/ISO regions.[14] Commenters state that one fundamental issue to be resolved is the amount of control RTOs/ISOs should exercise over co-located hybrid and integrated hybrid resources.[15] Commenters also note that it is unclear whether operating as an integrated hybrid resource as opposed to a co-located hybrid resource will result in a more economically efficient market solution for the system or for the hybrid asset itself.[16] Furthermore, some note that the use of AC or DC coupling of the component resources affects how the resource can interact with the market, and may affect how it is categorized (as a co-located hybrid or integrated hybrid).[17]

A number of commenters emphasize the need for flexibility at all stages of the co-located hybrid and integrated hybrid project lifecycle. This lifecycle includes: (1) entering the interconnection queue and determining whether the co-located hybrid or integrated hybrid project will operate as a single or multiple resource type; (2) navigating changes that may come up during the interconnection process; (3) determining how best to operate the resource; and (4) assessing how the resource can operate in the market most economically.[18] In addition, other commenters emphasize the need for integrated hybrid and co-located hybrid resources to be able to provide all services that they are capable of providing.[19] Furthermore, some commenters note that market power mitigation approaches may need to be modified, given that traditional reference levels based on opportunity costs may not be a good fit for co-located hybrid and integrated

[12] EEI Comments at 6-9.

[13] Solar Energy Industries Association (SEIA) Comments at 2-4.

[14] SEIA Comments at 3.

[15] American Council on Renewable Energy (ACORE) Comments at 4.

[16] Electric Power Research Institute (EPRI) Comments at 7.

[17] AWEA Comments at 14-15.

[18] ACORE Comments at 1-6; AWEA Comments at 1-34; R Street Institute Comments at 1-6; SEIA Comments at 1-8.

[19] AWEA Comments at 5, 13; R Street Institute Comments at 4.

hybrid resources because such resources may have different opportunity costs.[20]

## III. Current Approaches

This section provides a summary of the status of co-located hybrid and integrated hybrid resource interconnection and wholesale market participation in each of the RTOs/ISOs, as well as provides one example outside of the RTO/ISO markets. Staff notes that RTO/ISO stakeholder proceedings are ongoing, and therefore the summary below is subject to change. The RTOs/ISOs will be providing an update to the Commission in July 2021 in response to the Commission's January 19, 2021 Order Directing Reports.

### A. RTO/ISO Markets

#### 1. ISO New England Inc.

ISO-NE interprets "co-located facilities" to mean any combination of generation and electric storage connected behind a common point of interconnection, and states that these resources can participate in both the energy market and Forward Capacity Market as separate resources or as a single resource.[21] ISO-NE views integrated hybrid resources as the subset of co-located hybrid resources that participate as a single energy market asset or a single capacity resource, and also allows for their participation as a single combined asset representing the entire facility.[22]

ISO-NE allows co-located hybrid or integrated hybrid resources to choose how they will be modeled and indicates that its existing rules generally accommodate the participation of such resources. In ISO-NE, the majority of co-located hybrid and integrated hybrid facilities are currently solar PV and batteries, with output of less than five megawatts. In ISO-NE, 75 co-located hybrid or integrated hybrid facilities qualified in 2019 or were expected to qualify in 2020 for the Forward Capacity Market and, of those, 32 facilities requested to be modeled and dispatched as a single integrated hybrid resource. ISO-NE's interconnection queue includes 57 MW of co-located hybrid or integrated hybrid resources.[23]

ISO-NE has not developed or implemented a specific participation model for integrated hybrid or co-located hybrid resources. Co-located facilities are able to participate as separate resources in ISO-NE's energy and capacity markets, and it remains

[20] AWEA Comments at 29.

[21] ISO-NE Comments at 1.

[22] *Id.* at 2.

[23] *Id.* at 2-3.

the market participant's decision as to which participation model to choose. ISO-NE states that a single combined asset representing an integrated hybrid resource may participate as either a Continuous Storage Facility, a Settlement Only Generator (if the facility maximum output is under 5 MW and connected below 115 kV), or an Intermittent Generator (if the facility is primarily intermittent).[24] ISO-NE explains that, although a dominant configuration has not yet emerged in ISO-NE, from its perspective participation as an integrated hybrid Continuous Storage Facility is preferable to participation as separate co-located hybrid resources or as an integrated hybrid Intermittent Generator at this time because it reduces complexity related to dispatchability, reserve designations, and metering for DC-coupled facilities.[25] In April 2020, ISO-NE offered a training presentation for stakeholders, which details current market participation options for co-located hybrid and integrated hybrid facilities.[26] ISO-NE sees the task ahead as continuing to weigh the benefits and costs of all participation models as more integrated hybrid and co-located hybrid resources come online and dominant participation models begin to emerge.[27]

ISO-NE's existing interconnection process allows interconnection customers to propose a combined resource. ISO-NE does not limit the number and type of devices that may connect at the same point of interconnection as part of a single request, thus paired resources only need to submit one interconnection request.[28] ISO-NE also considers the addition of electric storage to an existing generating facility or to an existing Interconnection Request that is already in the interconnection queue to be a material modification, which requires the submission of a new interconnection request.[29] However, the interconnection studies required for such a Material Modification would

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[24] *Id.* at 2 n.1.

[25] *Id.* at 2, 7-10.

[26] *Id.* at 2. *See* ISO New England Inc., *Market Participation Options for Combined Intermittent/Electric Storage Facilities* (Apr. 2020), https://www.iso-ne.com/static-assets/documents/2020/04/20200408-co-located-market-participation.pdf.

[27] ISO-NE Comments at 8.

[28] *Id.* at 4.

[29] *Id.* at 5-6. Section 1 of the *pro forma* Large Generation Interconnection Procedure (LGIP) defines Material Modification as, "those modifications that have a material impact on the cost or timing of any Interconnection Request with a later queue priority date."

only include the incremental changes introduced with the addition of the electric storage resource; therefore, the interconnection process would likely proceed more quickly than a completely new interconnection request.[30]

With respect to capacity market participation, ISO-NE explains that a co-located hybrid resource generally qualifies as two separate capacity market resources: the storage component as a non-intermittent Generating Capacity Resource, and the generation component as an Intermittent Power Resource.[31] ISO-NE explains that an integrated hybrid resource qualifies in the Forward Capacity Market as a single non-intermittent Generating Capacity Resource or as a single Intermittent Power Resource depending on the configuration and relative size of the paired facilities.[32] ISO-NE states that it is currently conducting an Effective Load Carrying Capability (ELCC) analysis, which is one approach to capacity valuation discussed in greater detail below. ISO-NE notes that it will be studying hybrid resources as part of this effort, with initial results expected in 2021.[33]

### 2. New York Independent System Operator, Inc.

NYISO explains that co-located hybrid and integrated hybrid projects are growing in number in NYISO because of perceived benefits such as the ability to improve the performance and flexibility of renewable energy, reduced development costs from sharing interconnection facilities, and additional financial incentives when electric storage charges using renewable energy.[34] NYISO highlights how its ongoing market design initiatives would meet the needs of the grid operator without being overly-burdensome to market participants.[35]

NYISO requests that the Commission provide each RTO/ISO with the flexibility to implement any Commission regulations for co-located hybrid and integrated hybrid resources in a manner that best fits its existing market design, regional needs, and

[30] ISO-NE Comments at 5.

[31] *Id.* at 17 and Attachment A, Slides 11-18.

[32] *Id.*

[33] *Id.* at 17.

[34] NYISO Comments at 1.

[35] *Id.* at 6, 9-11.

regional and local reliability requirements.[36] In January 2021, NYISO made its first filing with the Commission specific to hybrid resources, which is limited to the co-located operation of an Energy Storage Resource (ESR) and a wind or solar intermittent power resource and builds upon existing market rules for dispatchable wind and solar intermittent power resources. NYISO articulates its decision to focus on co-located configurations as: (1) this resource combination is the most commonly requested by NYISO's stakeholders; and (2) NYISO expects that it will be able to develop the necessary market improvements and implement the proposed tariff revisions in the fourth quarter of 2021.[37] NYISO further states that, in 2021, it will work with NYISO stakeholders to develop a hybrid storage aggregation model that will allow an ESR and other resources located at the same point of interconnection to participate in the markets as an aggregated resource.[38]

In its co-located storage resource filing, NYISO states that its market design process identified a number of factors that support co-location of ESRs and renewables, including: (1) improving the performance and flexibility of renewable resources; (2) reducing development costs by sharing interconnection facilities; and (3) providing access to financial incentives that are available when ESRs use renewable energy to recharge or refill. In addition, NYISO states that its hybrid storage resource participation models will help reduce barriers to entry for ESRs moving forward.[39] NYISO also puts forth two new tariff-defined terms: "Co-Located Storage Resource (CSR)" and "CSR Scheduling Limit." NYISO defines a CSR as "a wind or solar Intermittent Power Resource and an Energy Storage Resource (two Generators) that: (a) are both located behind a single Point of Injection; (b) participate in the ISO Administered Markets as two distinct Generators; and (c) share a set of CSR Scheduling Limits."[40] NYISO defines CSR Scheduling Limit as establishing "the maximum, combined Regulation Capacity, Operating Reserve and Energy injection schedules for, and the maximum net injection by a CSR's Generators. The CSR withdrawal Scheduling Limit sets the maximum,

[36] *Id.* at 2.

[37] *N.Y. Indep. Sys. Operator, Inc.*, Transmittal, Docket No. ER21-1001-000, at 2 (filed Jan. 29, 2021).

[38] NYISO Comments at 6-7.

[39] *Id.* at 6.

[40] *Id.* at 8.

combined Regulation Capacity and Energy withdrawal schedules for, and the maximum net withdrawal by a CSR's Generators."[41]

The Commission accepted NYISO's proposed tariff revisions to implement its CSR Participation Model as just and reasonable. In particular, the Commission found that these tariff revisions will enhance the eligibility and participation of CSR component resources, as well as for ESRs more generally, in NYISO's energy, ancillary services and capacity markets. As such, the Commission accepted a portion of NYISO's proposed tariff revisions relevant to NYISO's co-located storage participation model, effective March 31, 2021, and directed a compliance filing identifying the proposed effective date for the remaining proposed tariff revisions in the fourth quarter of 2021.[42]

### 3. PJM Interconnection, L.L.C.

PJM's tariff does not include a formal definition of either "co-located" or "hybrid resources." In its post-technical conference comments, PJM uses the term "mixed technology resources" to describe both integrated hybrid and co-located resource types.[43] PJM is also unique in its usage of the terms "open-loop system," in which the storage component can charge from the grid, and "closed-loop system," in which the storage component is solely charged from the other component resource of the co-located or integrated hybrid.[44]

As of August 2020, PJM had 14,061 MW of mixed technology resources in its interconnection queue, including 13,645 MW of solar PV-battery combinations across 133 projects. PJM also reports that mixed technology resources account for 20% of all proposed solar PV generation in PJM on an energy basis, as of the same date.[45] PJM has undertaken a stakeholder process to make improvements to its business practice manuals to ensure mixed technology resources have clear business rules to guide their participation in the PJM markets. PJM also indicates that it is discussing how to facilitate the interconnection of integrated and co-located hybrid resources, as well as participation in its energy and ancillary services markets, as part of the ongoing stakeholder process.[46]

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[41] *Id*.

[42] *N.Y. Indep. Sys. Operator, Inc*, 174 FERC ¶ 61,242 (2021).

[43] PJM Comments at 2.

[44] *Id.*; Speaker materials of Andrew Levitt at 3 n.1.

[45] PJM Comments at 3.

[46] *Id.* at 3, 5.

While integrated and co-located hybrid resources can currently operate in PJM's energy, capacity, and ancillary services markets today, PJM acknowledges that very few are currently operating as an integrated hybrid resource in its markets.[47] PJM states that this can largely be attributed either to operator preference to run the respective components as separate (co-located hybrid) entities or to the queue status of the projects. PJM mentions that its Distributed Energy Resource & Inverter-based Resource Subcommittee is entertaining a proposal for integrated hybrid resources to participate in these markets as a single unit. Moreover, PJM states that, under this proposal, mixed technology with no significant interaction between the components may participate in these markets as separate (co-located hybrid) resources.[48]

PJM's approach to integrated and co-located hybrid resources presumes that the plant owner/operator is the party with the greatest insight and control over the resource's various components.[49] PJM notes that an approach which relies on each market participant to manage internal constraints may best align with a generic market model that is fuel-neutral.[50] However, PJM indicates that it does limit resource operator flexibility when necessary to ensure reliability. For example, PJM requires that solar PV-battery hybrids have direct measurement of the solar PV component alone because of forecast variability.[51] Similarly, PJM prefers that resources that share an inverter (DC-coupled), or have significant interaction between the separate inverters of components behind the same point of interconnection, be modeled as a single (integrated hybrid) resource. PJM explains that, prior to modeling resources separately that share a power flow constraint, it needs to address significant challenges, such as developing a cost-effective submetering solution that would provide sufficient visibility to PJM of individual resources behind a shared constraint.[52] On the topic of reliability, PJM also reports having had exploratory discussions with transmission owners and resource owners to explore opportunities for better coordination of reactive services provided by variable or combination resources.[53]

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[47] *Id.* at 3.

[48] *Id.* at 10-11.

[49] *Id.* at 4.

[50] *Id.*

[51] *Id.* at 13.

[52] *Id.* at 9.

[53] *Id.* at 11.

Under PJM's current business rules, hybrid resources cannot schedule charging (negative MW) or be dispatched to charge. Though resources that elect to use the electric storage participation model implemented in compliance with Order No. 841[54] would have the technical ability to schedule charging, PJM is still working with its stakeholders to identify whether open-loop hybrid resources should have access to that participation model or whether they will need a unique participation model to be able to schedule and manage charging.[55] The ongoing PJM stakeholder group devoted to hybrid resource needs is also examining whether any rule clarifications are necessary for metering and telemetry and minimum operating parameter values for scheduling.[56]

Further, under PJM's existing rules, closed-loop hybrids can sell capacity up to the run time-based eligibility limit of the intermittent resource, and open-loop hybrids are eligible to sell capacity in the amount of the sum of the capacity eligibility of each resource component.[57] PJM envisions that an Effective Load Carrying Capability (ELCC) construct could eventually replace this method.[58] On April 30, 2021, the Commission rejected PJM's ELCC proposal because it found a proposed transition mechanism component of the proposal to be unjust and unreasonable and unduly discriminatory, but the Commission noted that "PJM's ELCC framework, without the proposed transition mechanism, appears to be a just and reasonable approach to determining the accredited capacity value" of intermittent, storage, and hybrid resources.[59]

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[54] *Electric Storage Participation in Markets Operated by Regional Transmission Organizations & Independent System Operators*, Order No. 841, 83 FR 9580, 162 FERC ¶ 61,127, at P 78 (2018), *order on reh'g*, Order No. 841-A, 84 FR 23902, 167 FERC ¶ 61,154 (2019), *aff'd sub nom. Nat'l Ass'n of Regulatory Util. Comm'rs v. FERC, 964* F.3d 1177 (D.C. Cir. 2020); *see also PJM Interconnection, L.L.C.,* 169 FERC ¶ 61,049, at P 35 (2019).

[55] PJM Comments at 8.

[56] *Id. See also* https://insidelines.pjm.com/new-subcommittee-focuses-on-hybrid-resource-needs/.

[57] PJM Comments at 8.

[58] *Id.*

[59] *PJM Interconnection, L.L.C.*, 175 FERC ¶ 61,084, at P 17 (2021). On May 25, 2021, the Commission issued a notice holding the paper hearing in abeyance until the issuance of a Commission order on PJM's revised ELCC proposal, to be submitted by June 1, 2021.

PJM interconnection customers currently can propose the configuration best for their needs, i.e., by submitting a single interconnection request for two or more resource types at a single point of interconnection, or by submitting multiple interconnection requests for resources seeking a common point of interconnection.[60] PJM currently models these facilities based on the information provided by the interconnection customer about fuel types, applying the analysis tests laid out in PJM Manual 14B. PJM explains that this approach is also under ongoing discussion within its stakeholder process.[61] In the case of adding an electric storage resource to an existing interconnection request already in the queue, PJM would treat this request the same as any other, and require the full resource to progress through the interconnection process with a new queue position to be studied for additional load capability.[62]

**4. Southwest Power Pool, Inc.**

SPP states that it has considered several approaches to integrating co-located hybrid resources and integrated hybrid resources in its markets and is poised to move forward in determining the best approach. According to SPP's Hybrid Resource Modeling White Paper,[63] SPP working groups and operations staff have considered four options for modeling co-located generation and electric storage resources in SPP markets: (1) modeling the components separately with a combined capacity constraint to link the resources together; (2) representing the components as a single resource using the Market Storage Resource model it developed in compliance with Order No. 841; (3) allowing a market participant either to register each component as a separate resource or to register them as a single combined resource using existing registration types; and (4) adding to option 3 a limit on the maximum output capability of the co-located electric storage component. These four options apply exclusively to how SPP would represent the co-located components in its market models, not in reliability models. Regardless of the market modeling option chosen, in a report to the Market and Operation Policy Committee, SPP staff recommended that the co-located components be represented separately in reliability models.

Of the four options, the working groups and SPP staff recommend option 2, representing co-located generation and electric storage resources as a single resource

[60] PJM Comments at 5.

[61] *Id.*

[62] *Id.* at 6-7.

[63] *See* SPP, *MWG E2 Hybrid Resource Modeling White Paper: MOPC October 2020 Meeting Agenda and Materials* (Nov. 16, 2020), https://www.spp.org/spp-documents-filings/?id=212784.

under its Market Storage Resource model developed in compliance with Order No. 841. SPP staff, in a presentation to SPP's Markets and Operations Policy Committee, assert that this option would allow for greater flexibility in how hybrid resources participate in the market, would likely require fewer system changes as technology evolves, and would have the least impact on the performance of the Market Clearing Engine; the option for market participants to register each of the components separately using existing registration models would also be preserved. [64] In October 2020, the SPP Market and Operations Policy Committee approved this recommendation,[65] which moved the proposal to the next stage of stakeholder review.

SPP is also in early stages of determining an appropriate method to evaluate the resource adequacy value of co-located hybrid and integrated hybrid resources, including those that do not include an electric storage component. SPP's Supply Adequacy Working Group is considering how to incorporate co-located hybrid resources and integrated hybrid resources into an ELCC method and whether to value the resource adequacy of hybrid components combined or separately, among other issues.[66]

Effective April 1, 2020, SPP revised its interconnection procedures to collect information from electric storage resources regarding whether they will be stand-alone or co-located with a generating facility and whether the energy storage resource will ever charge from the transmission system or will charge exclusively from the co-located generating facility.[67] The revisions make reference to "stand-alone" storage, as well as electric storage which is "co-located with another Generating Facility (co-located means at the same point of interconnection)"—but this is the closest SPP has come to formally defining either term.[68]

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[64] *See* SPP, *MWG E2 HITT S3 E2 Hybrid Resource Modeling Recommendation*: *MOPC October 2020 Agenda & Materials* (Oct. 16, 2020), https://www.spp.org/spp-documents-filings/?id=212784.

[65] *See* SPP, *MOPC October 2020 Meeting Minutes* (Oct. 20, 2020), https://www.spp.org/documents/63235/mopc%20minutes%20201013.pdf.

[66] *See* SPP, *SAWG December 2020 Meeting Agenda and Background Materials* (Dec. 14, 2020), https://spp.org/spp-documents-filings/?id=76416.

[67] *Sw. Power Pool, Inc.*, Docket No. ER20-918-000 (Mar. 24, 2020) (delegated order).

[68] SPP OATT, Sixth Revised Volume No. 1, Attachment V (Generator Interconnection Procedures), Appendix 3.

### 5. Midcontinent Independent System Operator, Inc.

Co-located hybrid and integrated hybrid resources can meet MISO's definition of a generating resource, dispatchable intermittent resource, Stored Energy Resource – Type II,[69] or electric storage resource (once implemented). MISO notes that it does not need to make any market changes to allow these resources to participate under these frameworks.[70] However, MISO explains that it has not developed precise definitions for such resources.[71] In April 2019, the Commission accepted MISO's proposed changes to address co-located hybrid and integrated hybrid interconnection by establishing that an interconnection customer can submit a single interconnection request for a proposed co-located hybrid or integrated hybrid resource with two or more fuel types at a single point of interconnection.[72] Further, hybrid resources can participate in MISO markets either as separate resources behind the same point of interconnection or as a single integrated resource. However, co-located hybrid and integrated hybrid resources may not register as two different resource types.[73]

MISO is currently evaluating whether a separate co-located hybrid and integrated hybrid resource participation model is necessary, based on recommendations from its

[69] Stored Energy Resource – Type II is a category of resource on either side of the meter that is capable of supplying energy, capacity, spinning reserve, supplemental and regulating reserve, up ramp and/or down ramp capability, and whose state of charge is managed by the market participant operating the resource. MISO's Order No. 841 compliant electric storage resource definition and participation model, which will become effective in June 2022 will replace the Stored Energy Resource – Type II designation. On March 4, 2021, MISO filed a request to defer implementation of Order No. 841 compliance until March 1, 2025. That request was denied on May 17, 2021. *See Midcontinent Indep. Sys. Operator, Inc*., 175 FERC ¶ 61,120 (2021).

[70] MISO Comments at 8.

[71] *Id.* at 3.

[72] *Midcontinent Indep. Sys. Operator, Inc.*, Docket Nos. ER19-1103-000; ER19-1103-001 (Apr. 23, 2019) (delegated order).

[73] MISO Comments at 9.

Energy Storage Task Force[74] and via a dedicated stakeholder process.[75] Most recently, in October 2020, MISO's Market Subcommittee received stakeholder feedback on (1) the definition of hybrid resources, (2) market enhancements necessary to enable co-located hybrid and integrated hybrid resources to participate in MISO markets, and (3) the unique characteristics of co-located hybrid and integrated hybrid resources that are not recognized by markets but ought to be.[76] MISO's integrated roadmap schedule for its work on co-located and integrated hybrid resources incudes continued framing of the issue through the second quarter of 2021.

### 6. California Independent System Operator Corporation

CAISO was the first RTO/ISO to have Commission-approved tariff definitions for co-located hybrid or integrated hybrid resources.[77] CAISO defines a co-located resource as "[a] Generating Unit with a unique Resource ID that is part of a Generating Facility with other Generating Units." CAISO defines a hybrid resource as "[a] Generating Unit, with a unique Resource ID at a single Point of Interconnection, with components that use different fuel sources or technologies."[78]

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[74] *See* MISO, *Energy Storage Task Force Hybrid Storage Issue List* (May 2019), https://cdn.misoenergy.org/20190523%20ESTF%20Hybrid%20Storage%20Issue%20List%20-%20Submission%20Form341397.pdf.

[75] *See* MISO, *Issue Tracking* (Dec. 10, 2020), https://www.misoenergy.org/stakeholder-engagement/issue-tracking/hybrid-resource-participation-model/.

[76] *See* MISO, *Market Subcommittee Stakeholder Comments on Hybrid Generation Resources* (Oct. 2, 2020), https://cdn.misoenergy.org/20201008%20MSC%20Stakeholder%20Comments%20on%20Hybrid%20Generation%20Resources%20(IR086)481337.pdf.

[77] *Cal. Indep. Sys. Operator Corp.*, 173 FERC ¶ 61,146 (2020).

[78] CAISO Tariff Appendix A, Definitions. In its Hybrid Resources Phase 2 filing, which was accepted by the Commission in a DLO on March 9th, 2021, CAISO proposed to modify its definitions to distinguish between industry's generic usage of the term "hybrid resource" for any dual-fuel resource and CAISO's usage of the term as a single resource-ID participation model. Specifically, CAISO proposes to define a new term, a mixed-fuel resource as "a Generating Facility with components that use different fuel sources or technologies, participating as a Hybrid Resource or Co-located Resources." To incorporate this point into the existing definition of hybrid resource, CAISO proposes to redefine a hybrid resource as "a Mixed-fuel Resource with a single Resource ID at a single Point of Interconnection." *Cal. Indep. Sys. Operator Corp.,* Transmittal, Docket

CAISO has observed a "sudden and dramatic increase" in co-located hybrid and integrated hybrid projects in its interconnection queue. As noted earlier, of all active interconnection requests in CAISO, 47.6% are co-located hybrid or integrated hybrid, and of those submitted in 2020, 58% are co-located hybrid or integrated hybrid. Almost all of the co-located hybrid or integrated hybrid projects are combined generation and electric storage, with only two combined solar PV and wind hybrids.[79] Moreover, all the projects going through the material modification process through 2021 are co-located hybrid or integrated hybrid configurations.[80]

CAISO has developed rules for the participation of both co-located hybrid and integrated hybrid resources and continues to enhance those rules. Integrated hybrid resources participate as either a Non-Generator Resource if the configuration includes electric storage, or as a Participating Generator if it does not.[81] For co-located hybrid resources, on the other hand, each component participates in the wholesale markets based on its technology, e.g., a co-located resource composed of a solar resource and an energy storage resource would participate as one Variable Energy Resource and one Non-Generator Resource, respectively. In addition, the Commission recently approved a proposal from CAISO to establish wholesale market rules for using an aggregate capability constraint in its market model for co-located hybrid resources at a single generating facility. These rules will allow co-located hybrid resources to manage the sum of their maximum operating level without the need for additional interconnection upgrades.[82]

CAISO's phase two hybrid filing, which included changes for modeling and market participation by co-located hybrid and integrated hybrid resources,[83] was accepted by the Commission.[84] Under CAISO's filing, integrated hybrid resources will be able to:

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No. ER21-843-000, at 6 (filed Jan. 8, 2021); *Cal. Indep. Sys. Operator Corp*., Docket No. ER21-843-000 (Mar. 9, 2021) (delegated order).

[79] CAISO Comments at 3.

[80] *Id.*

[81] *Id.* at 9.

[82] *Cal. Indep. Sys. Operator Corp.*, 173 FERC ¶ 61,146, at P 3 (2020). The Commission also accepted tariff revisions establishing various data and forecasting requirements for hybrid resources.

[83] *Cal. Indep. Sys. Operator Corp*., Docket No. ER21-843-000 (Mar. 9, 2021) (delegated order).

[84] *Cal. Indep. Sys. Operator Corp*., 173 FERC ¶ 61,146 (2020) (delegated order);

(1) provide ancillary services and (2) communicate their availability in real-time via a new dynamic limit tool. Co-located hybrid resources will also be allowed to provide ancillary services and to deviate from dispatch under certain conditions in order to avoid renewables curtailment. The proposal also incorporates various data provision requirements in order to facilitate participation by both integrated hybrid and co-located hybrid resources and help CAISO better operate these resources. CAISO anticipates implementing these changes in the fourth quarter of 2021.

## B. Outside of RTO/ISO Markets

This section highlights an example of a transmission provider outside an RTO/ISO adapting to greater numbers of co-located hybrid and integrated hybrid resources. The transmission provider was chosen as an example because it participated in the technical conference. Many co-located hybrid and integrated hybrid resources are located outside of RTOs/ISOs and are facing similar issues to those seen in RTOs/ISOs with regard to interconnection. Staff recognizes that diverse entities outside of RTO/ISO markets are exploring many different issues related to co-located hybrid and integrated hybrid resources, and we are highlighting just one example here.

### Transmission Provider Example: Puget Sound Energy, Inc.

Puget Sound Energy, Inc. (PSE) is Washington State's largest privately-owned natural gas and electric utility, with a historical peak load of approximately 4,900 MW. PSE operates as a transmission owner, operator, and balancing authority area in the Western Electricity Coordinating Council where its transmission network is primarily in the Pacific Northwest, and is largely surrounded by Bonneville Power Administration, public utility districts, cooperatives and other entities not subject to Commission jurisdiction.[85]

PSE began participating in the Western Energy Imbalance Market (EIM), which is operated by CAISO, in 2016. Currently, PSE participates in CAISO's stakeholder process examining how co-located hybrid and integrated hybrid resources can operate within the CAISO market and in the EIM, which is targeted for implementation in Fall 2021. PSE is also exploring participating in CAISO's day-ahead market via the proposed Expanded Day-Ahead Market. CAISO is exploring how to expand day-ahead scheduling of resources and load to interested EIM Entities.[86]

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*Cal. Indep. Sys. Operator Corp*., Docket No. ER21-843-000 (Mar. 9, 2021) (delegated order).

[85] Speaker materials of Laura Hatfield at 1-2.

[86] *Id.* at 2.

In May 2019, Washington State passed the Washington Clean Energy Transformation Act (CETA).[87] Among other things, CETA requires electric utilities to eliminate coal-fired generation from their portfolios by 2026, to be carbon neutral by 2030, and to source electricity that is 100 percent clean by 2045. Like a number of other utilities,[88] PSE continues to see an increase in co-located hybrid and integrated hybrid resource interconnection requests as part of the effort to realize these goals. Presently, PSE has nearly 6,500 MW of active projects in its generator interconnection queue, and approximately a third of those are co-located hybrid or integrated hybrid and electric storage resources. Given this experience, PSE has noted some issues with interconnecting co-located hybrid or integrated hybrid resources with its system.[89]

From PSE's perspective, the current regulatory framework and rules for co-located hybrid or integrated hybrid resources seeking generator interconnection service could be further clarified, particularly regarding the study process and managing changing conditions when charging from the grid. PSE has found that the data submitted by interconnection customers for co-located hybrid or integrated hybrid resource projects can often be unclear or inconsistent, leading to difficulties in properly understanding and modeling these resources during the interconnection process. Additionally, PSE states that it is complicated to model the generating facility for co-located hybrid or integrated hybrid resources without the support of industry-wide modeling guidelines and requirements. Currently, PSE combines separate controllers[90] for hybrid resources into a simplified model for interconnection studies.[91]

Co-located hybrid or integrated hybrid resources that charge from the grid may be required to submit an interconnection request as a load (e.g., line and load requests). PSE notes that charging is an economic choice and often the charging assumptions and characteristics for co-located hybrid or integrated hybrid resources evolve over time, which can result in area load impacts and increasingly complex studies when generation interconnection and charging as a load are studied. PSE notes a lack of clarity regarding

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[87] S.B. 5116, 2019 Leg., 66th Sess. (Wa. 2019).

[88] *See* Energy Storage Association, *Hybrid Resources Are Arriving as Policy Catches Up* (May 19, 2020), https://energystorage.org/hybrid-resources-are-arriving-as-policy-catches-up/.

[89] Speaker materials of Laura Hatfield at 2-3.

[90] Controllers on co-located hybrid or integrated hybrid resources implement the rules for when different parts of the co-located hybrid or integrated hybrid are operational, allowing for optimal timing of generation and charging according to multiple factors, including weather conditions and load demand.

[91] Speaker materials of Laura Hatfield at 3.

the process for transmission providers in non-organized markets that currently offer separate generator interconnection service, line and load service, and transmission service.[92]

## IV. Analysis

As the record gathered to date demonstrates, co-located hybrid and integrated hybrid resources can add value to the electric grid. They can allow intermittent or duration-limited resources to achieve a higher combined capacity factor, facilitate more efficient transmission system operation by reducing congestion and curtailment in areas with high penetrations of intermittent resources, and provide transmission providers with more controllable ancillary services than standalone intermittent resources. Co-located hybrid resources and integrated hybrid resources also benefit the resource owner. The addition of another generation or electric storage resource to an intermittent resource may allow those resources to provide services that they alone could not provide (e.g., ancillary services in some RTOs/ISOs). These types of resource configurations can also allow the components to share permitting, siting, equipment, and interconnection costs. Combining generation and electric storage components into an integrated hybrid resource, rather than participating in markets as a co-located hybrid resource, can also allow a resource owner to optimize the design and operation of the components, potentially allowing that resource to provide additional services.

Notwithstanding the potential benefits of co-located hybrid or integrated hybrid resources, the rapid growth of such resources presents challenges to RTOs/ISOs and other FERC-jurisdictional transmission providers and federal and state regulators to keep up with the pace of technological change. In 2019 alone, the capacity of co-located hybrid and integrated hybrid resources in the RTO/ISO interconnection queues increased by 33 gigawatts, more than doubling in a single year.[93] Further, this growth in co-located hybrid and integrated hybrid resource interconnection requests comes as RTO/ISO implementation of stand-alone storage models in compliance with Order No. 841 has recently begun or in limited circumstances has not yet been implemented.[94]

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[92] *Id.*

[93] *See* Berkley Lab Electricity Markets & Policy, *Generation, Storage, and Hybrid Capacity in Interconnection Queues*, https://emp.lbl.gov/generation-storage-and-hybrid-capacity.

[94] The effective date of tariff changes in compliance with Order No. 841 in SPP is August 5, 2021. MISO's Order No. 841 compliant electric storage resource definition and participation model is currently scheduled to become effective in June 2022. On March 4, 2021, MISO filed a request to defer implementation of Order No. 841 compliance until March 1, 2025. That request was denied. *See Midcontinent Indep. Sys.*

Certain modifications to tariffs or business practice manuals could help to address the rapid growth of co-located hybrid and integrated hybrid resources. The sections below discuss four areas on which the Commission is requesting information in the Order Directing Reports issued in January 2021. While the RTOs/ISOs are currently undertaking a number of initiatives as detailed above, it appears likely that there will be a series of iterative changes as regions gain more experience integrating co-located hybrid and integrated hybrid resources and technology continues to evolve.

## A. Terminology

### 1. Current Terminology

Although the discussions at the technical conference made clear that commonly-accepted terminology to describe co-located hybrid and integrated hybrid resource has not yet been adopted, industry consensus has emerged around a key distinction in the operational approach of the two broad categories: "co-controlled,"[95] "integrated hybrid"[96] or "1R"[97] resources (where the components present to the RTO/ISO as one resource and share a single point of interconnection) and "co-located hybrid " or "2R"[98] resources (where the components present as two resources and share a single point of interconnection). In this paper, staff has chosen to use "co-located hybrid" and "integrated hybrid" to denote these two categories, but the use of particular terminology in this white paper is not meant to pre-judge the on-going discussions regarding terminology used by the RTOs/ISOs and elsewhere.

The RTOs/ISOs differ in their terminology, or the terminology they are considering in stakeholder or other processes, to address co-located hybrid or integrated hybrid resources. As discussed above, CAISO was the first RTO/ISO with Commission-approved tariff definitions for co-located hybrid or integrated hybrid resources; NYISO's co-located hybrid terminology was recently approved.[99] The RTOs/ISOs differ in how they treat, or are proposing to treat, co-located hybrid and integrated hybrid resources.

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*Operator, Inc*., 175 FERC ¶ 61,120 (May 17, 2021). *Sw. Power Pool, Inc.*, 170 FERC ¶ 61,164 (2020); *Midcontinent Indep. Sys. Operator, Inc.*, 169 FERC ¶ 61,137 (2019).

[95] Tr. 23 (Will Gorman).

[96] Tr. 13 (Mark Ahlstrom).

[97] Tr. 121 (Ted Ko).

[98] *Id.*

[99] *See N.Y. Indep. Sys. Operator, Inc.*, 174 FERC ¶ 61,242 (2021).

They also differ in whether co-located hybrid and integrated hybrid resources must include a battery storage component or just multiple fuel types. They further differ in whether and how storage that is part of a co-located hybrid or integrated hybrid resource may charge from the grid.

#### 2. Standardizing Terminology

In Order No. 841, the Commission established terminology for parameters essential for electric storage participation in wholesale markets, such as minimum run time and state of charge.[100] These terms have already begun to frame discussions concerning co-located hybrid and integrated hybrid configurations.

Similarly, standardized terminology specific to co-located hybrid and integrated hybrid resources might offer the benefit of creating a shared understanding of how wholesale market rules may accommodate co-located hybrid and integrated hybrid resources. In the Order Directing Reports, the Commission required the RTOs/ISOs to report on any definitions of, or proposals of definitions for, integrated or co-located hybrid resources in their tariffs or business practice manuals. The information received in these reports will help the Commission and industry to better understand the differences in terminology between RTOs/ISOs and whether further standardization of relevant terminology may be useful.

### B. Interconnection

Questions remain about the means by which co-located hybrid and integrated hybrid resources can interconnect in both RTO/ISO and non-RTO/ISO regions. Co-located hybrid and integrated hybrid resources face a number of challenges, both in RTOs/ISOs and outside RTOs/ISOs. These challenges include: (1) interconnection customers' desire for flexibility in interconnection requests; (2) material modification rules that do not allow for the addition of electric storage facilities to generation projects already in interconnection queues without the loss of queue positions; and (3) interconnection studies that may not appropriately model integrated hybrid resource operation.[101]

RTOs/ISOs and non-RTOs/ISOs are at various stages of addressing potential interconnection issues posed by co-located hybrid and integrated hybrid resources.[102]

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[100] Order No. 841, 162 FERC ¶ 61,127 at PP 251, 270.

[101] Gramlich Paper at 12-16; AWEA, *Facilitating Hybrid and Co-located Resource Participation in wholesale Electricity Markets*, at 25 (Aug. 2020).

[102] *See* CAISO Comments at 5-7; ISO-NE Comments at 4; MISO Comments at 5-8; NYISO Comments at 4-5; PJM Comments at 5-7; Speaker materials of Laura Hatfield

Whether a project's planned operation is understood and studied appropriately through the interconnection process can be crucial to a project's success. Throughout the technical conference and in the post-conference comments, participants noted three main elements of the interconnection process that bear upon the success of co-located hybrid and integrated hybrid resource projects: the clarity and consistency of interconnection procedures; requirements for adding to or changing projects in the queue; and modeling and data approaches. Staff notes that changes to these processes will need to balance the needs of many stakeholders.

### 1. Flexibility for Interconnection Requests

Two related issues affect co-located hybrid and integrated hybrid resources that have not yet entered the interconnection queue. First, by their nature, co-located hybrid and integrated hybrid resources require that two or more resources be permitted to share a single point of interconnection. All of the RTOs/ISOs either have tariff provisions to allow for this or are working on the issue, but implementation remains uneven. In addition, this concern remains an issue outside of RTOs/ISOs.

Second, the interconnection of co-located hybrid resources and integrated hybrid resources could be more efficient if interconnection customers were able to submit a single interconnection request that encompassed all parts of the co-located hybrid or integrated hybrid resource and proceed through the interconnection queue as one project. In various ways, all the RTOs/ISOs also currently allow for multiple resources to be studied under the same interconnection request, but the approaches employed by RTOs/ISOs differ from one another and not all stakeholders agree the current processes work well for co-located hybrid or integrated hybrid resources.

CAISO allows for the addition of electric storage to new or existing resources, and allows multiple resources to share one interconnection request.[103] NYISO allows co-located resources of different types to use the same point of interconnection, using its Aggregated Distributed Energy Resource participation model, and has also proposed changes to its interconnection rules as part of its recent co-located hybrid resources filing. MISO allows for a single interconnection request for a proposed hybrid resource with two or more fuel types.[104] SPP allows for the addition of electric storage to an existing facility via either a new interconnection request or Surplus Interconnection Service.[105]

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at 2-3.

[103] CAISO Comments at 5.

[104] MISO Comments at 5.

[105] AWEA Comments at 16.

ISO-NE does not impose any limitation on the number and types of devices that may connect to the same point of interconnection as part of a single interconnection request.[106] PJM also allows interconnection customers to propose two or more resource types at a single point of interconnection either in a single interconnection request with multiple resources or multiple interconnection requests seeking a common point of interconnection.[107] The *pro forma* Large Generator Interconnection Procedures (LGIP) and Large Generator Interconnection Agreement (LGIA) however, do not clearly provide for multiple customers to submit a single request.

One suggestion noted in comments is to work toward clarifying the rules to expand the use of surplus interconnection service, a reform enacted in Order No. 845.[108] The current surplus interconnection provisions in the *pro forma* LGIP and LGIA allow interconnection customers who have excess capacity at their point of interconnection to offer this capacity to their affiliates and possibly to the public. This provision applies to interconnection customers who have entered commercial operation. In post-conference comments, it was suggested that the Commission should require all transmission providers to allow interconnection customers to request surplus service even in situations where the host facility possesses an executed LGIA but has not yet reached commercial operation, with the caveat that the customer acquiring the surplus capacity could not reach commercial operation prior to the host facility.[109]

### 2. Material Modification

A project that has already entered the interconnection queue faces additional challenges if it wishes to add a resource, such as electric storage, in order to become a co-located hybrid or integrated hybrid resource. The addition of a resource to an existing interconnection request might be considered a material modification, and, in the event that it is, the interconnection customer would be required to either abandon the addition or lose the project's existing queue position. Several participants at the technical conference argue that the Commission should ensure queue positions are protected when a customer wants to add electric storage to an existing request.[110] They claim that adding

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[106] ISO-NE Comments at 4.

[107] PJM Comments at 5.

[108] *Reform of Generator Interconnection Procedures and Agreements*, Order No. 845, 163 FERC ¶ 61,043, at P 453 (2018), *order on reh'g*, Order No. 845-A, 166 FERC ¶ 61,137 (2019).

[109] Savion Comments at 5.

[110] SEIA Comments at 6.

an additional resource, in particular electric storage, can provide reliability benefits to the grid, such as creating a highly controllable resource by adding the ability to shift the timing of energy output. They add that allowing an interconnection customer to make such additions within their previously requested range of output would allow them to forego the significant added time and expense of dropping out of the queue and re-applying, and would cause no adverse effect on grid reliability or other customers. Some participants add that a resource should be able to avoid a new study process if it uses dispatch limiters or protection devices to avoid exceeding the established existing interconnection limits.[111]

One suggested approach is for RTOs/ISOs to develop best practice guidelines for establishing what constitutes a "material modification" and whether the addition of an electric storage resource can qualify as a "technological advancement" under the Commission's technological advancement procedure. Such practices could clarify that controllable output should not be considered a material modification if the customer commits to keeping the output within the range of the interconnection request and installs appropriate controls. With additional flexibility, grid operators would still be able to review the electrical properties of any proposed additions and, as they review new battery models, grid operators can help each other with these assessments, speeding up their review. Commenters note that it will be important to better understand electrical impacts of different technologies for the purpose of determining material modification, and suggest that forums such as IEEE, the Energy Systems Integration Group, or Commission technical conferences could help.[112]

Finally, material modification considerations may arise when an interconnection customer chooses to change its configuration between self-charging and grid-charging. Generally, once an entity opts to enter the interconnection queue without grid charging, they are not permitted to change this election to grid charging without a new service request for grid charging. Conversely, Load Serving Entities (LSEs) can add grid charging capability to a co-located hybrid or integrated hybrid facility while avoiding re-entry to the interconnection queue. In the cases where an LSE seeks to add grid charging to a co-located hybrid or integrated hybrid facility, the LSE can designate the storage component of the hybrid facility as system load and pursue grid charging via Network Integrated Transmission Service (NITS) under Section II of the *pro forma* Open Access Transmission Tariff (OATT). In some cases, this may give LSEs an advantage over independent generators in their ability to add grid charging to a co-located hybrid or integrated hybrid facility.[113]

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[111] AWEA Comments at 17-18.

[112] *Id.* at 18-19.

[113] Savion Comments at 7.

### 3. Modeling Approaches

In both the technical conference and post-conference comments, participants raise questions about how to appropriately model co-located hybrid or integrated hybrid resources for purposes of interconnection studies. Participants assert that because RTOs/ISOs currently model co-located hybrid or integrated hybrid resources as they do other resources, viewing them as separate components, without considering the actual operating characteristics of co-located hybrid or integrated hybrid resources and their actual impact on the transmission system, current modeling practices can lead to unnecessary and costly network upgrades. For example, one participant notes that "[c]urrently multiple ISOs study electric storage under worst case assumptions and assume that electric storage will charge during peak periods and discharge during light load periods. This can lead to exorbitant upgrade costs that make projects uneconomic."[114]

Commenters note that the conventional modeling approach generally does not reflect how a rational co-located hybrid or integrated hybrid resource owner would operate, as the resource owner would use the electric storage resource to control output in response to energy market price signals, which account for transmission congestion and reflect the real-time value of injecting energy at that location.[115] Additionally, modern controller technology can limit an entire co-located hybrid or integrated hybrid resource's impact at the point of interconnection but many transmission providers' interconnection procedures are rigid and only study the full injection impact of the co-located hybrid or integrated hybrid resource instead of studying the likely injection of a co-located hybrid or integrated hybrid resource based on economics.[116] Another participant suggests that developers should be granted more flexibility and be allowed the option to agree to operational constraints, including limits on when they can charge and discharge, if they wish to avoid costly upgrades.[117]

Some transmission providers are using different modeling approaches tailored to their regions and customer needs, recognizing some modeling approaches are difficult to conduct. For example, PSE mentions that modeling the cumulative generation (net output) of co-controlled resources and the fully integrated control of integrated hybrid resources at the point of interconnection has been challenging. Currently, PSE combines separate controllers for co-located hybrid and integrated hybrid resources into a simplified model for interconnection studies, but PSE believes that there may be other

[114] Enel Comments at 3.

[115] AWEA Comments at 20.

[116] Savion Comments at 7.

[117] Enel Comments at 3.

approaches to this modeling issue. PSE also identifies challenges studying and integrating the management of changing conditions when co-located hybrid and integrated hybrid resources charge from the grid. As stated above, co-located hybrid and integrated hybrid resources charging from the grid may be required to file for interconnection as a load (e.g., line and load requests). Often the charging assumptions and characteristics for co-located hybrid and integrated hybrid resources evolve over time, which can result in area load impacts and increasingly complex studies when generation interconnection and charging as a load are studied. PSE notes a lack of clarity regarding the process for interconnection customers in non-organized markets that currently offer separate generator interconnection service, line and load service, and transmission service.[118]

Additionally, co-located hybrid and integrated hybrid interconnection customers have concerns about whether their projects will be modeled for interconnection purposes in a manner that accounts for the project's full capability. Ideally, the modeling of co-located hybrid and integrated hybrid resources should not limit the operation of integrated hybrid or co-located hybrid resources, and the assumptions should be based upon the actual operating criteria of the resource. The modeling parameters should be flexible enough to accommodate management of the electric storage component's state-of-charge conducted by either the RTO/ISO or the resource owner or operator.[119]

RTOs/ISOs and other FERC-jurisdictional transmission providers may need to gain more experience with co-located hybrid and integrated hybrid resources' operation before determining if new modeling approaches are necessary, given the complexity of the varied operating modes of an integrated hybrid resource. Nevertheless, some commenters noted that a lack of integrated hybrid resource modeling currently is a barrier for interconnection of hybrid resources.[120]

### C. Eligibility to Participate in Energy, Capacity, and Ancillary Service Markets

While the specific dynamics may vary by RTO/ISO market, existing market rules limit co-located hybrid or integrated hybrid resources' ability to fully participate in energy, capacity, and ancillary services markets. For example, existing energy market rules may limit an integrated hybrid resource's ability to fully control its output or submit a single energy supply offer, and it may have limited flexibility while placing bids in real

[118] Speaker materials of Laura Hatfield at 3.

[119] AWEA Comments at 24-25.

[120] *Id.* at 20; Enel Comments at 6; Savion Comments at 5, 7.

time.[121] Tariff provisions, such as duration requirements, may prevent co-located hybrid or integrated hybrid resources from providing ancillary services they are technically capable of providing. In other cases, unclear market rules for these technologies may distort the incentives of hybrid and co-located project developers and scheduling coordinators. For example, rules across RTOs/ISOs differ as to whether transmission service is needed by the resource owner if they choose to charge from the transmission or distribution system.[122] Additionally, it is unclear whether a co-located hybrid or integrated hybrid could still be considered a variable energy resource and have access to the dispatch provisions available to variable energy resources.[123] Finally, must-offer obligations and telemetry requirements for co-located hybrid or integrated hybrid resources in some RTOs/ISOs remain ambiguous.[124]

### 1. Recognizing the Value that Hybrid Resources Can Provide

The record in this proceeding indicates that integrated hybrid and co-located hybrid resources are likely to provide benefits within RTO/ISO markets because of their ability to facilitate the integration of variable energy resources, shift generation from lower priced periods to higher priced periods when the energy is more valuable to customers, and enhance technical performance and capability by increasing operational flexibility.[125] Nevertheless, while each RTO/ISO that submitted post-conference comments notes that co-located hybrid and integrated hybrid resources could currently participate in its markets in some form, current market rules may not always recognize the full value of co-located and integrated hybrid resources.

It has been suggested by commenters that neither RTO/ISO software nor market power mitigation rules can accurately represent the factors that co-located or integrated hybrid resources consider when they determine when to charge their storage components.[126] EPRI asserts that no RTO's/ISO's software presently allows co-located hybrid and integrated hybrid resources to be fully represented in the RTO/ISO security-constrained unit commitment and economic dispatch models because absent a participation model, dispatch does not fully account for their integrated physical and

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[121] Gramlich Paper at 20.

[122] *Id.* at 17-23.

[123] AWEA White Paper at 4, 11; Gramlich Paper at 17-23; Tr. at 50 (Jason Burwen).

[124] Gramlich Paper at 20.

[125] AWEA White Paper at 3.

[126] *Id.* at 4-5.

operational characteristics.[127] EPRI notes that they do not recommend any participation model option over another. Indeed, EPRI suggests that, if the participation options are proven to be technically feasible, reliable and cost-effective, it could be useful for the RTOs/ISOs to allow various participation models so that asset owners have the option to choose the model that they use, subject to system reliability.[128] Similarly, AWEA states that current market power mitigation rules do not yet accurately reflect the opportunity costs that co-located hybrid or integrated hybrid resources face.[129]

### 2. Learning from Operational Experience

In an effort to learn from operational experience, each RTO/ISO has begun to examine how integrated hybrid and co-located hybrid resources might already be participating in its market under current rules, as well as the ways in which the full market values of the resources may not yet have been realized. This process has been augmented, at least in part, by Order No. 841, insofar as several RTOs/ISOs are considering whether integrated hybrid or co-located hybrid resources might be integrated into their electric storage resource participation models or whether they will require unique participation models for these resource types. During the technical conference, CAISO and PJM, in particular, state that they plan to study the operational data of existing integrated hybrid and co-located hybrid resources to learn from operational experience on their systems.[130] Along with NYISO and MISO, PJM also emphasize the importance of stakeholder discussions in its respective efforts.[131]

The RTOs/ISOs also raise several markets-related challenges during the technical conference and in post-conference comments. CAISO acknowledges that co-located hybrid and integrated hybrid resources may face challenges in following dispatch instructions—for example, due to diminished capacity in the variable energy resource or the battery's state of charge.[132] PJM expresses concern that it is unable to distinguish the

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[127] EPRI Comments at 8-9.

[128] *Id.* at 10.

[129] AWEA White Paper at 11.

[130] Tr. 108-109 (Deb Levine); Tr. 132, 156-159 (Gabe Murtaugh); Tr. 170-171 (Andrew Levitt).

[131] Tr. 162 (Mike DeSocio); Tr. 59-60 (Noel Augustine); Tr. 124 (Andrew Levitt).

[132] CAISO Comments at 11. The Commission has since accepted CAISO's "Hybrid Resources Phase 2" filing, which clarifies that when an intermittent resource produces energy above its dispatch instruction because meteorological conditions differ

behavior of the individual components of an integrated hybrid resource when the resource owner manages the operation of the resource. PJM indicates that this reduction in visibility could cause reduced situational awareness for grid operators.[133] NYISO observes that resources engaging in "price chasing" created concern in the stakeholder process. NYISO also observes that the ISO has the greatest amount of visibility of resources across its entire footprint to be able to monitor such activity.[134]

AWEA's white paper, based on examination of RTO/ISO stakeholder discussions, recommends that industry work toward five optimal outcomes concerning markets and market power mitigation.[135] First, where applicable, RTOs/ISOs should work with hybrid resource owners and other relevant stakeholders to develop standardized approaches to accurately account for the opportunity costs of these resources.[136] Second, RTO/ISO must-offer requirements for integrated hybrid and co-located resources should be clearly defined and reflective of the resources' unique physical parameters and operating characteristics.[137] Third, where desirable, hybrid resources should have the option to submit a single energy supply offer.[138] Fourth, RTOs/ISOs should clearly define under which conditions hybrid resources with variable energy resource components can retain some or all of the energy supply offer options available to stand-alone intermittent resources.[139] And finally, while hybrid level component telemetry can

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from what was forecasted, and the co-located energy storage resource produces less energy than its dispatch instruction to ensure the combined resources' output does not exceed their shared interconnection service capacity, CAISO would not consider co-located resources as non-compliant (and the scheduling coordinator would not be required to report an outage). *Cal. Indep. Sys. Operator Corp.*, Docket No. ER21-843-000 (Mar. 9, 2021) (delegated order).

[133] PJM Comments at 4.

[134] Tr. 162 (Mike DeSocio).

[135] AWEA White Paper at 25.

[136] *Id.* at 5, 23.

[137] *Id.* at 5, 24.

[138] *Id.* at 4, 10, 25.

[139] *Id.* at 4, 11, 25.

aid in the respective RTO's/ISO's situational awareness, the hybrid resource owner should maintain full operational control over its resource's respective components.[140]

### D. Capacity Valuation

Determining the proper capacity accreditation[141] for co-located hybrid and integrated hybrid resources may be a challenge because current capacity valuation methodologies may not adequately capture the value of a co-located hybrid and integrated hybrid resource. However, there is not sufficient data available to determine the best way to address this question.[142] Commenters note that, as an initial approximation of the capacity value of these resources, it is possible to use a sum of the component parts of the resource.[143] However, EPRI notes that its research suggests that the addition of storage to solar or wind materially changes the capacity value of the hybrid resource.[144] Regardless, some commenters, such as MISO, note that they believe that existing methods of capacity valuation can accommodate co-located hybrid and integrated hybrid resources in the near term, explaining that once verifiable performance data is available, new methods based on operational experience may be developed.[145]

Other commenters note that while it will be important to develop more accurate methods for capacity valuation, it will be important that the capacity value does not change suddenly.[146] Commenters suggest that any method of capacity valuation for these resources should be clear, equitable, and recognize the full reliability value of the resource.[147] Commenters note that one potential benefit of an integrated hybrid resource

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[140] *Id.* at 4, 25.

[141] For purposes of this section, "capacity accreditation" refers to the calculation of capacity value of a resource.

[142] For example, it is unclear whether the appropriate capacity value of a hybrid resource is simply the sum of the capacity value of the constituent resources, or whether the capacity value is greater than the sum of the individual components; see AWEA Comment at 33, which notes that the best capacity valuation method is still an "open question."

[143] ACORE Comments at 5.

[144] EPRI Comments at 17.

[145] MISO Comments at 16.

[146] R Street Comments at 6.

[147] AWEA Comments at 33.

is that it may present to the RTO/ISO as non-intermittent because the storage component of the resource can firm up the variable energy resource component, such as solar or wind. Commenters assert that participating in the markets as non-intermittent should increase the resource's capacity value because intermittent resources are de-rated significantly in capacity calculations.[148]

One method for determining capacity value is called the ELCC. CAISO, PJM, and ISO-NE are in various stages of exploring its use to better address capacity valuation for hybrid resources. Others, such as MISO, use ELCC for other classes of resources, such as wind resources.[149] While several RTOs/ISOs, such as MISO,[150] note that they need more experience with co-located hybrid resources and integrated hybrid resources before it is appropriate to develop an alternative to the current method of capacity accreditation, others, such as CAISO, PJM, and ISO-NE, have determined that applying ELCC may be appropriate in this context. In general terms, the ELCC provides "a measurement of that resource's ability to produce energy when the grid is most likely to experience electricity shortfalls."[151] This approach is typically expressed as a percentage of the resource's capacity, and requires probabilistic grid modeling.[152] ELCC is dynamic because it represents a "property of a portfolio of resources, not of individual resources themselves."[153] Resources interact with each other in increasingly complex ways, which affect their overall ability to provide capacity when most needed.

As noted above, PJM is undertaking a capacity valuation initiative, which includes co-located hybrid and integrated hybrid resources, and ISO-NE expects to have preliminary ELCC data for co-located hybrid and integrated hybrid resources in 2021, which it will use for further evaluation of its capacity valuation methods. CAISO is the furthest along in addressing capacity valuation. In June 2020, as part of a California Public Utility Commission (CPUC) proceeding, a California administrative law judge

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[148] Enel Comments at 3.

[149] MISO Comments at 14.

[150] *Id.* at 17.

[151] Mark Specht, *ELCC Explained: the Critical Renewable Energy Concept You Have Never Heard Of* (Oct. 12, 2020), https://blog.ucsusa.org/mark-specht/elcc-explained-the-critical-renewable-energy-concept-youve-never-heard-of.

[152] *Id.*

[153] Utility Dive, *Adding it All Up: Counting the Capacity Contribution of Variable and Duration Limited Resources* (Sep. 10, 2020), https://www.utilitydive.com/news/adding-it-all-up-counting-the-capacity-contribution-of-variable-and-durati/584843/.

issued a decision proposing to use an ELCC valuation method as part of the on-going co-located hybrid and integrated hybrid resources proceeding undertaken by CAISO.[154] The ELCC approach would be part of California's Resource Adequacy program, which is its version of a capacity product.

Since CAISO is the furthest along in its capacity valuation initiative, it may allow for stakeholders from other RTOs/ISOs to identify possible approaches to capacity valuation. While the ELCC method was ultimately proposed for use by a judge, stakeholders in CAISO also suggested that additional methodologies may be needed in the future that distinguish between different types of co-located hybrid and integrated hybrid resources. In particular, CAISO stakeholders felt that whether an integrated hybrid or co-located hybrid resource was using the federal Investment Tax Credit would affect its capacity calculation.[155] CAISO stakeholders also asserted that whether a resource is integrated hybrid or co-located hybrid should not affect its capacity calculation.[156] While the CPUC decision proposed to use ELCC, it also reviewed other approaches, including a "greater of" approach, an "additive" approach, and an "exceedance approach."[157] EPRI also noted that approaches ranging from derating methodologies to detailed simulation techniques which capture risk on an hourly basis can also be used.[158]

There is no current consensus about the best way to model capacity accreditation for co-located hybrid or integrated hybrid resources, other than the fact that the current methods are unlikely to reflect these resources' full value, and it will take further operational experience to determine the best methods.

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[154] CPUC, Proposed Decision of Administrative Law Judge Ali Chiv, Rulemaking 19-11-009, June 25, 2020, at 29.

[155] AWEA White Paper at 13.

[156] *Id.* at 13.

[157] *Id.* at 13-15; *see also* CAISO Track 2 Proposals, February 21, 2020 in CPUC Rulemaking 19-11-009, at 8 (defining "greater of" approach); SCE comments in CPUC Hybrid Rulemaking, October 14, 2019 (defining "additive" approach); CAISO, *Track 2 Proposals CPUC Rulemaking 19-11-009* at 8 (Feb. 20, 2020), http://www.caiso.com/Documents/Feb21-2020-ResourceAdequacy-Track2-Proposals-R19-11-009.pdf (defining "exceedance" approach).

[158] EPRI Comments at 15.

## XI. Conclusion

The rate of growth of co-located hybrid and integrated hybrid resources has accelerated over the past several years. RTOs/ISOs have begun to make changes to their wholesale electric markets, including market rules to accommodate such increases. Transmission providers in both RTO/ISO and non-RTO/ISO regions have begun to examine interconnection processes to accommodate the increase of such resources. However, given the fast pace of change, much remains to be addressed. As RTOs/ISOs and transmission providers gain additional experience with hybrid resources, they will be better able to address issues including a potential need to modify interconnection rules, modeling approaches in interconnection and reliability models, market participation rules such as bidding and modeling, and capacity valuation methods.