ESIG
ENERGY SYSTEMS INTEGRATION GROUP

Exploring Market Rules and Operations Related to the Participation of Hybrid Resources

FACT SHEET

Hybrid resources—a combination of generation, storage, and/or flexible load that share a common point of interconnection and are operated as a single integrated resource—have the ability to improve flexibility and provide a full suite of grid services. But how should a hybrid resource be treated in an electricity market? Is it a variable resource? A storage resource? Or something altogether different?

Participation Models Governing the Market Interaction of Hybrids

The U.S. electricity industry uses the term "participation model" to describe a resource's capacities, operating constraints, ranges, limits, and rates; how it is dispatched; and what grid services it is able to provide. The U.S. Federal Energy Regulatory Commission (FERC) defines participation models as "a set of tariff provisions that accommodate the participation of resources with particular physical and operational characteristics in the organized wholesale electric markets of the regional transmission organizations and independent system operators."[1] In FERC's Order 841, it further defines participation models as the tariff revisions that consist of market rules that, recognizing the physical and operational characteristics of the resource, facilitate its participation in the electricity markets.

Participation models exist for many different generation and demand-response resources. Conventional power plants (such as coal or natural gas), variable renewable resources, demand response resources, electricity storage technologies, and combined-cycle plants all have somewhat distinct participation models. FERC Order 841 provided the guidance for the independent system operators and regional transmission organizations (ISOs and RTOs) to establish participation models for electricity storage resources, including guidance around eligibility, parameters that are necessary to exchange with bids, rules around payments and sales, size requirements, metering practices, and state-of-charge management. FERC Order 2222 established similar guidelines for aggregations of distributed energy resources. Although hybrid resources include resources for which participation models exist, none of the FERC orders establish rules for large-scale hybrid facilities consisting of two or more technologies.

Possible Participation Models for Hybrid Resources

A key question when defining a participation model for hybrid resources is whether the hybrid interfaces with the market as a single resource (a hybrid model) or as two or more separate resources (a co-located model). An additional element is whether the ISO/RTO has some amount of information about or control over the resource. Four main configurations are the following.

- **Hybrid self-managed model:** The information exchanged with the ISO is about the hybrid and not any of its individual components.
- **Hybrid ISO-managed feasibility model:** The resource is treated as a single resource, and information such as variable renewable energy forecasts or telemetered state of charge of the storage resource is monitored by the ISO and used only during emergencies.

1 Federal Energy Regulatory Commission, "Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators," Docket nos. RM16-23-000 and AD16-20-000, Order No. 841 (Washington, DC: Department of Energy (2020)). https://www.ferc.gov/media/order-no-841.

This fact sheet is adapted from ESIG's report Unlocking the Flexibility of Hybrid Resources.

TABLE 1

Pros and Cons of Different Participation Models

	Pros	Cons
1R Hybrid self-managed model	• Asset owner has full flexibility to offer in full facility operation including impacts not included in market clearing model • Avoids computational issues with simpler market clearing software model	• Can reduce system reliability when infeasible schedules are produced • May not lead to theoretical economically efficient solution because state-of-charge management is not performed by the ISO • Subject to challenges associated with understanding verifiable cost rules, mitigation, and other market design features
1R Hybrid ISO-managed feasibility model	• Same as for the 1R hybrid self-managed model • Improves reliability by ensuring that infeasible schedules are not produced	• Same as for the 1R hybrid self-managed model except that it is not subject to impacted reliability from infeasible schedules
2R Co-located model	• Models mostly already exist; therefore, few rule and software updates needed • ISO has information to ensure reliability and feasible schedules • Is an economically efficient solution if the ISO manages feasible state of charge and uses solar and wind forecasts	• Less flexibility regarding offering strategies • May not be able to account for degradation costs • May impact the project's ability to meet requirements for the U.S. investment tax credit, as storage may sometimes be charged from the grid • Has software and computational limitations
2R Co-located linked model	• Same as for the 2R co-located model • Allows for projects to meet requirements for U.S. investment tax credit	• Same as for the 2R co-located model except that its ability to meet requirements for U.S. investment tax credit is not impacted

Note: These advantages and disadvantages may differ based on one's perspective.

Source: Energy Systems Integration Group.

- **Co-located model:** Each individual technology is treated separately by the ISO/RTO, with the only connection between the resources being that they share an aggregate injection limit at the point of interconnection (e.g., the California Independent System Operator calls this the aggregate capability constraint).
- **Co-located linked model:** Two resources are treated as distinct generating resources, but have additional, linking constraint(s) which the system operator must optimize around. Where there are linking constraints, the combined facility operates differently than each individual component, and this is represented in the market clearing. An example of a linking constraint would be a limitation on the amount of grid-charging for battery resources taking advantage of the investment tax credit.

The advantages and disadvantages of each model are described in Table. 1 It is important to note that these pros and cons may differ based on one's perspective, and modifications to the details of a given participation model may alleviate the disadvantages when effectively implemented.

Advantages across all of the models include the flexibility to utilize effective strategies for the resource, ability to ensure the system's reliability and theoretical economic efficiency, reduced costs and time associated with market rule and software changes, and minimized need for computational capabilities.

While the participation options for hybrid resources in electricity markets may continue to evolve, there are a few enhancements that have been suggested across all of the models. One is to allow hybrids to adjust their offers closer to real time. Most ISOs require offers to be submitted at least 30 minutes prior to an hour (and in some cases, up to 75 minutes) and for those offers to remain constant for that entire hour. However, when information about hybrids' projected output becomes available closer to real time, the offers that hybrids originally provided may no longer be practical, or additional capabilities could be available that would go unused. This enhancement could benefit hybrid resources as well as other generation types. Some issues regarding market power mitigation checks may need to be resolved for resources to be able to update bids as frequently as every five minutes.

While the participation model is unique to wholesale electricity markets, the same advantages apply to other market structures as well. In regions outside of organized electricity markets, and therefore where participation models are not required, hybrid resources are typically operated to minimize operating costs of the system. In these regions, the utility controls the hybrid to provide energy during the times of the day when it is most beneficial to reduce system costs. Various agreements may also dictate that the resource provide energy during certain time periods. In Hawaii, for example, a unique power purchase agreement structure was developed and applied to hybrid solar + storage resources. In contrast to most variable renewable plants, which are often paid solely for MWh of energy production, owners of hybrid resources sell the energy production from the facility, along with the rights of battery scheduling and dispatch, to the utility. In return, the utility pays a fixed monthly payment for the energy and capacity of the plant.

Recommendations for Wholesale Market Design, Participation, and Operations

Market design and regulatory requirements should allow for hybridization across many new types of resources and technologies, as this will allow engineers, developers, and asset owners to creatively design systems that meet the physical and financial needs of the system in a reliable and cost-effective manner. This approach will require unique market participation models that allow asset owners some degree of flexibility in state-of-charge management and internal operations.

System operators should consider the following actions related to market design rules, participation models, and operations for hybrid resources:

- Develop participation models that reflect various objectives and strategies of hybrid owners, such as maximizing capacity accreditation and revenues, providing ancillary services, and mitigating market uncertainty. This can lead to lower costs for consumers and efficient and fair profits for asset owners, while ensuring reliability and tractability within market clearing timelines, particularly for systems with high shares of hybrid resources.
- Investigate the possibility of allowing resources to provide offer updates regularly and closer to real time, while ensuring that market power mitigation tests can still be processed.
- Understand the technical capability of hybrid resources to provide ancillary services with their ability to sustain output, and ensure that duration requirements for services are based on true system needs.
- Continue to assess the value of existing and new hybrid make-ups against their alternatives, and continue to develop the techniques for studying resources and comparing values to costs in order to help the industry determine the value of hybridization into the future.
- Anticipate participation models that may allow for the market participation of multiple technologies in efficient ways, and avoid waiting until the technology is demonstrated before creating rules for participation.

Adapted from *Unlocking the Flexibility of Hybrid Resources*, a report by the Energy Systems Integration Group's Hybrid Resources Task Force. Four fact sheets and the full report are available at https://www.esig.energy/unlocking-the-flexibility-of-hybrid-resources.

To learn more about the recommendations described here, please send an email to info@esig.energy.

The Energy Systems Integration Group is a nonprofit organization that marshals the expertise of the electricity industry's technical community to support grid transformation and energy systems integration and operation. Additional information is available at https://www.esig.energy and info@esig.energy.