

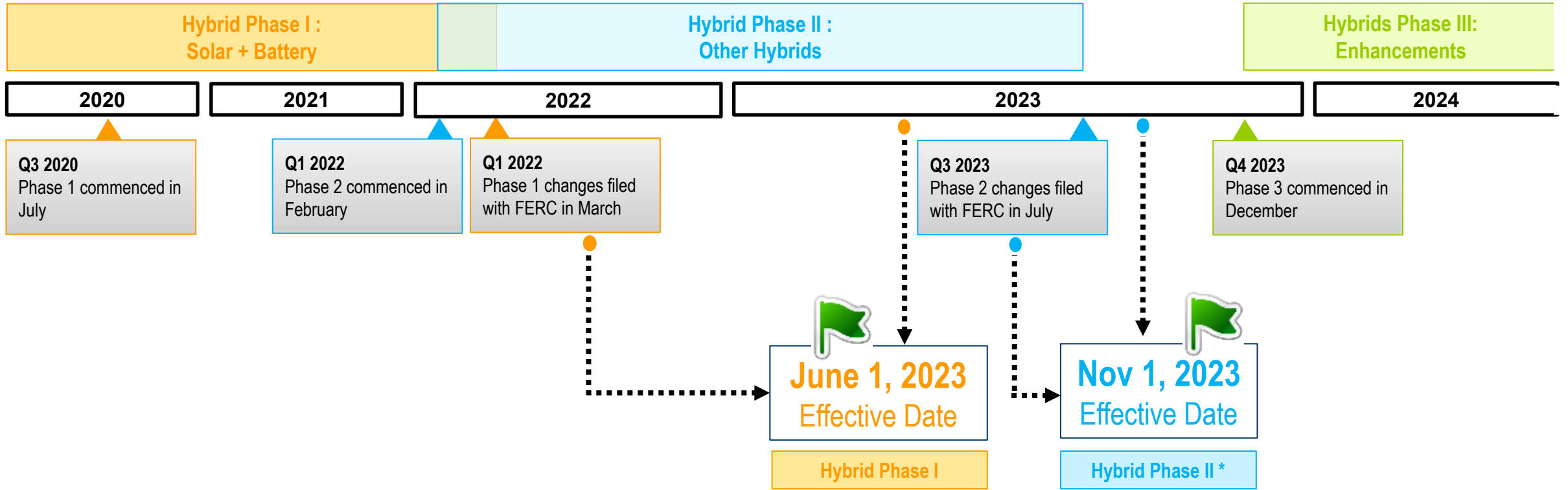


# Hybrid Resources in PJM Markets

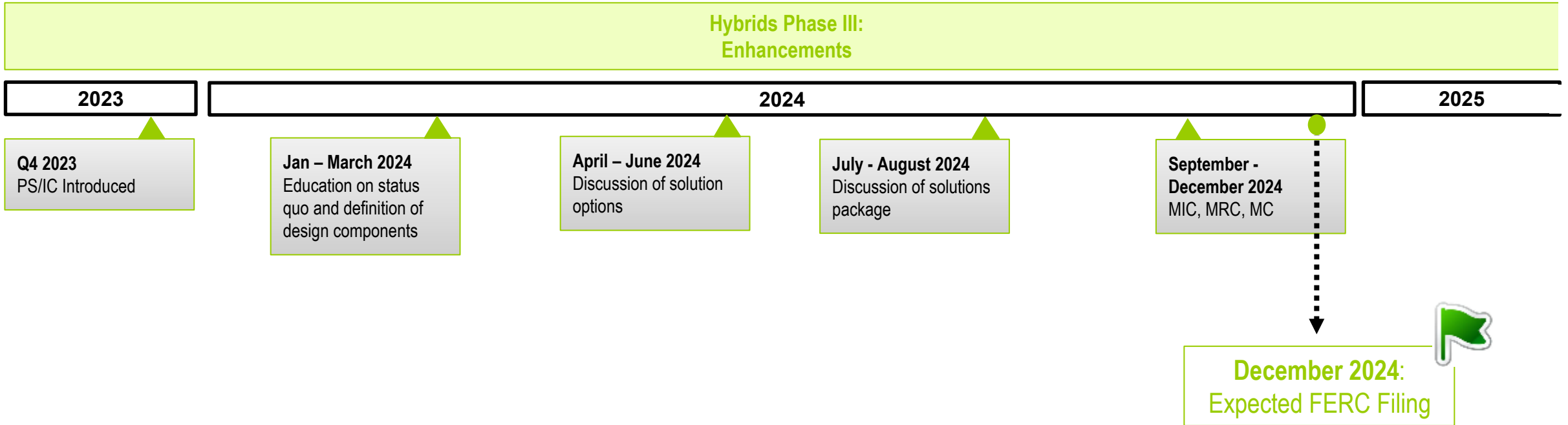
## Education on Status Quo & Proposed Enhancements

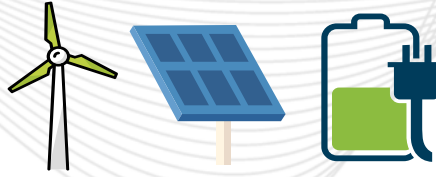
Maria Belenky  
Market Design & Economics

Special MIC – Hybrids Education  
September 26, 2024



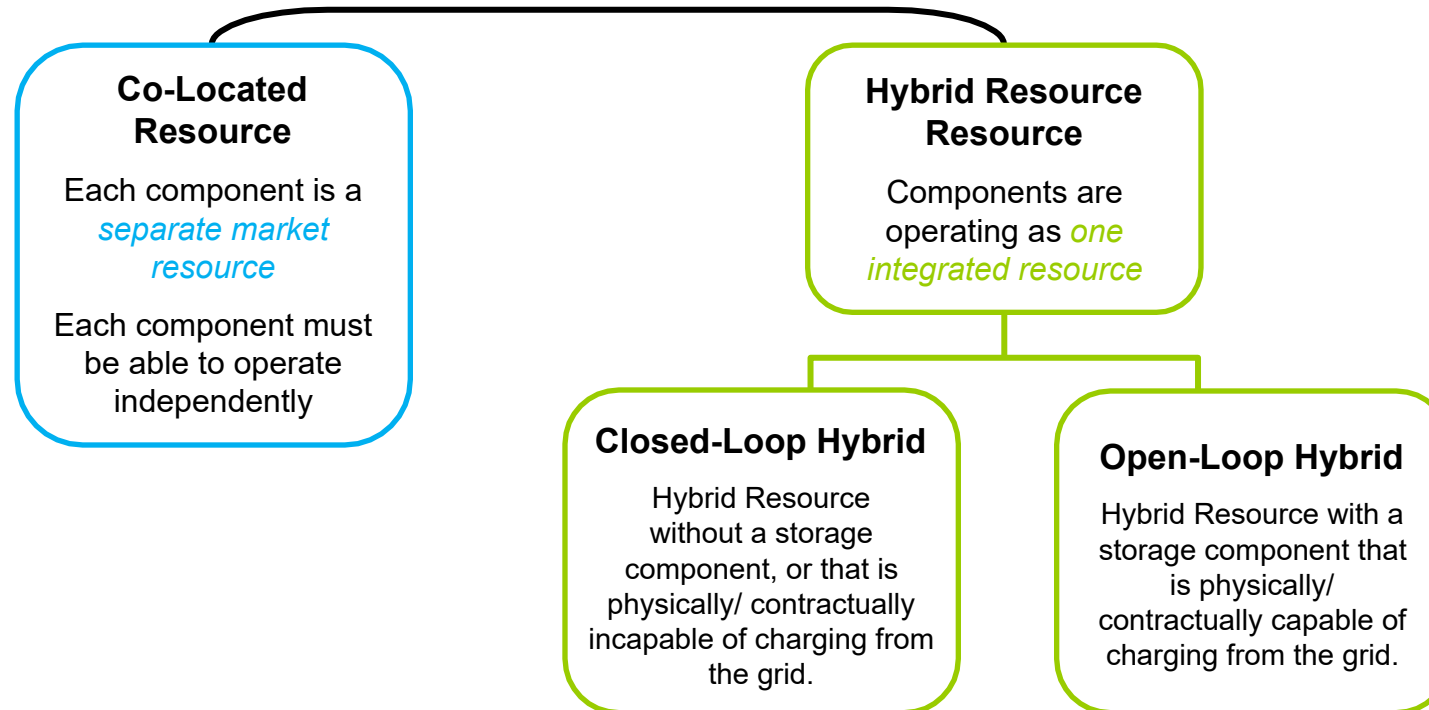
\* LOC component of Hybrids 2 expected effective Dec 2024.

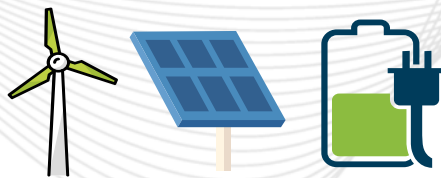




## Mixed Technology Facility

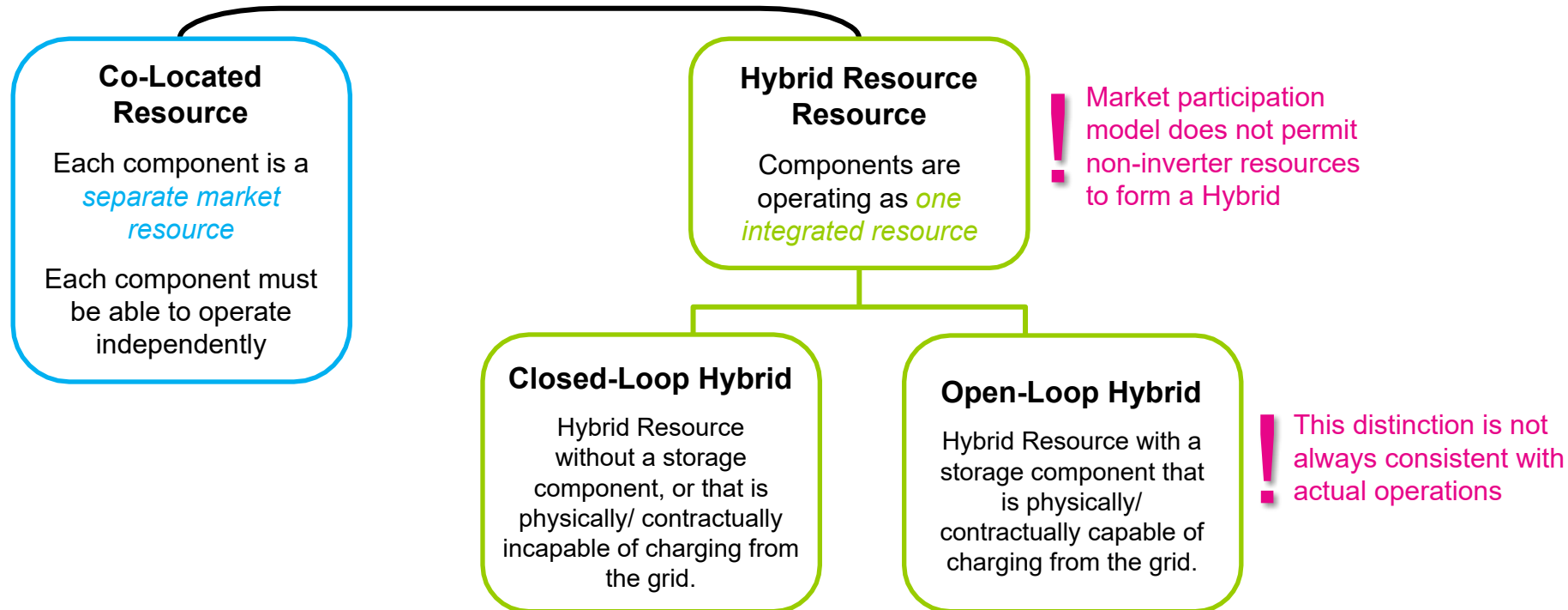
A facility that features multiple and distinct technology types behind the same point of interconnection

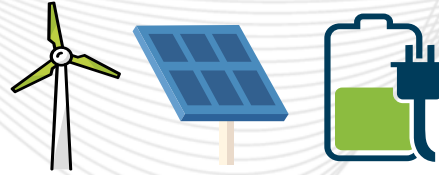




## Mixed Technology Facility

A facility that features multiple and distinct technology types behind the same point of interconnection





## Mixed Technology Facility

A facility that features multiple and distinct technology types behind the same point of interconnection

### Co-Located Resource

Each component is a *separate market*

### Hybrid Resource Resource

Components are operating as *one resource*

! Market participation model does not permit non-inverter resources to form a Hybrid

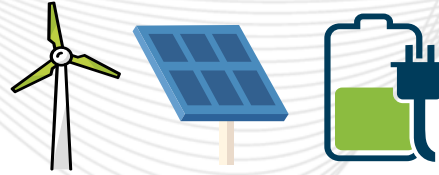
- A MTF with a non-inverter generation component and a battery component (e.g., gas + battery) is eligible to participate in PJM markets as a Hybrid Resource.
- A MTF with a non-inverter generation component and an intermittent component (e.g., gas + solar) is eligible to participate as separate co-located resources only.

### Open-Loop Hybrid

Hybrid Resource with a storage component that is physically/contractually capable of charging from the grid.

! This distinction is not always consistent with actual operations

- The expected use case for a non-inverter hybrid resource is a scenario where a battery is added to the POI of a traditional generator and becomes the primary unit. The traditional generator would not typically run, except to firm up the battery or in emergency conditions.
- Non-inverter hybrids will be required to follow existing rules for Hybrid Resources, including zero start-up and no-load costs. As such, only units that intend to operate primarily as a battery would choose the hybrid model.
- As a hybrid that operates primarily as a battery, the unit will be expected to be open-loop.
- As with all Hybrids, the a non-inverter hybrid would receive resource-specific capacity accreditation. Because the traditional generator would not typically be expected to run, the hybrid would be accredited based on the capability of the battery.



## Mixed Technology Facility

features multiple and distinct technology types  
at the same point of interconnection

- Market participant will determine and indicate to PJM whether or not the unit will operate in the market as an open or closed-loop resource, depending on whether it charges the storage component from the grid.
- MTFs that indicate intent to charge from on-site generation only during the interconnection process must participate as closed-loop Hybrid Resources.
- All Hybrid Resources that are capable of charging from the grid must execute a Network Integration Transmission Service (NITS) Agreement.

### Hybrid Resource Resource

Components are operating as *one integrated resource*

! Market participation model does not permit non-inverter resources to form a Hybrid

### Closed-Loop Hybrid

Hybrid Resource without a storage component, or that is physically/ contractually incapable of charging from the grid.

### Open-Loop Hybrid

Hybrid Resource with a storage component that is physically/ contractually capable of charging from the grid.

! This distinction is not always consistent with actual operations



- A Mixed Technology Facility with components that can operate independently may select to participate as *either* a Hybrid Resource or as multiple Co-Located Resources.
- Selecting and updating classification:
  - **Capacity resources:** classification can be changed every 5 years to match the frequency with which a technology may change its ELCC resource classification.
    - The same classification must be chosen in both the capacity and energy markets for an applicable delivery year.
  - **Energy market only:** classification can be changed 1x per calendar year with notice to PJM by May 30 for the upcoming Jan 1 to Dec 31 participation months.

- **Selection process is not clear** – **!** A Mixed Technology Facility with components that can operate independently may select to participate as *either* a Hybrid Resource or as multiple Co-Located Resources.
- Selecting and updating classification:
  - **Process & timeline are not clear** – **!** **Capacity resources:** classification can be changed every 5 years to match the frequency with which a technology may change its ELCC resource classification.
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- Selection process is not clear
- **!** A Mixed Technology Facility with components that can operate independently may select to participate as *either* a Hybrid Resource or as multiple Co-Located Resources.

New resources must inform PJM of their desired participation model at least 6 months ahead of their planned in-service date by contacting Member Relations at [custsvc@pjm.com](mailto:custsvc@pjm.com).

changed every 5 years to match the its ELCC resource classification.

- The same classification must be chosen in both the capacity and energy markets for an applicable delivery year.

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- The same classification must be chosen in both the capacity and energy markets

A planned resource must inform PJM of their intent to participate as a hybrid resource in accordance with the NOI deadline for the upcoming BRA/IA by emailing the RPM hotline at [rpm\\_hotline@pjm.com](mailto:rpm_hotline@pjm.com). All changes in classification made by an existing capacity resource must follow the status quo deadline for ELCC class changes and be communicated to PJM in the same manner. All other status quo requirements continue to apply.

Selection process is not clear

- **!** A Mixed Technology Facility with components that can operate independently may select to participate as *either* a Hybrid Resource or as multiple Co-Located Resources.

- Selecting and updating classification:

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- **!** **Capacity resources:** classification can be changed every 5 years to match the frequency with which a technology may change its ELCC resource classification.

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Process is not clear

- **!** **Energy market only:** classification can be changed 1x per calendar year with notice to PJM by May 30 for the upcoming Jan 1 to Dec 31 participation months.

All existing energy-only resources may change their classification (e.g., open to closed-loop, hybrid to co-located, etc.) by contacting Member Relations at [custsvc@pjm.com](mailto:custsvc@pjm.com). All other status quo requirements continue to apply.

- Hybrids that, in isolation, would be Intermittent Resources or Capacity Storage Resources are exempt from the capacity must offer requirement.
- Hybrid Resource are accredited using resource-specific ELCC ratings, as described in [Manual 21A](#).
- Hybrid resources must seek a resource-specific MOPR value determined in accordance with the process outlined in [Manual 18](#).

Translation  
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- Hybrids that, in isolation, would be Intermittent Resources or Capacity Storage Resources are exempt from the capacity must offer requirement.
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- Hybrid Resource are accredited using resource-specific ELCC ratings, as described in

Hybrid Resource with any component that is, in isolation, not exempt from the RPM must offer requirement, is itself not exempt.

OPR value determined in accordance



- The Hybrid Resources Participation Model intended to create as much overlap as is reasonable between the rules for the hybrid resource and those applicable to the individual component if it were operating independently.
  - A Hybrid Resource consisting solely of inverter-based components with **at least one storage component** (e.g., solar + storage) is eligible to participate in Energy and Ancillary Services markets using an approach similar to the **Energy Storage Resource Participation Model**.
  - A Hybrid Resource consisting **solely of non-storage inverter-based components** (wind + solar) is eligible to participate in Energy and Ancillary Services markets in the same manner as a standalone **wind or solar** resource.

## **What does it mean for a Hybrid Resource to participate in the market in a “similar manner as ESR Model Participants”?**

- Hybrid Resources with a battery component and ESR Model Participants are modeled the same way in the energy and ancillary services markets. I.e., these are both modeled as resource types that can draw from the grid for later injection. For example:
  - They have the same set of parameters available to them, including modes of operation—charge mode, discharge mode, continuous mode, intermittent mode.
  - They both self-schedule into the energy market. PJM does not make commitment decision for either type of resource.
  - They can both be dispatched for positive and negative MWs.
- Differences exist with respect to specific business rules for each resource type. For example:
  - ESR Model Participants have cost development guidelines documented in M15, hybrids do not.
  - ESR Model Participants can provide ancillary services only—without an energy schedule—hybrid resources cannot.



# Hybrid Resources: Energy & Ancillary Services Model

## Mode of Operation:

- *Continuous*: Includes both negative and positive MWs (i.e., the resource can continually and immediately transition from withdrawing MWs to injecting MWs onto the grid).
- *Charge*: Includes negative MWs only (i.e., the resource is only withdrawing MWs from the grid).
- *Discharge*: Includes positive MWs only (i.e., the participant is only injecting MWs onto the grid).
- *Intermittent*: Similar to Discharge Mode and indicates that the storage component is absent or is not actively managing the resource's output.

Mode	Hybrid Resource Type	
	Open-Loop Hybrid Resource	Closed-Loop Hybrid Resource
<b>Continuous</b>	Yes	N/A
<b>Discharge</b>	Yes	Yes
<b>Charge</b>	Yes	N/A
<b>Intermittent</b>	Same as Discharge	Same as Discharge

- The Hybrid Resources Participation Model intended to create as much overlap as is reasonable between the rules for the hybrid resource and those applicable to the individual component if it were operating independently.
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Participation model for non-inverter hybrids unclear

~~A Hybrid Resource consisting solely of non-storage inverter-based components (wind~~

PJM proposes to permit Hybrid Resources with a non-inverter component and a battery component (“non-inverter hybrid”) to participate in the Energy and Ancillary Services markets using a similar approach as the Energy Storage Resource Participation Model.

- Hybrid Resources with a capacity commitment have an energy must offer requirement.
- Hybrid Resources meet the must offer requirement by self-scheduling (i.e., self-committing) in the energy market. They may self-schedule at fixed MW quantities or offer a dispatchable range.
- Hybrid Resources may offer values that vary hour to hour from the capacity commitment.
- When self-scheduling a Hybrid with a storage component, the Market Sellers must specify the hourly mode of operation.
- The maximum cost-based offer is \$0. This is a default value as Hybrids cost guidelines are not defined in [Manual 15](#).

Additional  
specificity  
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- Hybrid Resources comprised exclusively of inverter-based components meet their must offer requirement by offering Eco Max MW equal to or greater than their hourly forecast as follows:
  - The hourly forecast of hybrids comprised exclusively generation components should equal the sum of the forecasted MW of each generation component, capped at the inverter size.
  - The hourly forecast of battery-backed hybrids must include the anticipated intermittent and battery output. The total offered energy over the course of 24 hours must be equal to or greater than the forecasted energy of the standalone intermittent resource when grossed up for the roundtrip efficiency of the battery.
- The market seller must provide the hourly forecasted capability of the Hybrid Resource to PJM. They may use PJM's forecast for the intermittent component or develop/procure their own forecast. If this forecast includes different confidence levels, the market seller must use the one closest to the median value (e.g. P50).
- *Energy market must offer rules for ESR and non-inverter Hybrid Resources (which are similar to stand-alone batteries) are not part of this Issue Charge.*



- Hybrid Resources are eligible to provide regulation and reserves.
- Reserves offer rules:
  - Hybrids with a capacity commitment *must offer* reserves.
  - Hybrids are not considered available by default, and must submit specific reserve offers to be considered.
  - The reserves quantity is determined by the Market Seller, not by PJM.
  - Hybrids cannot provide non-synchronized reserves and offline secondary reserves.
- Hybrid Resources will not be able to operate in “ancillary services-only” modes available in the Energy Storage Resource Participation Model because, unlike storage, a hybrid resource with a generation component is expected to have positive output in many hours of the day, and so must have an energy schedule.

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Hybrid Resources with a battery component are eligible to provide reserves (and must offer reserves if committed for capacity), with the exception of non-synchronized reserves and offline secondary reserves, per the status quo.

Hybrid resources comprised exclusively of inverter-based generation components are not eligible to provide reserves (and do not have a reserves must offer) unless an exception is requested and approved, mirroring existing rules for standalone wind and solar. An exception may be requested via the process outlined in M11.

- ESR Model Participants requested to charge more than their LMP-desired quantity in response to a PJM manual dispatch are eligible for uplift per Tariff Att K, Appdx, Section 3.2.3 (f).
- ESR and Hybrid Resources requested to reduce output in response to a PJM manual dispatch are eligible to receive LOC per Tariff Att K, Appdx, Section 3.2.3 (f-4).
- ESR model participants are eligible to seek compensation per Tariff Att K, Appdx, section 3.2.3(f-5) if they do not believe that they have been accurately compensated for opportunity costs associated with following PJM manual dispatch instructions. F-5 specifically accounts for unforeseen possibilities for LOC, especially with respect to manual curtailments of charging.
  - The market participant, PJM and the IMM are to discuss a mutually acceptable level of compensation and to be accepted by PJM. If the IMM disagrees with the compensation accepted by PJM, it may communicate its concerns to FERC.

Tariff  
reference  
incorrect;  
hybrids  
excluded

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ESR Model Participants and Hybrid Resources requested to charge more than their LMP-desired quantity are eligible for uplift per Tariff Att K, Appx, Section 3.2.3(e).

The energy market uplift rules will be consistently applied to the provision of reactive services.

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ESR *Model Participants* and Hybrid Resources are not eligible for LOC when reducing charging in response to PJM's manual dispatch.

Section  
exclude  
Hybrids

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Hybrid Resources may seek compensation per section 3.2.3(f-5) (or equivalent section in place for ESR model participants) if they do not believe that they have been accurately compensated for opportunity costs associated with following PJM manual dispatch instructions.



# Hybrids and ESR Model Participants: Charging Energy vs. Station Power

- **Direct Charging Energy:** The energy that an Energy Storage Resource or Open-Loop Hybrid Resource purchases from the PJM Interchange Energy Market and (i) later resells to the PJM Interchange Energy Market; or (ii) is lost to conversion inefficiencies, provided that such inefficiencies are an unavoidable component of the conversion, storage, and discharge process that is used to resell energy back to the PJM Interchange Energy Market.
- **Station Power:** The energy used for operating the electric equipment on the site of a generation facility located in the PJM Region or for the heating, lighting, air-conditioning and office equipment needs of buildings on the site of such a generation facility that are used in the operation, maintenance, or repair of the facility. *Station Power does not include any energy (i) used to power synchronous condensers; (ii) used for pumping at a pumped storage facility; (iii) used in association with restoration or black start service; or (iv) that is Direct Charging Energy.*

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Unclear how this distinction should be effectuated for settlement

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- **Station Power:** The energy used for operating the electric equipment on the site of a generation facility located in the PJM Region or for the heating, lighting, air-conditioning and office equipment needs of buildings on the site of such a generation facility that are used in the operation, maintenance, or repair of the facility. *Station Power does not include any energy (i) used to power synchronous condensers; (ii) used for pumping at a pumped storage facility; (iii) used in association with restoration or black start service; or (iv) that is Direct Charging Energy.*

Unclear how this distinction should be effectuated for settlement

- Hybrid Resources must have: 1) telemetry at the POI for MW and MVAR, and 2) revenue metering at the POI for MWh, consistent with any other generation resource.
- Each component of a Hybrid Resource is required to provide real-time MW output.
  - PJM requires direct sub-metering of at least one component. Telemetry values for the other component may be inferred as the difference between the POI telemetry and the directly-metered component telemetry (corrected for losses to the POI).
- Entering State of Charge information in Markets Gateway is currently optional and will only be used for PJM research purposes.
- Hybrids with a storage component are responsible for managing their own State of Charge.

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• Entering State of Charge information in Markets Gateway is currently optional and will only be used for PJM research purposes.

Hybrid resources are required to manage their own State of Charge.

As the SOC field in Markets Gateway is optional, PJM will use SOC telemetry data to calculate uplift.

- An intermittent or hybrid resource's Economic Minimum should represent the lowest operating MW point of the resource.
- An intermittent or hybrid resource's Emergency Minimum should be set to 0.
- The output of a hybrid resource should achieve its dispatch point within 5 minutes or consistent with the resource's ramp rate bid. PJM should be notified if the response time is expected to exceed 5 minutes.
- The operator of a hybrid resource with a battery component that is dispatchable must indicate to PJM the hours for which the plant is operating in "intermittent-only" mode, during which time the battery is not providing power for the purpose of maintaining hybrid output consistent with PJM dispatch. Dispatchable hybrids must follow dispatch in both "intermittent-only" mode and all other hybrid modes.

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Review for  
non-  
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Review for  
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- An intermittent or hybrid resource's Emergency Minimum should be set to 0.

- The Economic Minimum for an intermittent or Hybrid Resource comprised exclusively of inverter-based components should be set to 0. The Economic Minimum for a Hybrid Resource with a non-inverter component must be set at or below the Economic Minimum of the non-inverter component.
- The Emergency Minimum for an intermittent or Hybrid Resource that is dispatchable must be set to 0. In "intermittent-only" mode, during which time the battery is not providing power for the purpose of maintaining hybrid output consistent with PJM dispatch. Dispatchable hybrids must follow dispatch in both "intermittent-only" mode and all other hybrid modes.

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Language should be broadened to all hybrids

- The operator of a hybrid resource with a battery component that is dispatchable must indicate to PJM the hours for which the plant is operating in “intermittent-only” mode, during which the plant is required to follow dispatch in both “intermittent-only” mode and “generation-only” mode to be broadly applicable to all hybrids.

Change “intermittent-only” mode references to “generation-only” mode to be broadly applicable to all hybrids.

- Separate reporting in eDART for each component of a hybrid resource when unavailable or derated.
- GADS reporting required for the storage component of a hybrid resource.
- No eDART or GADS ticket is required for lack of solar irradiance, charging, or lack of charge.

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- No eDART or GADS ticket is required for lack of solar irradiance, charging, or lack of charge.

- Separate reporting in eDART for each component of a hybrid resource when unavailable or derated.

- Non-inverter hybrids not covered • **!** GADS reporting required for the storage component of a hybrid resource.

- **N** GADS reporting follows the requirements for the underlying resource type. E.g., GADS reporting is required for storage and  
**of** all non-inverter components of a hybrid resource. **!** diance, charging, or lack

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## Hybrids Enhancements



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