Hybrids III Conforming Manual Revisions

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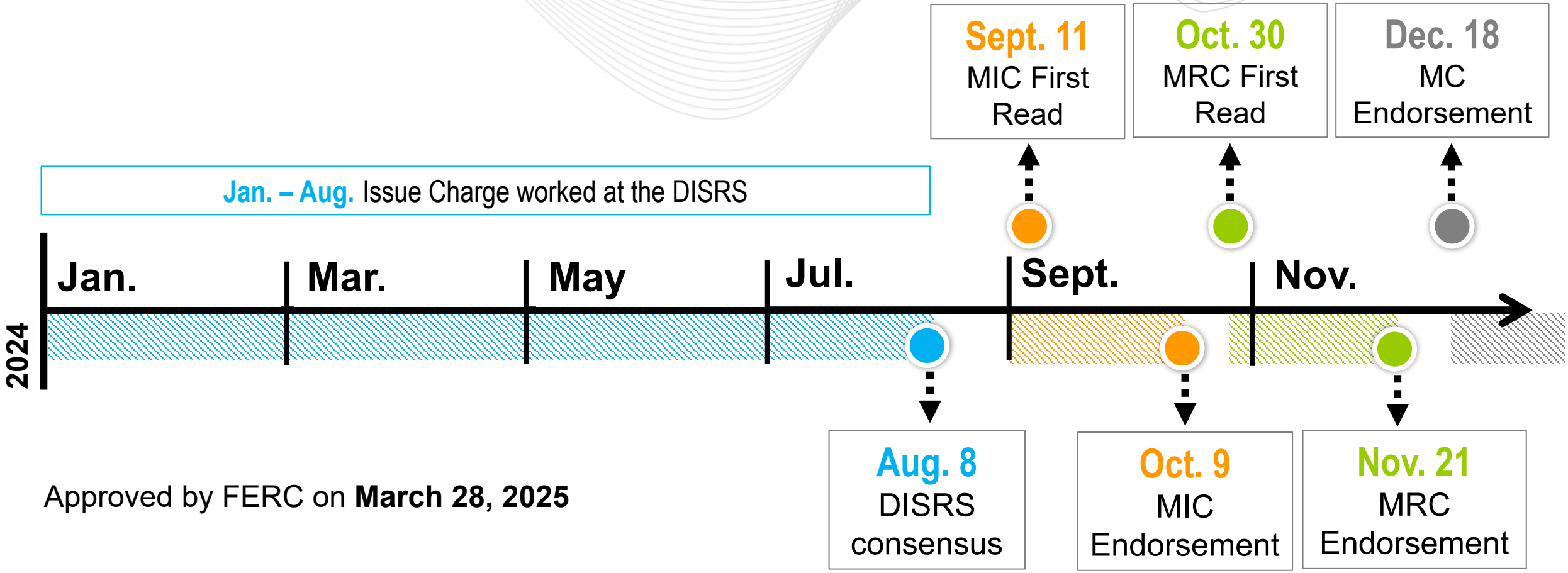
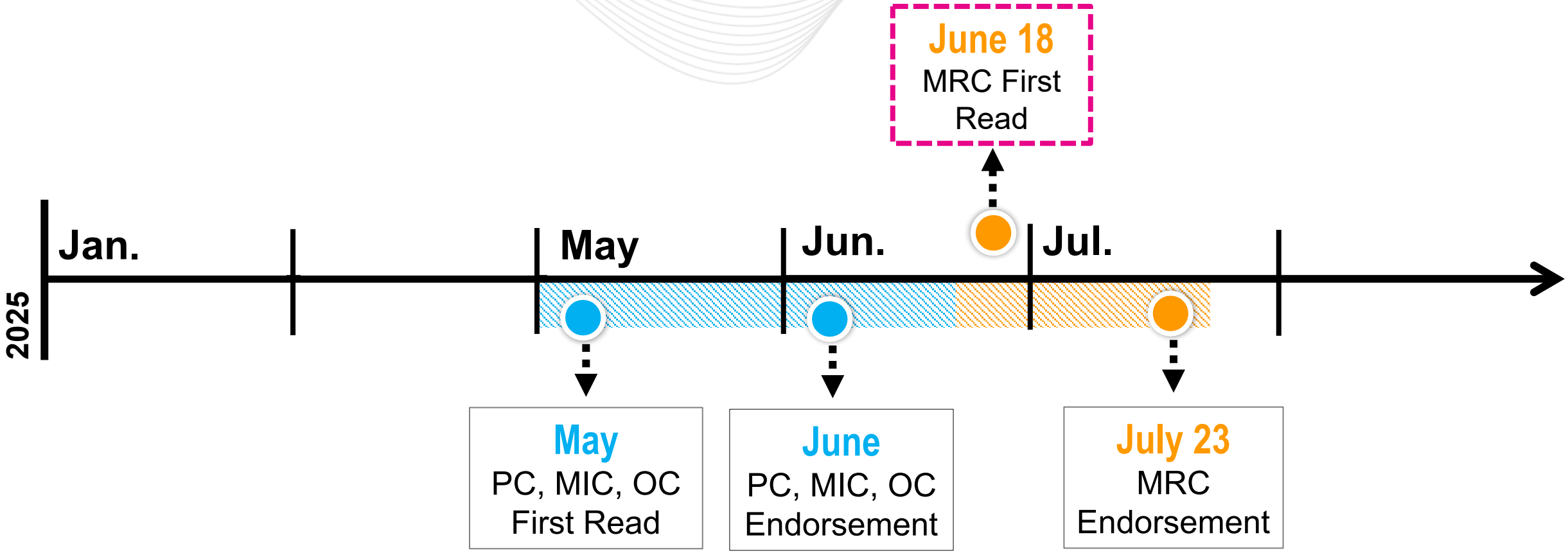
Hybrids 3 Timeline



Approved by FERC on **March 28, 2025**

Hybrids 3 Manual Revisions Timeline



Summary

FERC Docket ER25-1095:

- Expands the Hybrid Resources market model to permit a non-inverter component to pair with a storage component, e.g., gas plus storage, located behind the same POI to form one integrated market unit.
- Revises definitions of Open-Loop and Closed-Loop Hybrid Resources to permit market participants to determine and indicate to PJM the Hybrid Resource's classification based on whether the facility operates by charging its storage component from the grid.
- Provides additional information regarding how a Hybrid Resource can meet its energy must offer requirement.
- Makes certain non-substantive corrections and clarifications around existing market rules.

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2.3.3.1 Capacity Resource Offer Rules

- Intermittent Generation Resources~~, Hybrid Resources,~~ and Capacity Storage Resources that are committed Capacity Resources, except those that participating in the Energy Storage Resource Participation Model, shall meet the must offer requirement by either self-scheduling (Availability = Must Run) or may allow the Day-ahead Market to schedule by offering the unit as a dispatchable resource (Availability = Economic) equal to the level defined below.
- Intermittent Generation Resources meet their must offer requirement by offering Economic Maximum MW equal to or greater than their hourly forecast. If the Market Seller develops or procures forecast with different confidence levels, the Market Seller must use the one closest to the median value (e.g. P50). Forecasts can be adjusted to account for expected equipment availability. If the Market Seller does not have a forecast or has technical issues developing or receiving a forecast, the PJM developed forecast is available.
- Hybrid Resources and resources enrolled in the ESR participation model shall meet the must offer requirement by self-scheduling only.

2.3.3.1 Capacity Resource Offer Rules

- A Hybrid Resource comprised exclusively of inverter-based components meets its must offer requirement by offering Economic Maximum MW equal to or greater than their hourly forecast.
    - The hourly forecast of a Hybrid Resource comprised exclusively of generation components should equal the sum of the forecasted MW of each component, capped at the inverter size. The hourly forecast of storage-backed Hybrid Resource 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 component(s) when grossed up for the roundtrip efficiency of the battery.
    - The Market Seller may use PJM's forecast for the intermittent component or develop/procure their own forecast following the requirements for Intermittent Generation Resources described above.
- The hourly Day-ahead self-scheduled values for Intermittent Resources, Hybrid Resources and Capacity Storage Resources may vary hour to hour from the capacity obligation value.

2.3.4C Mixed Technology Facility

Mixed Technology Facility is a facility that features multiple and distinct generation technology types behind the same point of interconnection. Individual technology types are referred to as components. There are alternate ways that the components of a Mixed Technology Facility can participate in PJM Markets, as either (1) Co-Located Resources, where the components are modeled and dispatched as two or more separate resources; or (2) an integrated Hybrid Resource, where components are modeled and dispatched as a single integrated resource. ~~However,~~Two exceptions exist. A~~a~~ Mixed Technology Facility which features significant interactions between the generation and/or storage components are required to participate in markets as a single Hybrid Resource. An example of such a facility is one where the storage component was not studied to, and/or physically cannot, charge from the grid. Furthermore, a Mixed Technology Facility with a non-inverter generation component and an intermittent component is eligible to participate as Co-Located Resources only.

Co-Located Resources participate in the Capacity, Energy and/or Ancillary Services market(s) individually as separate resources and follow the relevant business rules for each modeled resource ~~accordingly~~. Hybrid Resources participate in accordance with Section 2.3.4C.1 below.

For a Mixed Technology Facility within the new resource queue process, the choice to participate in PJM's markets as a Hybrid Resource or as multiple Co-Located Resources must be made as part of the new interconnection onboarding process managed by PJM Client Management no later than six (6) months in advance of its initial start in the Energy markets. Six months provides sufficient time for the modeling choice to be reflected in PJM's market systems and settlement systems. Please contact Member Relations-Client Management at custsvc@pjm.com with any questions.

For an existing Mixed Technology Facility that has no components that participate in the Capacity market, and that is eligible to participate in the energy markets as either a Hybrid Resource or as multiple Co-Located Resources, the modeling classification can be changed once per calendar year with notice to PJM Member Relations (custsvc@pjm.com) by no later than May 30 for the upcoming January 1 to December 31 participation months. An annual modeling classification change provides adequate flexibility to accommodate the business interests of the owners of such resources, while providing a stable basis from which to administer market outcomes. Once a modeling status is chosen, it remains until another request is received.

For a Mixed Technology Facility that has components that participate in the capacity market, and that is eligible to participate in the capacity market as either a Hybrid Resource or as multiple Co-Located Resources, the modeling classification election must be indicated pursuant to the rules outlined in RAA, Schedule 9.2.

2.3.4C.1 Hybrid Resource

The Market Participant is to determine and indicate to PJM whether or not the unit will operate in the market as an open or closed-loop resource following the timelines and process described in section 2.3.4C. A Closed-Loop Hybrid Resource is a Hybrid Resource without a storage component, or that does not operate by charging its storage component ~~is physically or contractually incapable of charging~~ from the grid. An Open-Loop Hybrid Resource is a Hybrid Resource with a storage component that operates by charging ~~is physically or contractually capable of charging~~ its storage component from the grid.

For a Hybrid Resource that has no components that participate in the Capacity market, and that is eligible to participate in the energy markets as either a Closed-Loop or Open-Loop Hybrid Resource, the modeling classification timeline is the same as a Mixed Technology Facility.

A Hybrid Resource consisting ~~solely~~ of ~~inverter-based components~~ at least one generation component and ~~at least one~~ storage component is eligible to participate in Energy and Ancillary Services markets using a similar approach as the Energy Storage Resource participation model described immediately above in section 2.3.4B. A Hybrid Resource consisting solely of ~~non-storage~~ inverter-based generation components is eligible to participate in Energy and Ancillary Services markets using a similar energy market participation model as used by wind and solar resources. The operational modes are used as shown below in table 1. A Hybrid Resource does not have “ancillary-only mode” and “regulation only mode”. Closed-Loop Hybrid Resources that lack the Charge Maximum and Minimum parameters cannot submit offers for negative megawatts and do not have charge mode. Open-Loop Hybrid Resources must indicate to PJM the intervals in which the battery is idle (i.e., its output capability is solely a function of available non-storage energy) as ~~Intermittent~~Generation Mode.

Table 1. Hybrid Resource Operation Modes

	Hybrid Resource Type	
	Open-Loop Hybrid Resource	**Closed-Loop Hybrid Resource**
Continuous	Yes	N/A
Discharge	Yes	Yes
Charge	Yes	N/A
~~Intermittent~~Generation	Same as discharge	Same as discharge

9.1 Hourly Schedule Adjustments

The following Hybrid Resource and ESR participation model offer parameters may be updated during the Real-time update periods, with exceptions as noted below:

- Mode selection (charge, discharge, continuous, unavailable, generation ~~intermittent~~)
- Economic Minimum and Maximum Charge Limits
    - These parameters are not subject to the T-65 min update deadline and may be updated through the end of the operating hour to which the updates apply.
- …

Manual 21B

Hybrid Resource Classes

"Hybrid Resource Class" shall mean the ELCC Classes specified in RAA Schedules 9.2 Section B. Each Hybrid Resource Class has a specified combination of two components, whereby, absent being part of a Combination Resource, the individual~~one~~ component~~s~~ would be in a Capacity Storage Resource Class, ~~and the other component would be in~~ a Variable Resource Class or would be an Unlimited Resource. A resource that is a member of a Hybrid Resource Class has a single Point Of Interconnection, unless the resource is controlled in an integrated fashion, is at a single site, and is approved by PJM to be considered a single resource in accordance with **PJM Manual 14-D**: Generator Operational Requirements.

There are Hybrid Resource Classes for all "open-loop" combinations of each Capacity Storage Resource class and each Variable Resource class or Unlimited Resource class, as well as all "closed-loop" combinations of each Capacity Storage Resource class and each Variable Resource class or Unlimited Resource class. An "open-loop" resource operates by ~~is physically and contractually capable of~~ charging the storage component from the grid, while a "closedloop" resource does~~is~~ not. An example of a Hybrid Resource Class is "Tracking Solar plus 4-hour Storage—Open Loop".

Sec 2: ELCC Classes
2.6 Administration of ELCC Classes

The following business rules apply to each mixed-technology resource:

- A mixed-technology resource comprised of components that have significant interaction must participate as a single Combination Resource (or, if the components would all be Variable Resources, then as a single Variable Resource)
- A mixed-technology resource comprised of components that do not have significant interaction are eligible to participate as either a single Combination Resource or as separate resources
- A mixed-technology resource with a non-inverter generation component and an intermittent component is eligible to participate as Co-Located Resources only
- A mixed-technology resource that indicated its intent to charge the storage component from on-site generation only during the interconnection process can only participate as a Closed-Loop Hybrid Resource
- The Generation Capacity Resource Provider of a mixed-technology resource eligible to participate as either a single ELCC Resource or as multiple stand-alone resources shall elect, for a term of five consecutive Delivery Years, whether PJM is to model it as a single ELCC Resource or as multiple stand-alone resources.
- ….

8.1.4 Combination Resources (other than Hydropower with Non-Pumped Storage)

Combination Resources (other than Hydropower with Non-Pumped Storage) must provide the following data and information:

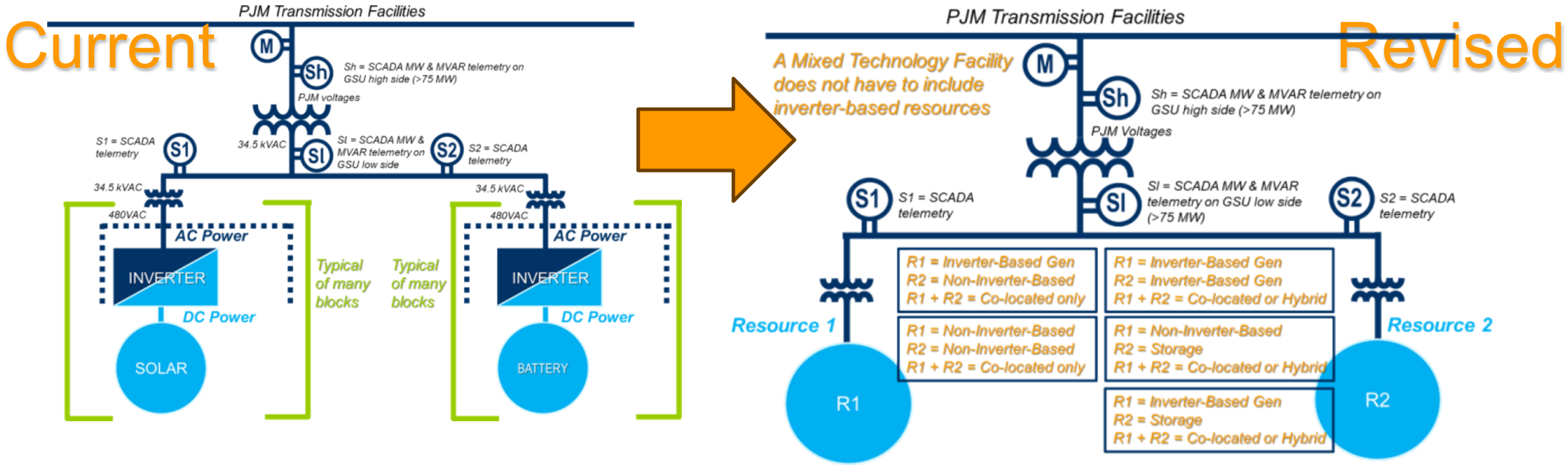
- All data required for the equivalent standalone components (e.g., solar data listed in Section 8.1.1 above)
- Maximum Output Facility (MFO) in MW
- Power rating capability associated with each component (in MW)
- Storage inventory capacity for energy storage resource component in MWh
- Operates by ~~Contractually and physically capable of~~ charging its storage component from the grid (yes/no)
- Components are DC-coupled (that is, they share inverters) (yes/no)
- Duration class of Limited Duration Resource component (including storage) (e.g., 4 hours, 6 hours, 8 hours, etc.)
- Black Start commitments in MW
- Any other firm commitments in MW and MWh
- Charging/discharging roundtrip efficiency of storage component (%)

Manuals 10 & 14D

- Section 2.1 Generation Outage Reporting Overview
  - Updated eDART Reportable MW table (Exhibit 3) to include the reportable MW value of non-inverter-based components of Hybrid Resources

Resource Type	eDART Reportable MW
For the inverter-based component of Hybrid Resource	Based on nameplate MW rating of the component
For the non-inverter-based component of Hybrid Resource	Total RPM (Owned) iCAP (Committed + Available) MW

- Section 4.2 Account Metering
  - Exhibit 7 generalized to include all resource types for Mixed Technology Facilities and Hybrid Resources

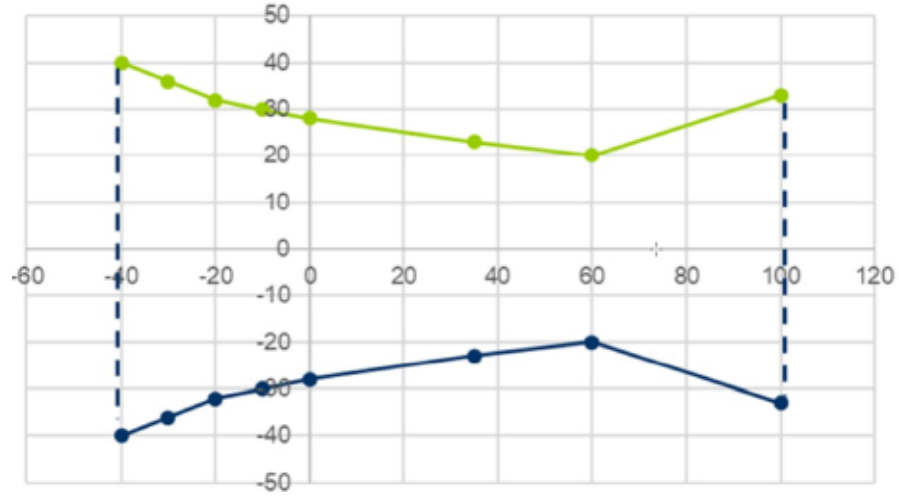


Manual 14D Changes

- Section 8.2.4 Generator Outage Reporting (Aggregate Turbine availability)
  - Updated language to emphasize wind outage reporting for all types of hybrids that include wind as a technology type
- Section 12.2.4 Generator Outage Reporting Section
  - Updated language to emphasize solar outage reporting for all types of hybrids that include solar as a technology type

- Section 13.1 Marketing and Classification of Mixed Technology Facilities
  - Modified language to broaden eligibility to participate as a Hybrid Resource
  - Clarified classifications of open-loop and closed-loop based on definition changes
  - Updated language and diagram to be inclusive of all eligible resource types for hybrids
  - Updated language to specify when a Mixed Technology Facility must participate as a Hybrid Resource
  - Noted classification of closed-loop for any Hybrid Resource without storage component
  - Clarified that for all Mixed Technology Facilities participation change notifications must be made no later than six (6) months in advance of its initial start in the energy markets.

- Attachment D PJM Generating Unit Reactive Capability Curve Specification and Reporting Procedures
  - Point 10 and Point 11 removed limiting language of inverter-based and non-inverter-based resources
  - Point 12 clarified language to only refer to Hybrid Resources with a storage component



Manual 14D Changes

- Attachment E PJM Generator and Synchronous Condenser Reactive Capability Testing
  - Updated table to specify testing requirements specific to Hybrid Resources with a storage component

UNIT TYPE	MW OUTPUT	MVAR OUTPUT	TEST DURATION
FOSSIL, HYDRO ELECTRIC, BLACKSTART	MAX MAX MIN MIN	MAX LAG MAX LEAD MAX LAG MAX LEAD	ONE HOUR WHEN LIMIT REACHED WHEN LIMIT REACHED WHEN LIMIT REACHED
SYNCHRONOUS CONDENSER or GENERATOR THAT OPERATES IN THE SYNCHRONOUS CONDENSING MODE TO PROVIDE REACTIVE SUPPORT	N/A N/A	MAX LAG MAX LEAD	ONE HOUR WHEN LIMIT REACHED
NUCLEAR	MAX MAX	MAX LAG MAX LEAD	ONE HOUR WHEN LIMIT REACHED
VARIABLE (Wind & Solar) (Testing done with at least 90% of turbines or inverters on line)	VARIABLE VARIABLE	MAX LAG MAX LEAD	WHEN LIMIT REACHED WHEN LIMIT REACHED
INVERTER-BASED ENERGY STORAGE RESOURCES **Max MW Output** = fully discharging **Min MW Output** = fully charging	ZERO ZERO MAX MAX MIN MIN	MAX LAG MAX LEAD MAX LAG MAX LEAD MAX LAG MAX LEAD	WHEN LIMIT REACHED WHEN LIMIT REACHED WHEN LIMIT REACHED WHEN LIMIT REACHED WHEN LIMIT REACHED WHEN LIMIT REACHED
DC-COUPLED INVERTER BASED STORAGE HYBRID RESOURCES **Max MW Output** = fully discharging/producing **Min MW Output** = fully charging with no production (or 0 MW net output if facility cannot charge from grid)	ZERO ZERO MAX MAX MIN MIN	MAX LAG MAX LEAD MAX LAG MAX LEAD MAX LAG MAX LEAD	WHEN LIMIT REACHED WHEN LIMIT REACHED WHEN LIMIT REACHED WHEN LIMIT REACHED WHEN LIMIT REACHED WHEN LIMIT REACHED
AC-COUPLED INVERTER BASED STORAGE HYBRID RESOURCES **Zero net MW point** must reflect the most conservative capability at that power level, for example with a battery at full charging and generation output matching as close to battery charge power as practicable. **Max MW Output** = fully discharging/producing **Min MW Output** = battery fully charging and generation at 0 MW (if facility cannot charge from grid, omit this point). **Max inverter operating point(MXIOP)**= generation as close to full output as practicable and battery at full charging. *Additional test points may be required if these do not capture the most restrictive capability scenarios.	ZERO ZERO MAX MAX MIN MIN MXIOP MXIOP	MAX LAG MAX LEAD MAX LAG MAX LEAD MAX LAG MAX LEAD MAX LAG MAX LEAD	WHEN LIMIT REACHED WHEN LIMIT REACHED WHEN LIMIT REACHED WHEN LIMIT REACHED WHEN LIMIT REACHED WHEN LIMIT REACHED WHEN LIMIT REACHED WHEN LIMIT REACHED

Manuals 27 & 28

8.1/22.1 Overview of Charging Energy

An Energy Storage Resource or Open-Loop Hybrid Resource is a resource capable of receiving electric energy from the grid and storing it for later injection to the grid that participates in the PJM Energy, Capacity and/or Ancillary Services markets as a Market Participant. Examples of Energy Storage Resource technologies include but are not limited to pumped storage hydroelectric plants, batteries, and flywheels. A hybrid resource is composed of more than one component, whereby each component is a separate generation component and/or ~~one~~ storage component behind the same Point of Interconnection operating as a single integrated resource; an Open-Loop Hybrid is a hybrid resource with a storage component that ~~is physically and contractually capable of~~ operates by charging its storage component from the grid.

8.2/22.2 Charges for Direct Charging Energy

An Energy Storage Resource or Open-Loop Hybrid Resource shall be considered charging when the Revenue Data for Settlements for a Real Time Settlement Interval corresponds to a withdrawal. In cases where Station Power is reported to PJM for settlements purposes as described in Manual 28 Section 13, Market Participants must report data separately in Power Meter for Direct Charging Energy and Station Power consumption. The determination of Non-Dispatched Charging Energy vs. Dispatched Charging Energy shall be made for each Real Time Settlement Interval. Hourly Non-Dispatched Charging Energy is the sum of Revenue Data for Settlements for the Real Time Settlement Intervals which are determined to be Non-Dispatched Charging Energy over the hour divided by 12.

Manual 28

Section 5: Lost Opportunity Cost Credits

5.2.6.4 Wind and Solar Generators, Hybrid Resources, and Energy Storage Resource Model Participants

Pool-scheduled or self-scheduled wind generators, solar generators, Hybrid Resources, or Energy Storage Resource Model Participants whose output is reduced or suspended at the request of the Office of the Interconnection due to a transmission constraint or reliability issue and the five minute real-time LMP at the unit's bus is higher than the unit's offer corresponding to the level of output requested by PJM are credited for each five minute interval in an amount equal to:

*[(LOC Deviation * Real-time LMP at the generator bus) – Total Lost Opportunity Cost Offer] / 12*, if the result of the calculation is greater than $0.00.

- The LOC Deviation is the difference between the wind, solar, Hybrid, Energy Storage Model Participants resource's scheduled output, which is the lesser of the PJM forecasted output inclusive of state of charge ("SOC") where applicable, or the Desired MW using the Final Offer based on the five minute real-time LMP at the resource's bus, and the resource's actual output, where the actual output of the unit is floored at 0. The Desired MW is also limited to the lesser of the resource's Ee~~e~~conomic M~~m~~aximum, the stability limit in effect, or the resource's maximum output as specified in the Generator Interconnection Agreement.

5.2.6.4 Wind and Solar Generators, Hybrid Resources, and Energy Storage Resource Model Participants

An Energy Storage Resource Model Participant or a Hybrid Resource instructed to increase charging at the request of PJM due to a transmission constraint or other reliability issue will be compensated for the increase in charging in the same manner as described in Section 5.2.2, Balancing Operating Reserve credits. An Energy Storage Resource Model Participant or a Hybrid Resource instructed to reduce charging is not eligible for compensation under this section.

Section 5: Reactive Service make whole and LOC credits

5.2.8 Credits for Resources Providing Reactive Services – clarified current language

At the end of each month, PJM credits each PJM Member for Reactive Services that are provided during the month.

Generators whose active energy output (positive generation output) is increased at the request of PJM for the purpose of maintaining reactive reliability within the PJM Region and the five minute real-time LMP at the generator bus is lower than its offer corresponding to the level of output requested by PJM are credited for each five minute interval in an amount equal to:
*[(Real-time MW – Desired MW) * (Offer - Five Minute real-time LMP at the generator bus)] / 12*
Only if the difference between the Offer and the Five Minute real-time LMP at the generator bus is positive.

Section 5: Reactive Service make whole and LOC credits

5.2.8 Credits for Resources Providing Reactive Services – added calculation descriptions for increase in charging and references for reductions

If an Energy Storage Resource Model Participant or a Hybrid Resource is instructed to increase charging at the request of PJM for the purpose of maintaining reactive reliability within the PJM region, and the LMP revenues at the generator's bus are lower than its offer corresponding to the increase in charging requested by PJM, the resource is credited for each five minute interval in an amount equal to:

[(Real-time MW - Desired MW) * (Offer - Five Minute real-time LMP at the generator bus)] / 12

- Desired MW is the MW amount of the generator using the Final Offer based on the five minute real-time LMP at the generator bus. The Desired MW is adjusted for any effective regulation or synchronized reserve assignments and capped at the stability limit in effect.
- Offer is the cost for the generator using the lesser of the Final Offer or Committed Offer for the increase in charging MWs.

In addition, generators instructed to reduce or suspend output from a positive output level for the purposes of maintaining reactive reliability ~~these generators~~ are also credited for lost opportunity costs if the five minute real-time LMP at the generator's bus is higher than its offer corresponding to the level of output requested by PJM. Hybrid Resources and Energy Storage Resource Model Participants are credited in the same manner as described in Section 5.2.6.4. Pool-scheduled generators are credited in the same manner as described in Section 5.2.6.1, and self-scheduled generators are credited in the same manner as described in Section 5.2.6.2.

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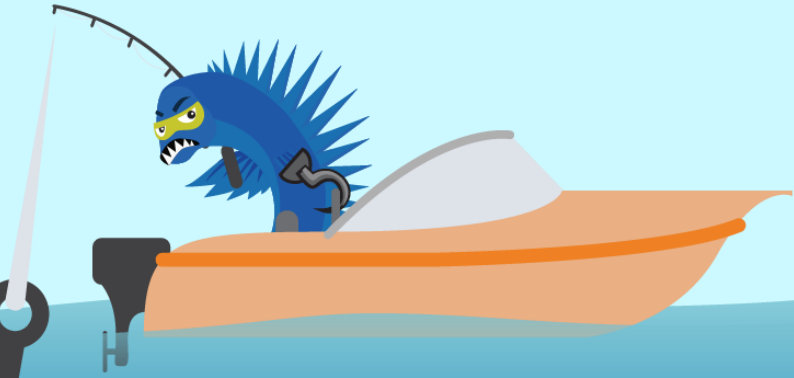

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