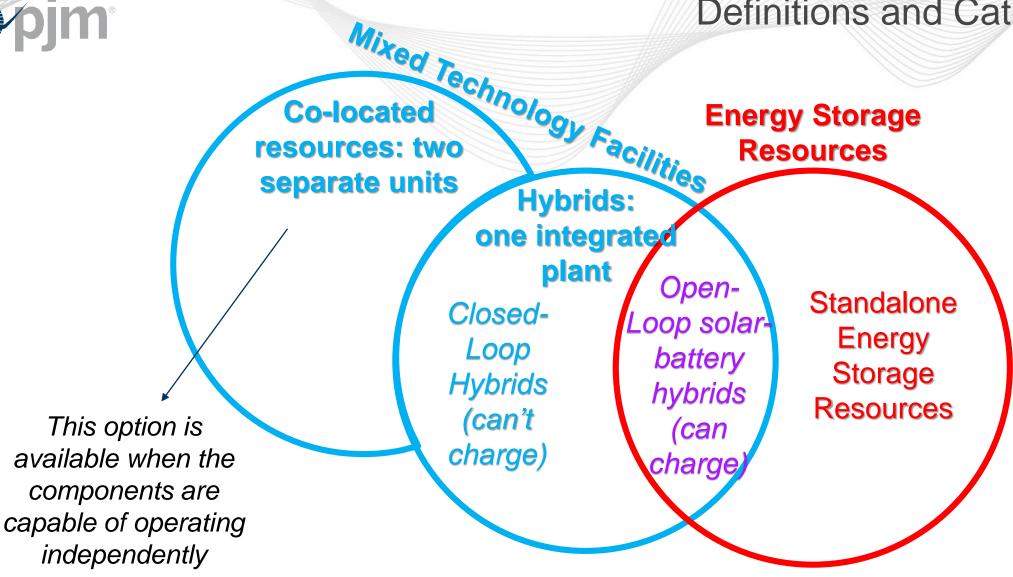# PJM Proposal to Clarify Market Participation by Solar-Battery Hybrids and Other Mixed Technology Facilities (Package A)

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MIC

Co-located resources: two separate units

Mixed Technology Facilities

Energy Storage Resources

Hybrids: one integrated plant

Closed-Loop Hybrids (can't charge)

Open-Loop solar-battery hybrids (can charge)

Standalone Energy Storage Resources

This option is available when the components are capable of operating independently

- **Mixed Technology Facility** - a facility composed of more than one generation and/or energy storage resource component behind the same point of interconnection.

- **Hybrid Resource** - a resource composed of one generation component and one energy storage resource component behind the same point of interconnection operating in the capacity, energy, and/or ancillary services market(s) as a single unit.
    - Mixed Technology Facilities with components that are physically incapable of operating independently are modeled and participate in Capacity and Energy markets as a single Hybrid Resource.
    - Conditions that make a Mixed Technology Facility physically incapable of operating independently include: the sum of the nameplate AC power rating of the components is greater than the Maximum Facility Output; the unit is not physically and contractually capable of charging the battery component from the grid.

- **Co-located Resource** – a component of a Mixed Technology Facility that operates in the capacity, energy, and/or ancillary services market(s) as a separate resource from the other components of such facility.

- **Open-Loop Hybrid Resource:** A Hybrid Resource that can charge from the grid. An Open-Loop Hybrid Resource consisting of a solar component and a storage component is an Energy Storage Resource.

- *Add to definition of **Energy Storage Resource***: "An Open-Loop Hybrid Resource consisting of a solar component and a storage component is an Energy Storage Resource."

- **Standalone Energy Storage Resource** - an Energy Storage Resource that is not a Hybrid Resource.

- Some Mixed Technology Facilities can be classified either as a Hybrid Resource or as multiple Co-located Resources.

- Energy Market modeling must match Capacity Market modeling for the same Delivery Year.

- The Effective Load Carrying Capability proposal holds that resources that can choose co-located vs. hybrid modeling must retain the choice for 5 years.

- Energy-only Mixed Technology Facilities that have a choice of hybrid vs. co-located modeling can change classifications once per year with notice to PJM by no later than May 30 for the upcoming January 1 to December 31 participation months. Once a status is chosen, it remains until another request is received. For an Energy-only Mixed Technology Facility within the new services interconnection queue process, the modeling choice must be made no later than 6 months in advance of their initial start in the energy markets.
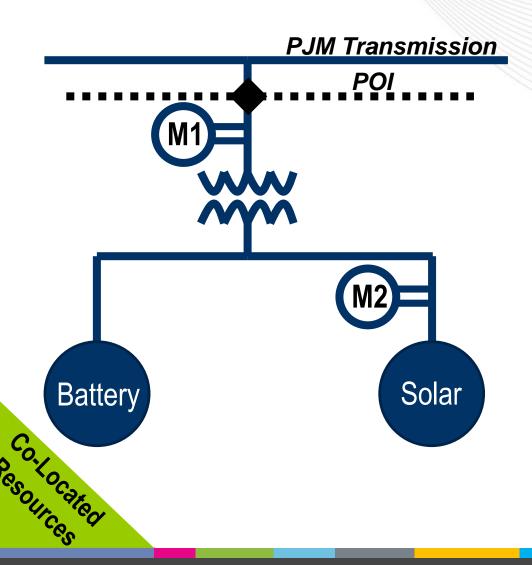
Co-Located Resources

Co-Located
Resources

PJM Transmission

POI

M1

M2

Battery

Solar

Co-Located Resources

- Each Co-Located Resource at a facility has separate metering, offers, schedules, dispatch, settlement, etc.

- Each resource follows the respective rules of the corresponding standalone resource: e.g., rules for solar, rules for storage, etc.

- Metering at POI required.

- PJM requires direct metering of at least one component (with correction for losses to the POI).

- Metering scheme requires consultation with applicable Fully-Metered EDC via Queue process.

- MW from each component. One of the components is calculated as POI minus the other components.

- MVAR from each component, adjusted for impedance to the high side of the generator step-up transformer (e.g., PJM voltage).

- Battery state of charge in MWh

- Solar meteorological data:

  – Irradiance (required)

  – Back panel temperature (required)

  – Ambient air temperature, wind speed, and wind direction (optional)

Co-Located Resources

- Recognizing obligations in an ISA or WMPA regarding ownership of Mixed Technology Facilities, PJM can potentially provide markets settlements to separate Members for the separate components of a Co-Located Resource, or any fraction thereof.

Co-Located Resources

Solar-Battery Hybrid Resources

- New "family" of models for resource with batteries, to include three types:
  1. Existing standalone Energy Storage Resource (ESR) Participation Model
  2. Open-Loop Solar-Battery Hybrid Resource Model (can charge from grid, type of ESR)
  3. Closed-Loop Solar-Battery Hybrid Resource Model (cannot charge from grid, not a type of ESR)

- Participation models for solar-battery hybrids will be similar to existing ESR Participation Model, except: add "solar-only mode", delete non-energy Regulation & reserves modes, closed-loop model lacks negative MW functions.

- Hybrid Resources submit a single offer, receive a single dispatch point, have a single settlement value.
  - Cost Offers equal to $0 are acceptable; other methods follow rules in Manual 15.
  - Energy Market Must Offer rules for hybrids match those currently used for ESR and solar.

Hybrids

- Due to variability in solar resource availability, PJM would expect different behavior from dispatchable batteries relative to dispatchable solar.

- PJM therefore proposes that operators of solar-battery hybrids must indicate to PJM which of two modes the resource is operating in at any given time:

  – "Hybrid mode", a dispatchable mode in which the battery is providing power to keep total hybrid plant output consistent with dispatch.

  – "Solar-only mode", a dispatchable mode in which the battery is *not* providing power to keep total hybrid plant output consistent with dispatch, but the plant is nonetheless dispatchable downward relative to solar availability.

- Deviations penalties and uplift eligibility are the same in hybrid mode an solar-only mode.

Hybrids

- Hybrid Resources submit a single energy market and regulation market offer, receive a single dispatch point, have a single settlement value.

  - The dispatch basepoint is a function of offer prices and Economic Minimum and Economic Maximum values.
  - Offer prices potentially eligible to be updated hourly (65 minutes before the hour)
  - Economic limits can be updated in real time.

- Regulation is scheduled and dispatched the same as it is today for Energy Storage Resource Model Participants:

  - Co-optimization option

  - Self-schedule option

  - *Remove the "Non-Energy" Regulation and reserves option*

Hybrids

- Reserves scheduling and dispatch for hybrids will match the approach under the "reserves filing" for Energy Storage Resource Model Participants.

  – Day-Ahead and Real-Time equivalents of 10 minute and 30 minute online reserves and 10 minute offline reserves.

  – The proposed model, like the ESR model, is not capable of committing offline resources and cannot assign offline reserves.

  – *Remove the "Non-Energy" Regulation and reserves option.*

- Hybrid Resources by default **may offer** all such reserves they are capable of providing, and (like storage) are responsible for determining the quantity of such reserves that they are physically capable of reliably providing.

- Hybrid Resources **must offer** such reserves consistent with the rules for all resources.
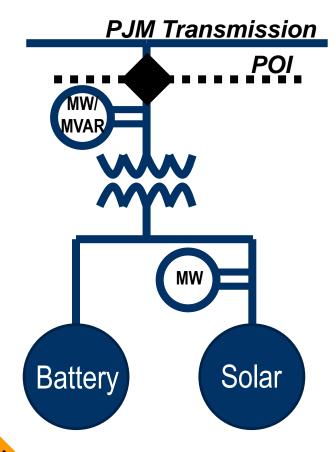
Hybrids

- Effective Load Carrying Capability (ELCC) to set the UCAP value that hybrids may offer starting with Delivery Year 2023/24.

- If FERC approves PJM ELCC proposal, then starting August 1, 2021, Hybrid Resources may make Queue requests for CIRs at or above ELCC UCAP values (as applicable).

- Present hybrid proposal provides that Hybrid Resources are exempt from the Capacity Market Must Offer rule if all of the components are so exempt.

Hybrids

PJM Transmission
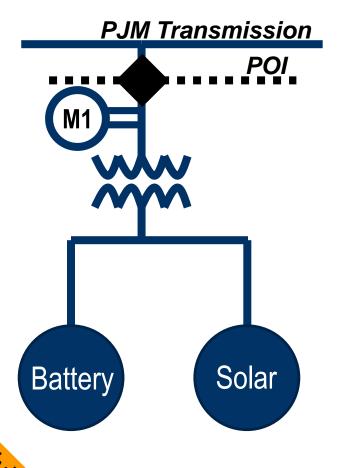
POI

MW/ MVAR

MW

Battery

Solar

Hybrids

Real-time telemetered values required for:

- MW and MVAR at the POI
  - Accuracy must meet existing requirements in Manual 01 Section 5.2.3
- MW output of each component, where one component is directly measured and compensated for losses to the POI, and the other is calculated vs. POI.
  - Accuracy must meet existing requirements in Manual 01 Section 5.2.6
- Battery state of charge, in MWh
- Solar met data:
  - Irradiance (required)
  - Back panel temperature (required)
  - Ambient air temperature, wind speed, and wind direction are optional

- Metering at POI required.

PJM Transmission

POI

M1

Battery

Solar

Hybrids

- Recognizing obligations in an ISA or WMPA regarding ownership of Mixed Technology Facilities, PJM can provide settlements to separate Members any fraction of an overall hybrid.

  – PJM cannot separately settle the solar component from the battery component.

Hybrids

- A solar-battery hybrid's Economic Minimum shall not exceed the level of its CIR

- A solar-battery hybrid's Emergency Minimum should be set to 0

- The output of a solar-battery hybrid 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 solar-battery hybrid that is dispatchable must indicate to PJM the hours for which the plant is operating in "solar-only" mode, during which time the battery is *not* providing power for the purpose of maintaining hybrid output consistent with PJM dispatch.

- Dispatchable solar-battery hybrids must follow dispatch in both "solar-only" mode and "hybrid mode".
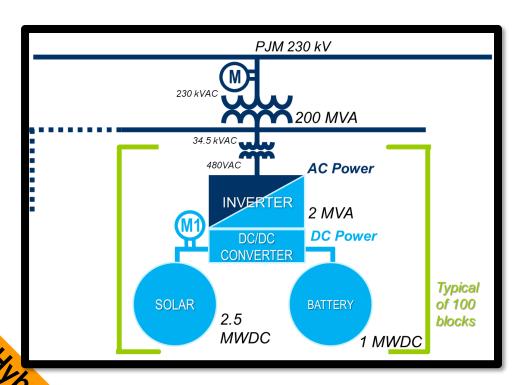
Hybrids

- For solar-battery hybrid Generating Facilities, eDART and GADS outages shall be reported separately for the solar component and storage component whenever unavailable or derated. No eDART ticket is required for lack of solar irradiance, charging, nor lack of charge.
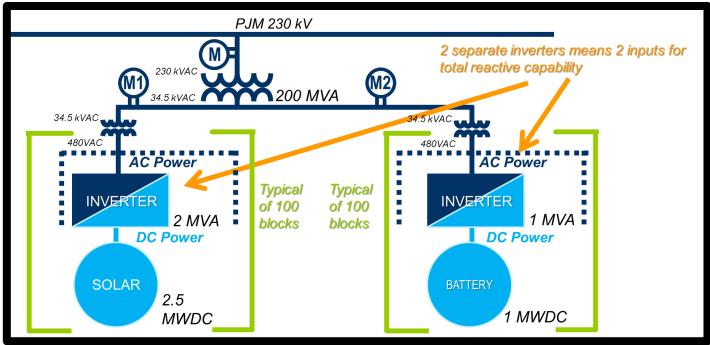
Hybrids

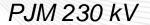Hybrid Resources do reactive testing as a single resource. Expectations depend on AC-coupled vs DC-coupled.

Hybrids

Ex: Solar-Storage *Shared Inverter (DC-coupled)* Hybrid,
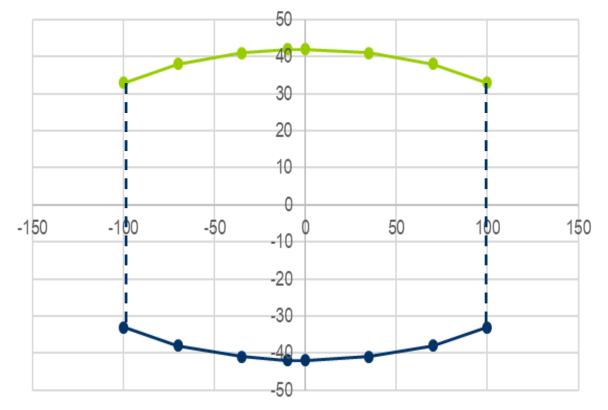**Open or Closed Loop**

PJM 230 kV

M

230 kVAC

200 MVA

34.5 kVAC

480VAC

AC Power

INVERTER

2 MVA

M1

DC/DC CONVERTER

DC Power

M2

Station Power

SOLAR

2.5 MWDC

BATTERY

1 MWDC

Typical of 100 blocks

Hybrids

	MW	Min MVAR	Max MVAR
Point 1	-100	-33	33
Point 2	-70	-38	38
Point 3	-35	-41	41
Point 4	-10	-42	42
Point 5	0	-42	42
Point 6	35	-41	41
Point 7	70	-38	38
Point 8	100	-33	33

Example of inverter-based DC-coupled solar-storage hybrid

Hybrids

PJM 230 kV

M

230 kVAC

M1

34.5 kVAC

200 MVA

M2

2 separate inverters means 2 inputs for total reactive capability

34.5 kVAC

34.5 kVAC

480VAC

480VAC

AC Power

AC Power

INVERTER

INVERTER

2 MVA

1 MVA

DC Power

DC Power

Typical of 100 blocks

Typical of 100 blocks

SOLAR

BATTERY

2.5 MWDC

1 MWDC

Hybrids

	MW	Min MVAR	Max MVAR	Example of output at battery terminals	Example of output at solar terminals
Point 1	-40	-40	40	-40	0
Point 2	-30	-36	36	-40	10
Point 3	-20	-32	32	-40	20
Point 4	-10	-30	30	-40	30
Point 5	0	-28	28	-40	40
Point 6	35	-23	23	-40	75
Point 7	60	-20	20	-40	100
Point 8	100	-33	33	0	100

Example of inverter-based AC-coupled solar-storage hybrid with 100 MW solar and 40 MW battery operated as a single combined unit

Hybrids

Unit Type	MW Output	MVAR Output	Test Duration
DC-COUPLED SOLAR-BATTERY HYBRIDS *Max MW Output = fully discharging* *Min MW Output = fully charging*	MAX	MAX LAG	WHEN LIMIT REACHED
	MAX	MAX LEAD	WHEN LIMIT REACHED
	ZERO	MAX LAG	WHEN LIMIT REACHED
	ZERO	MAX LEAD	WHEN LIMIT REACHED
	MIN	MAX LAG	WHEN LIMIT REACHED
	MIN	MAX LEAD	WHEN LIMIT REACHED
AC-COUPLED SOLAR-BATTERY HYBRIDS *Max MW Output = fully discharging* *Min MW Output = fully charging* *Max inverter operating point = solar at full output and battery at full charging*	MAX	MAX LAG	WHEN LIMIT REACHED
	MAX	MAX LEAD	WHEN LIMIT REACHED
	MAX INVERTER OPERATING NET MW POINT	MAX LAG	WHEN LIMIT REACHED
	MAX INVERTER OPERATING NET MW POINT	MAX LEAD	WHEN LIMIT REACHED
	ZERO	MAX LAG	WHEN LIMIT REACHED
	ZERO	MAX LEAD	WHEN LIMIT REACHED
	MIN	MAX LAG	WHEN LIMIT REACHED
*Additional test points may be required if these do not capture the most restrictive capability scenarios.	MIN	MAX LEAD	WHEN LIMIT REACHED

Hybrids

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PJM Proposal to Clarify Market Participation by Solar-Battery Hybrids and Other Mixed Technology Facilities (Package A)

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