Energy Storage (Order 841) Education

December 6, 2019

1. Update on 841 filing status
2. Overview
3. Rule/manual changes
4. Opt-in process/timeline
5. Markets Gateway changes
6. Operating in the Energy Markets
7. Participating in Ancillary Services
8. Settlements

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"In this order, we accept PJM's proposed revisions, to become effective December 3, 2019, **subject to a further compliance filing,** to become effective on a date to be established by PJM, as discussed below. We also institute an investigation pursuant to section 206 of the Federal Power Act (FPA) and establish **paper hearing procedures** regarding the justness and reasonableness of PJM's minimum run-time rules and procedures." - Issued October 17, 2019

https://www.ferc.gov/whats-new/comm-meet/2019/101719/E-2.pdf

New filing by December 16, 2019 in existing docket ER19-469:

1. Add additional definitions and items into the Tariff.

2. Add to the Model to account for additional parameters.

   – FERC allowing PJM to propose a later effective date in order to achieve full compliance with the Final Rule.

New filing by Dec 12, 2019 in new docket EL19-100 (including paper hearing):

3. Add provisions reflecting "minimum run-time" * rules and procedures applicable to all resources into the Tariff.

4. Brief on "minimum run-time" rules as applied to Capacity Storage Resources (10 hour rule).

*"Minimum run-time" in Order 841 refers to the continuous output capability requirement in the Capacity market. This usage is not related to the PJM Tariff Term "Minimum Run Time".

A. Add Minimum and Maximum Charge Limit; Minimum and Maximum Discharge Limit; and Charge and Discharge Ramp Rate bidding parameters into Tariff language.

B. Add descriptions of three modes (continuous, charge, discharge) into Tariff language.

C. Add which services constitute "dispatched to provide a service" in Dispatched Charging Energy definition into Tariff language.

D. Add a general description and references for metering and accounting practices into Tariff language.

E. Add provisions ensuring the separation and proper accounting of wholesale and retail uses into Tariff language.

F. Add statement that PJM will not charge a distribution-connected Energy Storage Resource for charging energy if the distribution utility is unwilling or unable to net out any energy purchases associated with the Energy Storage Resource's wholesale charging activities from the host customer's retail bill into Tariff language.

G. Enhance the participation model to more appropriately account for an ESR's State of Charge, Maximum State of Charge, and Minimum State of Charge through bidding parameters or other means in both PJM's day-ahead and real-time market dispatch.

Energy Storage Overview

1. Can sell* energy, <u>Capacity</u>, and A/S (incl. Black Start etc.) the resource is technically capable of providing
2. <u>Dispatched</u> and <u>sets price</u> as seller and buyer
3. Bid parameters that account for ESR characteristics
4. Min market threshold is 100 kW ✔ = already in compliance
5. Stored MWh are billed at LMP as wholesale

* *"Eligible to provide…"*

- Electric Storage Resource (**ESR**)= "a resource capable of receiving electric energy from the grid and storing it for later injection of electric energy back to the grid."

- Connected at: transmission, distribution, or behind a customer meter.
  - PJM has ESR at both T and D today, none behind a meter **that inject**.

- Excludes demand response.

- Includes pumped hydro

Over 5,300 MW of Electric Storage Resources currently in PJM

Other Storage
4%

Pumped Hydro
96%
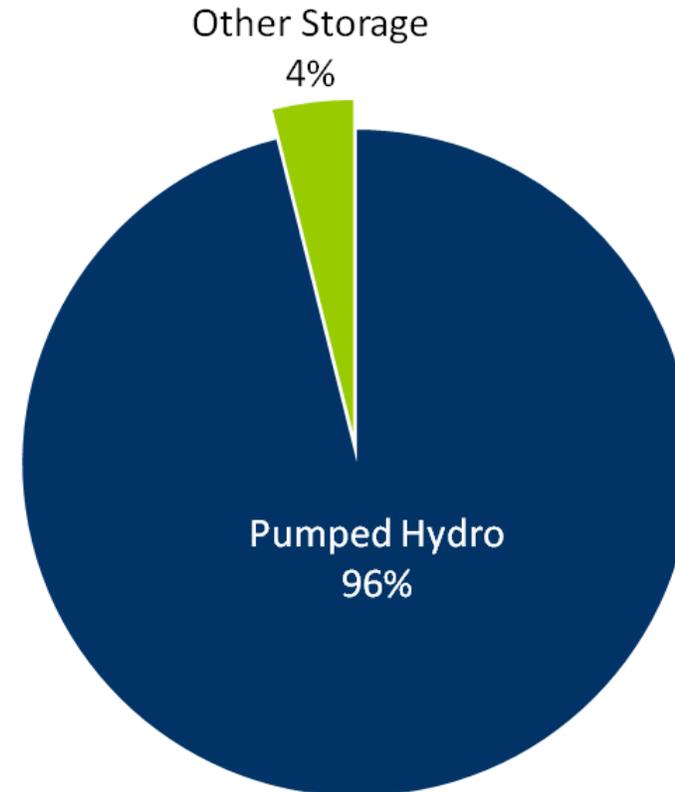
** Data taken from Generation Queue and EIA 860

- ESRs will be modeled as one continuous resource

- PJM will not make commitment decisions in the ESR model
  - Start-up and no load cost will not be considered

- PJM will not manage state of charge
  - Resource owners use mode of operation, offers, and parameters

- 3 modes of operation:
  - Continuous, Charge & Discharge

- Parameters
  - Max/Min charge/discharge, etc
  - Ramp rate considered infinite only in continuous mode

ESRs can update their max charge and discharge limits hourly in day-ahead, and more frequently in real-time.

Max **discharge** limit

Continuous operations

0 MW

Max **charge** limit

** State of charge telemetry will be requested for telemetered resources

Price	MW
$10.00	20
$ 9.00	15
$ 8.00	10
$ 7.00	5
$ 6.00	0
$ 5.00	0
$ 4.00	0
$ 3.00	-5
$ 2.00	-10
$ 1.00	-15

Discharge Mode

Max

Min · · O MW · Min

Max

Charge Mode

10 MWh energy storage resource

1 MWh → 1 MW Available Capacity

= 1 MWh

PJM maintaining the requirement, per manual 21, that capacity resources have a minimum 10 hour duration.

ESR capacity interconnection rights will be derated based on the total energy capability of the resource
- Total MWh/10h

Review of Manual Updates

2019 FERC 841 Manual Changes

	Committee	May	Jun	Jul	Aug	Sep	Oct
Manual 15	MIC	● 5/10	○ 6/12	★ 7/10			
	MRC			● 7/25	★ 8/22		
	MC				● 8/22	★ 9/26	
	Board						★
Manual 18 & 11	MIC		● 6/12	★ 7/10			
	MRC			● 7/25	★ 8/22		
Manual 27, 28 & 29	MSS		● 6/20				
	MIC			● 7/10	★ 8/7		
	MRC				● 8/22	★ 9/26	
Manual 36, 40 & 14D	SOS		● 6/6			★ 9/5	
	OC		● 6/11			★ 9/10	
	MRC					○ 9/26	10/31 ★
Manual 36	DTS		○ 6/18				

Legend:
● Information
○ First Read
★ Endorsement
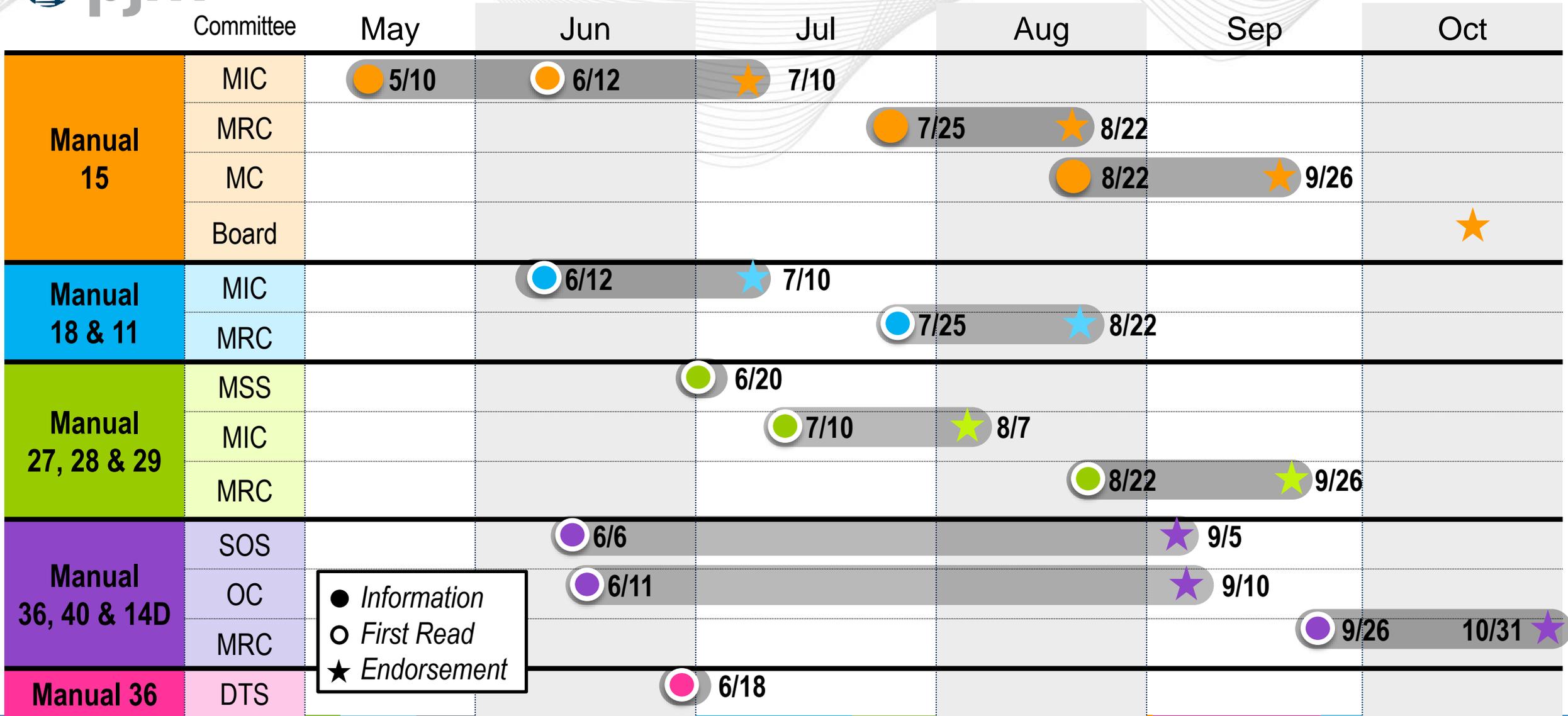
Review Opt-in Process

- Per Manual 11: ESR Participation Model Election (i.e. Opt In/Opt Out)
  - Existing resources must send opt-in requests no later than September 30 for the upcoming January 1 to December 31 participation months.
  - Resources within the new resource queue process must send an opt in request no later than three months in advance of their initial start in the energy markets.

Markets Gateway Changes

Generator > Unit > Synchronized Reserve Ramp Rates

Generator > Unit > ESR Updates   (information only)

Operating in the Energy Markets (DA & RT)

- ESRs will be modeled as one continuous resource
- PJM will not make commitment decisions in the ESR model
  - Start-up and no load cost will not be considered
- PJM will not manage state of charge
  - Resource owners use mode of operation, offers, and parameters
- 3 modes of operation:
  - Continuous, Charge & Discharge
- Parameters
  - Max/Min charge/discharge, etc
  - Ramp rate considered infinite only in continuous mode

ESRs can update their max charge and discharge limits hourly in day-ahead, and more frequently in real-time.

Price	MW
$10.00	20
$ 9.00	15
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$ 2.00	-10
$ 1.00	-15

Max **discharge** limit

Continuous operations

O MW

Max **charge** limit

** State of charge telemetry will be requested for telemetered resources
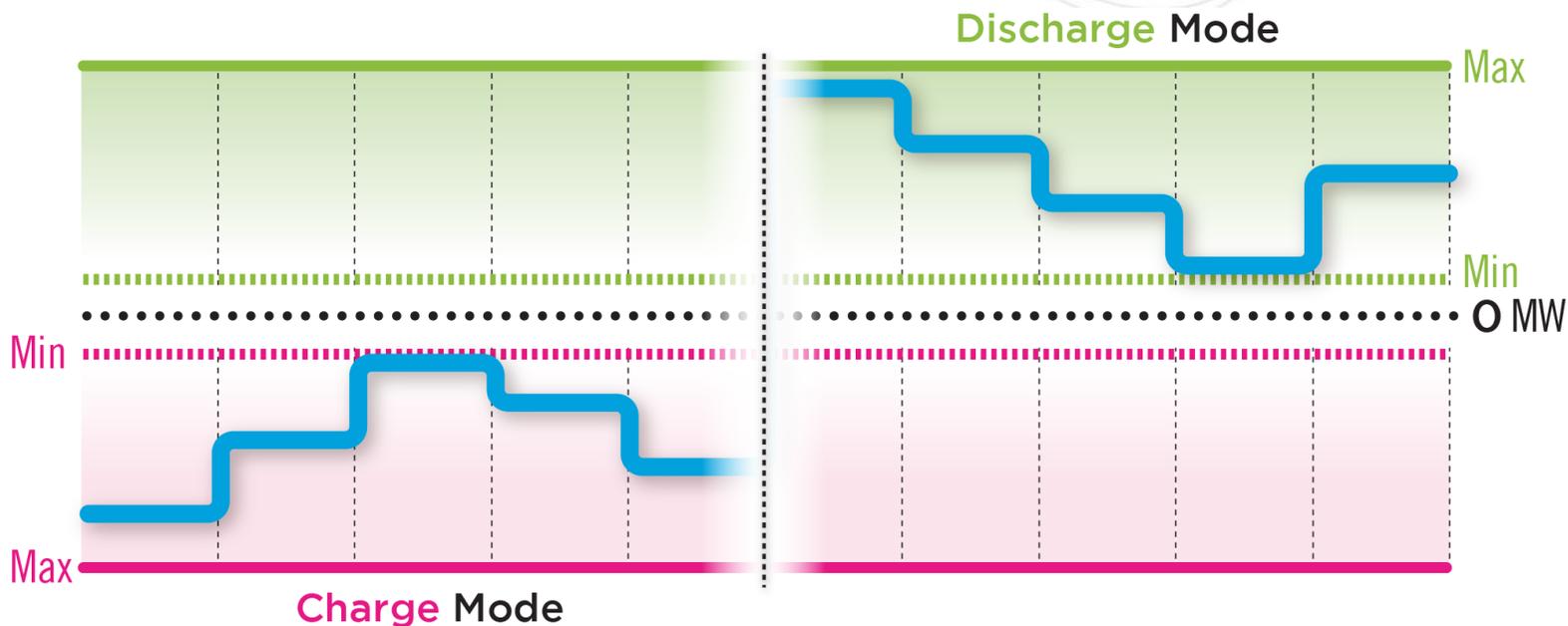
Charge & Discharge mode will be available to ESR resources in Day Ahead and Real Time.

- ESRs will be dispatched following the operational mode for the applicable hour.

  – Economic limits for the operational mode will be honored.

  – Ramp considered infinite only in continuous mode.

  – State of charge managed by the market participant.

- Dispatchable ESRs will have the ability to set price.

  – Applies to all three operational modes.

- Regulation assignments for ESR will be honored in the real time dispatch.

  - No change from current logic.

Participating in Ancillary Services

- Resources cannot be both in the ESR model and also a non-energy resource
- However, ESRs can select Ancillary Only = 'Yes' for any hours they wish to provide Regulation or Reserves and not provide Energy

- ESRs can provide Synchronized Reserve in charge, discharge, or continuous modes

- An ESR that is providing both Energy and Reserves will be considered flexible Tier 2 SR

- For ESRs that choose Ancillary Only:
  - Pumped storage hydro will need to offer as Spin as Condenser = Yes and will be considered inflexible Tier 2 SR
  - All other Ancillary Only ESRs can set their flexibility by the Flexible parameter under Unit > Synchronized Reserve Market > Offers (Daily) or Updates (Hourly)

- By default, ESRs are not included in the Tier 1 Synchronized Reserve calculation, but can follow the current process to request an exception

- Available ESRs are always considered online, therefore they are not eligible to be considered for Non-Synchronized Reserve

New Parameters	Location
Charge Spin Max	Unit > Detail (Default) Synchronized Reserve Market > Updates (Hourly)
Flexible	Synchronized Reserve Market > Offers (Daily) & Updates (Hourly)
Ancillary Only	Unit > Hourly Updates
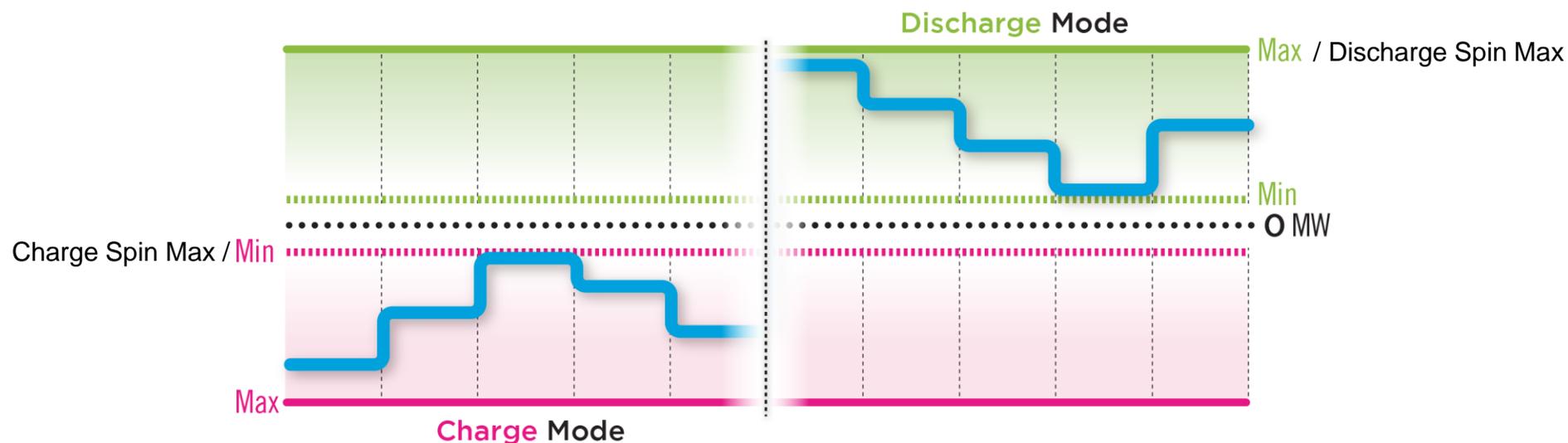
- ESRs can provide Regulation in charge, discharge, or continuous modes

The Regulation MWs available to clear are bounded by the following limits:

$$RegMW \leq Min[\frac{Abs[RegHigh - RegLow]}{2}, Reg\ Offer]$$

Economic Maximum — **High Regulation Limit**

Economic Basepoint

MW Regulation Capability Offered into Markets Gateway

Basepoint + Capability

If high and low regulation limits are not most restrictive, then ASO uses most restrictive min and max*

Basepoint + Capability

Economic Minimum — **Low Regulation Limit**
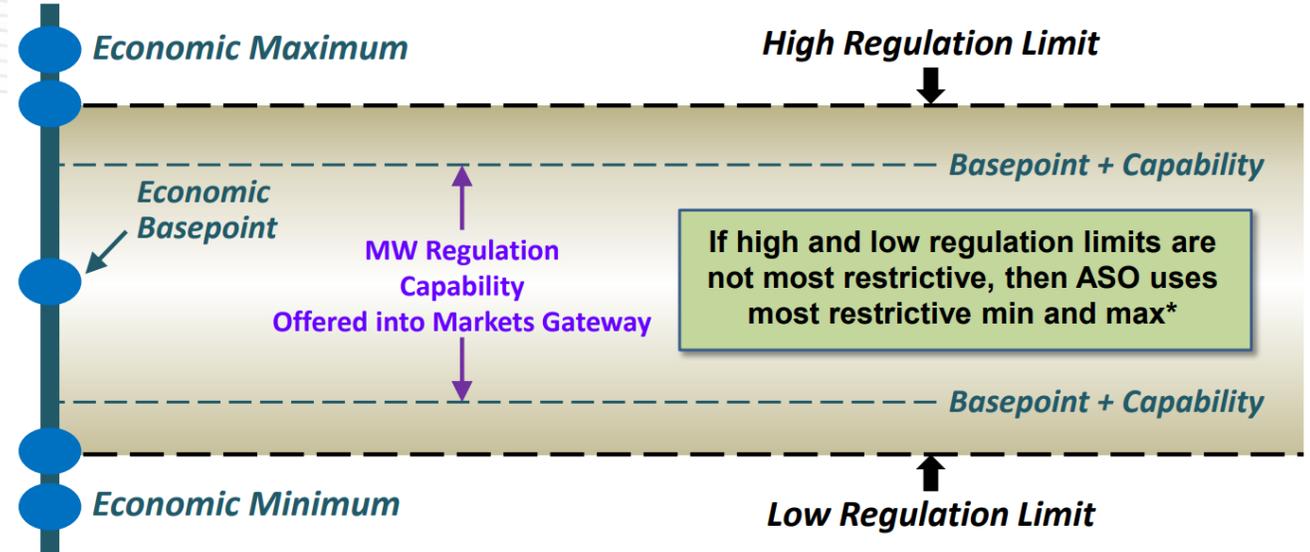
	Charge Mode	Discharge Mode	Continuous Mode
RegHigh =	Min(RegMax, ChargeMin)	Min(RegMax, DischargeMax)	Min(RegMax, DischargeMax)
RegLow =	Max(RegMin, ChargeMax)	Max(RegMin, DischargeMin)	Max(RegMin, ChargeMax)

Settlements

PJM Order 841 Compliance filing
ER19-462 and current Tariff:
"Energy Storage Resource" shall mean 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.

M28 draft:
"An Energy Storage Resource shall be considered charging when the Revenue Data for Settlements for a Real Time Settlement Interval corresponds to a withdrawal."

MWh   PJM Market   **MWh**

Charge   Discharge

ESR

MWh
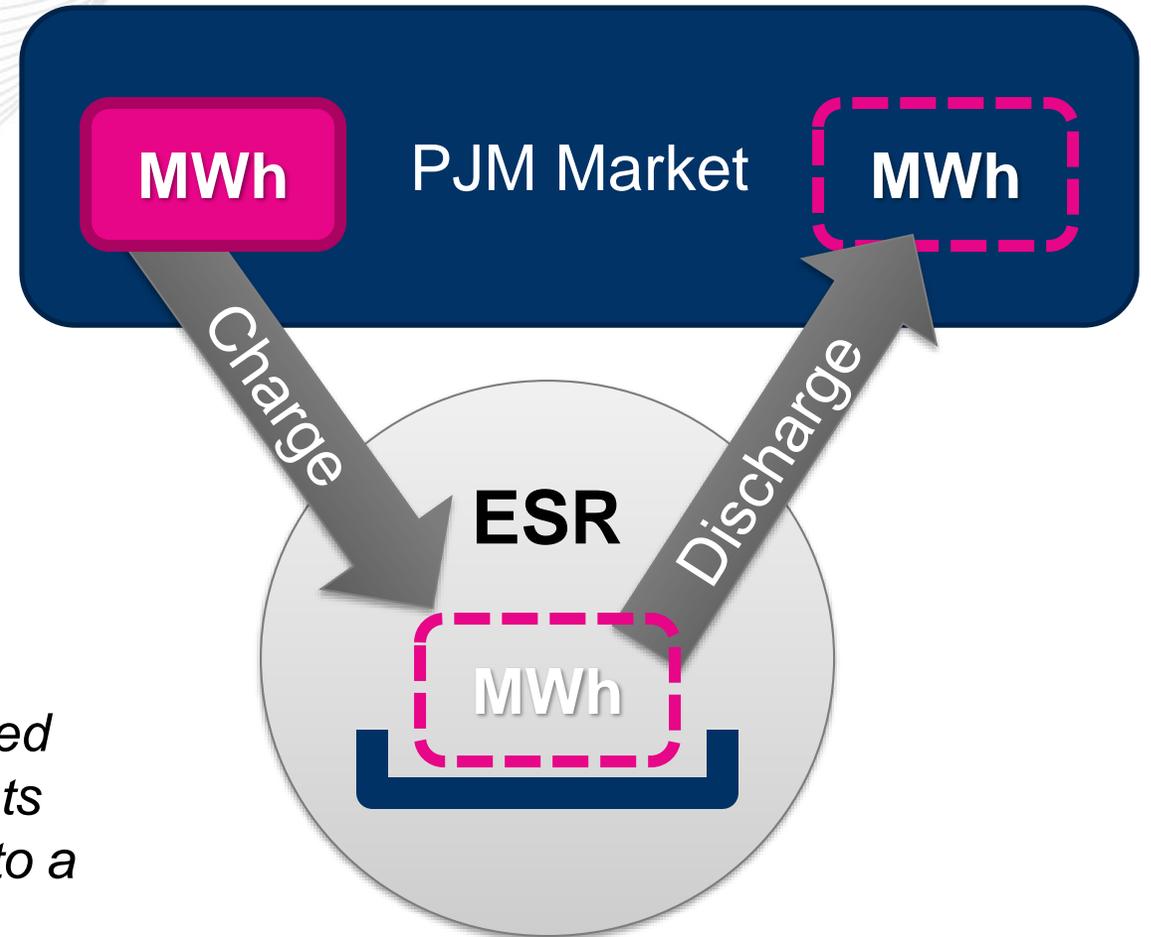
Non-Dispatched Charging Energy

- New sections 22.1 and 22.2 of Manual 28 and matching new sections 8.1 and 8.2 of Manual 27
- Manual 28 new section 8.4

- **Dispatched Charging Energy**
  - Dispatched for a service
    - Economically dispatched by PJM in real-time
    - Assigned Regulation, Tier 2 Sync Reserves or Reactive Service
    - Manually dispatched for system reliability
- **Non-Dispatched Charging Energy**
  - Pays applicable transmission service charges as a Network Service User

"Therefore, Non-Dispatched Charging Energy is eligible for allocation of the following non-LMP charges and credits:"

- *Schedule 1A Transmission Owner Scheduling, System Control and Dispatch Service*
- *Schedule 9-3, 9-FERC, 9-OPSI, 9-CAPS, 9-FINCON, 9-MMU, and 9-PJM Settlement*
- *Schedule 10-NERC and 10-RFC*
- *Network Integration Transmission Service*
- *Network Transmission Service Offset*

- *Network Integration Transmission Service (ATSI Low Voltage)*
- *MTEP Project Cost Recovery*
- *Transmission Enhancement*
- *Other Supporting Facilities*
- *Non-Firm Point-to-Point Transmission Service*
- *RTO Start-up Cost Recovery*
- *Black Start Service*
- *Unscheduled Transmission Service*
- *Reactive Supply and Voltage Control from Generation and Other Sources Service"*

Load Serving Charging Energy

- New section 22.1 of Manual 28 and matching new section 8.1 of Manual 27
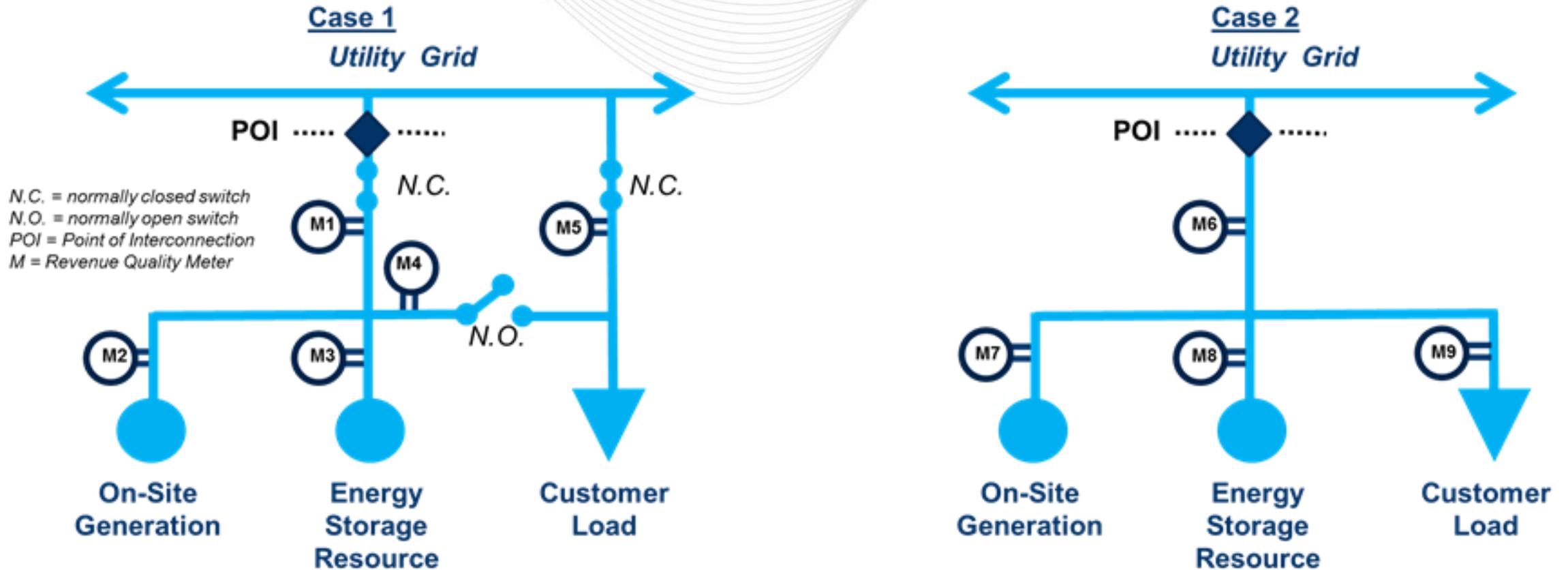- Manual 27 new section 8.3
- Manual 28 new sections 22.3, 22.4, and 22.5

PJM Energy Market

ESR
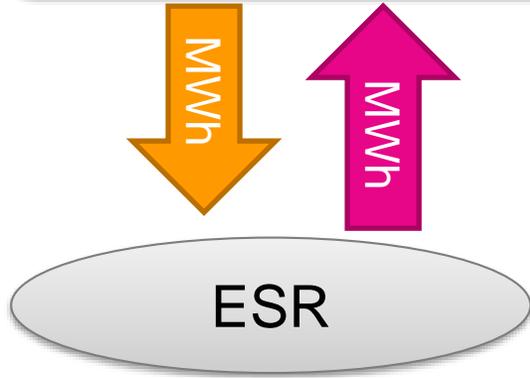
Charging stored for later wholesale sale = "**Direct Charging Energy**"

Dispatched Charging Energy

Non-Dispatched Charging Energy

LSE

ESR
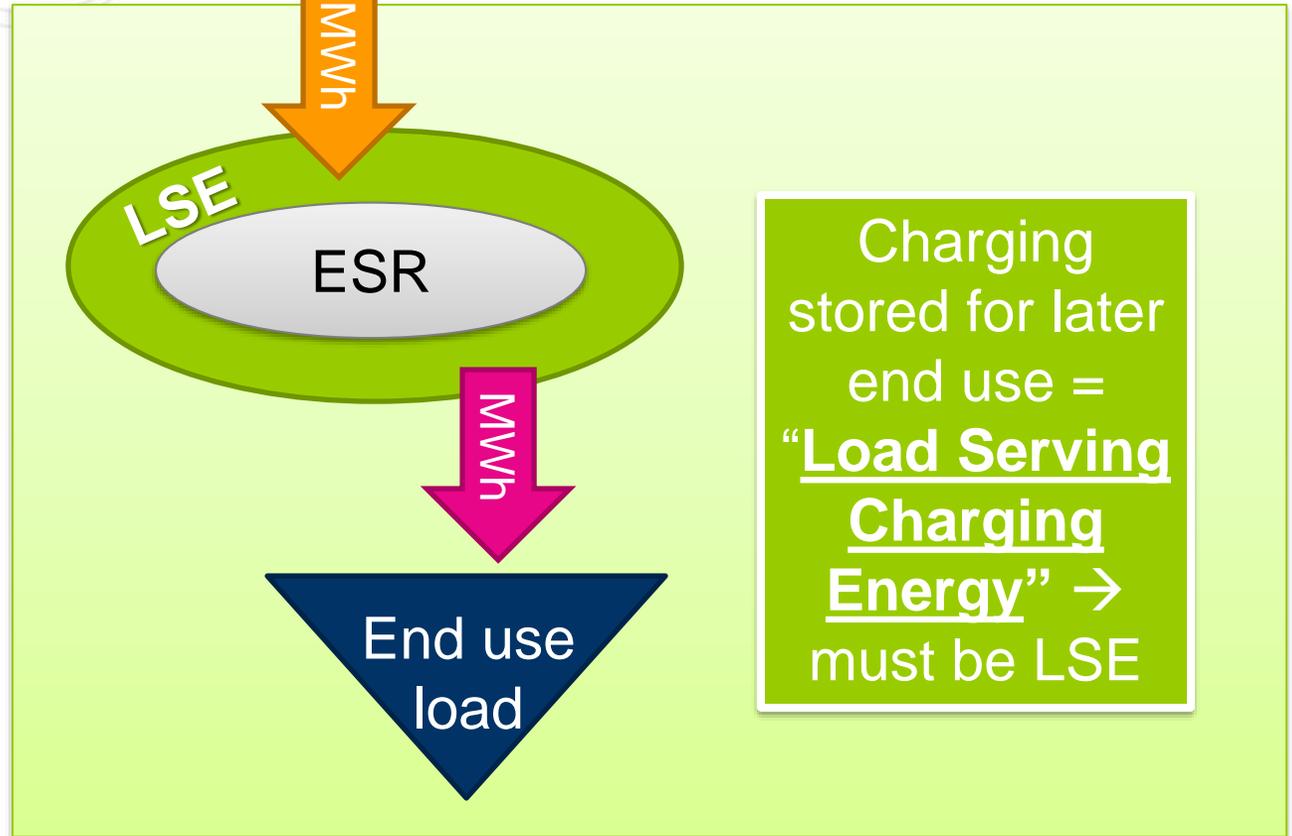
End use load

Charging stored for later end use = "**Load Serving Charging Energy**" → must be LSE

- Load Serving Energy Storage Resources are capable of directly serving end use load.

- Metering and methods are defined to distinguish:

  1. Charging energy that is later returned to PJM ("Direct Charging Energy") from

  2. Charging energy that is later provided to end use load ("Load Serving Charging Energy")

- PJM to provide Electric Distribution Company with processes to appropriately account for Direct Charging Energy (as negative generation) vs. Load Serving Charging Energy (as load).

- 100% of withdrawals initially settled as negative generation (i.e., Direct Charging Energy)

- ESR can only charge from grid.

- **Monthly M4 appropriately captures stored grid energy that is sent to end user→ monthly "Load Serving Charging Energy".**

- The sum of M4 over a month is the monthly quantity that should be ex-post adjusted from "Direct Charging Energy" into "Load Serving Charging Energy".
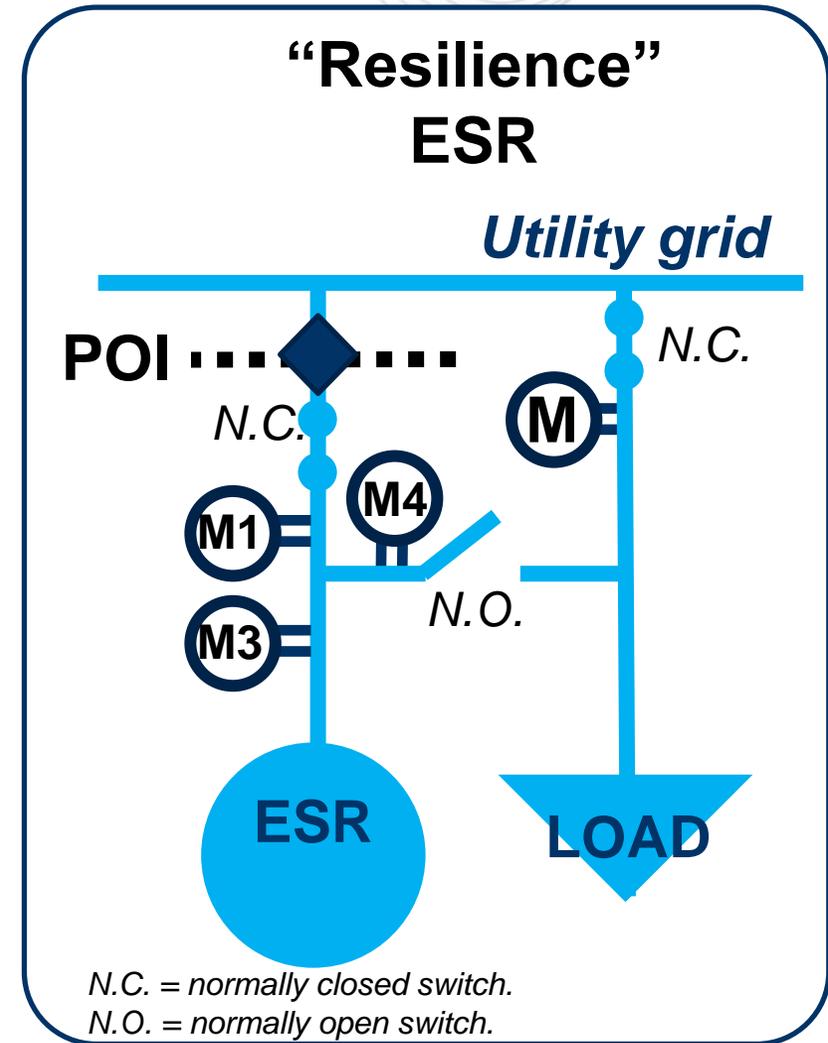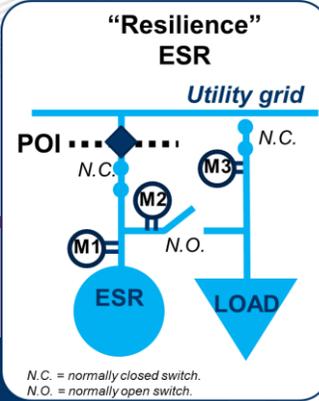
"Resilience" ESR

Utility grid

POI

N.C.

N.C.

M

M4

M1

N.O.

M3

ESR

LOAD

N.C. = normally closed switch.
N.O. = normally open switch.
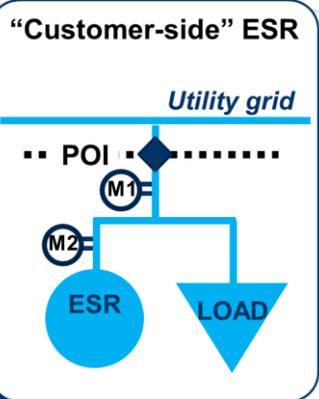
- 100% of withdrawals initially settled as negative generation (i.e., Direct Charging Energy)
- ESR can charge from grid or on-site gen.
- EDC to determine how much of the ESR inventory that was discharged to the end user consisted of energy charges from the grid → "Load Serving Charging Energy"
- **An appropriate billing convention: if monthly M2 > monthly M4, then all end-use energy came from stored or directly-provided on-site gen, and no Load Serving Charging Energy was consumed.**

"**Resilience**"
ESR

Utility grid

POI

N.C.

M5

N.C.

M1   M4

M2   M3

N.O.

GEN   ESR   LOAD

N.C. = normally closed switch.
N.O. = normally open switch.
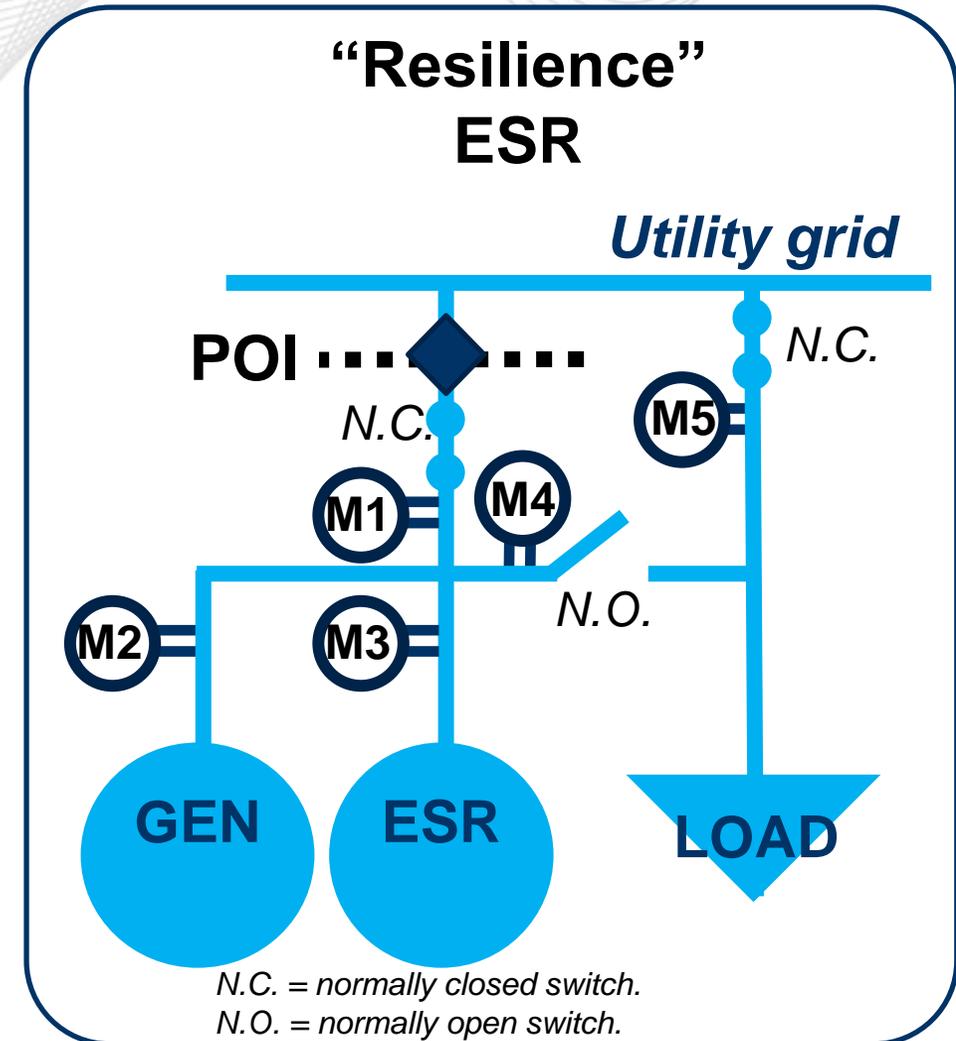
- 100% of withdrawals initially settled as load (i.e., load and/or Load Serving Charging Energy)
- Net injections measured at M6 consist of previously-stored Direct Charging Energy.
  - Corresponding losses are also Direct Charging Energy. ESR can report losses to EDC through PJM, or EDC can work directly with ESR to quantify losses.
  - **Monthly Direct Charging Energy is the sum of monthly injections at meter "M6" plus associated losses.**
  - EDC calculates monthly quantity for ex-post adjustment from Load Serving Charging Energy into Direct Charging Energy.
- M8 is required to identify which intervals the ESR was charging to use in ex-post adjustment.

"Customer-side" ESR

Utility grid

POI

M6

M8

ESR

LOAD
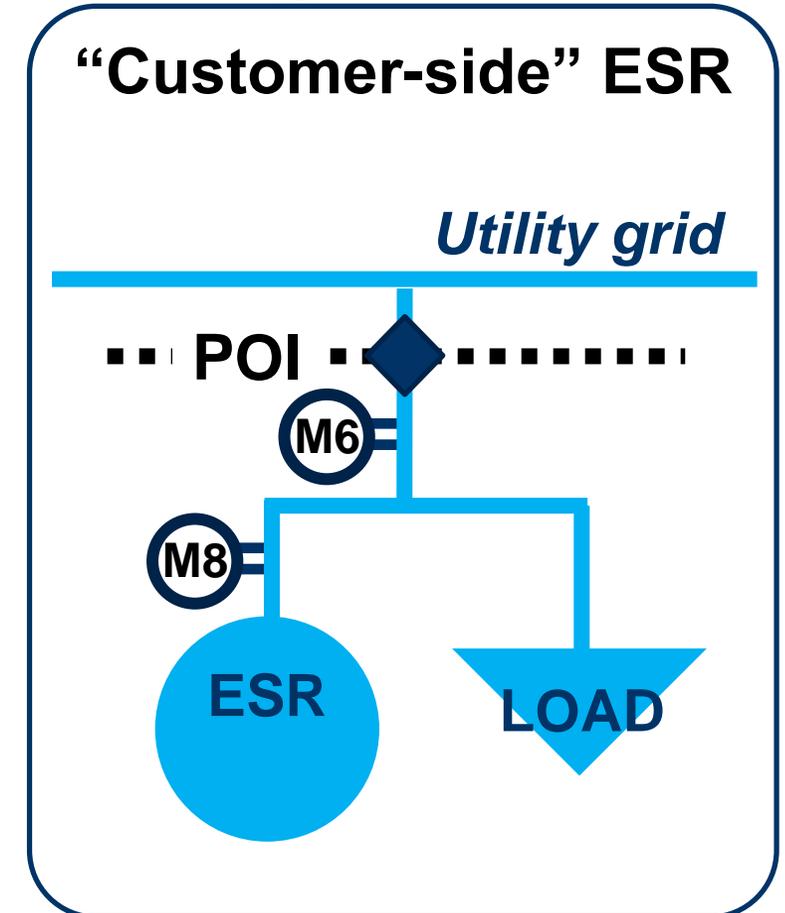
- Net injections measured at M6 could consist of Direct Charging Energy, self-supplied charging energy, and/or on-site Generation.
  - The inventory in the ESR could also consist of a mix of grid energy and self supplied energy.
  - Losses corresponding to stored grid energy that is resold to PJM is also Direct Charging Energy.
- **EDC calculates monthly Direct Charging Energy for ex-post adjustment.**
- M8 is required to identify which intervals the ESR was charging for ex-post adjustment.

"Customer-side" ESR

Utility grid

POI

M6

M7   M8

GEN   ESR   LOAD

Questions?