

FERC Order 841: Electric Storage Participation in Markets

PJM Manual 11: Energy & Ancillary Service Operations

PJM Manual 18: PJM Capacity Market

PJM Manual 15: Cost Development Guidelines

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Action Required	Deadline	Who May Be Affected
<p>Review and be aware of implementation of Electric Storage Resource Participation Model</p>	<p>12/3/2019, or effective date of FERC approval, or opt-in date of any new resources</p>	<p>Energy Storage Resource marketers</p>
<p>Opt-in for ESR Participation model starting December 3, 2019 by October 1, 2019</p>		
<p>Review cost offer development for batteries and flywheels</p>		



1. Can sell* energy, Capacity, and A/S (incl. Black Start etc.)
the resource is technically capable of providing
2. Dispatched and sets price 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..."

- Update for FERC Order 814 Electric Storage Resource Participation Model
 - Added section 2.3.4B Energy Storage Resource (ESR) Participation Model and clarification throughout where appropriate
 - Defined modes: charge, discharge and continuous
 - Opt in and out process for the ESR participation model
 - Updated ESR hourly limits

- Clarifying update on pumping cost equations in Section 7.3

Basic Pumped Storage Fuel Cost – Pumped storage fuel cost shall be calculated on a seven (7) day rolling basis by multiplying the real time bus LMP at the plant node by the actual power consumed when pumping divided by the pumping efficiency. The pumping efficiency is determined annually based on actual pumping operations or by OEM curves if annual data is not available due to the immaturity of the unit. The following equations govern pumping storage fuel cost:

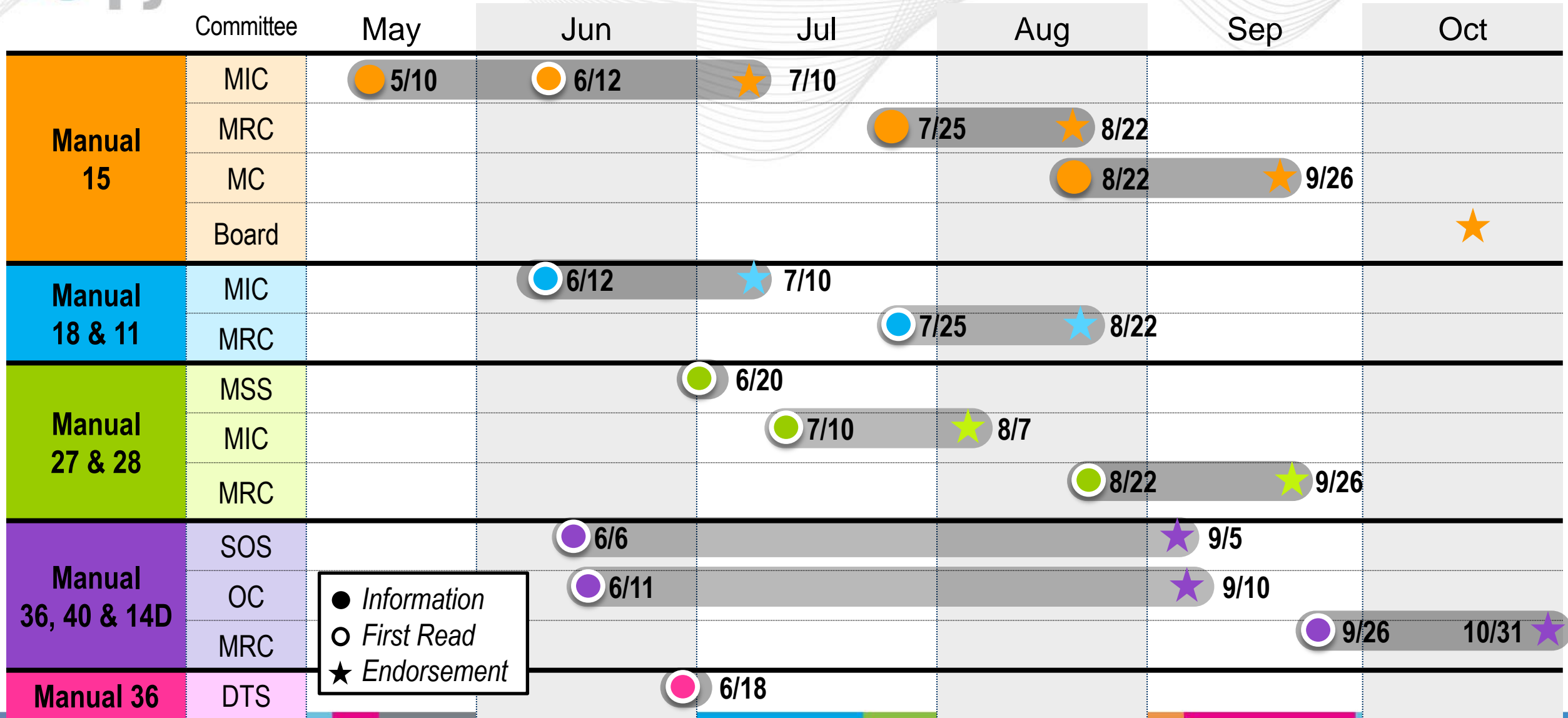
$$\text{Pumping Power Cost } (\$/MWh) = \text{Real Time LMP } (\$/MWh) * \text{Pumping Power } (MWh)$$

$$\text{Pumping Power Cost } \left(\frac{\$}{MWh} \right) = \frac{\sum_{168}^1 \text{Real Time LMP } \left(\frac{\$}{MWh} \right) * \text{Pumping Power } (MWh)}{\sum_{168}^1 \text{Pumping Power } (MWh)}$$

$$\text{Pumped Storage Fuel Cost } (\$/MWh) = \frac{\text{Pumping Power Cost } (\$/MWh)}{\text{Pumping Efficiency}}$$

- Updates to define Efficiency Factor, Fuel Cost, VOM and Ancillary Service costs
 - Efficiency factors measure the ratio of generation produced to the amount of electricity used to charge
 - Fuel cost using the average charging cost and defined in resource's FCP
 - Maintenance and Operating cost inclusion and exclusion guidelines and submitted in resource's VOM template
 - Ancillary Services – status quo definitions

- Manual 18: PJM capacity Market
 - Updated definition of Capacity Storage Resource
 - » Capacity Storage Resources shall mean Energy Storage Resource that participates in the Reliability Pricing Model or is otherwise treated as capacity in PJM's markets such as through a Fixed Resource Requirement Capacity Plan
 - Clarified that ESRs may not receive Peak Load Contributions for energy they charge and then later sell back to the grid



- Questions: esr@pjm.com
- [Issue Tracking: Electric Storage Participation - FERC Order 841](#)

Appendix A: More information on M15 edits

Section 11: ~~Energy Storage Resource~~ Batteries and Flywheels

This section contains information for the development of ~~Energy Storage Resource~~ battery and flywheel cost offers. . Regulation only resources should see Section 11.8.

Battery- device to store electrical energy via chemicals

Flywheel- mechanical device for storing rotational energy

11.1 ~~Heat Rates~~ Efficiency Factor

Efficiency factor is a battery or flywheel version of a heat rate. Efficiency factors measure the ratio of generation produced to the amount of electricity used to charge.

$$\text{Efficiency Factor} = \frac{\text{MWh Discharged}}{\text{MWh Charged}}$$

Efficiency factors can be calculated over the time period specified by the Market Seller in the Fuel Cost Policy. A Market Seller must make the choice of method in their fuel cost policy and cannot change to another method for a period specified in Section 2.1

~~Energy Storage Resources do not burn fuel so heat rates are not applicable.~~

11.2 Performance Factors

Note:

The information in Section 2.2 contains basic Performance Factor information relevant for all unit types. The following additional information only pertains to batteries and flywheels~~Energy Storage Resources~~.

~~Energy Storage Resources~~ Battery and flywheel ~~do not burn fuel so~~ Performance Factors are equal to 1.0.

11.3 Fuel Cost

Note:

The information in Section 2.3 contains basic Fuel Cost information relevant for all unit types. The following additional information only pertains to **Energy Storage Resources batteries and flywheels**:

Energy Storage Resource's fuel costs are equal to zero.

To be consistent throughout the manual, the term fuel cost is used to account for the energy necessary to charge the battery or flywheel.

11.3.1 Total Fuel Cost

Market Sellers for batteries and flywheels must identify in their Fuel Cost Policies the methodology they are using to calculate fuel cost (charging cost).

$$Fuel\ Cost\ \left(\frac{\$}{MWh}\right) = \left(average\ charge\ cost\ \left(\frac{\$}{MWh}\right) * efficiency\ factor\right)$$

11.3.2 Operating Costs

Operating Costs may include, but are not limited to: acids and lithium ion replacements

11.4 Start-up Cost

~~Energy Storage Resource's~~ Battery and flywheel Start Fuel and Total Fuel Related Costs are equal to zero.

11.5 No-Load Cost

~~Energy Storage Resources do not have No-load costs.~~ Battery and flywheel no-load costs are equal to zero.

11.6 Maintenance

Note:

The information in Section 2.6 contains basic Maintenance Cost information relevant for all unit types. The following additional information only pertains to ~~Energy Storage Resources~~ batteries and flywheels.

Batteries and flywheels cannot include costs that can be included in their capacity offer such as straight time labor. Maintenance costs for batteries and flywheels may include, but are not limited to: cell repairs/replacements, inverter maintenance, and generation owned GSU/ Interconnection Transmission maintenance.

11.7 Synchronized Reserve Cost

Note:

The information in Section 2.7 contains basic Synchronized Reserve Cost information relevant for all unit types. The following additional information only pertains to ~~Energy Storage Resources~~ batteries and flywheels if applicable.

The cost to provide synchronous reserves from battery or flywheel resources shall be equal to the margin up of \$7.50 per MWh of reserves offered plus the maintenance adder

11.8 Regulation Cost

Note:

The information in Section 2.8 contains basic Regulation Cost information relevant for all unit types. The following additional information only pertains to ~~Energy Storage Resources~~ batteries and flywheels.

~~Energy Storage Resources~~ Batteries and flywheels shall calculate Energy Storage Unit Losses in accordance with the equation below. The “Cost Increase due to Heat Rate Increase

Appendix B: Additional Information



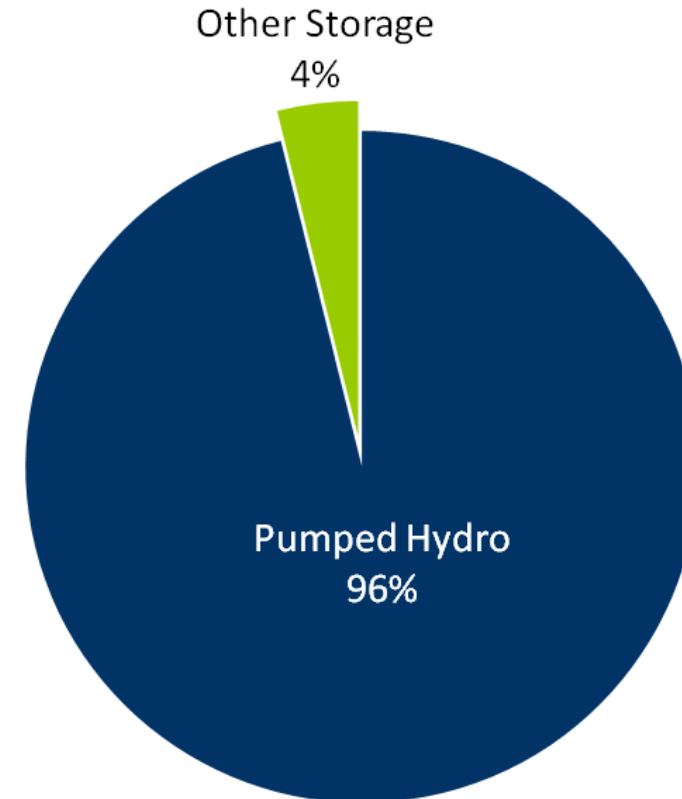
Timeline of FERC Order 841

	2016	2018				2019			
	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
FERC NOPR on Energy Storage & Distributed Energy Resources	● Nov. 4, 2016								
FERC Final rule Electric Storage Participation Markets		● Feb. 15, 2018							
PJM ESR Accounting Proposal Filing					● Dec. 3, 2018				
PJM ESR Markets & Operations Proposal					● Dec. 3, 2018				
PJM limited answer to ESR Filing					● Dec. 10, 2018				
PJM Responds to Protests & Comments						● Mar. 5, 2019			
FERC Request for Additional Information						● Apr. 1, 2019			
PJM Response to FERC Questions						● May 1, 2019			
PJM Submits Additional Answers						● May 14, 2019			
FERC Order on Rehearing and Clarification						● May 16, 2019			
Implementation									● Dec. 3, 2019

Electric Storage Resource Definition

- 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

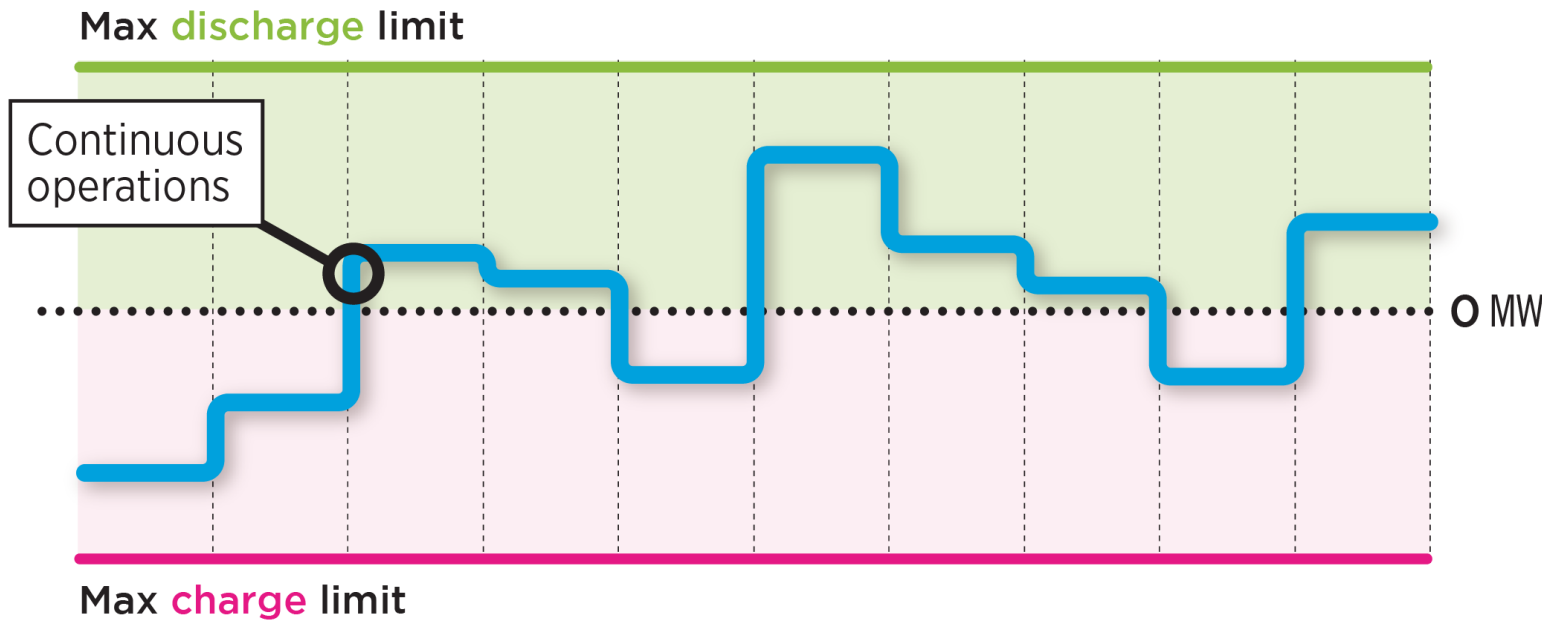
Over 5,300 MW of Electric Storage Resources currently in PJM



** Data taken from Generation Queue and EIA 860

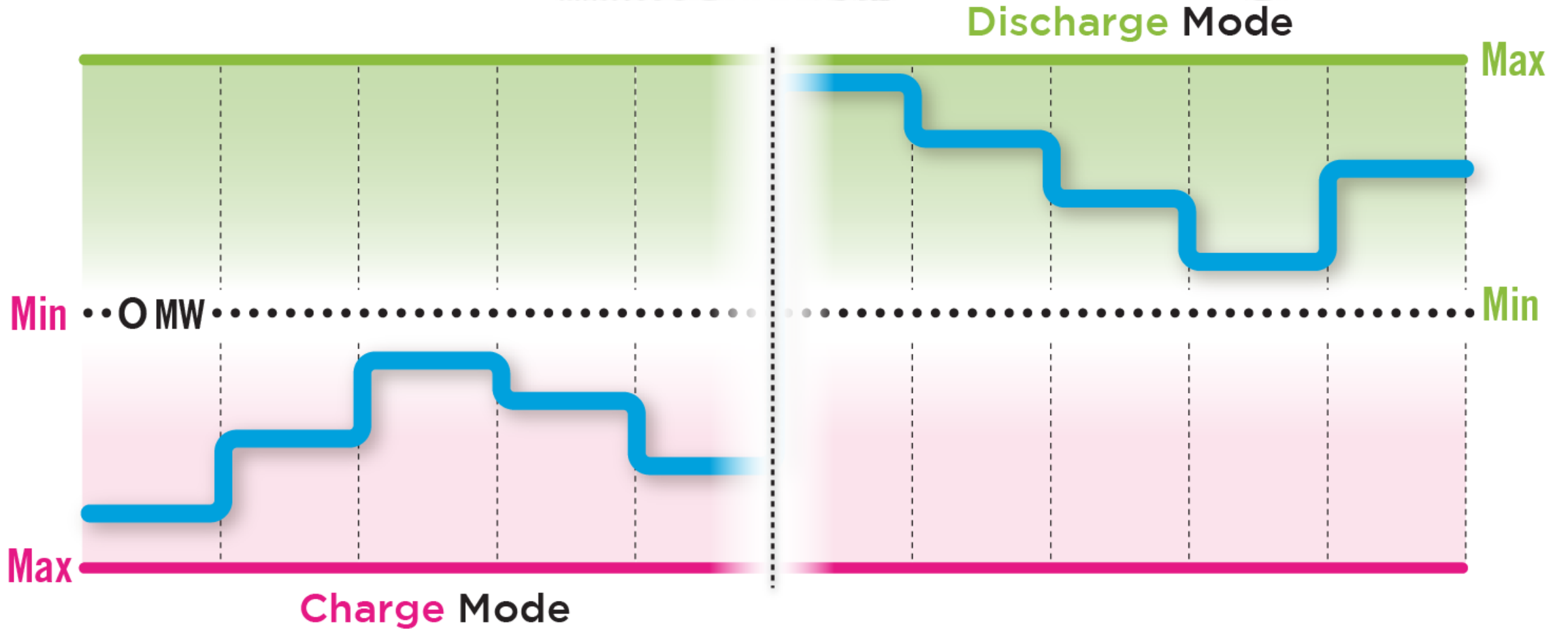
- ESRs will be modeled as one continuous resource
- PJM will not make commitment decisions in the ESR model
 - Start-up and no load cost will not be considered
- PJM will not manage state of charge
 - Resource owners use mode of operation, offers, and parameters
- 3 modes of operation:
 - Continuous,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

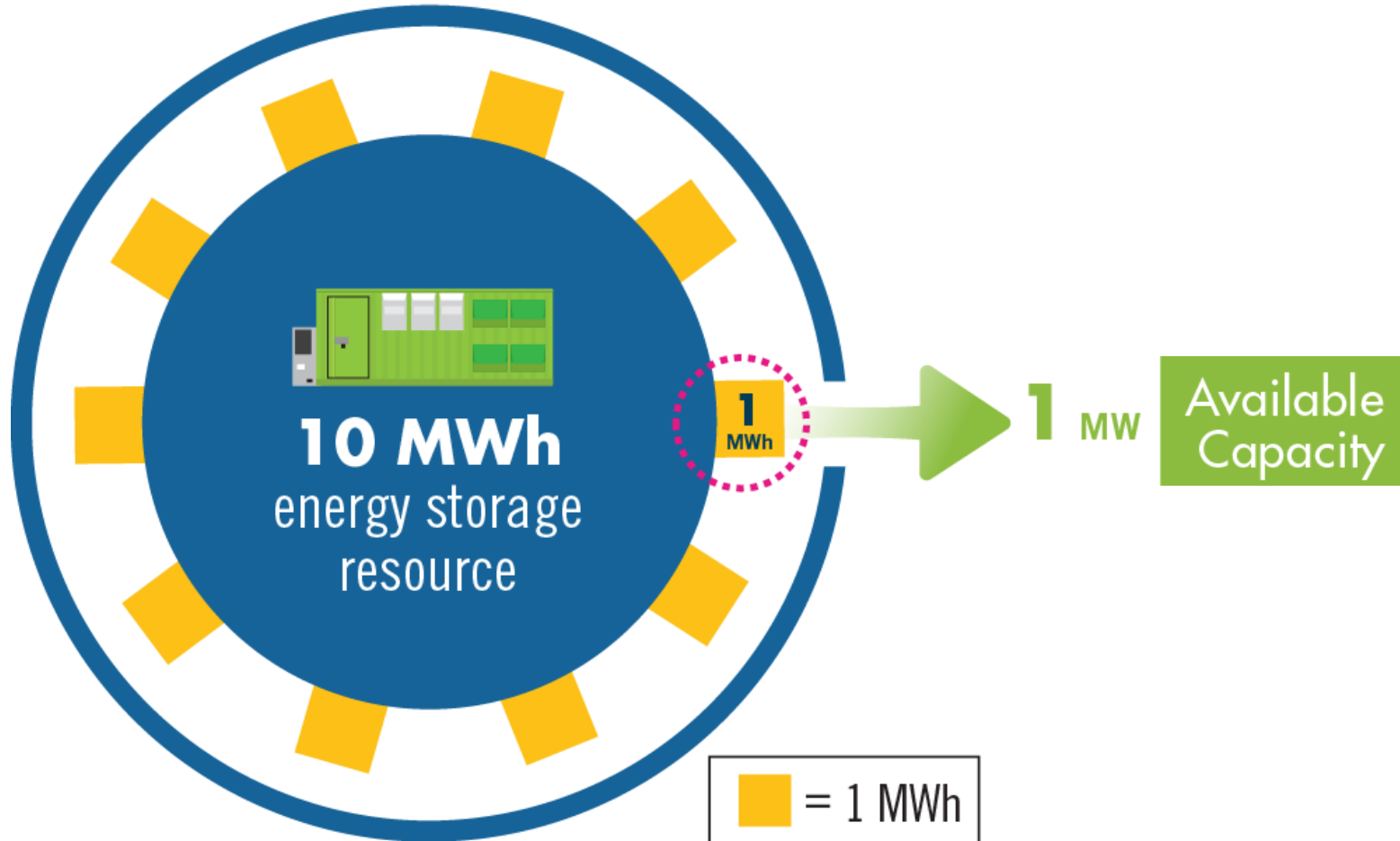
ESRs can update their max charge and discharge limits hourly in day-ahead, and more frequently in real-time.



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

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





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

- November 4, 2016 [FERC NOPR on Energy Storage and Distributed Energy Resources.](#)
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- December 3, 2018
 - [PJM ESR Accounting Proposal filing](#)
 - [PJM ESR Markets and Operations Proposal](#)
- December 10, 2018 [PJM limited answer to ESR filing](#)
- March 5, 2019 [PJM responds to protests and comments](#)
- April 1, 2019 [FERC Request for Additional Information](#)
- May 1, 2019 [PJM Response to FERC Questions](#)
- May 16, 2019 [FERC Order on Rehearing and Clarification](#)
- May 14, 2019 [PJM submits additional answers](#)
- **Dec 3, 2019 [Implementation Issue Tracking](#)**