ESIG-NARUC Training Series on Bulk Power System Issues: Integration of Utility-Scale Storage Market Design Considerations for Battery Operation

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## Agenda

### Integration of Utility-Scale Storage

- »FERC Order No. 841 Summary
- » Electric Storage Resource
  - Participation Model
  - State-of-Charge (SoC) Management Options
- » Storage Performance during Extreme Weather Conditions
  - California ISO September Heatwave

## FERC Order No. 841: Summary

- ✓ ISOs must include a participation model for electric storage resources (ESRs) that allows them to participate in energy, ancillary service, and capacity markets when technically capable of doing so
- ✓ ESRs must be eligible to set the wholesale price as both a buyer and seller when the marginal resource
- ✓ ISOs must account for physical parameters of ESRs through bidding or otherwise
- ✓ ISOs must allow a minimum size requirement that is at most **100 kW**
- Sale of energy that is stored from purchases in the wholesale market must be sold at wholesale nodal prices
- ✓ ISOs must allow **self-management** of state of charge (SOC)

Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators, FERC Order 841, Final Rule, 162 FERC 61, 127 (February 15, 2018) ("Order No. 841").



## **Participation Model: Introduction**

#### What does it mean?

- FERC NOPR: Defined as "a set of tariff provisions that accommodate the participation of resources with particular physical and operational characteristics in the organized wholesale electric markets of the RTOs and ISOs."
- FERC Order No. 841: Tariff revisions that consist of market rules that, recognizing the physical and operational characteristics of the resource, facilitates their participation in RTO/ISO markets
- ERPI: Definition of a participation model also includes the set of market clearing software provisions required to represent the physical and operational characteristics of the resource.





## **ESR Participation Model**

#### **O841: Requirement**

 ISOs must include a participation model for ESRs that allows them to participate in energy, ancillary service, and capacity markets when technically capable of doing so. ISOs must account for physical parameters of ESRs through bidding or otherwise.



Charge/discharge ramp rate

Order No. 841 Aspect	NYISO	PJM	SPP	ISO-NE	MISO	CAISO
Participation Model	1. Most entities are proposing two separate participation models: Continuous (e.g., batteries) and discontinuous (e.g., PSH) models					
	Z. ESRS can particip	can participate in energy, ancillary services, and capacity markets (wherever applicable)				
	ESKS and ELKS; PSH		<b>IVISKS</b> ; PSH plants	CSFs and BSFs	ESRs	
	cannot submit a	<b>ESRS;</b> PSH plants can	cannot submit a			NGRs and PSH model
	charge and	still use <b>pumped</b>	charge and			
	discharge offer in	hydro optimizer	discharge offer in			
	the same hour		the same hour			

**BSF**: Binary Storage Facility; **CSF**: Continuous Storage Facility; **ELR**: Energy Limited Resource; **ESR**: Electric Storage Resource; **MSR**: Market Storage Resource; **NGR**: Non-Generator Resource; **PSH**: Pumped Storage Hydro



## **SoC Management Options**



ESR asset owner participation responsibility and flexibility / computational efficiency



## **Operation and Market Design**

#### Low Renewable Scenario



#### High Renewable Scenario

- ✓ Self-management found to <u>increase</u> costs when storage deployed
- ✓ *Greatest* cost reduction and profits observed when ISO manages state of charge and optimizes to lower costs
- Self-management still benefits efficiency if feasibility checked, allowing <u>greater flexibility</u> for participant
- ✓ Challenges may be <u>exacerbated</u> by duration of storage, amount of storage, and amount of renewables

The way electric storage is operated and how it participates within the market may have a substantial impact on the magnitude of benefits it provides to the system.

Ela, Singhal, Integrating Electric Storage Resources into Electricity Market Operations: Evaluation of State of Charge Management Options, EPRI, Palo Alto, CA: 2019. 3002013868.



### **The Forecast Dilemma**





## Storage Performance during Extreme Weather Conditions

Insights on recent experiences with utility-scale storage operation during the September heatwave in California



# **California ISO**

### Storage Resource Performance in Summer 2022

By end of 2022, about 60% of the new batteries in the US markets were in the CAISO footprint, including just over 3 GW of new standalone lithium-ion battery storage and just under 2 GW of batteries in hybrid projects (almost all solar)

- CAISO experienced record-breaking summer weather conditions from Aug 31<sup>st</sup> through Sep 9<sup>th</sup>, 2022
  - Several cities saw their century-old temperature records broken
- CAISO usually operates with peak demand during the summer reaching around 50,000 MW
  - Encountered a significant deviation from historical norms on Sep 6<sup>th</sup>, setting a new load record of 52,061 MW
- Despite this challenge, the ISO managed to avert the need for rotating outages
  - Demand response initiatives
  - Flex alerts
  - Energy conservation efforts promoted through government emergency notifications that collectively reduced demand by about 1,500 MW
  - Use of storage resources that played a crucial role in maintaining system reliability

CAISO, Summer Market Performance Report September 2022, Published Nov. 2, 2022. [Online]. Available: http://www.caiso.com/Documents/SummerMarketPerformanceReportforSeptember2022.pdf

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## Storage Performance in Summer 2022

RTD is limited in its ability to forecast conditions that may arise more than an hour in the future due to its short-sightedness



Impact of an inaccurate estimation of initial SoC parameter



- 1. Initial SoC parameter in the day-ahead market
- 2. Challenges with real-time SoC management
- 3. Impact of merit order dispatch and market power mitigation
- 4. Minimum SoC requirement tool for resource adequacy storage resources
- Dynamic horizon length of the Real-time Dispatch (RTD) market
- 6. Out-of-merit exceptional dispatch instructions by operators
- 7. Adjusted bid cap as per FERC O831
- 8. Impact of ancillary services on SoC management



RUC - RTD Impact of high scarcity pricing and congestion-related challenges



CAISO, Summer Market Performance Report September 2022, Published Nov. 2, 2022. [Online]. Available: http://www.caiso.com/Documents/SummerMarketPerformanceReportforSeptember2022.pdf



### Storage Performance in Summer 2022



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#### Misalignment of dispatch instructions and telemetered storage production levels



CAISO, *Performance of Storage Resources in Summer 2022*, EPRI ISO/RTO Energy Storage Market Modeling Technical WG, Feb. 2022. [Online]. Available: <u>http://www.caiso.com/Documents/SummerMarketPerformanceReportforSeptember2022.pdf</u>



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# Appendix



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## **Market Clearing Software Differences**

#### ISO-SOC-Management Simultaneous SCED Approach



#### • RTO/ISO: CAISO, NYISO

- **DASCED Objective**: Maximizes social welfare / minimizes total system operating costs over the entire DA operating horizon (i.e., 24-hours)
- Previous hour's SOC and dispatch schedules (charge, discharge decisions) are <u>variables</u> in the SOC and ramp rate constraints (impacts dispatch/LMP calculations)

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#### SOC-Management-Lite Sequential SCED Approach



- RTO/ISO: SPP, ISO-NE, MISO, PJM
- **DASCED Objective**: Maximizes social welfare / minimizes total system operating costs for each DA time period or market interval individually (i.e., 1-hour)
- Previous hour's SOC and dispatch schedules (charge, discharge decisions) are <u>parameters</u> in SOC and ramp rate constraints (impacts dispatch/LMP calculations)

\*PJM uses a separate software program, referred to as pumped hydro optimizer, for determining pumped storage hydro (PSH) schedules



# **SOC Management Options**

## **ISO-SOC-Management**

- 1. <u>Simultaneous Multi-interval</u> economic dispatch
- 2. All 24 hours are solved simultaneously as one problem
- 3. Previous hour's SOC is a <u>variable</u> in economic dispatch/ LMP calculation
- 4. SOC is managed across a <u>known horizon</u> to ensure <u>feasibility</u> and <u>optimality</u>
- 5. Does not require offers, but ESRs can still submit offers, e.g., to account for degradation costs
- May include an additional feature to avoid myopic decisions, particularly if no offers are attached, e.g., a desired SOC at the end of the horizon, or a value in \$/MWh provided by the ESR to demonstrate the value of keeping energy left over at the end of the day

### **SOC-Management-Lite**

- 1. <u>Sequential</u> economic dispatch
- 2. Each hour is solved independently and sequentially, only using previous hour's data for initial conditions
- 3. Previous hour's SOC is a <u>parameter</u> in economic dispatch/ LMP calculation
- 4. SOC is used in <u>each market interval</u> to ensure the ESR's schedule is <u>feasible</u>
- 5. Requires offers to be submitted by market participants
- 6. Because offers must be submitted by ESRs, no additional features required to avoid myopic decisions at the end of horizon

