Impacts of Market Design on Storage Valuation

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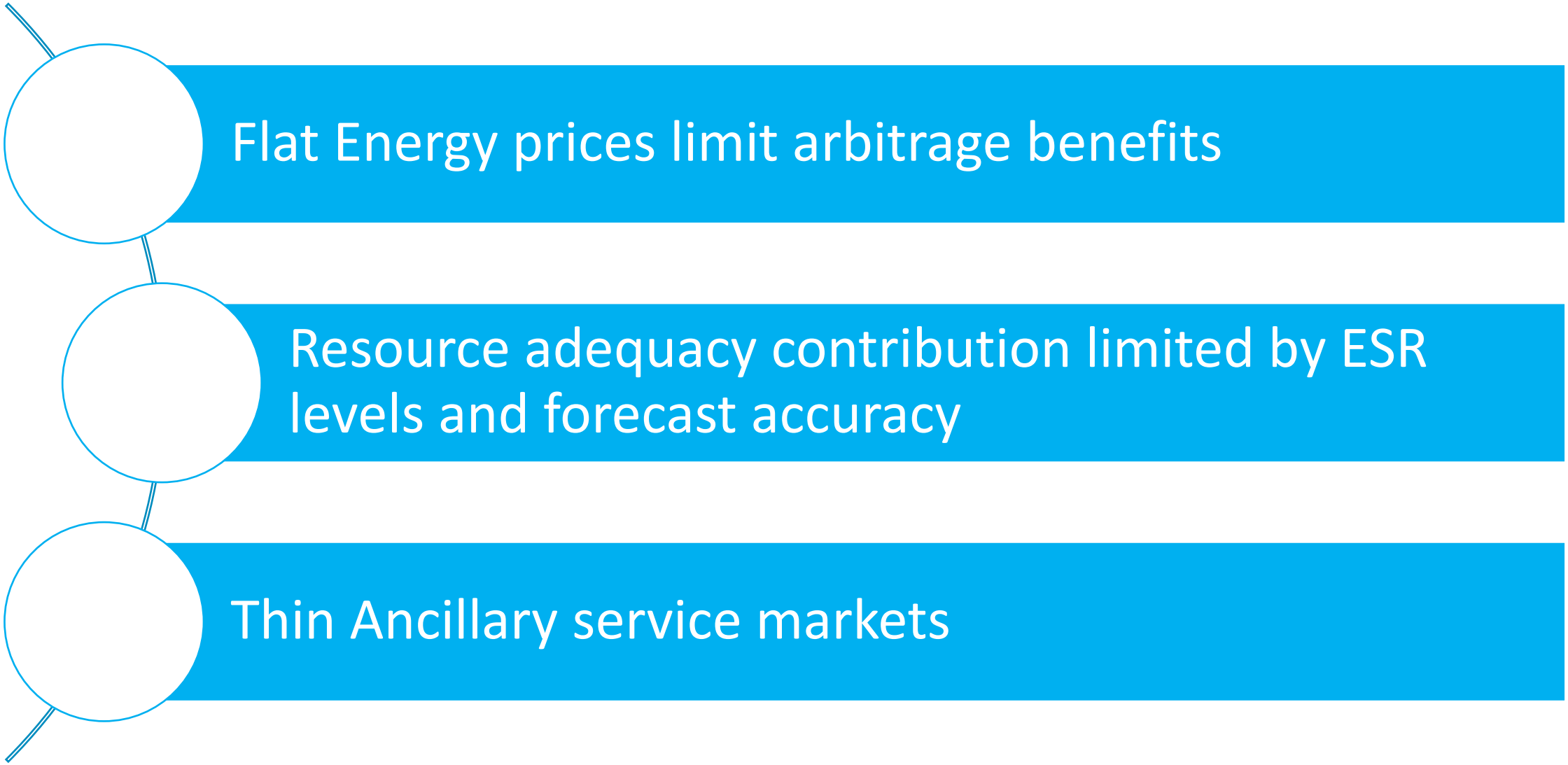
Key Challenges to value of ESRs as a flexibility resource



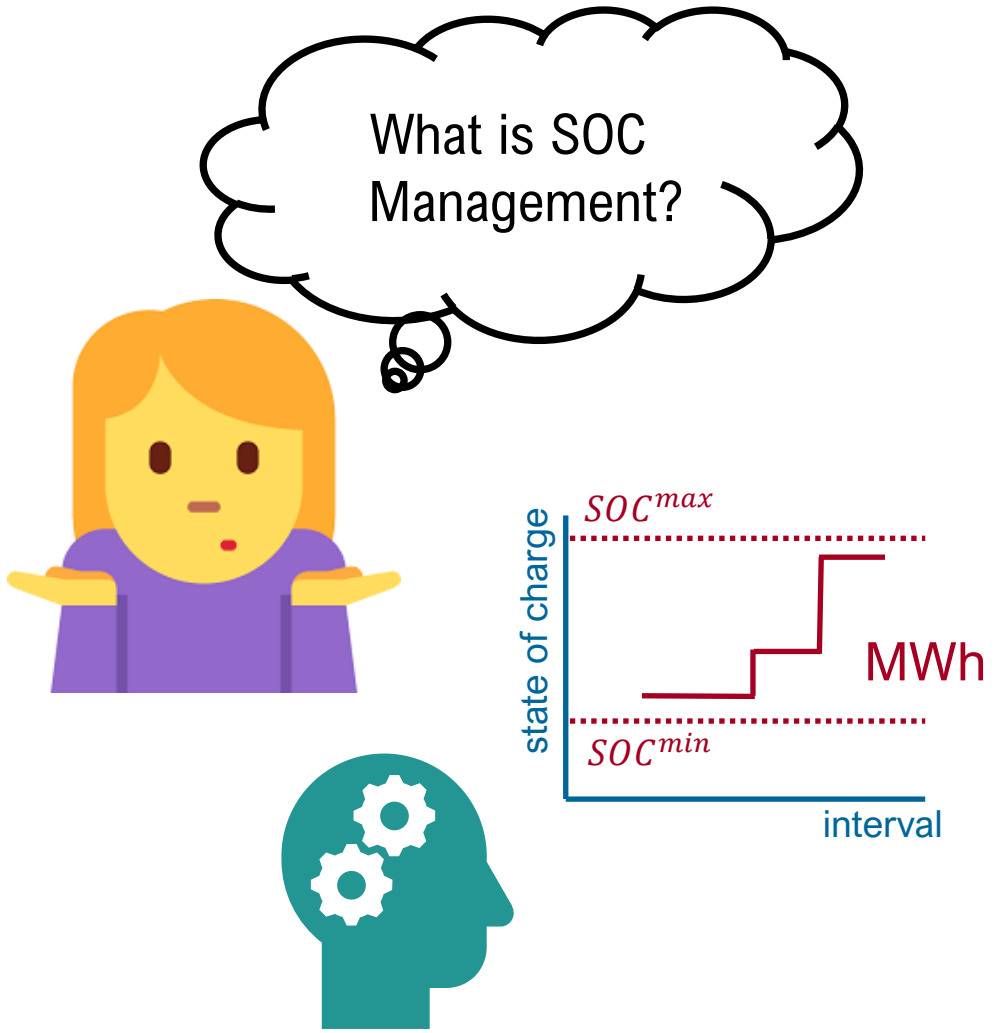
Key Challenges to value of ESRs as a flexibility resource

- State of charge management option may impact amount of value provided by ESRs
- Ability to manage VER forecast deviations is limited by real-time market horizons
- Degradation impacts and costs may limit the amount of flexibility that would otherwise be available
- ISO software influences what an ESR offer may actually represent

Based on EPRI Research

State of Charge Management: Introduction

- No *definitive* statement within FERC Order 841 on what SOC-Management means resulting in different interpretations and requests for clarifications (does not require ISO-SOC-Management; requires provision of SOC related bid parameters by ESRs and for ISOs to "*consider them*")

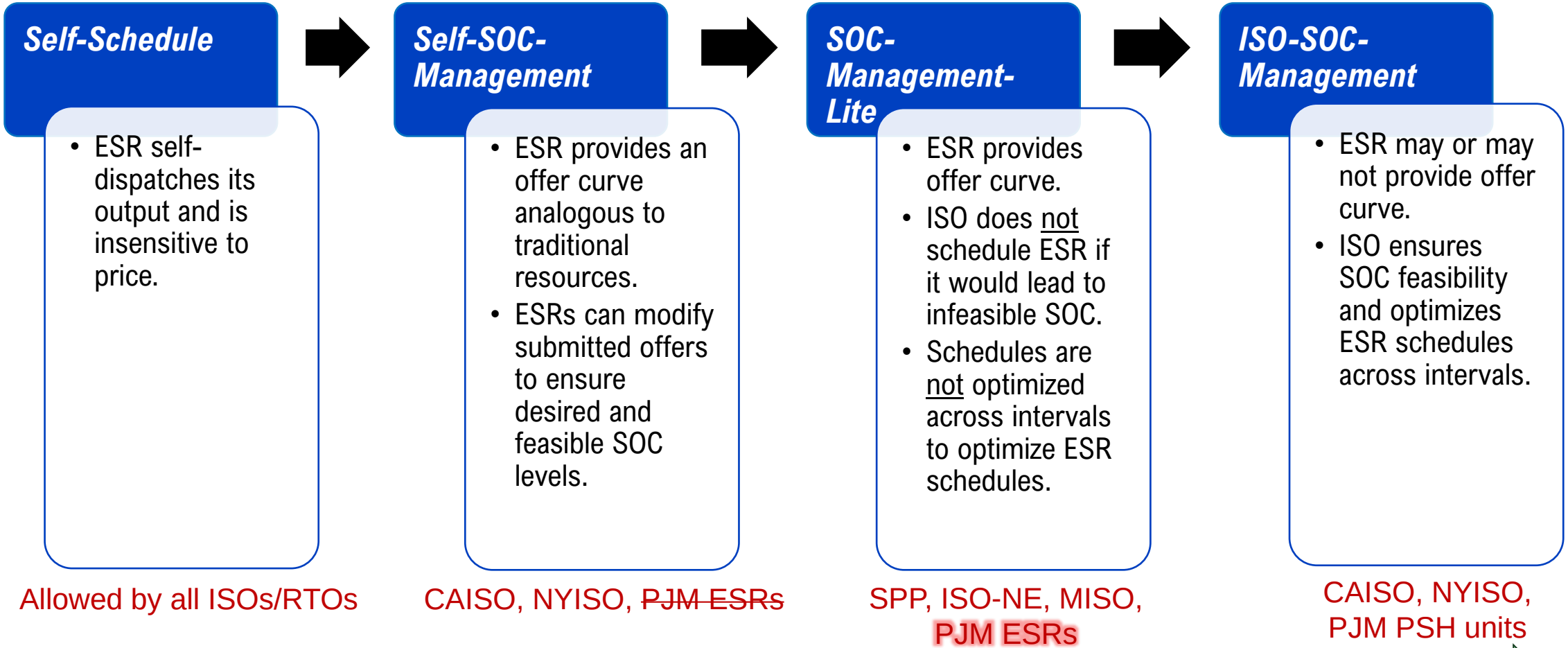


State of Charge Management: Introduction

- **Energy Storage Alliance[1]:**
  - **SOCM**: involves monitoring and causing to change the SOC, normally by adjusting resource operating parameters or power level, and perhaps including the placing and/or adjusting of offers/bids, to modify dispatch, generally to achieve a desired SOC level or range, or avoid an undesired SOC level or range, generally in real-time.
  - **Self SOCM**: should include the ability to adjust offers/bids and/or operating parameters, such as upper and lower limits, on a short-term basis, including from one dispatch interval to the next (i.e., every 5 minutes).
- **Electric Power Research Institute:**
  - **ISO-SOCM**: ISO monitors current SOC, monitors and calculates anticipated SOC, and other related ESR parameters (e.g., roundtrip efficiency levels) and makes scheduling decisions that explicitly lead to a bid-based optimal and feasible energy level at all times.
  - **Self SOCM**: ESR asset owners (market participants) provide cost/quantity offer curves that, to the best ability of the owner, lead to desired and feasible SOC level at all times without need for explicit ISO intervention.

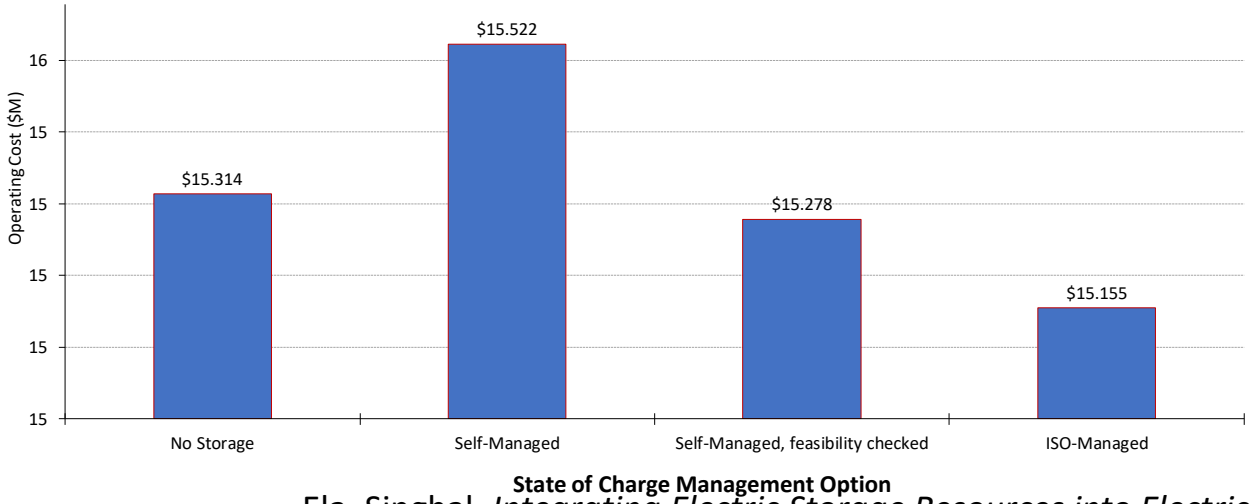
[1] ***Private communication with the Energy Storage Alliance, used with permission.***

State of Charge Management: Options

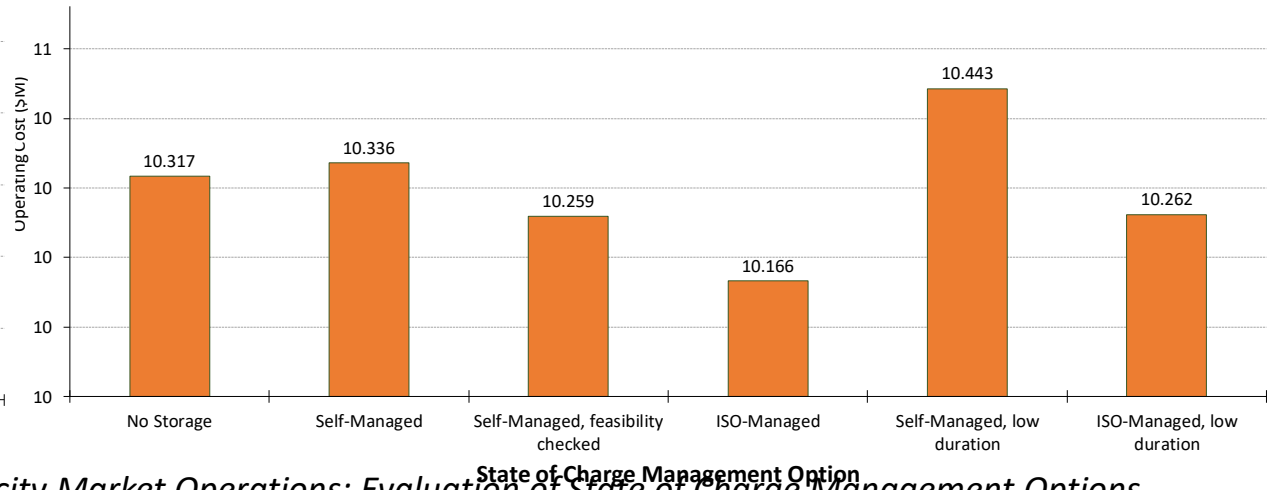


Benefits dependent on market design

Low Renewable Scenario



High Renewable Scenario



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

- ✓ Self-management found to ***increase*** 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 ***greater flexibility*** for participant
- ✓ Challenges may be ***exacerbated*** 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.

Importance of Energy Storage Modeling

	Case 1	Case 2
Production Costs	$2.523B	$2.587B
Cost savings of applying dynamic reserves to area	$-1.1M	$31M
Reserve shortages*	16 MWh	85,000 MWh

*All shortages are non-NERC reserves (e.g., regulation or replacement)

- **Case 1**: Simplistic Modeling. Four pumped storage resources can each operate from 400 MW pumping to 400 MW generating within five minutes
- **Case 2**: Validated pumped storage model. Fixed speed pumping, 75% min gen, 10 MW/min, 30-min transition, etc.
- Combined pumped storage unit capacity less than 5% of peak load

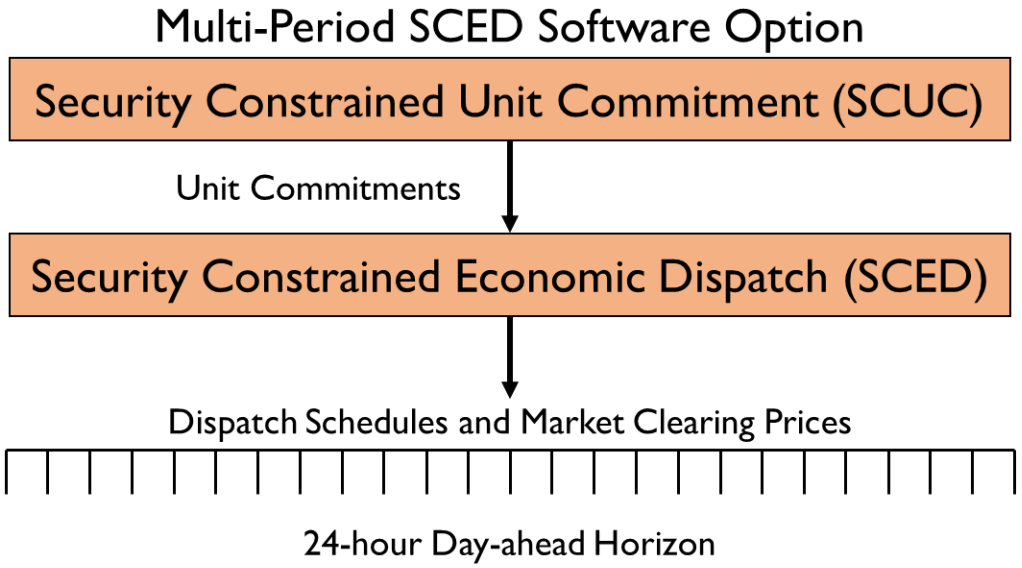
Careful modeling avoided a $60M mistake, and difference between a good and bad proposal!

Questions?

Together…Shaping the Future of Electricity

Market Clearing Software Subtleties

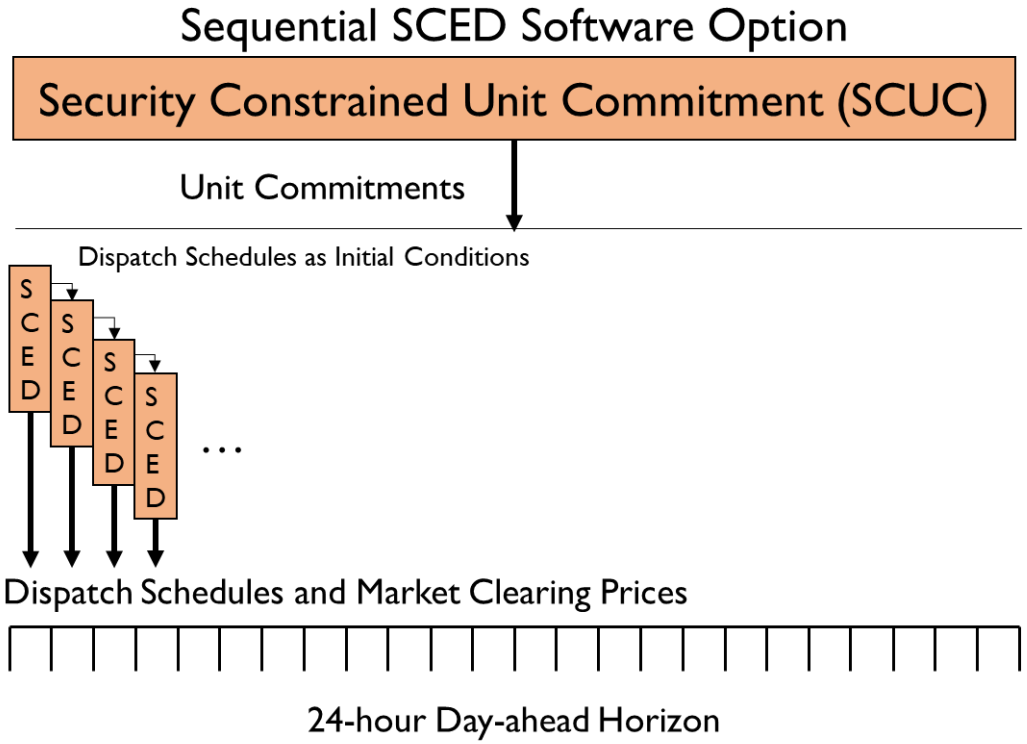
ISO-SOC-Management



CAISO, NYISO

Previous hour's SOC is a variable in dispatch/LMP calculation

SOC-Management-Lite



SPP, ISO-NE, MISO, PJM

Previous hour's SOC is a parameter in dispatch/LMP calculation

1) **SIEMENS**: CAISO, 2) **ABB**: NYISO, ERCOT, 3) **GE/ AREVA**: SPP, ISO-NE, MISO, PJM