



Using Market Optimization Software to Develop a MISO Multi-Day Market Forecast

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Purpose

- MISO analyses show that multi-day market forecasts can improve economic commitment decisions

Key Takeaways

- MISO's Day-Ahead Market not designed to forecast economic commitments beyond the next day
- Self commitments comprise 78% of the MISO Day-Ahead Market committed capacity
- MISO used market simulation software along with actual production data to quantify benefits of a multi-day optimization window

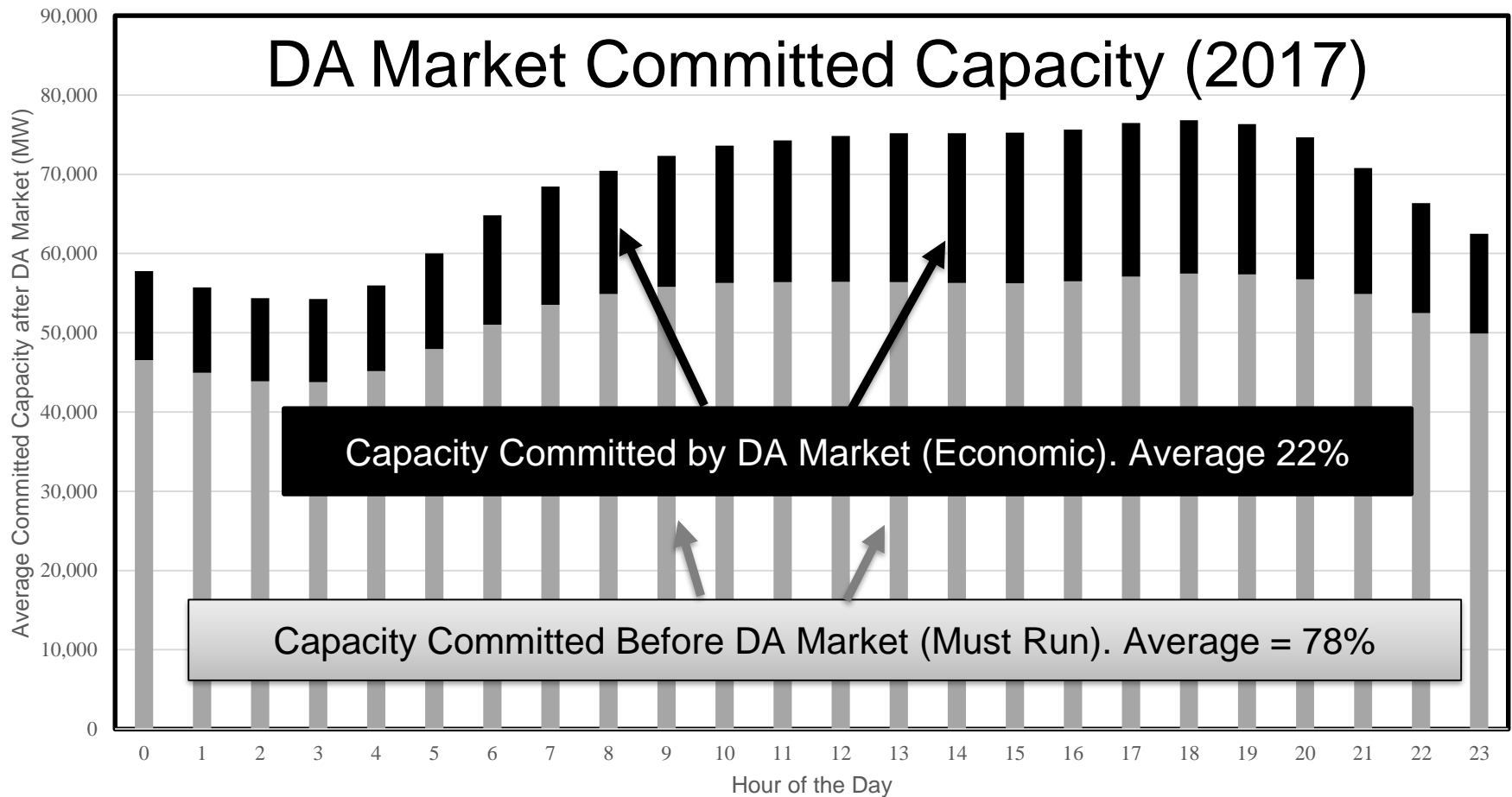
Outline

- Background
- Market Simulation
- Project status

Background

- The current Day-Ahead Market construct is not designed to forecast *economic* commitments beyond the next day
 - A Multi-Day RAC process commits for reliability
- This results in the inability to economically commit long-lead (or high startup cost) units and can cause uneconomic cycling of certain units across multiple days

Most Capacity is not Economically Committed in the DA Market



There is an opportunity to improve commitment decisions made before the DA Market

Multi-Day Market Forecast Would Have Many Benefits

- Improved market forecasts will allow Market Participants to improve the self-commitment of:
 - Long lead-time resources (>24 hours)
 - Resources with high start-up costs that can't be recovered in a single day
- Also assist MISO operators to decide if MISO-committed generation should continue to run through low-demand night and/or weekend hours

Multi-Day Market Forecast Would Have Many Benefits (cont.)

- Additionally, a multi-day price forecast will be helpful for:
 - Fuel purchasing and management
 - Large scale pumped-storage scheduling originally designed for weekly scheduling
 - Limited energy resources
 - Improving visibility of operations beyond next day, especially for the DA, FRAC and IRAC functions
 - Some units may allow limited number of starts in a week that can't be enforced with Single-Day design

Initial Screening/Evaluation

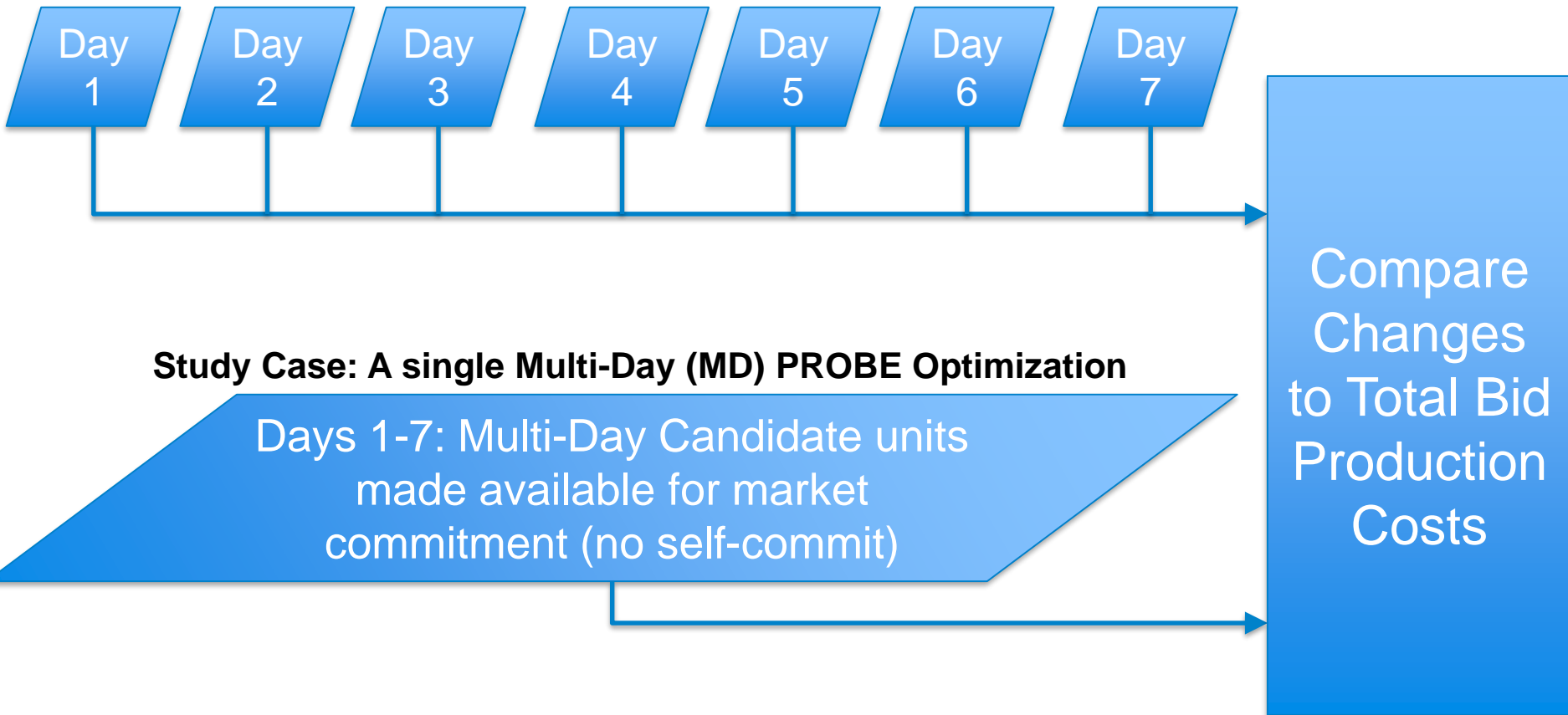
- A Screening Tool estimated potential BPC Reductions by examining units, one-at-a-time
 - Uneconomic commitment decisions were identified by comparing Day-Ahead LMPs and generator offers over several timeframes
- Only examined units in “Multi-Day Candidate List”
 - Have long-lead time or high-startup costs;
 - Can respond to multi-day commitment decisions
 - Many units cannot respond because of must-take fuel contracts, difficulties in cycling, emission constraints, local reliability needs, etc.
- About 10% of MISO Generators were evaluated

Screening Tool Results for 2016

- Multi-Day Candidate List: 113 generators
- Estimated BPC Reduction: **\$3.03 million/week**
- Study assumptions make this optimistic:
 - DA LMPs are known ahead-of-time (i.e. no forecast uncertainty)
 - Inefficient production can be replaced with generation at hourly LMP
 - Congestion impacts not considered
- Realistic Market Simulation was needed

Detailed Multi-Day Market Simulation using 1 week of data

Reference Case: 7 Consecutive Single-Day (SD) PROBE Optimizations



Detailed Multi-Day Market Simulation Setup

- Study Period: August 23-29, 2017 (7 days)
- PowerGEM PROBE software used to replicate MISO DA Market Clearing engine
 - Single Day solution is used regularly
 - PROBE can also optimize over multiple days – developed for multi-day FRAC
- PROBE input data based on production Day-Ahead Market cases, except:
 - Forecasted loads used instead of demand bids and virtuals
 - Outage schedules taken from Weekly RAC case, to ensure consistency between single-day and multi-day simulations

PROBE Model

- PROBE models all details and complexities of MISO Day-Ahead markets consistent with MISO market rules
- Currently configured to solve multiple days sequentially as separate days, or as a single multi-day solution window

PROBE MAIN MENU

Input Files | Viewer | Probe Simulator | EMS Model Setup | Select M...

Simulator Options

Application

BidsToOptimize

UnitComm

UnitComm(adv)

CongAnalysis

Solution

Solution(adv)

Penalties

Losses

Ancil_Service

Select Application

SCED SCUC

Select Time Step

Total number of hours to solve

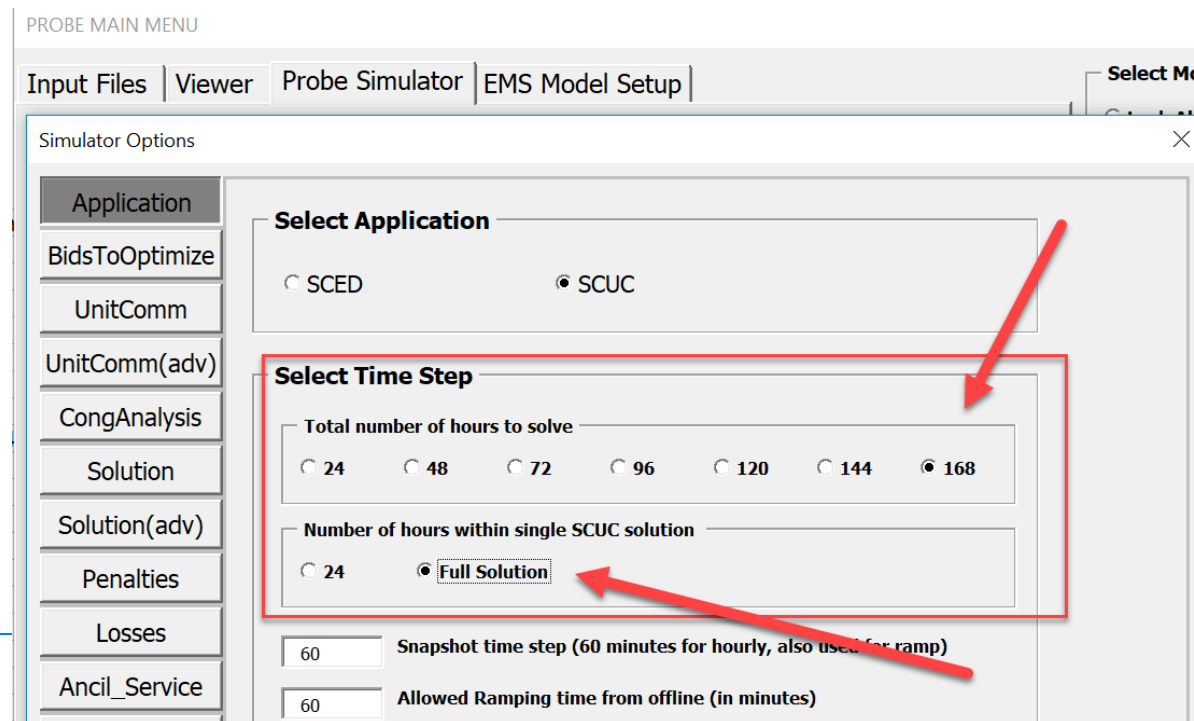
24 48 72 96 120 144 168

Number of hours within single SCUC solution

24 Full Solution

60 Snapshot time step (60 minutes for hourly, also used for ramp)

60 Allowed Ramping time from offline (in minutes)



PROBE Model

- No MISO market modeling simplifications were made to enable the Multi-Day (MD) optimization:
 - UC optimized over 168 hours as a single solution window
 - EMS-level modeling, assuming every hour has different topology with hourly transmission outages applied
 - Full transmission model with EMS breaker level N-1 contingency analysis (nearly 10,000 monitored branches and 1000+ contingencies)
 - All MISO complex ancillary services rules were modeled and co-optimized with energy
 - Marginal losses updated iteratively
 - Limited energy generation optimized over full solution window

Detailed Multi-Day Market Simulation Performance

- Advances in software methodology enable solving such an enormous optimization
 - Provides confidence that software is capable of further pursuing a Multi-Day market forecast
- PROBE performance and solution time
 - Reference Case: 7 Consecutive Single-Day (SD) PROBE Optimizations
 - ~30 minutes (i.e. average 4+ minutes per day)
 - Study Case: A single Multi-Day PROBE Optimization
 - ~60 minutes
 - No special hardware, no third party MIP solvers
 - Using single core Windows laptop

Detailed Market Simulation Results: Single Multi-Day (MD) vs Consecutive Single-Day (SD)

- Single Multi-Day Optimization reduced Bid Production Costs by 1.19%, or **\$2.69 Million/week**

Resource Type	BPC Reduction (MD vs. SD)
Generators (Energy)	\$2.56 M
Generators (Ancillary Service)	\$0.07 M
Imports/Exports	\$0.06 M
TOTAL	\$2.69 M

BPC Impacts of Multi-Day (MD) Market Simulation, by Generator Type

Bid Production Cost Reduction for Multi-Day Optimization (\$ Millions)

	CC	CT	Steam	Hydro	Total
MD Candidates	\$ 2.61M	\$ 0.94M	\$ 7.03M		\$ 10.58M
Other	\$ -7.71M	\$ -1.09M	\$ 0.91M	\$ -0.06M	\$ -7.95M
Total	\$ -5.10M	\$ -0.15M	\$ 7.94M	\$ -0.06M	\$ 2.63M

Overall BPC reduction resulted by

- Improved commitment of Multi-Day Candidate List units, and
- Moving some Multi-Day Candidate List generation to other more efficient units

MW Production Impacts of Multi-Day (MD) Market Simulation, by Generator Type

Average MW Production Impacts for Multi-Day Optimization

	CC	CT	Steam	Other	Total
MD Candidates	-569 MW	-145 MW	-1,294 MW		-2,009 MW
Other	+1,888 MW	+297 MW	-163 MW	13 MW	+2,009 MW
Total	1,319 MW	152 MW	-1,457 MW	13 MW	

- On average, more than 1,400 MW of Steam output moved to Combined Cycle and CT units, compared to Single-Day (SD) basecase

Develop Multi-Day Market Forecast Prior to Considering Multi-Day Financial Commitment

- Proceed first with the design and implementation of a Multi-Day Market Forecast
 - Design decisions to be made during Conceptual System Design (e.g. input data, study length, results to publish, sensitivity analyses, process changes)
- Eighteen months after go-live, MISO will:
 - Present an analysis which details the costs and benefits of making financially-binding multi-day commitments
 - Decide whether or not to pursue that option

Next Steps

- Multi-Day Market Forecast project is currently Not Active
 - Conceptual System Design to begin in 2020
- Implementation expected to be in Q4 2021
 - Depends on scope and available resources

Appendix

For More Information

- MISO Market Subcommittee (MSC) Presentations
 - [Feb 2018](#)
 - [Dec 2017](#)
 - [Sep 2017](#)
 - [May 2017](#)
 - [May 2016](#)
- [PowerGEM PROBE](#)