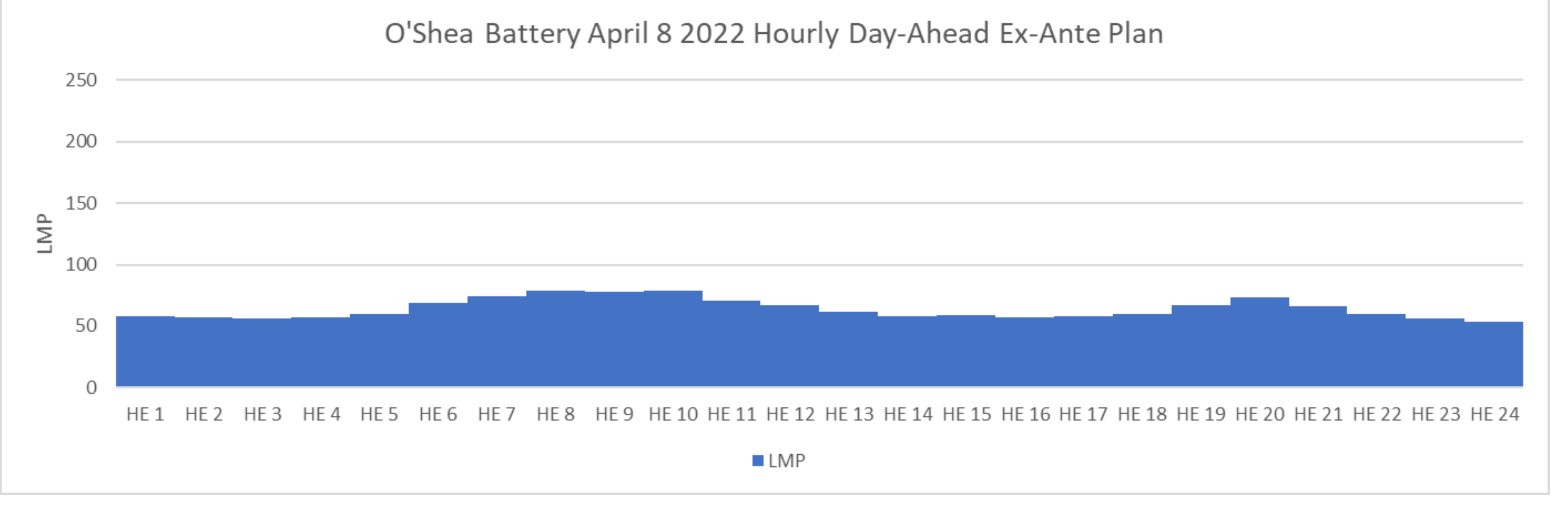
Integrating Batteries into Resource Planning: A Day in the Life of a Battery

Douglas Jester, Managing Partner
5 Lakes Energy
djester@5lakesenergy.com

www.5lakesenergy.com

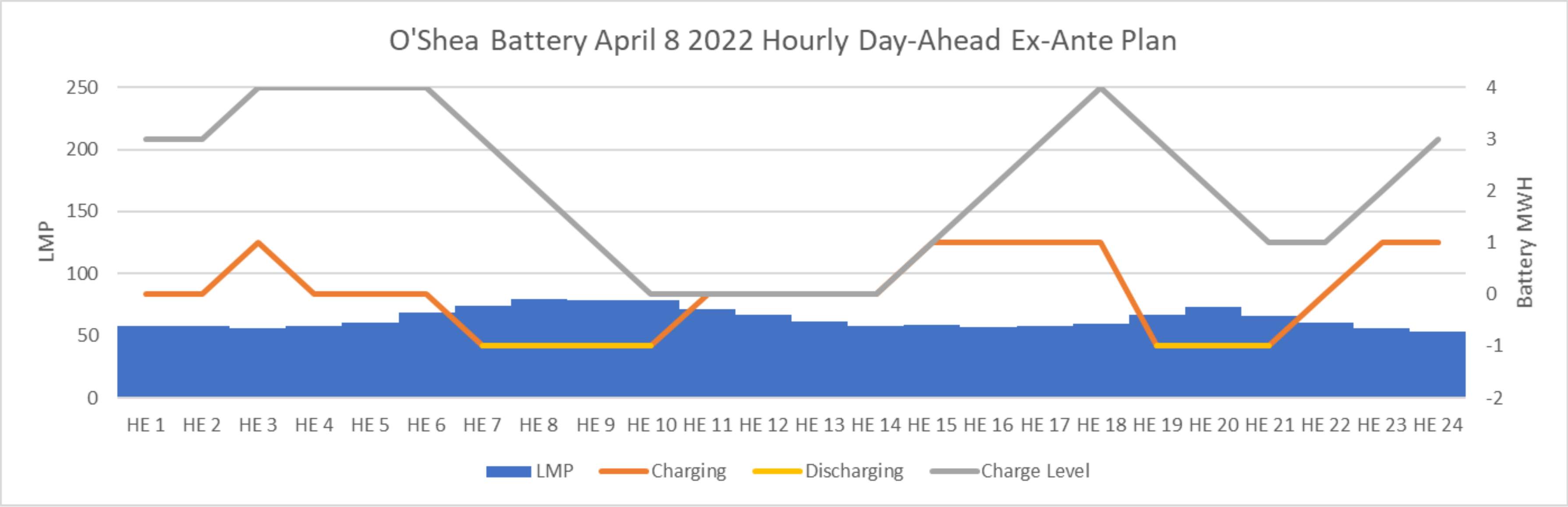
Energy Arbitrage

MISO makes the day-ahead market by merit order dispatch of the available generators at an hourly scale, subject to transmission constraints. This is very similar to standard IRP modeling. The graph below is the resulting day-ahead locational marginal prices (LMPs) at MISO generation node DECO.OSHEA.BAT, DTE’s O’Shea Park on April 8 2022.



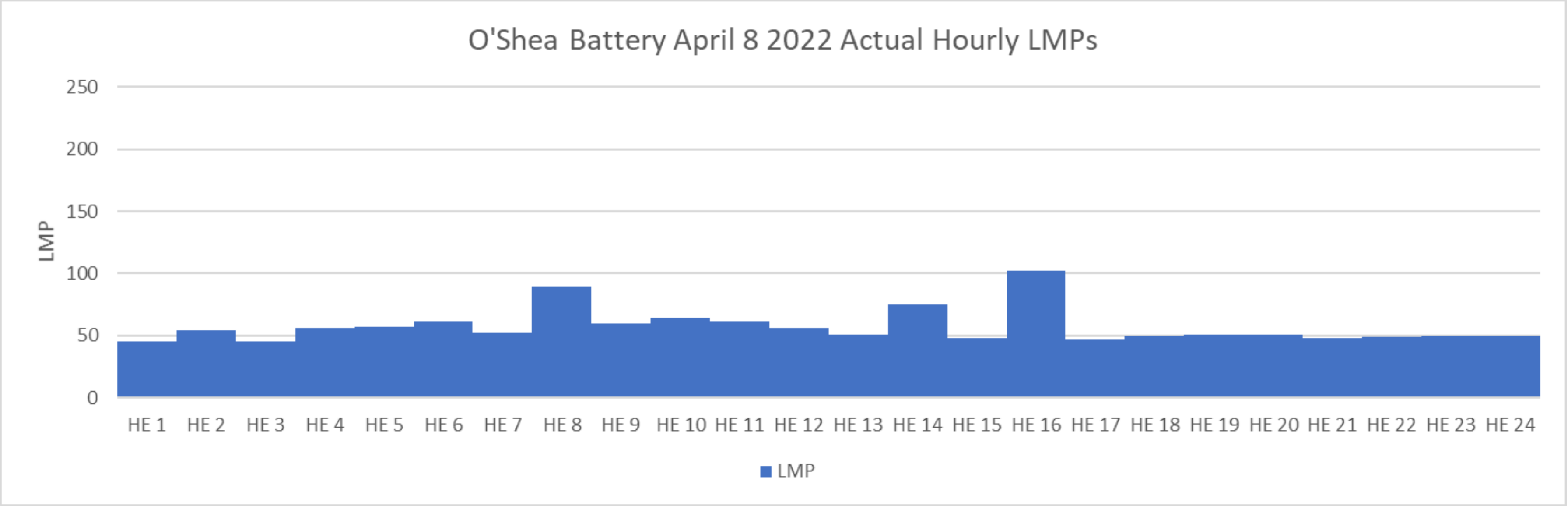
Energy Arbitrage

This graph depicts revenue-maximizing operating plan of a 1 MW throughput, 4 MWH storage battery at MISO generation node DECO.OSHEA.BAT, DTE's O'Shea Park on April 8 2022, assuming MISO's day-ahead hourly LMPs. Net revenue is $117.35.



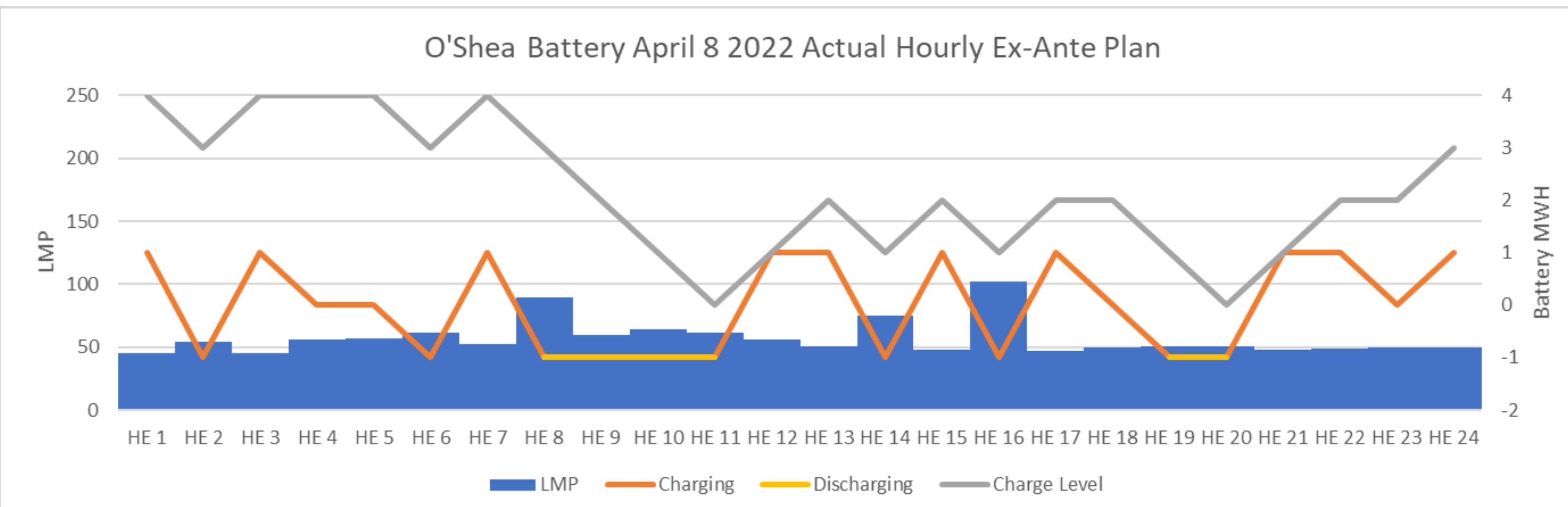
Energy Arbitrage

Actual Hourly LMPs are more variable than projected LMPs. Stuff happens.



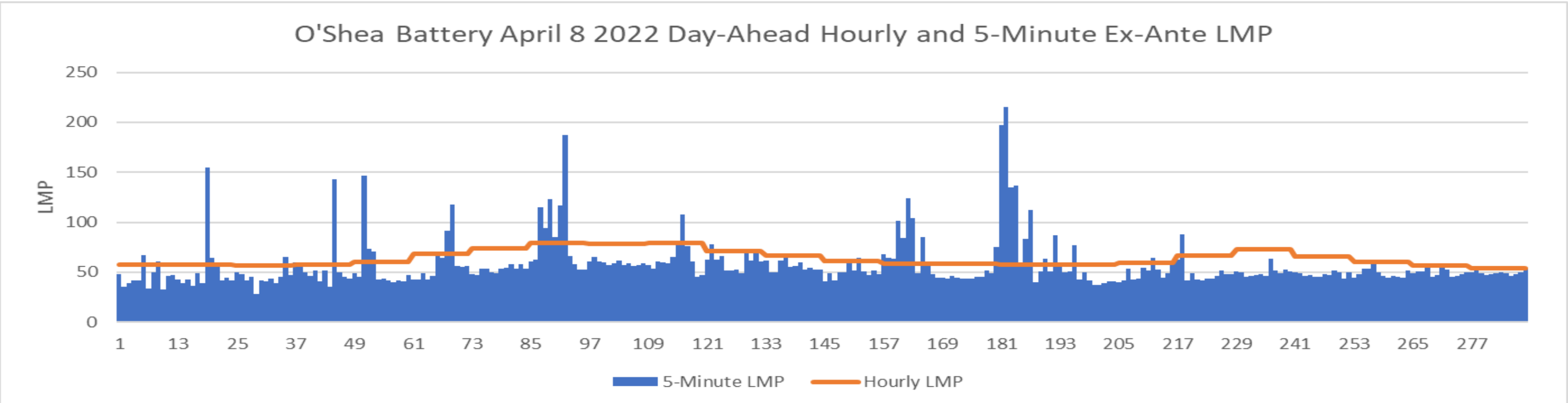
Energy Arbitrage

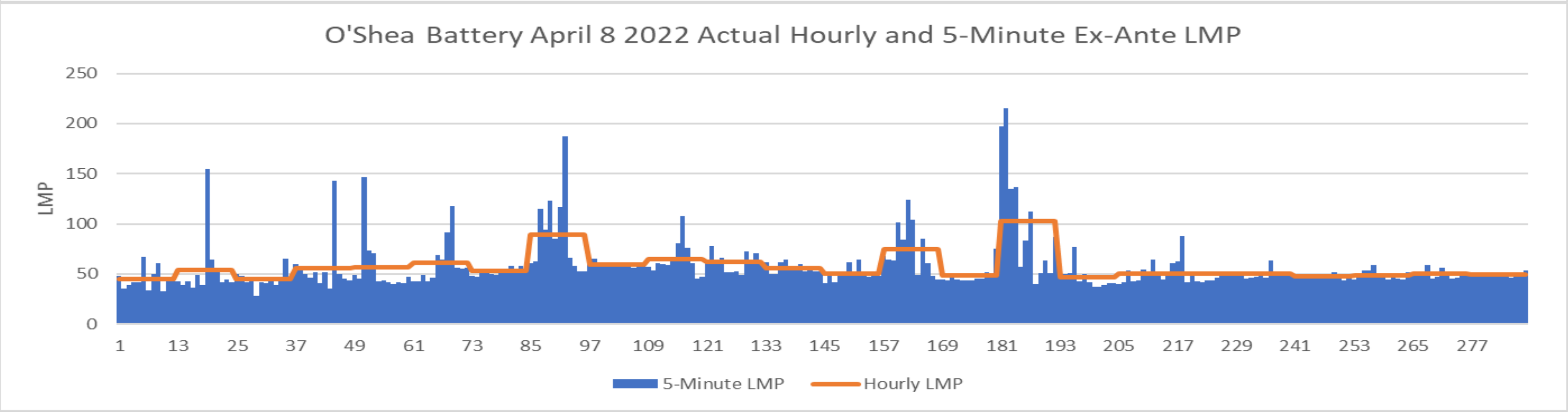
This graph depicts revenue-maximizing operating plan of a 1 MW throughput, 4 MWH storage battery at MISO generation node DECO.OSHEA.BAT, DTE's O'Shea Park on April 8 2022, assuming the actual hourly LMPs. Net revenue is $177.65.



Energy Arbitrage

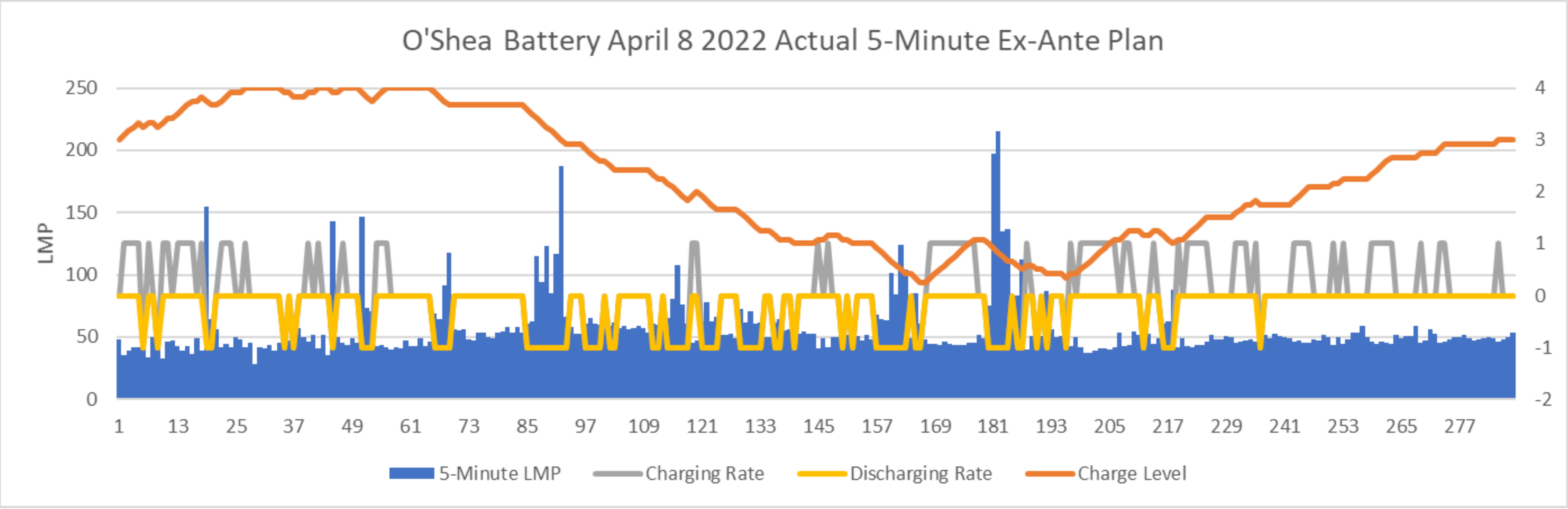
5 Minute Ex-ante LMPs at DECO.OSHEA.BAT show much greater volatility than the hourly day-ahead LMPs or the actual hourly average LMPs.





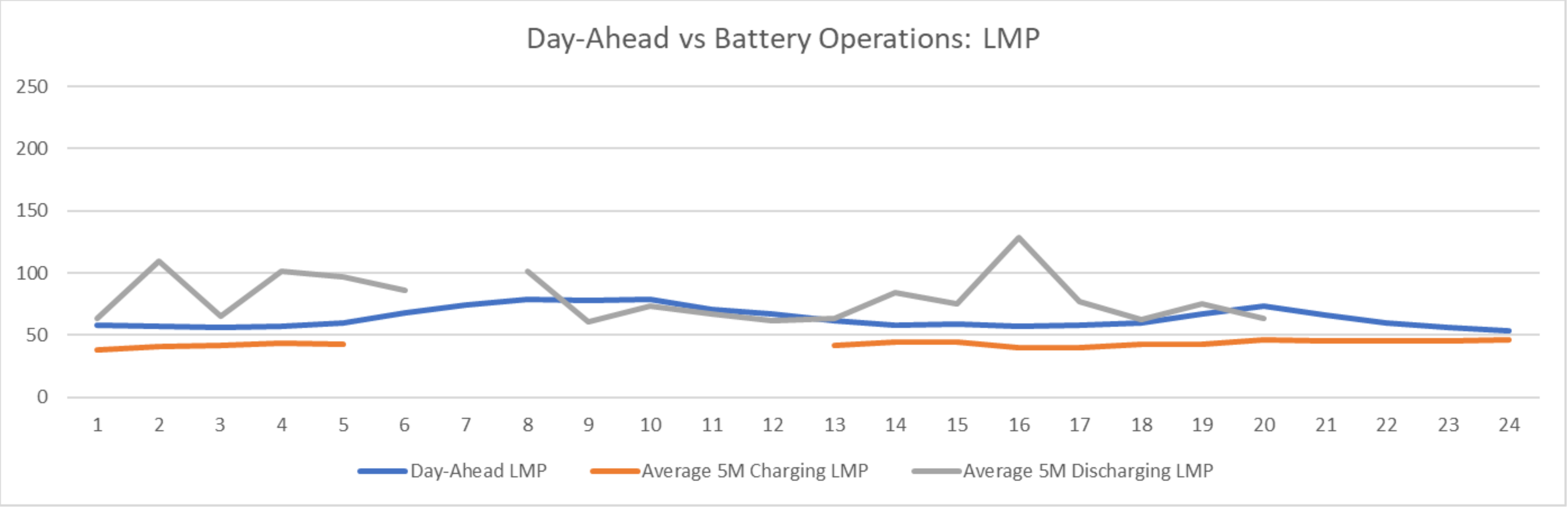
Energy Arbitrage

This graph depicts revenue-maximizing operation of a 1 MW throughput, 4 MWH storage battery at MISO generation node DECO.OSHEA.BAT, DTE's O'Shea Park on April 8 2022, if the battery operator responded to the ex-ante 5-minute LMPs with a simple optimized cost-triggered control band. Net revenue is $253.43 due to the opportunity to exploit volatility in the 5-minute market. A model-predictive controller or approximate dynamic programming solution would do even better.



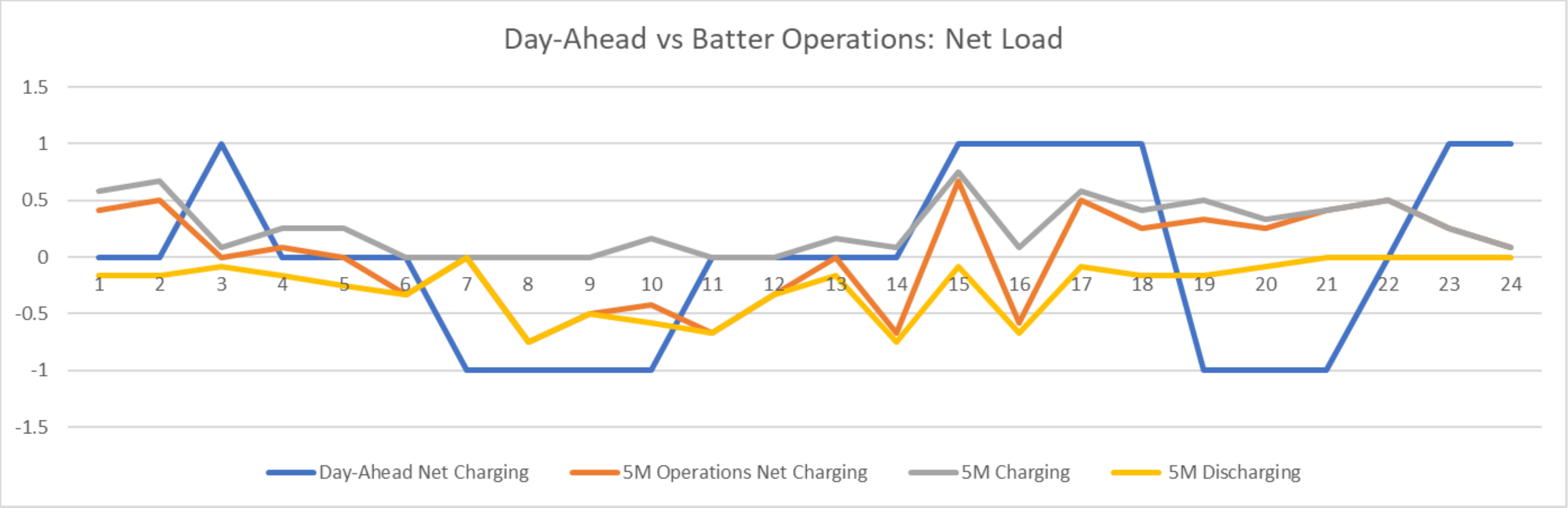
Energy Arbitrage

This graph contrasts LMP as seen in an IRP model with LMP as seen in a battery operator's ability to buy low and sell high to generate revenue. This mismatch drives erroneous battery economic analysis in the IRP. On April 8 2022 an IRP modeler would have made $117.35 on battery operations while a market arbitrager would have made $253.43.



Energy Arbitrage

This graph contrasts battery charging and discharging as seen in an IRP model with charging and discharging as seen by a battery operator. If batteries are deployed at scale, this drives erroneous hourly battery contributions to load balance. An IRP modeler sees larger load shifts than a market arbitraging battery operator.



Energy Arbitrage

- Deterministic dispatch models understate price variation and battery revenue from energy arbitrage.
- Hourly dispatch models, deterministic or stochastic, understate price variation and battery revenue from energy arbitrage.
- Standard models understate energy arbitrage value of a battery and therefore overstate net capacity cost of batteries under current grid conditions.

Energy Arbitrage

- Energy Arbitrage is not the only value of a battery
  - Operating value for ancillary services, including reserve capacity
  - Contribution to resource adequacy
  - Locational transmission and distribution considerations
- These can also be addressed through similar modeling *for current grid conditions*
  - Co-optimize battery operations for energy arbitrage and ancillary services including capacity availability using current grid conditions
  - Calculate Effective Load-Carrying Capacity (ELCC) of a battery using the usual methods
  - Substation and circuit analyses

Analyzing Near-Term Resource Additions

- What can we do about this in IRP modeling?
  - Model battery operations outside IRP software to determine net cost of capacity and buy batteries if justified as a pure capacity resource priced at net cost of capacity.
  - Issue an RFP for battery capacity credits and let a battery operator determine net cost of capacity, competing on operating algorithms as well as overnight capital cost, round trip efficiency, and cost of capital.

Analyzing Long-Term Resource Portfolios

- Preceding methods do not work for analysis of resource portfolios that are very different from the current grid
  - LMP stochastic process will be different so battery operations will be different
  - If economics indicate battery additions, the preceding methods do not help to determine the right quantities of batteries in the portfolio because they do not characterize how battery and other resource values change with portfolio changes

Analyzing Long-Term Resource Portfolios

- Until we have new planning methods and tools that incorporate stochastic optimization,
  - Climate and cost considerations suggest high future use of renewables
  - With high renewables penetration, all resources including batteries are valued primarily as reliability resources rather than net energy margin
  - My 15 minutes today does not allow deep exploration of storage in reliability modeling
  - Suggestion: model hourly energy sufficiency with limited or no fossil generation to determine renewables and storage quantities and begin building that in steady increments

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