LS Power/Rev Renewables' Experience with Multi-Interval Optimization (MIO)

October 1, 2021

Multi-interval optimization in theory better positions resources

- **In real-time markets, CAISO resources are not strictly dispatched according to either their bids or binding interval energy prices**.
  - Instead, real-time dispatch is optimized over a horizon of advisory prices through multi-interval optimization (MIO).
  - In theory for storage, and certainly for slower traditional generators with long start-up and ramp times, this should be helpful.

In practice, for storage resources…

Multi-interval optimization in practice creates risk

- **MIO can lock in losses at binding prices in anticipation of advisory prices that never materialize.**
  - Resources can be discharged to make room for projected price dips that never materialize, and held back or charged at times of high LMPs for projected high prices later that never occur.
- **MIO can dispatch resources outsides of bid curves where it sees a potential better opportunity ahead**.
  - When duration is limited in either direction within the lookahead horizon, MIO converts actual *fixed* $/MWh marginal costs into *fungible* 'spreads'.
  - MIO introduces risk by producing dispatch that will 'chase' arbitrage outside the limits of resource bid curves.
- **MIO performs poorly when reliable dispatch is needed most.**
  - MIO relies on advisory prices which, inferring from our dispatch results, tend to be least accurate during extreme volatility when supply is scarce.

Multi-interval optimization can create financial and reliability risk

- Specifically, we are concerned by the following patterns that MIO can produce:
  - **Resources discharged early or prevented from charging prior to evening peak** where bids would otherwise have preserved more charge and enabled delivery of day-ahead energy awards.
    - This reduces MWh available for the evening peak, with obvious negative impacts to system reliability.
  - **Resources not discharged when energy is needed most**. We have seen resources held back at prices $100s/MWh above our bid curve because the system saw higher advisory prices ahead that never materialized.
  - **As a result of the above scenarios, increased reliance on out-of-market measures** like exceptional dispatch, which are inefficient and undesirable to both resource owners and CAISO.

MIO affects fundamental battery operations across all markets

- **Delivery of day-ahead awards requires reliable real-time dispatch.**
  - A functioning real-time market is even *more* important for resources carrying substantial day-ahead wholesale market obligations, as those obligations financially flow through and must be settled in real-time.
  - MIO is a fundamental problem for all batteries operating across any of the CAISO wholesale markets.
- **MIO impairs the only tool currently available for resources to control state of charge.**
  - The bid curve is the only economic tool that resource owners currently have to control state of charge.
  - MIO impairs that ability by dispatching resources outside of their bid curve.

There is currently no compensation for damages from MIO

- **No bid cost recovery for MIO dispatch outside bid curves**
  - There is currently no compensation for losses incurred due to MIO relative to if dispatch had strictly followed resource bids and binding interval prices.
- **Effects of MIO are uniquely damaging to storage resources**
  - Because storage resources have limited duration, the effects of dispatch outside resource bid curves ‘ripple’ into the future, creating more adverse effects than on traditional generators.
  - For example, if a battery is discharged outside its bid curve or not charged according to its bid curve in the afternoon, it can adversely affect its ability to deliver energy in the evening.

Illustrative examples of MIO in action

from recent summer 2021 morning at two LS batteries

LS Battery 1 prevented from selling during day's highest prices

Real-time energy prices and dispatch at LS Battery 1 on summer 2021 morning

Hour Ending	Time	RTM Price [$/MWh]	RTM Dispatch [MW]	Plant Energy [MWh]
7	6:00:00	$83	132	243
	6:05:00	$105	176	231
	6:10:00	$109	176	217
	6:15:00	$82	132	203
	6:20:00	$85	132	192
	6:25:00	$86	132	181
	6:30:00	$106	176	169
	6:35:00	$107	176	155
	6:40:00	$97	137	141
	6:45:00	$120	176	128
	6:50:00	$93	73	115
	6:55:00	$236	0	108
8	7:00:00	$179	176	109
	7:05:00	$165	176	106
	7:10:00	$87	132	100
	7:15:00	$78	132	95
	7:20:00	$76	132	91
	7:25:00	$75	132	85
	7:30:00	$75	109	80
	7:35:00	$74	0	74
	7:40:00	$76	132	74
	7:45:00	$70	0	77
	7:50:00	$66	0	85
	7:55:00	$56	0	94

- The table to the left shows the real-time energy price, real-time dispatch instructions, and available energy at LS Battery 1 on a recent summer morning.

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	7:15:00	$78	132	95
	7:20:00	$76	132	91
	7:25:00	$75	132	85
	7:30:00	$75	109	80
	7:35:00	$74	0	74
	7:40:00	$76	132	74
	7:45:00	$70	0	77
	7:50:00	$66	0	85
	7:55:00	$56	0	94

- **LS Battery 1 was held back at 0MW during the day's highest prices**, presumably in anticipation of higher advisory prices ahead that never materialized. According to its bids, LS Battery 1 should have been discharged at full power.
- **During the highest-price interval of the day, dispatch was more than 200MW and hundreds of dollars per MWh outside of the resource's bid curve**.
- MIO instead discharged the battery into lower prices that followed.

- *Note: There were no upward day-ahead ancillary service or energy self-schedule awards within the look-ahead horizon to otherwise account for uneconomic dispatch. There were no real-time ancillary service awards at the battery throughout this period.*

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LS Battery 2 forced to charge during in the day's highest prices

Real-time energy prices and dispatch at LS Battery 2 on summer 2021 morning

Hour Ending	Time	RTM Price [$/MWh]	RTM Dispatch [MW]	Plant Energy [MWh]
7	6:00:00	$86	0	13
	6:05:00	$108	27	13
	6:10:00	$112	30	11
	6:15:00	$88	23	8
	6:20:00	$91	23	5
	6:25:00	$94	23	3
	6:30:00	$107	11	1
	6:35:00	$107	0	1
	6:40:00	$97	0	1
	6:45:00	$124	0	1
	6:50:00	$96	-17	1
	6:55:00	$244	-24	2
8	7:00:00	$186	23	4
	7:05:00	$172	11	5
	7:10:00	$91	20	4
	7:15:00	$82	0	4
	7:20:00	$80	0	4
	7:25:00	$78	0	4
	7:30:00	$78	0	6
	7:35:00	$77	23	7
	7:40:00	$79	0	8
	7:45:00	$73	0	8
	7:50:00	$69	0	8
	7:55:00	$58	0	9

- **During the highest real-time price interval of the day, MIO charged LS Battery 2 at hundreds of $/MWh outside of its bid curve, forcing it to buy power at the most expensive time.**
- In the last interval of HE7, LS Battery 2 was charged at prices hundreds of $/MWh outside of its bid curve, presumably in anticipation of higher advisory prices ahead that did not materialize.
- As a result, the battery locked in a financial loss with no compensation.

- *Note: There were no upward day-ahead ancillary service or energy self-schedule awards within the look-ahead horizon to otherwise account for uneconomic dispatch. There were no real-time ancillary service awards at the battery throughout this period.*

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MIO produces inefficient dispatch and risk for storage resources

- **The examples from this day are typical of what we see in MIO dispatch**. The system appears to have held back LS Battery 1 and charged LS Battery 2 during the highest price of the day, locking in financial losses for both resources using dispatch outside of their bid curves and with no bid cost recovery.
- **We believe this is the system working as designed**—with the real-time market engine optimizing dispatch over a horizon of advisory prices that fail to materialize.

In this case, as in most others we see with MIO, this results in less efficient dispatch of the resource than if market dispatch had simply adhered to resource bids and binding interval prices.

Recommendations to address MIO

Improving NGR dispatch and cost representation

Recommendations

- **Allow storage resources to opt out of multi-interval optimization.** Allow resources to forgo any potential benefits of MIO so that they can preserve state of charge, accurately represent their marginal costs, and ensure that they are able to meet day-ahead market and other obligations.
- **In practice, this would mean dispatching storage resources on only binding interval prices**. This would remove ‘phantom’ arbitrage that locks resources into binding losses based on advisory prices that often do not materialize. It would also prevent resources from being dispatched outside of their bid curves.
- **Provide bid cost recovery** where MIO produces losses relative to if submitted resource bids had been followed on binding prices.
  - Compensate resources based on settlements that would have resulted had resources been dispatched on actual bids and binding prices, ‘undoing’ any financial damage from MIO, inclusive of day-ahead, fifteen-minute, and real-time market runs and awards.
- **In the interim, publish documentation of MIO and advisory price performance** so that resource owners can make more informed decisions.