

# Five Minute Dispatch and Pricing

MIC

August 7, 2019

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# Background

- Problem Statement and Issue Charge
  - First read at May MIC
  - Approved at June MIC
  - First Education Session at July MIC on RT SCED execution



# Background

- August MIC – Education on LPC
- Key work activities:
  3. Review and provide education on the current LPC execution process, including but not limited to the frequency of cases, the inputs used, the target interval of the cases, approval process, solution time frame, and use of solution output.
  4. Review and provide education on the criteria for selecting RT SCED cases to be used in LPC.
  5. Review and provide education on the criteria for triggering reruns of LPC cases, and LMPs.



# LPC Background and Timeline

- LPC uses an approved RT SCED solution to calculate real time LMPs and ancillary service prices.
- Linear optimization engine, same as RT SCED.
- LPC is executed every five minutes.
- For each five minute interval that LPC calculates prices for, LPC is executed 90 seconds into that five minute interval.
- For example, LPC is executed at 10:16:30 to calculate prices for the five minute interval beginning 10:15:00.
- Majority of LPC cases solve in less than 90 seconds.



# SCED cases used in LPC

- Not all RT SCED cases used to send dispatch signals are used to calculate LMPs in LPC.
- On average, dispatch signals are sent with approximately 1.5 times the frequency with which prices are calculated (every 5 minutes)

| Month (2019) | Number of Five Minute Intervals | Number of Approved RT SCED Cases | Number of Approved RT SCED Cases Used in LPC | Percent of Approved RT SCED Cases Used in LPC |
|--------------|---------------------------------|----------------------------------|--|---|
| Jan          | 8,928                           | 12,177                           | 7,656  | 62.9%   |
| Feb          | 8,064                           | 11,484                           | 7,186  | 62.6%   |
| Mar          | 8,916                           | 12,942                           | 7,966  | 61.6%   |
| Apr          | 8,640                           | 12,759                           | 7,768  | 60.9%   |
| May          | 8,928                           | 12,890                           | 7,808  | 60.6%   |
| Jun          | 8,640                           | 12,988                           | 7,651  | 58.9%   |

# LPC Reuse of RT SCED Cases

- LPC uses the latest approved SCED case at the time it is executed.
- If there is no new approved RT SCED case, LPC continues to use the latest approved RT SCED case to calculate prices for multiple intervals.
  - In the first six months of 2019, 11.4% of approved RT SCED cases were used in multiple LPC cases.

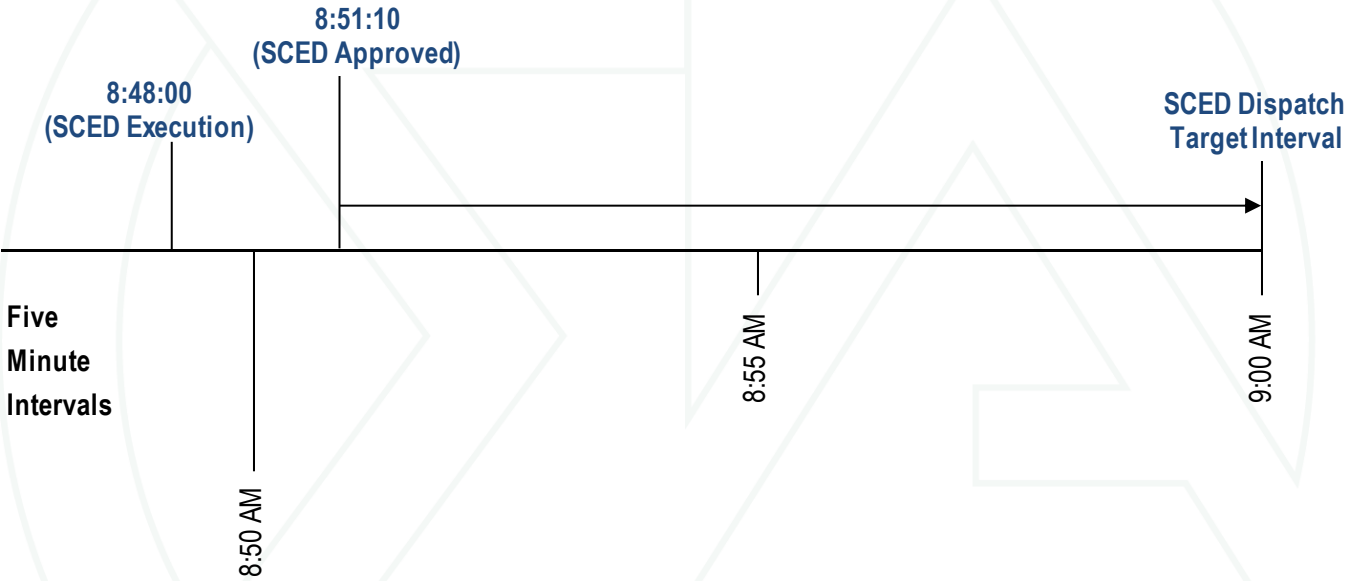
# LPC vs RT SCED Target Interval

- For 94.3 percent of the intervals, the five minute interval for which LPC calculates the prices is not the same as the target interval of the RT SCED case used to calculate the prices.
- For 93 percent of intervals, LPC assigns LMPs based on RT SCED dispatch for a future target interval.

| Difference between RT SCED<br>and LPC Target Intervals (mins) | Percent of Five Minute Intervals |                  |
|---|----------------------------------|------------------|
|   | 2018                             | 2019 (Jan - Jun) |
| (10)  | 0.2%                             | 0.1%             |
| (5)   | 0.9%                             | 0.5%             |
| 0   | 5.7%                             | 4.0%             |
| 5   | 30.5%                            | 27.7%            |
| 10  | 62.5%                            | 67.6%            |

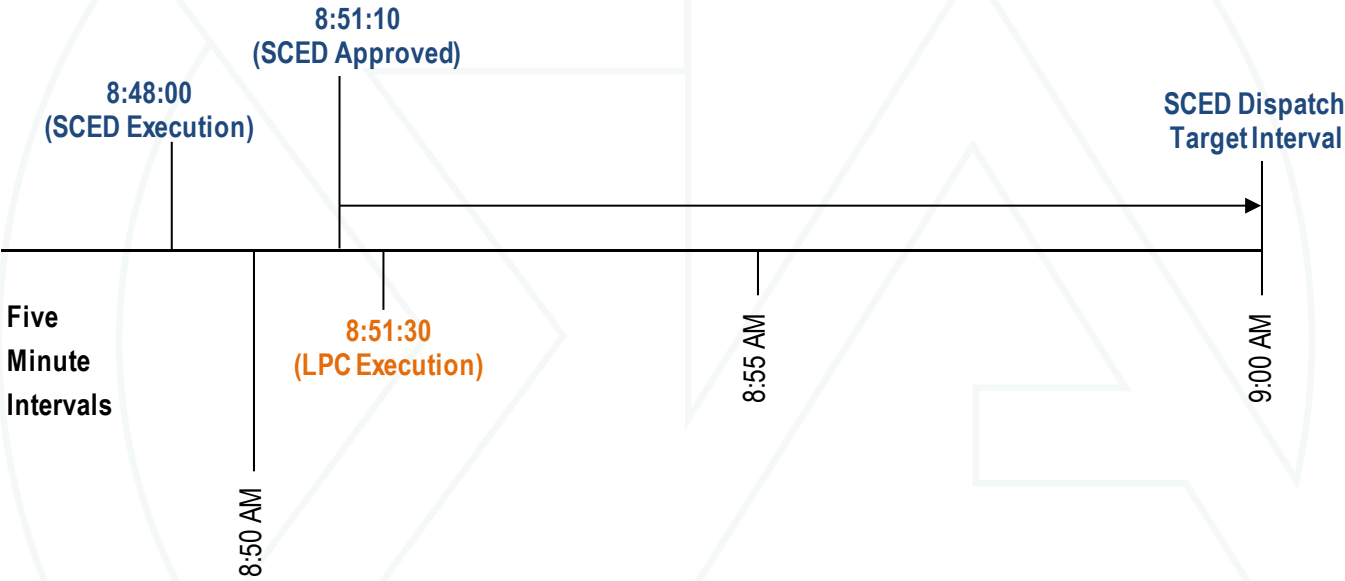
\*Five minute settlements implemented April 1, 2018.

# Timeline

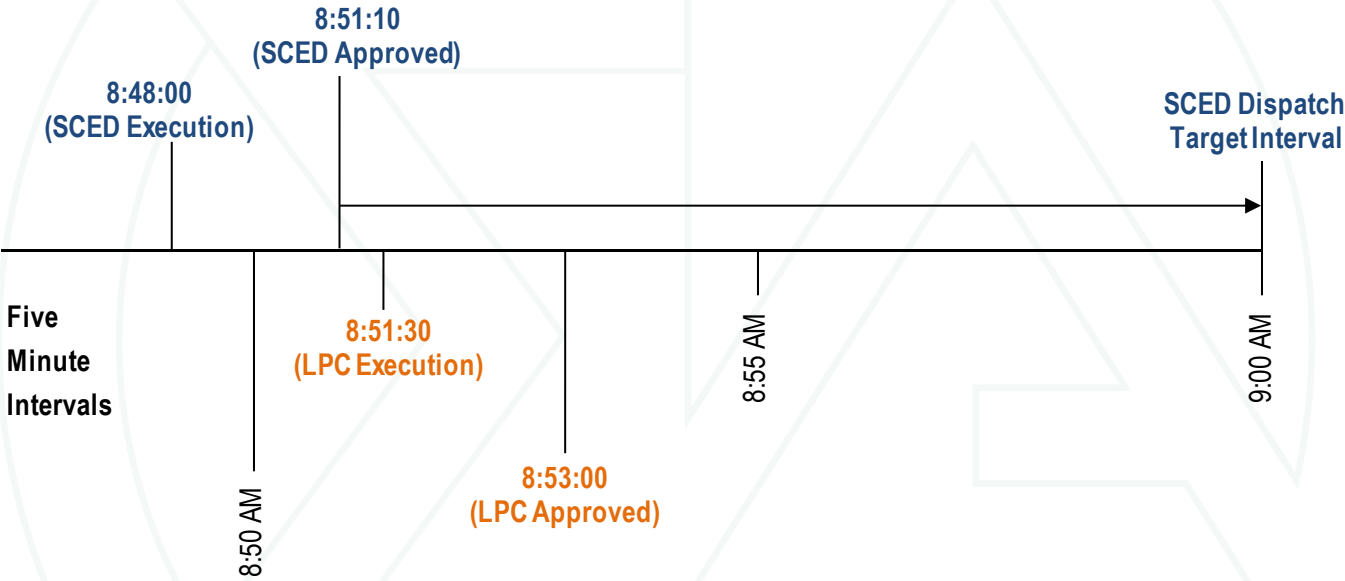




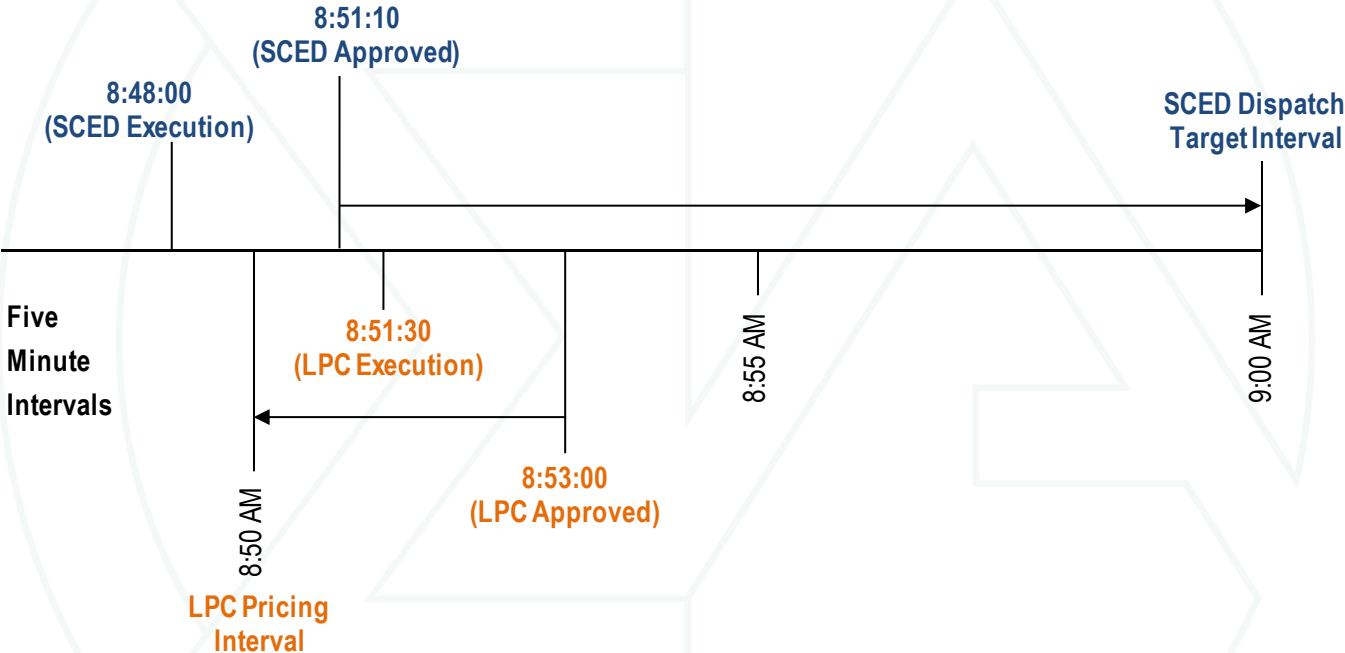
# Timeline



# Timeline



# Timeline



# Impact of Interval Difference - Energy

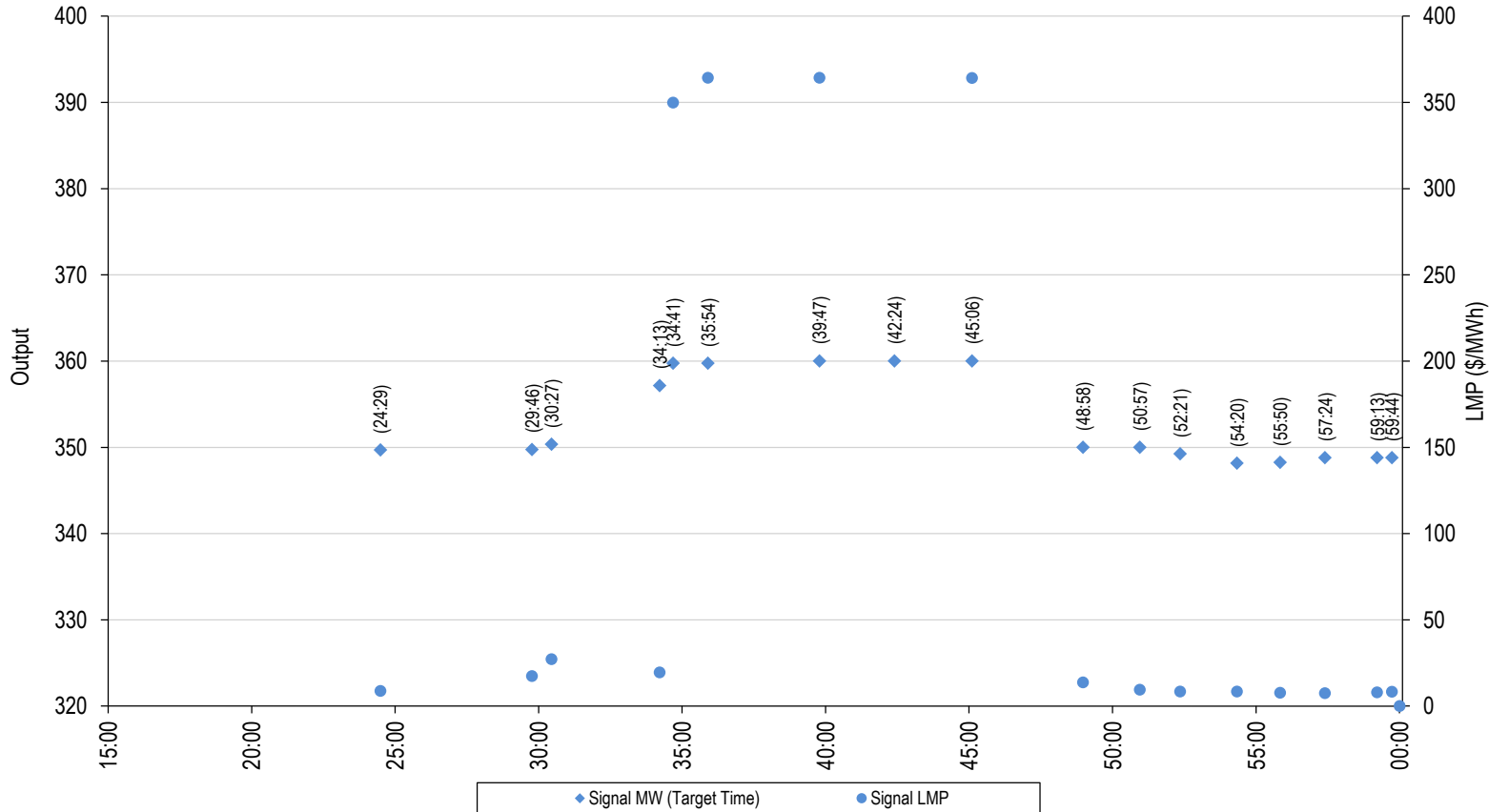
- The MMU observed, for energy settlements:
  - The MW come from Power Meter submissions by generators.
  - The prices come from LPC for each five minute interval.
  - The interval for which LPC calculates prices, does not match the target interval from the SCED case used to calculate the dispatch signals.
- As a result, a unit that follows dispatch is not settled using the price consistent with the dispatch signal.
- The MMU is further looking into the settlements impact.
  - Impact on uplift

# Example of Interval Difference Impact - Energy

- Unit receives MW signals to ramp up around minute 24 for minute 34.
- SCED LMPs reflect the need for the unit to ramp up.
  - SCED LMPs provide a price signal consistent with the MW dispatch signal.



# Example of Interval Difference Impact - Energy

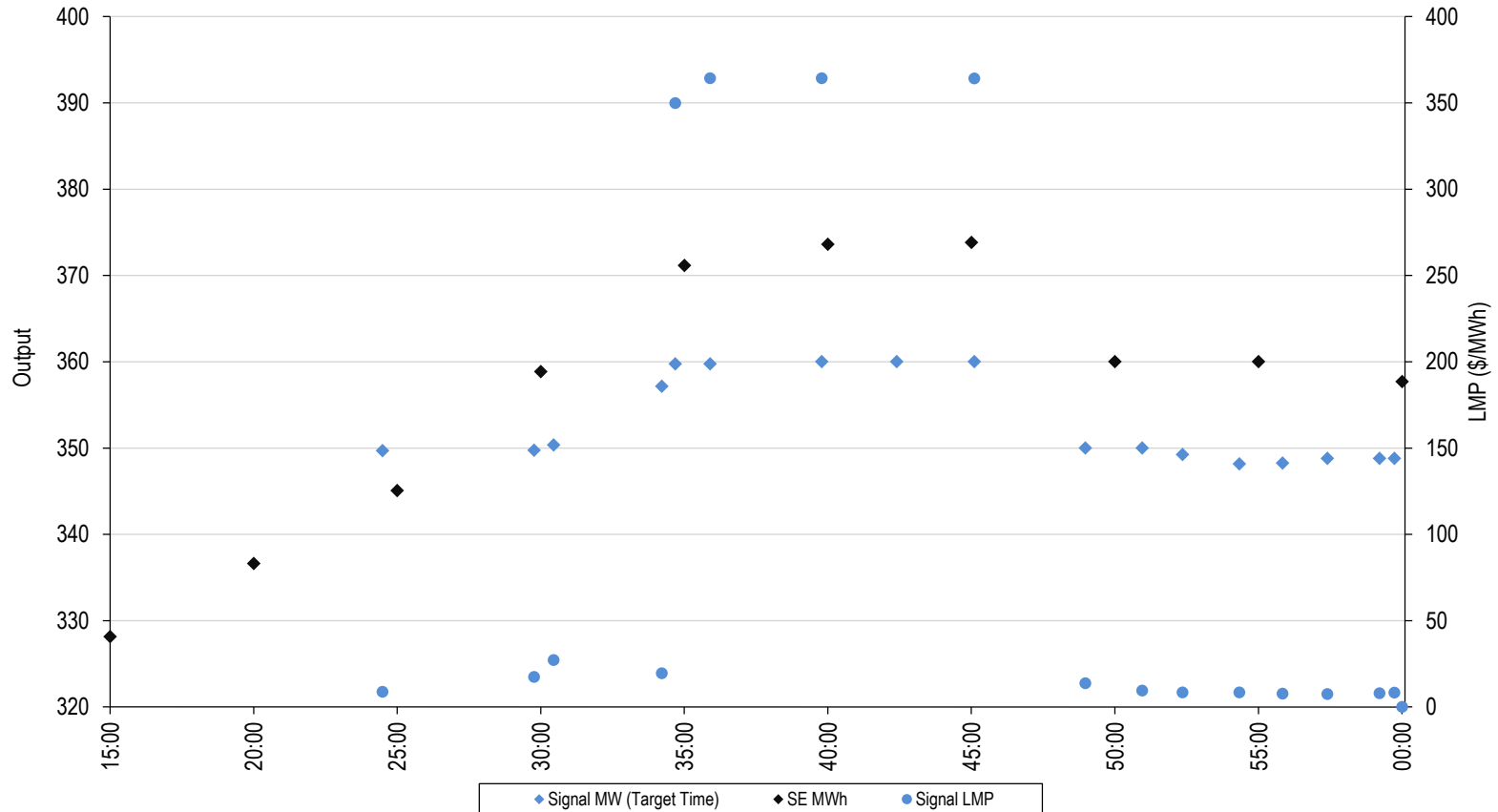


# Example of Interval Difference Impact - Energy

- Unit follows dispatch
  - In this example, the unit exceeds the dispatch MW instruction, most likely based on an incorrect and outdated ICAP MW ambient adjustment.
- When instructed, the unit ramps down.



# Example of Interval Difference Impact - Energy



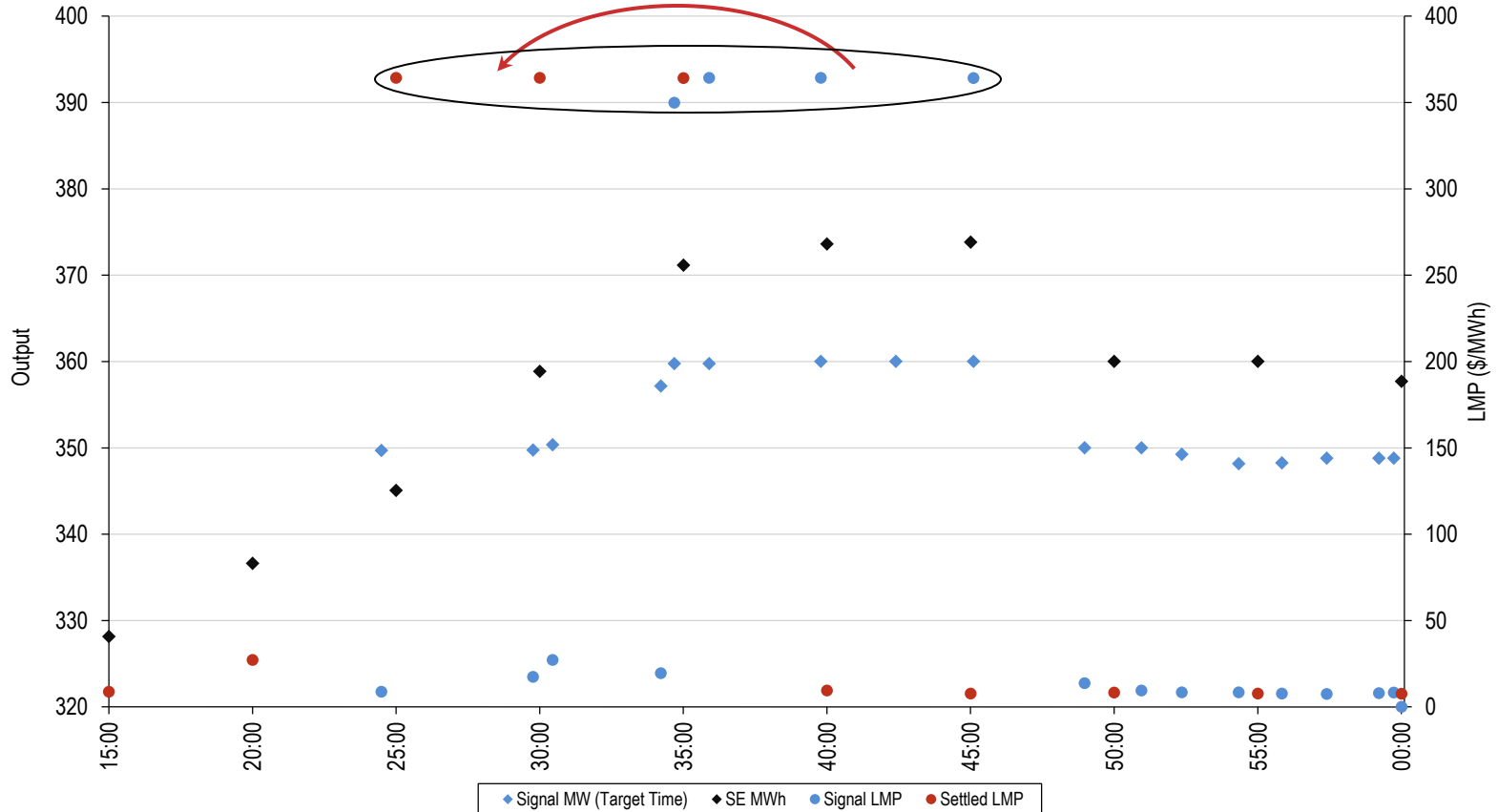


# Example of Interval Difference Impact - Energy

- LMPs are generally calculated based on the last SCED case approved prior to the LPC calculation.
- LPC (and settlements) assigns the LMPs to the interval in which the LPC case was executed.
- LPC assigns LMPs to an interval prior to the target interval of the SCED case producing the dispatch MW.
- The result is a mismatch between the LMP and the dispatch MW.
- The unit is paid the high LMPs for intervals in which the unit was not instructed to ramp up and paid the low LMPs for intervals in which the unit was instructed to ramp up.



# Example of Interval Difference Impact - Energy



# Example Revenue Loss

| Interval      | MW Output | SCED Price | LPC Price | SCED Revenue | LPC Revenue  | Difference    |
|---------------|-----------|------------|-----------|--------------|--------------|---------------|
| 0:00:00       |           |            |           |              |              |               |
| 0:05:00       |           |            |           |              |              |               |
| 0:10:00       |           |            |           |              |              |               |
| 0:15:00       | 328.1     |            | \$8.78    |              |              |               |
| 0:20:00       | 336.6     |            | \$27.12   |              |              |               |
| 0:25:00       | 345.1     | \$8.78     | \$364.24  | \$3,029.06   | \$125,689.41 | \$122,660.35  |
| 0:30:00       | 358.8     | \$27.12    | \$364.25  | \$9,732.01   | \$130,710.30 | \$120,978.30  |
| 0:35:00       | 371.2     | \$364.24   | \$364.06  | \$135,187.49 | \$135,120.68 | -\$66.81      |
| 0:40:00       | 373.6     | \$364.25   | \$9.44    | \$136,083.51 | \$3,527.17   | -\$132,556.34 |
| 0:45:00       | 373.8     | \$364.06   | \$7.73    | \$136,094.81 | \$2,888.93   | -\$133,205.88 |
| 0:50:00       | 360.0     | \$9.44     | \$8.28    | \$3,398.76   | \$2,979.72   | -\$419.04     |
| 0:55:00       | 360.0     | \$7.73     | \$7.61    | \$2,782.08   | \$2,741.04   | -\$41.04      |
| 1:00:00       | 357.7     | \$8.28     | \$7.50    | \$2,960.70   | \$2,682.77   | -\$277.93     |
| Total Revenue |           |            |           | \$429,268.41 | \$406,340.02 | -\$22,928.39  |

# Interval Difference Impact - Reserves

- For reserve settlements:
  - The MW assigned come from the last approved SCED case for the target five minute interval.
  - The reserve prices come from the LPC case solved during the five minute interval using a SCED case for a later target interval.
  - These two solutions do not match.
- Example (next slide) shows that the settlement MW match the last approved SCED case for the target interval, while the settlement price matches the LPC price using a different SCED case.
- In this example, the unit receives less revenues due to the mismatch between the cleared MW (last approved SCED case for the target interval) and the assigned prices (LPC).

# Example of Interval Difference – Reserves

| Interval Beginning | Settled Reserve MW | Last SCED Reserve MW | LPC Reserve MW |
|--------------------|--------------------|----------------------|----------------|
| 17:10:00           |                    |                      | 2.0            |
| 17:15:00           |                    |                      |                |
| 17:20:00           | 2.0                | 2.0                  |                |
| 17:25:00           |                    |                      |                |
| 17:30:00           |                    |                      |                |

# Example of Interval Difference – Reserves

| Interval Beginning | Settled Reserve MW | Last SCED Reserve MW | LPC Reserve MW |
|--------------------|--------------------|----------------------|----------------|
| 17:10:00           |                    |                      | 2.0            |
| 17:15:00           |                    |                      |                |
| 17:20:00           | 2.0                | 2.0                  |                |
| 17:25:00           |                    |                      |                |
| 17:30:00           |                    |                      |                |



# Example of Interval Difference – Reserves

| Interval Beginning | Settled Reserve MW | Last SCED Reserve MW | LPC Reserve MW | Settled Reserve MCP | Last SCED Reserve MCP | LPC Reserve MCP |
|--------------------|--------------------|----------------------|----------------|---------------------|-----------------------|-----------------|
| 17:10:00           |                    |                      | 2.0            | \$0.45              |                       | \$0.45          |
| 17:15:00           |                    |                      |                |                     |                       |                 |
| 17:20:00           | 2.0                | 2.0                  |                | \$1.79              | \$0.45                | \$1.79          |
| 17:25:00           |                    |                      |                |                     |                       |                 |
| 17:30:00           |                    |                      |                |                     | \$1.79                |                 |

# Example of Interval Difference – Reserves

| Interval Beginning | Settled Reserve MW | Last SCED Reserve MW | LPC Reserve MW | Settled Reserve MCP | Last SCED Reserve MCP | LPC Reserve MCP |
|--------------------|--------------------|----------------------|----------------|---------------------|-----------------------|-----------------|
| 17:10:00           |                    |                      | 2.0            | \$0.45              |                       | \$0.45          |
| 17:15:00           |                    |                      |                |                     |                       |                 |
| 17:20:00           | 2.0                | 2.0                  |                | \$1.79              | \$0.45                | \$1.79          |
| 17:25:00           |                    |                      |                |                     |                       |                 |
| 17:30:00           |                    |                      |                |                     | \$1.79                |                 |

MCPs are rising. The MW are paid a higher price than required to clear them.



# Example of Interval Difference - Reserves

| Interval Beginning | Settled Reserve MW | Last SCED Reserve MW | LPC Reserve MW |
|--------------------|--------------------|----------------------|----------------|
| 23:00:00           |                    |                      | 0.3            |
| 23:05:00           | 0.3                | 0.3                  | 6.7            |
| 23:10:00           | 6.7                | 6.7                  | 0.4            |



# Example of Interval Difference - Reserves

| Interval Beginning | Settled Reserve MW | Last SCED Reserve MW | LPC Reserve MW | Settled Reserve MCP | Last SCED Reserve MCP | LPC Reserve MCP |
|--------------------|--------------------|----------------------|----------------|---------------------|-----------------------|-----------------|
| 23:00:00           |                    |                      | 0.3            | \$870.40            |                       | \$870.40        |
| 23:05:00           | 0.3                | 0.3                  | 6.7            | \$310.91            | \$870.40              | \$310.91        |
| 23:10:00           | 6.7                | 6.7                  | 0.4            | \$91.63             | \$310.91              | \$91.63         |

# Example of Interval Difference - Reserves

| Interval Beginning | Settled Reserve MW | Last SCED Reserve MW | LPC Reserve MW | Settled Reserve MCP | Last SCED Reserve MCP | LPC Reserve MCP |
|--------------------|--------------------|----------------------|----------------|---------------------|-----------------------|-----------------|
| 23:00:00           |                    |                      | 0.3            | \$870.40            |                       | \$870.40        |
| 23:05:00           | 0.3                | 0.3                  | 6.7            | \$310.91            | \$870.40              | \$310.91        |
| 23:10:00           | 6.7                | 6.7                  | 0.4            | \$91.63             | \$310.91              | \$91.63         |

The settled MCP is lower than the cost of clearing the reserves, resulting in uplift.

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# APPENDIX



# LPC Rerun Statistics

- PJM can rerun LPC to recalculate and post revised LMPs.

| Month    | Number of Five Minute Intervals | Number of Five Minute Intervals for which LMPs were recalculated |
|----------|---------------------------------|--|
| January  | 8,928                           | 10   |
| February | 8,064                           | 14   |
| March    | 8,916                           | 51   |
| April    | 8,640                           | 19   |
| May      | 8,928                           | 19   |
| June     | 8,640                           | 28   |
| Total    | 52,116                          | 141  |

# Recalculating Prices: OATT Language

- OATT Attachment K Appendix Section 1.10.8 (e):

*If the Office of the Interconnection discovers an error in prices and/or cleared quantities in the Day-ahead Energy Market, Real-time Energy Market, Ancillary Services Markets or Day Ahead Scheduling Reserve Market after it has posted the results for these markets on its Web site, the Office of the Interconnection **shall notify Market Participants of the error as soon as possible after it is found, but in no event later than 12:00 p.m. of the second Business Day following the Operating Day for the Ancillary Services Markets and Real-time Energy Market, and no later than 5:00 p.m. of the second Business Day following the initial publication of the results for the Day-ahead Scheduling Reserve Market and Day-ahead Energy Market.***

# Recalculating Prices: OATT Language

*After this initial notification, if the Office of the Interconnection **determines it is necessary to post modified results, it shall provide notification of its intent to do so, together with all available supporting documentation, by no later than 5:00 p.m. of the fifth Business Day following the Operating Day for the Ancillary Services Markets and Real-time Energy Market, and no later than 5:00 p.m. of the fifth Business Day following the initial publication of the results in the Day-ahead Scheduling Reserve Market and the Day-ahead Energy Market. Thereafter, the Office of the Interconnection **must post on its Web site the corrected results by no later than 5:00 p.m. of the tenth calendar day following the Operating Day for the Ancillary Services Markets, Day-ahead Energy Market and Real-time Energy Market, and no later than 5:00 p.m. of the tenth calendar day following the initial publication of the results in the Day-ahead Scheduling Reserve Market.*****



# Load Bias in RT SCED

## All executed RT SCED cases:

| Load Bias | 2018              |                              | 2019 (Jan through June) |                              |
|-----------|-------------------|------------------------------|-------------------------|------------------------------|
|           | Average Bias (MW) | Percentage of Executed Cases | Average Bias (MW)       | Percentage of Executed Cases |
| Negative  | -874              | 74.2%                        | -846                    | 73.3%                        |
| Positive  | 462               | 14.5%                        | 458                     | 14.5%                        |
| Unbiased  | 0                 | 11.3%                        | 0                       | 12.2%                        |

## Approved RT SCED cases:

| Load Bias | 2018              |                              | 2019 (Jan through June) |                              |
|-----------|-------------------|------------------------------|-------------------------|------------------------------|
|           | Average Bias (MW) | Percentage of Approved Cases | Average Bias (MW)       | Percentage of Approved Cases |
| Negative  | -874              | 77.2%                        | -837                    | 77.9%                        |
| Positive  | 466               | 12.2%                        | 463                     | 11.1%                        |
| Unbiased  | 0                 | 10.7%                        | 0                       | 11.1%                        |

# Load Bias in RT SCED cases used in LPC

| Load Bias | 2018              |                      | 2019 (Jan through June) |                      |
|-----------|-------------------|----------------------|-------------------------|----------------------|
|           | Average Bias (MW) | Percent of LPC Cases | Average Bias (MW)       | Percent of LPC Cases |
| Negative  | -864              | 77.4%                | -828                    | 78.2%                |
| Positive  | 463               | 11.7%                | 457                     | 10.7%                |
| Unbiased  | 0                 | 10.8%                | 0                       | 11.0%                |