Markets Report

MC Webinar
April 25, 2022
• PJM Wholesale Cost for 2022 YTD is $79.37/MWh, up from full-year 2021 costs of $64.07/MWh. (Slides 5 & 6)

• Slides pertaining to weather conditions, in addition to slides showing average fuel prices, generation on-line fuel mixes, and System Marginal Prices have been combined into a Market Conditions section. (Slides 8-19)

• In March, temperatures were above average for most of the month. Thus, the sum of Heating and Cooling Degree Days was below its historic average. (Slides 8-10)

• Energy use was also below its historic average for March. (Slides 8-10)

• In March, uplift exceeded $800,000 on one day. (Slides 24 & 25)
• Load-weighted average LMP for 2022 YTD is $54.61/MWh: (Slides 33 & 34)
  – March 2022 was $43.60/MWh, which is higher than March 2021 ($26.30/MWh) and March 2020 ($17.90/MWh).
• There were five 5-minute intervals that experienced shortage pricing in March. (Slides 31 & 32)
• FTR revenue adequacy for the month of March is 100% and the 2021-2022 Planning Year is currently funded at 98%. (Slides 49-52)
• Congestion values have been trending upwards. March’s value is much more in line with recent history than January’s. (Slide 50)
• Regulation and Synchronized Reserve market costs have generally tracked with energy prices over time. (Slides 65-67)
Markets Report
PJM Wholesale Cost

$/MWh

- Energy
- Reliability Capacity
- Transmission
- Other

2018: $37.83, $11.89, $8.84, $60.00
2019: $27.15, $11.05, $9.52, $48.98
2020: $21.65, $9.45, $11.03, $43.41
2021: $39.79, $11.04, $11.72, $64.07
2022: $54.16, $11.71, $11.98, $79.37
Market Conditions
The weather parameter shown in the following slide is a monthly sum of daily Heating Degree Days (HDD) and Cooling Degree Days (CDD).

Degree days represent a deviation from a baseline temperature, in this case 60 degrees for HDD and 65 degrees for CDD. As temperatures get more extreme, colder or hotter, either HDDs or CDDs, respectively, will increase.

Typically, winter months will only record HDDs, while summer months will only record CDDs. Shoulder months may have both HDDs and CDDs.

Degree Days are calculated using a daily load weighting that weights values from stations in each TO zone according to the zonal contribution to the RTO peak on that day.

Average values use data from 1998 to the most recent complete year, in this case, 2021. Averages include load data for all of TO zones in the current RTO footprint.
Historic Average Weather and Energy versus Current Month

- Current Month Total Energy
- Current Month HDD+CDD
- Average Monthly Total Energy
- Average Monthly HDD + CDD

TWh

Heating Degree Days + Cooling Degree Days


TWh
Historic Average Weather and Energy versus Current Month - Daily

- Daily Energy as a Percent of the Historic Average for March
- Daily HDD + CDD as a Percent of the Historic Average for March
- Daily Temperature as a Percent of the Historic Average for March

Percent of Daily Average

0% 50% 100% 150% 200%

Average Fuel Prices - Daily

% Deviation from Monthly Average Fuel Price

Fuel Price Source: S&P Global Platts

- Average Gas: $4.47
- Average Coal: $4.79
- Average Oil: $24.16
- Average LMP: $43.14
Daily Difference Between Day-Ahead and Real-Time System Marginal Prices

Positive values represent days when the DA daily average price was higher than RT. Negative values represent days when the DA price was lower.

Average price difference for March = $1.84
Load Forecast Error - March Daily Peaks, 10:00 Forecast

Chart showing error at peak hour and weekend/holiday periods.
PJM prepares a day-ahead load forecast at 10:00 am for use by our members. This forecast is not used to clear the day-ahead market and is not utilized for the reliability tools that run subsequent to the day-ahead market.

On March 12, a large storm was impacting the PJM footprint with snow, rain and a dramatic drop in temperature from the day prior. This dynamic weather, coupled with impacts to behind-the-meter solar production, lead to larger than normal error in our forecast models. On March 16, the morning peak forecast was impacted by model error, due in part to the Daylight Saving Time shift the weekend before, and over-forecasted temperatures in the Western zones.
Monthly Generation by Fuel

'Other' includes Hydro, Oil, Solar, Wind, and Other
'Other' includes Flywheels, Multiple Fuels, Storage, and Other Renewables.
Daily Generation by Fuel - March

'Mother' includes Hydro, Oil, Solar, Wind, and Other
Daily Generation by Fuel, Other - March

‘Other’ includes Flywheels, Multiple Fuels, Storage, and Other Renewables
Operating Reserve

(Uplift)
Monthly Uplift - $/MWh Load

- Day-Ahead Operating Reserve
- Balancing Operating Reserve
- Reactive
- Blackstart
- Lost Opportunity Cost

$/MWh

- $0.5
- $0.4
- $0.3
- $0.2
- $0.1
- $0.0

MARCH 2020 to MARCH 2022

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Zonal Uplift - March

- Day-Ahead Operating Reserve
- Balancing Operating Reserve
- Reactive
- Blackstart
- Lost Opportunity Cost

$ Millions

- AECO
- AEP
- APS
- ATSI
- BGE
- COMED
- DAY
- DEOK
- DOM
- DPL
- DUQ
- EKPC
- JCPL
- METED
- PECO
- PENELEC
- PEPCO
- PPL
- PSEG
Daily Uplift - March

$ Millions

Day-Ahead Operating Reserve
Balancing Operating Reserve
Reactive
Blackstart
Lost Opportunity Cost

$2.0
$1.5
$1.0
$0.5
$0.0

01MAR2022 02MAR2022 03MAR2022 04MAR2022 05MAR2022 06MAR2022 07MAR2022 08MAR2022 09MAR2022 10MAR2022 11MAR22 12MAR22 13MAR22 14MAR22 15MAR22 16MAR22 17MAR22 18MAR22 19MAR22 20MAR22 21MAR22 22MAR22 23MAR22 24MAR22 25MAR22 26MAR22 27MAR22 28MAR22 29MAR22 30MAR22 31MAR2022
• In March, uplift exceeded $800,000 on one day – March 23\textsuperscript{rd}.
• Contributing factors to uplift were:
  • A localized issue not allocated to members

More information on Uplift can be found on the PJM website at Drivers of Uplift
Percent of Total CT, CC and Steam Hours with LMP < Offer
• Beginning in December 2008, the daily Balancing Operating Reserves (BOR) rate was replaced with six different BOR rates: RTO BOR for Reliability Rate, RTO BOR for Deviations Rate, East BOR for Reliability Rate, East BOR for Deviations Rate, West BOR for Reliability Rate, West BOR for Deviations Rate.

• Reliability rates are charged to all real-time load and exports, whereas deviation rates, as before, are charged only to real-time deviations. RTO rates are charged to the whole footprint, whereas East and West rate adders are charged based on location.
Reliability Balancing Operating Reserve Rates

$/MWh

RTO
East
West

MAR20 MAY20 AUG20 NOV20 MAR21 MAY21 AUG21 NOV21 MAR22
Deviation Balancing Operating Reserve Rates

- RTO
- East
- West

$/MWh

- MAR20
- MAY20
- AUG20
- NOV20
- MAR21
- MAY21
- AUG21
- NOV21
- MAR22
Energy Market

LMP Summary
Shortage Pricing Intervals

- MAD Primary Reserves
- MAD Synchronized Reserves
- RTO Primary Reserves
- RTO Synchronized Reserves

Count of Shortage Intervals

- APR21
- MAY21
- JUN21
- JUL21
- AUG21
- SEP21
- OCT21
- NOV21
- DEC21
- JAN22
- FEB22
- MAR22
<table>
<thead>
<tr>
<th>Date</th>
<th>5-Minute Interval</th>
<th>Reserve Penalty Factors</th>
<th>5-Minute Interval SMP</th>
<th>Hourly Integrated SMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wednesday, March 2, 2022</td>
<td>17:25 - 17:30</td>
<td>RTO Synchronized Reserves; MAD Synchronized Reserves</td>
<td>$653.14</td>
<td>$166.68</td>
</tr>
<tr>
<td>Wednesday, March 2, 2022</td>
<td>17:30 - 17:35</td>
<td>RTO Synchronized Reserves; MAD Synchronized Reserves</td>
<td>$875.00</td>
<td>$166.68</td>
</tr>
<tr>
<td>Saturday, March 12, 2022</td>
<td>10:20 - 10:25</td>
<td>RTO Synchronized Reserves; MAD Synchronized Reserves</td>
<td>$740.58</td>
<td>$139.27</td>
</tr>
<tr>
<td>Sunday, March 20, 2022</td>
<td>19:40 - 19:45</td>
<td>RTO Synchronized Reserves; MAD Synchronized Reserves</td>
<td>$639.00</td>
<td>$122.90</td>
</tr>
<tr>
<td>Monday, March 21, 2022</td>
<td>6:40 - 6:45</td>
<td>RTO Synchronized Reserves</td>
<td>$324.73</td>
<td>$100.33</td>
</tr>
</tbody>
</table>

Information on constraints and shadow prices can be found here:

Fuel Cost Adjusted LMP (Referenced to 1999 Fuel Prices)

- Fuel Cost Adjusted LMP
- Load Weighted LMP

$/MWh

Spikes seen in March and April 2021 are incorrect and due to a software bug which has since been fixed. The February 2022 rate is due to reruns for the Lanexa-Dunsville outage.
Energy Market

Demand Response Summary
Demand Side Response Estimated Revenue

- Capacity
- Ancillary Services
- Emergency Energy
- Economic Energy
- Economic Energy Incentives

$ Millions

Economic Demand Response Activity

*Data for the last few months are subject to significant change due to the settlement window.
Total Registered MW in PJM's Economic Demand Response
Energy Market

Virtual Activity Summary
The following six charts depict trends in submitted and cleared virtual and up-to-congestion transactions, in terms of number and volume, into the PJM Energy Market. The first two of these charts show the submitted and cleared increment and decrement bids (virtual transactions or virtuals) and they are the same as what was previously being presented in this report. The two charts after them display the trends in submitted and cleared up-to-congestion transactions into the PJM Energy Market. The last two of these six charts combine the virtual and up-to-congestion transactions and show the sum of these two categories.

To clarify what a bid or transaction is, please consider the following example: An offer (increment, decrement or up-to-congestion) of 10 MW, valid for eight hours for a given day, is captured in the charts as eight submitted bids/transactions and 80 submitted MWh. If this offer fully clears for three of the hours it was submitted for, it shows in the charts as three cleared bids/transactions and 30 cleared MWh.
Virtual Bids (INC's & DEC's) - Total Number

Number of Bids (Millions)

- Submitted Bids
- Cleared Bids

<table>
<thead>
<tr>
<th>Month</th>
<th>MAR20</th>
<th>APR20</th>
<th>MAY20</th>
<th>JUN20</th>
<th>JUL20</th>
<th>AUG20</th>
<th>SEP20</th>
<th>OCT20</th>
<th>NOV20</th>
<th>DEC20</th>
<th>JAN21</th>
<th>FEB21</th>
<th>MAR21</th>
<th>APR21</th>
<th>MAY21</th>
<th>JUN21</th>
<th>JUL21</th>
<th>AUG21</th>
<th>SEP21</th>
<th>OCT21</th>
<th>NOV21</th>
<th>DEC21</th>
<th>JAN22</th>
<th>FEB22</th>
<th>MAR22</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
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<td>1.5</td>
</tr>
</tbody>
</table>
Virtual Bids (INC & DEC) - Total Volume

MWh (Millions)

- Submitted MWh
- Cleared MWh

| Month  | MAR20 | APR20 | MAY20 | JUN20 | JUL20 | AUG20 | SEP20 | OCT20 | NOV20 | DEC20 | JAN21 | FEB21 | MAR21 | APR21 | MAY21 | JUN21 | JUL21 | AUG21 | SEP21 | OCT21 | NOV21 | DEC21 | JAN22 | FEB22 | MAR22 |
|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
Up-To-Congestion Transactions - Total Number
INCs, DECs and Up-To-Congestion Transactions - Total Number
INCs, DECs and Up-To-Congestion Transactions - Total Volume
Energy Market

Congestion and FTR Summary
<table>
<thead>
<tr>
<th>Period</th>
<th>Surplus / Underfunding</th>
<th>Payout Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>March, 2022</td>
<td>$6,536,951</td>
<td>100%</td>
</tr>
<tr>
<td>2022</td>
<td>$59,330,522</td>
<td>100%</td>
</tr>
<tr>
<td>2021/2022</td>
<td>$-40,154,879</td>
<td>98%</td>
</tr>
</tbody>
</table>
Ten Most Heavily Congested Transmission Facilities - Overall, March

Overall, March

The ten most heavily congested facilities account for 62% of total congestion for March.

Nottingham Reactor 230 (PECO)

Prest-Tibb 138 kV (MISO)

Cumberland-Juniata 230 (PPL)

Conastone-Peach Bottom 500 (EHV)

Face Rock FAROZBR 138 (PPL)

Lenox-N Meshoppen 115 (PN)

Lafayette 230/138 T1 (MISO)

Cedar Creek-Silver Run 230 (DPL)

Highland-Lordstown 345 (ATSI)
Ten Most Heavily Congested Transmission Facilities - Overall, 2022

The ten most heavily congested facilities account for 57% of total congestion for 2022.

- BED-BLA Interface (EHV)
- Cumberland-Juniata 230 (PPL)
- APSOUTH Interface (EHV)
- Frackville-Siegfried 230 (PPL)
- Greys Point-Harmony 1021B 115 (DOM)
- Nottingham Reactor 230 (PECO)
- Lenox-N Meshoppen 115 (PN)
- AEP-DOM Interface (EHV)
- Prest-Tibb 138 kV (MISO)
- Cedar Sub-Roseland 230 Y (PSEG)
Energy Market
Interchange/Seams Summary
Hourly Difference Between PJM and MISO Real-Time Prices

Positive values represent hours when the PJM price was higher. Negative values represent hours when the PJM price was lower.

Average price difference for March = $-2.23
Percent of hours in which the direction of flow is consistent with price differentials = 60.75%
Positive values represent hours when the PJM price was higher. Negative values represent hours when the PJM price was lower.
Hourly Difference Between PJM and NYISO Real-Time Prices

Positive values represent hours when the PJM price was higher. Negative values represent hours when the PJM price was lower.

Average price difference for March = $-3.49
Percent of hours in which the direction of flow is consistent with price differentials = 66.80%
Hourly Difference Between PJM and NYISO Day-Ahead Prices

Positive values represent hours when the PJM price was higher. Negative values represent hours when the PJM price was lower.

Average price difference for March = $-2.28
Negative M2M Credit represents PJM payment to MISO
Ancillary Service Market

Summary
Regulation Costs

$ Millions

- MAR20
- APR20
- MAY20
- JUN20
- JUL20
- AUG20
- SEP20
- OCT20
- NOV20
- DEC20
- JAN21
- FEB21
- MAR21
- APR21
- MAY21
- JUN21
- JUL21
- AUG21
- SEP21
- OCT21
- NOV21
- DEC21
- JAN22
- FEB22
- MAR22
Synchronized Reserve and Synchronous Condenser Costs

$ Millions

- Synchronized Reserve Market Payments
- Synchronous Condenser Payments

Data for each month (MAR20 to MAR22) is shown, with varying amounts for each category.
Load-Adjusted Synchronized Reserve and Synchronous Condenser Costs

Synchronized Reserve Market Payments / MWh
Synchronous Condenser Payments / MWh

Cents/MWh

MARCH 2020
APRIL 2020
MAY 2020
JUNE 2020
JULY 2020
AUGUST 2020
SEPTEMBER 2020
OCTOBER 2020
NOVEMBER 2020
DECEMBER 2020
JANUARY 2021
FEBRUARY 2021
MARCH 2021
APRIL 2021
MAY 2021
JUNE 2021
JULY 2021
AUGUST 2021
SEPTEMBER 2021
OCTOBER 2021
NOVEMBER 2021
DECEMBER 2021
JANUARY 2022
FEBRUARY 2022
MARCH 2022
DR Participation in PJM Synchronized Reserve Markets

- **Total Payments ($ Millions)**
- **MWh Cleared (MWh)**

$ Millions

$0.0  $0.5  $1.0  $1.5  $2.0

MWh

0  50,000  100,000  150,000  200,000

- MAR20
- APR20
- MAY20
- JUN20
- JUL20
- AUG20
- SEP20
- OCT20
- NOV20
- DEC20
- JAN21
- FEB21
- MAR21
- APR21
- MAY21
- JUN21
- JUL21
- AUG21
- SEP21
- OCT21
- NOV21
- DEC21
- JAN22
- FEB22
- MAR22
Synchronized Reserve Market Daily Prices and Charges

- Total Daily Synchronized Reserve Charges ($ Millions)
- Minimum Interval Price ($/MWh)
- Average Interval Price ($/MWh)
- Maximum Interval Price ($/MWh)

Graph showing daily prices and charges from March 1 to March 31, 2022.
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