Markets Report

MC Webinar
December 19, 2022
• PJM Wholesale Cost 2022 is $96.68/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 8-22)

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

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

• In November, uplift exceeded $800,000 on five days. (Slides 25 & 26)
• Load-weighted average LMP for 2022 is $74.01/MWh: (Slides 35-37)
  – November 2022 was $52.90/MWh, which is lower than November 2021 ($63.00/MWh) but higher than November 2020 ($20.70/MWh). (Appendix)

• There were no 5-minute intervals that experienced shortage pricing in November. (Slides 33-34)

• FTR revenue adequacy for the month of November is 99% and the 2022-2023 Planning Year is currently funded at 95%. (Slides 52-55)

• Congestion values have been trending upwards. November’s value is in-line with recent history. (Slide 53)

• Regulation and Synchronized Reserve market costs have generally tracked with energy prices over time. (Slides 69-71)
PJM Wholesale Cost

- **Energy**
- **Reliability Capacity**
- **Transmission**
- **Other**

Year | Energy | Reliability Capacity | Transmission | Other | Total
--- | --- | --- | --- | --- | ---
2018 | $37.83 | $11.05 | $27.15 | | $60.00
2019 | $21.65 | $9.45 | $11.03 | $5.03 | $48.98
2020 | $21.65 | $9.45 | $11.03 | | $43.13
2021 | $39.79 | $11.04 | $11.72 | $12.57 | $64.07
2022 | $74.01 | $8.32 | $12.57 | $96.68

Note: The total cost for 2022 is $96.68, with Energy accounting for $74.01, Reliability Capacity for $8.32, Transmission for $12.57.
PJM Wholesale Cost - Other

- Regulation
- Operating Reserve
- PJM Cost
- Reactive
- Transmission Owner Control
- Synchronized Reserve
- Black Start

$/MWh

2018: $1.44
  - Regulation: $0.18
  - Operating Reserve: $0.25
  - PJM Cost: $0.36
  - Reactive: $0.41
  - Transmission Owner Control: $0.38
  - Synchronized Reserve: $0.38
  - Black Start: $0.25

2019: $1.26
  - Regulation: $0.18
  - Operating Reserve: $0.44
  - PJM Cost: $0.38
  - Reactive: $0.38
  - Transmission Owner Control: $0.40
  - Synchronized Reserve: $0.47
  - Black Start: $0.47

2020: $1.28
  - Regulation: $0.18
  - Operating Reserve: $0.47
  - PJM Cost: $0.38
  - Reactive: $0.38
  - Transmission Owner Control: $0.42
  - Synchronized Reserve: $0.23
  - Black Start: $0.23

2021: $1.51
  - Regulation: $0.18
  - Operating Reserve: $0.49
  - PJM Cost: $0.47
  - Reactive: $0.40
  - Transmission Owner Control: $0.33
  - Synchronized Reserve: $0.29
  - Black Start: $0.29

2022: $1.79
  - Regulation: $0.18
  - Operating Reserve: $0.50
  - PJM Cost: $0.49
  - Reactive: $0.40
  - Transmission Owner Control: $0.34
  - Synchronized Reserve: $0.29
  - Black Start: $0.29
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, 2020. Averages include load data for all of TO zones in the current RTO footprint.
Historic Average Weather and Energy versus Current Month
Historic Average Weather and Energy versus Current Month - Daily

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

Percent of Daily Average

0% 50% 100% 150% 200% 250% 300%

Average Fuel Prices - Monthly

Monthly Average Fuel Price ($/MMBtu)

- Average Natural Gas
- Average Coal
- Average Real-time LMP

Fuel Price Source: S&P Global Platts
Average Fuel Prices - Daily

% Deviation from Monthly Average Fuel Price

Fuel Price Source: S&P Global Platts

- Average Gas: $4.66
- Average Coal: $6.71
- Average Oil: $22.83
- Average LMP: $52.12
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 November = $2.18

Difference between DA and RT SMP - $
Load Forecast Error - Monthly Absolute Error, 10:00 Forecast

The chart displays the load forecast error for monthly absolute error from November-December 2020 to November 2022, showing data for all hours and peak hours only. The chart includes data for winter and summer seasons, as well as 25-month averages.
Load Forecast Error - November Daily Peaks, 10:00 Forecast

- Error at Peak Hour
- Weekend / Holiday

Graph showing the error at peak hours with data points for each day from 1 to 30, with error percentages ranging from -8% to 8%.
Load Forecast Error

- 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.

Load forecast error experienced in November was primarily driven by unusual weather. Temperatures were unseasonably warm at times, and that caused the peaks of November 6\textsuperscript{th} and 25\textsuperscript{th} to be over-forecasted. Error on the 25\textsuperscript{th}, the Friday after Thanksgiving, may have been also been caused in part by the holiday.

Under-forecasting on November 12\textsuperscript{th} and 30\textsuperscript{th} happened at the end of stretches of warm weather. On these days, temperatures dropped drastically throughout the day, and the models struggled with this unusual temperature profile.

On November 15\textsuperscript{th} and 17\textsuperscript{th}, under-forecasting was driven by temperatures coming in cooler than expected in the afternoons and evenings.
Monthly Generation by Fuel

'Mother' includes Hydro, Oil, Solar, Wind, and Other
Monthly Generation by Fuel, Other

'Mother' includes Flywheels, Multiple Fuels, Storage, and Other Renewables
Daily Generation by Fuel, Other - November

'Mother' includes Flywheels, Multiple Fuels, Storage, and Other Renewables
Operating Reserve
(Uplift)
Monthly Uplift

$ Millions

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

$0 $10 $20 $30 $40 $50

NOV20 DEC20 JAN21 FEB21 MAR21 APR21 MAY21 JUN21 JUL21 AUG21 SEP21 OCT21 NOV21 DEC21 JAN22 FEB22 MAR22 APR22 MAY22 JUN22 JUL22 AUG22 SEP22 OCT22 NOV22
• In November, uplift exceeded $800,000 on five days -
• Contributing factors to uplift were:

  The high uplift days are a result of CTs and steam units running for localized congestion.

• 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

<table>
<thead>
<tr>
<th></th>
<th>NOV20</th>
<th>JAN21</th>
<th>MAY21</th>
<th>AUG21</th>
<th>NOV21</th>
<th>JAN22</th>
<th>MAY22</th>
<th>AUG22</th>
<th>NOV22</th>
</tr>
</thead>
<tbody>
<tr>
<td>RTO</td>
<td>0.05</td>
<td>0.10</td>
<td>0.15</td>
<td>0.10</td>
<td>0.15</td>
<td>0.10</td>
<td>0.05</td>
<td>0.10</td>
<td>0.05</td>
</tr>
<tr>
<td>East</td>
<td>0.02</td>
<td>0.03</td>
<td>0.04</td>
<td>0.01</td>
<td>0.02</td>
<td>0.03</td>
<td>0.01</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>West</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>
Energy Market

LMP Summary
Shortage Pricing Intervals

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

Count of Shortage Intervals

DEC21 | JAN22 | FEB22 | MAR22 | APR22 | MAY22 | JUN22 | JUL22 | AUG22 | SEP22 | OCT22 | NOV22

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40
Information on constraints and shadow prices can be found here:

http://dataminer2.pjm.com/feed/rt_marginal_value
Monthly Load-Weighted Average Real-time LMP

<table>
<thead>
<tr>
<th>Month</th>
<th>Price ($/MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOV20</td>
<td>$21</td>
</tr>
<tr>
<td>DEC20</td>
<td>$26</td>
</tr>
<tr>
<td>JAN21</td>
<td>$25</td>
</tr>
<tr>
<td>FEB21</td>
<td>$42</td>
</tr>
<tr>
<td>MAR21</td>
<td>$26</td>
</tr>
<tr>
<td>APR21</td>
<td>$27</td>
</tr>
<tr>
<td>MAY21</td>
<td>$29</td>
</tr>
<tr>
<td>JUN21</td>
<td>$34</td>
</tr>
<tr>
<td>JUL21</td>
<td>$37</td>
</tr>
<tr>
<td>AUG21</td>
<td>$47</td>
</tr>
<tr>
<td>SEP21</td>
<td>$50</td>
</tr>
<tr>
<td>OCT21</td>
<td>$58</td>
</tr>
<tr>
<td>NOV21</td>
<td>$63</td>
</tr>
<tr>
<td>DEC21</td>
<td>$69</td>
</tr>
<tr>
<td>JAN22</td>
<td>$39</td>
</tr>
<tr>
<td>FEB22</td>
<td>$47</td>
</tr>
<tr>
<td>MAR22</td>
<td>$44</td>
</tr>
<tr>
<td>APR22</td>
<td>$64</td>
</tr>
<tr>
<td>MAY22</td>
<td>$98</td>
</tr>
<tr>
<td>JUN22</td>
<td>$93</td>
</tr>
<tr>
<td>JUL22</td>
<td>$114</td>
</tr>
<tr>
<td>AUG22</td>
<td>$93</td>
</tr>
<tr>
<td>SEP22</td>
<td>$78</td>
</tr>
<tr>
<td>OCT22</td>
<td>$56</td>
</tr>
<tr>
<td>NOV22</td>
<td>$53</td>
</tr>
</tbody>
</table>
Fuel Cost Adjusted LMP (Referenced to 1999 Fuel Prices)
Spikes seen in March and April 2021 are incorrect and due to a software bug which has since been fixed.
Energy Market

Demand Response Summary
Demand Side Response Estimated Revenue

- Capacity
- Ancillary Services
- Emergency Energy
- Economic Energy
- Economic Energy Incentives
- Capacity Bonus Payment
- Price Responsive Demand Credits

$ Millions

*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

MW

- NOV20
- JAN21
- MAY21
- AUG21
- NOV21
- JAN22
- MAY22
- AUG22
- NOV22

3,000
2,500
2,000
1,500
1,000
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 (INCs & DECs) - Total Number

Number of Bids (Millions)

- Submitted Bids
- Cleared Bids

NOV20: Submitted Bids - 1.5, Cleared Bids - 0.5
DEC20: Submitted Bids - 1.7, Cleared Bids - 0.4
JAN21: Submitted Bids - 1.8, Cleared Bids - 0.4
FEB21: Submitted Bids - 1.6, Cleared Bids - 0.4
MAR21: Submitted Bids - 1.7, Cleared Bids - 0.4
APR21: Submitted Bids - 1.6, Cleared Bids - 0.4
MAY21: Submitted Bids - 1.7, Cleared Bids - 0.4
JUN21: Submitted Bids - 1.6, Cleared Bids - 0.4
JUL21: Submitted Bids - 1.7, Cleared Bids - 0.4
AUG21: Submitted Bids - 1.6, Cleared Bids - 0.4
SEP21: Submitted Bids - 1.7, Cleared Bids - 0.4
OCT21: Submitted Bids - 1.8, Cleared Bids - 0.4
NOV21: Submitted Bids - 1.6, Cleared Bids - 0.4
DEC21: Submitted Bids - 1.8, Cleared Bids - 0.4
JAN22: Submitted Bids - 2.0, Cleared Bids - 0.5
FEB22: Submitted Bids - 1.8, Cleared Bids - 0.4
MAR22: Submitted Bids - 1.6, Cleared Bids - 0.4
APR22: Submitted Bids - 1.7, Cleared Bids - 0.4
MAY22: Submitted Bids - 1.5, Cleared Bids - 0.4
JUN22: Submitted Bids - 1.6, Cleared Bids - 0.4
JUL22: Submitted Bids - 1.7, Cleared Bids - 0.4
AUG22: Submitted Bids - 1.6, Cleared Bids - 0.4
SEP22: Submitted Bids - 1.7, Cleared Bids - 0.4
OCT22: Submitted Bids - 1.8, Cleared Bids - 0.4
NOV22: Submitted Bids - 1.9, Cleared Bids - 0.5
Virtual Bids (INCs & DECs) - Total Volume

- Submitted MWh
- Cleared MWh

MWh (Millions)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Up-To-Congestion Transactions - Total Volume

MWh ( Millions)

Submitted MWh
Cleared MWh

NOV20  DEC20  JAN21  FEB21  MAR21  APR21  MAY21  JUN21  JUL21  AUG21  SEP21  OCT21  NOV21  DEC21  JAN22  FEB22  MAR22  APR22  MAY22  JUN22  JUL22  AUG22  SEP22  OCT22  NOV22
INCs, DECs and Up-To-Congestion Transactions - Total Number

Number of Transactions (Millions)

- Submitted Transactions
- Cleared Transactions

|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
INCs, DECs and Up-To-Congestion Transactions - Total Volume

MWh (Millions)

Submitted MWh
Cleared MWh

NOV20 DEC20 JAN21 FEB21 MAR21 APR21 MAY21 JUN21 JUL21 AUG21 SEP21 OCT21 NOV21 DEC21 JAN22 FEB22 MAR22 APR22 MAY22 JUN22 JUL22 AUG22 SEP22 OCT22 NOV22
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>November 2022</td>
<td>$-1,700,837</td>
<td>99%</td>
</tr>
<tr>
<td>2022</td>
<td>$157,983,460</td>
<td>100%</td>
</tr>
<tr>
<td>2022/2023</td>
<td>$63,877,440</td>
<td>100%</td>
</tr>
</tbody>
</table>
Ten Most Heavily Congested Transmission Facilities - Overall, November

The ten most heavily congested facilities account for 65% of total congestion for November.
Ten Most Heavily Congested Transmission Facilities - Overall, 2022

The ten most heavily congested facilities account for 47% of total congestion for 2022.
Balancing Congestion Charge Revenues (BLI 2215)
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 November = $0.65
Percent of hours in which the direction of flow is consistent with price differentials = 48.06%
Hourly Difference Between PJM and MISO 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 November = $-0.83
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 November = $2.73
Percent of hours in which the direction of flow is consistent with price differentials = 66.67%
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 November = $4.34
Negative M2M Credit represents PJM payment to MISO
PJM-NYISO Market-to-Market Coordination Settlement

Negative M2M Credit represents PJM payment to NYISO
Ancillary Service Market Summary
DR Participation in PJM Synchronized Reserve Markets

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

$ Millions

MWh

NOV20  DEC20  JAN21  FEB21  MAR21  APR21  MAY21  JUN21  JUL21  AUG21  SEP21  OCT21  NOV21  DEC21  JAN22  FEB22  MAR22  APR22  MAY22  JUN22  JUL22  AUG22  SEP22  OCT22  NOV22
Regulation Market Daily Prices and Charges

- Total Daily Regulation Charges ($ Millions)
- Minimum Interval Price ($/MWh)
- Average Interval Price ($/MWh)
- Maximum Interval Price ($/MWh)
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)**

The chart shows the daily prices and charges for synchronized reserve markets over a period from 01NOV22 to 30NOV22. The y-axis represents the $ Millions, while the x-axis represents the dates from 01NOV22 to 30NOV22.
Contact

Jennifer Warner-Freeman
Jennifer.Freeman@pjm.com

Member Hotline
(610) 666 – 8980
(866) 400 – 8980
custsvc@pjm.com