Markets Report

MC Webinar
December 13, 2021
PJM Wholesale Cost for 2021 is $63.97/MWh, up from full-year 2020 costs of $43.41/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 November, temperatures were below average throughout the month. Thus, the sum of Heating Degree Days was above their historic average. (Slides 8-10)

Energy use was approximately equal to its historic average for November. (Slides 8-10)

In November, uplift exceeded $800,000 on eleven days. (Slides 24 & 25)
Executive Summary

• Load-weighted average LMP for 2021 is $39.86/MWh: (Slides 33 & 34)
  – November 2021 was $63.00/MWh, which is higher than November 2020 ($20.70/MWh) and also higher than November 2019 ($27.20/MWh).

• There were four 5-minute intervals that experienced shortage pricing in November. (Slides 31 & 32)

• FTR revenue adequacy for the month of November is 81% and the 2021-2022 Planning Year is currently funded at 95%. (Slides 49-52)

• Congestion values have been trending upwards with November's level being the highest level in the last several years. (Slide 50)

• Regulation and Synchronized Reserve market costs have generally tracked with energy prices over time. (Slides 65-67)
Markets Report
PJM Wholesale Cost - Other

$/MWh

2017 | 2018 | 2019 | 2020 | 2021

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

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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

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

<table>
<thead>
<tr>
<th>Month</th>
<th>Heating Degree Days</th>
<th>Heating Degree Days + Cooling Degree Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nov20</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Dec20</td>
<td>0</td>
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<td>Oct21</td>
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<td>0</td>
</tr>
<tr>
<td>Nov21</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
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
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.
Load Forecast Error – Monthly Absolute Error, 10:00 Forecast

The chart illustrates the monthly absolute error in load forecasting for different months from 2019 to 2021. It categorizes the data into All Hours, Peak Hours Only, Winter, and Summer. The dashed lines represent the 25-month average for comparison.
Load Forecast Error – November Daily Peaks, 10:00 Forecast

- Error at Peak Hour
- Weekend / Holiday

![Graph showing load forecast error](image)
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.

- **PJM experienced some of the first cold weather of the season early in the month of November, contributing to the load forecast model error observed on the morning of November 6th. The most significant outliers in the hourly error this month occurred over Thanksgiving and Black Friday during non-peak hours. The unique and highly weather-dependent nature of this holiday load paired with a passing cold front made this year’s shape particularly difficult to forecast, though manual adjustments made to the model output were beneficial.**
Monthly Generation by Fuel

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

'MOther' includes Hydro, Oil, Solar, Wind, and Other
Daily Generation by Fuel, Other - November

'Mother' includes Flywheels, Multiple Fuels, Storage, and Other Renewables
Operating Reserve

(Uplift)
Zonal Uplift - November

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

<table>
<thead>
<tr>
<th>Company</th>
<th>$ Millions</th>
</tr>
</thead>
<tbody>
<tr>
<td>AECO</td>
<td></td>
</tr>
<tr>
<td>AEP</td>
<td></td>
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<tr>
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<td>PPL</td>
<td></td>
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</tr>
</tbody>
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In October, uplift exceeded $800,000 on eleven days. Contributing factors to uplift were:

- Constraint volatility is contributing to the more recent trend of higher BOR/LOC.

More information on Uplift can be found on PJM’s 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.
Deviations Balancing Operating Reserve Rates

$/MWh

RTO
East
West

NOV19  JAN20  MAY20  AUG20  OCT20  JAN21  MAY21  AUG21  NOV21
Energy Market

LMP Summary
Shortage Pricing Intervals

Count of Shortage Intervals

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

Month: DEC20 JAN21 FEB21 MAR21 APR21 MAY21 JUN21 JUL21 AUG21 SEP21 OCT21 NOV21

Values: 0, 1, 3, 4, 5, 6, 7, 8, 9, 10
Information on constraints and shadow prices can be found here: [http://dataminer2.pjm.com/feed/rt_marginal_value](http://dataminer2.pjm.com/feed/rt_marginal_value)

<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>
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<tr>
<td>Friday, November 12, 2021</td>
<td>17:20 - 17:25</td>
<td>2nd step penalty for Synchronized Reserve deficiencies in MAD</td>
<td>$710.58</td>
<td>$346.46</td>
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<td>Friday, November 12, 2021</td>
<td>17:25 - 17:30</td>
<td>2nd step penalty for Synchronized Reserve deficiencies in MAD</td>
<td>$702.09</td>
<td>$346.46</td>
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<tr>
<td>Friday, November 12, 2021</td>
<td>17:30 - 17:35</td>
<td>2nd step penalty for Synchronized Reserve deficiencies in MAD</td>
<td>$918.17</td>
<td>$346.46</td>
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<td>Friday, November 12, 2021</td>
<td>17:35 - 17:40</td>
<td>2nd step penalty for Synchronized Reserve deficiencies in MAD</td>
<td>$918.17</td>
<td>$346.46</td>
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</table>
Load-Weighted Average LMP

$/MWh

- $27
- $23
- $22
- $19
- $18
- $18
- $20
- $27
- $25
- $20
- $22
- $21
- $26
- $25
- $42
- $26
- $27
- $29
- $34
- $37
- $47
- $50
- $58
- $63

From NOV19 to NOV21.
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

$ Millions


- Capacity
- Ancillary Services
- Emergency Energy
- Economic Energy
- Economic Energy Incentives
*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 (INCs & DECs) - Total Number

Number of Bids (Millions)

- Submitted Bids
- Cleared Bids

<table>
<thead>
<tr>
<th>Month</th>
<th>NOV19</th>
<th>DEC19</th>
<th>JAN20</th>
<th>FEB20</th>
<th>MAR20</th>
<th>APR20</th>
<th>MAY20</th>
<th>JUN20</th>
<th>JUL20</th>
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<th>SEP20</th>
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<td>1.40</td>
<td>1.35</td>
<td>1.30</td>
<td>1.25</td>
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<td>0.80</td>
<td>0.75</td>
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<td>0.65</td>
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<td>0.55</td>
<td>0.50</td>
<td>0.45</td>
<td>0.40</td>
<td>0.35</td>
<td>0.30</td>
<td>0.25</td>
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Up-To-Congestion Transactions - Total Number

Number of Transactions (Millions)

- Submitted Transactions
- Cleared Transactions

Month: NOV19, DEC19, JAN20, FEB20, MAR20, APR20, MAY20, JUN20, JUL20, AUG20, SEP20, OCT20, NOV20, DEC20, JAN21, FEB21, MAR21, APR21, MAY21, JUN21, JUL21, AUG21, SEP21, OCT21, NOV21
Up-To-Congestion Transactions - Total Volume
INCs, DECs and Up-To-Congestion Transactions - Total Number

Number of Transactions (Millions)

- Submitted Transactions
- Cleared Transactions

<table>
<thead>
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<th>Cleared</th>
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<td>1</td>
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<tr>
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<td>1</td>
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<tr>
<td>JAN20</td>
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<tr>
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<tr>
<td>NOV21</td>
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</tbody>
</table>
INCs, DECs and Up-To-Congestion Transactions - Total Volume

MWh (Millions)

- Submitted MWh
- Cleared MWh

|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
Energy Market

Congestion and FTR Summary
<table>
<thead>
<tr>
<th>Period</th>
<th>Surplus / Underfunding</th>
<th>Payout Ratio</th>
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</thead>
<tbody>
<tr>
<td>November, 2021</td>
<td>$-48,173,341</td>
<td>82%</td>
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<tr>
<td>2021</td>
<td>$-86,155,953</td>
<td>94%</td>
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<tr>
<td>2021/2022</td>
<td>$-79,758,383</td>
<td>91%</td>
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</table>
FTR Revenue vs. FTR Target Allocation

- Total FTR Revenues
- Total FTR Targets

$ Millions

$0  $50  $100  $150  $200  $250  $300

- NOV19
- DEC19
- JAN20
- FEB20
- MAR20
- APR20
- MAY20
- JUN20
- JUL20
- AUG20
- SEP20
- OCT20
- NOV20
- DEC20
- JAN21
- FEB21
- MAR21
- APR21
- MAY21
- JUN21
- JUL21
- AUG21
- SEP21
- OCT21
- NOV21
Monthly FTR Payout

Monthly FTR Payout Ratio

- November 2019 (NOV19)
- December 2019 (DEC19)
- January 2020 (JAN20)
- February 2020 (FEB20)
- March 2020 (MAR20)
- April 2020 (APR20)
- May 2020 (MAY20)
- June 2020 (JUN20)
- July 2020 (JUL20)
- August 2020 (AUG20)
- September 2020 (SEP20)
- October 2020 (OCT20)
- November 2020 (NOV20)
- December 2020 (DEC20)
- January 2021 (JAN21)
- February 2021 (FEB21)
- March 2021 (MAR21)
- April 2021 (APR21)
- May 2021 (MAY21)
- June 2021 (JUN21)
- July 2021 (JUL21)
- August 2021 (AUG21)
- September 2021 (SEP21)
- October 2021 (OCT21)
- November 2021 (NOV21)
Ten Most Heavily Congested Transmission Facilities - Overall, November

The ten most heavily congested facilities account for 72% of total congestion for November.
The ten most heavily congested facilities account for 44% of total congestion for 2021.

Congestion on both TMI 500/230 and Graceton-Safe Harbor impacted because construction of Market Efficiency Project 9A has been delayed and suspended due to regulatory reasons.
Energy Market

Interchange/Seams Summary
Monthly Average MISO Interface Pricing

$/MWh

- PJM MISO Price (RT)
- MISO PJM Price (RT)
- PJM MISO Price (DA)
- MISO PJM Price (DA)

NOV19  JAN20  MAY20  AUG20  OCT20  JAN21  MAY21  AUG21  NOV21
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 = $-1.49
Percent of hours in which the direction of flow is consistent with price differentials = 60.28%

Average + 1 Standard Deviation
Average - 1 Standard Deviation
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 = $0.42
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 = $-0.80
Percent of hours in which the direction of flow is consistent with price differentials = 53.61%
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.
Negative M2M Credit represents PJM payment to MISO
Negative M2M Credit represents PJM payment to NYISO.
Ancillary Service Market
Summary
Synchronized Reserve and Synchronous Condenser Costs

Synchronized Reserve Market Payments
Synchronous Condenser Payments

$ Millions

NOV19  DEC19  JAN20  FEB20  MAR20  APR20  MAY20  JUN20  JUL20  AUG20  SEP20  OCT20  NOV20  DEC20  JAN21  FEB21  MAR21  APR21  MAY21  JUN21  JUL21  AUG21  SEP21  OCT21  NOV21
Load-Adjusted Synchronized Reserve and Synchronous Condenser Costs

- Synchronized Reserve Market Payments / MWh
- Synchronous Condenser Payments / MWh

Cents/MWh

|       | NOV19 | DEC19 | JAN20 | FEB20 | MAR20 | APR20 | MAY20 | JUN20 | JUL20 | AUG20 | SEP20 | OCT20 | NOV20 | DEC20 | JAN21 | FEB21 | MAR21 | APR21 | MAY21 | JUN21 | JUL21 | AUG21 | SEP21 | OCT21 | NOV21 |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
DR Participation in PJM Synchronized Reserve Markets

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

$ Millions

$2.0

$1.5

$1.0

$0.5

$0.0

0

50,000

100,000

150,000

200,000

MWh

Nov19
Dec19
Jan20
Feb20
Mar20
Apr20
May20
Jun20
Jul20
Aug20
Sep20
Oct20
Nov20
Dec20
Jan21
Feb21
Mar21
Apr21
May21
Jun21
Jul21
Aug21
Sep21
Oct21
Nov21
Regulation Market Daily Prices and Charges

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

$ Millions  $/MWh

01NOV21 02NOV21 03NOV21 04NOV21 05NOV21 06NOV21 07NOV21 08NOV21 09NOV21 10NOV21 11NOV21 12NOV21 13NOV21 14NOV21 15NOV21 16NOV21 17NOV21 18NOV21 19NOV21 20NOV21 21NOV21 22NOV21 23NOV21 24NOV21 25NOV21 26NOV21 27NOV21 28NOV21 29NOV21 30NOV21
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)
Jennifer Warner-Freeman
Jennifer.Freeman@pjm.com

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