Markets Report

MC Webinar
February 21, 2023
PJM Wholesale Cost in 2023 is $55.11/MWh, down from full-year 2022 costs of $102.56/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 January, temperatures were below average for most of the month. Thus, the sum of Heating and Cooling Degree Days was also below its historic average. (Slides 8-10)

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

In January, uplift exceeded $800,000 on all but one days. (Slides 25 & 26)
• Load-weighted average LMP for 2023 is $35.71/MWh: (Slides 35-37)
  – January 2023 was $35.80/MWh, which is lower than January 2021 ($69.10/MWh) and higher than January 2021 ($25.30/MWh).

• There was three 5-minute intervals that experienced shortage pricing in January. (Slides 33-34)

• FTR revenue adequacy for the month of January is 100% and the 2022-2023 Planning Year is currently funded at 100%. (Slides 52-55)

• Congestion values have been trending upwards. However, January’s value is lower than recent months. (Slide 53)

• Regulation and Synchronized Reserve market costs have generally tracked with energy prices over time. (Slides 69-71)
Markets Report
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 January**
- **Daily HDD + CDD as a Percent of the Historic Average for January**
- **Daily Temperature as a Percent of the Historic Average for January**
Average Fuel Prices - Daily

Fuel Price Source: S&P Global Platts

- Average Gas - $3.06
- Average Coal - $5.06
- Average Oil - $21.83
- Average LMP - $35.55
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 January = -$1.01
Load Forecast Error - Monthly Absolute Error, 10:00 Forecast

The chart above illustrates the load forecast error for different periods and regions over the years 2021 to 2023. The error is measured in terms of absolute percentage, with specific data points for "All Hours," "Peak Hours Only," "Winter," and "Summer." The chart also includes 25-month average lines for comparison.
Load Forecast Error - January Daily Peaks, 10:00 Forecast
• 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.

Three days in January experienced peak load forecast error that exceeded 3%.

Sunday, January 1st was unusual in that it was the New Year’s Day holiday, but not the observed holiday, which occurred on Monday, January 2nd. This complexity made it difficult to anticipate model error, leading to over-forecasting at the evening peak.

On January 14th, the peak load was under-forecasted as temperatures throughout much of the RTO came in colder than forecasted.

The evening peak on January 30th was over-forecasted as staff worked to correct for significant under-forecasting the previous afternoon, and an unusual weather pattern existed across the RTO, with extreme cold in the western areas and unseasonably warmth in the eastern RTO.
'Other' includes Hydro, Oil, Solar, Wind, and Other
'Other' includes Flywheels, Multiple Fuels, Storage, and Other Renewables.
Daily Generation by Fuel - January

'MOther' includes Hydro, Oil, Solar, Wind, and Other

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Daily Generation by Fuel, Other - January

'Mother' 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
Uplift as a Percent of Energy Costs

The graph shows the uplift as a percent of energy costs from January 2021 to January 2023. The uplift varies significantly over time, with peaks and troughs indicating changes in energy costs relative to uplift.
• In January, uplift exceeded $800,000 on one day -

• Contributing factors to uplift were:

  On January 10, LOC was paid to unit’s that were needed after shortage cases and higher prices following a spin event.

  On January 14 and 15, localized congestion in DA didn’t materialized in RT and caused LOC.

  On January 23, the DA OR was higher due to reliability needs for north and south flows.

• 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

JAN21 APR21 JUL21 OCT21 JAN22 APR22 JUL22 OCT22 JAN23
Deviations Balancing Operating Reserve Rates

$/MWh

- RTO
- East
- West

JAN21  APR21  JUL21  OCT21  JAN22  APR22  JUL22  OCT22  JAN23
Energy Market

LMP Summary
Shortage Pricing Intervals

Count of Shortage Intervals

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

FEB22 MAR22 APR22 MAY22 JUN22 JUL22 AUG22 SEP22 OCT22 NOV22 DEC22 JAN23
<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>Tuesday, January 10, 2023</td>
<td>7:10 -  7:15</td>
<td>RTO Primary Reserves; MAD Primary Reserves</td>
<td>$1,075.69</td>
<td>$650.83</td>
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<tr>
<td>Tuesday, January 10, 2023</td>
<td>7:15 -  7:20</td>
<td>RTO Synchronized Reserves; RTO Primary Reserves; MAD Synchronized Reserves; MAD Primary Reserves</td>
<td>$3,703.69</td>
<td>$650.83</td>
</tr>
<tr>
<td>Tuesday, January 10, 2023</td>
<td>7:20 -  7:25</td>
<td>RTO Primary Reserves; MAD Primary Reserves</td>
<td>$1,814.83</td>
<td>$650.83</td>
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</table>

Information on constraints and shadow prices can be found here:

http://dataminer2.pjm.com/feed/rt_marginal_value
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
- Capacity Bonus Payment
- Price Responsive Demand Credits

*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 & DEC) - Total Volume

- Submitted MWh
- Cleared MWh

Months: JAN 21, FEB 21, MAR 21, APR 21, MAY 21, JUN 21, JUL 21, AUG 21, SEP 21, OCT 21, NOV 21, DEC 21, JAN 22, FEB 22, MAR 22, APR 22, MAY 22, JUN 22, JUL 22, AUG 22, SEP 22, OCT 22, NOV 22, DEC 22, JAN 23

MWh (Millions)
Up-To-Congestion Transactions - Total Number
Up-To-Congestion Transactions - Total Volume

MWh (Millions)

Submitted MWh
Cleared MWh

JAN21  FEB21  MAR21  APR21  MAY21  JUN21  JUL21  AUG21  SEP21  OCT21  NOV21  DEC21  JAN22  FEB22  MAR22  APR22  MAY22  JUN22  JUL22  AUG22  SEP22  OCT22  NOV22  DEC22  JAN23
INCs, DECs and Up-To-Congestion Transactions - Total Number

- Submitted Transactions
- Cleared Transactions

Days:
- JAN21
- FEB21
- MAR21
- APR21
- MAY21
- JUN21
- JUL21
- AUG21
- SEP21
- OCT21
- NOV21
- DEC21

Transactions (Millions):
- 0
- 2
- 4
- 6
- 8
- 10
INCs, DECs and Up-To-Congestion Transactions - Total Volume

MWh (Millions)

- Submitted MWh
- Cleared MWh

<table>
<thead>
<tr>
<th>Month</th>
<th>JAN21</th>
<th>FEB21</th>
<th>MAR21</th>
<th>APR21</th>
<th>MAY21</th>
<th>JUN21</th>
<th>JUL21</th>
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Energy Market

Congestion and FTR Summary
<table>
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<tr>
<th>Period</th>
<th>Surplus / Underfunding</th>
<th>Payout Ratio</th>
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<tbody>
<tr>
<td>January 2023</td>
<td>$16,993,768</td>
<td>100%</td>
</tr>
<tr>
<td>2023</td>
<td>$16,993,768</td>
<td>100%</td>
</tr>
<tr>
<td>2022/2023</td>
<td>$150,538,458</td>
<td>100%</td>
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Monthly FTR Payout Ratio

- JAN21
- FEB21
- MAR21
- APR21
- MAY21
- JUN21
- JUL21
- AUG21
- SEP21
- OCT21
- NOV21
- DEC21
- JAN22
- FEB22
- MAR22
- APR22
- MAY22
- JUN22
- JUL22
- AUG22
- SEP22
- OCT22
- NOV22
- DEC22
- JAN23

Values range from 0% to 100%.
Planning Period FTR Payout Ratio

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<tbody>
<tr>
<td>%</td>
<td>100%</td>
<td>100%</td>
<td>80%</td>
<td>70%</td>
<td>60%</td>
<td>50%</td>
<td>40%</td>
<td>30%</td>
<td>20%</td>
<td>10%</td>
<td>0%</td>
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Ten Most Heavily Congested Transmission Facilities - Overall, January

The ten most heavily congested facilities account for 77% of total congestion for January.
Ten Most Heavily Congested Transmission Facilities - Overall, 2023

The ten most heavily congested facilities account for 77% of total congestion for 2023.

- Nottingham Reactor 230 (PECO)
- Gardners-Texas Eastern 115 (METED)
- Allen IM-RPMone 345 (AEP OH IM)
- Graceton-Safe Harbor 230 (BGE)
- E Lima-Haviland 138 (AEP OH)
- Pipe Creek-Mulfb Tap 138 (AEP IM)
- Sayreville-Sayre Converter (Neptune) 230 (JCPL-NY)
- Collins 765/345 T92 (COMED)
- Fremont-W Fremont 138 (AEP OH)
- Haviland J CB 138 (AEP)
Balancing Congestion Charge Revenues (BLI 2215)
Energy Market

Interchange/Seams Summary
Monthly Average MISO Interface Pricing

$/MWh

JAN21  APR21  JUL21  OCT21  JAN22  APR22  JUL22  OCT22  JAN23

PJM MISO Price (RT)
MISO PJM Price (RT)
PJM MISO Price (DA)
MISO PJM Price (DA)
Monthly Average NYISO Interface Pricing
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 January = $-1.01
Percent of hours in which the direction of flow is consistent with price differentials = 62.10%
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 January = $-1.50
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 January = $-0.57
Percent of hours in which the direction of flow is consistent with price differentials = 61.96%
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.
PJM-MISO Market-to-Market Coordination Settlement

Negative M2M Credit represents PJM payment to MISO.
Negative M2M Credit represents PJM payment to NYISO.
Ancillary Service Market
Summary
Regulation Costs

$ Millions

|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
Synchronized Reserve and Synchronous Condenser Costs

- **Synchronized Reserve Market Payments**
- **Synchronous Condenser Payments**

$ Millions

- JAN21
- FEB21
- MAR21
- APR21
- MAY21
- JUN21
- JUL21
- AUG21
- SEP21
- OCT21
- NOV21
- DEC21
- JAN22
- FEB22
- MAR22
- APR22
- MAY22
- JUN22
- JUL22
- AUG22
- SEP22
- OCT22
- NOV22
- DEC22
- JAN23
Load-Adjusted Synchronized Reserve and Synchronous Condenser Costs

Chart showing the cost in cents per MWh for synchronized reserve market payments and synchronous condenser payments from January 2021 to January 2023. The chart highlights a significant increase in costs during the month of June 2022.

- **Synchronized Reserve Market Payments / MWh**
- **Synchronous Condenser Payments / MWh**
DR Participation in PJM Regulation Markets

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

$ Millions

25,000
20,000
15,000
10,000
5,000
0

MWh

JAN21 | FEB21 | MAR21 | APR21 | MAY21 | JUN21 | JUL21 | AUG21 | SEP21 | OCT21 | NOV21 | DEC21 | JAN22 | FEB22 | MAR22 | APR22 | MAY22 | JUN22 | JUL22 | AUG22 | SEP22 | OCT22 | NOV22 | DEC22

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DR Participation in PJM Synchronized Reserve Markets

![Chart showing DR Participation in PJM Synchronized Reserve Markets](chart-image)

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

$ Millions

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<td>300,000</td>
<td>250,000</td>
<td>200,000</td>
<td>150,000</td>
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<td>150,000</td>
<td>200,000</td>
<td>250,000</td>
<td>300,000</td>
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Regulation Market Daily Prices and Charges

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

Chart showing daily prices and charges from 01 JAN 23 to 31 JAN 23.
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 over a period from 01 Jan 2023 to 31 Jan 2023, with price spikes indicating significant variations in costs.
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