Markets Report

Jennifer Warner-Freeman
Senior Economist, Advanced Analytics
December 3, 2018
• PJM Wholesale Cost through October 2018 was $60.66/MWh, up from full-year 2017 costs of $49.64/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 7-16)

• In October, the range of temperatures was greater than a typical October, thus the sum of Heating and Cooling Degree Days was above its historic average (Slides 8-10).

• Energy use was slightly above its historic average. (Slides 8-10)

• In October uplift exceeded $800,000 on 2 days; October 4th and October 8th. (Slides 21 & 22)
Executive Summary

- Load-weighted average LMP through October 2018 is $38.93/MWh: (Slides 28-29)
  - October 2018 was $33.9/MWh, which is somewhat higher than October 2017 ($28.3/MWh) and October 2016 ($28.1/MWh).

- In June 2017, the calculation of FTR surplus was changed to no longer include Balancing congestion and Market to Market payments. (Slide 45)

- FTR revenue adequacy for the month of October is 95% and the 2018-2019 Planning Year is currently fully funded. (Slides 44-47)

- Congestion remained at relatively low levels in October. (Slide 45)

- Regulation and Synchronized Reserve market costs have generally tracked with energy prices over time. (Slides 60-62)
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, 2017. 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


0 20 40 60 80 100 1250

0 250 500 750 1000
Historic Average Weather and Energy versus Current Month - Daily

- Daily Energy as a Percent of the Historic Average for October
- Daily HDD + CDD as a Percent of the Historic Average for October
Average Fuel Prices - Daily

% Deviation from Monthly Average Fuel Price

- Average Gas - $2.91
- Average Coal - $2.41
- Average Oil - $15.38
- Average LMP - $33.57

Fuel Price Source: S&P Global Platts
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.
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 - October

'Model' includes Hydro, Oil, Solar, Wind, and Other
Daily Generation by Fuel, Other - October

‘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

$0.0 $0.2 $0.4 $0.6 $0.8 $1.0

OCT16  NOV16  DEC16  JAN17  FEB17  MAR17  APR17  MAY17  JUN17  JUL17  AUG17  SEP17  OCT17  NOV17  DEC17  JAN18  FEB18  MAR18  APR18  MAY18  JUN18  JUL18  AUG18  SEP18  OCT18
Daily Uplift - October

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

$ Millions

01OCT2018 to 31OCT2018
• In October uplift exceeded $800,000 on 2 days; October 4th and 8th.
• Contributing factors to uplift were:
  – System Outages and Congestion Control
  – Reactive Charges Associated with Area High Voltage
  – Localized Reliability Concerns

More information on Uplift can be found on PJM’s website at [Drivers of Uplift](#)
Percent of Total CC, CT 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.
Energy Market

LMP Summary
Load-Weighted Average LMP

<table>
<thead>
<tr>
<th>Month</th>
<th>LMP $/MWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>OCT16</td>
<td>$28</td>
</tr>
<tr>
<td>NOV16</td>
<td>$26</td>
</tr>
<tr>
<td>DEC16</td>
<td>$33</td>
</tr>
<tr>
<td>JAN17</td>
<td>$33</td>
</tr>
<tr>
<td>FEB17</td>
<td>$26</td>
</tr>
<tr>
<td>MAR17</td>
<td>$32</td>
</tr>
<tr>
<td>APR17</td>
<td>$29</td>
</tr>
<tr>
<td>MAY17</td>
<td>$32</td>
</tr>
<tr>
<td>JUN17</td>
<td>$28</td>
</tr>
<tr>
<td>JUL17</td>
<td>$33</td>
</tr>
<tr>
<td>AUG17</td>
<td>$28</td>
</tr>
<tr>
<td>SEP17</td>
<td>$34</td>
</tr>
<tr>
<td>OCT17</td>
<td>$28</td>
</tr>
<tr>
<td>NOV17</td>
<td>$29</td>
</tr>
<tr>
<td>DEC17</td>
<td>$41</td>
</tr>
<tr>
<td>JAN18</td>
<td>$84</td>
</tr>
<tr>
<td>FEB18</td>
<td>$26</td>
</tr>
<tr>
<td>MAR18</td>
<td>$33</td>
</tr>
<tr>
<td>APR18</td>
<td>$35</td>
</tr>
<tr>
<td>MAY18</td>
<td>$38</td>
</tr>
<tr>
<td>JUN18</td>
<td>$31</td>
</tr>
<tr>
<td>JUL18</td>
<td>$33</td>
</tr>
<tr>
<td>AUG18</td>
<td>$34</td>
</tr>
<tr>
<td>SEP18</td>
<td>$35</td>
</tr>
<tr>
<td>OCT18</td>
<td>$34</td>
</tr>
</tbody>
</table>
Fuel Cost Adjusted LMP (Referenced to 1999 Fuel Prices)
Energy Market
Demand Response Summary
Demand Side Response Estimated Revenue

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

$ 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

OCT16  DEC16  APR17  JUL17  OCT17  DEC17  APR18  JUL18  OCT18

1,500  1,600  1,700  1,800  1,900  2,000  2,100  2,200  2,300  2,400  2,500  2,600  2,700  2,800  2,900  3,000
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 (INC & DEC) - Total Number

Number of Bids (Millions)

- Submitted Bids
- Cleared Bids

OCT16  NOV16  DEC16  JAN17  FEB17  MAR17  APR17  MAY17  JUN17  JUL17  AUG17  SEP17  OCT17  NOV17  DEC17  JAN18  FEB18  MAR18  APR18  MAY18  JUN18  JUL18  AUG18  SEP18  OCT18
Up-To-Congestion Transactions - Total Number

- Submitted Transactions
- Cleared Transactions

Number of Transactions (Millions)

Jan 17: 8
Feb 17: 7
Mar 17: 6
Apr 17: 5
May 17: 4
Jun 17: 3
Jul 17: 2
Aug 17: 1
Sep 17: 0.5
Oct 17: 0.2
Nov 17: 0.1
Dec 17: 0.05
Jan 18: 0
Feb 18: 0
Mar 18: 0
Apr 18: 0
May 18: 0
Jun 18: 0
Jul 18: 0
Aug 18: 0
Sep 18: 0
Oct 18: 0

OCT16: 2
NOV16: 2
DEC16: 2
JAN17: 2
FEB17: 2
MAR17: 2
APR17: 2
MAY17: 2
JUN17: 2
JUL17: 2
AUG17: 2
SEP17: 2
OCT17: 2
NOV17: 2
DEC17: 2
JAN18: 2
FEB18: 2
MAR18: 2
APR18: 2
MAY18: 2
JUN18: 2
JUL18: 2
AUG18: 2
SEP18: 2
OCT18: 2
Up-To-Congestion Transactions - Total Volume

- Submitted MWh
- Cleared MWh

| Month | OCT16 | NOV16 | DEC16 | JAN17 | FEB17 | MAR17 | APR17 | MAY17 | JUN17 | JUL17 | AUG17 | SEP17 | OCT17 | NOV17 | DEC17 | JAN18 | FEB18 | MAR18 | APR18 | MAY18 | JUN18 | JUL18 | AUG18 | SEP18 | OCT18 |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| MWh   | 80    | 80    | 80    | 80    | 80    | 80    | 80    | 80    | 80    | 80    | 80    | 80    | 80    | 80    | 80    | 80    | 80    | 80    | 80    | 80    | 80    | 80    | 80    | 80    | 80    | 80    |
INCs, DECs and Up-To-Congestion Transactions - Total Volume

MWh (Millions)

- Submitted MWh
- Cleared MWh
Energy Market

Congestion and FTR Summary
### FTR Funding

<table>
<thead>
<tr>
<th>Period</th>
<th>Surplus / Underfunding</th>
<th>Payout Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>October, 2018</td>
<td>$-5,113,933</td>
<td>96%</td>
</tr>
<tr>
<td>2018</td>
<td>$321,559,852</td>
<td>100%</td>
</tr>
<tr>
<td>2018/2019</td>
<td>$33,378,411</td>
<td>100%</td>
</tr>
</tbody>
</table>
Monthly FTR Payout

<table>
<thead>
<tr>
<th>Month</th>
<th>Payout Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>OCT16</td>
<td>90%</td>
</tr>
<tr>
<td>NOV16</td>
<td>90%</td>
</tr>
<tr>
<td>DEC16</td>
<td>90%</td>
</tr>
<tr>
<td>JAN17</td>
<td>90%</td>
</tr>
<tr>
<td>FEB17</td>
<td>90%</td>
</tr>
<tr>
<td>MAR17</td>
<td>90%</td>
</tr>
<tr>
<td>APR17</td>
<td>90%</td>
</tr>
<tr>
<td>MAY17</td>
<td>90%</td>
</tr>
<tr>
<td>JUN17</td>
<td>90%</td>
</tr>
<tr>
<td>JUL17</td>
<td>90%</td>
</tr>
<tr>
<td>AUG17</td>
<td>90%</td>
</tr>
<tr>
<td>SEP17</td>
<td>90%</td>
</tr>
<tr>
<td>OCT17</td>
<td>80%</td>
</tr>
<tr>
<td>NOV17</td>
<td>90%</td>
</tr>
<tr>
<td>DEC17</td>
<td>90%</td>
</tr>
<tr>
<td>JAN18</td>
<td>90%</td>
</tr>
<tr>
<td>FEB18</td>
<td>90%</td>
</tr>
<tr>
<td>MAR18</td>
<td>90%</td>
</tr>
<tr>
<td>APR18</td>
<td>90%</td>
</tr>
<tr>
<td>MAY18</td>
<td>90%</td>
</tr>
<tr>
<td>JUN18</td>
<td>90%</td>
</tr>
<tr>
<td>JUL18</td>
<td>90%</td>
</tr>
<tr>
<td>AUG18</td>
<td>90%</td>
</tr>
<tr>
<td>SEP18</td>
<td>90%</td>
</tr>
<tr>
<td>OCT18</td>
<td>90%</td>
</tr>
</tbody>
</table>
Ten Most Heavily Congested Transmission Facilities - Overall, October

The ten most heavily congested facilities account for 55% of total congestion for October.
Ten Most Heavily Congested Transmission Facilities - Overall, 2018

The ten most heavily congested facilities account for 43% of total congestion for 2018.

- AEP-DOM Interface (EHV)
- Cloverdale 765/345 T.10 (AEP AP)
- Miami Fort-Tanners Creek 345 (AEP IM-DEOK)
- Graceton-Safe Harbor 230 (BGE)
- 50045005 Interface (EHV)
- Batesville-Hubble 138 (MISO)
- Conastone-Peach Bottom 500 (EHV)
- Greenfield-Lakeview 138 (ATSI)
- Ashburn-Pleasant View 230 274D (DOM)
- BED-BLA Interface (EHV)
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)

OCT16  DEC16  APR17  JUL17  OCT17  DEC17  APR18  JUL18  OCT18
Positive values represent hours when the PJM price was higher. Negative values represent hours when the PJM price was lower.

Average price difference for October = $-0.99
Percent of hours in which the direction of flow is consistent with price differentials = 60.89%
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.
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 October = $2.61
Percent of hours in which the direction of flow is consistent with price differentials = 50.40%
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 October = $1.11
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

OCT16  NOV16  DEC16  JAN17  FEB17  MAR17  APR17  MAY17  JUN17  JUL17  AUG17  SEP17  OCT17  NOV17  DEC17  JAN18  FEB18  MAR18  APR18  MAY18  JUN18  JUL18  AUG18  SEP18  OCT18

$0 $10 $20 $30 $40 $50
Load-Adjusted Synchronized Reserve and Synchronous Condenser Costs

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

Cents/MWh

OCT16  NOV16  DEC16  JAN17  FEB17  MAR17  APR17  MAY17  JUN17  JUL17  AUG17  SEP17  OCT17  NOV17  DEC17  JAN18  FEB18  MAR18  APR18  MAY18  JUN18  JUL18  AUG18  SEP18  OCT18
DR Participation in PJM Regulation Markets

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

**Graph Details:**
- Y-axis: $ Millions
- X-axis: Months (OCT16 to OCT18)
- Data points show trends in Total Payments and MWh Cleared over time.
DR Participation in PJM Synchronized Reserve Markets

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

<table>
<thead>
<tr>
<th>Month</th>
<th>OCT16</th>
<th>NOV16</th>
<th>DEC16</th>
<th>JAN17</th>
<th>FEB17</th>
<th>MAR17</th>
<th>APR17</th>
<th>MAY17</th>
<th>JUN17</th>
<th>JUL17</th>
<th>AUG17</th>
<th>SEP17</th>
<th>OCT17</th>
<th>NOV17</th>
<th>DEC17</th>
<th>JAN18</th>
<th>FEB18</th>
<th>MAR18</th>
<th>APR18</th>
<th>MAY18</th>
<th>JUN18</th>
<th>JUL18</th>
<th>AUG18</th>
<th>SEP18</th>
<th>OCT18</th>
</tr>
</thead>
<tbody>
<tr>
<td>$ Millions</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>
Regulation Market Daily Prices and Charges

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