Operational Events and Market Impacts
January 2014 Cold Weather

July 2, 2014
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Vice President – Federal Government Policy
PJM Interconnection, L.L.C.
Polar Vortex

Source: University of Illinois at Urbana-Champaign
Minimum Temperatures – January 2014
Columbus, Philadelphia, Chicago and Richmond

Winter Storm
Maximum Winter Peak Demands

Megawatt

142,000
140,000
138,000
136,000
134,000
132,000
130,000

1/7/2014 p.m.  1/7/2014 a.m.  1/24/2014 a.m.  1/28/2014 p.m.  1/30/2014 a.m.  2/5/2007 p.m.  1/29/2014 a.m.  1/22/2014 p.m.  1/23/2014 p.m.  2/6/2007 a.m.

141,846
January 7 Load Compared to Typical January Day

January 7: Hourly MW Load
(Preliminary)

- **Morning Peak:** 138,733
- **Evening Peak:** 141,846

Typical January Demand Curve

- **Morning Peak:** 100,801
- **Evening Peak:** 106,182

Hour Ending

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

Megawatt

80,000 90,000 100,000 110,000 120,000 130,000 140,000 150,000 160,000
**Forecasting**

Jan. 2
- Weather — PJM’s meteorologist began tracking snow storm
- Load — PJM utilized worst-case forecasts of load to proactively prepare

Jan. 3
- PJM directed transmission and generation owners to cancel planned outages
- PJM prepared a plan and communicated with stakeholders
- PJM held first operational call with major pipeline operators

Jan. 4
- Gas operators expected tight conditions through January 7
- PJM requested permission to share certain operational info with natural gas pipelines

Jan. 5
- PJM refines plan based on revised forecasts to system conditions
- Unit commitments finalized
- PJM issued alerts and increased frequency of communication

Jan. 6
- FERC Commission granted waiver
Forced Outages – January 7 Evening Peak (7pm)

Total Forced Outages
**40,200 MW**
(22% Total PJM Capacity)

- Gas Plant Outages
  - 9,700 MW
  - 24%
- Natural Gas Interruption
  - 9,300 MW
  - 23%
- Nuclear
  - 1,400 MW
  - 3%
- Other
  - 6,100 MW
  - 15%
- Coal
  - 13,700 MW
  - 34%
<table>
<thead>
<tr>
<th>WEATHER CONDITIONS</th>
<th>Emergency Actions</th>
<th>Operation Expectations</th>
<th>Gas Expectations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snowstorm across PJM Tracking extreme cold</td>
<td>Jan. 2 Voltage reduction and shortage pricing</td>
<td>Issues with oil and emissions</td>
<td>Gas unavailability</td>
</tr>
<tr>
<td>Record low temps</td>
<td>Jan. 6 Reserve action</td>
<td>Concern about reserves and losing units</td>
<td>Gas interruptions</td>
</tr>
<tr>
<td>Breaking cold weather records</td>
<td>Jan. 7</td>
<td>22% forced outage rate</td>
<td>Gas conditions deteriorate</td>
</tr>
</tbody>
</table>
### Timeline – Operations

<table>
<thead>
<tr>
<th>Weather Expectations</th>
<th>Conditions</th>
<th>Operation Expectations</th>
<th>Gas Expectations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Jan. 17</strong></td>
<td>Unknown forced outage rate</td>
<td>Dispatchers contact units on fuel availability</td>
<td>Conditions seem tighter</td>
</tr>
<tr>
<td><strong>Jan. 22</strong></td>
<td>Max. emergency conditions</td>
<td>Oil inventories depleted</td>
<td></td>
</tr>
<tr>
<td><strong>Jan. 25</strong></td>
<td></td>
<td></td>
<td>Critical notices across footprint</td>
</tr>
<tr>
<td><strong>Jan. 27</strong></td>
<td>Lack of oil inventory</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Jan. 28-27</strong></td>
<td>Snow storm in the south and east</td>
<td></td>
<td></td>
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<tr>
<td><strong>Forecast more severe than actual</strong></td>
<td></td>
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</tbody>
</table>

- Dispatchers contact units on fuel availability
- Oil inventories depleted
- Conditions seem tighter
- Critical notices across footprint
- Weekend packages
Generation Outages – January 2014

Megawatt

Forced
Planned
Maintenance

Polar Vortex – Wind Generation

Megawatt
6,000

Wind Capability
Wind Generation
Wind Capacity

Wind Generation
Jan. 6 Jan. 7 Jan. 8 Jan. 9
Demand Response – Winter Storms

Load Reductions (MW)

<table>
<thead>
<tr>
<th>Event Period</th>
<th>Jan 7 a.m.</th>
<th>Jan 7 p.m.</th>
<th>Jan 8 a.m.</th>
<th>Jan 22 p.m.</th>
<th>Jan 23 a.m.</th>
<th>Jan 23 p.m.</th>
<th>Jan 24 a.m.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected</td>
<td>1,500</td>
<td>3,000</td>
<td>500</td>
<td>100</td>
<td>1,400</td>
<td>2,000</td>
<td>1,000</td>
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<tr>
<td>Settled</td>
<td>1,400</td>
<td>2,500</td>
<td>500</td>
<td>100</td>
<td>1,400</td>
<td>2,000</td>
<td>1,000</td>
</tr>
</tbody>
</table>

Notes:
1. DR events dispatched during non-compliance period.
2. Expected Energy Load Reductions (MW) - CSP reported estimate based on current market rule.
3. MW value is average hourly load reduction for non-ramp in hours.
4. Event on Jan. 8 was cancelled by PJM prior to official start time. In order to honor the Emergency DR resource 2-hour minimum down time, PJM allowed CSPs to settle if their load reduction had started prior to cancellation and/or needed to reduce for 2 hours. PJM estimated amount of DR that needed to continue to reduce for 2 hours. “Performance” for this event cannot be measured based on the circumstances of this event.
Gas Prices (Market East) – January 2014

$/MMbtu

<table>
<thead>
<tr>
<th>Jan. 1</th>
<th>Jan. 8</th>
<th>Jan. 15</th>
<th>Jan. 22</th>
<th>Jan. 29</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>60</td>
<td>40</td>
<td>120</td>
<td>20</td>
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Winter Storm
Balancing Operating Reserves

Reliability Credit
- Generator committed in advance of the operating day and outside of the Day-Ahead Market.
- Generator committed during the operating day and is out of the economic merit order.

Deviation Credit
- Generator is needed to meet anticipated load plus reserves.
- Generator is committed during the operating day and cost is greater than locational marginal prices most of the time.
Balancing Operating Reserves – January 2014

$ Millions

- Total Deviation Credit
- Total Reliability Credit

Winter Storm


$0  $10  $20  $30  $40  $50  $60  $70  $80  $90
Gas Prices and Reliability Balancing Operating Reserves – January 2014
Uplift Costs – January 2014

Total Balancing Operating Reserves & Lost Opportunity Cost
$555 M

Jan. 3 - Jan. 9
$98 M

Rest of January
$19 M

Jan. 21 - Jan. 30
$438 M
Key Recommendations

- Improve generator availability and performance during extreme weather events,
- Implement performance verification or testing of generation in advance of winter operations,
- Continue to engage in discussions with industry and regulators to improve natural gas and electricity market alignment,
• Implement market mechanisms that encourage better generator availability, such as incentives for ensuring fuel availability or dual-fuel capability, and
• Review the cost allocation for uplift charges and investigate a mechanism to allocate uplift costs during emergency operations that minimizes volatility.
LET’S TALK…

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