Managing Winter Reliability in PJM

June, 2014
Overview

• While PJM was able to manage the polar vortex without a loss of load event, the episode revealed a number of systematic weaknesses in the supply portfolio of resources procured via the Reliability Pricing Model.

• Specifically, during the hours of peak system stress on January 7, 2014, PJM’s firm resources as procured via the RPM were insufficient to cover load and primary operating reserves, and PJM was forced to rely on a combination of luck and voluntary, outside-RPM resources in order to avoid a voltage reduction or load shed event.

• While this series of events was fortunate, it does not constitute a sound reliability plan going forward. Furthermore, PJM’s supply portfolio of capacity resources is set to evolve over the next several years in a fashion which exacerbates the problems laid bare in the polar vortex, and would make a significant load shed event unavoidable were polar vortex conditions (or worse) to reoccur in the coming winters.
During the Polar Vortex, peak system stress occurred during the morning of January 7\textsuperscript{th}, well prior to peak load

- PJM has focused its analysis of polar vortex planning reliability and outages around the hour of peak load at 7pm on January 7\textsuperscript{th}, 2014
- However, the hour of peak system stress (as measured by prices and operating reserve shortfalls) actually occurred in the morning, despite somewhat lower load (roughly 2 GW lower)
- The morning hours were a time of higher system stress despite marginally lower load because:
  - Generator forced outages were higher
  - Imports collapsed to near zero due to conditions on neighboring systems
- A proper analysis of the polar vortex must begin with the period of peak stress
System-wide generator unavailability reached 25% during peak stress conditions

Generator unavailability (excluding intermittent renewables) in PJM peaked at about 46 GW in the morning of January 7th - an unavailability rate of about 25%. This exceeds the forced outage rate of 22% cited by PJM in its various studies of the Polar Vortex which generally appear to focus on the forced outage rate later in the day during the hour of peak load, rather than peak system stress.

In peak unavailability hour (morning 1/7) during period of maximum system stress, the following amounts were unavailable:

- ~ 24.5 GW of gas (47%)
- ~ 15 GW of coal (21%)
- ~ 2.5 GW of oil (26%)
- ~ 1.5 GW of nuclear (5%)
- ~ 1.5 GW of other (16%)

Plus 1 GW of planned outages (not shown)

For an overall unavailability rate of about 25% (46 GW out of 184 GW of ICAP)

Source: PJM Interconnection, Response to Committee Questions of U.S. House of Representatives Committee on Energy and Commerce, April 18, 2014, Figure 4. Notes on capacity totals provided by NorthBridge.
Imports collapsed during peak stress and would have been zero but for voluntary emergency energy purchases

- Despite indicating roughly 3.35 GW of external firm resources in its NERC 2013/14 NERC Winter Assessment, without voluntary emergency energy purchases PJM’s net interchange would have been zero during the peak system stress hour of January 7.

- Similarly challenging weather conditions on neighboring systems (particularly MISO) along with conflicting emergency operating rules limited PJM’s ability to enforce its capacity rights on external RPM resources.

- The polar vortex experience suggests that imports are not a reliable source of capacity during extreme winter conditions, even if cleared in the RPM and ostensibly backed by firm transmission capacity. The pseudo-tie exemption for some imports addresses some of these problems, but has no impact prior to 2017/18.

During peak stress interchange fell to as low as 1.1GW, and would have been zero but for voluntary emergency energy purchases (at ~$1800/MWh).
PJM relied heavily on voluntary demand response during January 7th

- Despite clearing roughly 10 GW of demand response in the RPM for 2013/14, PJM lacked mandatory non-summer interruption rights on all of this capacity.

- During the morning of January 7th, PJM issued a voluntary emergency DR deployment request, to which about 2100 GW (about 20%) voluntarily responded and successfully deployed, despite being under no obligation to so.

- Going forward, PJM lacks mandatory winter interruption rights for the vast majority of demand response qualified and cleared in the RPM for 2014/15 through 2016/17. While PJM’s procurement of annual DR has increased for the 2017/18 RPM auction, annual DR still comprises less than 15% of total DR.

Wind generation over-performed during peak stress, but later events indicate that this was simply a lucky coincidence

- PJM was fortunate that wind over-performed relative to its RPM capacity rating during the hour of peak stress.

- However, as the pattern of wind generation over the Polar Vortex indicates, this was simply luck – wind underperformed relative to its capacity rating later during the event.

- The level of wind output is not under PJM’s control, and relying on the vagaries of intermittent resources to fill a gap during critical periods does not constitute a sound reliability plan going forward.

Altogether PJM relied on about 4.7 GW of non-firm resources to avoid load shed during peak stress

- In total, PJM was forced to rely on a combination of non-firm voluntary resources (demand response and emergency energy imports), intermittent resource luck (excess wind), and risky operations (operating with a reserve shortfall) in order to meet demand during the hour of peak stress on January 7th.

- Without this supply, PJM would have exhausted its primary reserve, and a voltage reduction would not have been sufficient to avoid load shed.

- While PJM was fortunate in this case, reliance on non-firm resources to meet peak demand is not good planning practice.

PJM Reliance on Non-Firm Resources to Maintain Reliability During the Polar Vortex (Jan 7th, 8-9 am)
Going forward PJM is expecting a net decline of “iron in the ground”, and the mix of new resources is not favorable

New Resource composition (estimated):

~9.5 GW of natural gas projected by PJM through 2016/17, plus

~6 GW of new gas and gas repowering cleared in 2017/18 RPM auction

Retiring Resource composition (estimated)

~ 13 GW of capacity with on-site fuel projected to retire by PJM through 2016/17 (10 GW coal, 3 GW oil/dual-fuel)

~ 10 GW of generation with on-site fuel not cleared in 2017/18 RPM auction that has not yet announced retirement, including 4.3 GW of nuclear and 6 GW of coal (in ICAP terms)

- Going forward, PJM projects a cumulative net reduction in generation capacity of about 3.5 GW through 2016/17

- However, the potential reduction in winter reliability is much greater than this:

  - Essentially 100% of the new capacity is gas that largely appears to lack dual-fuel capability. On winter peak days the marginal unavailability of this capacity is likely to be close to 100% without supporting gas infrastructure investments

  - Roughly 10 GW of nuclear and coal capacity that has not yet announced retirement did not clear in the 2017/18 RPM auction and could potentially retire as early as late 2014.
Going forward, the unavailability rate of marginal new gas resources may approach 100%

- During the polar vortex, about 20 to 30% of all existing gas was forced out due to fuel availability issues.
- By 2017 however, the replacement of retiring coal resources with gas generation will increase gas consumption across the PJM footprint during cold days by almost 2 bcf/day.
- Based on this increased gas demand from power generation we would expect to see roughly the same overall gas demand as 2014 when temperatures are 5 to 6 degrees warmer.
- The marginal new power-related gas consumption comes on top of a gas network that was effectively maxed-out during the Polar Vortex; without dedicated new physical infrastructure there is no way to supply this incremental new gas demand on peak days.
- Accordingly, on the margin, new build gas capacity that lacks dual-fuel capability essentially contributes nothing to reliability in extreme winter conditions, while the coal capacity it is replacing was able to contribute close to 80% of its rated ICAP, respectively, during the peak stress hour of the Polar Vortex.
- This does not include impact of nuclear/coal which has not cleared RPM but has not announced retirement (~10GW in 2017/18) which would increase gas demand by an additional 1 bcf/day.

Note: Estimated gas demand for all purposes in PJM states; retirement replacement gas also includes impact of MISO border region retirements (CINERGY/MECS/SMAIN zones) of 4.1GW by 2017/18;
Winter peak load is projected to grow while physical generation capacity shrinks and becomes less reliable

- While PJM’s physical generation supply with on-site fuel is shrinking in absolute terms, winter peak load is projected to continue to grow

- If polar vortex conditions were to occur in 2017/18, PJM’s load forecast suggests that peak stress loads would be about 7 GW higher than they were in January 2014.
The 4.7 GW winter firm resource shortfall will expand to about 25 GW by 2017/18 if additional steps are not taken

- The combination of about 6 GW of load growth and a net reduction of about 9 GW of generation capacity under winter extreme conditions added onto the observed deficiency of just under 5 GW leads to a shortfall of just under 20 GW by 2016/17 with just scheduled retirements. Retirement of uncleared capacity could push the 2016/17 shortfall to 23 GW.

- Although pseudo-tie imports and increased annual DR alleviates some of the shortfall in 2017/18, this is more than offset by about 10 GW of nuclear and coal that did not clear the RPM and could retire.

- Going forward, a sound reliability plan must address this shortfall in the coming winters.

**PJM’s Ability to Avoid Load Shed Degrades Significantly in Coming Winters**

- Total net impact of load growth, projected retirements/additions (with new gas assigned 0% availability), and annual DR procurement:
  - 4.7 GW

- Impact of pseudo-tie imports and increased procurement of annual DR:
  - 7.0 GW

- With scheduled retirements only:
  - 17.5 GW

- With retirement of nuclear, coal and oil capacity not cleared in RPM and not yet scheduled for retirement (4.6 GW of ICAP in 2016/17 and ~10 GW in 2017/18):
  - 19.6 GW

- Total impact:
  - 23.2 GW

- Projected shortfalls:
  - 2016/17: 17.5 GW
  - 2017/18: 24.9 GW
## Appendix – Detailed Calculation of Projected Winter Stress Shortfall

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<td>Nuclear</td>
<td>33.3</td>
<td>95%</td>
<td>31.7</td>
<td>31.8</td>
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<td>Coal</td>
<td>70.8</td>
<td>79%</td>
<td>55.8</td>
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<td>Hydro</td>
<td>8.3</td>
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<td>Oil</td>
<td>9.5</td>
<td>74%</td>
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<td>Existing Gas</td>
<td>51.8</td>
<td>53%</td>
<td>27.3</td>
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<td>New Gas</td>
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<td>Wind</td>
<td>0.9</td>
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<td>Other</td>
<td>9.4</td>
<td>84%</td>
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<td>Demand Response</td>
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<td>0%</td>
<td>0</td>
<td>0.5**</td>
<td>0.4**</td>
<td>0.1**</td>
<td>1.5**</td>
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<td>Imports</td>
<td>~3.4</td>
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<td>0</td>
<td>3.1***</td>
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<tr>
<td>Total</td>
<td>197.3</td>
<td>137.3</td>
<td>136.9</td>
<td>128.5</td>
<td>124.7</td>
<td>124.1</td>
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<td>Polar Vortex Winter Peak Stress Load (50/50 peak times 1.063)</td>
<td>140.0</td>
<td>141.9</td>
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<td>Plus Primary Reserve</td>
<td>2.0</td>
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<td>Total Required Winter Firm Capacity</td>
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<td>Shortfall</td>
<td>(4.7)</td>
<td>(7.0)</td>
<td>(17.5)</td>
<td>(23.2)</td>
<td>(24.9)</td>
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** Annual demand response only from 2014/15 onward (no annual product existed in 2013/14)

*** Pseudo-tie imports only in 2017/18, with assumed 79% availability during peak stress