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Transmission System Reliability with Changing Generation Mixes

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Introduction – Is our system secure and reliable?

- Power system is at a crossroads: how electricity is reliably generated and delivered given environmental policies and economic considerations
  - Renewable, although intermittent, is driven by Renewable Portfolio Standards (RPS)
  - Natural gas generation is deemed more economical than nuclear and coal.
- Electric system increasingly relies on gas generation to support system operations via real and reactive power dispatch/redispatch that requires
  - High fuel availability all the time -- a challenge for gas fired generation which typically does not have on-site natural gas; gas is delivered real time via gas pipelines
  - Sustained fuel supply over long period of time -- a challenge for the dual fuel because emission standards and on-site storage limitation.
- NERC Reliability Standards
  - Essential Reliability Services – stabilizing inertia, voltage support, and ramping and regulation under various emergency conditions
  - synthetic inertia with wind and solar PV does not have magnetic inertia to sustain large short circuit, thus cannot recover voltage as fast as large baseload units
  - N-1 and N-1-1 planning and operation criteria – Difficult to satisfy without a reliable generation to re-dispatch and mitigate criterion violations.

Impact of Generation Availability on Transmission Reliability

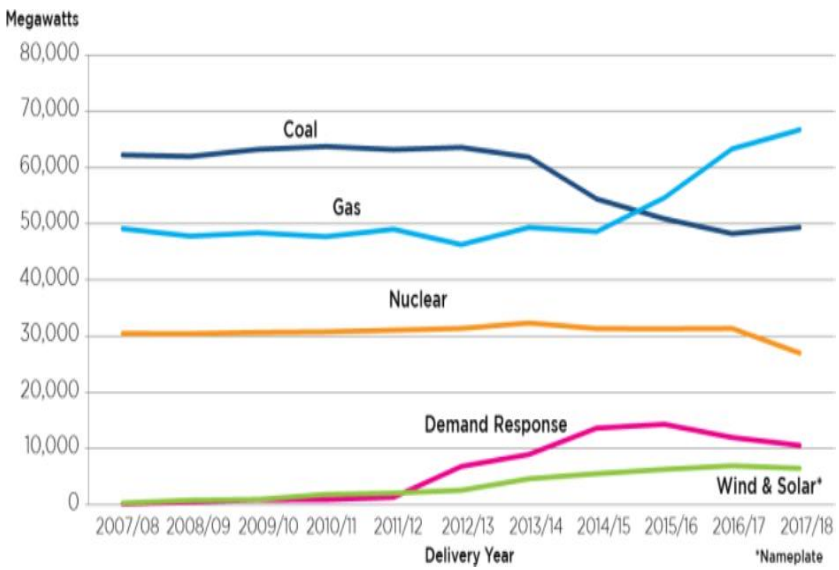
- When a gas pipeline is interrupted, gas-fired generation is not available for dispatch, limiting the ability of the electric system to operate reliably and have the resilience to recover from an emergency
  - Gas pipeline represents a single point of failure for many generators, and from an engineering design perspective, redundancy should be addressed in a similar way as the N-1-1 criterion in the electric system planning
  - Gas infrastructure failures would render even gas delivered on a firm contractual basis unavailable.
- A failure of the pipeline can result in multiple power plants being unable to produce electricity to supply the load or to maintain transmission system security.
  - This single common mode failure can affect more than one transmission control area, causing simultaneous resource shortfalls in multiple regions and curtailing emergency assistances between the regions
  - To be resilient, the power industry must take into account the possibility of larger scale disruptions of the natural gas supply system, similar to the reliability standards CIP-014.

Fuel Mix

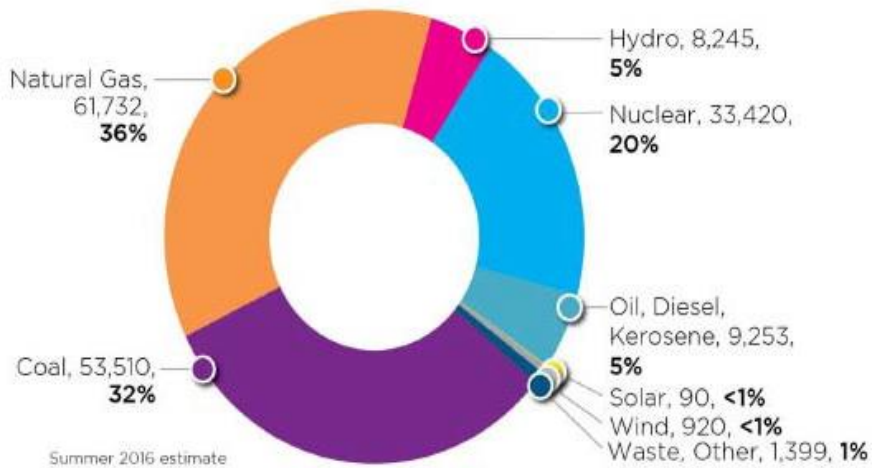
- Diversity of fuel and technology mix is required to withstand:
  - Fuel supply or delivery disruptions
  - Fuel supply vulnerability (e.g., pipeline failures) and price volatility
  - Technical and manmade disturbances on the system.
- For system planning, it is imperative to effectively mitigate the risks brought on by a concentration of a single fuel to the system reliability
  - A common mode gas infrastructure failure rendering several pipelines out of service (e.g. during a sustained cold snap) has not been planned for system & market operations
  - With limited capital available for wholesale replacements of aging gas pipelines, the risk of fuel delivery interruption is high, affecting reliable and economic electrical services.
- The limitation of local distribution companies (LDCs) to supply natural gas for electric generation highlights the needs of fuel diversity –
  In many regions, high percentage (i.e., 50% in PJM) of gas fired generation is connected to the LDC gas networks.

Example - PJM Generation Resources

- Peak Demand 154GW
- Resource Capacity 190GW
- Reserve Margin 31%



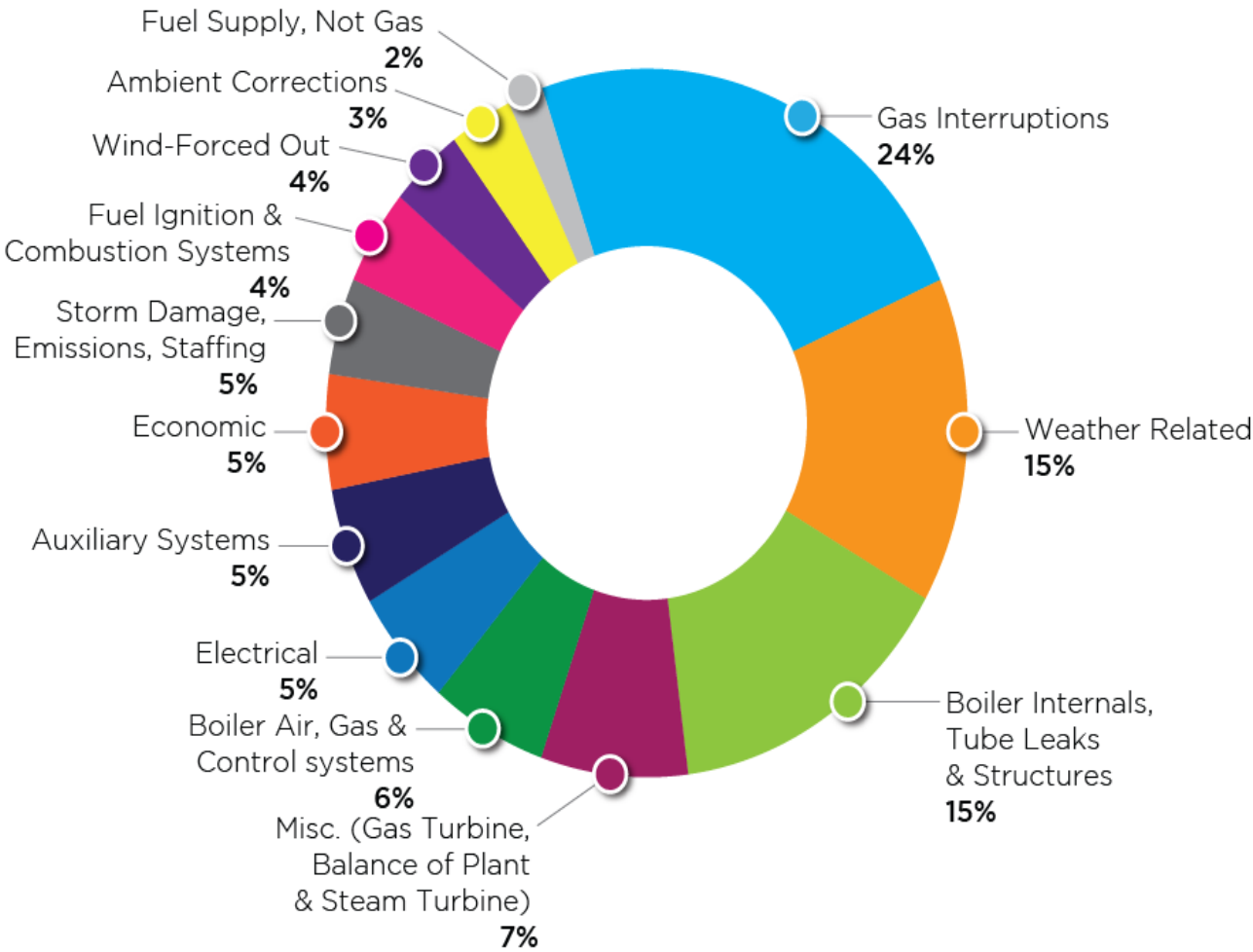
- Generation 171GW
  - Coal 32%
  - Gas 36%
  - Nuclear 20%
  - Hydro 5%
  - Oil 5%
  - Wind/Solar/.. 2%



- Gas Plants are expected to continue growing in PJM.

Gas Vulnerability Fully Addressed – No!

- Most gas storages are remote from the load centers while the gas fired plants are close to the load - when gas pipelines/LDCs get constrained, these remote storage facilities do not help
- True performance of gas fired plants has not properly measured in the resource planning nor in the marketplace with regard to fuel vulnerability
- Polar Vortex – A 60 year events, but twice in a row causing millions of dollars for the consumers during and after those events.



Causes of Forced Outages in PJM (Jan 7, 2014)

Winter Peak - PJM, February 20th 2015

- Despite precautions, due to higher Residential/Industrial/Commercial demand, several operational flow orders were issued, restricting natural gas availability in the PJM region.

Pipeline	# of Effective OFOs (or Force Majeure) in PJM			
	Jan-14	Jan-15	Feb-14	Feb-15
Transco	4	3	1	2
TCO	0	1	0	0
ANR	0	0	0	0
NGPL	2	1	0	1
TETCO	3	1	0	2
TGP	0	4	0	2
DTI	4	3	0	1
Total	13	13	1	8

- Most at-risk generation was geographically located in areas behind LDC or constrained by the physical pipeline limits.

Solutions to Improve System Reliability

- Need to address fuel mix for grid reliability as adequate and reliable primary fuel is critical to maintaining transmission security and system reliability and resilience
  - The default assumption in resource adequacy assessment and capacity market clearing is that the primary fuel is always there – leading an inequality treatment to the coal and nuclear resource
  - In some markets, there is a mechanism to measure capacity performance, but fuel availability is explicitly excluded from EFORd that is the method for measuring generator performance.
- Avoid overreliance on a high concentration of a single fuel type that could make transmission system vulnerable to fuel supply interruption
  - The coal and nuclear infrastructure is unlikely to run out of fuel
  - For natural gas because it is essentially on a tap, any number of events could cause disruptions
  - Renewable energy is intermittent
  - Storage can help.

More Transmission Helps

- Judicious transmission expansion can help improving fuel mix:
  - A control area may have a well-balanced system wide resource mix but it does not necessarily mean the different sub-systems maintain the same level of resource balance
  - A strong transmission grid between the sub-systems is required to bridge the differences in fuel mix. Similarly is true to regional
- Without a robust electric transmission system, even a well balanced generation fleet with diversified fuel mix can have reduced reliability and system resilience in providing economic and reliability services to the consumers.
- The unreliable/unavailable generation limited by the LDC capability can be replaced or mitigated by transmission solutions.

Conclusions

- The importance of strengthening the natural gas infrastructure requires focusing on the critical dependence between the regional power grid and gas pipelines
  - Expansion to either system, whichever is more economic to the consumers, is an increasingly crucial issue for regulators, industry stakeholders, and consumers.
  - Diversified generation mix and robust gas delivery system provide a unique value to power system reliability.
- The rapid and growing switch to natural gas has exhausted available interruptible service during periods of high gas demand
  - Only short term market mechanisms have been explored in the marketplace
  - A long-term solution has not adequately been investigated to address the fuel delivery vulnerability issue.
- To mitigate natural gas vulnerability, not only are dual-fuel and firm gas contracts needed, but also fuel diversity from nuclear, coal, hydro, etc. is essential for the reliability and resilient electric system.

Thank You!

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