Gas Electric Coordination

National Academy of Science, Engineering and Medicine

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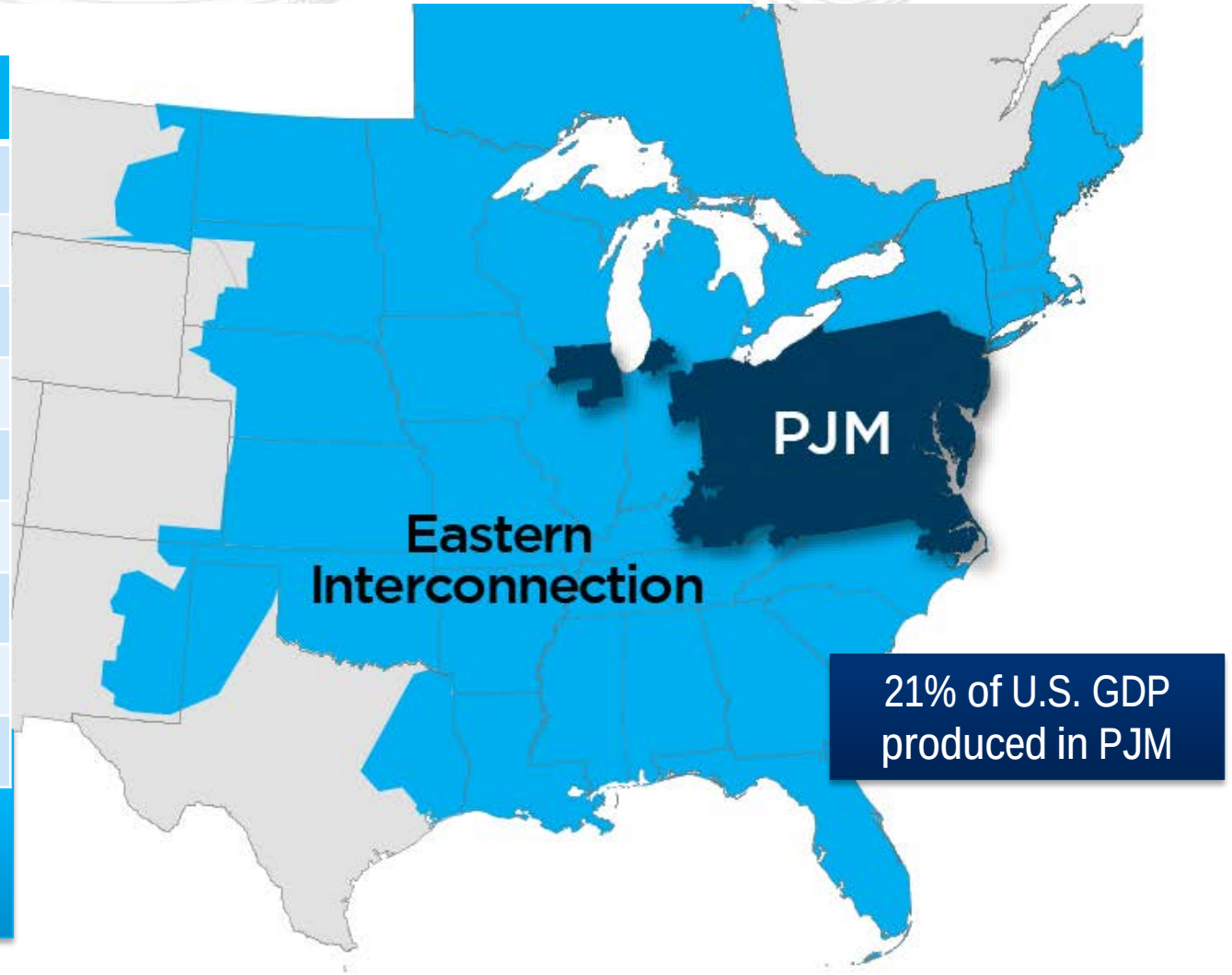
PJM as Part of the Eastern Interconnection

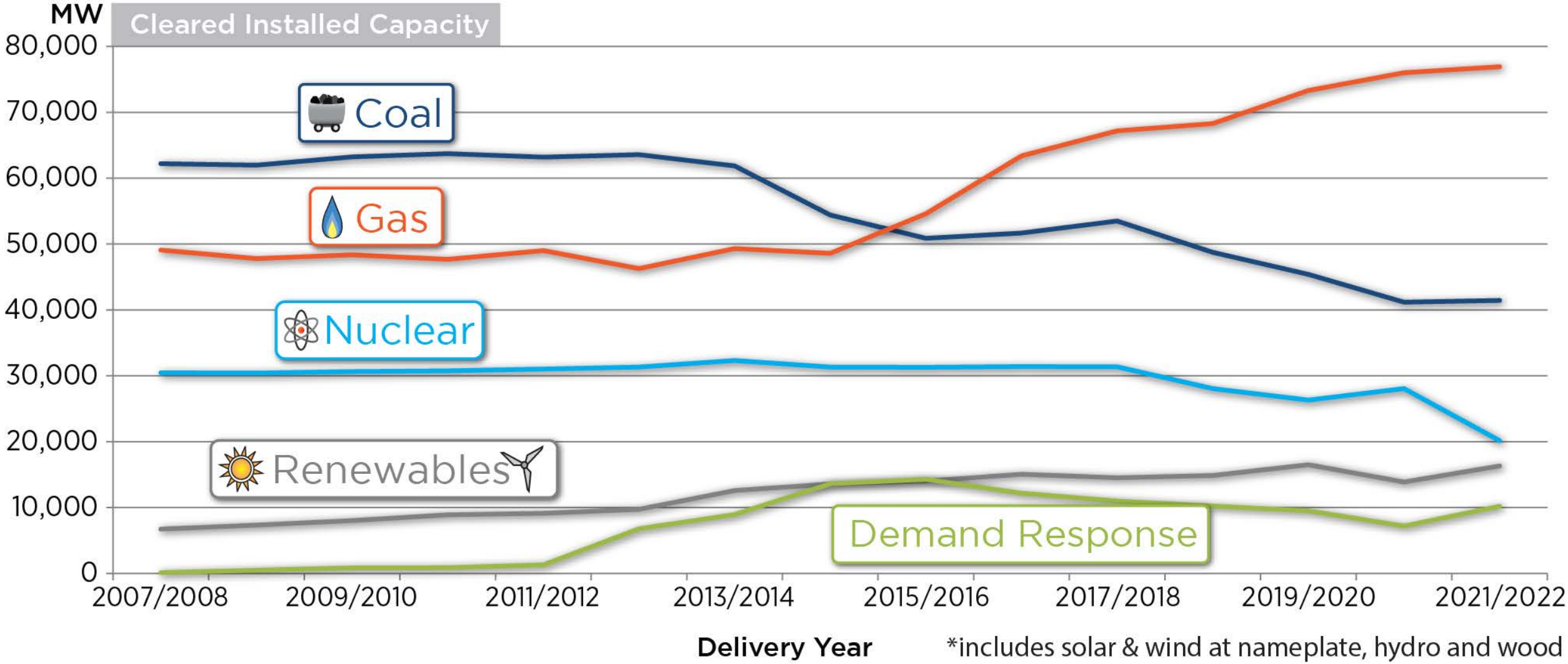
Key Statistics	
Member companies	1,010+
Millions of people served	65
Peak load in megawatts	165,492
MW of generating capacity	180,086
Miles of transmission lines	84,042
2018 GWh of annual energy	806,546
Generation sources	1,379
Square miles of territory	243,417
States served	13 + DC

- 26% of load in Eastern Interconnection
- 20% of transmission assets in Eastern Interconnection

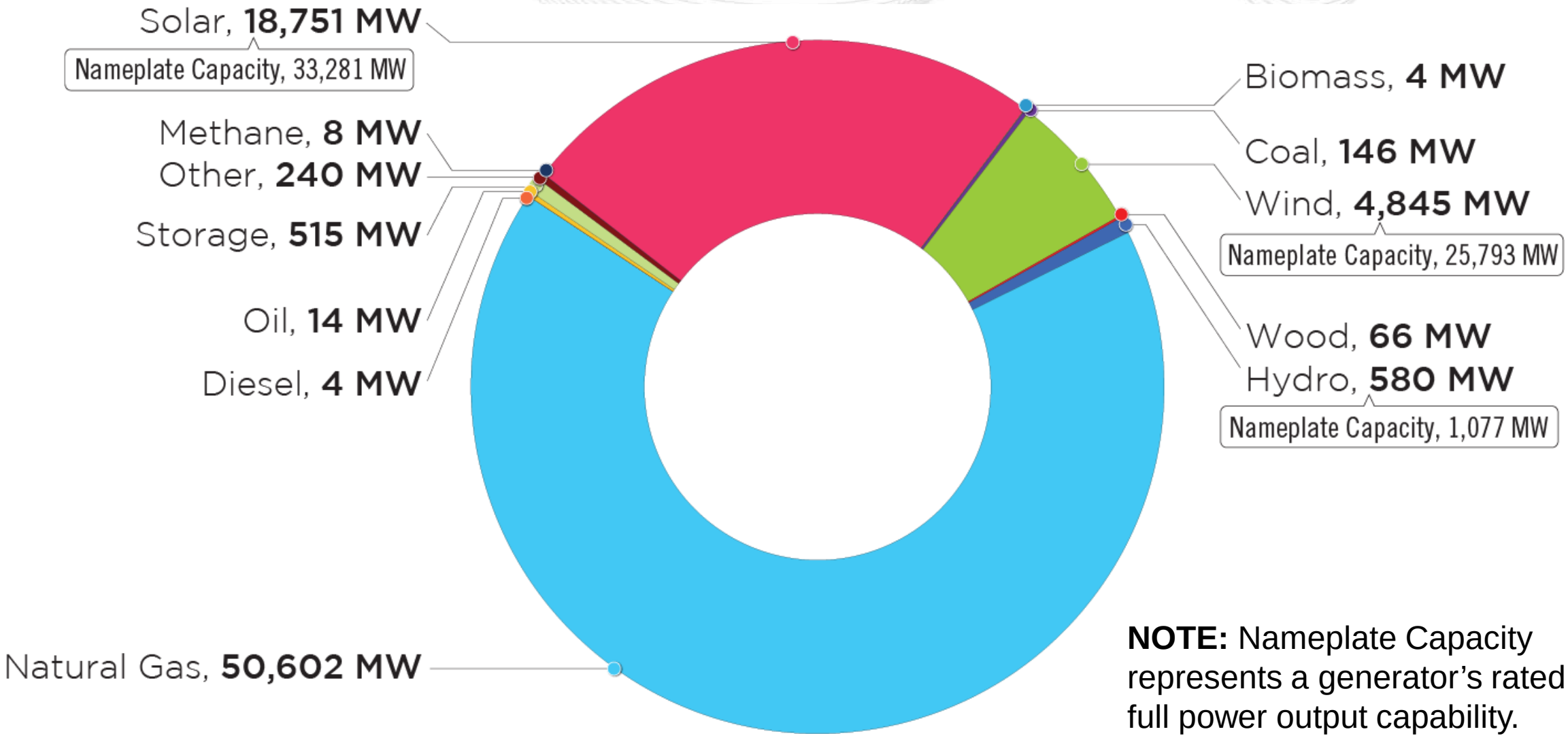


As of 1/2019

Cleared Installed Capacity

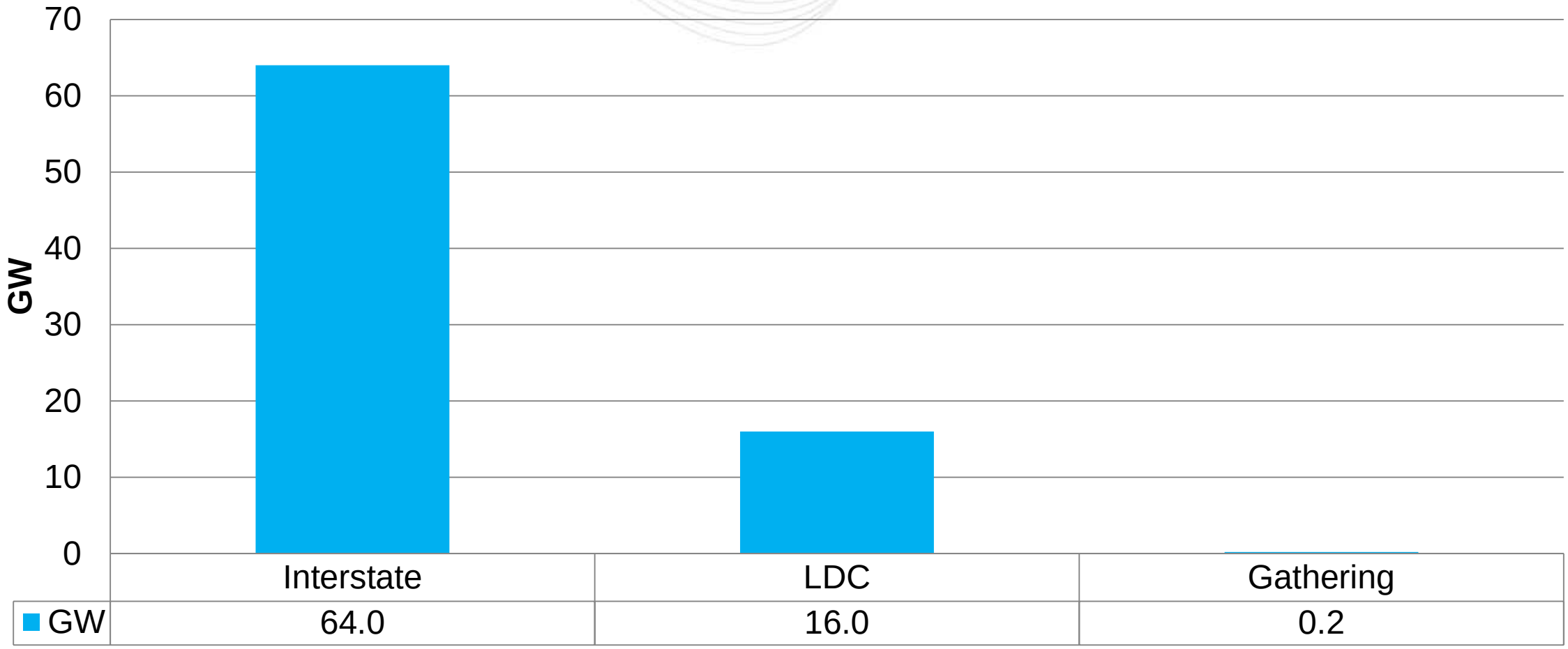


Queued Generation Fuel Mix (December 31, 2018)



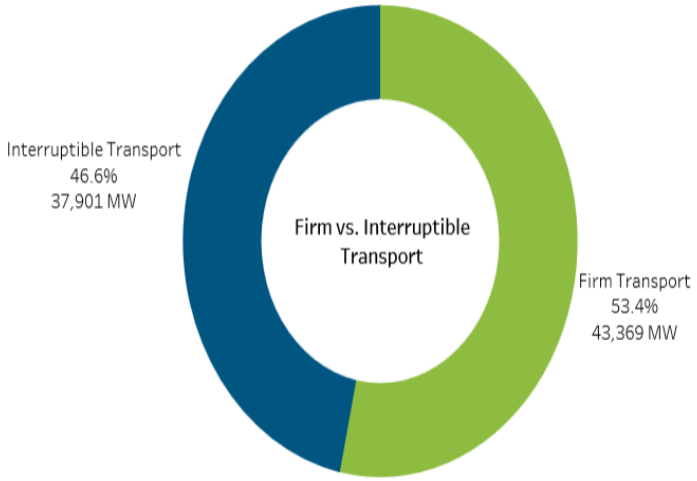
NOTE: Nameplate Capacity represents a generator's rated full power output capability.

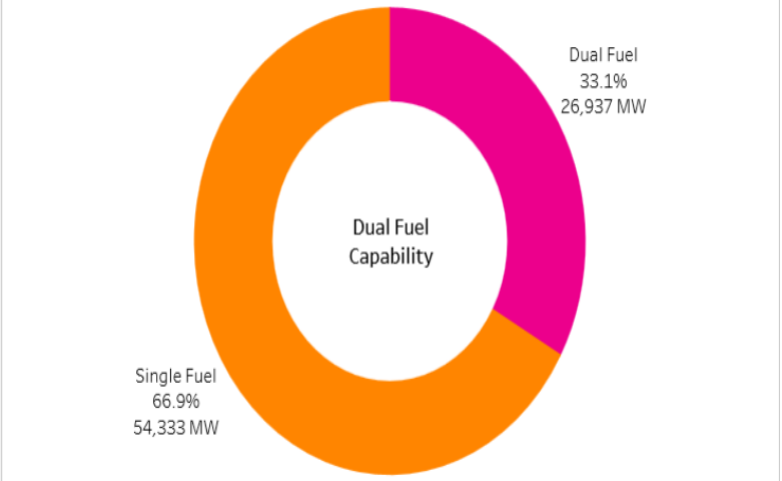
PJM Natural Gas Generation Supply Sources

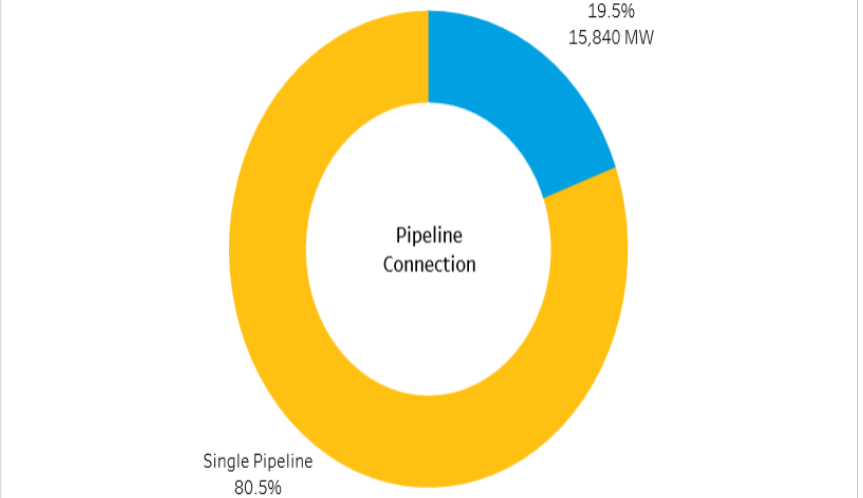


Key PJM Natural Gas Generator Stats

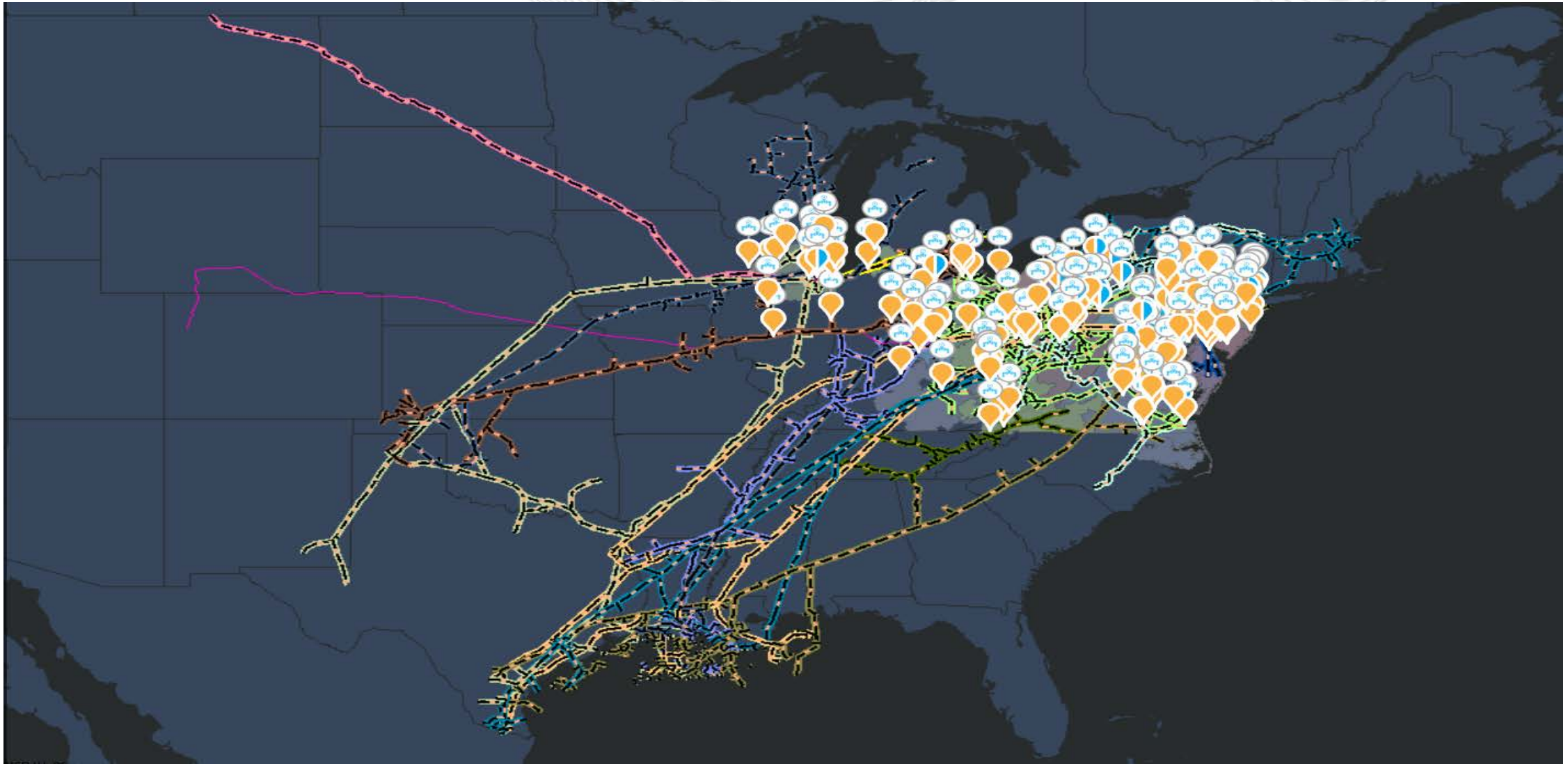
Total MWs of Gas-fired Generation (81,270 MWs)







Dispatch Interactive Mapping Application



Gas-Electric Coordination

- FERC Orders
  - Order 787 (2013)
    - Allows for the voluntary sharing of non-public operating information between interstate pipelines, public utilities and electric transmission operators
  - Order 809 (2016)
    - Adjustment of interstate gas pipeline nomination cycles to improve gas-electric coordination
      - Timely nomination deadline moved from 12:30pm Eastern time to 2:00pm Eastern time
      - Addition of 3rd intraday nomination cycle

Gas-Electric Coordination Team

Comprised of personnel from across Operations and Markets Divisions

4 primary staff	10 secondary support staff

Focused on understanding and evaluation of interstate pipeline and local distribution company conditions

Gas Electric Coordination Team Focus

- Weekly calls with interstate pipeline gas operations personnel (Primarily November through March)
- Daily analysis of natural gas scheduled deliveries to generators (Is the gas nomination sufficient to meet electric obligation?)
- Daily assessment of pipeline operating conditions (OFO's, Critical Days, Ratable Take Requirements, Force Majeure)
- Coordination of pipeline, generator and transmission maintenance outages (Primarily April through October)
- Daily report(s) to PJM Dispatch on gas delivery risks which could impact generation

Summary of Pipeline Critical Notifications

pjm | Gas Pipeline

Feedback

Critical Notifications

Critical notifications from the following pipelines are currently unavailable:

Dominion Gas Transmission - last update

Equitrans, L.P. - last update

Guardian Pipeline, L.L.C. - last update

Midwestern Gas Transmission - last update

Search (Pipeline, ID, Type, Subject) Reset

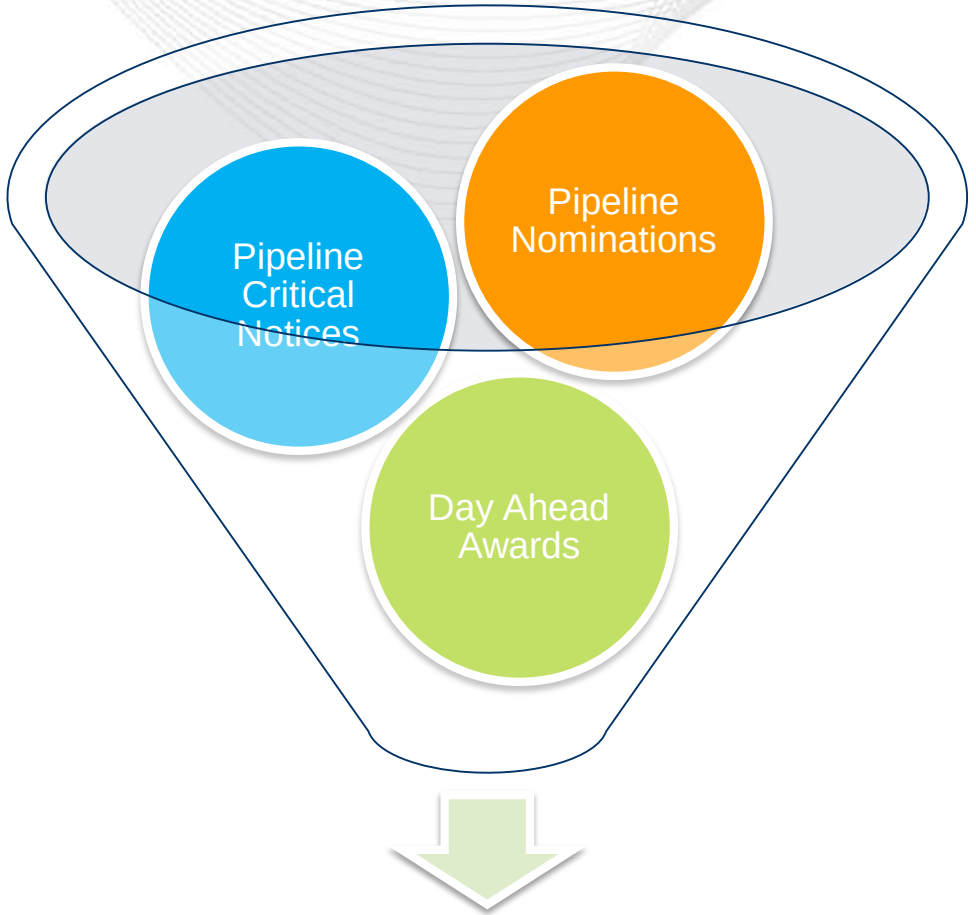
472 records Export: CSV | Print

Critical Notifications

Records Per Page: 15 (1 of 32)

Pipeline	ID	Type	Subject	Posted UTC	Effective UTC	End UTC
TET	82018	Capacity Constraint	Te Pipeline Conditions For 2/25/2019	2/24/2019 21:46	2/25/2019 15:00	2/26/2019 15:00
NGPOA	39722	Force Majeure	Force Majeure - Segment 8 & Aa 5/6	2/24/2019 21:29	2/24/2019 21:29	12/31/2049 14:00
AGT	82017	Capacity Constraint	Agt Pipeline Conditions For 2/25/2019	2/24/2019 20:35	2/25/2019 14:00	2/26/2019 14:00
TGP	370575	Current Pipeline Conditions	Restrictions For 02-24-19 Id2	2/24/2019 20:29	2/24/2019 20:29	12/31/2049 14:00
ETNG	82015	Capacity Constraint	Etng Pipeline Conditions For 2/25/2019	2/24/2019 20:25	2/25/2019 14:00	2/26/2019 14:00
TGP	370574	Current Pipeline Conditions	Restrictions For 2-25-19 Timely Cycle	2/24/2019 19:32	2/24/2019 19:32	12/31/2049 14:00
TGP	370572	Current Pipeline Conditions	Restrictions For 02-24-19 Id1	2/24/2019 15:58	2/24/2019 15:58	12/31/2049 14:00
TGP	370570	Current Pipeline Conditions	Restrictions For 2-23-19 Id3	2/24/2019 00:52	2/24/2019 00:52	12/31/2049 14:00
TGP	370569	Current Pipeline Conditions	Restrictions For 02-23-19 Ec	2/24/2019 00:16	2/24/2019 00:16	12/31/2049 14:00
TET	81993	Capacity Constraint	Te Pipeline Conditions For 2/24/2019	2/23/2019 21:21	2/24/2019 15:00	2/25/2019 15:00
TGP	370568	Current Pipeline Conditions	Restrictions For 2-23-19 Id2	2/23/2019 20:24	2/23/2019 20:24	12/31/2049 14:00
ETNG	81990	Capacity Constraint	Etng Pipeline Conditions For 2/24/2019	2/23/2019 20:17	2/24/2019 14:00	2/25/2019 14:00

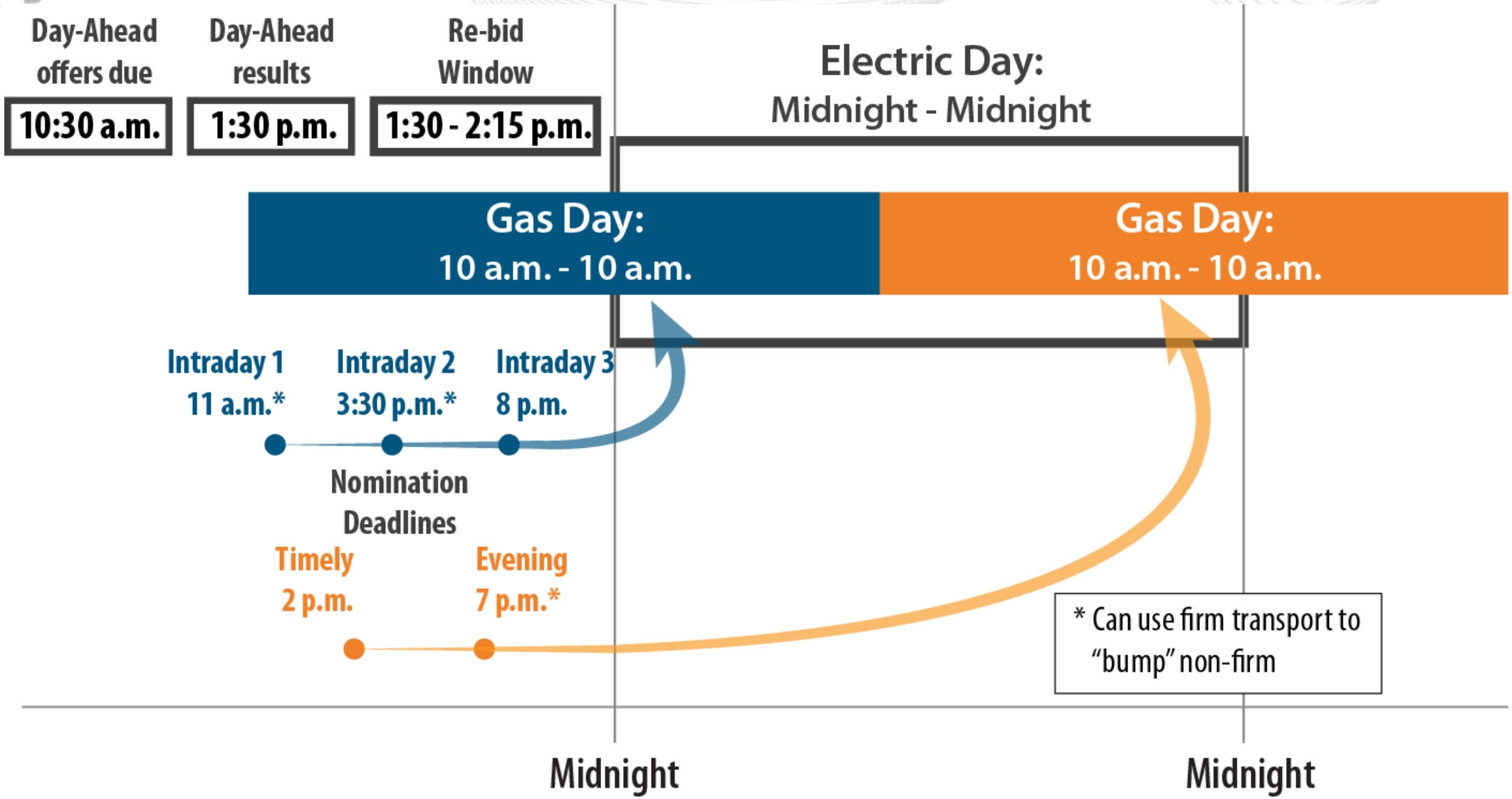
Gas Generator Risk Assessment Tool Process



Generator Risk Assessment Report

Adjusted Market Timing

March 31, 2016



Gas Electric Coordination Initiatives

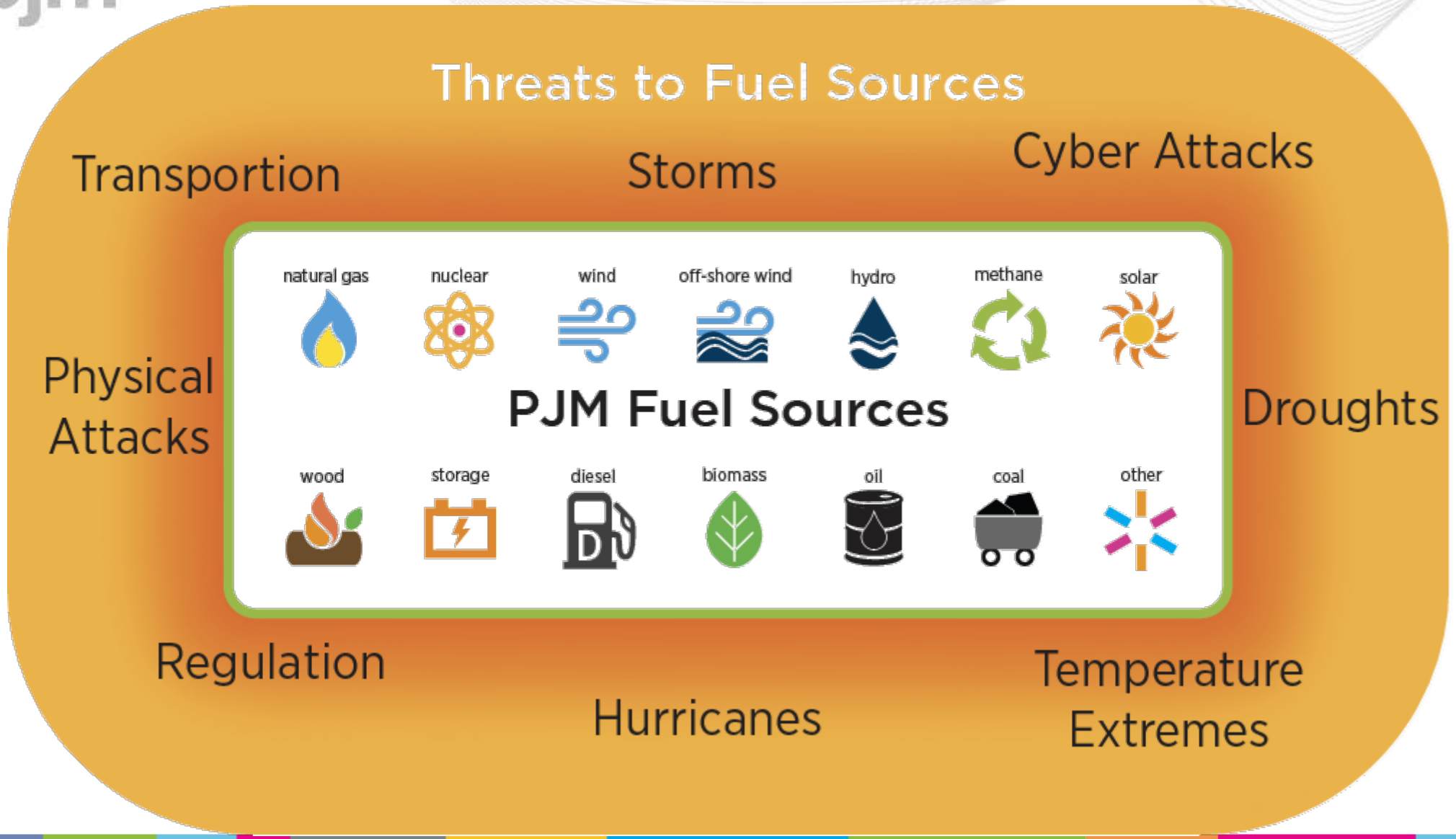
Gas Electric Coordination Team **2014**	• Assembled after 2013/2014 Polar Vortex • Focused on coordination and collaboration with interstate pipelines and local distribution companies and fuel delivery risk assessment
Capacity Performance **2016-2021**	• 5 year phase in • Generators must perform when called on during Performance Assessment Interval • Significant penalties can be assessed for non-performance
Market Timing Change **April 2016**	• PJM moved Day Ahead Award notification from 4:00pm to 1:30pm • NAESB timely gas nomination deadline moved from 12:30pm to 2:00pm
Hourly Offers **November 2017**	• Allows generators to updated their offers on an hourly basis if they choose to reflect changing market conditions

2019 Gas Electric Coordination Initiatives

PJM/Interstate Pipeline Tabletop Exercise – Spring 2019	• Pilot exercise • Testing operational and communication protocols between PJM and Interstate Pipeline personnel under various system disruption scenarios
GridEx V – November 2019	• Including representatives from an Interstate Pipeline in this year's exercise
NPCC Tabletop Exercise November 2019	• Focus on New York/New England but with some impact on eastern PJM
Gas Electric Coordination Database	• Central repository for all gas generation related data • Single tool to consolidate and enhance existing daily team processes
Contingency Planning	• Continue to identify/refine gas contingencies • System restoration coordination with pipelines/Black Start Fuel Assurance

What's Keeping Us Up At Night?

Threats



Fuel Security Summary

FOCUS

1. Define fuel security considering risks in fuel delivery to critical generators
2. Reaffirm the value of markets to achieving a cost-effective, fuel-secure fleet of resources
3. Identify fuel security risks with a primary focus on resilience
4. Establish criteria to value fuel security in PJM markets

APPROACH

1 Phase 1: Analysis
Identify potential system vulnerabilities and develop criteria to address them

2 Phase 2: Modeling
Model incorporation of vulnerabilities into PJM's markets

3 Phase 3: Ongoing Coordination
Address specific security concerns identified by federal and state agencies

TIMING

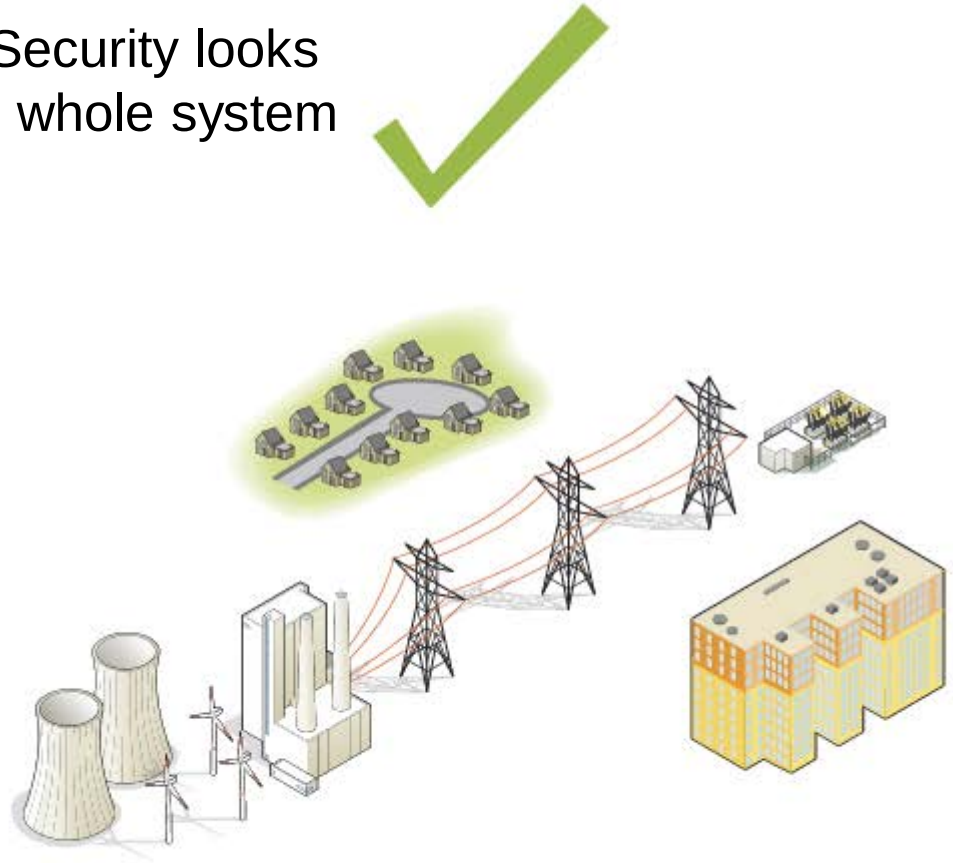
May–November 2018
Analysis

May 2018 – December 2019
Phase 3 ongoing coordination

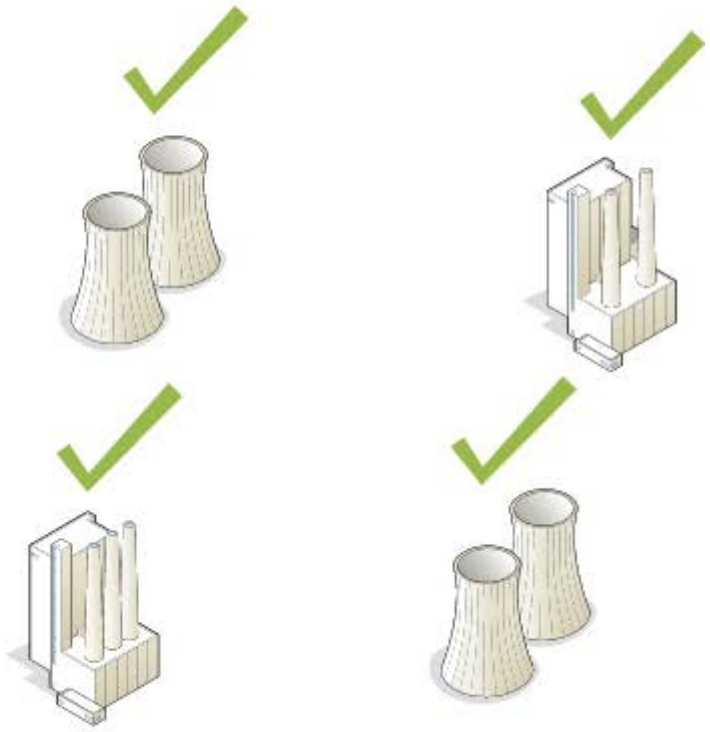
2019/2020
Phase 2 - Assess market design in 2019 and target solution filed with FERC early 2020

Fuel Security vs. Capacity Performance

Fuel Security looks at the whole system



Capacity Performance looks at each unit individually



Scenarios Analyzed

Dispatch	Retirement	Winter Load	Non-Firm Gas	Refueling	Pipeline Disruption (med. impact)	Pipeline Disruption (high impact)	Forced Outages
Economic	Announced	Typical 50/50 134,976 MW	62.5% Avail.	Moderate	Looped 1	Looped 1	Five Year Avg.
Max. Emergency	Escalated 1	Extreme 95/5 147,721 MW	0% Avail.	Limited	Looped 2	Looped 2	Modeled Outages
	Escalated 2				Single 1	Single 1	
					Single 2	Single 2	

300+

combinations

Is The Sky Falling?

Highlights from Fuel Security Analysis Phase I

There is NO immediate threat to the reliability of the PJM RTO.

- PJM is reliable in the announced retirements and escalated retirements cases under all typical winter load scenarios.
- PJM is reliable in the announced retirements cases under all extreme winter load scenarios.

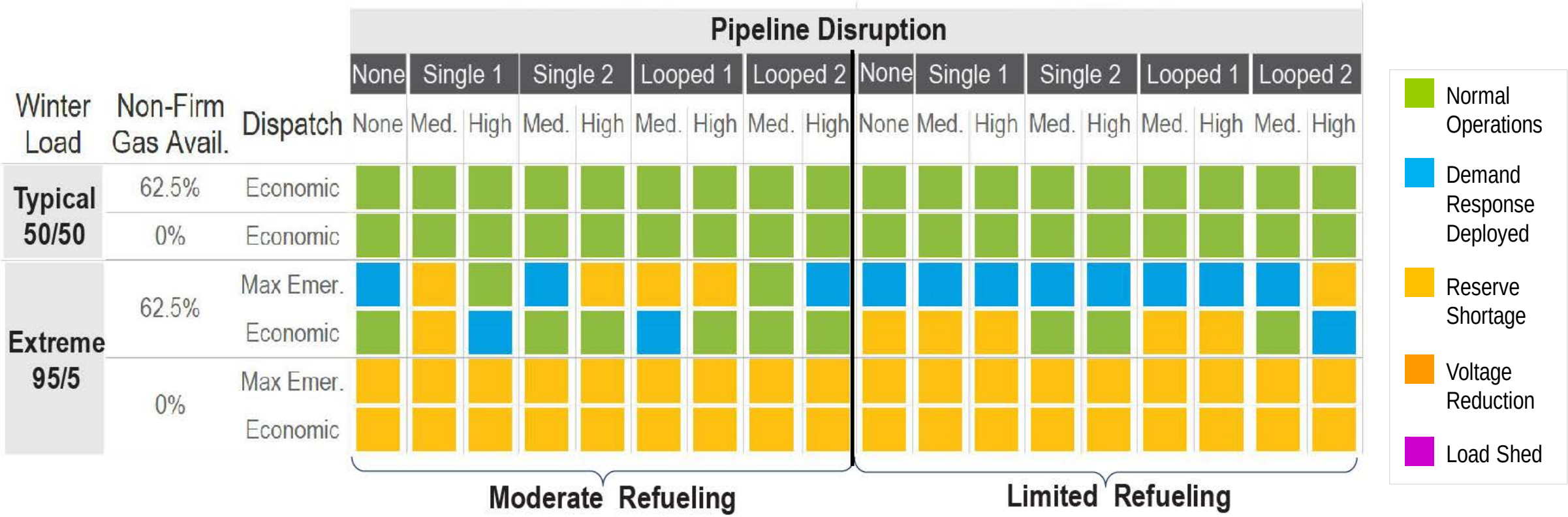
- Scenarios to identify points at which an assumption or combination of assumptions begin to impact the ability to reliably serve customers.
- The stressed scenarios resulted in a loss of load under extreme but plausible conditions.

Contributing factors:

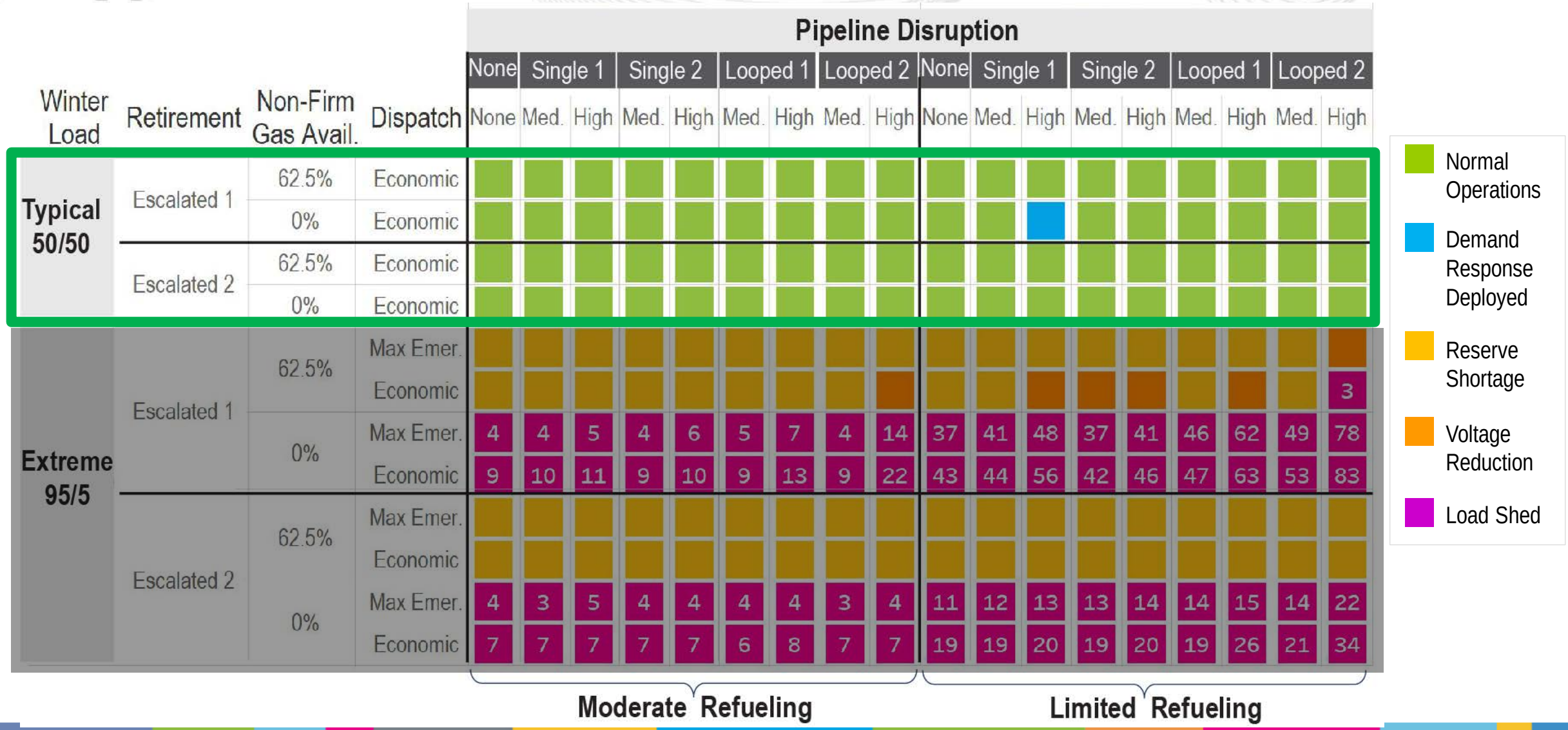
- The level of retirements and replacements
- The level of non-firm gas availability
- The ability to replenish oil supplies
- The location, magnitude and duration of pipeline disruption
- Pipeline configuration

Emergency Procedures Summary

Announced Retirement Summary



Emergency Procedures Summary
Escalated Retirement Models



Fuel Security Study Documentation

- Fuel Security Analysis **PDF**12.18.2018
- Fuel Security Analysis - Technical Appendix **PDF**1.2.2019
- Fuel Security Analysis – Scenario Summaries **PDF**(133MB)1.16.2019
- Fuel Security Study - Presentation **PDF**11.1.2018
- Fuel Security: Analyzing Fuel Supply Resilience in the PJM Region **PDF**11.1.2018
- Fuel Security FAQs **XLS**11.21.2018
- Valuing Fuel Security **PDF**4.30.2018

Challenges and Opportunities

- Staying ahead of cyber and physical threats
  - Collaboration with federal agencies
  - Exercises and drills between gas and electric industries
- Fuel assurance during a system restoration event
  - Black start and critical generation
    - How much gas would be available?
    - Emergency order to raise priority of gas deliveries?
    - On-site fuel requirements
- Continuing to enhance coordination with pipelines
  - Control room to control room communications during emergencies