

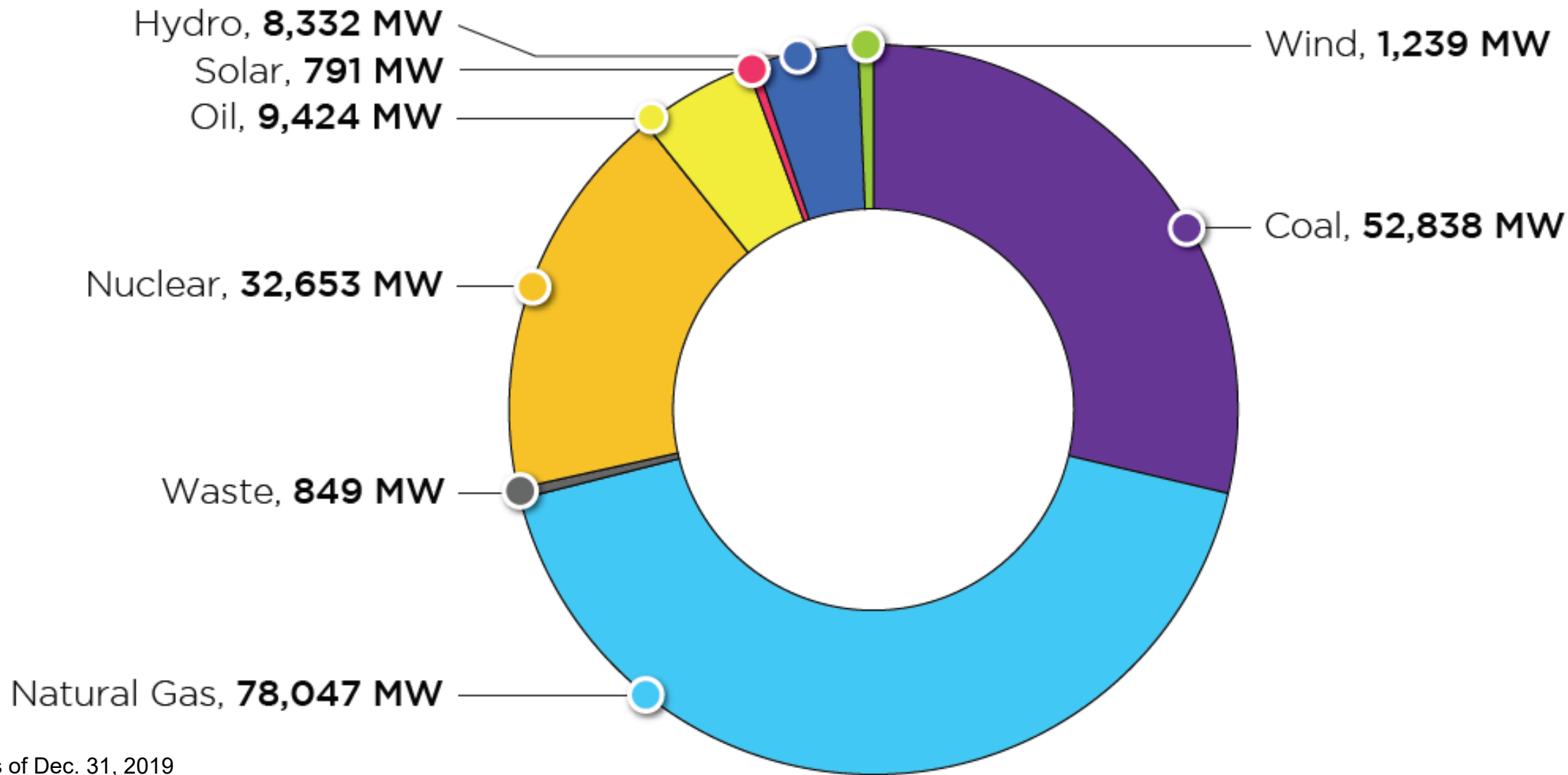


# PJM's Changing Resource Mix

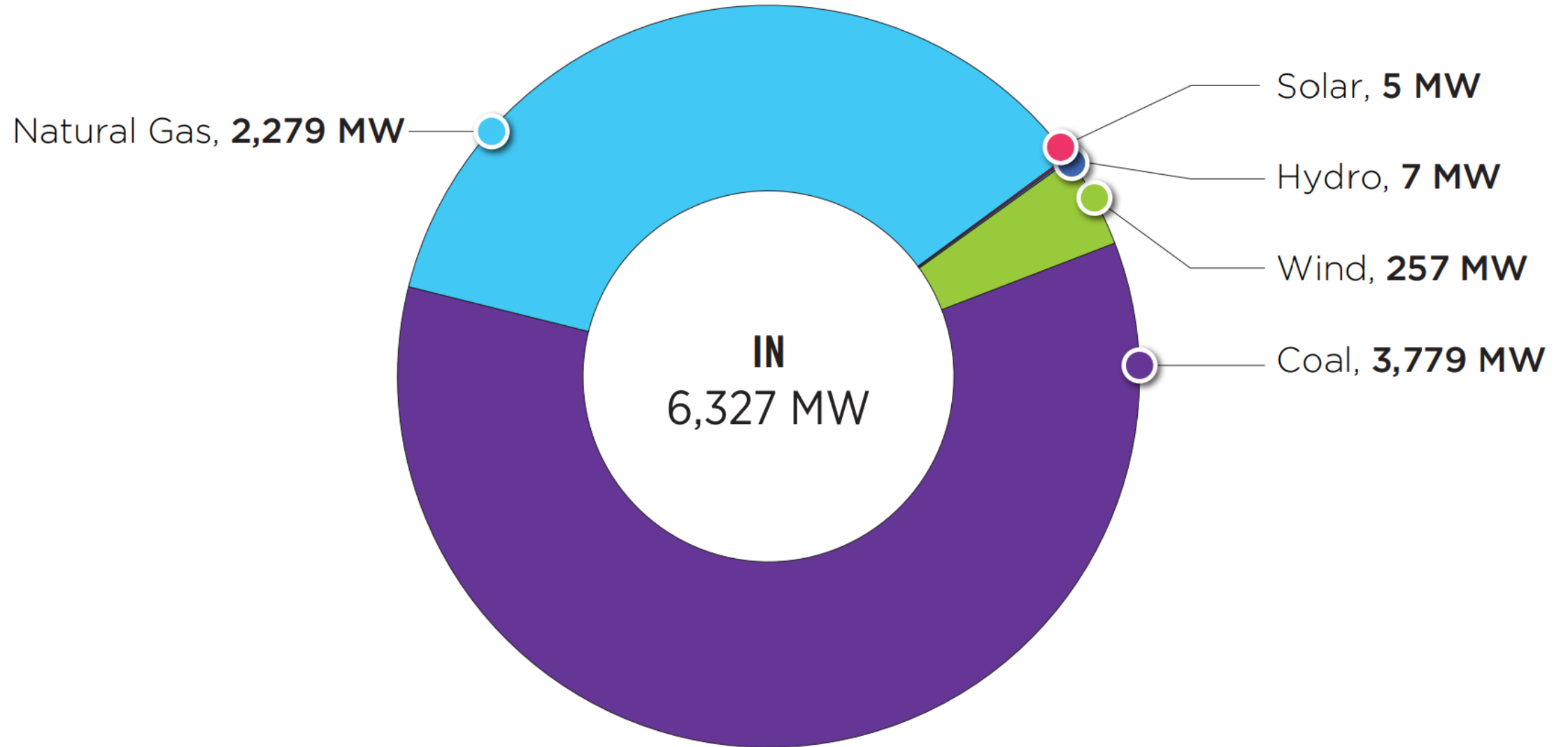
Indiana Utility Regulatory Commission  
August 25, 2020

Tom Falin  
Director Resource Adequacy Planning  
PJM Interconnection

# PJM Existing Installed Capacity Mix

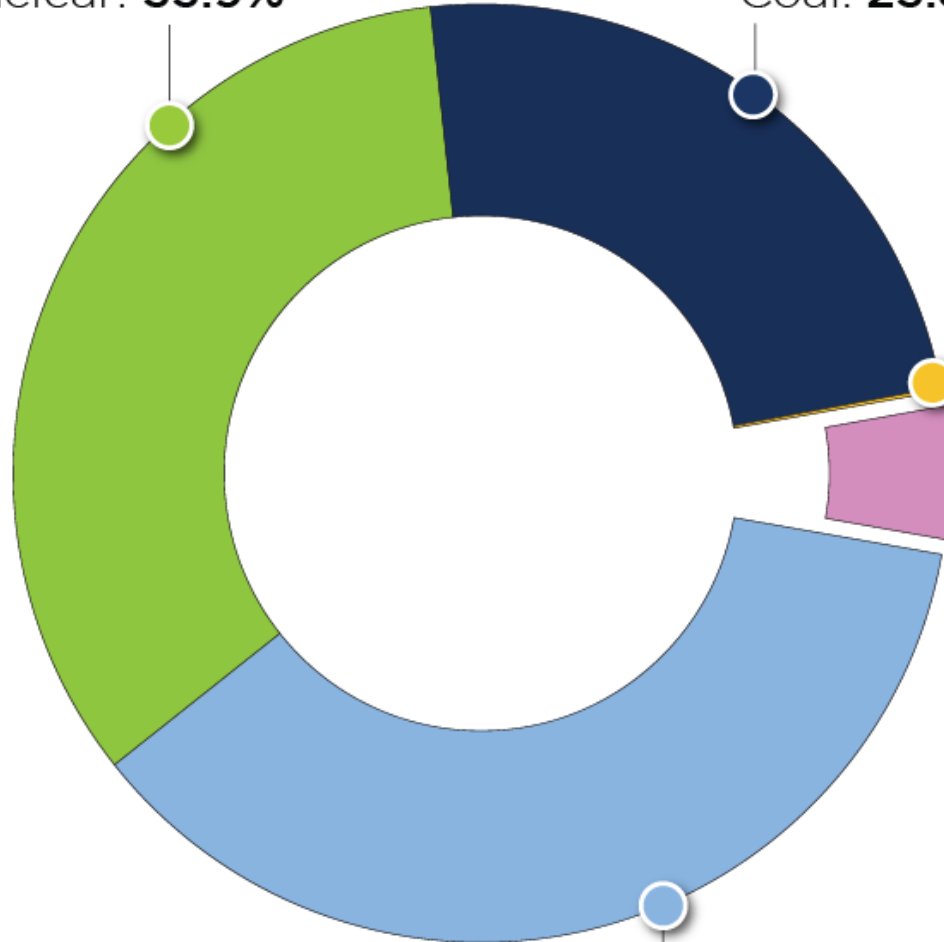


As of Dec. 31, 2019



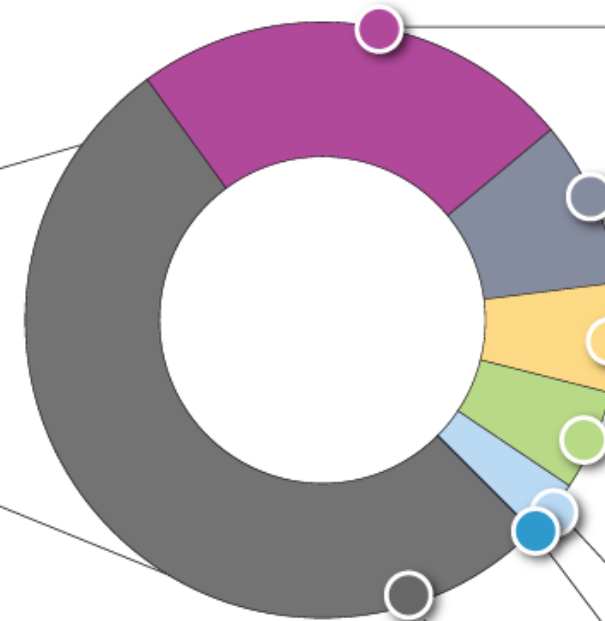
Nuclear: **33.9%**

Coal: **23.8%**



Oil: **0.1%**

Other: **5.6%**



Water: **1.3%**

Waste: **0.5%**

Solar: **0.3%**

Methane: **0.3%**

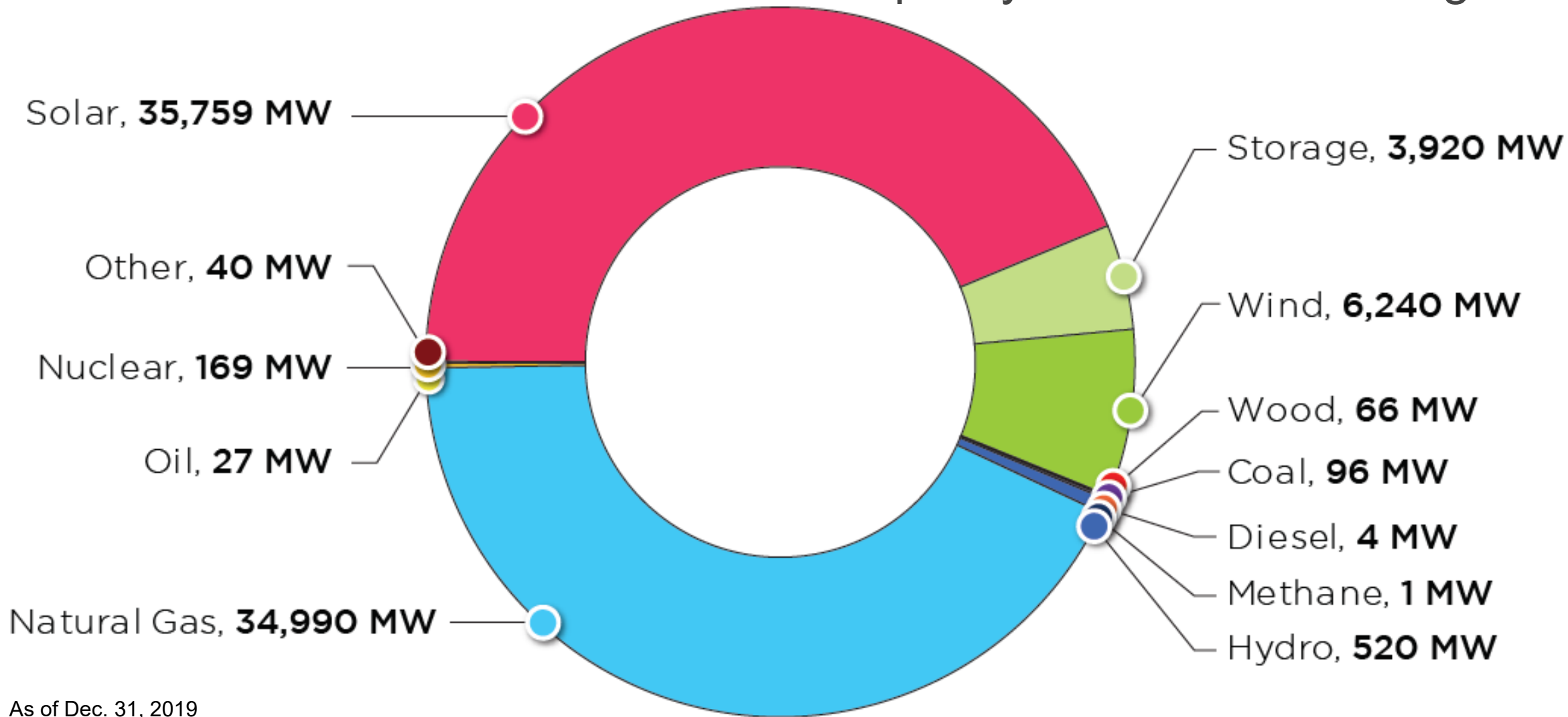
Wood: **0.2%**

Biomass: **0.0%**

Wind: **2.9%**

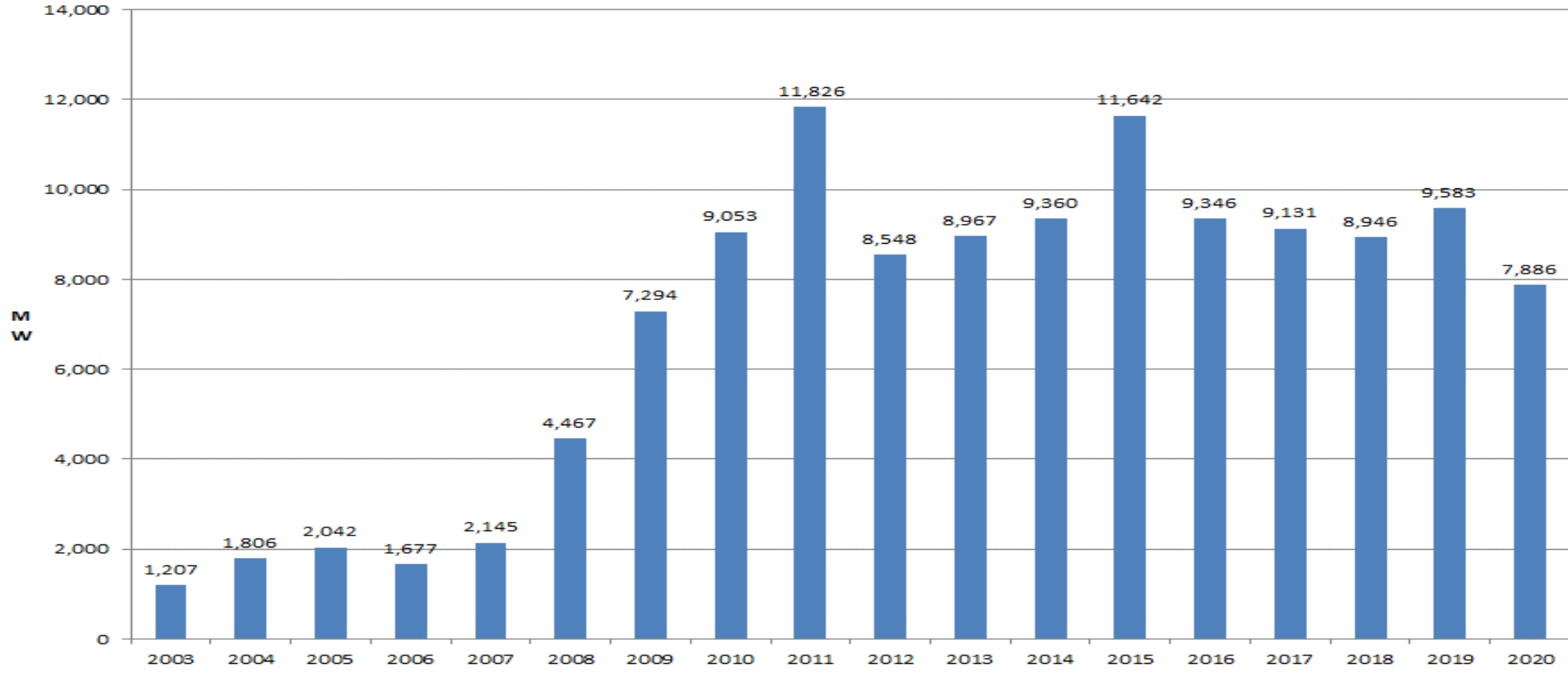
(% Annual Energy)

# PJM Queued Generation Fuel Mix – Requested Capacity Interconnection Rights



As of Dec. 31, 2019

### PJM Interconnection 2003 - 2020 Load Management Summary



## **Qualitative Approach**

PJM examined the ability of a wide range of potential fuel portfolios to provide essential reliability attributes. The performance of each portfolio was expressed with a Composite Reliability Index (CRI) and compared to the performance of the 2018 PJM resource portfolio.

## **Quantitative Approach**

PJM examined 324 different cases under “stressed” conditions regarding weather and load levels, generation retirement scenarios, gas pipeline availability, etc. The frequency and duration of emergency actions were noted for each case.

● = Exhibits Attribute  
◐ = Partially Exhibits Attribute  
○ = Does Not Exhibit Attribute

Resource Type	Essential Reliability Services (Frequency, Voltage, Ramp Capability)					Fuel Assurance		Flexibility			Other		
	Frequency Response (Inertia & Primary)	Voltage Control	Ramp			Not Fuel Limited (> 72 hours at Eco. Max Output)	On-site Fuel Inventory	Cycle	Short Min. Run Time (< 2 hrs.) / Multiple Starts Per Day	Startup / Notification Time < 30 Minutes	Black Start Capable	No Environmental Restrictions (That Would Limit Run Hours)	Equivalent Availability Factor
Regulation	Contingency Reserve	Load Following											
Hydro	●	●	●	●	●	◐	●	●	●	●	●	◐	●
Natural Gas - Combustion Turbine	●	●	◐	●	◐	●	○	●	●	●	●	◐	◐
Oil - Steam	●	●	●	●	●	●	●	●	○	○	○	○	○
Coal - Steam	●	●	●	●	●	●	●	◐	○	○	○	○	○
Natural Gas - Steam	●	●	●	●	●	●	○	●	○	○	○	○	○
Oil/ Diesel - Combustion Turbine	●	●	○	●	○	○	●	●	○	○	○	○	○
Nuclear	◐	●	○	○	◐	●	●	○	○	○	○	○	○
Battery/ Storage	◐	◐	●	●	○	○	○	●	●	●	◐	●	●
Demand Response	○	○	◐	◐	◐	◐	◐	●	●	◐	○	●	●
Solar	◐	◐	○	○	◐	○	○	●	●	●	○	●	●
Wind	◐	◐	○	○	◐	○	○	●	●	●	○	◐	●

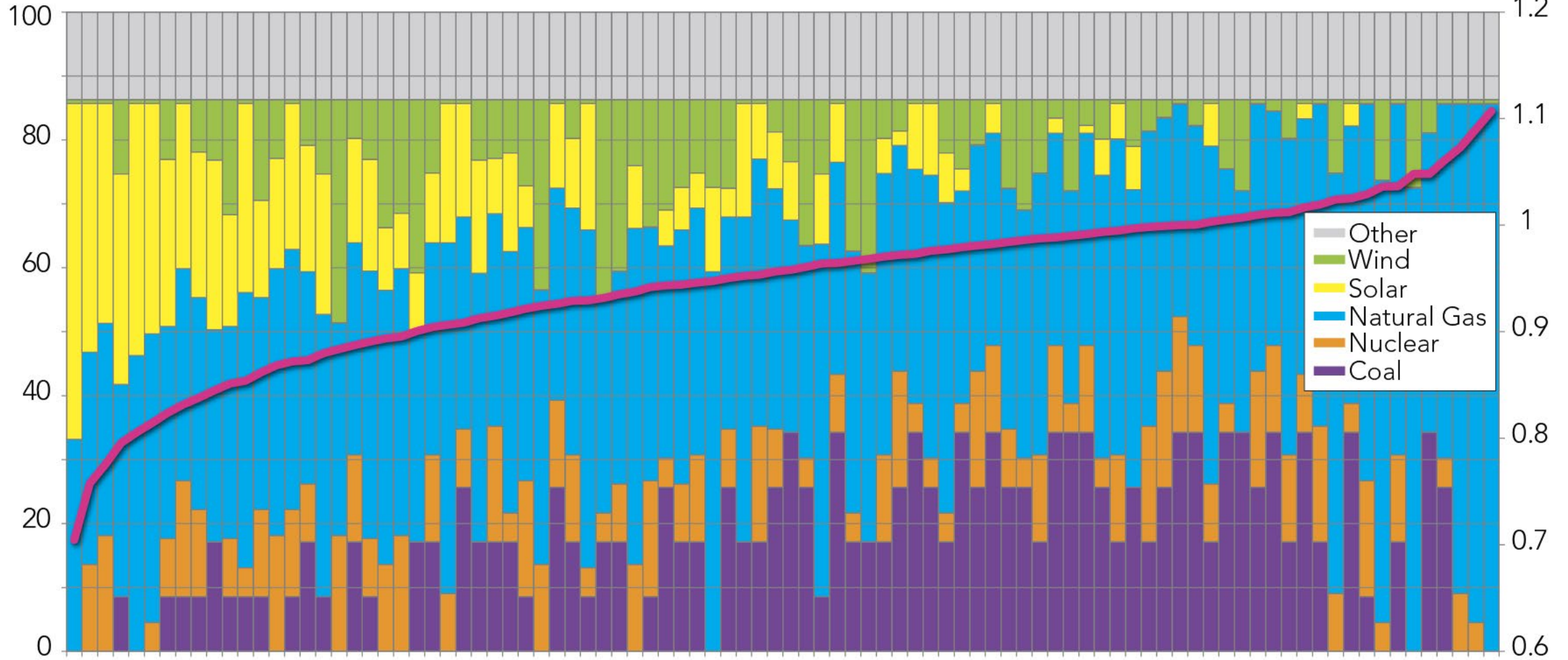
Capabilities needed by the grid to ensure reliability

Contribution of each resource type to a particular attribute

Qualitative approach to describing resource attributes essential for system reliability



% Share Unforced Capacity

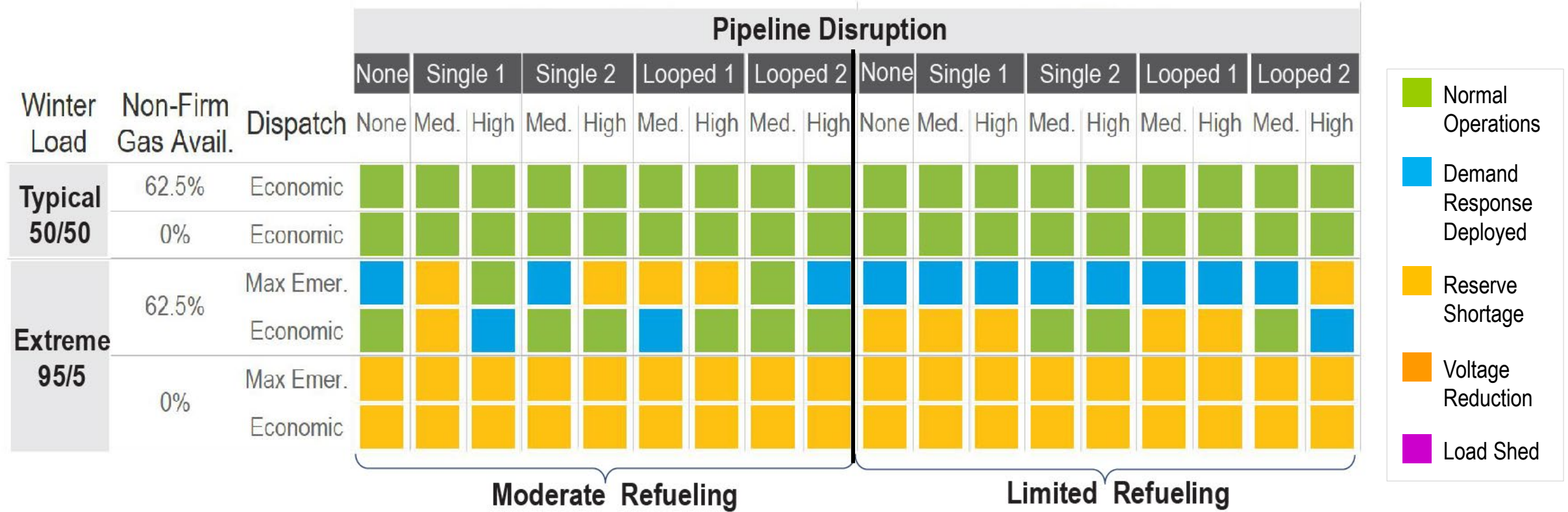


Portfolios

Dispatch	Retirement	Winter Load	Non-Firm Gas	Refueling	Pipeline Disruption (med. impact)	Pipeline Disruption (high impact)	Forced Outages
<b>Economic</b> 	<b>Announced</b> 	<b>Typical 50/50</b> <b>134,976 MW</b> 	<b>62.5% Avail.</b> 	<b>Moderate</b> 	<b>Looped 1</b> 	<b>Looped 1</b> 	<b>Five-Year Avg.</b> 
<b>Max. Emergency</b> 	<b>Escalated 1</b> 	<b>Extreme 95/5</b> <b>147,721 MW</b> 	<b>0% Avail.</b> 	<b>Limited</b> 	<b>Looped 2</b> 	<b>Looped 2</b> 	<b>Modeled Outages</b> 
	<b>Escalated 2</b> 				<b>Single 1</b> 	<b>Single 1</b> 	
		<b>324</b> <b>combinations</b>			<b>Single 2</b> 	<b>Single 2</b> 	

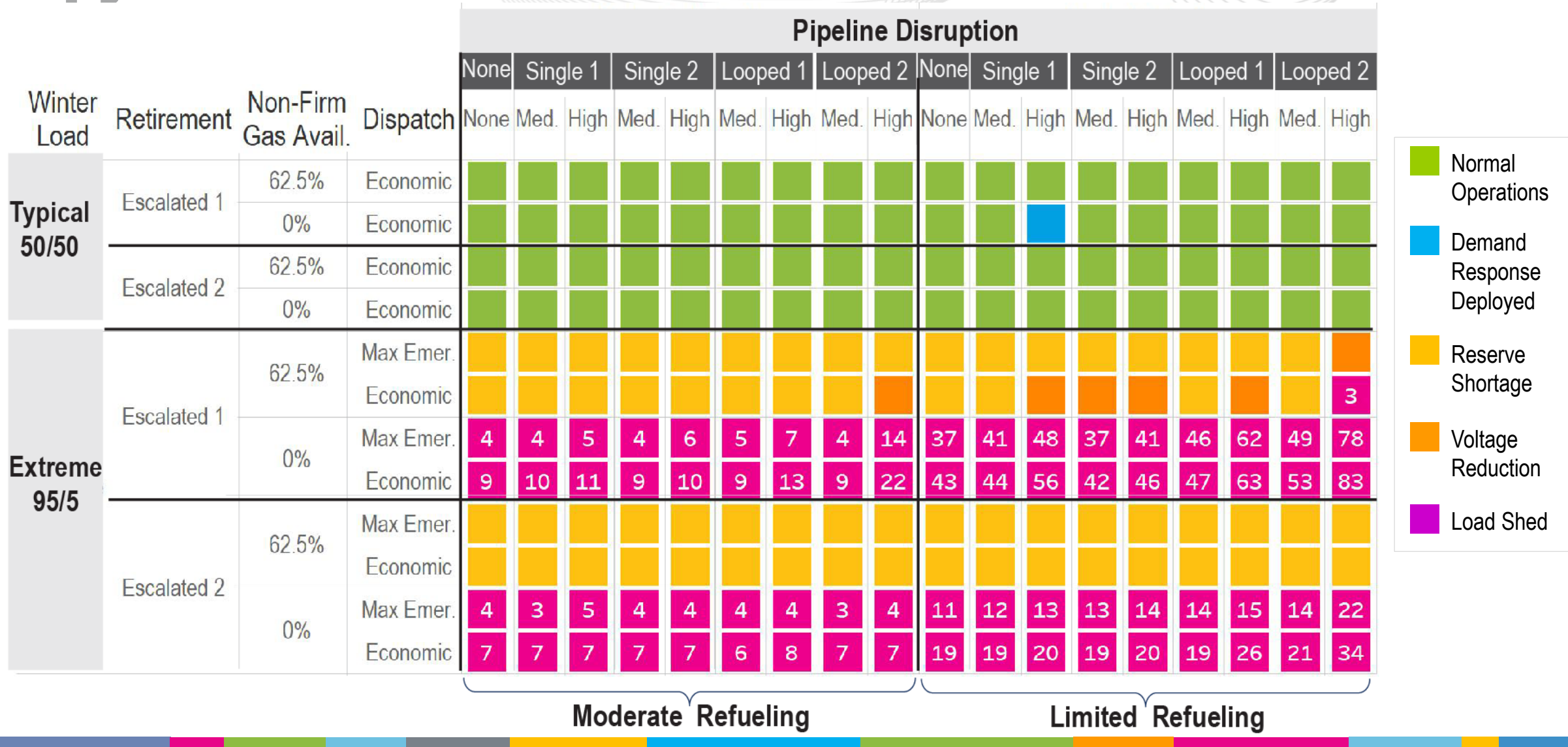
# Emergency Procedures Summary

## Announced Retirement Models



# Emergency Procedures Summary

## Escalated Retirement Models



# Emergency Procedures Summary

## Escalated Retirement Models

Winter Load	Retirement	Non-Firm Gas Avail.	Dispatch	Pipeline Disruption																			
				None		Single 1		Single 2		Looped 1		Looped 2		None		Single 1		Single 2		Looped 1		Looped 2	
				None	Med.	High	Med.	High	Med.	High	Med.	High	None	Med.	High	Med.	High	Med.	High	Med.	High	Med.	High
<b>Typical 50/50</b>	Escalated 1	62.5%	Economic	Normal Operations																			
		0%	Economic	Normal Operations																			
	Escalated 2	62.5%	Economic	Normal Operations																			
		0%	Economic	Normal Operations																			
<b>Extreme 95/5</b>	Escalated 1	62.5%	Max Emer.	Reserve Shortage																			
			Economic	Reserve Shortage																			3
		0%	Max Emer.	4	4	5	4	6	5	7	4	14	37	41	48	37	41	46	62	49	78		
			Economic	9	10	11	9	10	9	13	9	22	43	44	56	42	46	47	63	53	83		
	Escalated 2	62.5%	Max Emer.	Reserve Shortage																			
			Economic	Reserve Shortage																			
		0%	Max Emer.	4	3	5	4	4	4	4	3	4	11	12	13	13	14	14	15	14	22		
			Economic	7	7	7	7	7	6	8	7	7	19	19	20	19	20	19	26	21	34		

- Normal Operations
- Demand Response Deployed
- Reserve Shortage
- Voltage Reduction
- Load Shed

Moderate Refueling

Limited Refueling

# Emergency Procedures Summary

## Escalated Retirement Models

Winter Load	Retirement	Non-Firm Gas Avail.	Dispatch	Pipeline Disruption																	
				None		Single 1		Single 2		Looped 1		Looped 2									
				None	Med.	High	Med.	High	Med.	High	Med.	High	None	Med.	High	Med.	High	Med.	High		
Typical 50/50	Escalated 1	62.5%	Economic	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal		
		0%	Economic	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Demand Response Deployed	
	Escalated 2	62.5%	Economic	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	
		0%	Economic	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	
Extreme 95/5	Escalated 1	62.5%	Max Emer.	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage		
			Economic	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	3	
		0%	Max Emer.	4	4	5	4	6	5	7	4	14	37	41	48	37	41	46	62	49	78
			Economic	9	10	11	9	10	9	13	9	22	43	44	56	42	46	47	63	53	83
	Escalated 2	62.5%	Max Emer.	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	
			Economic	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	
		0%	Max Emer.	4	3	5	4	4	4	4	3	4	11	12	13	13	14	14	15	14	22
			Economic	7	7	7	7	7	6	8	7	7	19	19	20	19	20	19	26	21	34

Moderate Refueling

Limited Refueling

# Emergency Procedures Summary

## Escalated Retirement Models

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				None	Med.	High	Med.	High	Med.	High	Med.	High	Med.	High							
Typical 50/50	Escalated 1	62.5%	Economic	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	
		0%	Economic	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
	Escalated 2	62.5%	Economic	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
		0%	Economic	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Extreme 95/5	Escalated 1	62.5%	Max Emer.	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	
			Economic	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	3
		0%	Max Emer.	4	4	5	4	6	5	7	4	14	37	41	48	37	41	46	62	49	78
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			Economic	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage	Reserve Shortage
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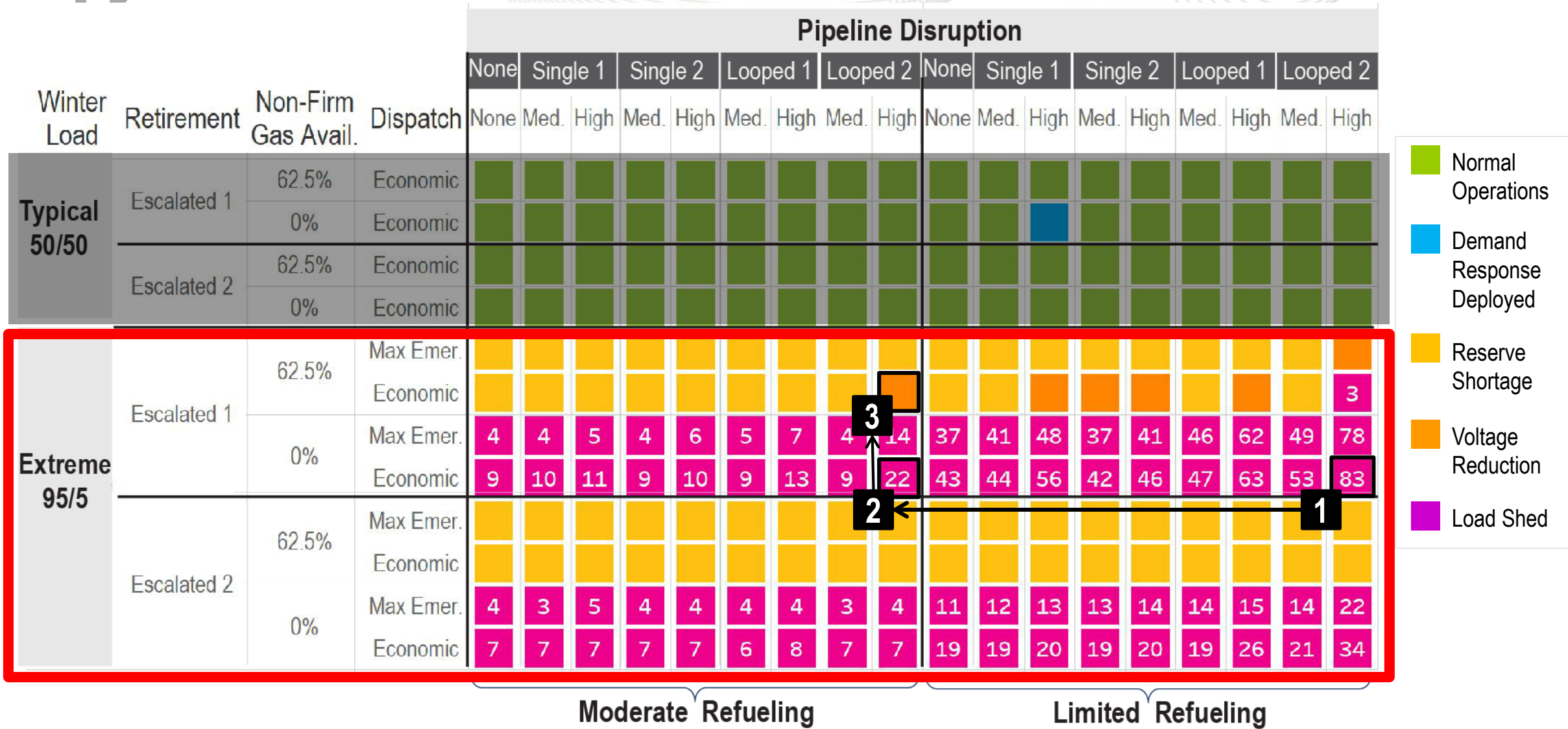
- Normal Operations
- Demand Response Deployed
- Reserve Shortage
- Voltage Reduction
- Load Shed

Moderate Refueling

Limited Refueling

# Emergency Procedures Summary

## Escalated Retirement Models







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.

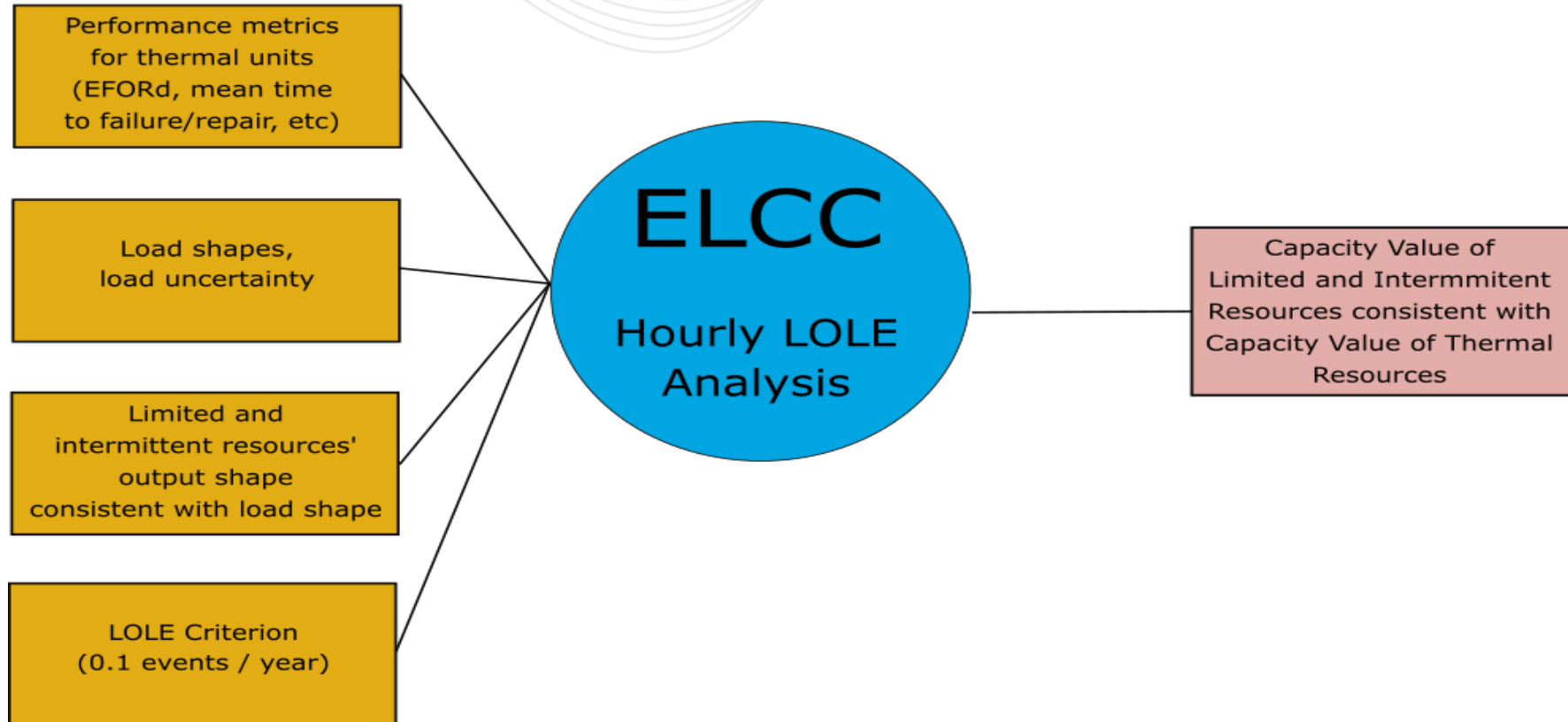
## Contributing factors:

- 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

- The current rules set the capacity value of wind and solar units at their average output over the peak hours of summer days over the last three years.
- Shortcomings of the current treatment:
  - Includes many hours in which there is little to no loss of load risk
  - Fails to recognize the decreasing reliability value of intermittent resources as their penetration level increases
- PJM is developing with stakeholders a more robust approach that bases the capacity value of wind and solar resources on their **Effective Load Carrying Capability (ELCC)**. This method can be extended to include storage and hybrid resources.

# Inputs

# Output



- PJM is currently reviewing the various ELCC proposals with stakeholders.
- The FERC filing regarding the capacity treatment of these resources is due on October 30, 2020.
- It is anticipated that any rule changes would take effect no earlier than the 2022/2023 Delivery Year.