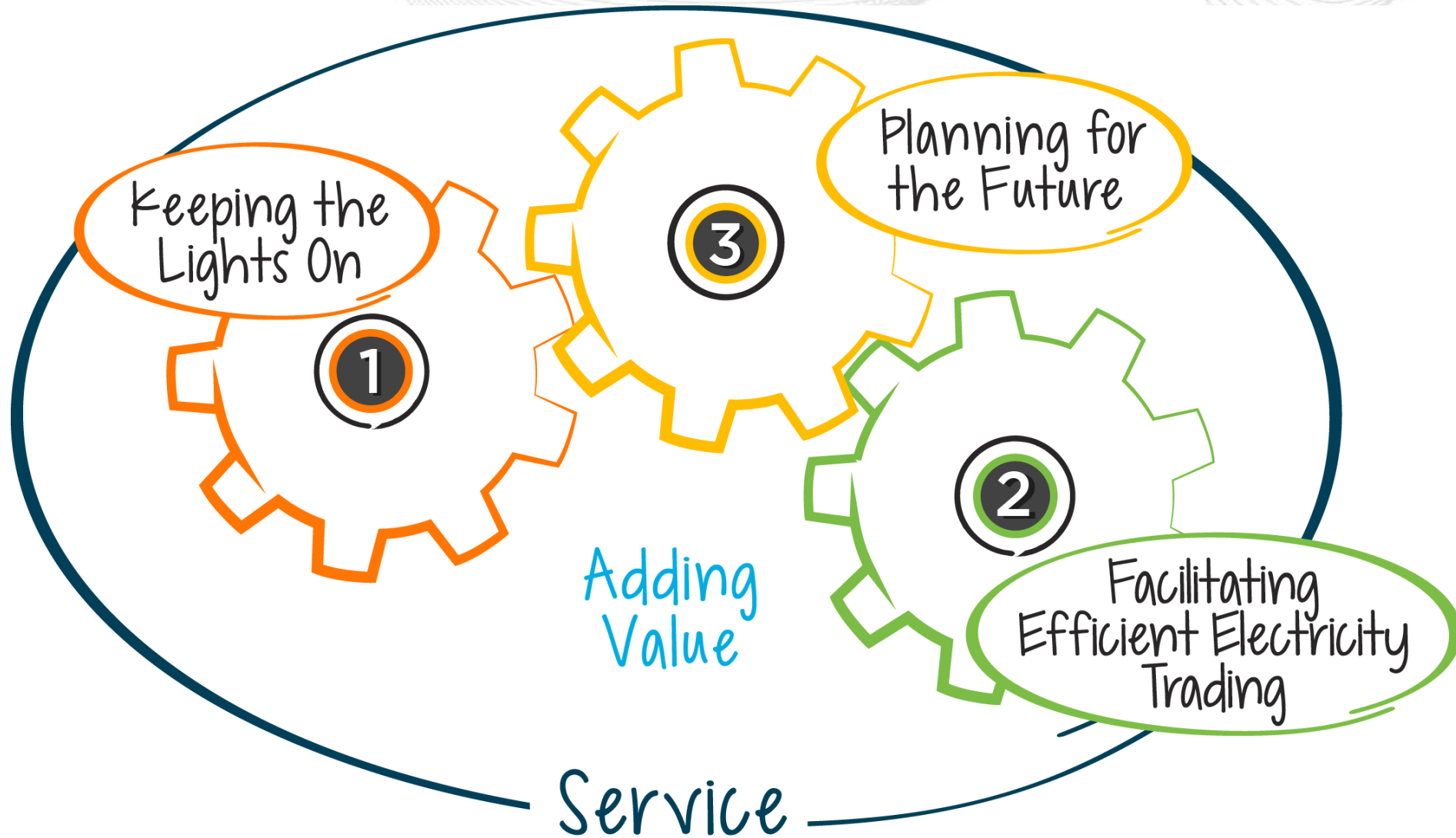
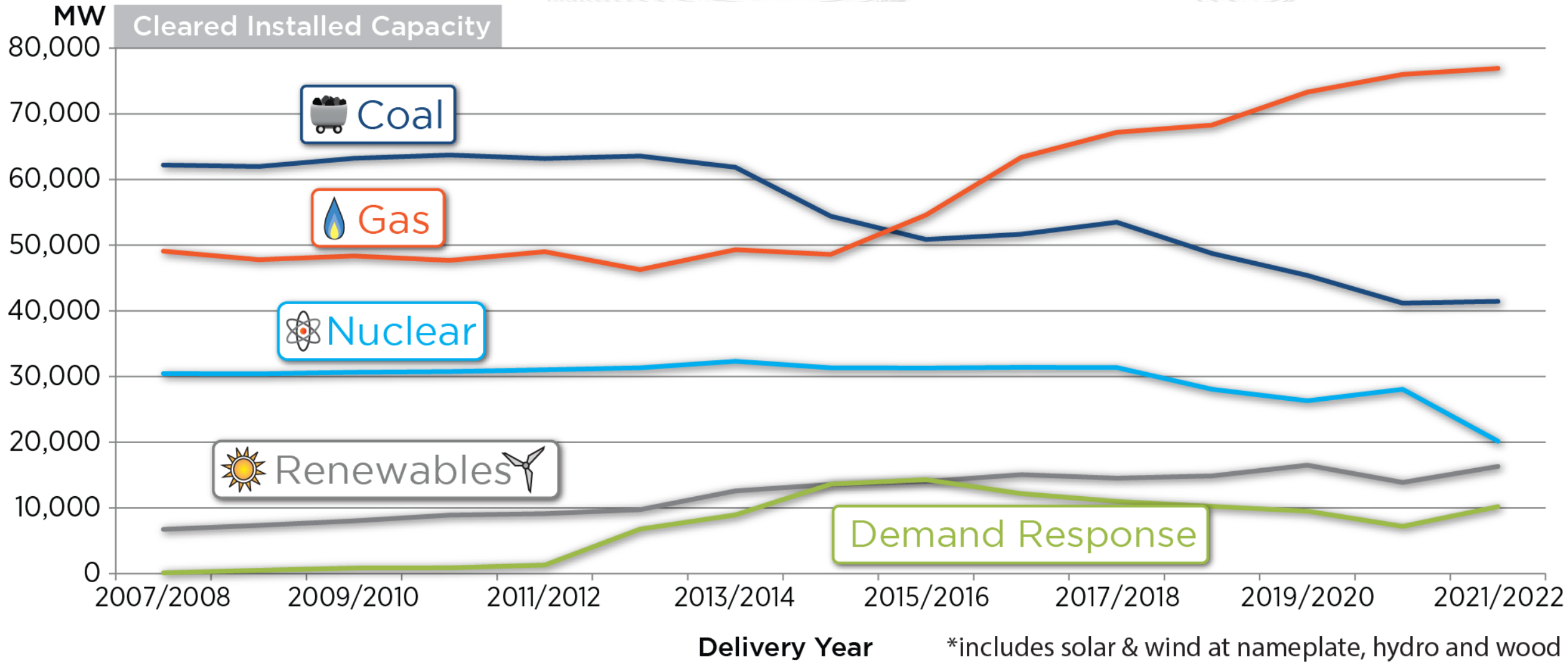


Managing the Risk: Concerns about the Reliability of Natural Gas Electricity Generation

Michael Bryson
Vice-President, Operations
PJM Interconnection

NASUCA 2018
Minneapolis, MN





Active Interstate Pipeline Restrictions

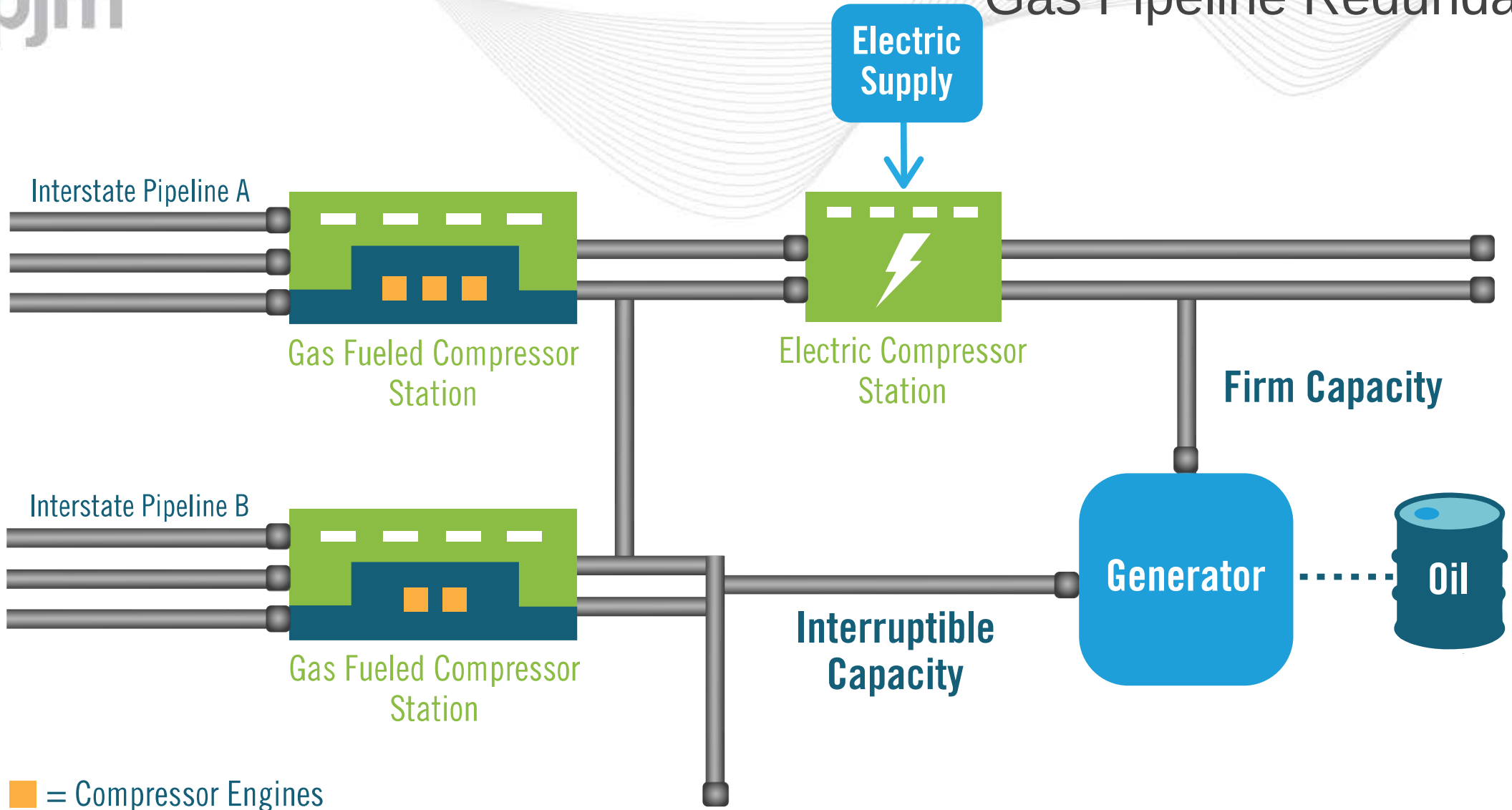
LEGEND	
Color Code for Restriction Severity	
	No Restrictions
	Scheduling Operational Flow Order
	Non-Firm Restriction
	Rateable Take
	Force Majeure

	December 2017										January 2018							
Pipeline	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8
Dominion DTI																		
Dominion Cove Point																		
Transco																		
Texas Eastern																		
Tennessee																		
Columbia																		
ANR																		
NGPL																		
Eastern Shore																		
Northern Border																		
Panhandle Eastern																		
Texas Gas																		

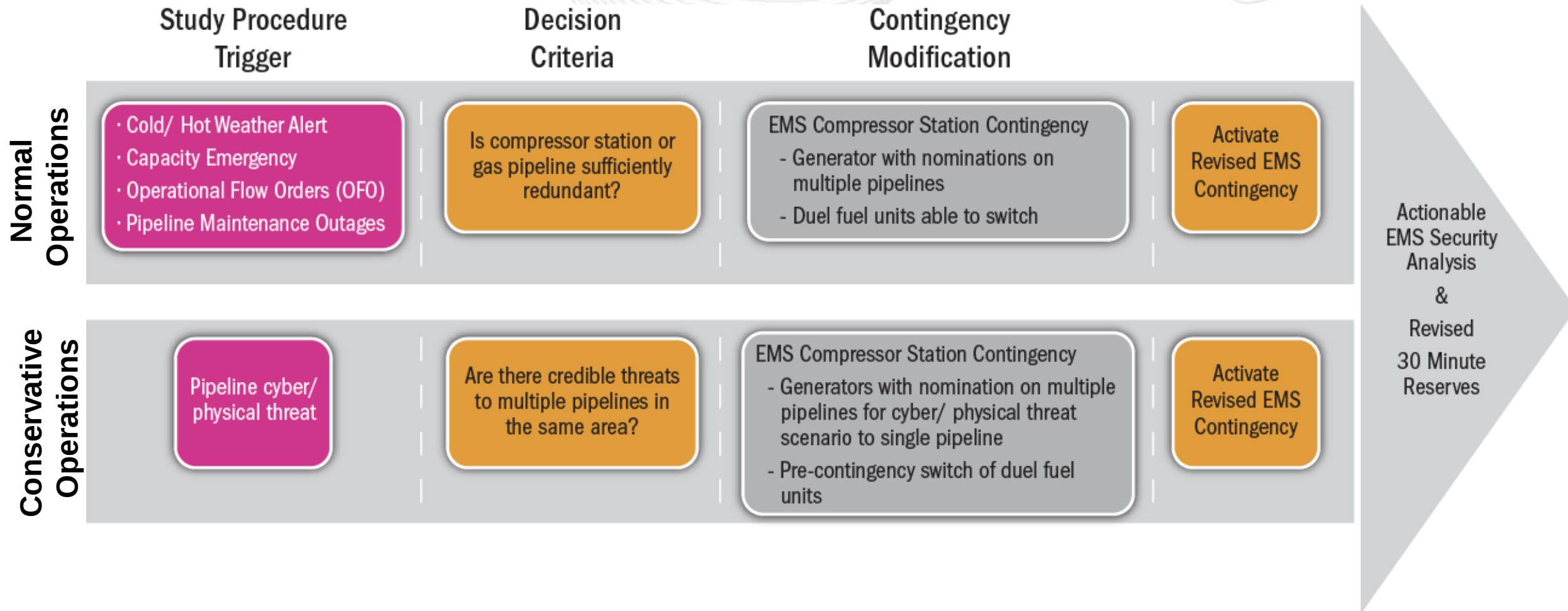


Estimated Cost-Based Offer Level vs. Natural Gas Prices

Hub Price	Combined Cycle 7.5 Heat Rate	Steam 10.0 Heat Rate	Combustion Turbine 15.0 Heat Rate
\$5.0/MMBtu	\$37.5/MWh	\$50.0/MWh	\$75/MWh
\$20.0/MMBtu	\$150/MWh	\$200/MWh	\$300/MWh
\$75.0/MMBtu	\$562.5/MWh	\$750/MWh	\$1,125/MWh
\$100.0/MMBtu	\$750/MWh	\$1,000/MWh	\$1,500/MWh
\$125.0/MMBtu	\$937.5/MWh	\$1,250/MWh	\$1,875/MWh



Operationalizing Gas Pipeline Contingencies Process Flow Diagram



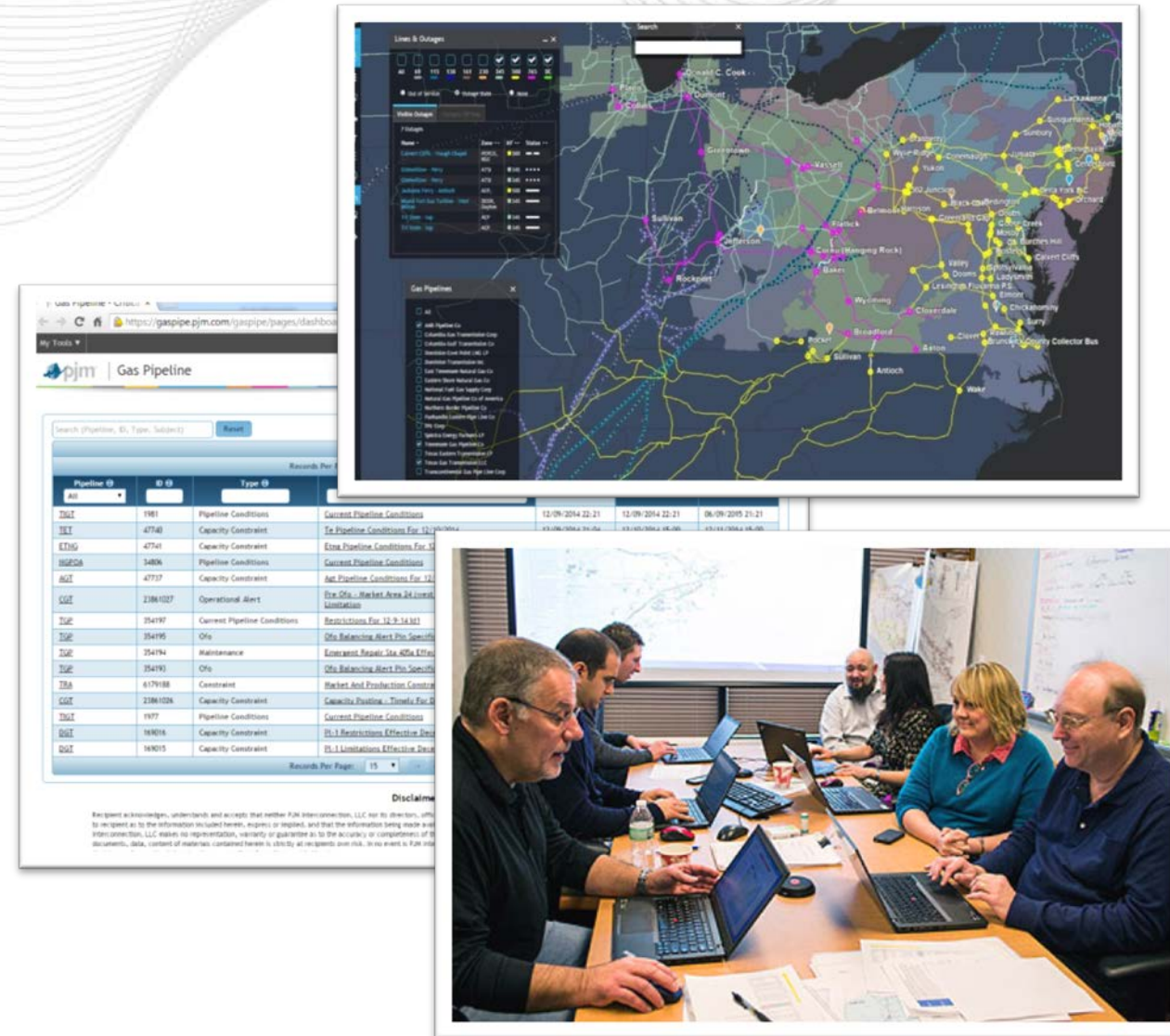
Pipeline	Compressor Station	EMS Contingency with Impacted Generating Units	Unit ICAP	Dual Fuel Details			Alternate Gas Pipeline		Study Results
				Capable	Alternate Fuel MW	Fuel Transition Time(h)	Pipeline(s)	Source MW	Issue Type
Pipeline A	Station A	Unit A 1-4	231	No	-	-	Pipeline B	231	Reactive Transfer
		Unit B	545	Yes	545	1	Pipeline C, Pipeline B	545	
		Unit C	565	Yes	565	1	Pipeline C, Pipeline B	565	
		Unit D	450	Yes	450	2	Pipeline C, Pipeline B	450	
		Unit G	174	No	-	-	Pipeline C, Pipeline B	174	
		Unit F	86	No	-	-	Pipeline C, Pipeline B	86	
		Unit G	1240	No	-	-	-	-	
		Unit H	760	No	-	-	-	-	
		Contingency Totals	4051		1560			2051	

Modified Operational EMS Contingency = UNIT G + UNIT H

Required 30 Minute Reserves = 2000 MW (1240 MW + 760 MW)

PJM team formed to:

- Analyze data related to gas delivery to units
- Provide operational info that allows PJM operators to make better decisions
- Improve coordination with pipelines and LDCs
- Develop tools to support processes



Natural Gas Generator Statistics				
	Count		MW	
		% of Total		% of Total
All Units	1338		187000	
Natural Gas Units	450	33.6%	72159	38.6%
		% of Gas		% of Gas
Natural Gas Units	450		72159	
Dual Fuel Capable	164	36.4%	25323	35.1%
Multiple Pipelines	60	13.3%	13654	18.9%
Dual Fuel and Multiple Pipeline	22	4.9%	4986	6.9%
		% of CP Gas		% of CP Gas
CP Natural Gas Units	230		35648	
CP and Dual Fuel Capable	108	47.0%	12812	35.9%
CP and Multiple Pipeline	40	17.4%	7706	21.6%
CP / Dual Fuel / Multiple Pipeline	22	9.6%	2873	8.1%

FOCUS

1. Define fuel security **as risks in fuel supply and delivery** to critical generators
2. Reaffirm the **value of markets in** 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 of incorporation of vulnerabilities into PJM's markets
- 3 Phase 3: Ongoing Coordination**
Address specific security concerns identified by federal and state agencies

TIMING

May – July 2018:
Analysis

Aug. – Oct. 2018:
Modeling/ Market Design

Nov. 2018 – March 2019:
Ongoing coordination
January 2019: FERC filing