Education

FSSTF

June 26, 2019

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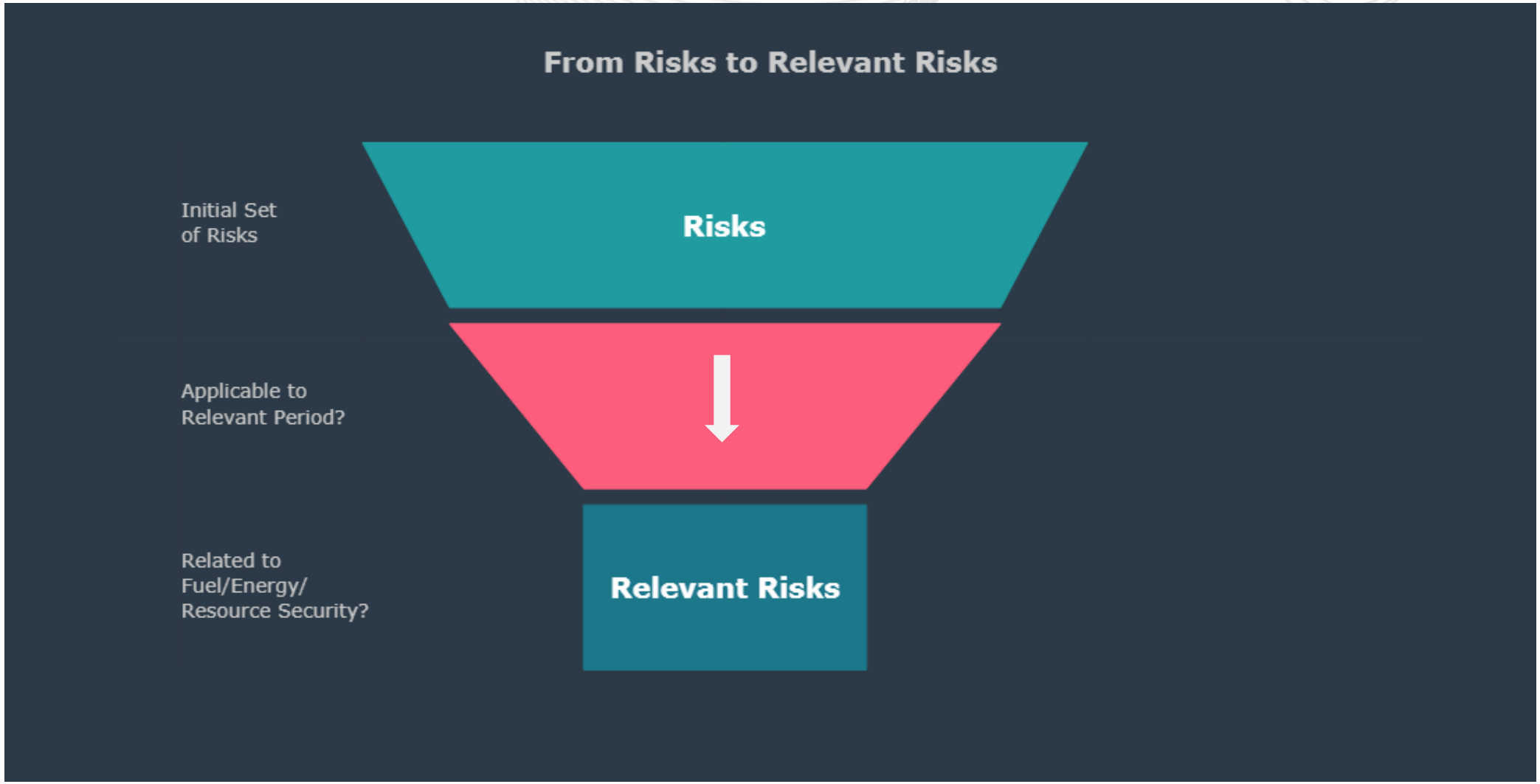
Introduction

- At the previous FSSTF, PJM presented the approach to filter the Relevant Risks
  - This entailed determining a Relevant Period

Introduction

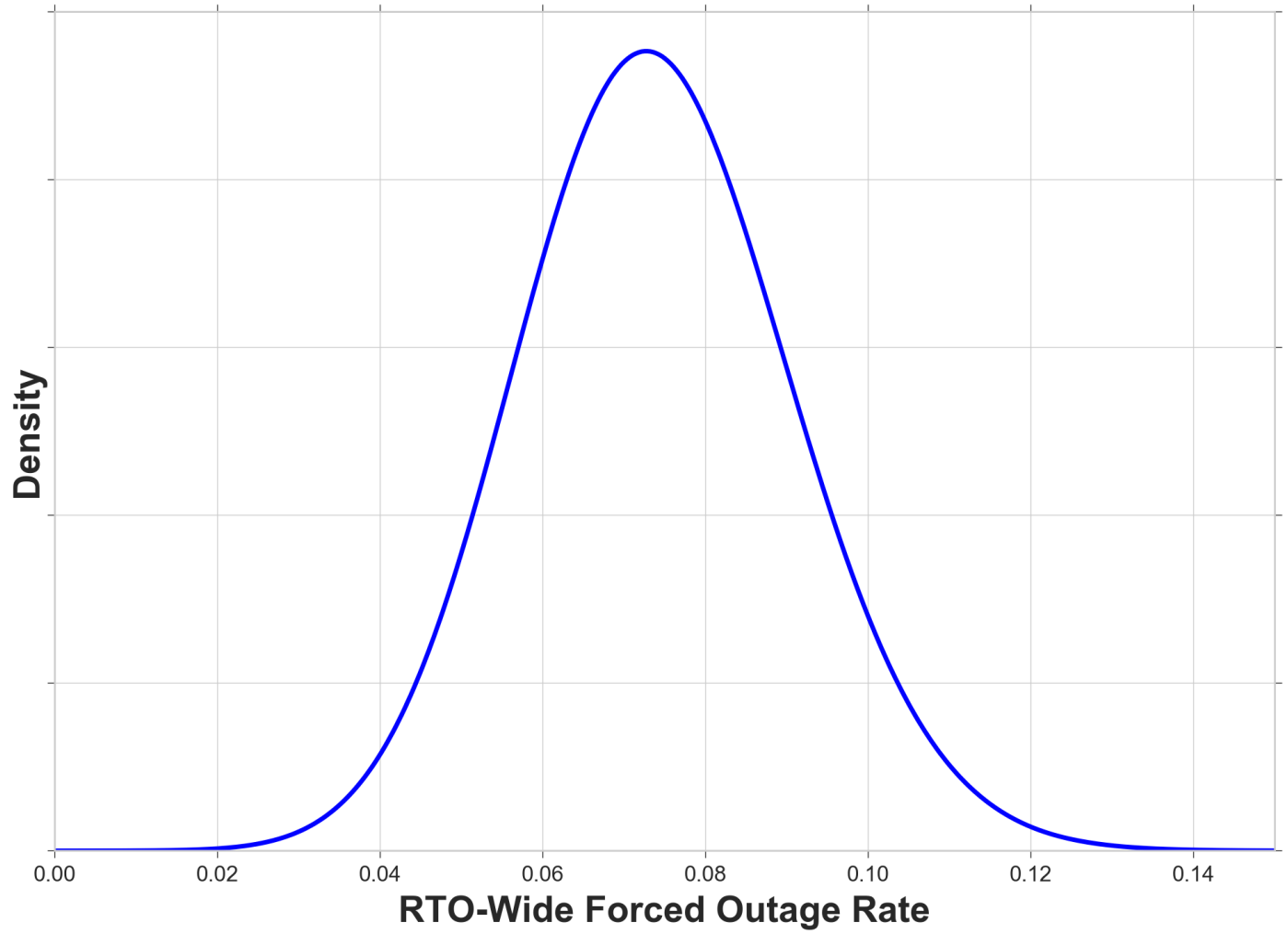


Introduction

- At today's FSSTF, PJM will make presentations
  - Supporting Winter as the Relevant Period
  - Showing a preliminary version of the Relevant Risks filtering process
  - Showing more information about current Products/Mechanisms that address the most typical uncertainties/risks
- At the July FSSTF, as part of the Gap Analysis, PJM will examine if the identified Relevant Risks are addressed by the current Products/Mechanisms

Relevant Period Identification and Methodology

Theoretical RTO-wide Forced Outage Rate



If individual forced outages are random and independent

Mean: ~7.0%
StDev: ~1.4%
90th Perc: ~9.2%

Development of Empirical RTO-wide Forced Outage Rates

- For the last 11 years, the top 3 peak-load weeks of each season are identified
- The RTO-wide Forced Outage Rate at the peak hour of each weekday within each of the above weeks is recorded
- Therefore, for instance, for Winter Week 1
  - There are 11 winter peak weeks (one for each year)
  - There are 5 peak hours within each of the above weeks (one for each weekday)
  - We end up with 55 RTO-wide forced outage observations

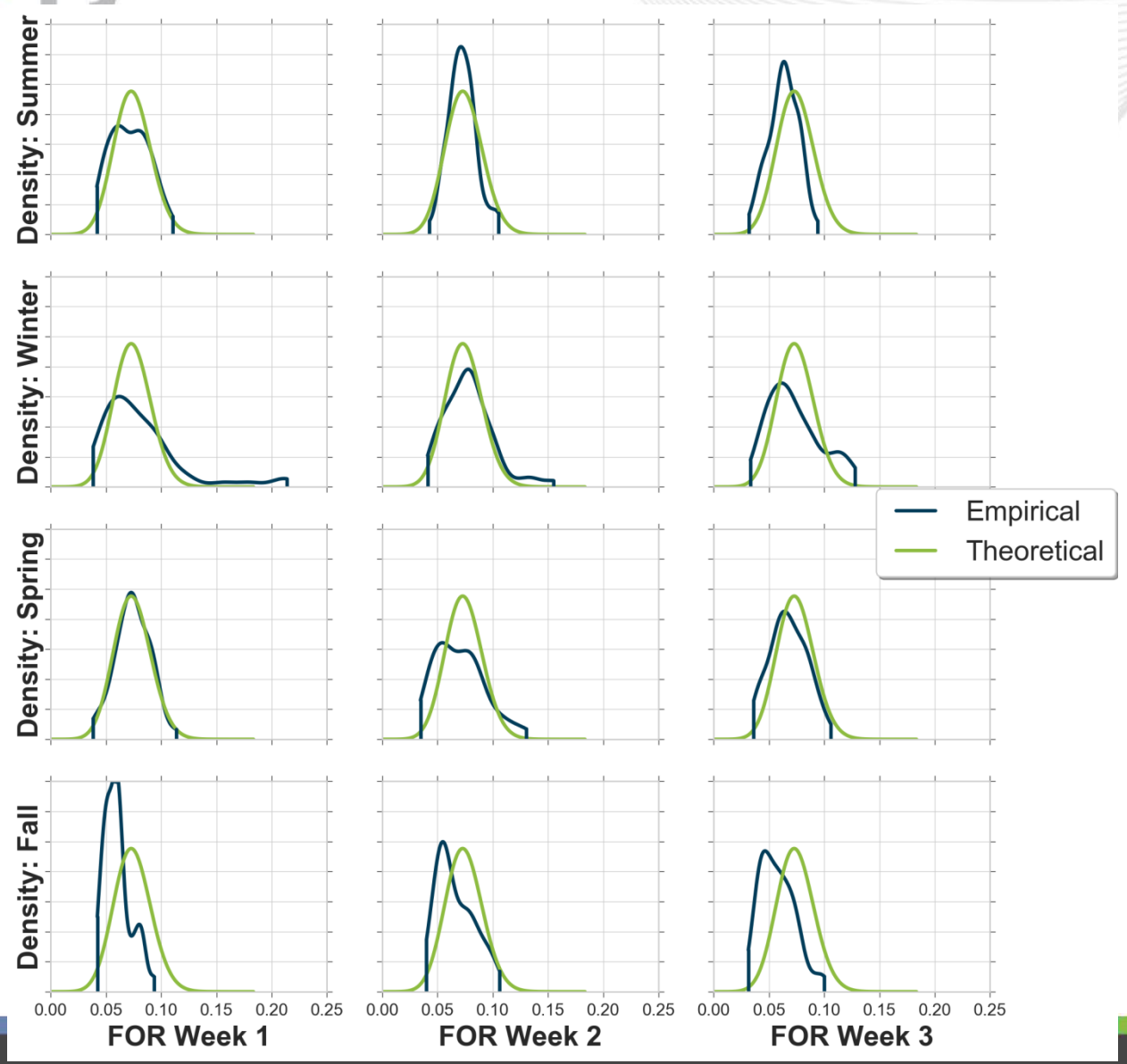
Empirical RTO-wide Forced Outage Rates

Season	Load-Magnitude Ordered Week	RTO-Wide Forced Outage Rate Mean	StDev	90th perc
Summer	1	7.1%	1.8%	9.3%
Summer	2	7.2%	1.3%	8.5%
Summer	3	6.3%	1.3%	7.9%
Winter	1	8.2%	3.8%	11.8%
Winter	2	7.8%	2.3%	10.2%
Winter	3	7.3%	2.4%	11.3%
Spring	1	7.4%	1.6%	9.2%
Spring	2	7.0%	2.3%	10.1%
Spring	3	6.7%	1.7%	8.8%
Fall	1	6.0%	1.2%	8.0%
Fall	2	6.6%	1.7%	9.3%
Fall	3	5.8%	1.6%	7.6%

For comparison, the Theoretical distribution has the following statistics:

Mean: ~7.0%
StDev: ~1.4%
90th Perc: ~9.2%

Empirical vs Theoretical Distributions



Height of line represents how often forced outage rates in x-axis have occurred in the last 11 years for each of the season-week combinations.

In the Top 3 winter weeks, the empirical forced outage distribution (blue line) has a longer right-hand side tail than the theoretical forced outage distribution (green line).

Observations

- The previous slide shows that historical RTO-wide Forced Outage Rates during the Top 3 Winter weeks do not comport with the independence assumption
  - For the Top 3 weeks of the rest of the seasons the independence assumption seems to hold
- Why have RTO-wide forced outage rates been historically greater during the Top 3 Winter weeks?

Forced Outages due to Lack Of Fuel

- Using the Empirical RTO-wide Forced Outage Rate data, but only considering those forced outages with cause codes related to lack of fuel yields the following table

		RTO-Wide Forced Outage MW due to Lack of Fuel		
Season	Load-Magnitude Ordered Week	Mean	StDev	90th perc
Winter	1	2,310	2,670	6,649
Winter	3	1,744	2,307	4,572
Winter	2	1,600	1,640	3,404
Spring	2	794	1,448	1,648
Spring	1	570	651	1,284
Spring	3	563	516	1,351
Fall	3	476	497	1,219
Fall	2	307	486	1,170
Summer	3	194	368	871
Fall	1	172	307	654
Summer	1	131	300	339
Summer	2	113	308	317

The weeks showing the highest volume of forced outages due to lack of fuel (Winter 1, Winter 3, Winter 2, Spring 2) are the same weeks showing a longer right-hand side tail for the empirical forced outage distribution in Slide 5.

The top 3 Winter weeks are by far the weeks with the highest volume of forced outages due to lack of fuel

Seasonal Peak Load Consideration

- In addition, Winter is the season with the second highest peak loads. For instance, according to the 2019 PJM Load Forecast for Delivery Year 2023

  Forecasted 50/50 Seasonal Peaks:

  - Summer: 152,854 MW
  - Winter: 133,882 MW
  - Spring: 120,617 MW
  - Fall: 130,255 MW

Conclusion

- Putting together the above Forced Outages and Seasonal Peak Load considerations, the Winter Peak Period is the most concerning period from a Fuel/Resource Security perspective given the potential for high forced outage levels and high peak loads that may result in loss-of-load events
  - This supports the approach taken in Phase 1 whose results show loss-of-load events during a Winter cold snap under a high volume of forced outages

Risk Filtering Process and Scenario Review

Definitions

Risk

- Any event that may pose a resource adequacy issue for the PJM system

Relevant Period(s)

- Period(s) of the year in which Fuel/Energy/Resource Security issues may result in potential resource adequacy issues

Relevant Risk

- A subset of the identified Risks relevant to Fuel/Energy/Resource Security scope and that may occur during the determined Relevant Period

Relevant Scenarios

- Combination of potential realizations of Relevant Risks that create a set of conditions to be evaluated

Objectives and Process

Identify Risks

- Review historical data and solicit input from stakeholders and area experts to list Risks to the PJM system

Narrow to Relevant Risks

- Analyze the Risks identified to develop a list of risks within the Fuel/Energy/Resource Security scope and the identified Relevant Period

Collect Data on Study Risks

- Collect data on the frequency of occurrence, generation impact, locational nature, and other factors necessary to model the Study Risks and their affect of Fuel/Energy/Resource Security

Define Relevant Scenarios

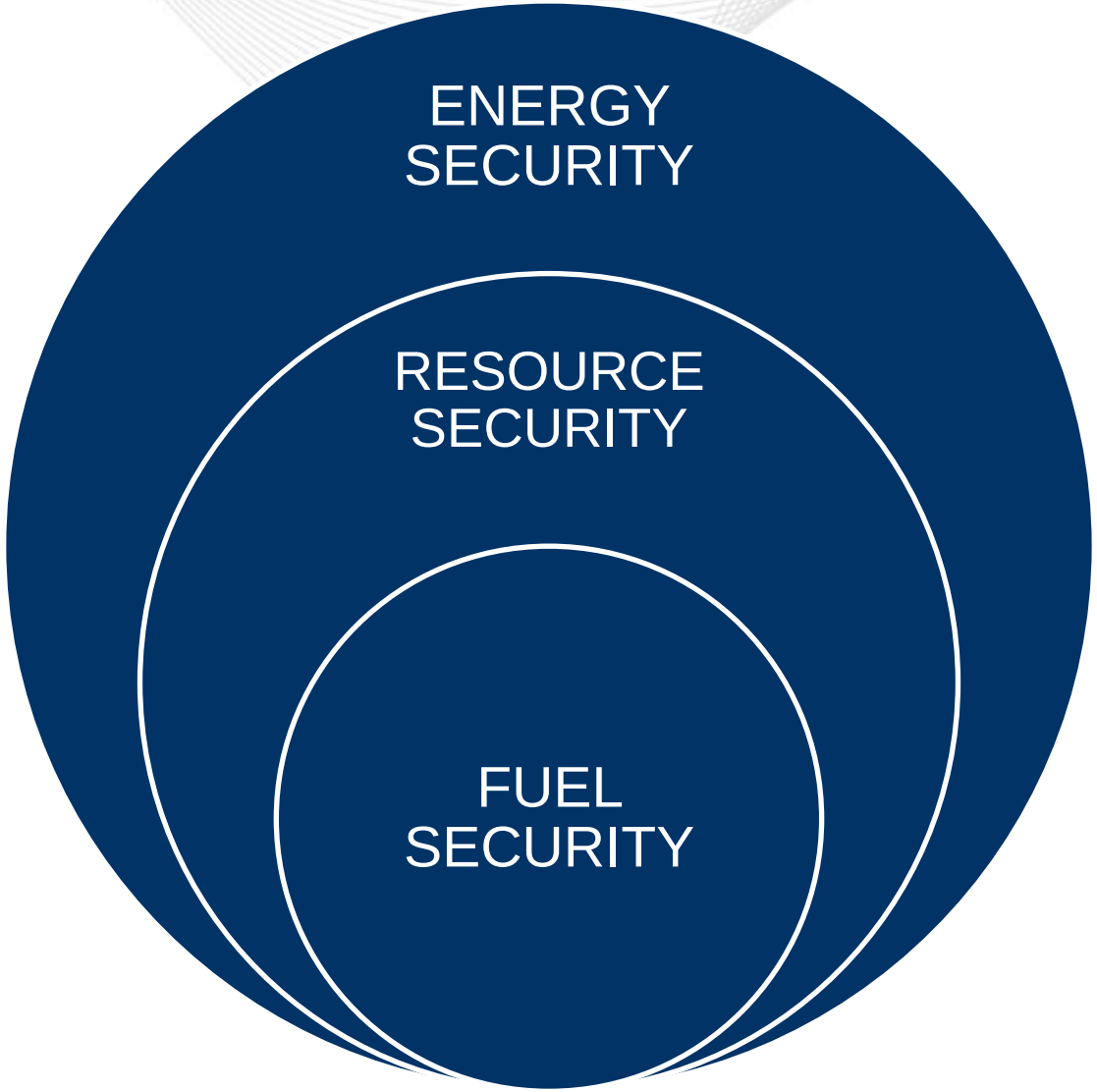
- Combine the Relevant Risks into event scenarios and identify any significant gaps from Phase 1 scenarios

Evaluate Relevant Scenarios

- Identify Relevant Scenarios with high loss of load impact to the PJM system

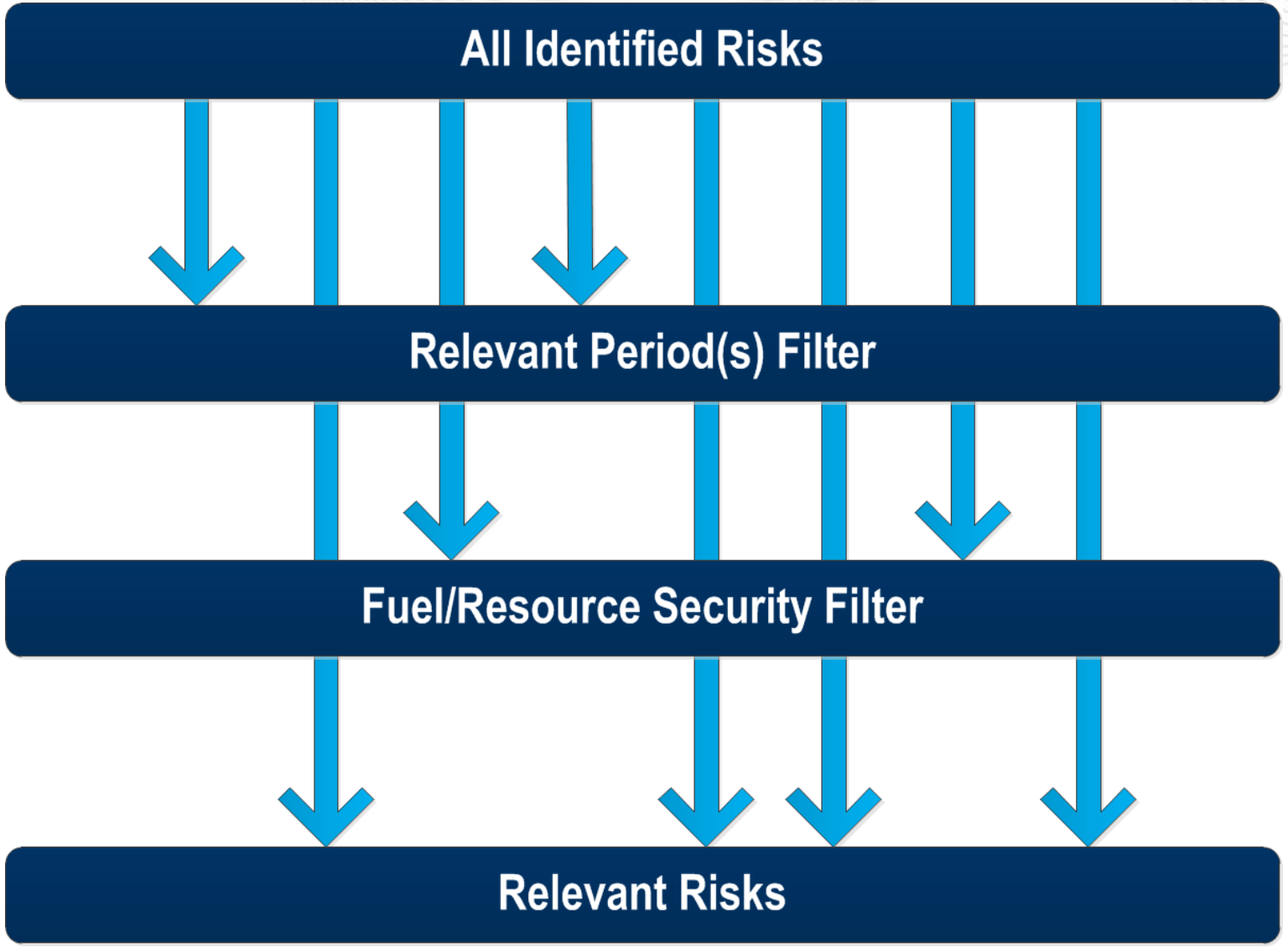
Senior Task Force Charter Terms

Fuel Security:
This can be categorized as the availability of fuel both on-site and assessed from delivery systems required for a unit to generate consistent with dispatch signals or operating instructions. This includes all resource types



Resource Security:
Availability of a set of resources with the same fuel type associated with different types of common vulnerabilities. Includes all resource types.

Relevant Risk Identification



Identified Risks (1 of 3)

INDEX	RISK	DESCRIPTION
1	Long Duration Cold Snap	Consecutive days below a temperature threshold greater than a set duration
2	Short Duration Cold Snap	Consecutive days below a temperature threshold less than a set duration
3	Long Duration Heat Wave	Consecutive days above a temperature threshold greater than a set duration
4	Short Duration Heat Wave	Consecutive days above a temperature threshold less than a set duration
5	Coal Refueling (Bridge Failure)	Reduced coal refueling capacity due to a bridge failure
6	Coal Refueling (Lock and Dam Failure)	Reduced coal refueling capacity due to a lock and dam failure
7	Coal Refueling (Rail Failure)	Reduced coal refueling capacity due to a failure of the rail infrastructure
8	Coal Refueling (River Freezing)	Reduced coal refueling capacity due to freezing rivers impacting barge traffic
9	Coal Unavailability (Coal Quality)	The unavailability of coal fired units due to poor fuel quality (wet coal, low quality coal, etc.)

Identified Risks (2 of 3)

INDEX	RISK	DESCRIPTION
10	Natural Gas Pipeline Disruptions	Any disruption to the natural gas pipeline infrastructure (pipe, gas compressor, etc.) that impacts the ability to transport natural gas, excluding malicious causes (to be included in Phase 3)
11	Natural Gas Unavailability Non-Firm Units	The curtailment or unavailability of natural gas delivery to units with interruptible transportation for any reason
12	Oil Refueling (Oil Terminal)	Reduced oil refueling capacity due to limitations at oil terminals or other oil supply centers
13	Oil Refueling (Truck Restrictions)	Reduced oil refueling capacity due to truck transportation limitations
14	Nuclear Regulatory Shutdown (Fuel Related)	A mandated shutdown or power reduction of nuclear units for reasons related to fuel issues
15	Nuclear Regulatory Shutdown (Non-Fuel Related)	A mandated shutdown or power reduction of nuclear units for reasons not related to fuel issues
16	Nuclear Unavailability (High Winds)	The preemptive shutdown or power reduction of nuclear units due to high wind speeds

Identified Risks (3 of 3)

INDEX	RISK	DESCRIPTION
17	Hydro Unavailability (Drought / Low Water Level)	Reduced hydro availability due to low water levels or droughts
18	Hydro Unavailability (Freezing Rivers)	Reduced hydro availability due to river freezing
19	Solar Intermittency	The inherent intermittency of solar resources throughout the year
20	Wind Intermittency	The inherent intermittency of wind resources throughout the year; Temperature-triggered shutdown based on turbine settings
21	High River Temperatures / Drought (Cooling Water Impacts)	Plant efficiency impacts caused high river water temperatures reducing cooling capabilities
22	River Freezing (Cooling Water Impacts)	Plant efficiency impacts caused by river freezing (ice on screens, reduced water intake capabilities, etc.)
23	Earthquake	An earthquake that affects the PJM footprint
24	Hurricane / Tropical Storms	A hurricane or tropical storm that affects the PJM footprint
25	Ice Storm (Transportation Impacts)	An ice storm that affects the PJM footprint and adversely impacts the transportation of fuel or other commodities

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Scenario Feedback Mapped to Identified Risks

- A matrix combining feedback on risks/scenarios submitted by stakeholders with a mapping to the identified risks is located on the FSSTF webpage:
  - https://www.pjm.com/committees-and-groups/task-forces/fsstf.aspx

Next Steps

Identify Risks

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Gap Analysis Review

Gap Analysis Overview

- **Existing Mechanism Assessment**
  - Document what mechanisms and products exist today that contribute to fuel/energy/resource security in PJM
- **Risk Identification**
  - Identify credible risks to fuel/energy/resource security and narrow down the list to those in scope for Phase 2 analysis
- **Scenario Assessment**
  - Identify and run additional scenarios that help assess the impact of credible risks for Phase 2 analysis

Gap Analysis

Identify any potential gaps that exist between existing mechanisms and the credible risks to fuel/energy/resource security that are in scope for Phase 2 analysis

Schedule

- **Today:**
  - Assess what current mechanisms exist today that contribute toward fuel/energy/resource security and what uncertainties/risks are currently accounted for by these mechanisms

- **Next Meeting**:
  - After we have identified what additional fuel/energy/resource security risks we want to account for, we will revisit these mechanisms and then determine if any potential gaps may exist in mitigating these risks

Survey of Existing Mechanisms

- Capacity Performance (CP)
- Energy Market (DA and RT)
- Contingency Reserves – Current and Proposed
- Regulation
- Maximum Generation Emergency Procedure
- “Resource Limited” Unit Dispatch
- Voltage Reduction
- Gas Contingency Procedures
- Gas/Electric Coordination
- Transmission Planning Solution
- Restoration Plan (Black Start Services)
- Emergency Operating Procedures

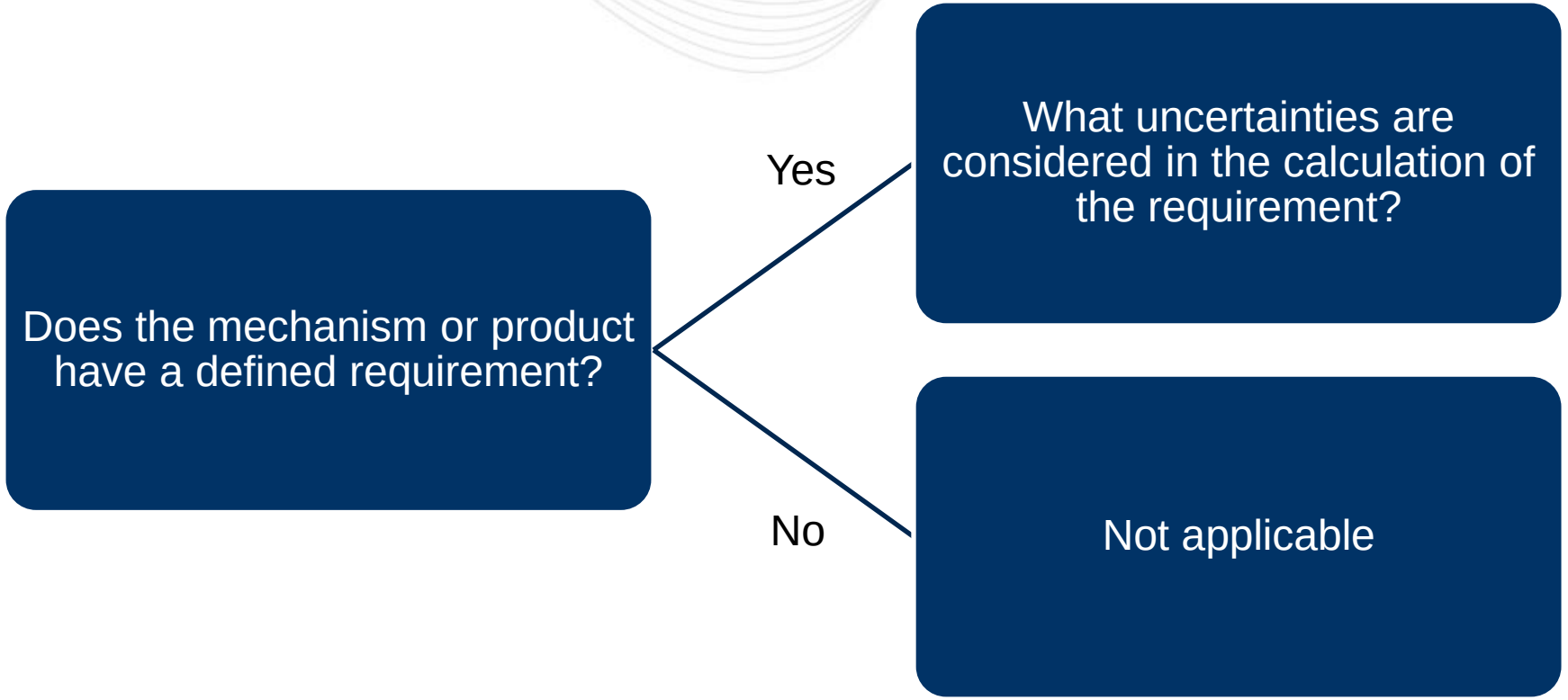
Existing Mechanisms Matrix

- A matrix of the existing mechanisms and products with their associated details is located on the FSSTF webpage:
  - https://www.pjm.com/committees-and-groups/task-forces/fsstf.aspx

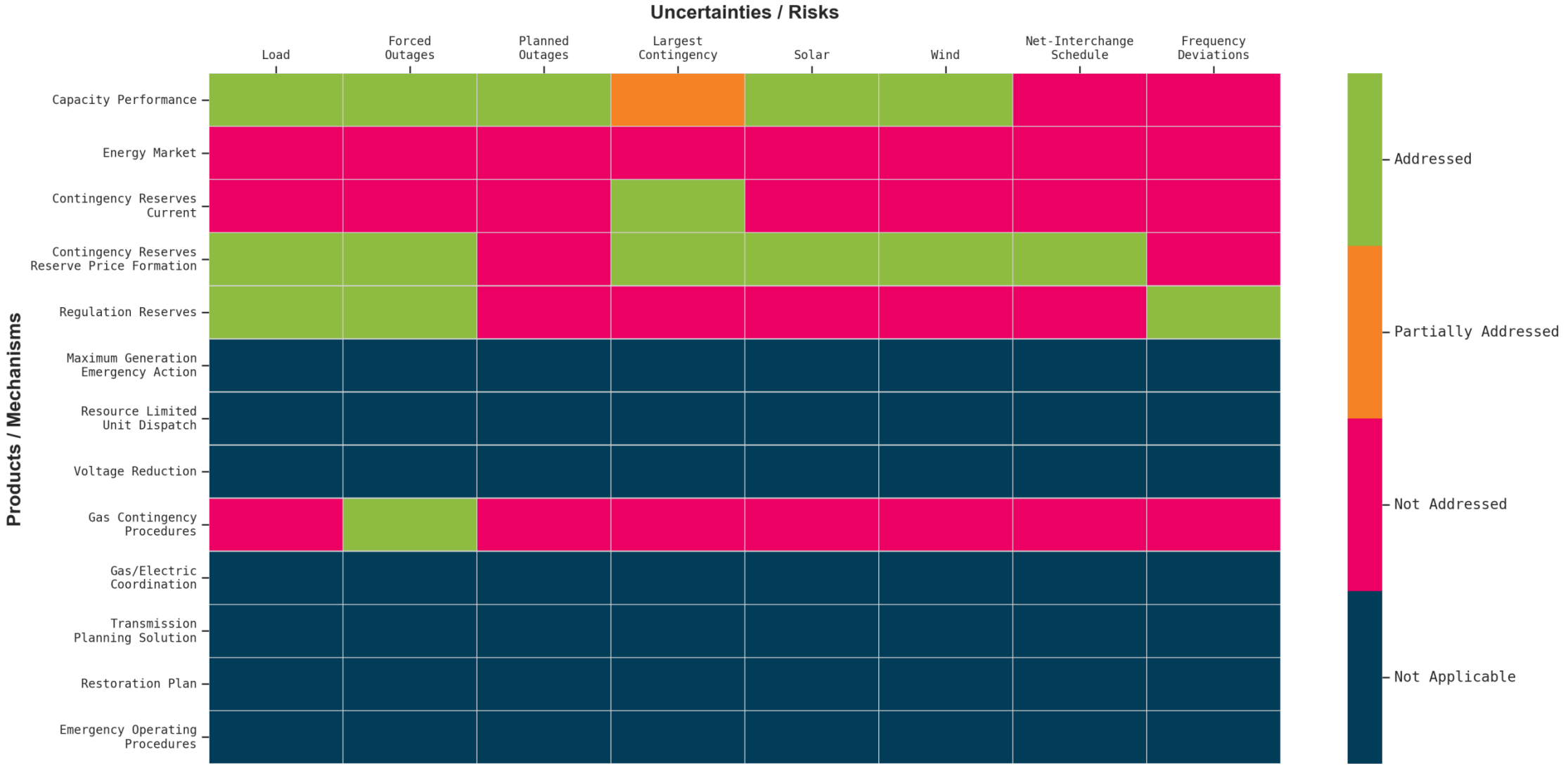
Outline

- **Comparison of Existing Mechanisms and Products**
  - Uncertainties included in Requirements
  - Procurement Time Period
  - Compensation

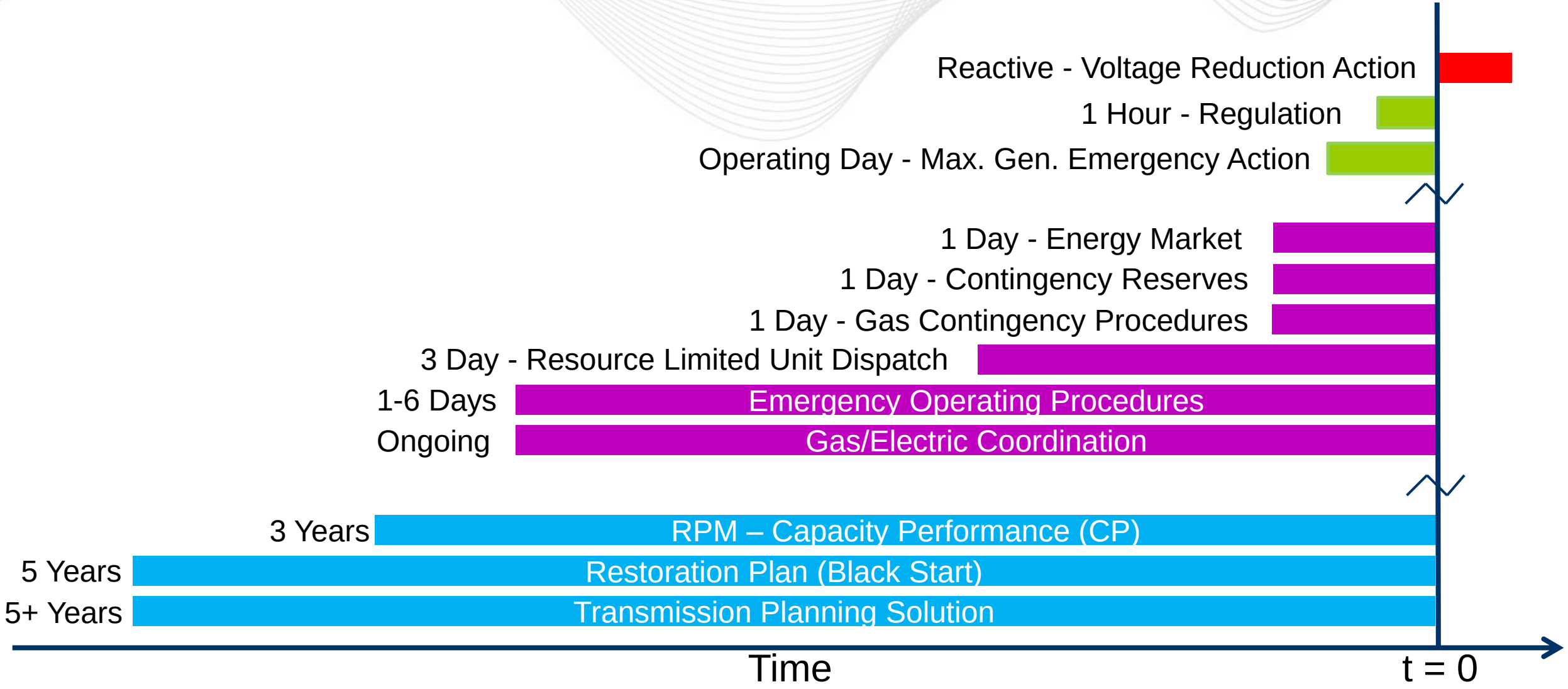
Uncertainties in Requirements



Uncertainties in Requirements Heatmap



Procurement Time Period – Existing Mechanisms



Compensation - Existing Mechanisms

Mechanism	Compensation	Compensation Structure
Capacity Performance	RPM Auction Clearing Prices (+) PAI Bonus Performance Credits (-) PAI Non-Performance Charges	Auction (3-year Forward); PAIs (RT)
Energy Market	Locational Marginal Prices	Auction (DA/RT)
Contingency Reserves	Reserve Market Clearing Prices	Auction (DA/RT)
Regulation Reserves	Regulation Market Clearing Prices	Auction (RT)
Transmission Planning Solution	Cost Recovery Rates	RFP - Cost/Benefit Analysis (5-year Forward+)
Gas Contingency Procedures	Reserve Clearing Price / Switching Cost Recovery (under discussion)	Auction (DA/RT) / Administrative
Restoration Plan (Black Start)	Cost Recovery Rates	RFP (5-year Forward or as needed)
Gas/Electric Coordination	No specific compensation	-
Maximum Generation Emergency Procedure	No specific compensation	-
"Resource Limited" Unit Dispatch	No specific compensation	-
Voltage Reduction	No specific compensation	-
Other Emergency Operating Procedures	No specific compensation	-