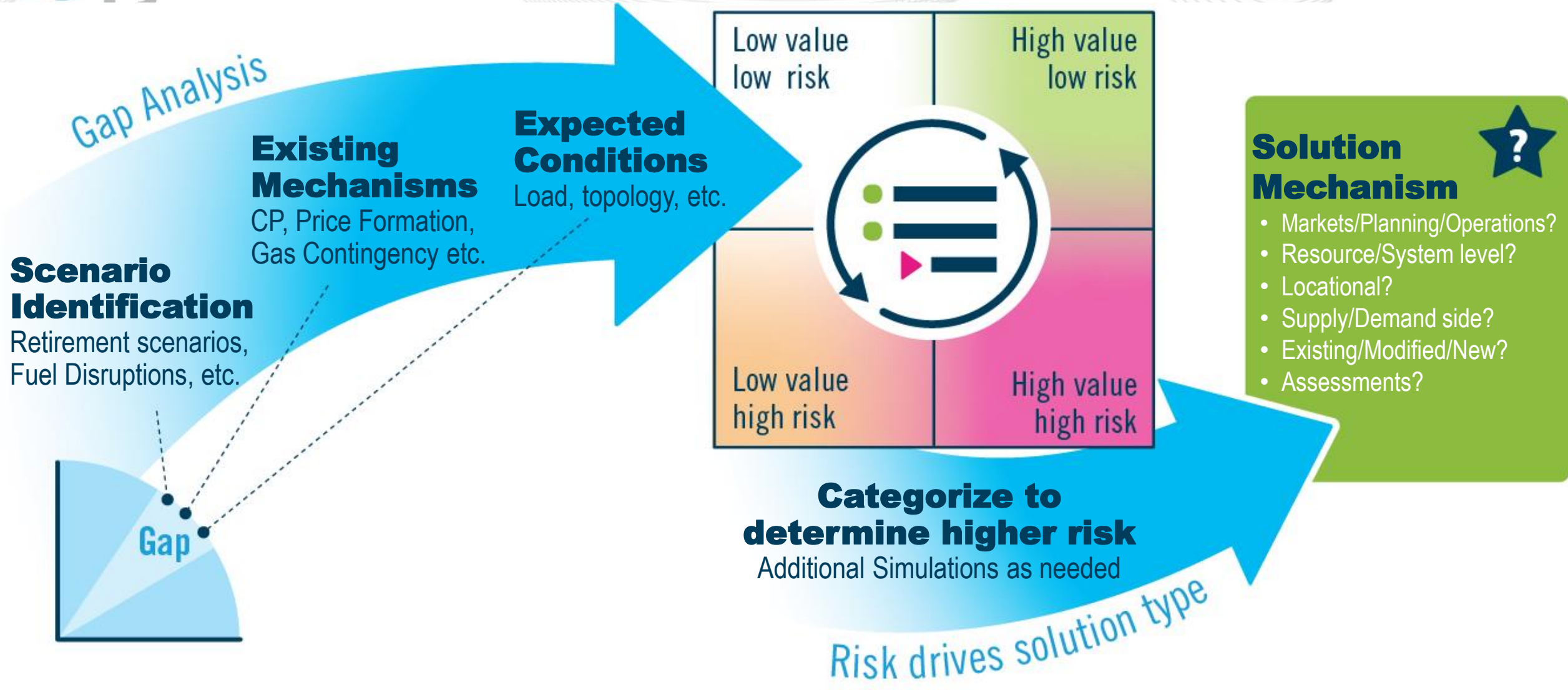


Update on Gap Analysis and Risk Assessment



- **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



Existing Mechanisms: Matrix Overview

Mechanism	Time Period	Compensation	Requirement / Risk Addressed	Eligibility
Capacity Performance	3-year forward (BRA); Real-time (PAIs)	RPM Auction Clearing Prices (+) PAI Bonus Performance Credits (-) PAI Non-Performance Charges	VRR curve based on IRM Study - 1 in 10 year LOLE - Load uncertainty, Generator outages, etc.	Capacity Resources capable of meeting performance requirements
Reserve Products (Current)	Day-ahead and Real-time	Reserve Market Clearing Prices	Day-ahead Scheduling Reserves (DASR) - load forecast error and forced outages Operating Reserve Demand Curves (ORDCs) - Sync Reserves: Largest contingency + 190 MW - Primary Reserves: 1.5 x Largest contingency + 190 MW	Units capable of 30-minute response time for DASR, 10-minute response time for sync/primary reserves
Reserve Products (Price Formation)	Day-ahead and Real-time	Reserve Market Clearing Prices	Operating Reserve Demand Curves (ORDCs) - Based on largest contingency plus accounts for load forecast, solar forecast, wind forecast, net interchange schedule forecast and thermal forced outages uncertainty	Units capable of 30-minute response time for secondary reserves, 10-minute response time for sync/primary reserves
Regulation	Real-time	Regulation Market Clearing Prices	800 MW (ramping hours); 525 MW (non-ramping hours)	Units capable of responding to automatic regulation signals
Gas/Electric Coordination	On-going	Cost recovery for fuel switching under review	No set MW requirement; Provides operational awareness for potential impacts of the natural gas industry / pipelines on reliable operation of the electric grid	Not applicable
Black Start Service	5-year review or as needed	Cost recovery (RFP process)	In general, must be sufficient critical black start units to serve critical load (plus a 10% margin) in each transmission zone	Must meet black start unit requirements and be selected for black start service by PJM - Fuel assurance requirements under review in stakeholder process

* Additional Mechanisms to be included in Matrix: Reporting and dispatch of Resource Limited units, Deployment of Demand Response, Market Efficiency Planning, others?

Risk

- Any event that may pose a loss of load issue for the PJM system

Relevant Period(s)

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

Relevant Risks

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

Relevant Scenarios

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

Identify Risks

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

Narrow to Relevant Risks

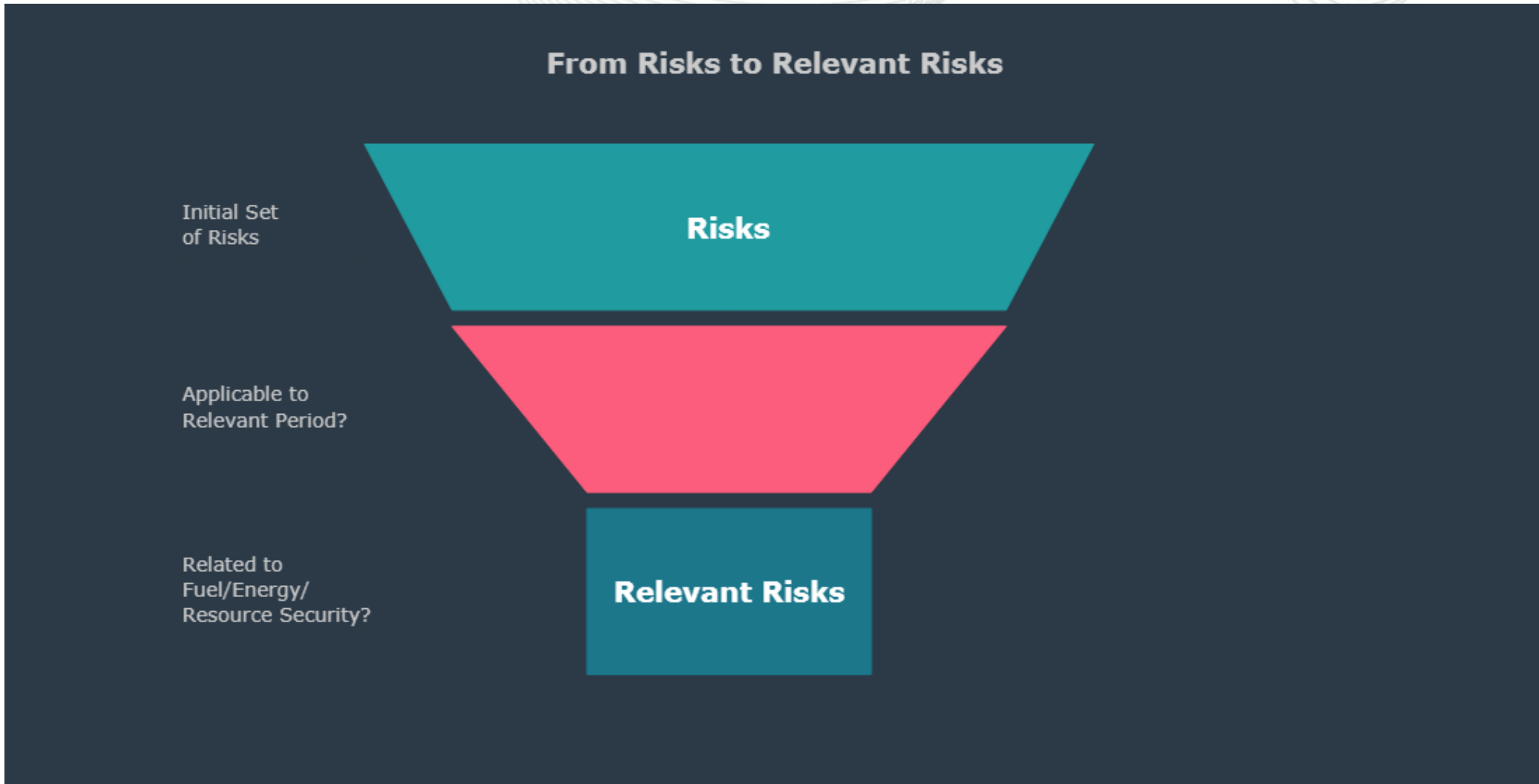
- Analyze the Risks identified to develop a list of Risks within the Fuel/Energy/Resource Security scope and the identified Relevant Period

Define Relevant Scenarios

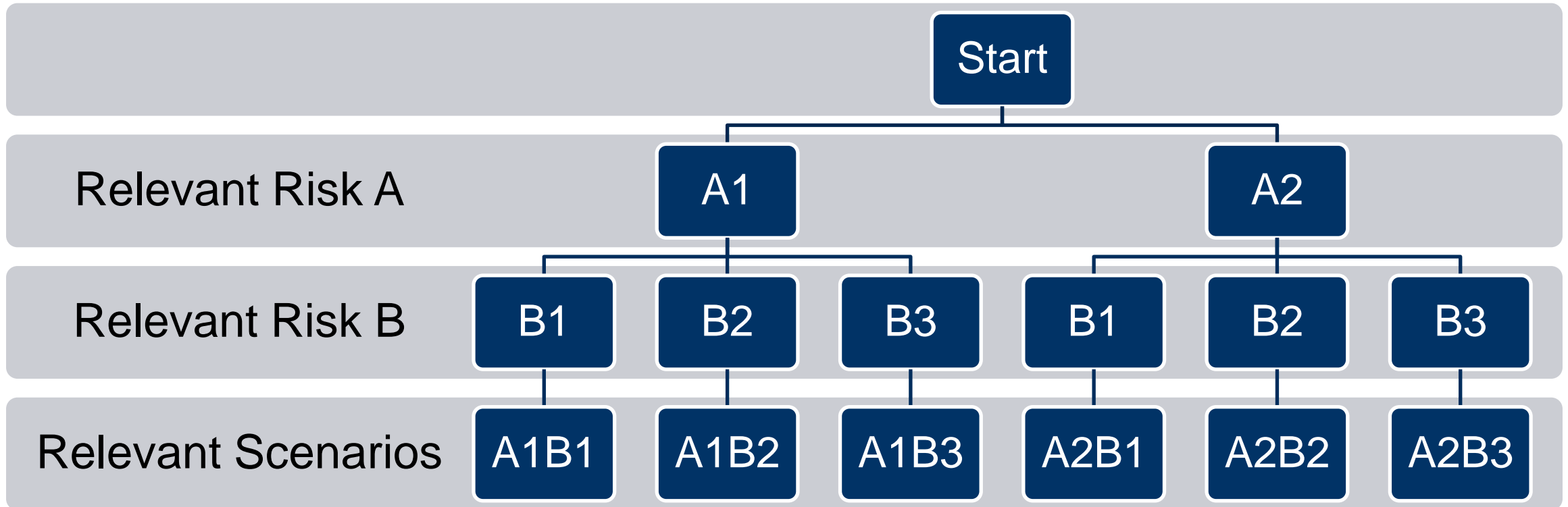
- Combine the Relevant Risks into event scenarios and identify any significant gaps from Phase 1 scenarios

Evaluate Relevant Scenarios

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



- Relevant Scenarios will be created based on combinations of the potential realizations of the identified Relevant Risks. For instance,
 - If the Relevant Risks are A and B where Risk A can be realized in two ways A1 and A2 and Risk B can be realized in three ways B1, B2, B3
 - Then, the Relevant Scenarios are
A1B1, A1B2, A1B3, A2B1, A2B2, A2B3



- The Phase 1 Scenario Gaps can be identified from the list of Relevant Scenarios

Relevant Scenarios	Evaluated In Phase 1?
A1B1	Yes
A1B2	No
A1B3	Yes
A2B1	No
A2B2	Yes
A2B3	Yes

- The loss of load impact of the Relevant Scenarios can be established based on performance metrics (loss of load events, loss of load hours, etc.) and associated tolerable thresholds. This will determine if a Relevant Scenario has a High, Low, or No Impact.
- In addition, the loss of load impact can be classified as zonal or system-wide.

Relevant Scenarios	Evaluated In Phase 1?	Loss of Load Impact
A1B1	Yes	High Impact / Zonal
A1B2	No	High Impact / System-wide
A1B3	Yes	Low Impact / Zonal
A2B1	No	No Impact
A2B2	Yes	No Impact
A2B3	Yes	Low Impact / System-wide

The subset of Relevant Scenarios with High Loss of Load Impact can then be used to determine a potential fuel/energy/resource security solution.

- PJM is seeking feedback on additional scenarios to be considered in risk assessment
 - Sensitivities on inputs to Phase 1 analysis
 - Risks not covered in Phase 1 analysis
- Please provide description of risk or scenario, and justification related to key work activities by **Friday 5/24/2019**
 - Spreadsheet to be posted and updated with new feedback

Phase 1 Sensitivities

- Concurrent peak load and infrastructure disruption
- Vary infrastructure outage duration (entire 14 days, other)
- Vary non-firm gas availability assumptions
- Vary initial oil tank inventory to use 50-60%
- Vary oil refueling frequency
- Evaluate a full 90-day winter
- Examine infrastructure disruption scenarios lasting at least 90 days
- 'High renewable' replacement in Escalated 1 portfolio to reflect buildout projections based on RPS compliance

Other Risks

- Rail failures
- Ice storm / river freezing
- Shoulder month heat wave / cold snap
- Drought / high river water temperatures / low river water levels
- High winds impacting nuclear
- Hurricane