Update on Gap Analysis and Risk Assessment
How to Use Gap and Risk Analysis?

**Scenario Identification**
Retirement scenarios, Fuel Disruptions, etc.

**Existing Mechanisms**
CP, Price Formation, Gas Contingency etc.

**Expected Conditions**
Load, topology, etc.

**Solution Mechanism**
- Markets/Planning/Operations?
- Resource/System level?
- Locational?
- Supply/Demand side?
- Existing/Modified/New?
- Assessments?

**Gap Analysis**

**Categorize to determine higher risk**
Additional Simulations as needed

Risk drives solution type
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
<table>
<thead>
<tr>
<th>Mechanism</th>
<th>Time Period</th>
<th>Compensation</th>
<th>Requirement / Risk Addressed</th>
<th>Eligibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity Performance</td>
<td>3-year forward (BRA); Real-time (PAIs)</td>
<td>RPM Auction Clearing Prices (&lt;) PAI Bonus Performance Credits (+) PAI Non-Performance Charges</td>
<td>VRR curve based on IRM Study - 1 in 10 year LOLE - Load uncertainty, Generator outages, etc.</td>
<td>Capacity Resources capable of meeting performance requirements</td>
</tr>
<tr>
<td>Reserve Products (Current)</td>
<td>Day-ahead and Real-time</td>
<td>Reserve Market Clearing Prices</td>
<td>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</td>
<td>Units capable of 30-minute response time for DASR, 10-minute response time for sync/primary reserves</td>
</tr>
<tr>
<td>Reserve Products (Price Formation)</td>
<td>Day-ahead and Real-time</td>
<td>Reserve Market Clearing Prices</td>
<td>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</td>
<td>Units capable of 30-minute response time for secondary reserves, 10-minute response time for sync/primary reserves</td>
</tr>
<tr>
<td>Regulation</td>
<td>Real-time</td>
<td>Regulation Market Clearing Prices</td>
<td>800 MW (ramping hours); 525 MW (non-ramping hours)</td>
<td>Units capable of responding to automatic regulation signals</td>
</tr>
<tr>
<td>Gas/Electric Coordination</td>
<td>On-going</td>
<td>Cost recovery for fuel switching under review</td>
<td>No set MW requirement; Provides operational awareness for potential impacts of the natural gas industry / pipelines on reliable operation of the electric grid</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Black Start Service</td>
<td>5-year review or as needed</td>
<td>Cost recovery (RFP process)</td>
<td>In general, must be sufficient critical black start units to serve critical load (plus a 10% margin) in each transmission zone</td>
<td>Must meet black start unit requirements and be selected for black start service by PJM - Fuel assurance requirements under review in stakeholder process</td>
</tr>
</tbody>
</table>

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

**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
Risk Assessment: 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

**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 Risks

From Risks to Relevant Risks

- Initial Set of Risks
- Applicable to Relevant Period?
- Related to Fuel/Energy/Resource Security?

Relevant Risks
Relevant Scenarios

- 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
Relevant Scenarios - Example

Start

Relevant Risk A
- A1
- A2

Relevant Risk B
- B1
- B2
- B3

Relevant Scenarios
- A1B1
- A1B2
- A1B3
- A2B1
- A2B2
- A2B3
The Phase 1 Scenario Gaps can be identified from the list of Relevant Scenarios

<table>
<thead>
<tr>
<th>Relevant Scenarios</th>
<th>Evaluated In Phase 1?</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1B1</td>
<td>Yes</td>
</tr>
<tr>
<td>A1B2</td>
<td>No</td>
</tr>
<tr>
<td>A1B3</td>
<td>Yes</td>
</tr>
<tr>
<td>A2B1</td>
<td>No</td>
</tr>
<tr>
<td>A2B2</td>
<td>Yes</td>
</tr>
<tr>
<td>A2B3</td>
<td>Yes</td>
</tr>
</tbody>
</table>
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.
### Loss of Load Impact of Relevant Scenarios

<table>
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<th>Relevant Scenarios</th>
<th>Evaluated In Phase 1?</th>
<th>Loss of Load Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1B1</td>
<td>Yes</td>
<td>High Impact / Zonal</td>
</tr>
<tr>
<td>A1B2</td>
<td>No</td>
<td>High Impact / System-wide</td>
</tr>
<tr>
<td>A1B3</td>
<td>Yes</td>
<td>Low Impact / Zonal</td>
</tr>
<tr>
<td>A2B1</td>
<td>No</td>
<td>No Impact</td>
</tr>
<tr>
<td>A2B2</td>
<td>Yes</td>
<td>No Impact</td>
</tr>
<tr>
<td>A2B3</td>
<td>Yes</td>
<td>Low Impact / System-wide</td>
</tr>
</tbody>
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The subset of Relevant Scenarios with High Loss of Load Impact can then be used to determine a potential fuel/energy/resource security solution.
Potential Scenarios for Additional Analysis

- 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