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P173.005
Operator Tools for Integrating Variable Resources and Demand Response

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Mid-Year Project Review
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Outline

- Introduction
- 2008 – 2010 Contributions
- Project Plan and Status
- Realistic Simulation of Reserve Determination
- Reserve Determination Case Study
- Summary

Introduction
Importance

Traditional reserve procurement may not be efficient or sufficiently reliable under future system conditions

- We need methods to dynamically procure reserve in anticipation of dynamic system conditions
  - Wind ramping
  - Uncertain production and demand
- Stochastic modeling offers hope of accomplishing this
  - A drawback is lack of transparency
- Use dynamic reserve requirements from an *off-line* calculation fed into current operating practice

This offers augmentation with minimum disruption

Introduction
Progress

- We include realism of multiple decision cycles
- We will continue work in 2012
  - Include impacts of transmission congestion
  - Include multiple types of dynamic reserve and rules for deploying them for power balance
  - Assess the right time frame for dynamic procurement
- Work with members to make sure it is deployable with the goal is to have an operator assess its true usefulness

This is a work in progress with increasing realism

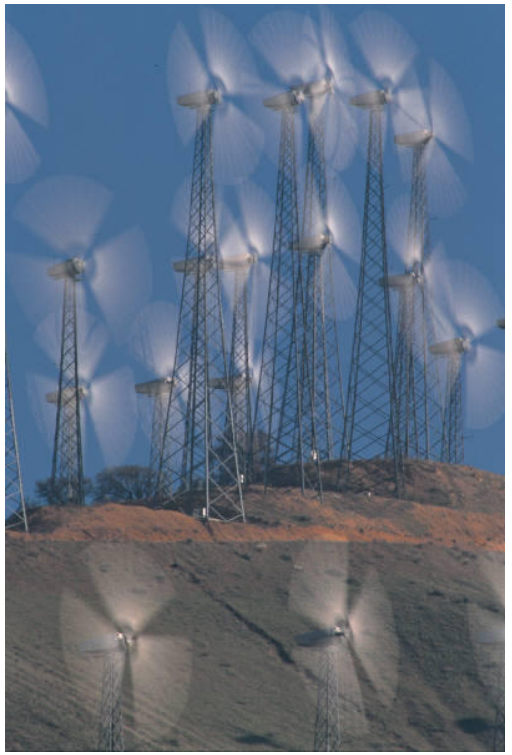
Introduction

R&D Plan Map

FS3 – Integrate Resources

FS7 – Situation Awareness

- **Background**
  - Research 2008 – 2010 achieved scope & scale on static systems
  - Research 2011 adds dynamic decision making
- **Project Goal**
  - Evaluate and demonstrate the value in a real world environment
- **Scope of Work for 2011**
  - Functional Requirements specification
  - Adapt Reserve Determination technique developed in 2010 for realistic business process



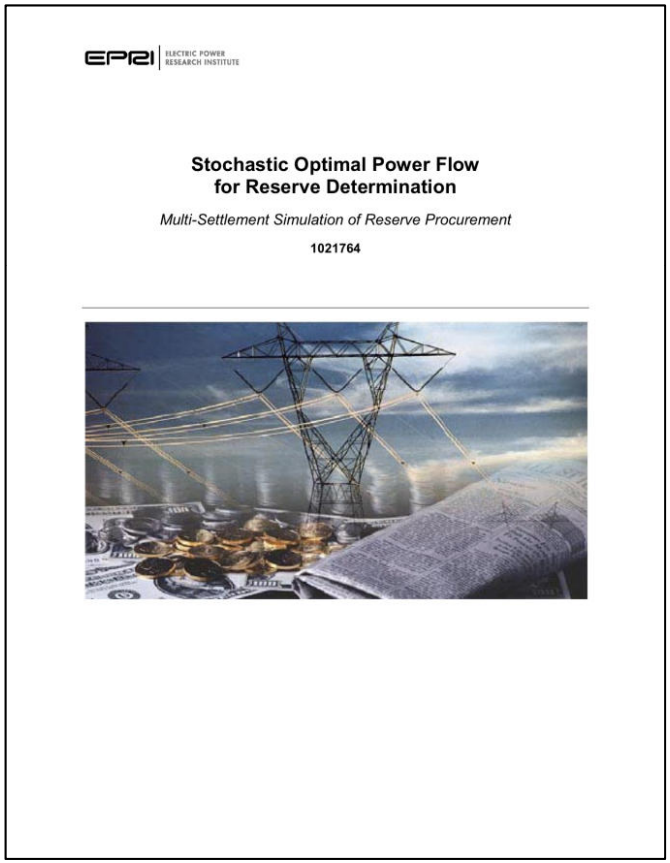
Introduction

- **Scope of Work for 2011 (continued)**
  - Application Testing
    - Using Power Systems Optimizer modeling tool
    - Using WECC system data
    - Simulate multi-settlement process for critical weeks of operations
- **2011 Deliverables**
  - Presentation & Webcast: Functional Requirements for Applications of Stochastic OPF
  - Technical Update: *Stochastic Optimal Power Flow for Reserve Determination: Multi-Settlement Simulation of Reserve Procurement* ***(1021764)***

R&D Plan Map

FS3 – Integrate Resources

FS7 – Situation Awareness



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2008 – 2010 Contributions
Three Applications

- ✓ **Reserve Determination**
  - Decide energy and reserve schedules
  - Estimate the expected costs for redispatch
- ✓ **Reserve Validation**
  - *Given energy and reserve schedules*
  - Estimate the expected costs for redispatch
  - Estimate risk levels
- ✓ **Rapid Redispatch**
  - *Given a sampling of redispatch scenarios*
  - *An actual event takes place*
  - Rapidly compute a optimal or near-optimal re-dispatch

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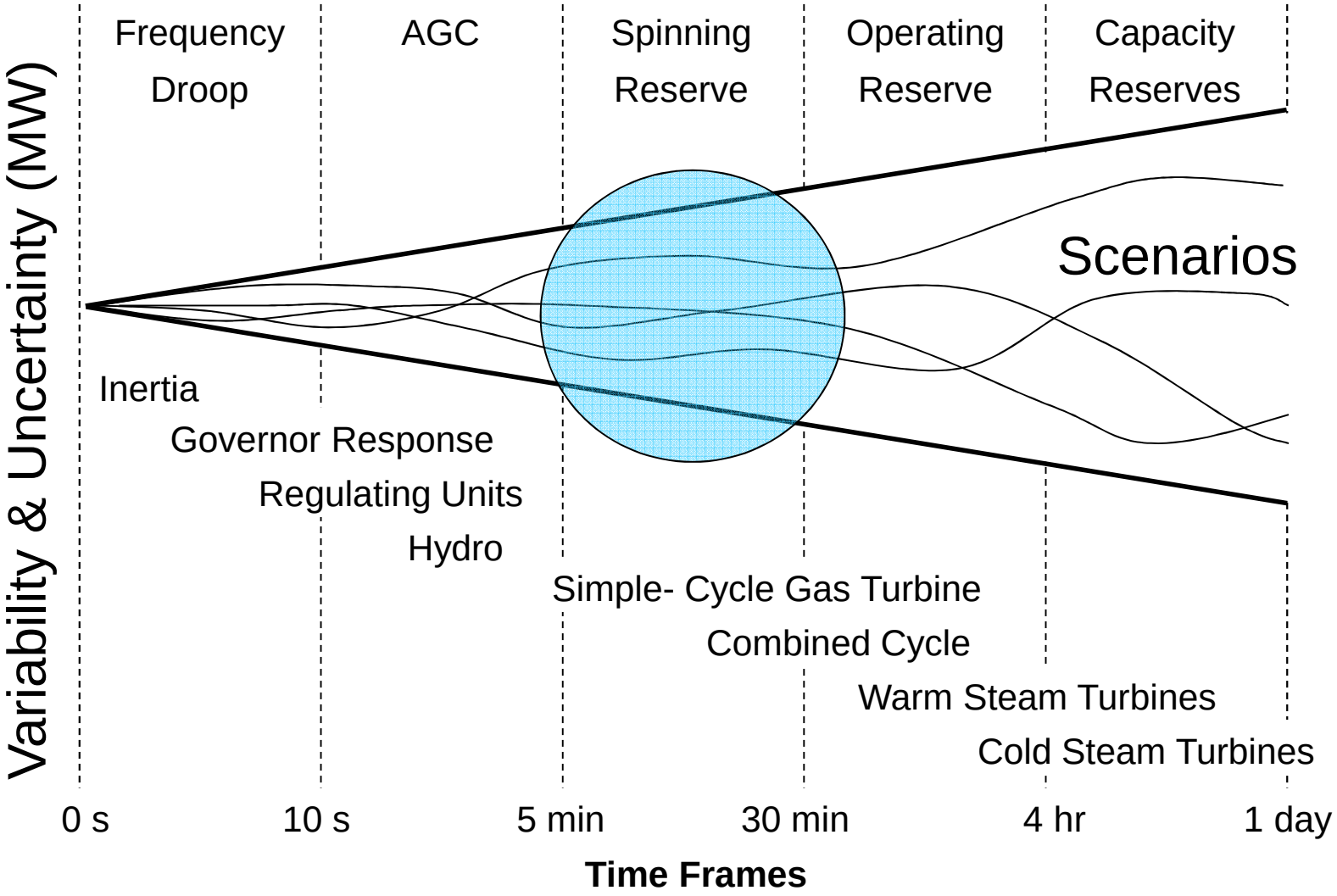
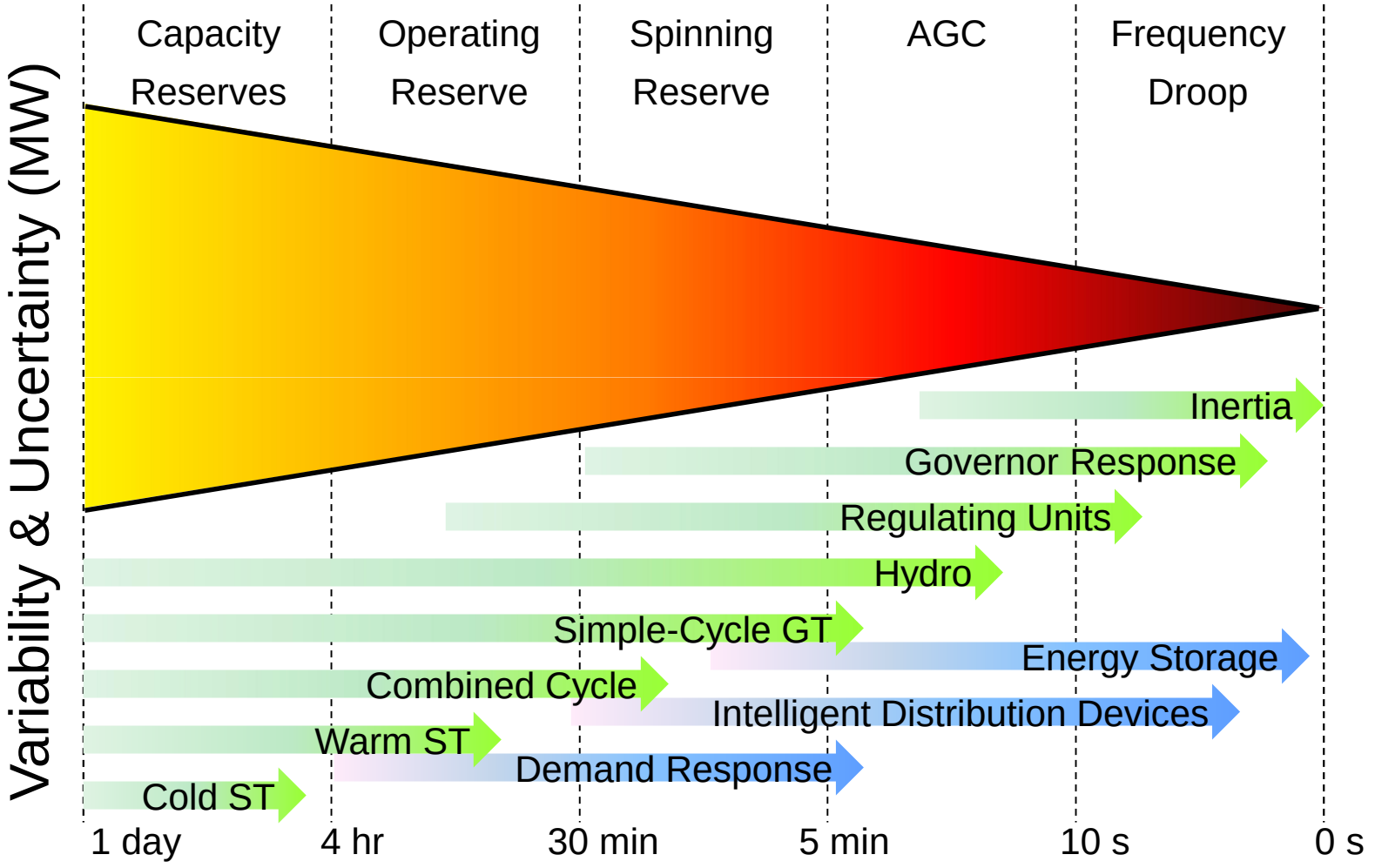
Realistic Simulation
Layers Time Frames



Source: Russ Philbrick, PES General Meeting, Detroit, July 2011

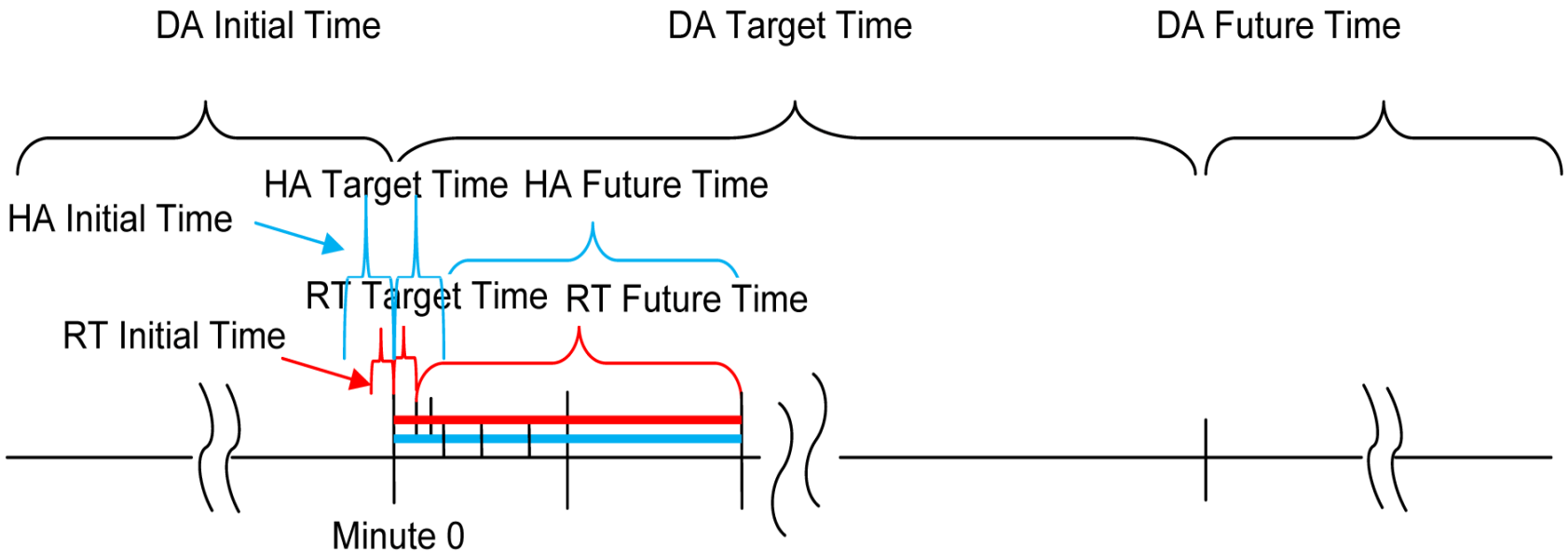
Realistic Simulation
Resolves Uncertainty & Responds to Variability



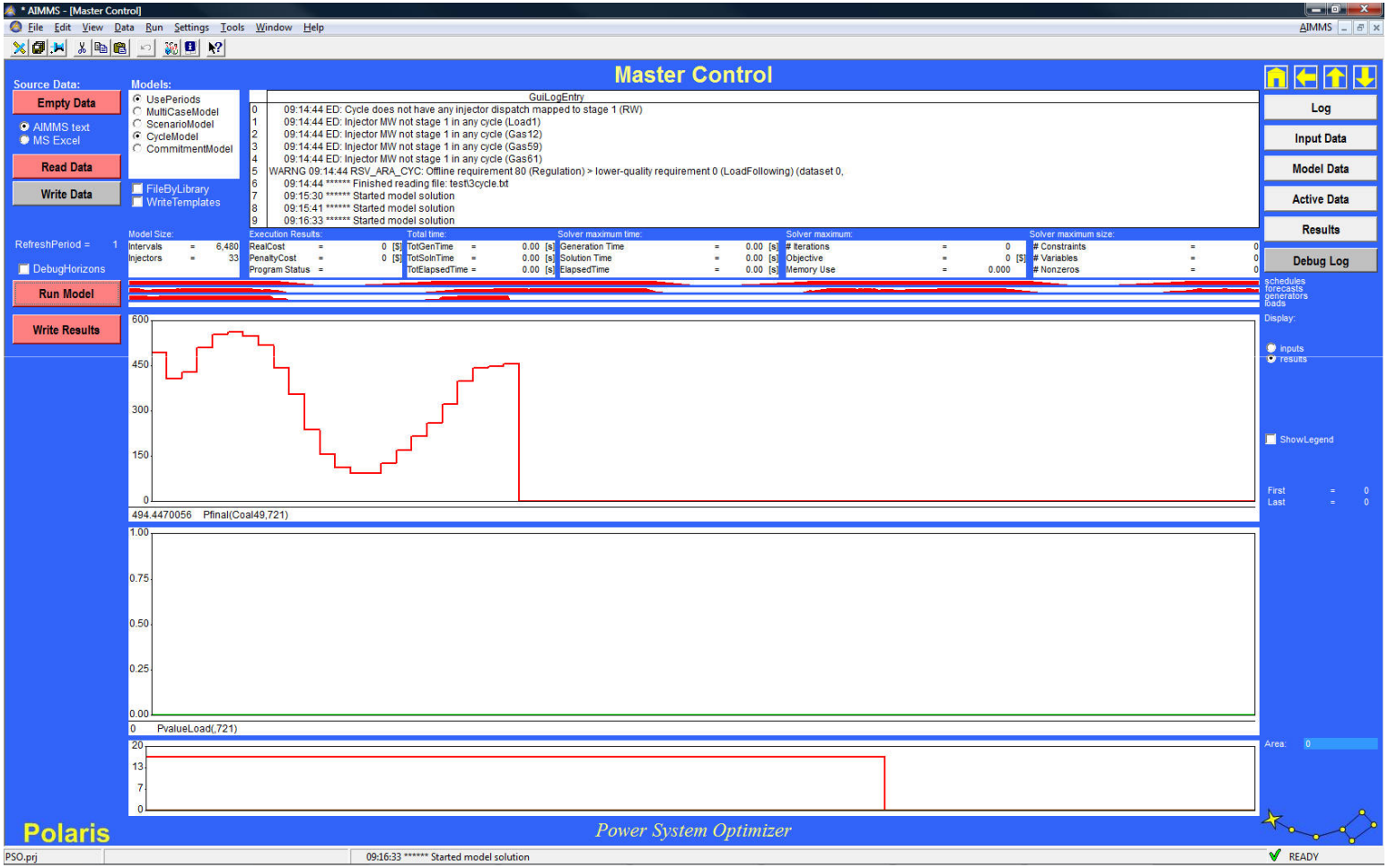
Source: Russ Philbrick, PES General Meeting, Detroit, July 2011

Realistic Simulation

Time Frames of the Multi-Cycle Model



Realistic Simulation
Visualization 1



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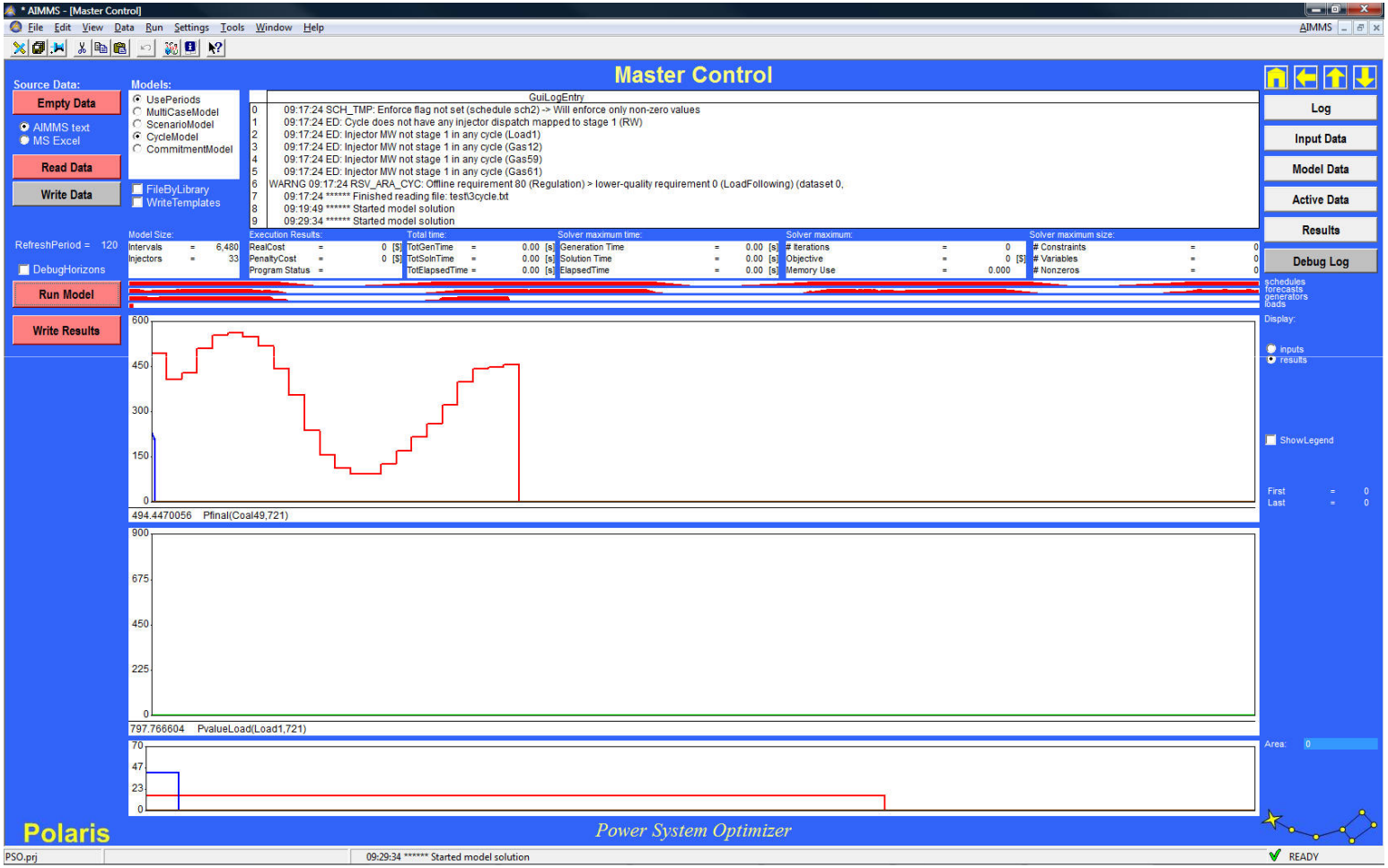
Realistic Simulation
Visualization 2



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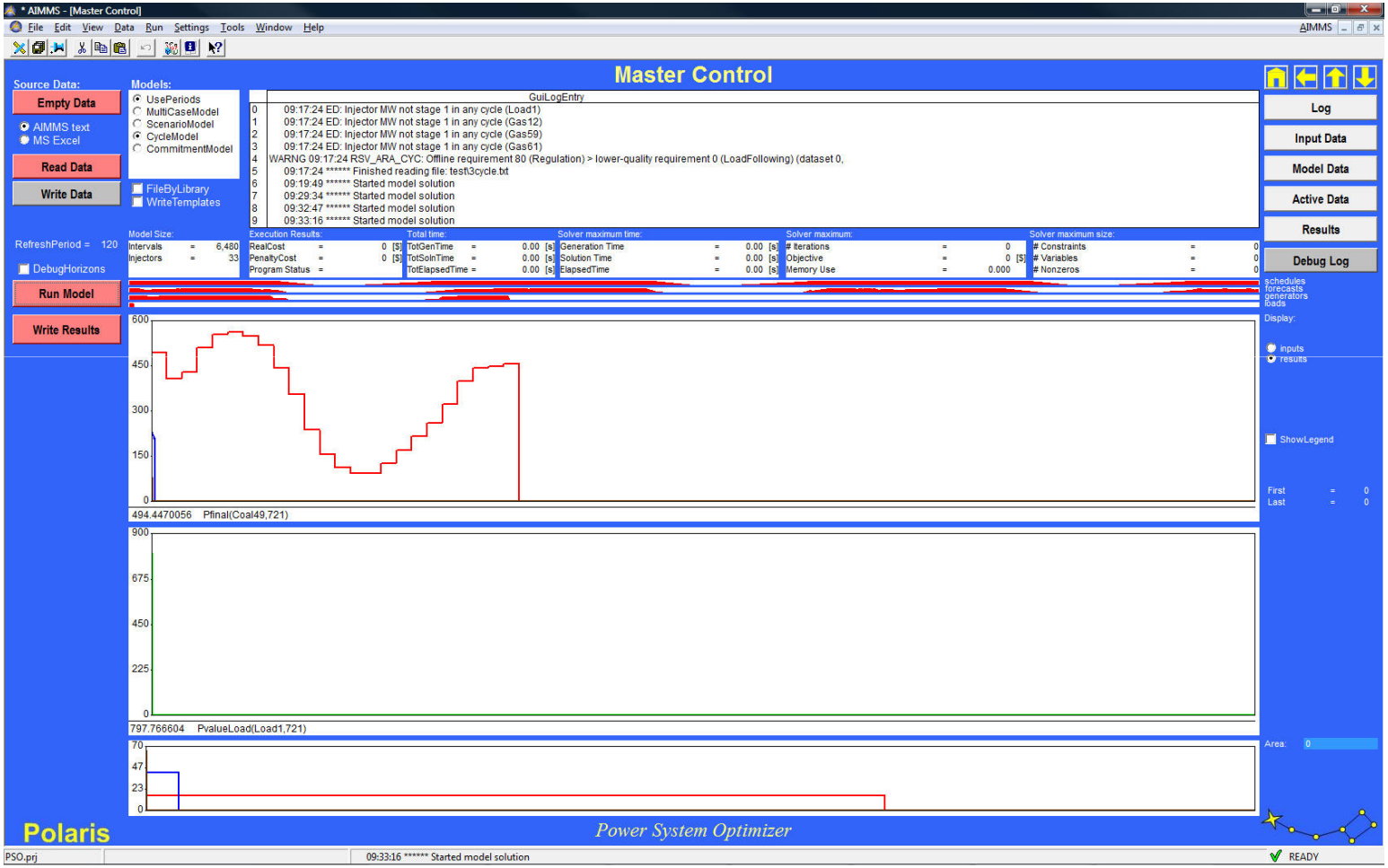
Realistic Simulation
Visualization 3



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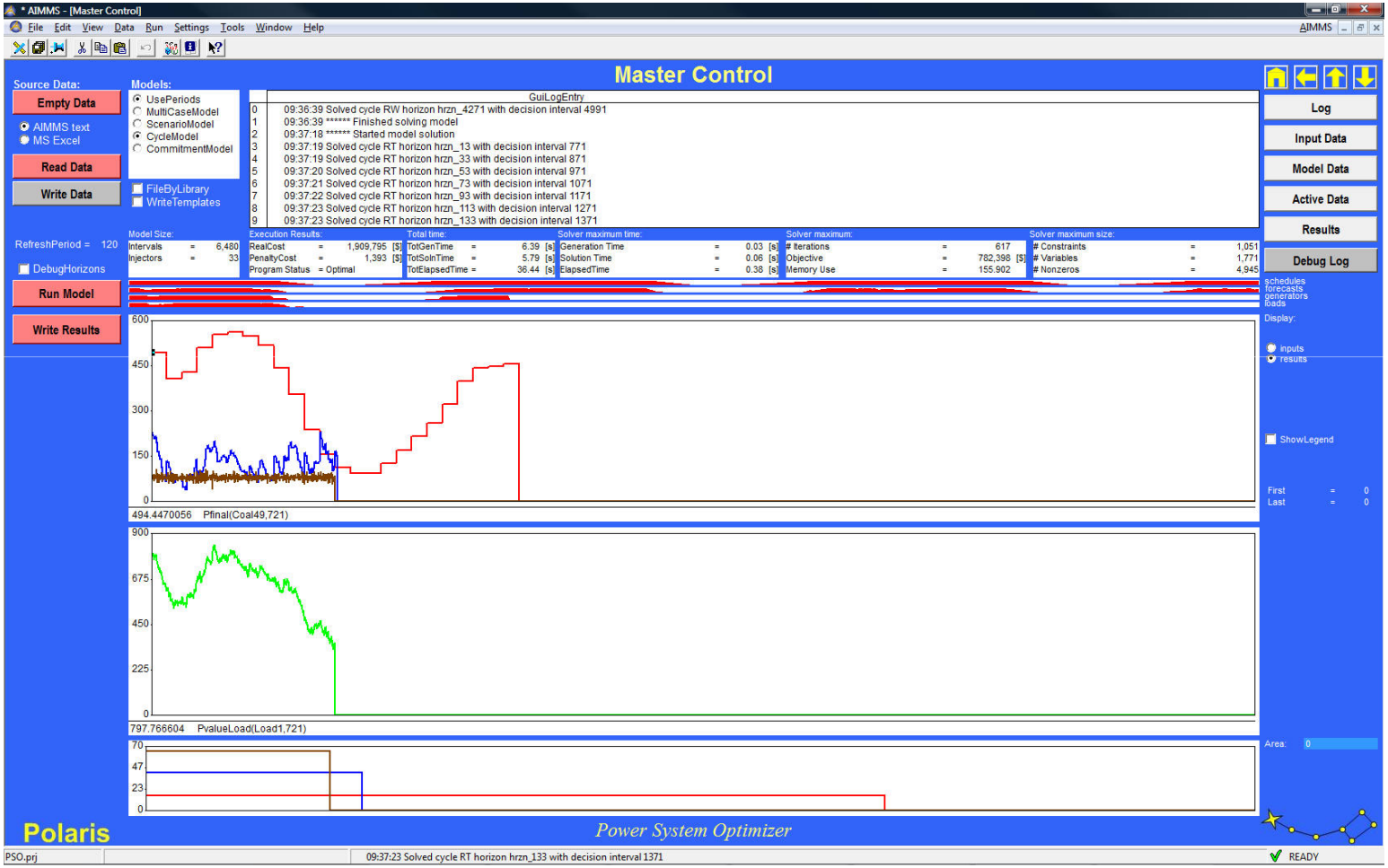
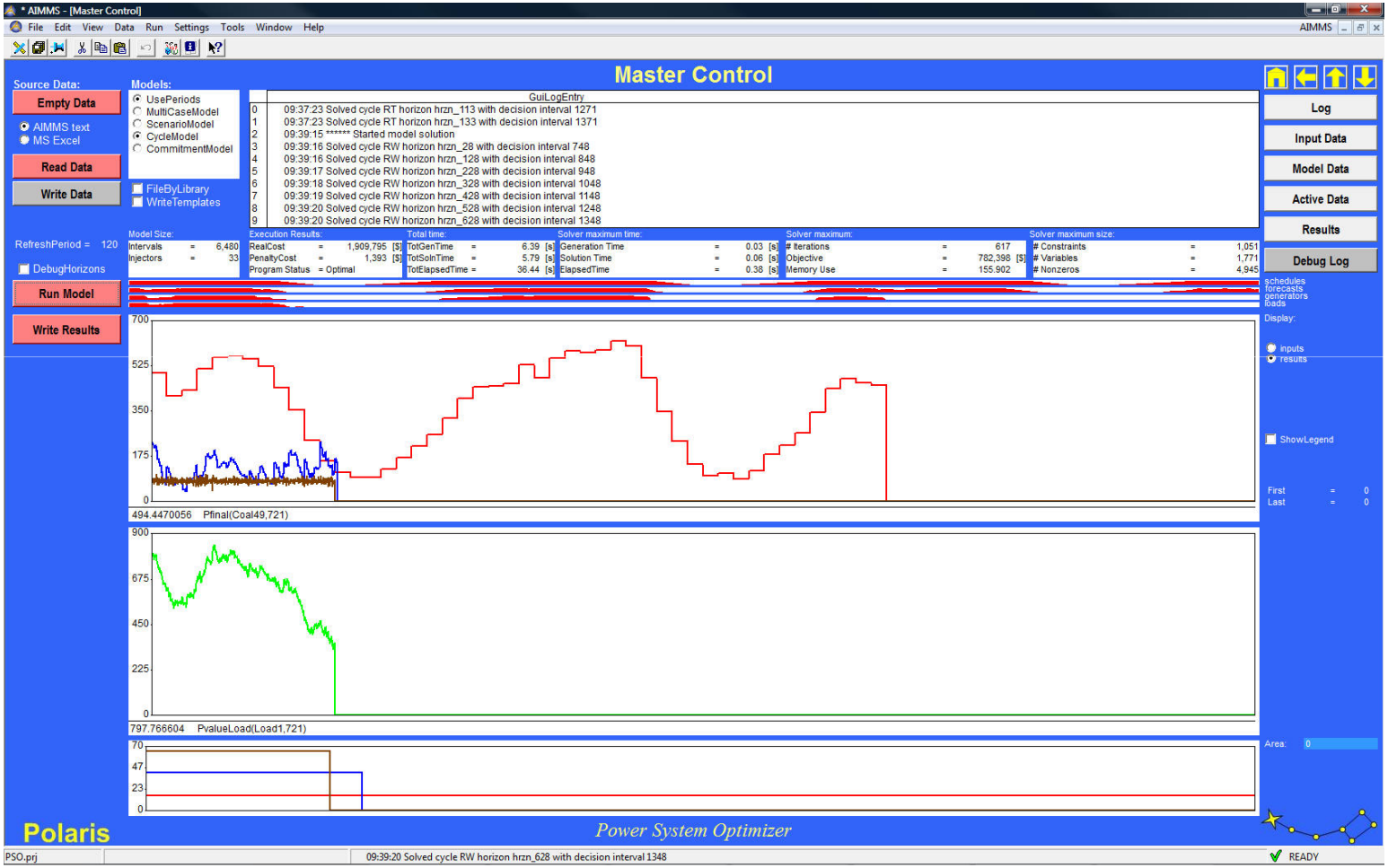
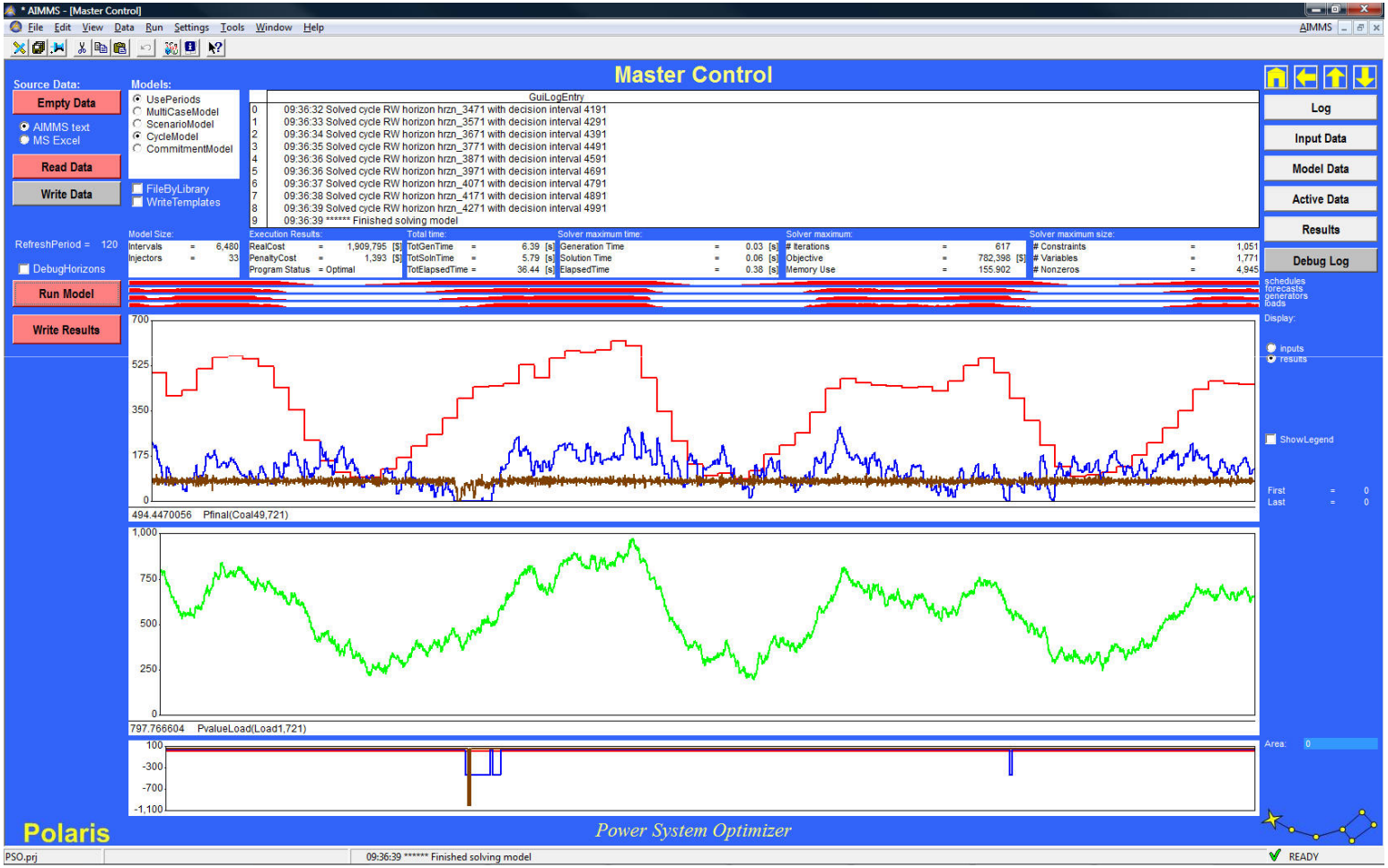
Realistic Simulation
Visualization 4



Realistic Simulation
Visualization 5

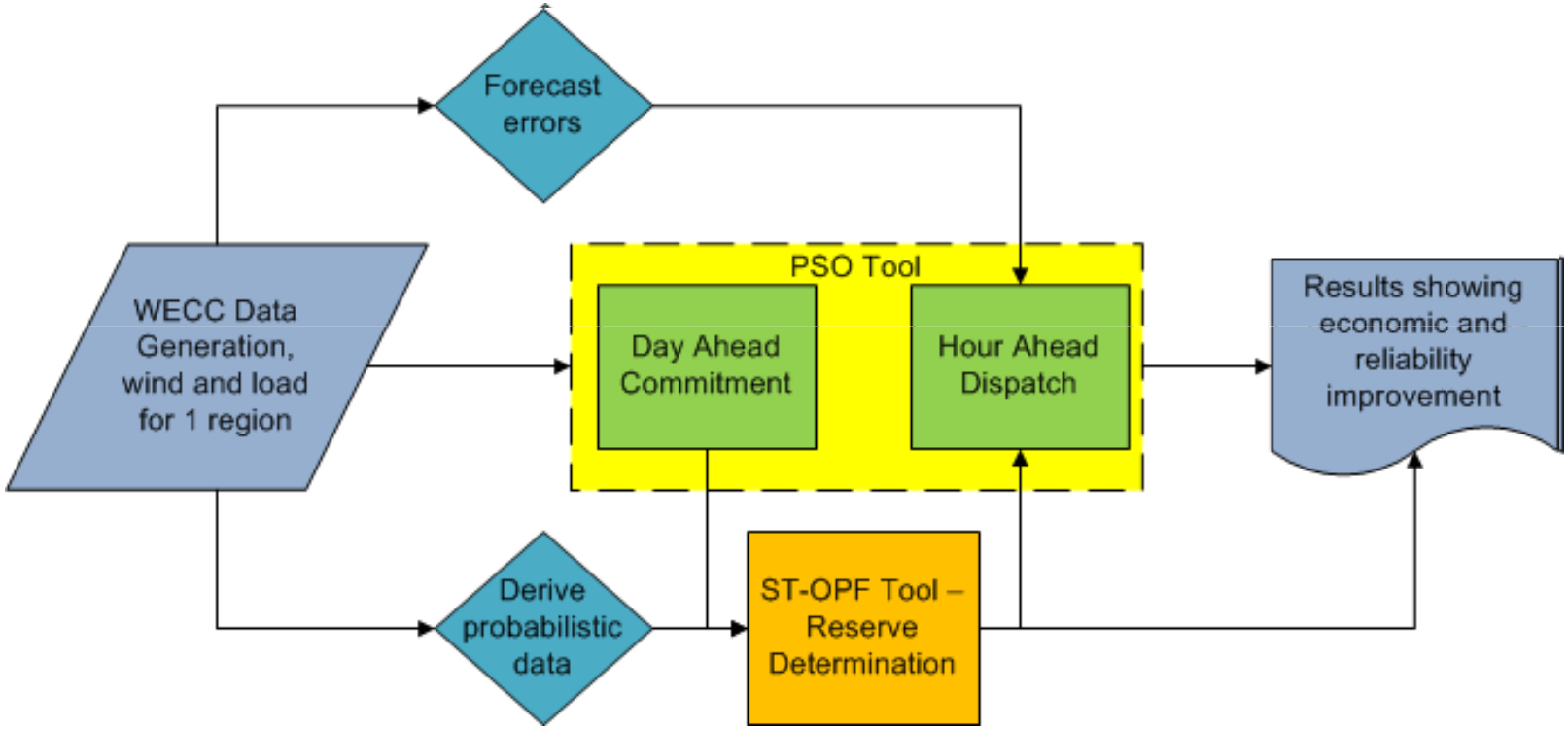


Realistic Simulation
Visualization 6



Realistic Simulation of Reserve Determination

Adding Reserve Determination



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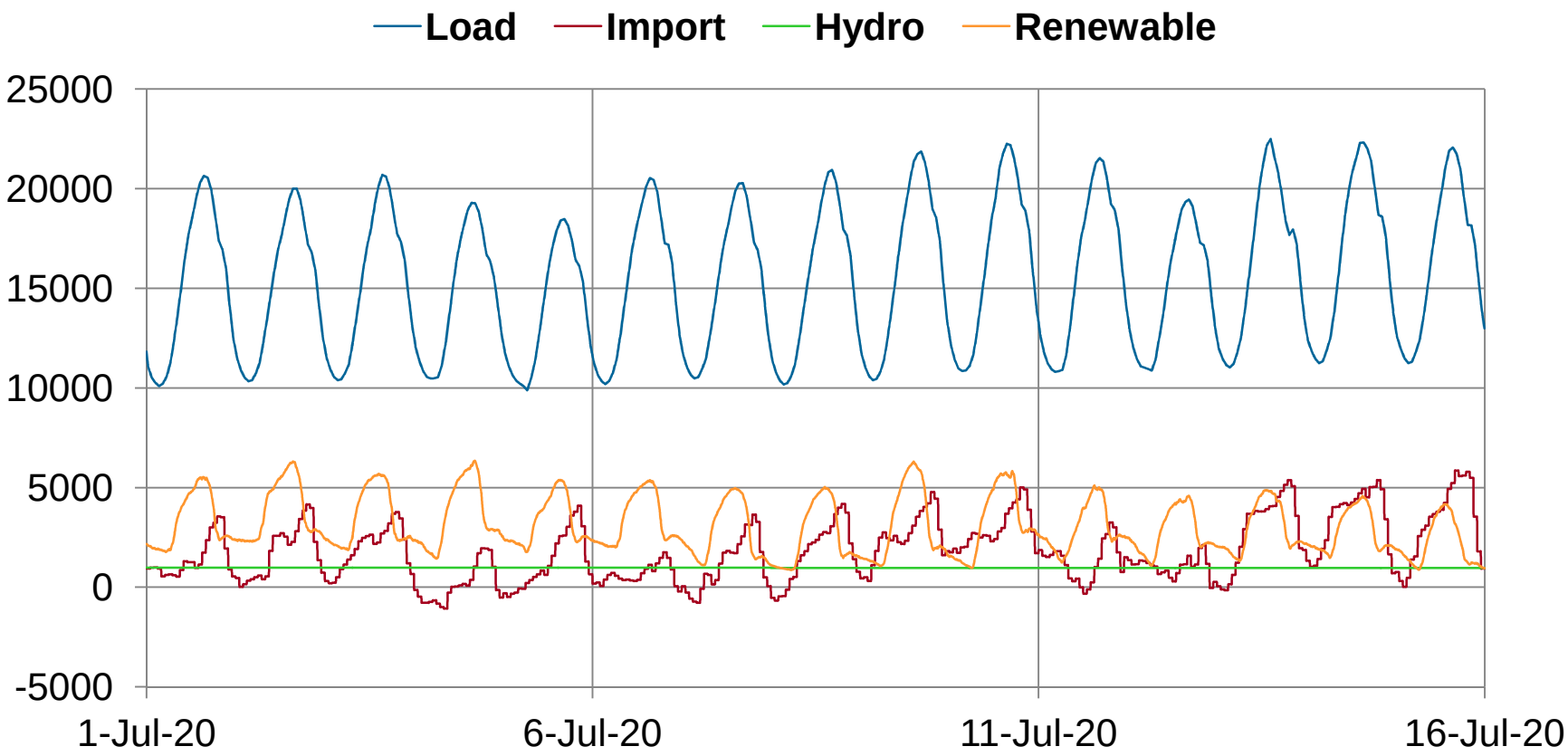
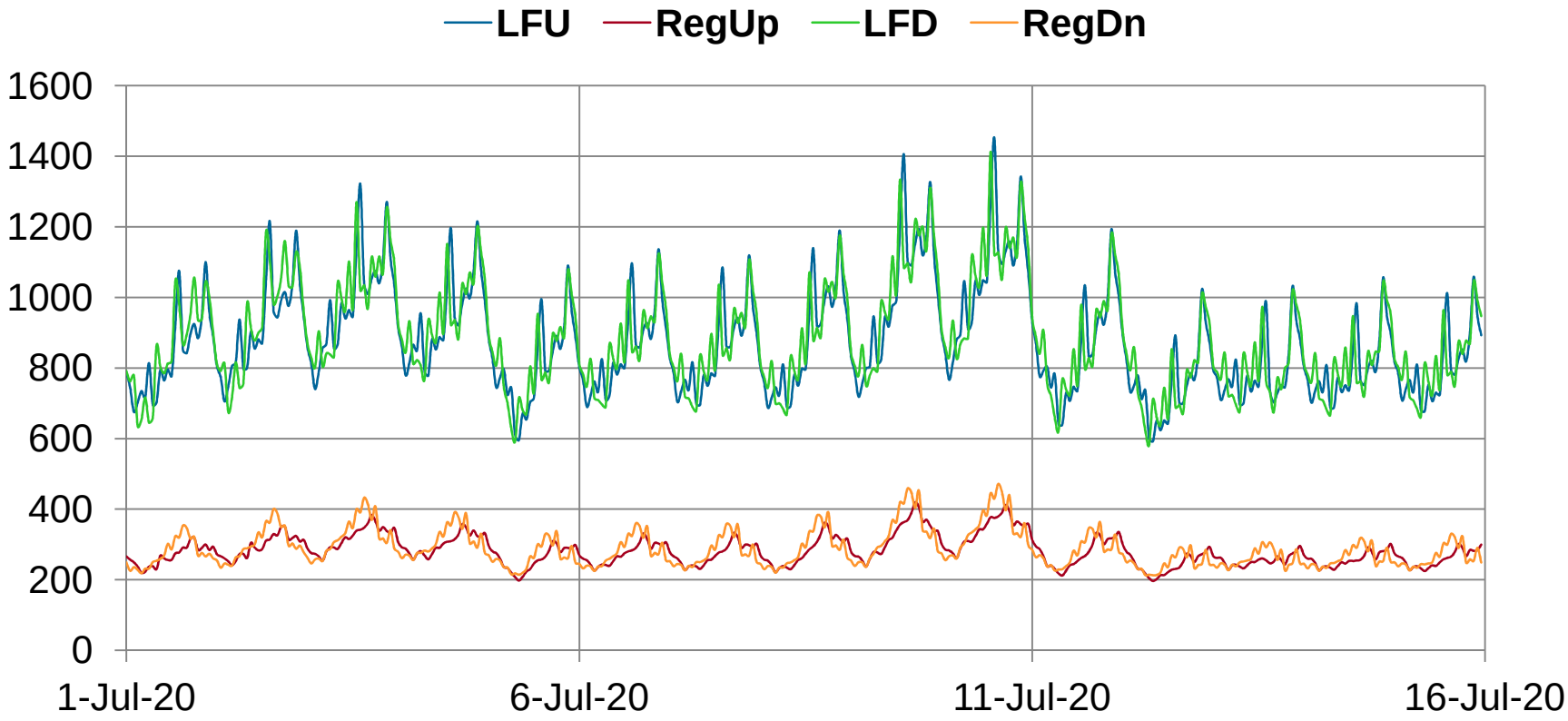
Reserve Determination Case Study
Load, Imports, Hydro and Renewable Inputs



CAISO 33% Renewables Study

- Focus on SCE area without transmission congestion
- Additional data represents renewable uncertainty

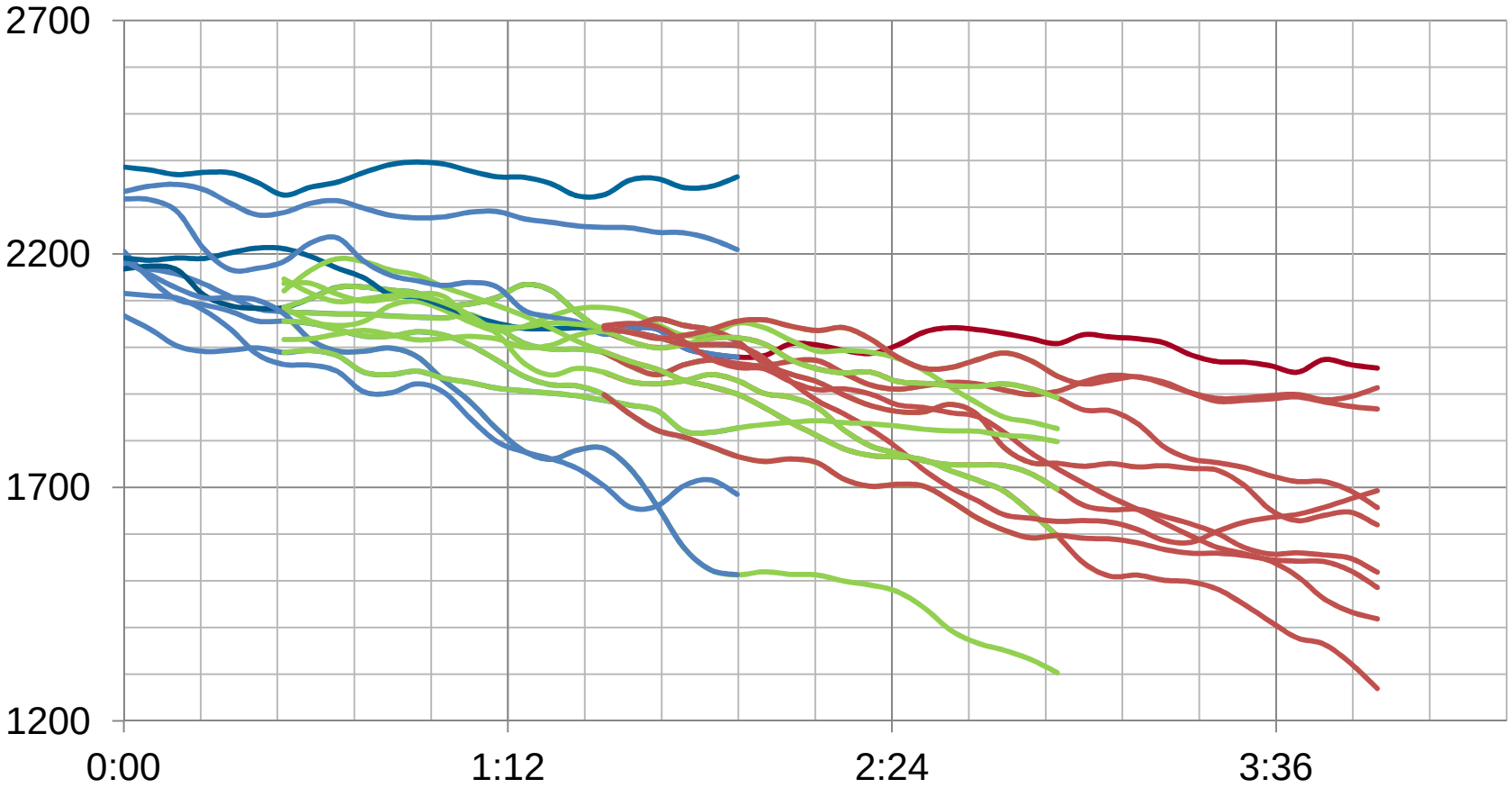
Reserve Determination Case Study
Pro-Rated Reserve Requirements



- LFU – Load Following Up
- RegUp – Regulation Up
- LFD – Load Following Up
- RegDn – Regulation Down

Pro rated requirement for SCE area, may overestimate need

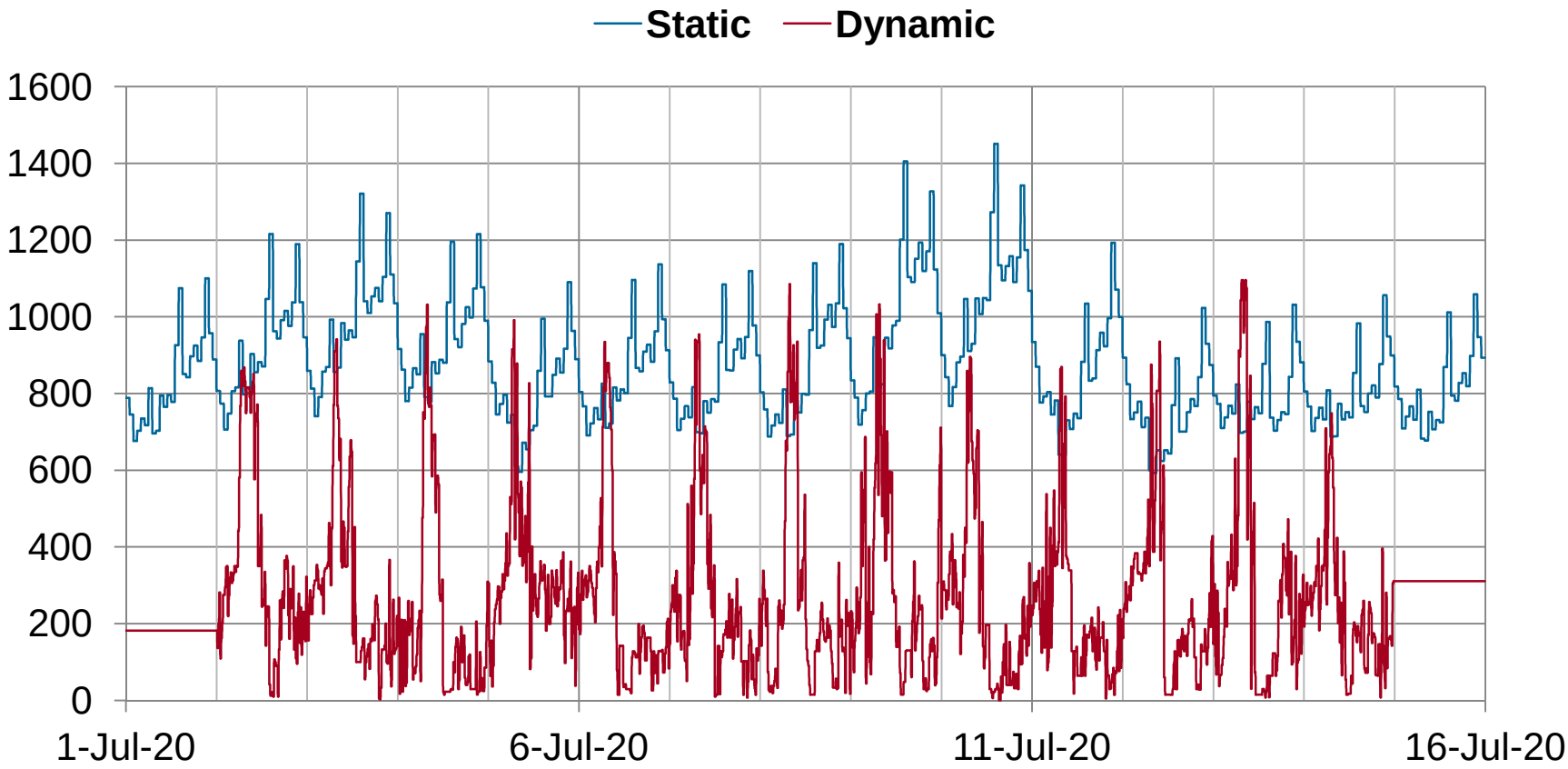
Reserve Determination Case Study
Random Renewable Generation Schedules



- Uncertainty of renewable generation included in the pre-dispatch cycle
- Only LFU is procured dynamically

Reserve Determination Case Study

Comparison of Load Following Up Procurements (MW)



- Static – Given LFU Requirement
- Dynamic – SFU determined via Stochastic OPF Solution
- Suggests that traditional procurement may be inefficient
- Needs more investigation

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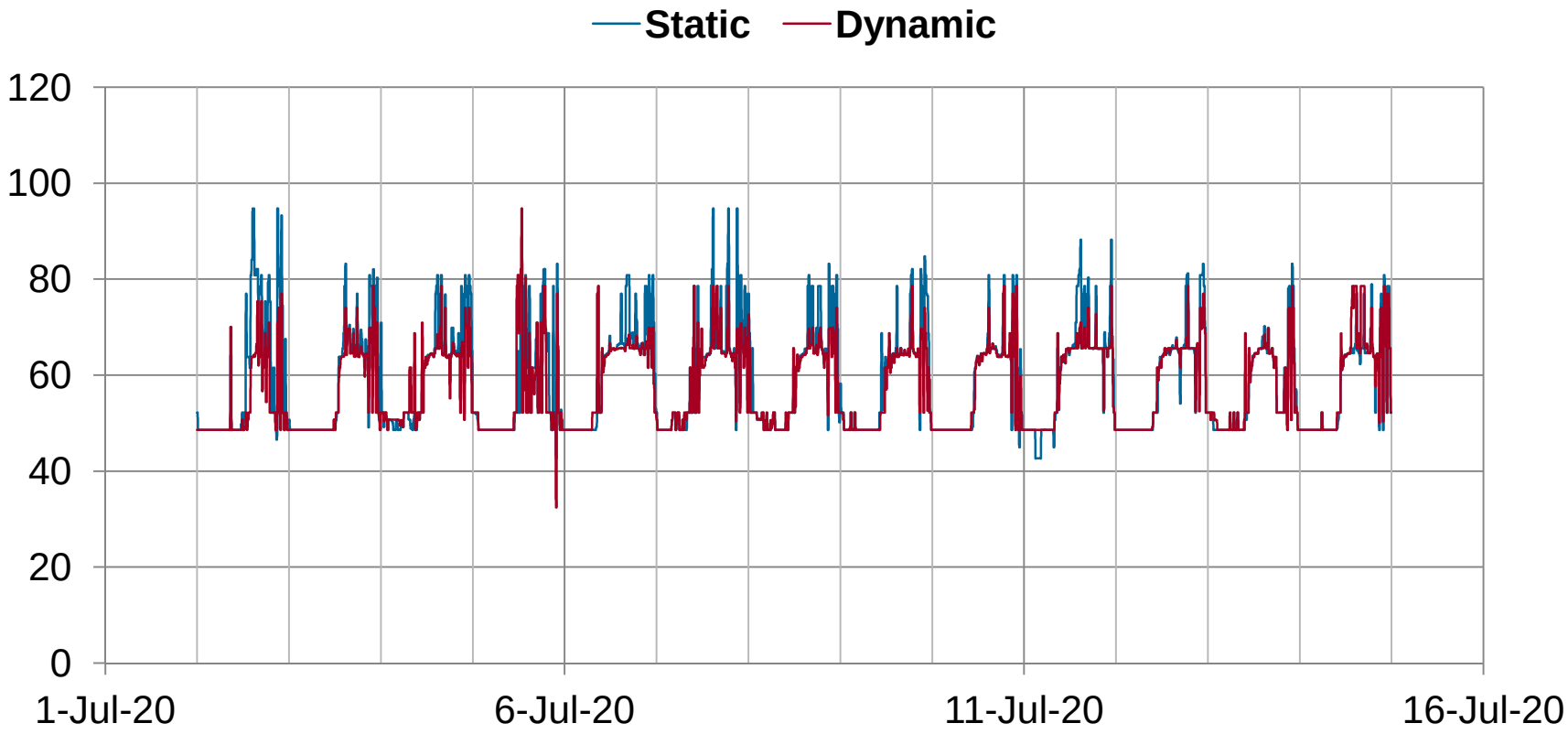
Reserve Determination Case Study
Comparison of Total Production Costs ($)

Static Requirement	Dynamic Requirement	Delta Cost	% of Saving
126,014,101	114,703,621	-11,310,479	-9.0%

- For the system conditions studied,

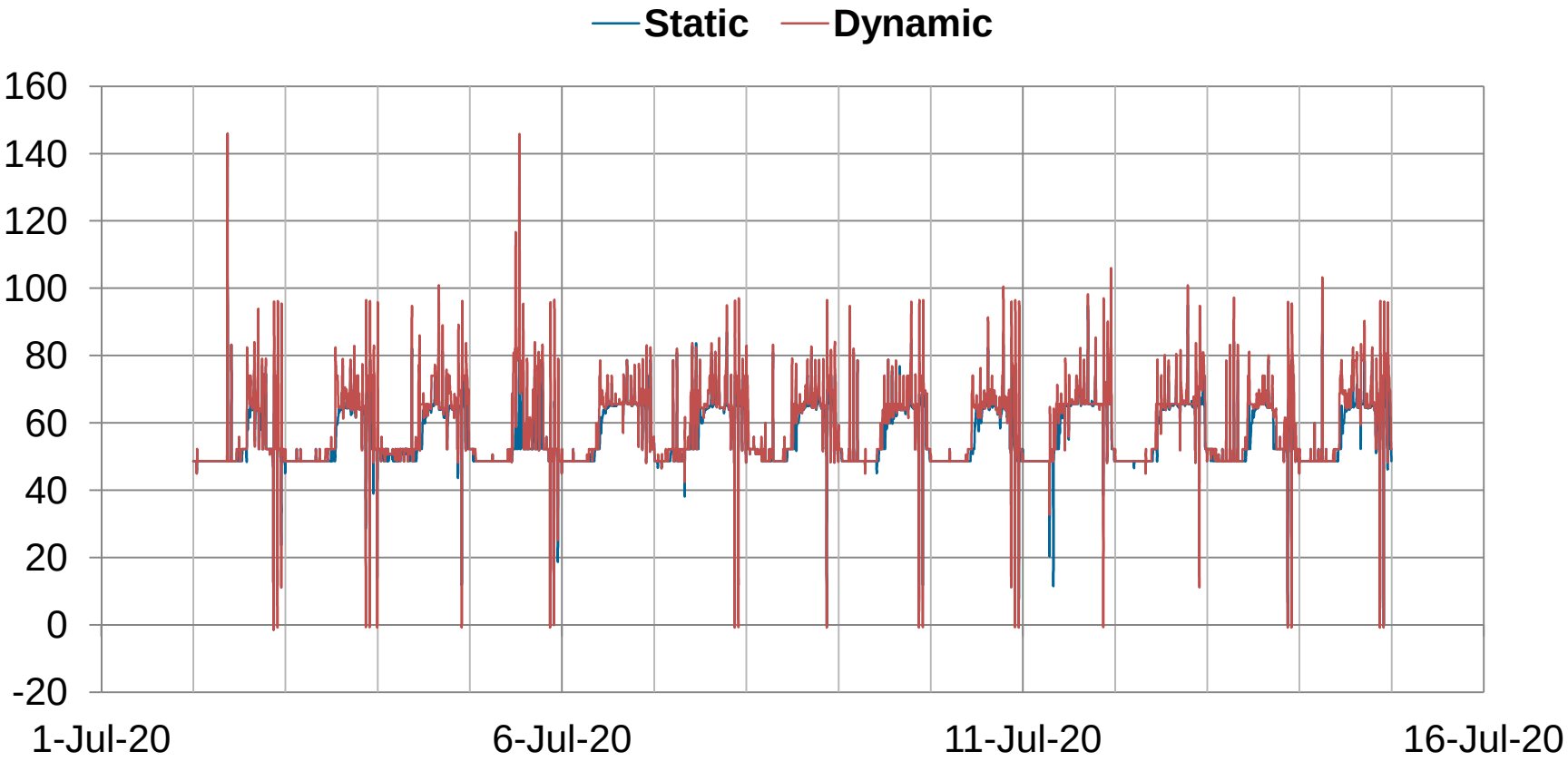
  Dynamic Reserve Determination reduces LFU costs by 9%

Reserve Determination Case Study
Comparison of Pre-Dispatch Energy Prices ($/MWh)



- Dynamic Load-Following Up Procurement
  - Shows no Pre-Dispatch energy deficiency
  - Fewer energy price spikes

Reserve Determination Case Study
Comparison of Real Time Energy Prices ($/MWh)



- Dynamic Load-Following Up Procurement
  - Shows no Real Time Energy deficiency
  - Prices vary more, because of reduced LFU procurement

Reserve Determination Case Study
Summary of Results

- Dynamic Reserve Procurement can be inserted into the current market pre-dispatch process for better management of reserves
- Total production costs are reduced.
- Reliability is not adversely affected, for the given range of random scenarios.
- May be a need for more realism in the Pre-Dispatch cycle

OR

The current static requirements may inefficiently procure reserves for some conditions

Reserve Determination Case Study
Next Steps

- Engage utility staff to validate methodology and prioritize
- Improve decision cycles to capture formal and informal decision processes
- Include locational impacts of transmission congestion
- Impacts of random generator outages, transmission deratings, load forecast errors, etc.
- Improved forecasting and scenario creation

Reserve Determination Case Study
Next Steps

- Modeling enhancements
  - Dynamically procure multiple reserve types in other decision cycles
  - Facilitate calling reserves for different reasons, like ramping, contingencies, etc.
  - Assess the best time to procure dynamically

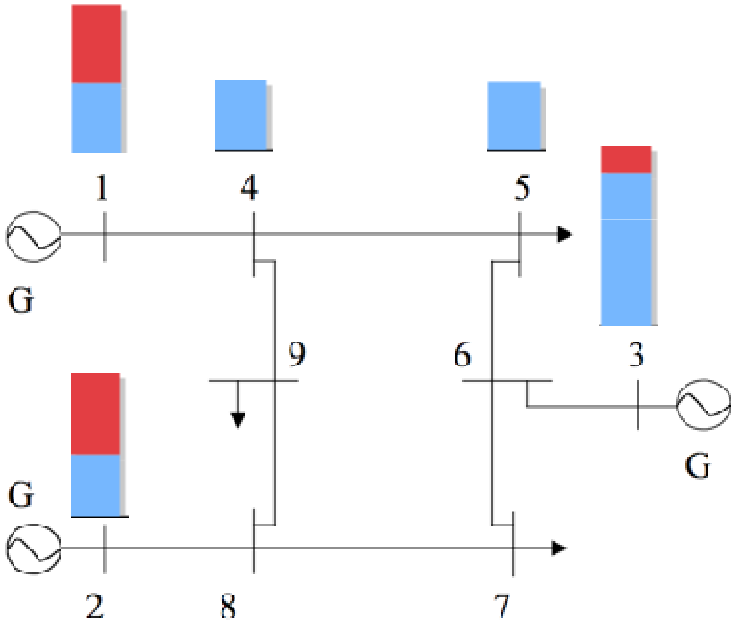
Questions & Discussion

Together…Shaping the Future of Electricity

Appendix

Stochastic OPF Benefit

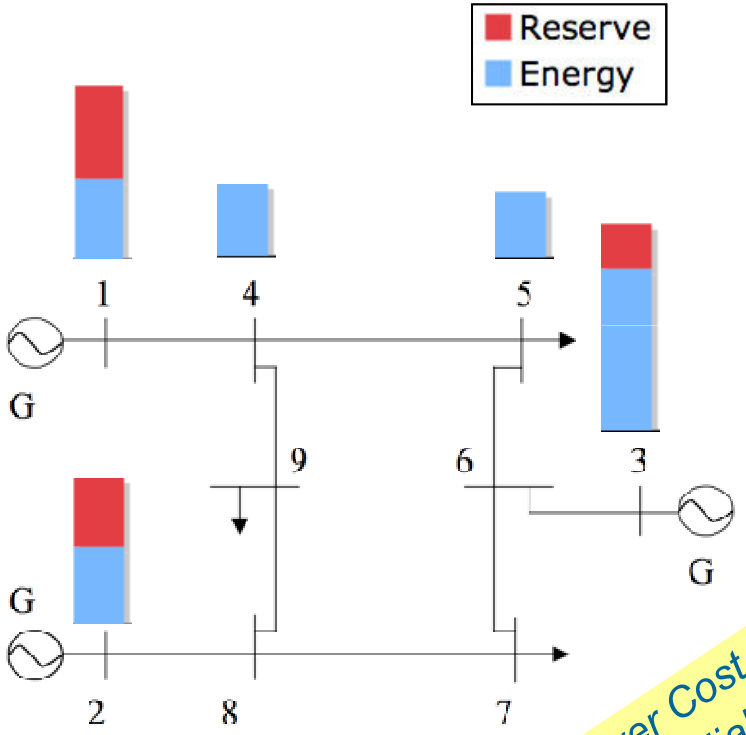
- High wind penetration makes a difference between deterministic and stochastic



Deterministic

Cost = ~~11026~~ 13793

LOLE = ~~0.134~~ 0.495



Stochastic

Cost = 12599

LOLE = 0.290

Lower Cost
Higher Reliability

Previous Contributions

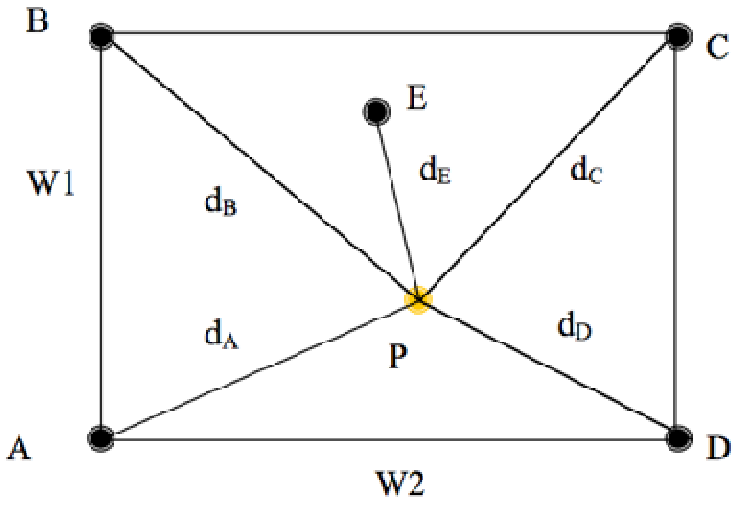
Reporting Benefits and Risk Measures

- NERC Reliability Metrics Working Group proposals
- New estimates for measuring benefits and risk
  - Loss of Load Expectation
  - Expected Unserved Energy
  - System Reserve Margin
  - Duration and Frequency of Outages

Previous Contributions

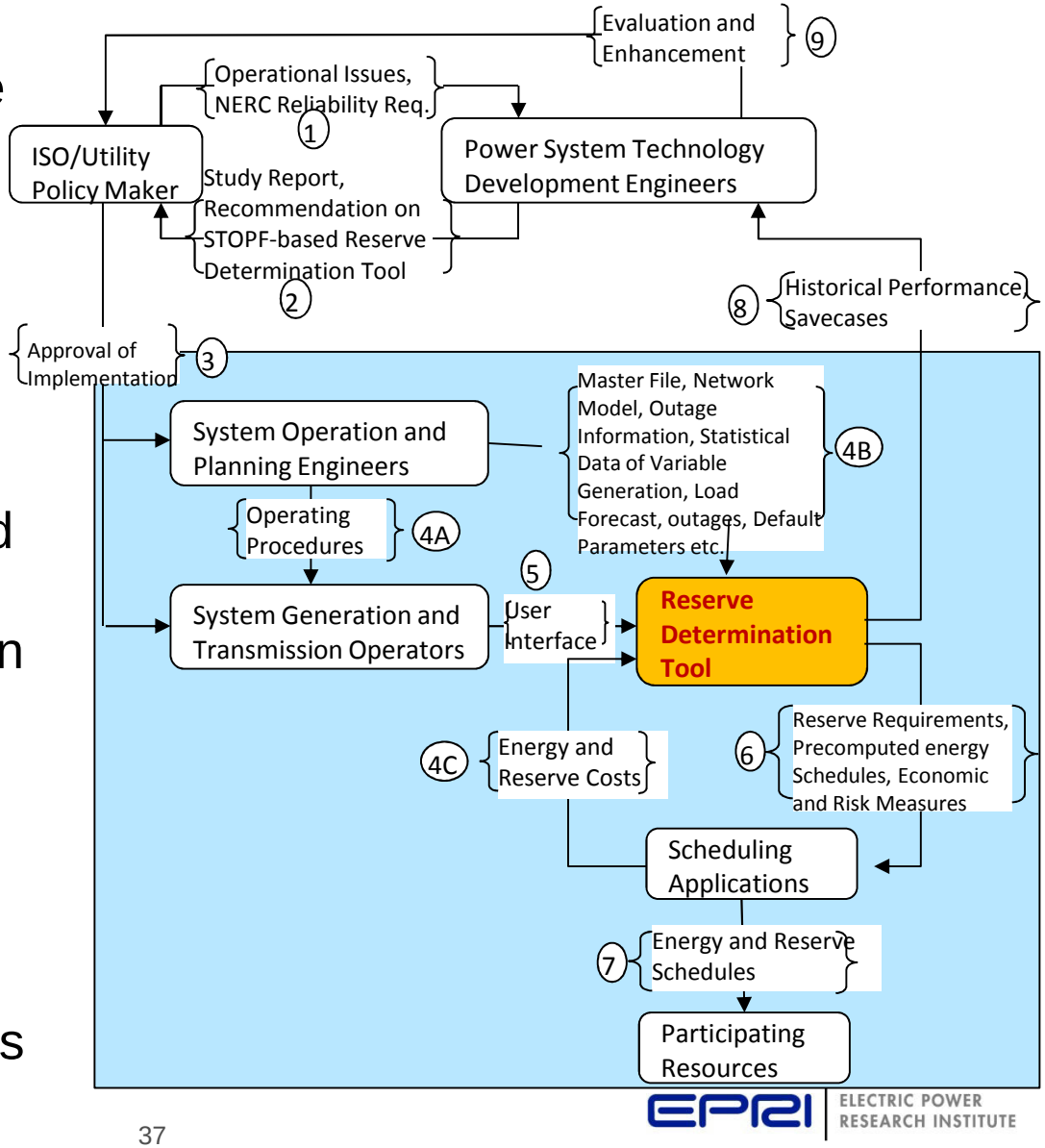
Example Rapid Redispatch

- Pre-computed Redispatch Solutions
  - A, B, C, D, E
- Compute New Redispatch
  - P
  - Combination of closest points: A, E, D
- Simple Formulation Allows for Added Features
  - Limit Number and Location of Control Operations



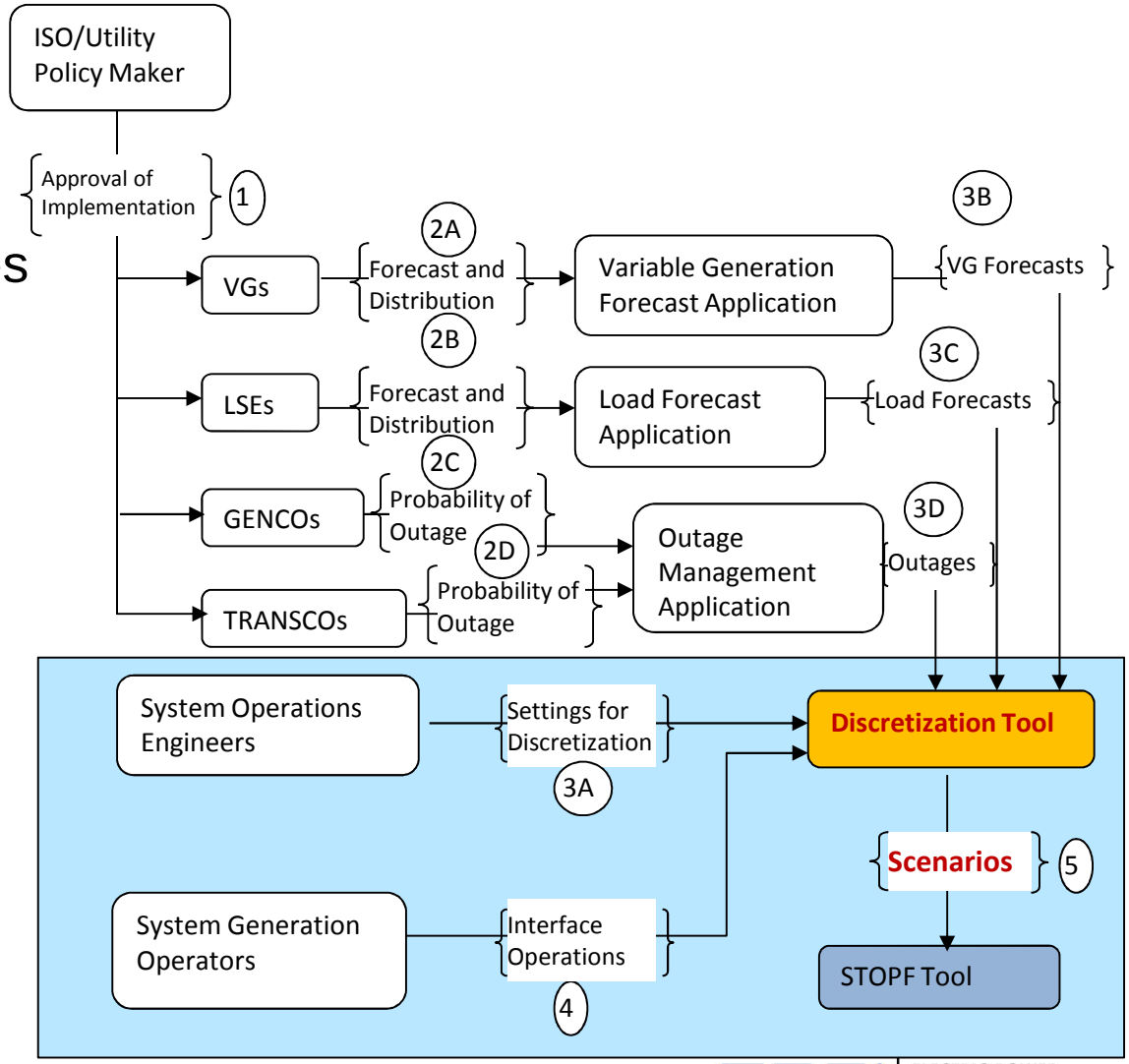
Use Case: Reserve Determination

- Market may or may not have cleared
- Collect Market Data
  - Master File
  - Network model
  - Market bid (actual or forecast)
  - Contingency and Planned Outage information
- Collect stochastic information
- Execute
- Export Results
  - Reserve requirements
  - Precomputed resource schedules
  - Economic and risk metrics



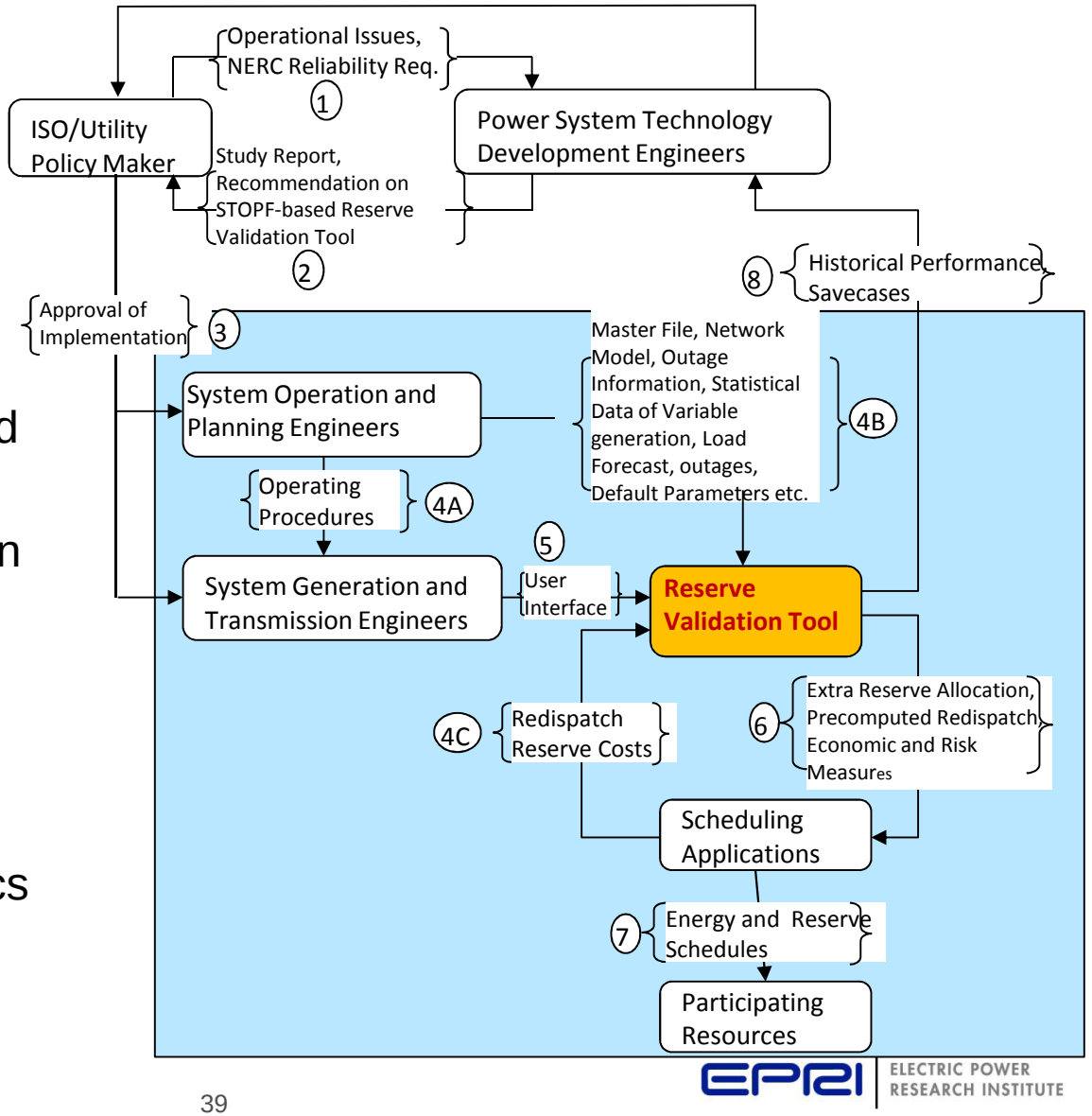
Use Case: Discretize Random Variables

- Collect Random Variables Data
  - Master File
  - Select random variables for representing uncertainty
  - Procure forecast error distributions
  - Set parameters (sampling rates, confidence level) for discretization process
- Execute
- Export Results
  - Stochastic information



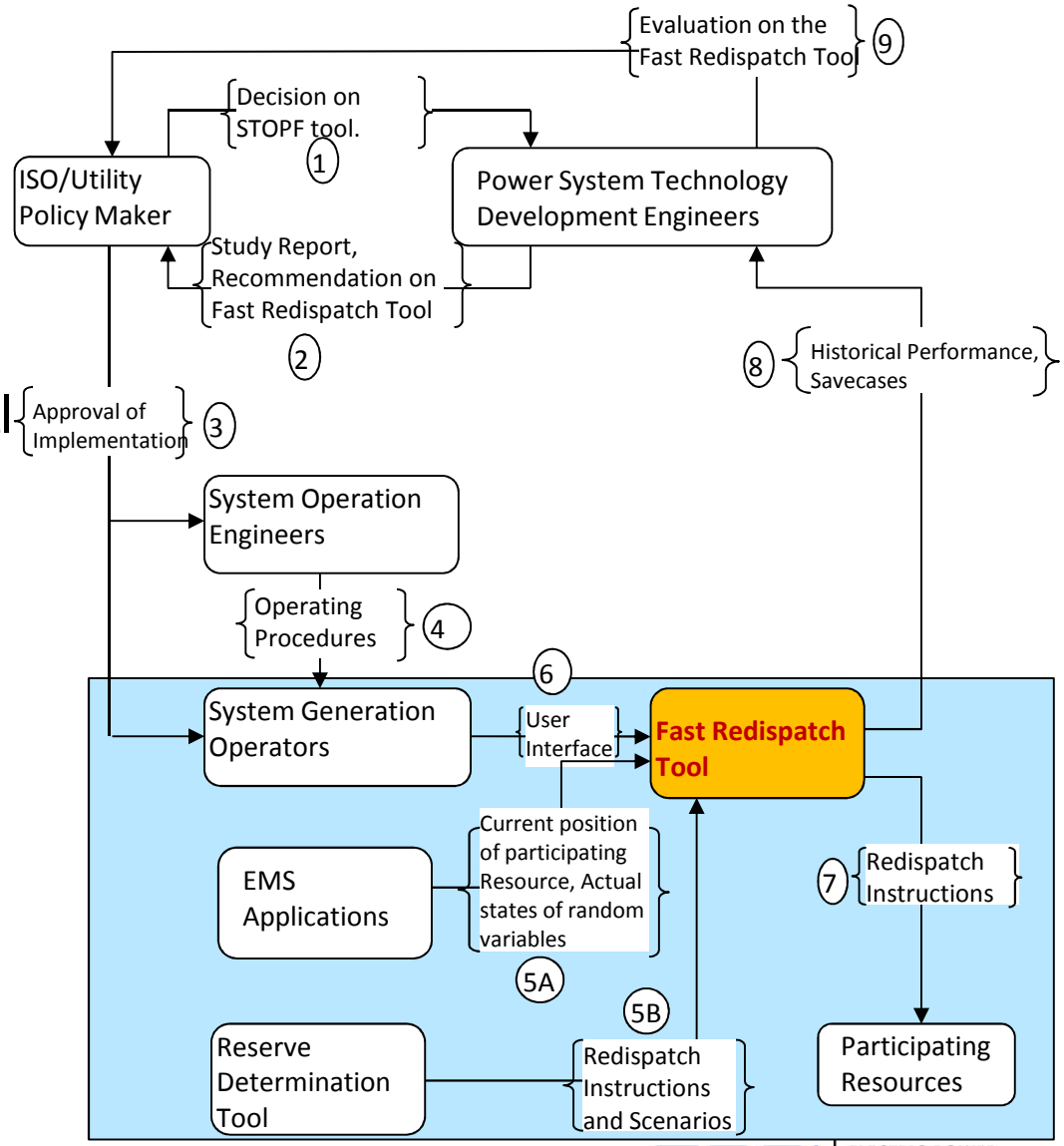
Use Case: Validate Reserve Deliverability and Sufficiency

- Clear Market
- Collect Market Data
  - Master File
  - Network model
  - Market schedules
  - Contingency and Planned Outage information
- Collect stochastic information
- Execute
- Export Results
  - Precomputed resource schedules
  - Economic and risk metrics



Use Case: Post-Contingency Re-Dispatch

- Contingency occurs in RT operations
- Collect Real-Time Data
  - Master File
  - EMS system status (actual outcome)
  - Precomputed resource schedules
  - Operator preferences
- Execute
- Export Results
  - “Recommended” re-dispatch options
  - Economic metrics



Functional Requirements-Data Structure

- Execution Control Data
  - Case Identification
  - Execution Control Options
  - Default Parameters
- Input Data
  - Network Model(Generator, Load, Transmission, Zone etc.)
  - Cost Data (Energy, Reserve and Redispatch)
  - Random Variables (Intermittent Generation, Load Forecast, Outages)
  - Constraints Boundaries (Interface flow limits, Resource operating ranges etc.)
- Output Data
  - Energy and Reserve Schedules, and Prices
  - Scenario Solutions,
  - Economic and risk metrics
  - Binding Constraints
  - etc.

Realistic Simulation of Reserve Determination
Status

1. **Plan the Approach** (Done)
   - Adopt the nested market simulation tool- PSO (developed by Russ Philbrick) which solves unit commitment or economic dispatch with uncertainty.
   - Modify the deterministic reserve requirements in the formulation to the STOPF based reserve determination.
   - Run the PSO for the day-ahead scheduling with deterministic reserve requirements.
   - Run the PSO with the stochastic reserve determination in the hourly scheduling process.
   - Run real time dispatches with both deterministic and stochastic reserve procurements.
   - Compare the risk measures and the expected production costs to demonstrate the benefit of stochastic reserve determination.

Realistic Simulation of Reserve Determination
Status Continued

2. **Prepare Data** (Done)
   - A simplified WECC dataset will be used in the simulation. The original WECC data was adopted by CAISO in planning study for 2020 33% RPS.
   - Data includes both dispatchable generators and intermittent renewable generators.
   - Prepare data in PSO data format
3. **Run Analysis** (Done)
   - Set up the simulation tool. (NDA, License etc.)
   - Modify PSO to incorporate the stochastic reserve determination.
   - Perform about 2-week period of simulation with both deterministic reserve requirements and stochastic reserve determination.
   - Analyze the simulation and review the results.
4. **Produce Technical Update** (Done)