Dynamic Reserve Policies for Market Management Systems

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CERTS Annual Review
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Arizona State University

CERTS Success

- Prior CERTS Funding:
  - Optimal Transmission Switching (Hedman, Oren)
- ARPA-E: >$7M to two teams on transmission switching under GENI
- **July 14, 2015: PJM issued an RFP on Topology Control Applications**

Outline

- Key Takeaway Points
- Background
- Industry Practices
- Dynamic Reserve Zones
- Results
- Ongoing and Future Work
- Summary

Key Takeaway Points

Key Takeaway Points

- Existing models: deterministic (not stochastic); typically linearized AC
- SuperOPF: enhance optimization engines by capturing AC, uncertainty, FACTS, demand response, storage, …

This project:

- Policy functions (dynamic reserves) that improve deterministic and stochastic SCUC/SCED
- Offline stochastic optimization to produce dynamic reserves: improve reserve proxy constraints

IEEE PES General Meeting 2015

Panel: Stochastic Optimization vs. Dynamic Reserves: Which will win?

- Stoch. programming: a sub-class of stoch. opt.
- Dynamic reserves (a policy): stochastic optimization
- The title translates: stoch. opt. vs. stoch. opt.
- The challenge:
  - What complexity is worth modeling explicitly (and how)
  - What complexity is best handled by policies (and how)
  - **Goal: determine the right balance (changes over time)**

Background

Background

- Existing reserve requirements (contingency/spinning and non-spinning reserve) inside SCUC/SCED:
  - Do not guarantee N-1 because congestion may prevent reserves from being deliverable (voltage is also an issue)
- Ensuring sufficient and **deliverable** reserves (quantity + **location**) will be increasingly more difficult with renewables
- Potential solutions:
  - Implement stochastic programming

    Computational challenge
  - Use existing reserve requirements/increase reserve quantity

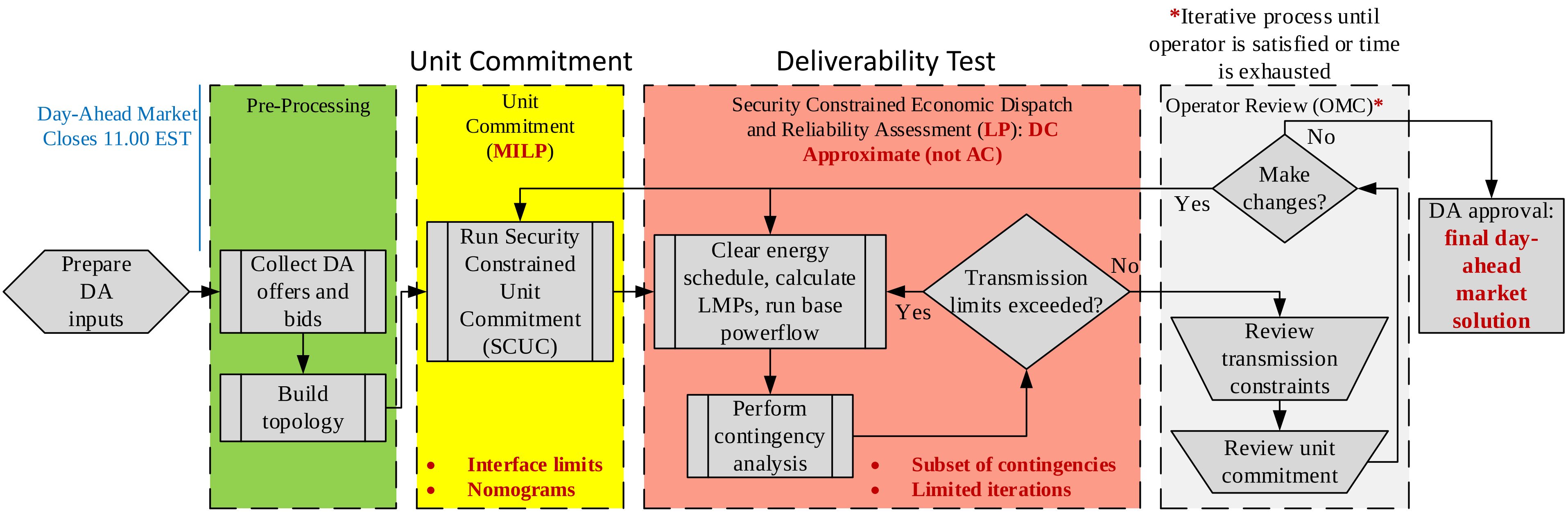
    Costly
- **Best solution: a balanced approach** that combines advanced reserve policies with stochastic programming algorithms

Dynamic Reserve Policies

- Proxy reserve requirements
- Generated based on the results of stochastic simulations/stochastic programming (offline)
- Stochastic simulations produce inputs for the deterministic SCUC/SCED formulations

Industry Practices

Day-Ahead Scheduling in Midcontinent Independent System Operator (MISO)



MISO Day-Ahead Scheduling Procedure

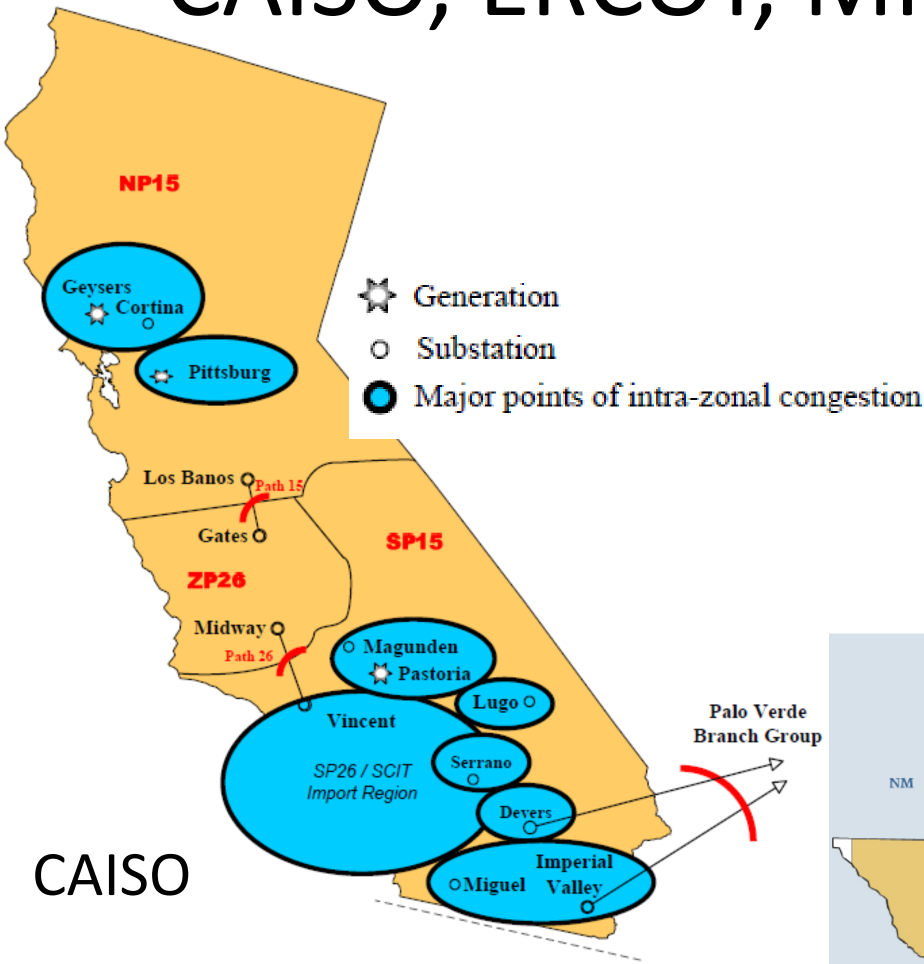
[1] Aaron Casto, “Overview of MISO day-ahead markets,” *Midwest ISO*, [Online]. Available: http://www.atcllc.com/oasis/Customer_Notices/NCM_MISO_DayAhead111507.pdf.

MISO’s Reserve Zones

- Evaluated quarterly
  - Little to no change has been made
- Software created by James Mitsche (Founder, PowerGem)
  - Identify key transmission bottlenecks
  - Use historical power flow information
  - Group generators (zones) based on generators that have similar PTDFs associated to the key transmission bottlenecks
- ERCOT has a similar procedure by identifying: Commercially Significant Constraints (CSCs)

CAISO, ERCOT, MISO's Reserve Zones

- CAISO has 3 reserve zones
- Their reserve rules do not account for intra-zonal congestion
- Intra-zonal congestion is accounted for by other rules

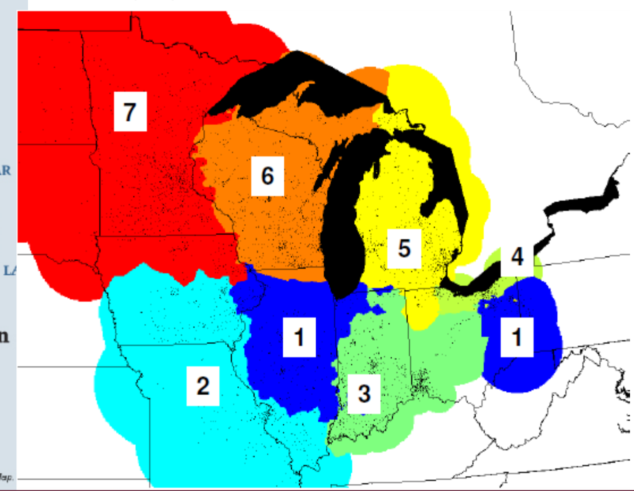


CAISO

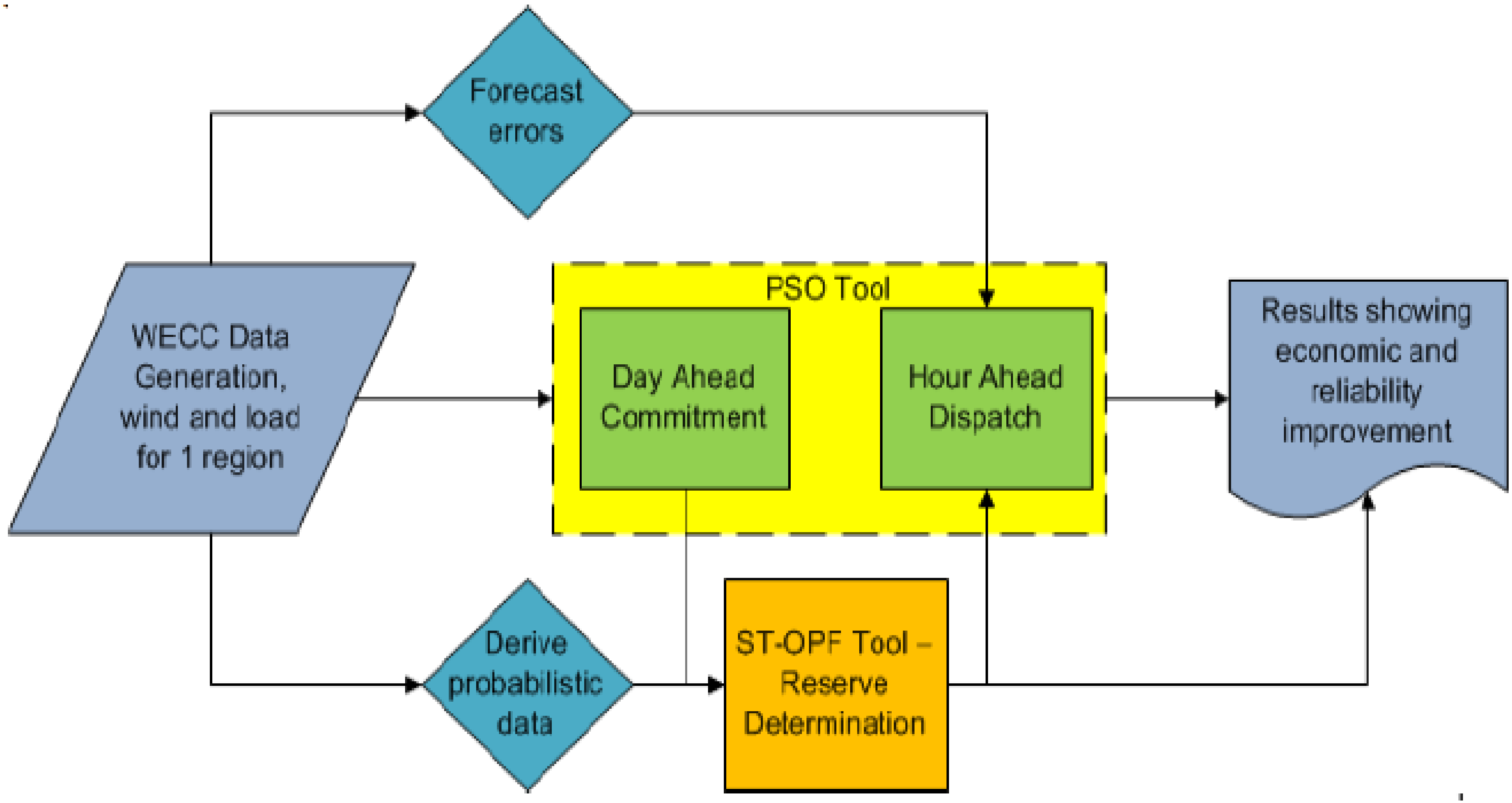
ERCOT

Area 1 is a part of PJM

MISO

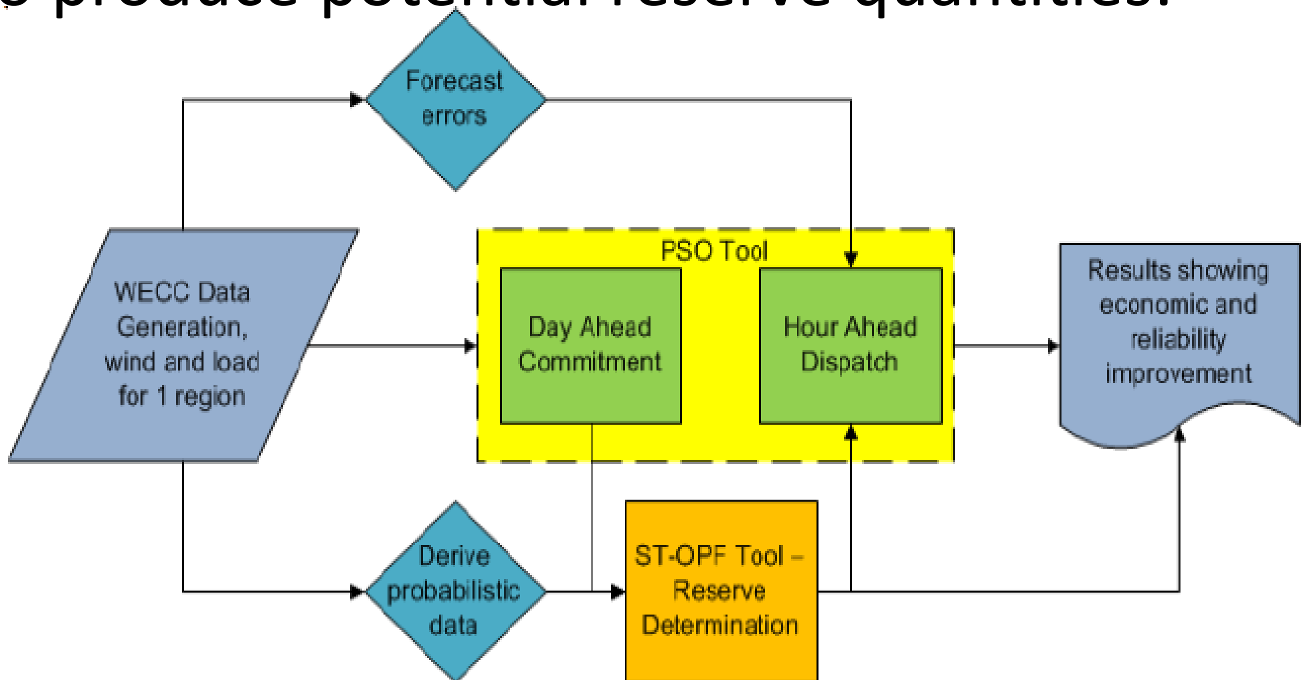


EPRI: Stochastic Reserve Determination



EPRI: Stochastic Reserve Determination

EPRI's suggested offline stochastic programming approach for the CAISO to produce potential reserve quantities:



- CAISO has 3 static reserve zones
- Issues: congestion, reserve sharing, locational reserve needs

[1] A. Tuohy, *et al.*, "Multi-settlement simulation of stochastic reserve determination: project status upgrade," in Technical Conference on Increasing Market Efficiency through Improved Software, Washington, DC, Jun. 2013.

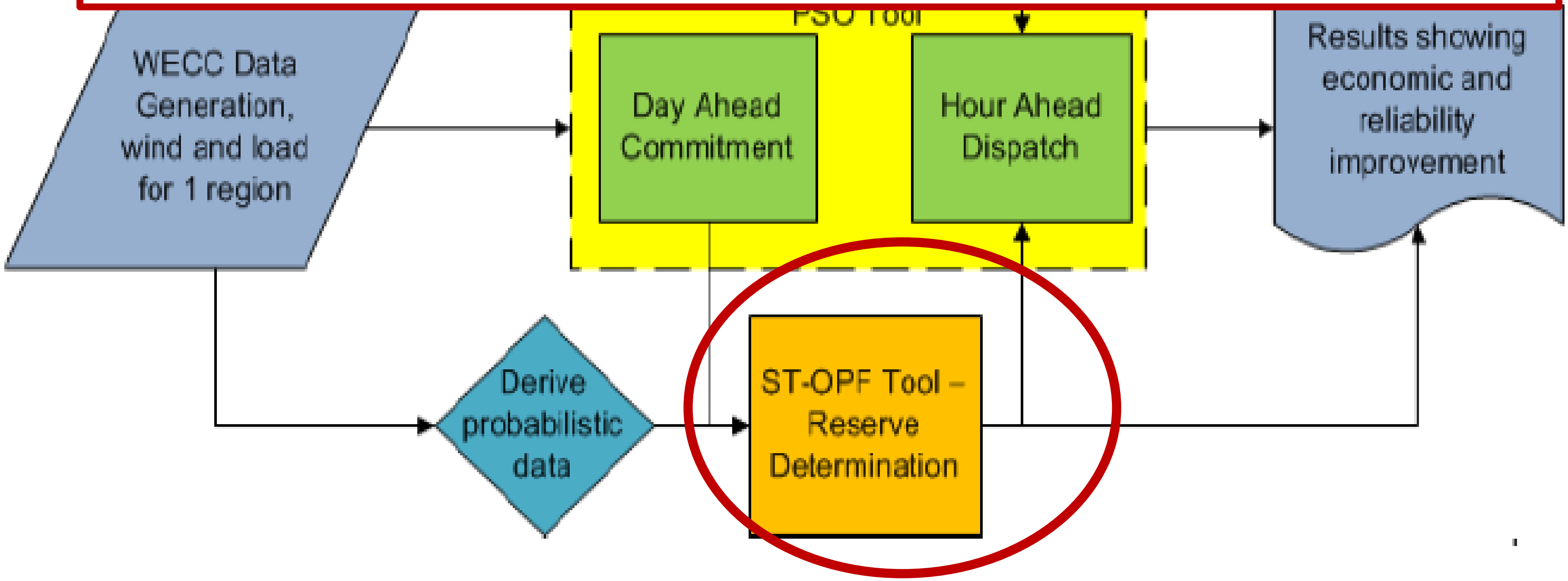
Dynamic Reserve Zones

From Last Year: Proposed Work

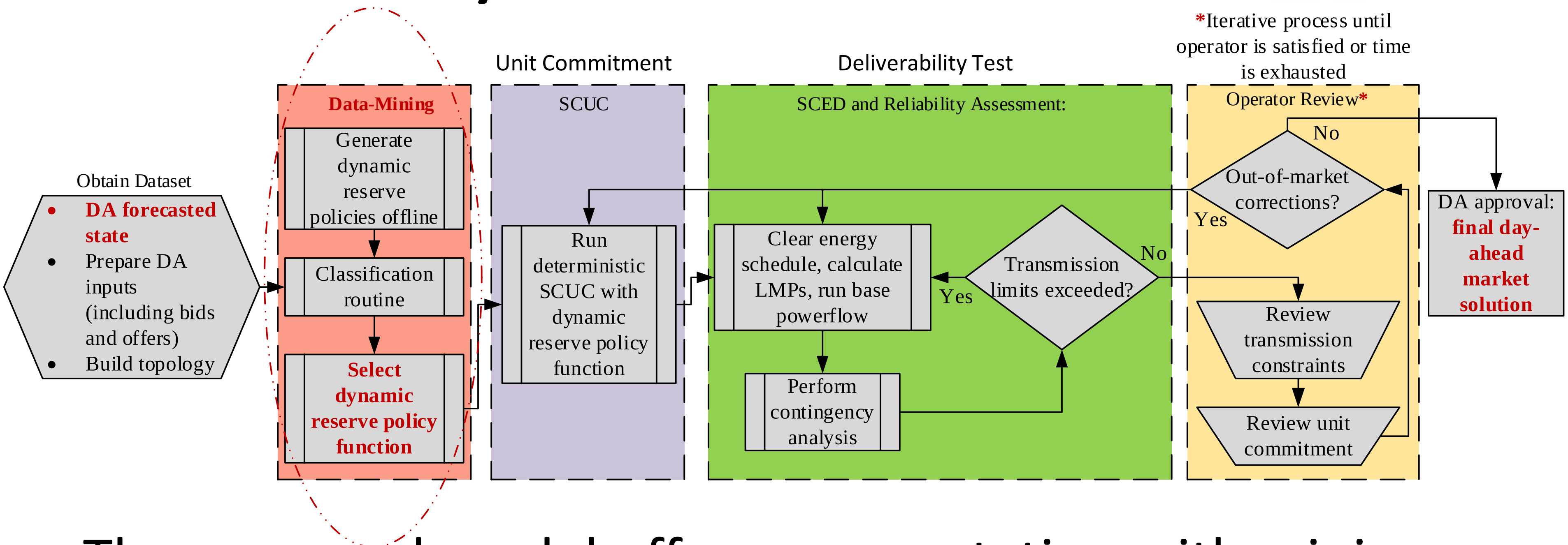
- Create algorithms that mimic ad-hoc reserve disqualification procedures used today
- Create dynamic reserve zones
- Reduce the need for expensive out-of-market correction
- Examine market implications

EPRI: Stochastic Reserve Determination

- Standard stochastic program
- Critical challenge: how to translate a stochastic program solution to an input for a deterministic SCED and yet produce an efficient, reliable solution?



Day-Ahead Flowchart



- The proposed model offers augmentation with minimum disruption
- Dynamic reserves can be determined before the day-ahead SCUC market model or before the real-time SCED market model

Process: Dynamic Reserve Zones

Offline

- Gene
- Dete s proximity, critical lines

Stochastic optimization

Market

- Input dynamic (h
- Deterministic SCU ng, and supplemental res

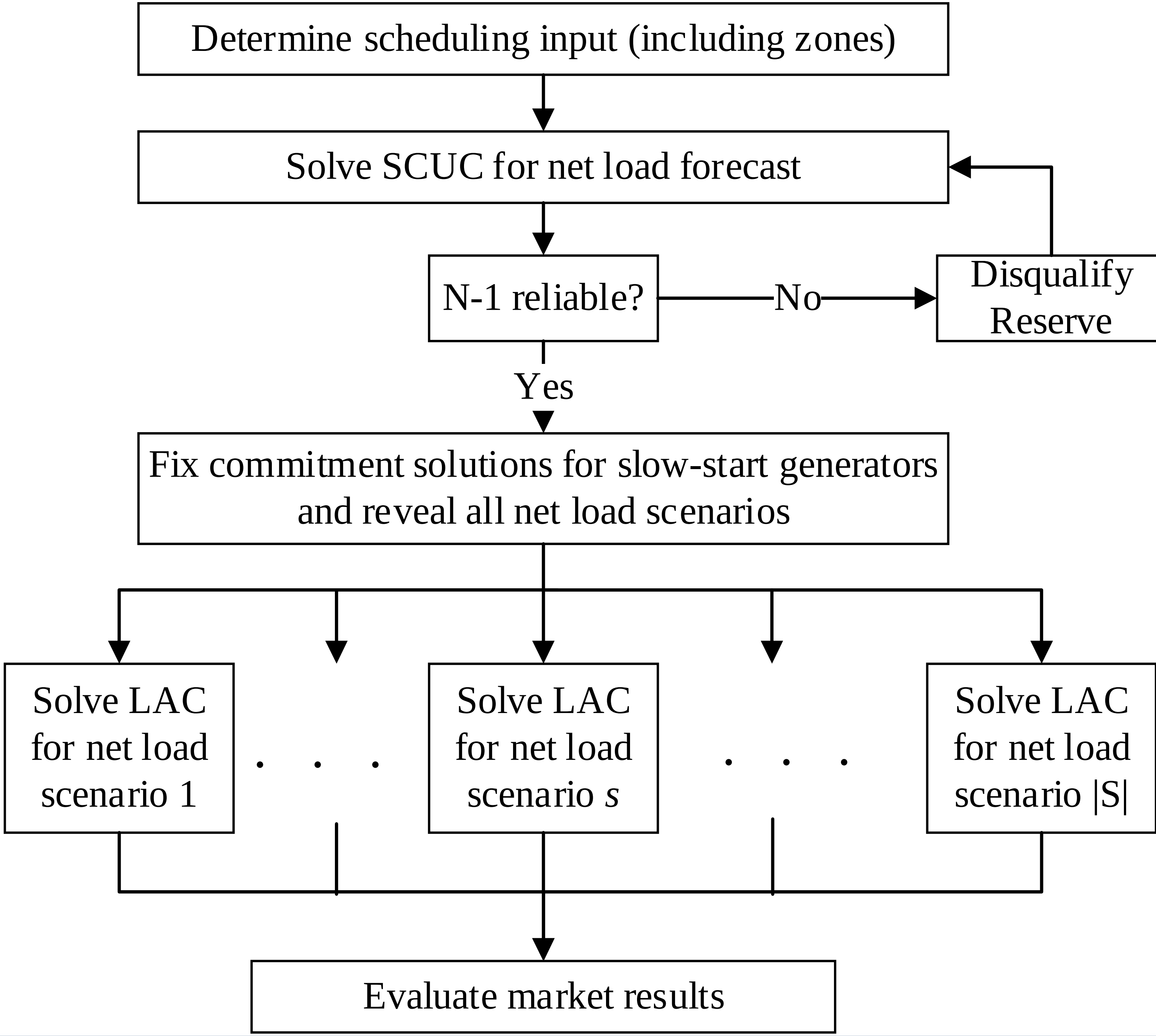
Deterministic market model

Correct, Analyze

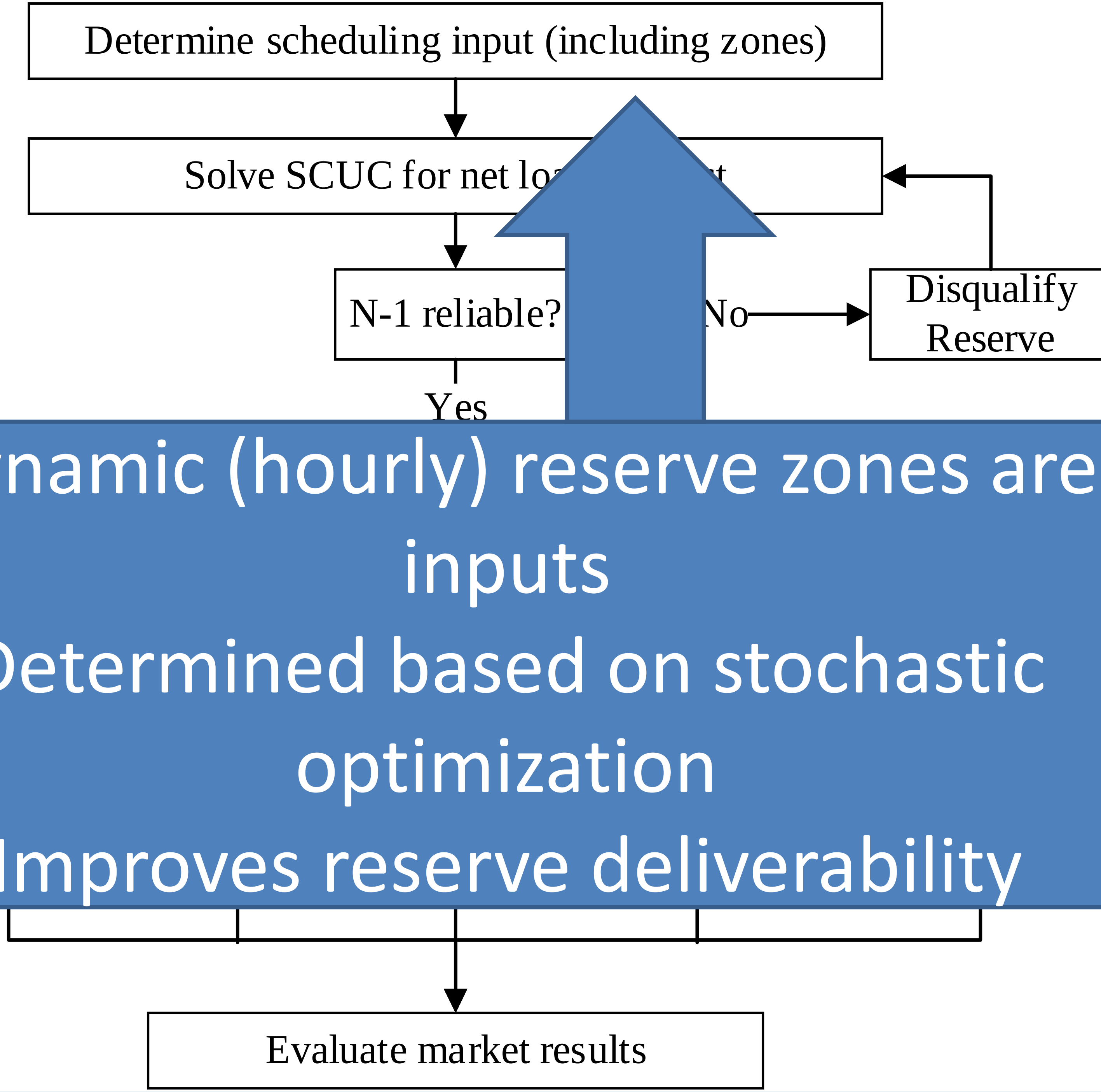
- Test deterministic SCUC/
- Refine market solution b process

Unreliable solutions are corrected based on MISO process

Scheduling Process for DAM and RTM



Scheduling Process for DAM and RTM

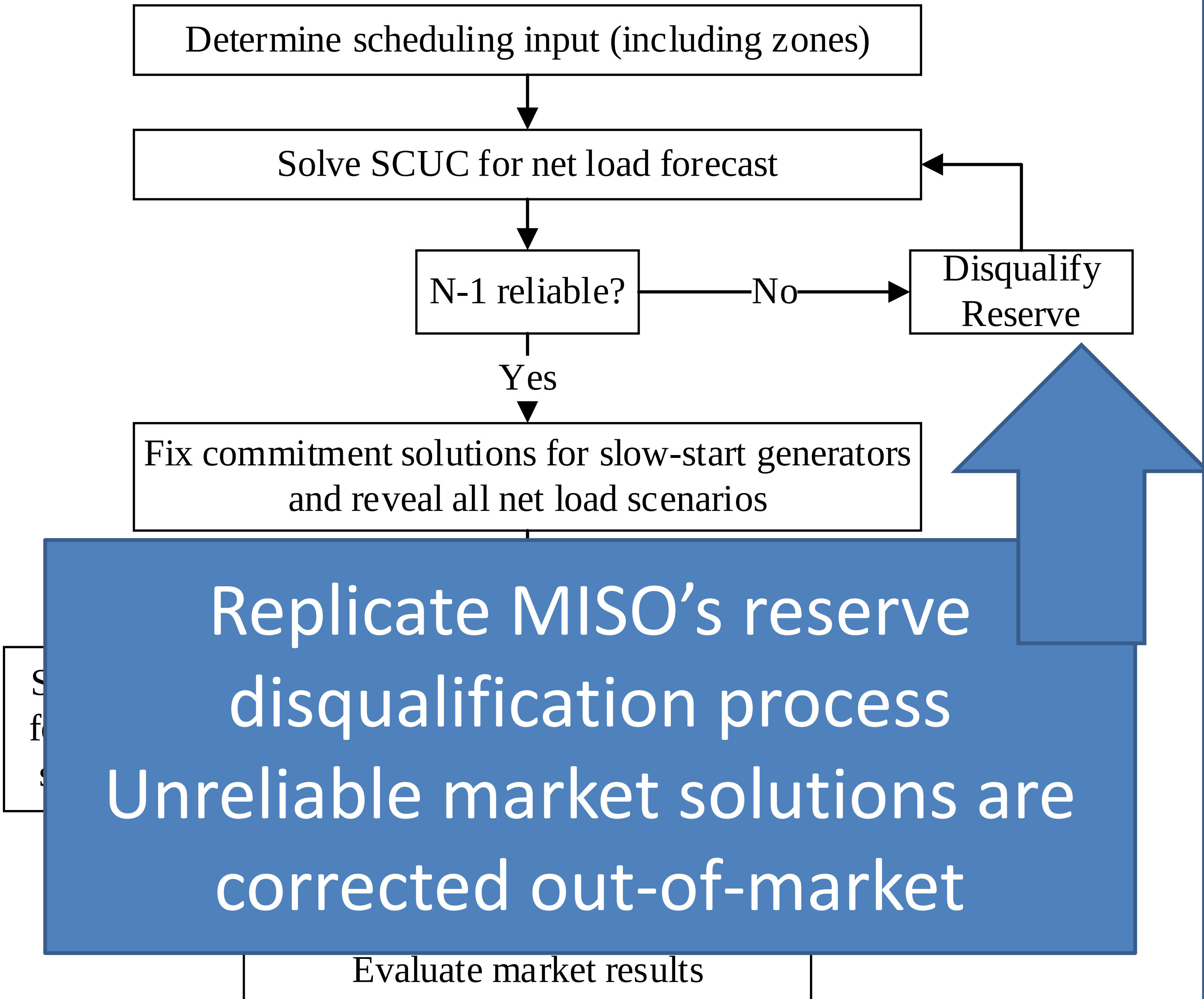


Dynamic (hourly) reserve zones are inputs

Determined based on stochastic optimization

Improves reserve deliverability

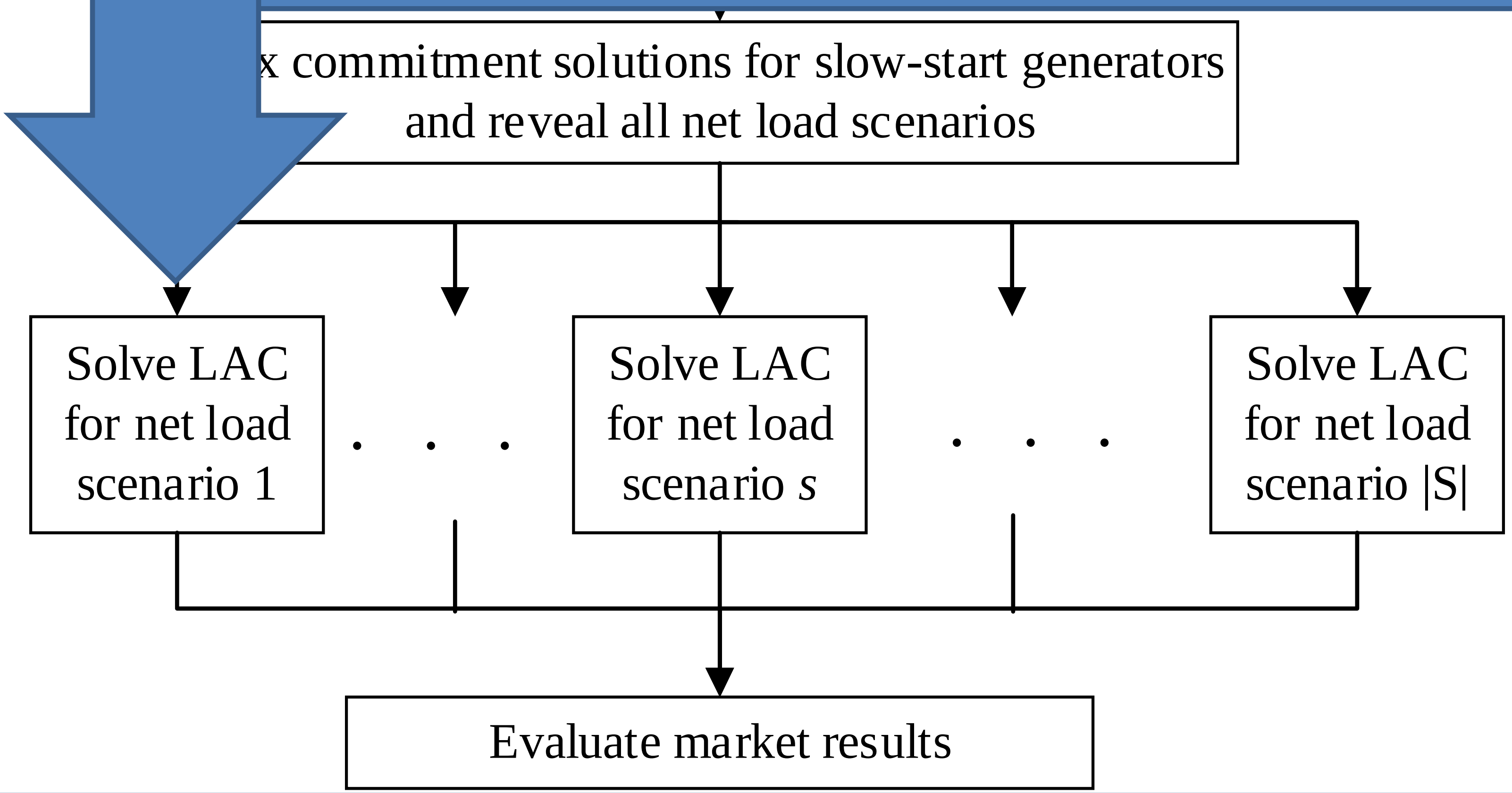
Scheduling Process for DAM and RTM



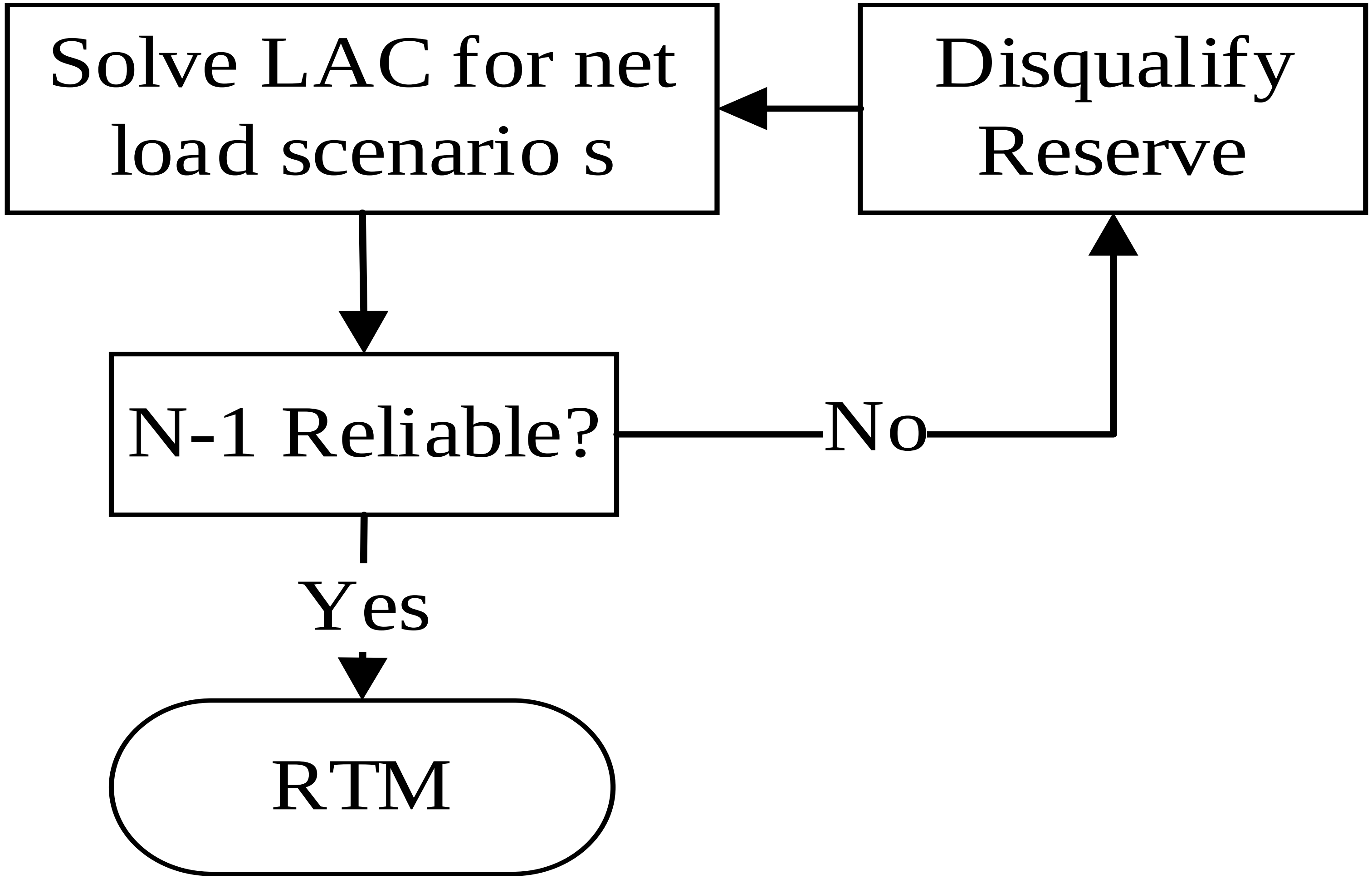
Replicate MISO's reserve disqualification process
Unreliable market solutions are corrected out-of-market

Scheduling Process for DAM and RTM

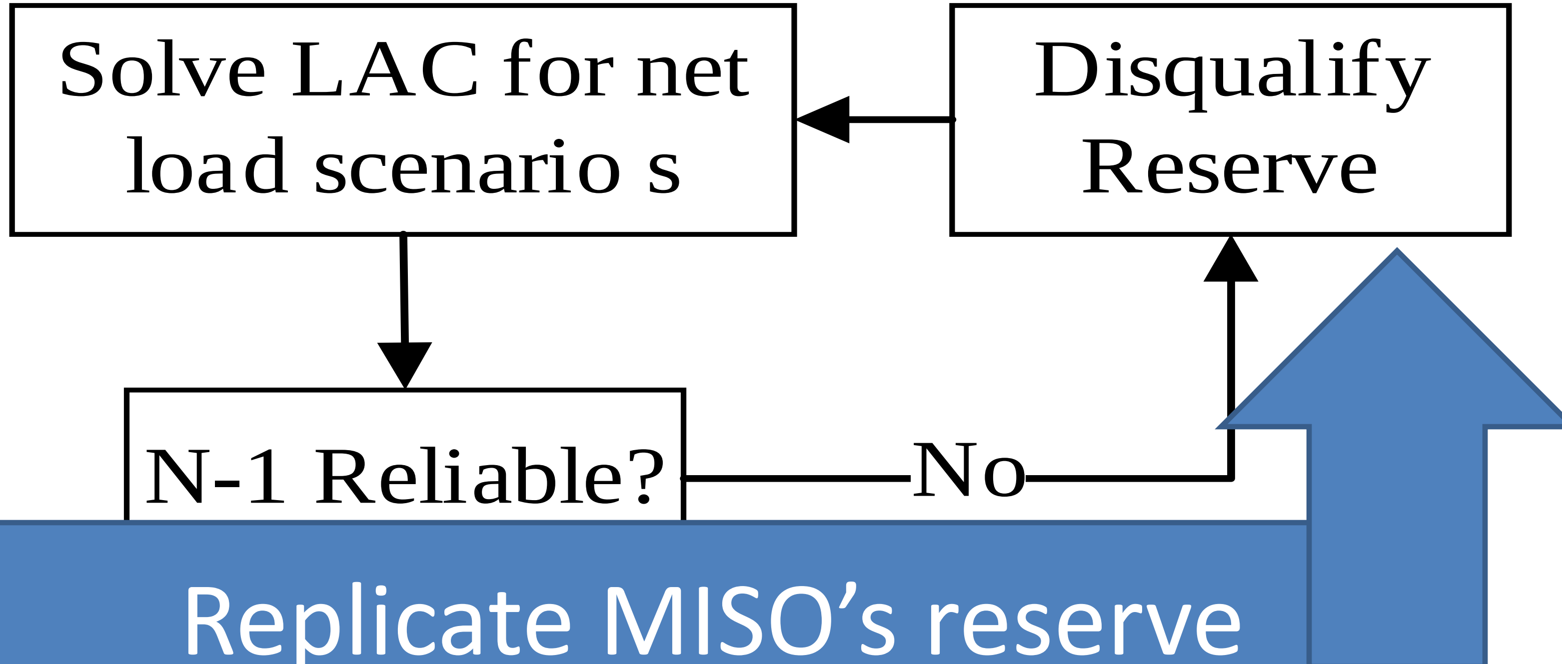
Energy and reserve schedule tested against net load uncertainty and N-1 (Monte-Carlo simulations)



Detailed LAC Process



Detailed LAC Process



Replicate MISO’s reserve disqualification process

Market solutions are corrected out-of-market

Results

Test Case, Market Design

- Test case: RTS 96
  - Plan to extend this work to MISO's actual market data
- Market SCUC/SCED design and reserve modeling: **MISO**
  - Regulation, spinning, supplemental
  - Zonal reserve deployment constraints
- Uncertainties: N-1 combined with 100 net load/renewables scenarios

Results: Cost and Out-of-Market Corrections

- Average renewable production: 12%
- **Average cost savings: 2.6%**
- Out-of-market corrections:
  - Number or reserve disqualifications

Day:	1	2	3	4	5	6	7
Dynamic	0.3	2.1	1.7	16.0	0.65	10.6	8.7
Seasonal	0.9	3.7	4.0	20.6	0.72	15.8	10.7

Enhancement to reserve policies lowers costs, market procures from generators that have better reserve deliverability, out-of-market corrections and uplifts reduce

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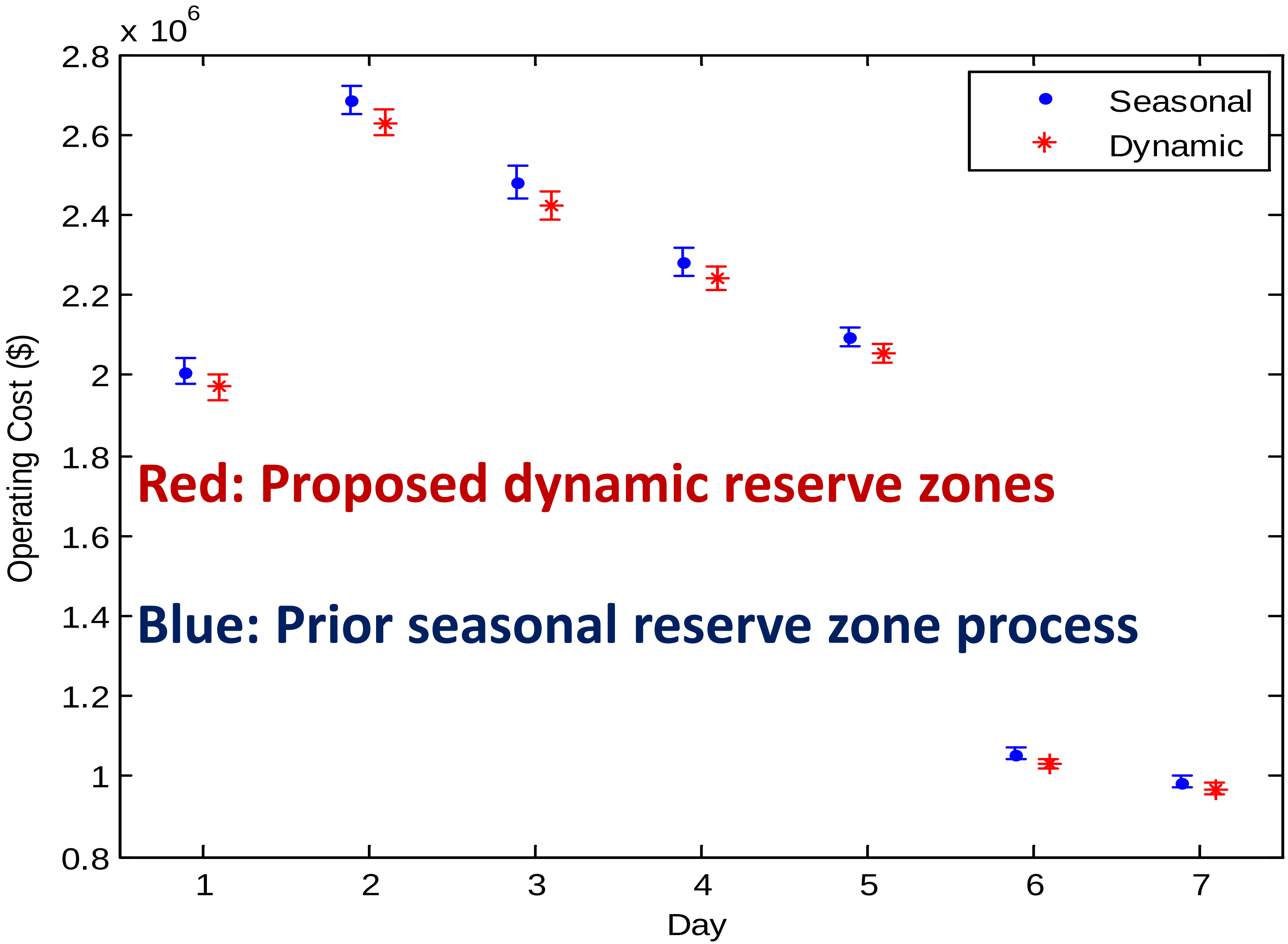
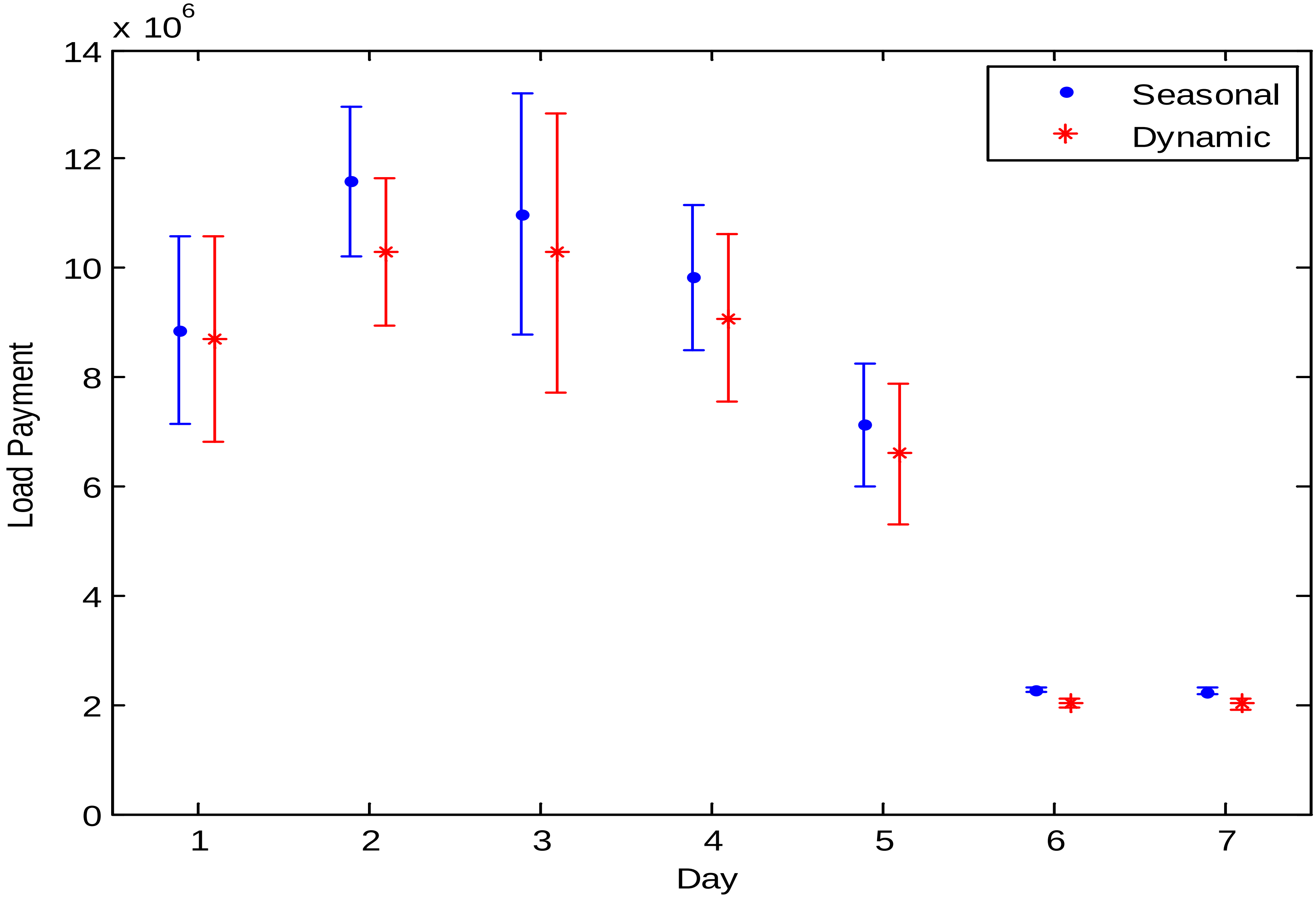
95% Confidence Interval: Total Cost



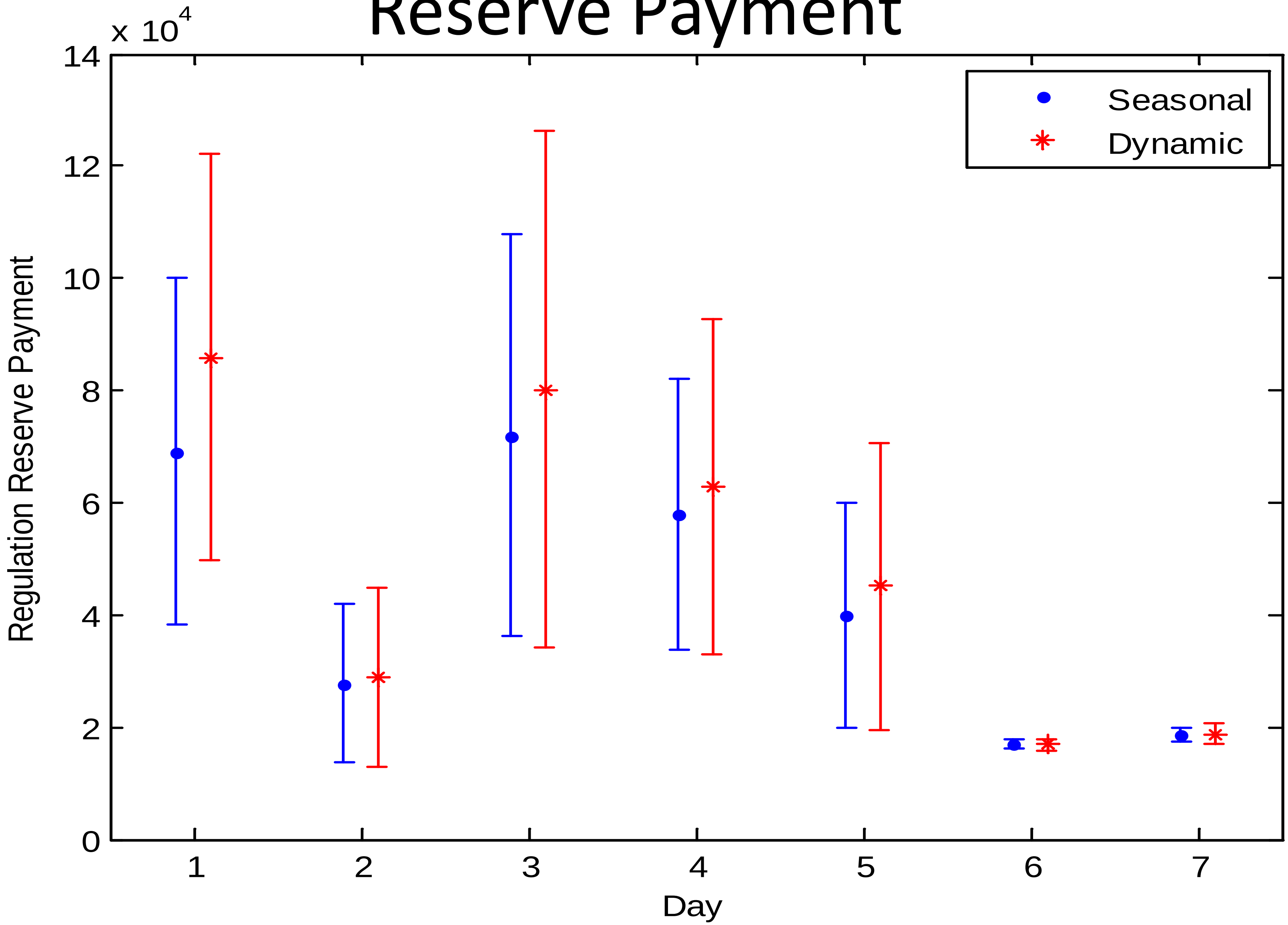
Red: Proposed dynamic reserve zones

Blue: Prior seasonal reserve zone process

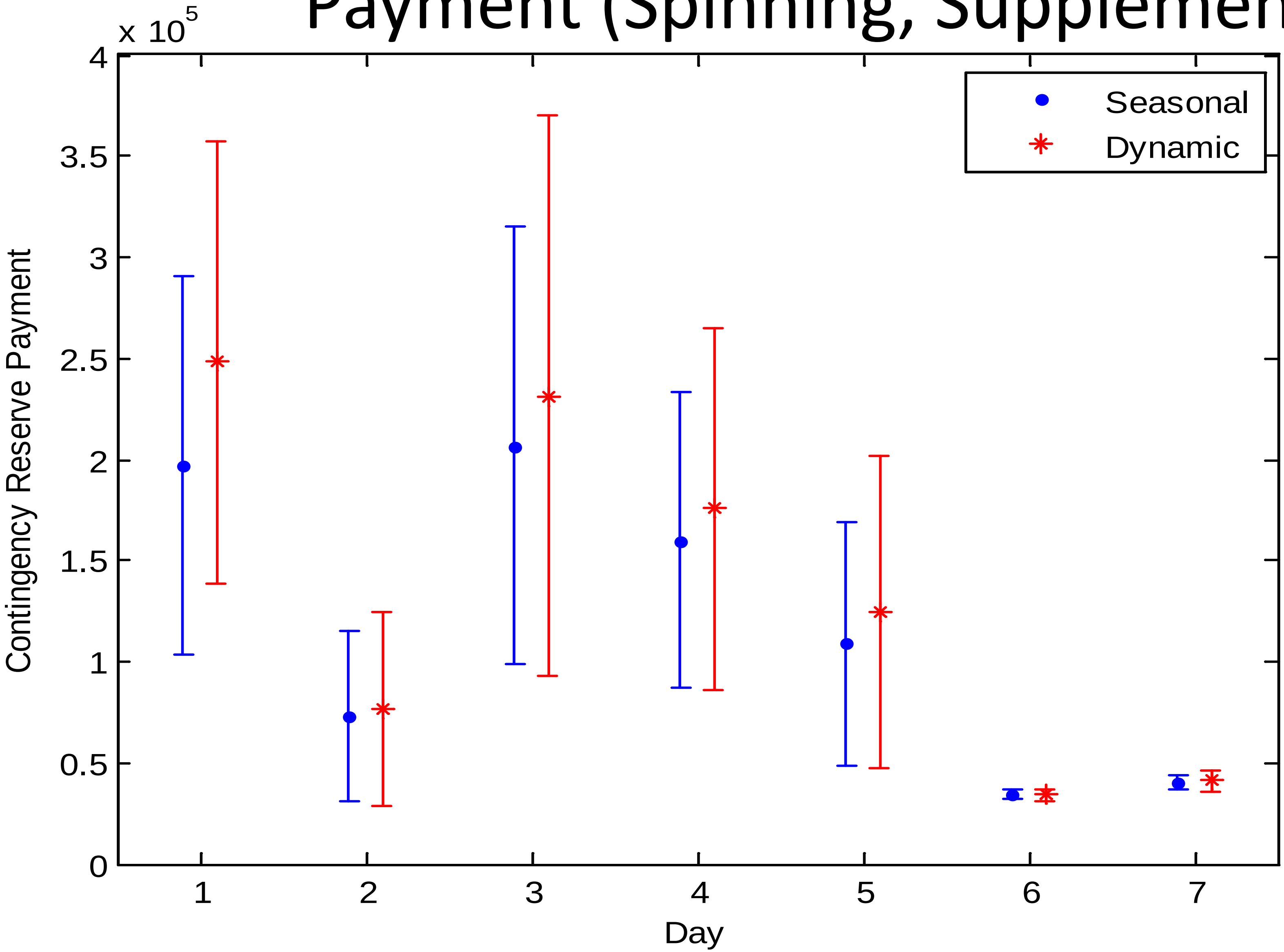
95% Confidence Interval: Load Payment



95% Confidence Interval: Regulation Reserve Payment



95% Confidence Interval: Contingency Reserve Payment (Spinning, Supplemental)



Summary of Results

Total Costs: 2.6%

Load Payment: 6%

Regulation Reserve Payment 1.2%

Contingency Reserve Payment 30%

Market Barriers

- **Transparency:** market participants want to know the reserve policies in advance and may not want adjustments

Dynamic reserves:

- Operational costs reduce
- Reduces procurement of undeliverable reserves and out-of-market corrections
- Reserve payments increase
  - Price signals more appropriately reflect reliability
  - Compensation better reflects quality of service
  - Variability increases

Market Barriers

- Existing practices are inefficient
- Market participants are not entitled to maintain existing inefficient policies
- It is **hard** to design the **markets around the physics**
- It is **harder** to design the **physics around the market**

Industry Impact

- This work was performed by Fengyu Wang
- Fengyu now works under Dr. Yonghong Chen of MISO
- Market research and development engineer
  - Ancillary services market structure, reserve modeling
  - MIP model for DAM and RTM
  - Combined cycle modeling
  - Uplift payment issues

Ongoing and Future Work

Ongoing and Future Work

- Reserve demand curves
  - NYISO uses reserve demand curves for price control and such curves are stakeholder driven, not based on a methodology
- Locational reserve
  - Explore data-mining techniques to identify any existing patterns in the distribution of reserves from the outcomes of offline stochastic simulations
  - Can we predict where reserve is needed, the locational value of reserve?

Ongoing and Future Work

- Reserve sharing
  - EPRI's work for CAISO has struggled with addressing the complex issue of reserve sharing between reserve zones
- Final goal: hybrid model with stochastic programming
  - Similar to scenario reduction, use dynamic reserves to reduce the complexity to be modeled

Summary

Summary

Market barriers:

- Stochastic programming: challenge due to pricing (and has scalability issues)
- Dynamic reserves: avoids pricing issues (and is scalable)

Practical impact:

- Even modest reserve policy improvements: reduce costs, improve computational tractability, and enhance price signals
- Dynamic reserves: complement to stochastic programming: can be used to reduce scenarios for stochastic programs to reduce computational burden

Questions?

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