



Grand Challenges in Electric Power Engineering
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Modeling RTO/ISO Power Systems for Real Time Operations and Planning

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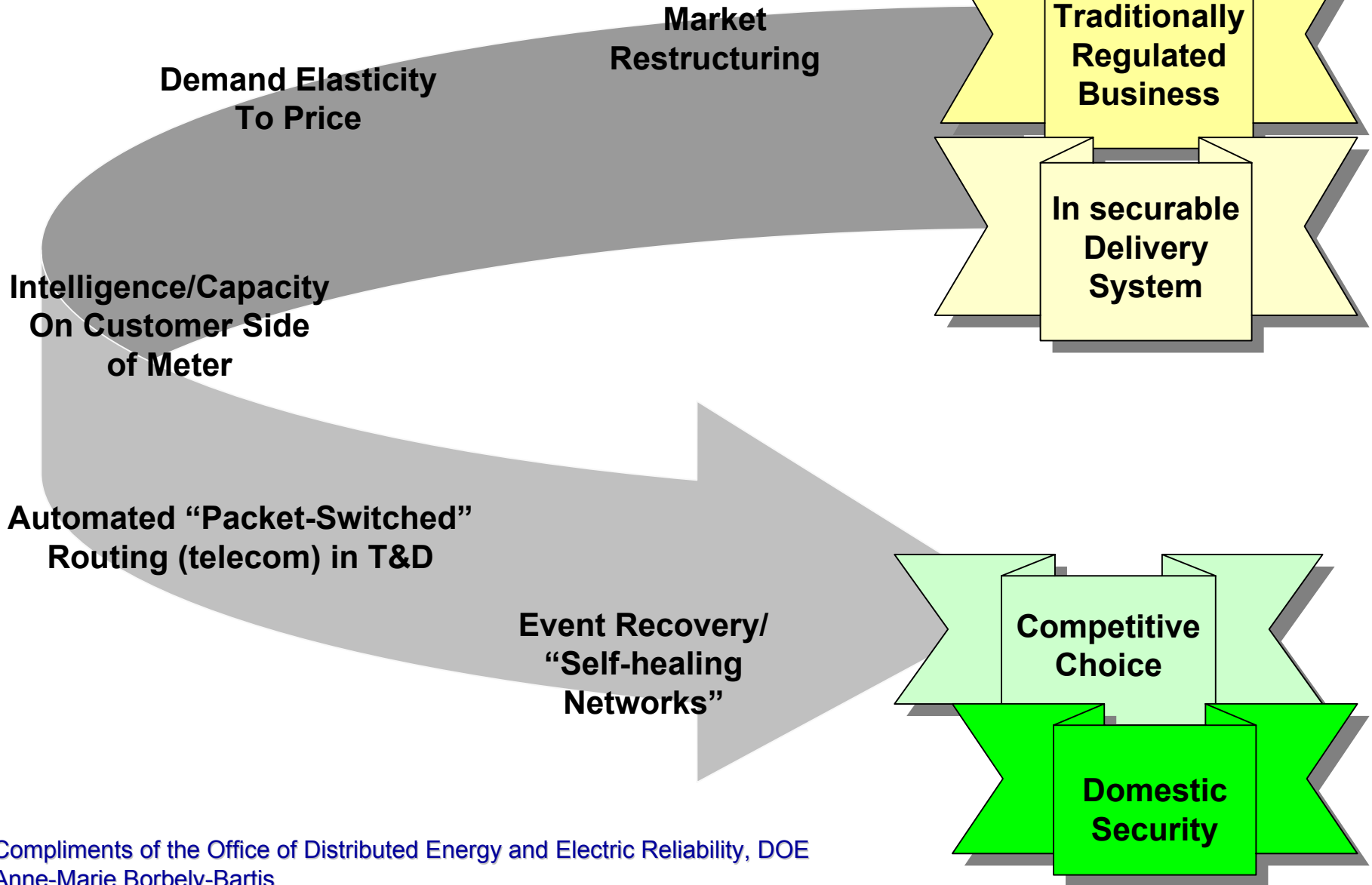
Ken Donohoo Juan Santos

ERCOT

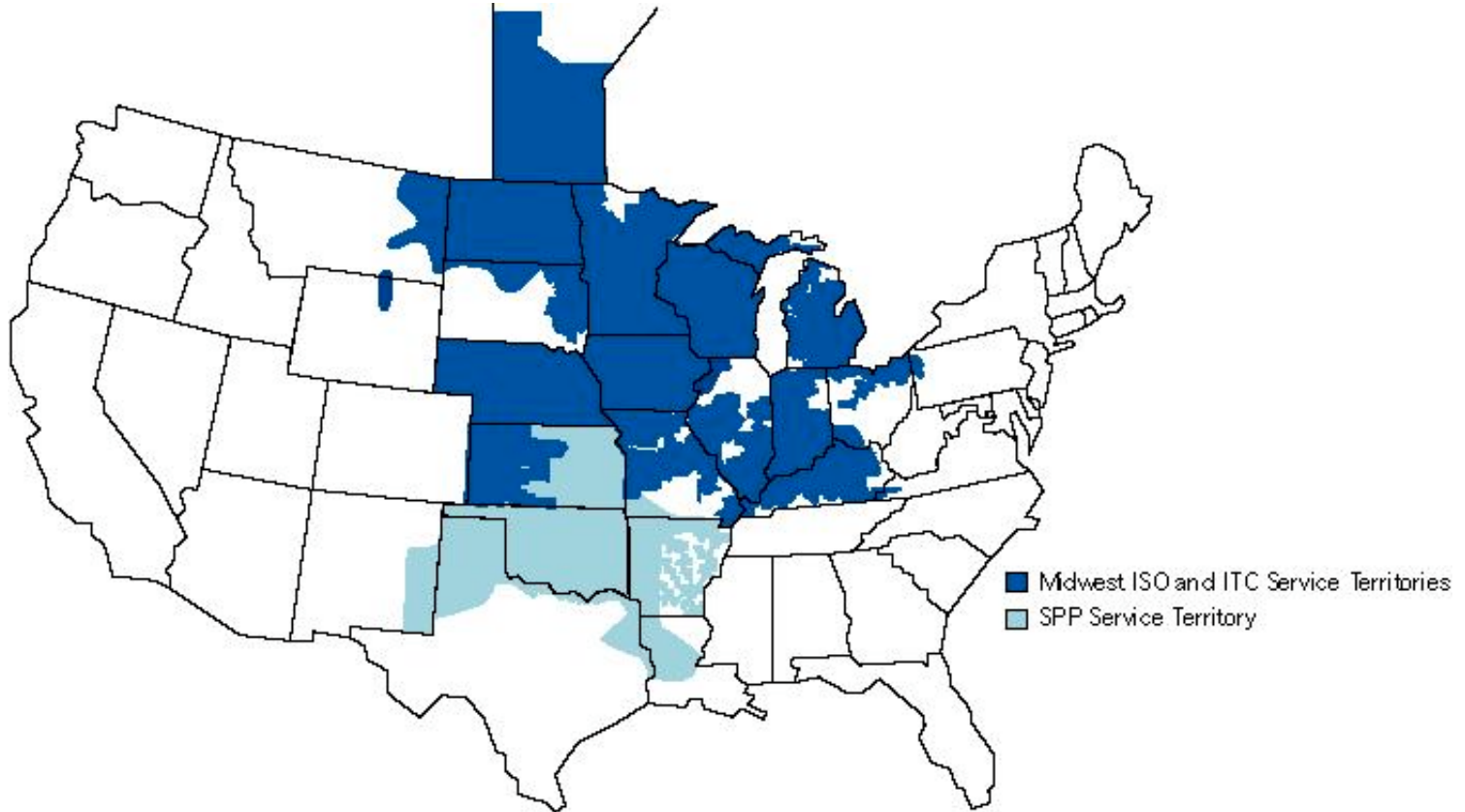
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Outline

- Background
- Large Systems Requirements
- Modeling Issues
 - UNCERTAINTY
- Modeling Complex Phenomena
- Conclusion



US Midwest Electricity Markets

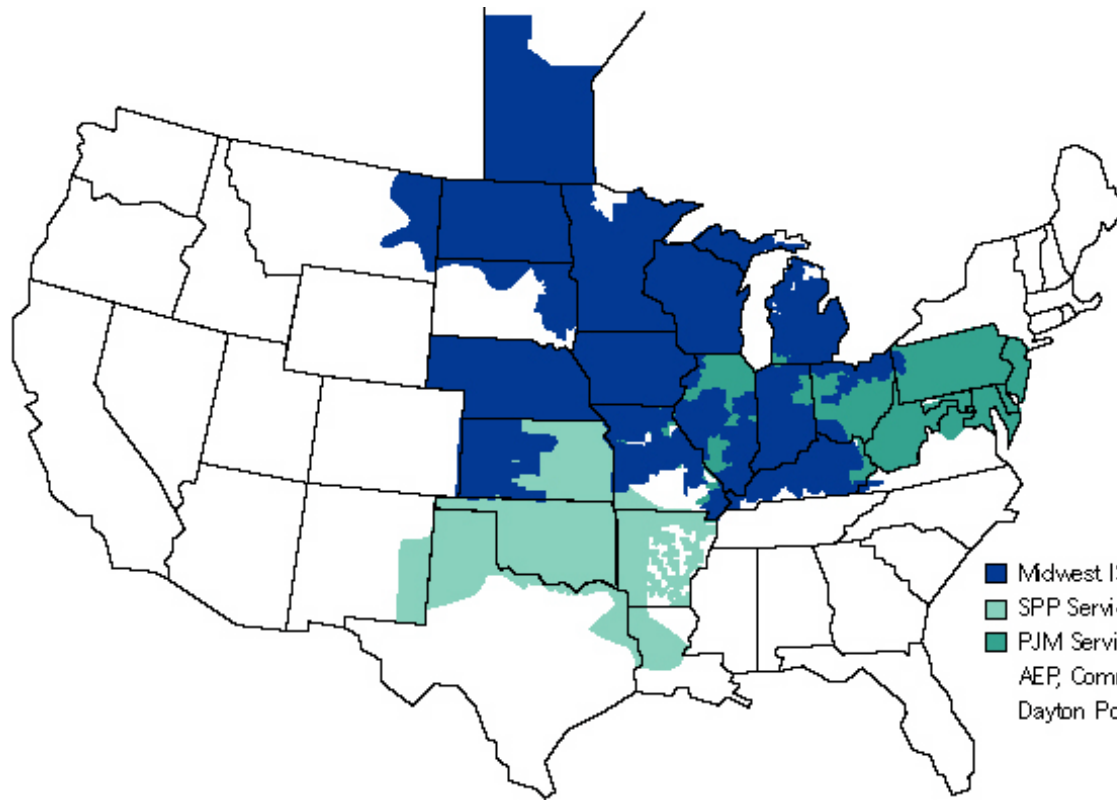


150 GW peak load

144,000+ miles of transmission lines

20.9 million customers

MISO-SPP-PJM Single Market



- 213 GW peak load
- 236 GW generating capacity
- 158,000 miles of transmission lines
- 300 members; 33 million customers
- 1.5 million + square miles

Key Questions

- What models are needed in today's deregulated utility environment?
- Who will be responsible for what?
- Model Accuracy - How Accurate is Accurate?
- What is the cost (\$) of inaccurate models?
- Is quality convergence performance of the algorithms a measure of modeling success?

Types of Models

- Network Models
- Devices
 - Generation
 - Lines
 - Controls
 - New Devices
- Complex Phenomena
- Market Models
- Systems Operation
- System Planning



RTO/ISO Requirements

- Many Sources / Participants
 - Owners
 - Operators
 - Regional Authorities
 - NERC
 - RTOs

- Initial Population
 - Topology
 - Naming
 - Ancillary Models

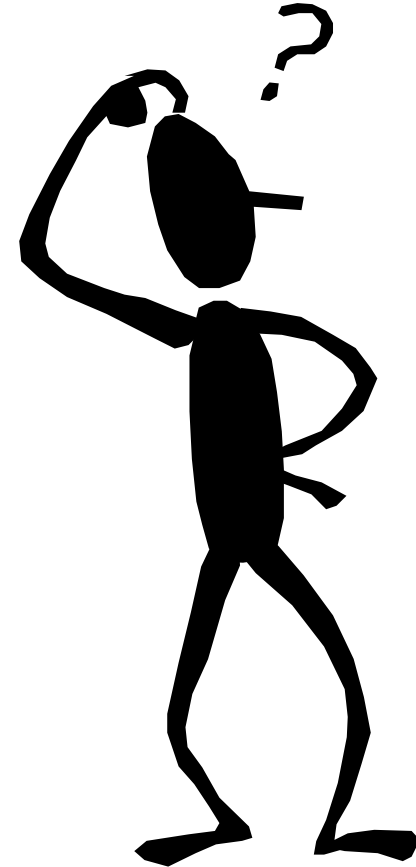
- Continuing Update

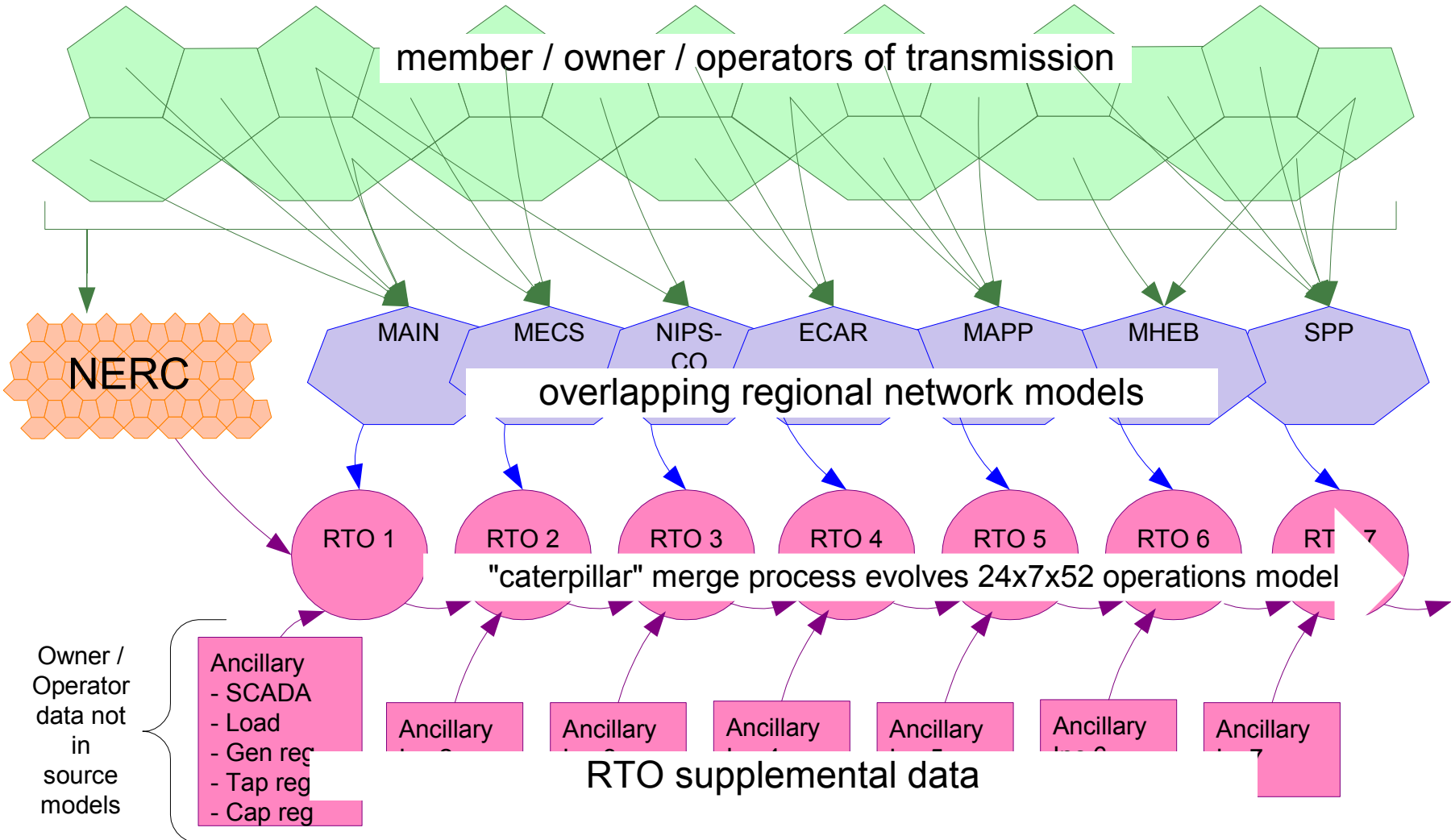
Modeling Issues

- Increased frequency of topology changes
- System size will make comprehension/problem resolution more difficult
- RTO/ISO Structure
 - RTO/ISO is further removed from data sources
 - Model assembly from various independently considered models is complex and prone to errors
- Model accuracy has to cover multiple area models
- Use standard protocol for models exchange (CIM, XML)

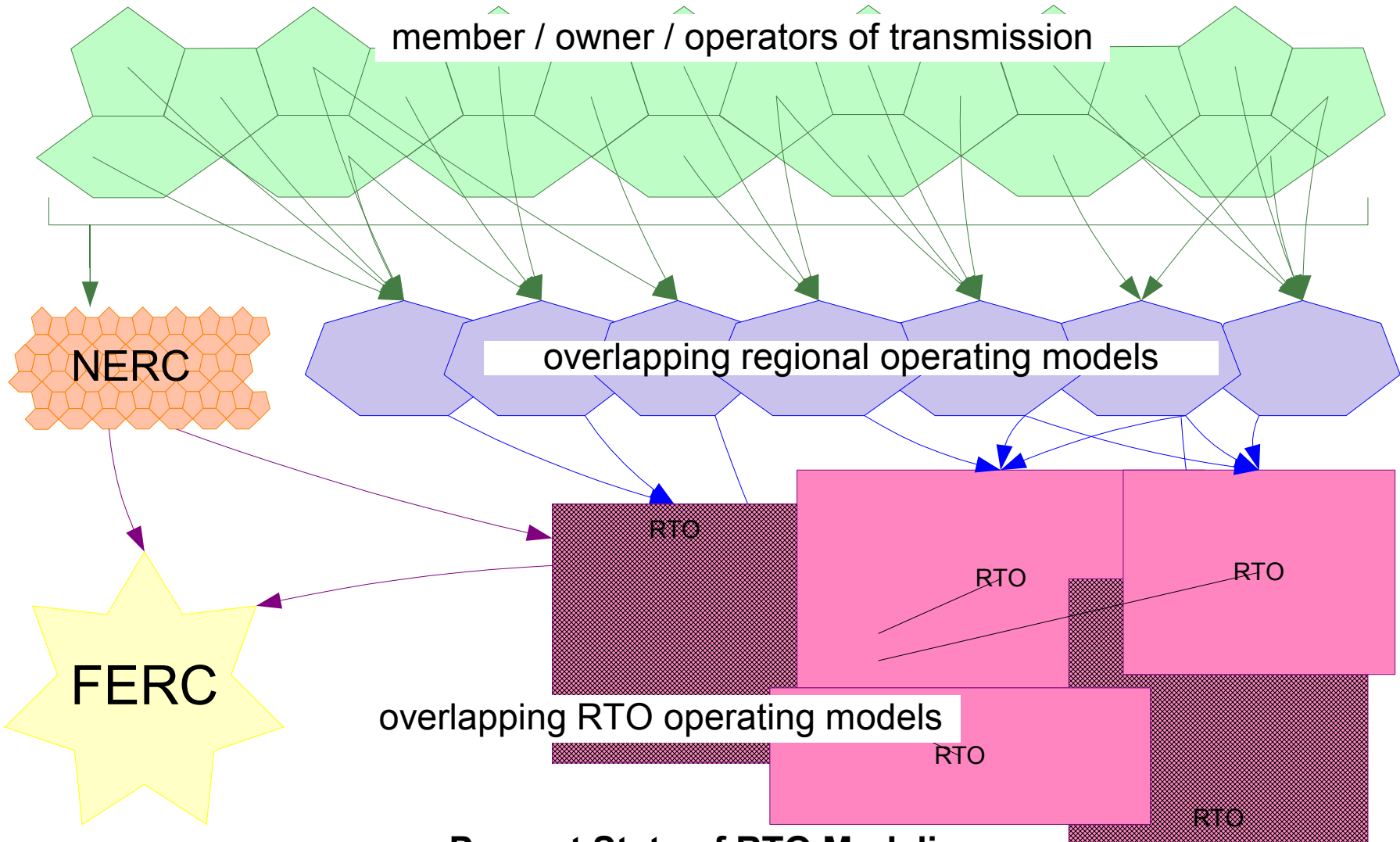
Sources of Uncertainty

- Structural
- Data
- Conflicting Objectives
 - Reliability
 - Economics
- Market/System Operations
- Regulatory
- Stakeholders
- Human Factor
- New Phenomena
 - Market/System Dynamics





Initial Population of an RTO Operating Model



Present State of RTO Modeling

Accommodating Uncertainty

- How will we account for uncertainty in models of large system?
- Characterization and probabilistic models for uncertainty are needed
- System planning and operations data and models should match

Model Uncertainties...

- Uncertainties in power system dynamic equivalents
- Uncertainties in system controls
 - Tuning Power System Stabilizers, HVDC and FACTS controllers
- Uncertainties about power system protection devices
 - Hidden Failures
- Uncertainties in market and system studies and operational guidelines
 - Inaccurate system models ==> Inaccurate system operational limits ==> Inefficient market operations

Research in Modeling Systems and Complex Phenomena

- Cascading Failures
 - Modeling Blackout Dynamics (Dobson, DeMarco)
- Hybrid Systems / Inverse Problems (Hiskens)
 - Impact of protection devices on system dynamics
- Power Systems and Market Dynamics (Alvarado, DeMarco)
- Model Calibration and Validation (Hauer)
- Modal Resonance (Dobson, Jones, Knyazkin)
- Hidden Failures (Phadke)
- Modeling of Information Embedded Power System (Carullo, Nwankpa)
- Modeling of Distributed Resources (Guttromson)

Conclusions

- Models will become more complex
- With markets, models directly impact the financial outcome for all participants and consumers.
- Models will be used in monitoring energy markets for exercise of market power.
- Models inevitably will get close scrutiny.
- Standards for model quality are going to be required.
- Shortage of experienced system planners and operators will affect system modeling
- More research is needed to model new devices and complex phenomena