



Holistic Power Supply and Delivery Chain – Foundations for a Smart Grid

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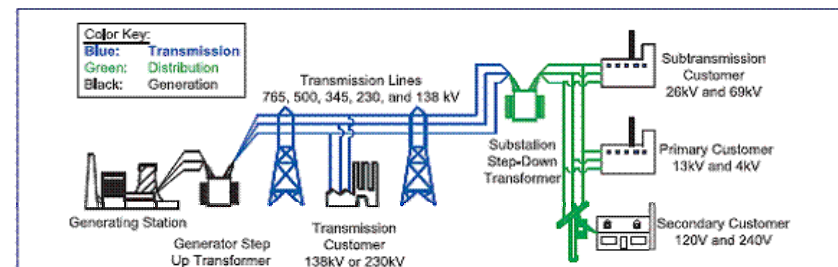
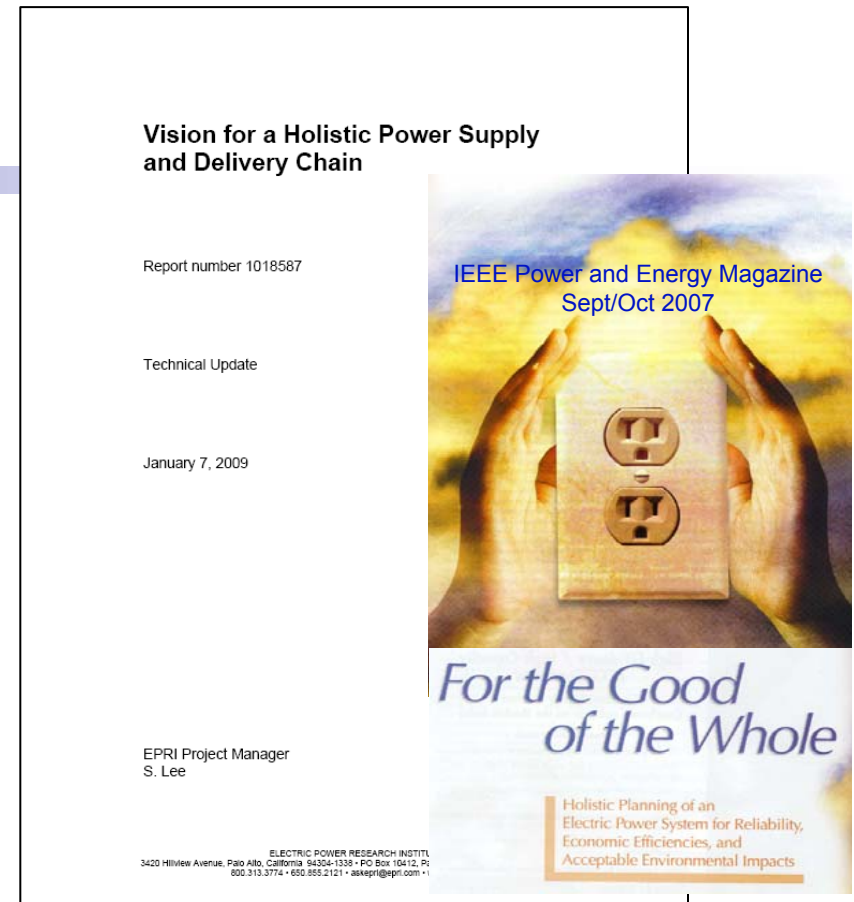


Outline Of Presentation

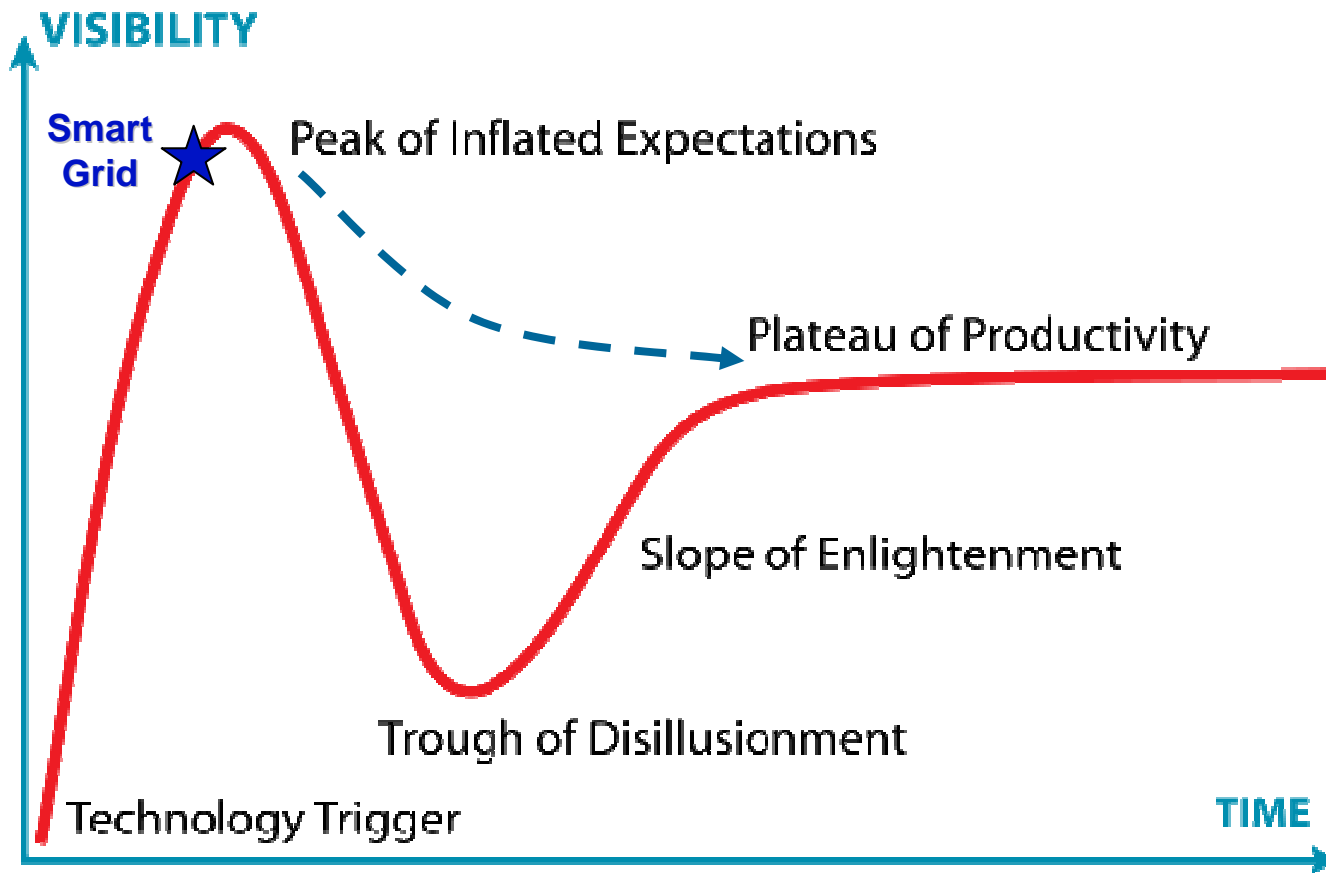
- Key Messages
 - Avoid hype
 - Consider all parts together (Holistic approach)
 - Remove deficiencies in foundations
 - Implement new solutions
- Useful References
- Holistic Power Supply & Delivery Chain
- Conclusions

Useful Public References

- www.iso-ne.com/pubs/whtpprs/smart_grid_report_021709_final.pdf
- EPRI (www.epri.com)
 - Facilitate the development of a smart grid interoperability roadmap for NIST (National Institute of Standards and Technology)
 - Vision for a Holistic Power Supply and Delivery Chain (#1018587)
 - The Green Grid (#1016905)
- North American Electric Reliability Corporation (www.nerc.com)
 - About NERC -> Understanding the Grid -> Reliability Concepts / Terminology / Technical Reports
 - NASPI (<http://www.naspi.org>)
- Stephen Lee (LinkedIn)
<http://www.linkedin.com/in/stylee>

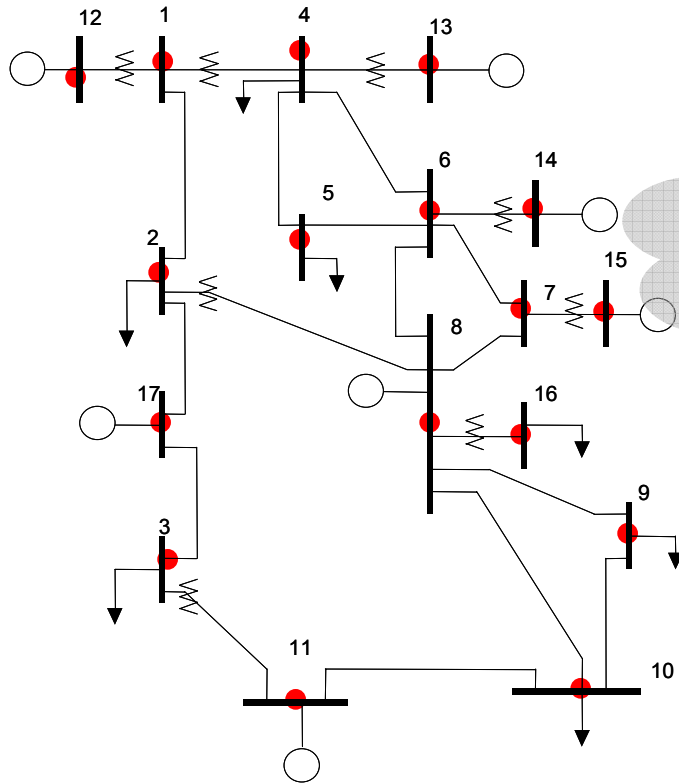


Smart Grid: Hype Cycle



Need an Objective Assessment of the Potential for Smart Transmission and the Path to Achieve it

Current State – Power Grid Operations



Limited Grid Visibility

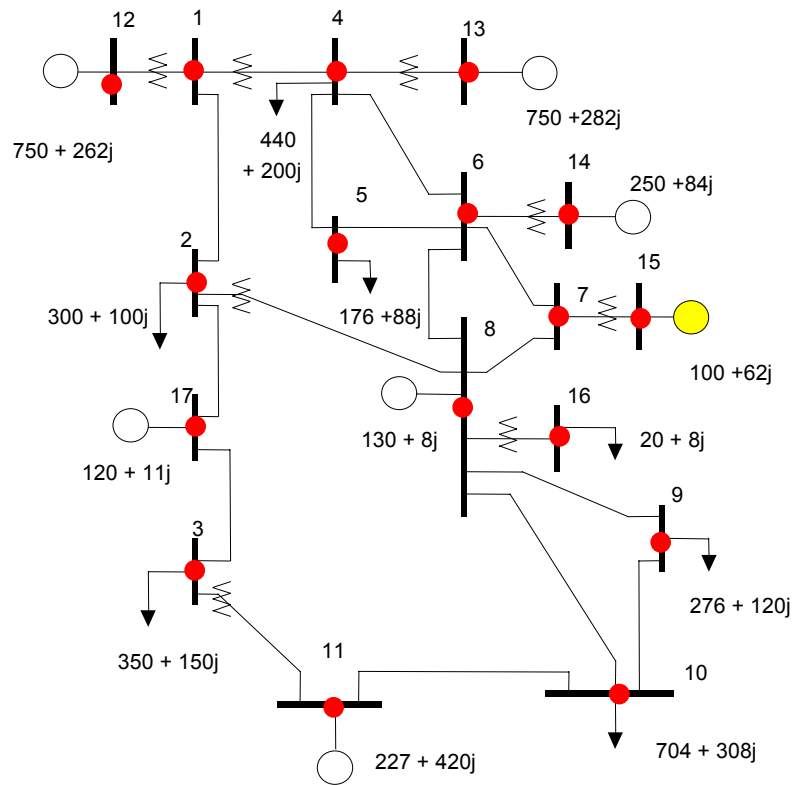


2-4 Sec scan rates

**Limited to info from lines and
transformers at substations**

MW, MVAR, KV breaker status

Smart Transmission State – Power Grid Operations

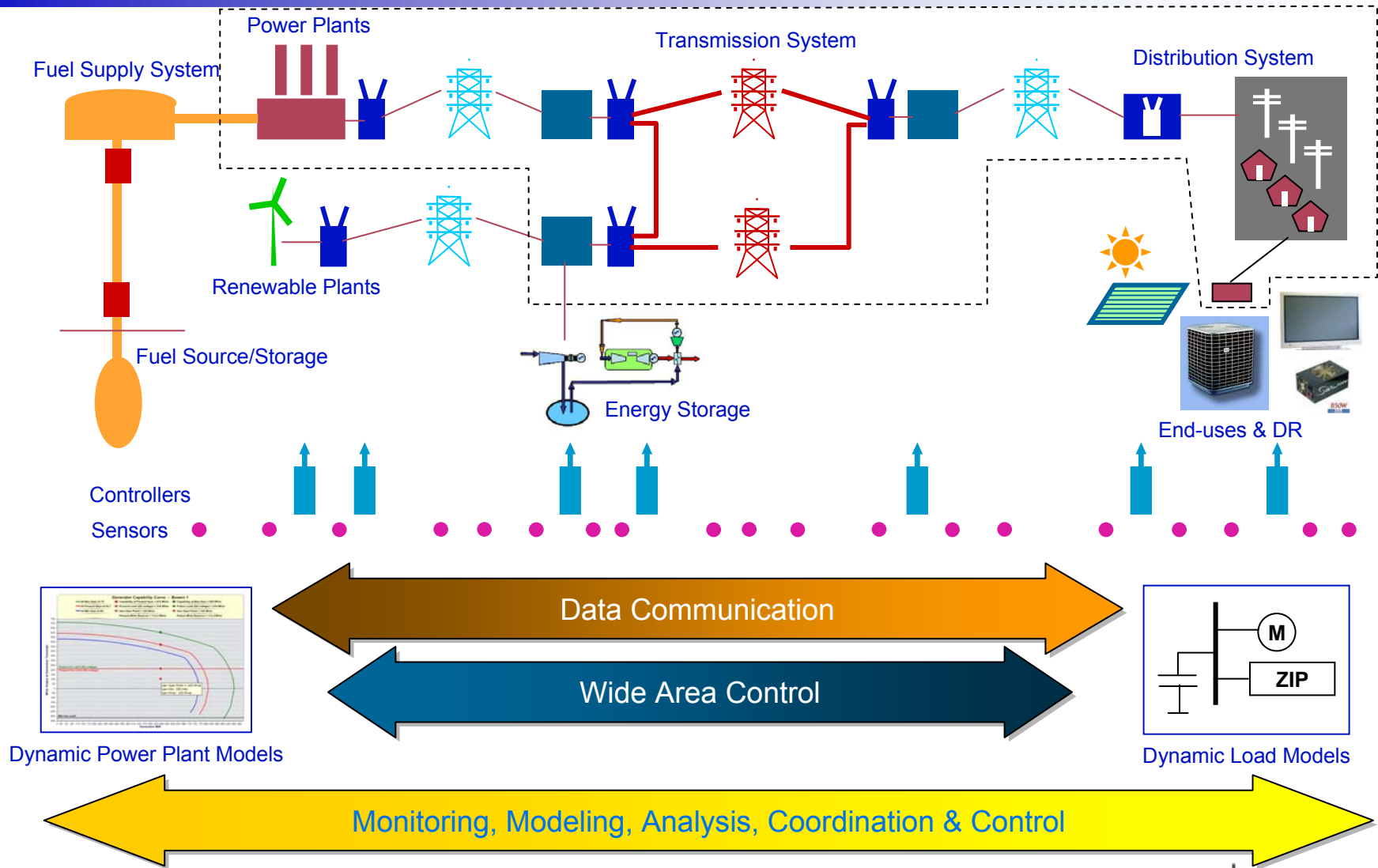


Enhanced Grid Visibility

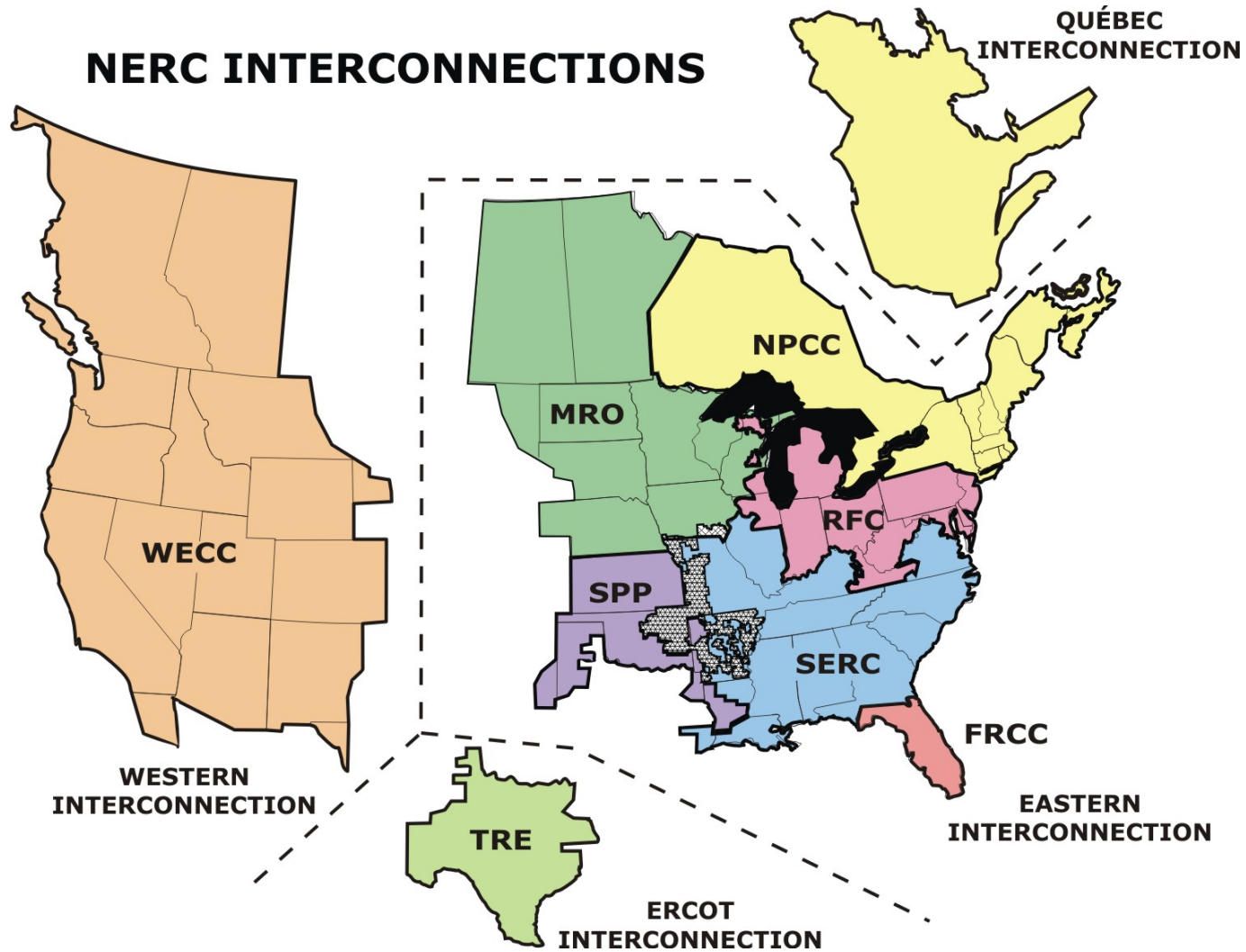


**Higher speed scan rates
Allows more frequent analysis of
system state**

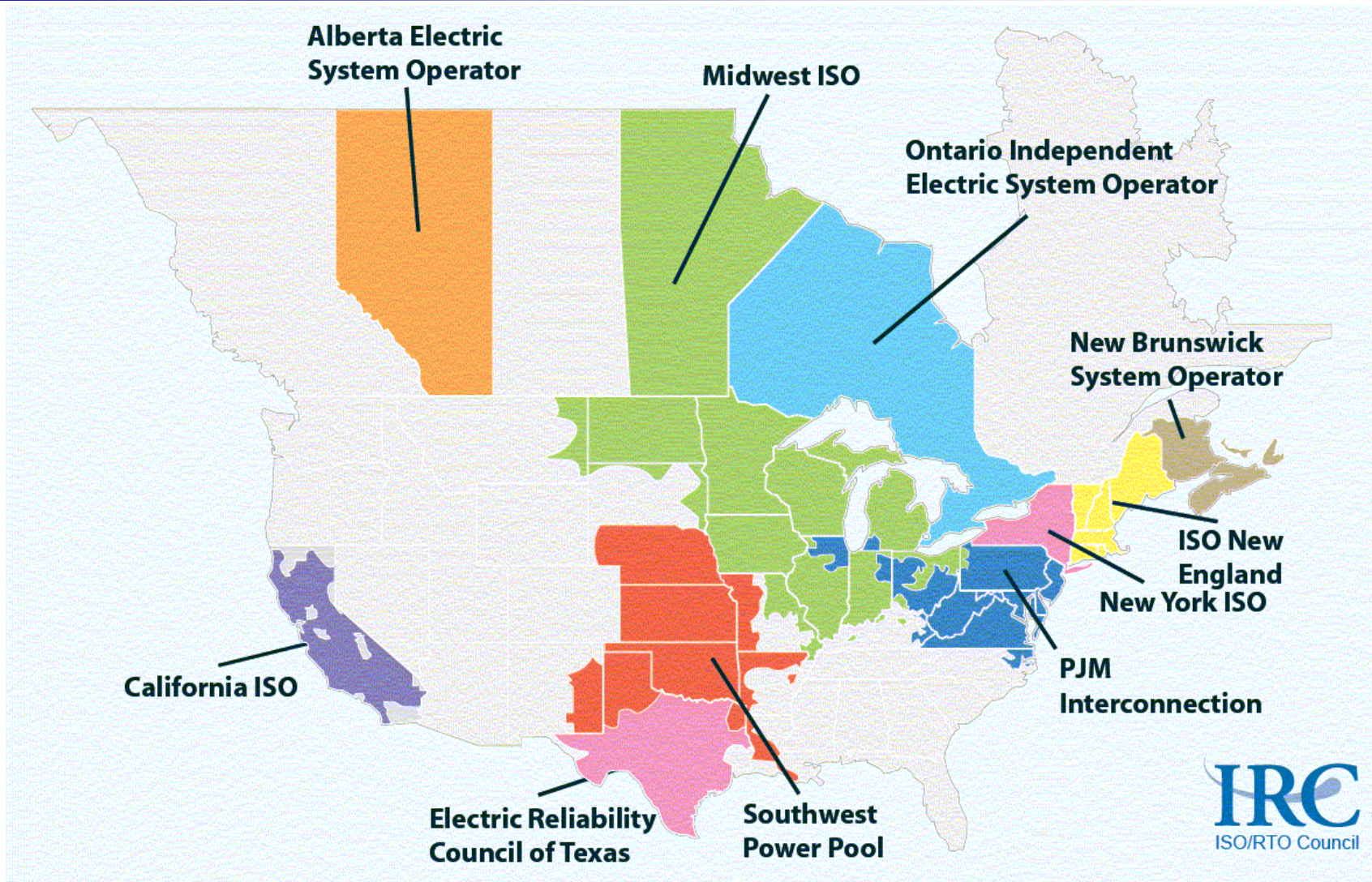
End-to-End Power Delivery Chain Operation & Planning



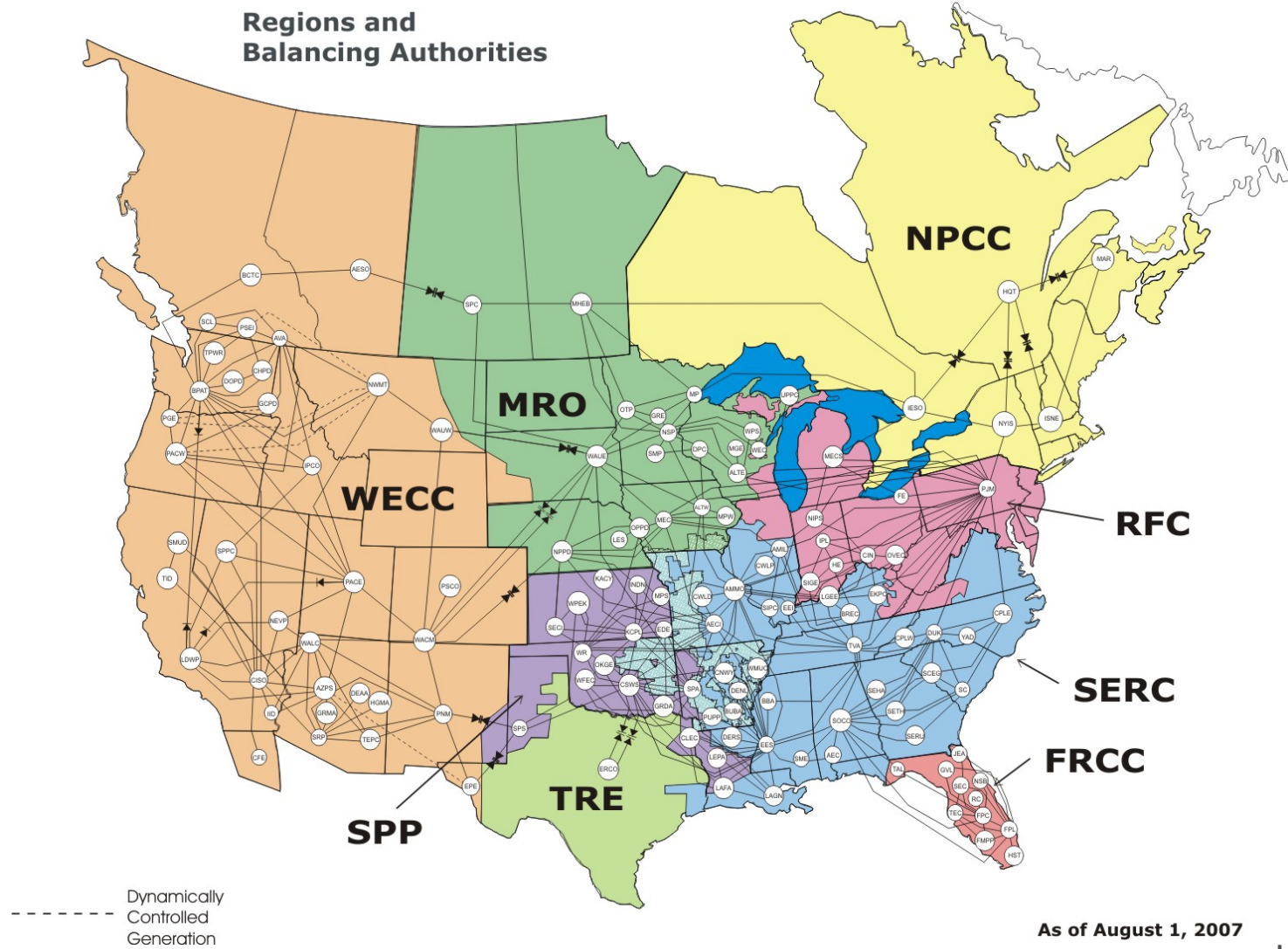
North America Electricity Interconnections



Independent System Operators / Regional Transmission Operators (ISO/RTO)



North America Electricity Balancing Authorities



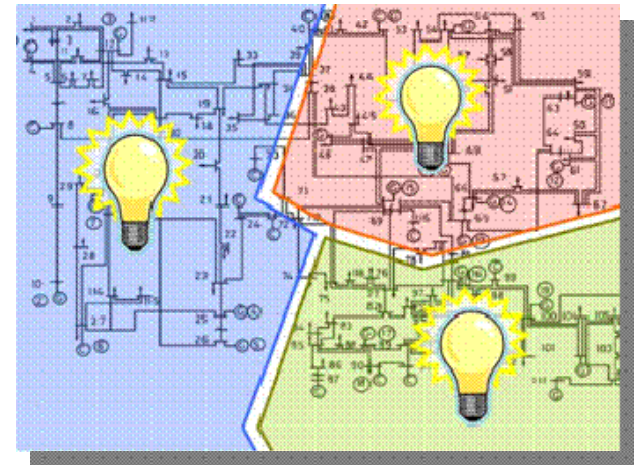
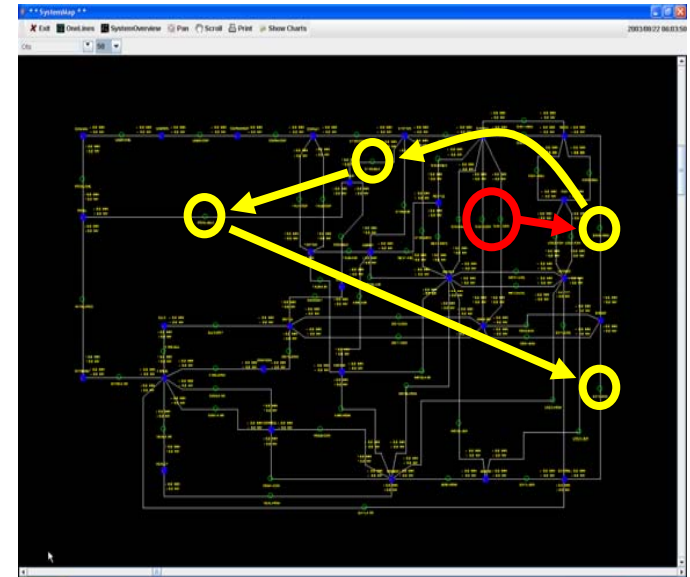
As of August 1, 2007

New Challenges for a Smart Grid

- Need to integrate:
 - Large-scale stochastic (uncertain) renewable generation
 - Electric energy storage
 - Distributed generation
 - Plug-in hybrid electric vehicles
 - Demand response (smart meters)
- Need to deploy and integrate:
 - New Synchronized measurement technologies
 - New sensors
 - New System Integrity Protection Schemes (SIPS)

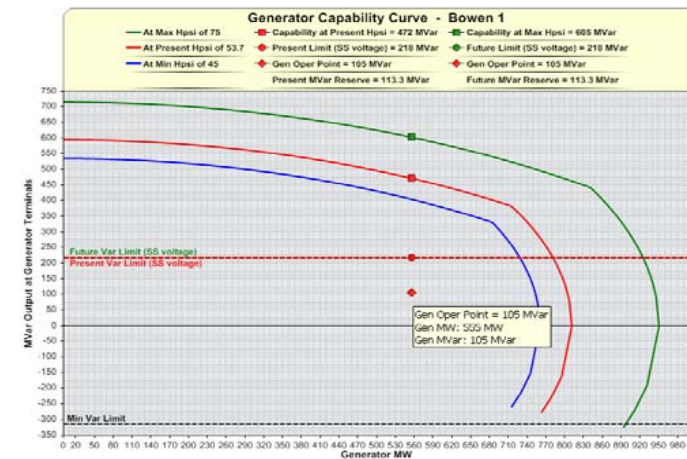
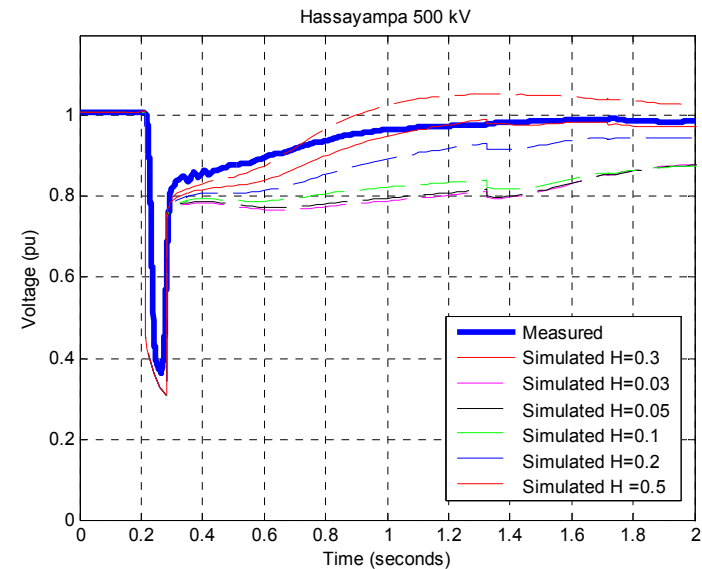
Foundations Need Strengthening

- End-to-End Situational Awareness
- Alarm Management and Real-Time Root-Cause Diagnosis
- Dynamic Models of all Generators and Loads
- Faster System Restoration
- System Integrity Protection Schemes
 - Faster reflex actions on wide-area problems
 - Measurement-based safety nets to prevent cascading blackouts, e.g., load shedding, islanding/separation, damping



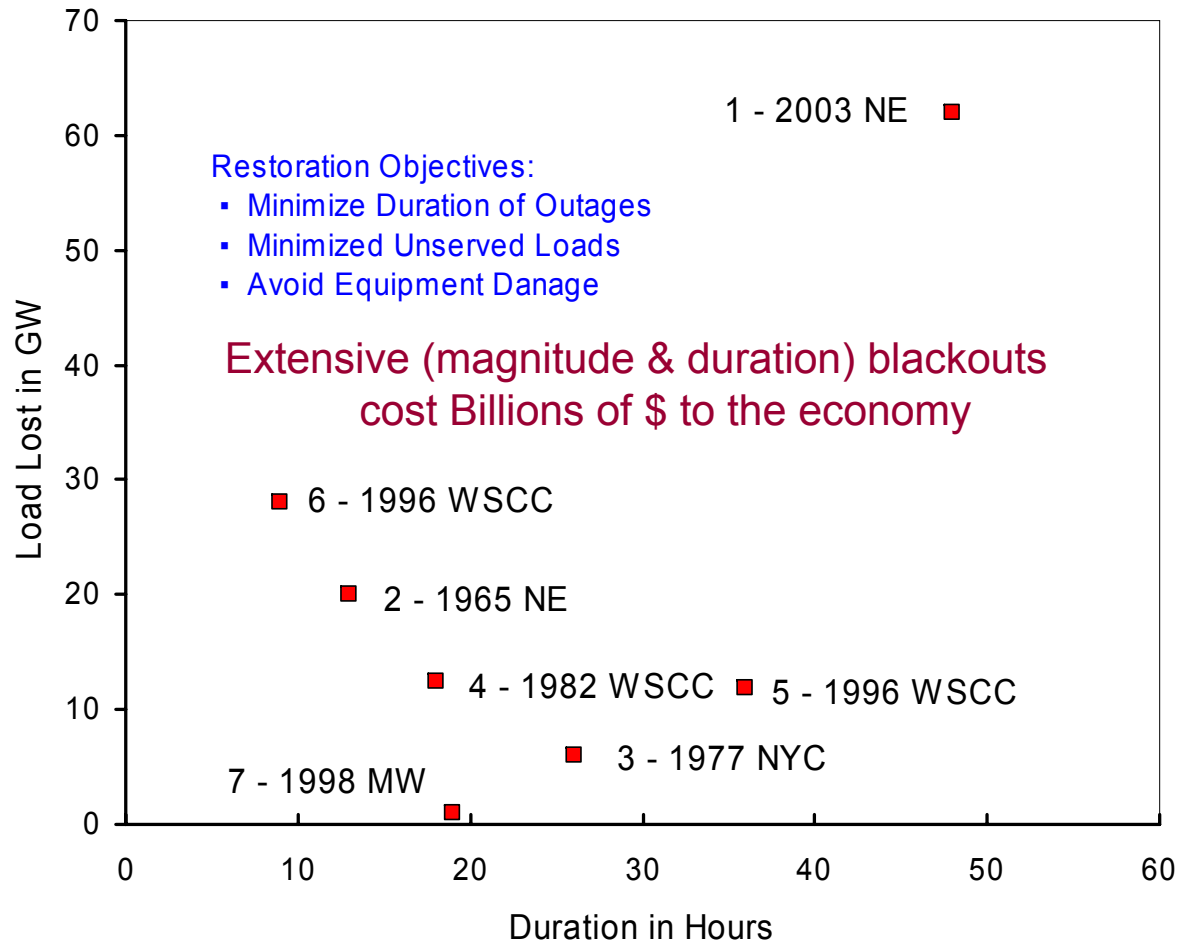
Why Accurate Models of Loads (Electricity Consumption) and Generators Are Needed?

- Inadequacy of current model data
 - Inaccurate voltage recovery simulation after disturbances
 - Uncertainty about generator reactive power capabilities
- Implications
 - Uncertainty about the stability margin of the power grid
 - Hidden risk of cascading blackouts, or
 - Under utilization of available transmission capacity for greater economic benefits



Effective System Restoration Can Reduce The Societal Impact Of Widespread Blackouts

Major Power System Disturbances



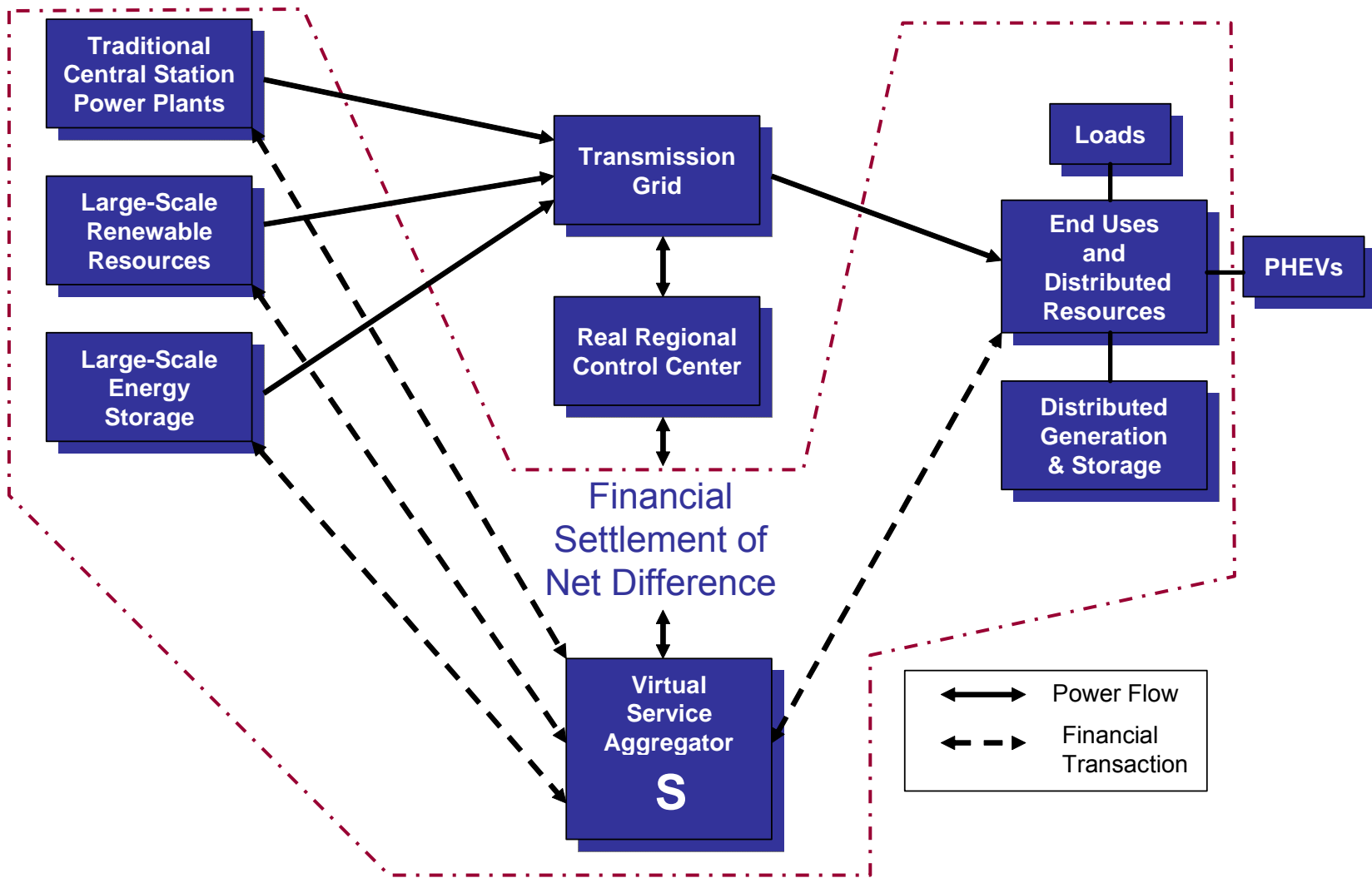
Source: NSF/EPRI Workshop on Understanding and Preventing Cascading Failures in Power Systems, Oct 28, 2005.

New Solutions Are Needed

- Optimal end-to-end commitment and dispatch by ISO/RTO as backstop for system reliability
- Virtual Service Aggregators serving as Energy Balancing Authorities
 - Dispatch and control stochastic renewable generation
 - Dispatch and control (and own?) large scale energy storage plants
 - Manage demand response proactively
 - Manage smart electric vehicle charging
- “Virtual” Vertically Integrated Utilities
 - Own/operate Generation/renewable/storage, some transmission, & Virtual Service Aggregator
 - Interstate ownership and operation (overcome NIMBY-ism)
- National/Continental Backbone Transmission Grid
 - Holistic transmission planning
 - Virtual RTO
 - Transmission toll collection system

http://www.energypulse.net/centers/author.cfm?at_id=259

Potential Role of the Virtual Service Aggregator (Virtual Vertically Integrated Utility)



Conclusions

- Urgent Need to Make the Bulk Power System Really Smart
- Failure to Make this a High Priority would Jeopardize the Modernization of the Electric Power System
- Key Messages:
 - Avoid hype
 - Consider all parts together (Holistic approach)
 - Remove deficiencies in foundations
 - Implement new solutions

THANK YOU!

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