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

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- Presented and used in Brainstorming session in support of NASPI (North America Synchro-Phasor Initiative)
- Hosted by EPRI
- Charlotte
- October, 2008

- Major Building Blocks to turn the Smart Grid from Hype to Reality

Vision for a Holistic Power Supply and Delivery Chain
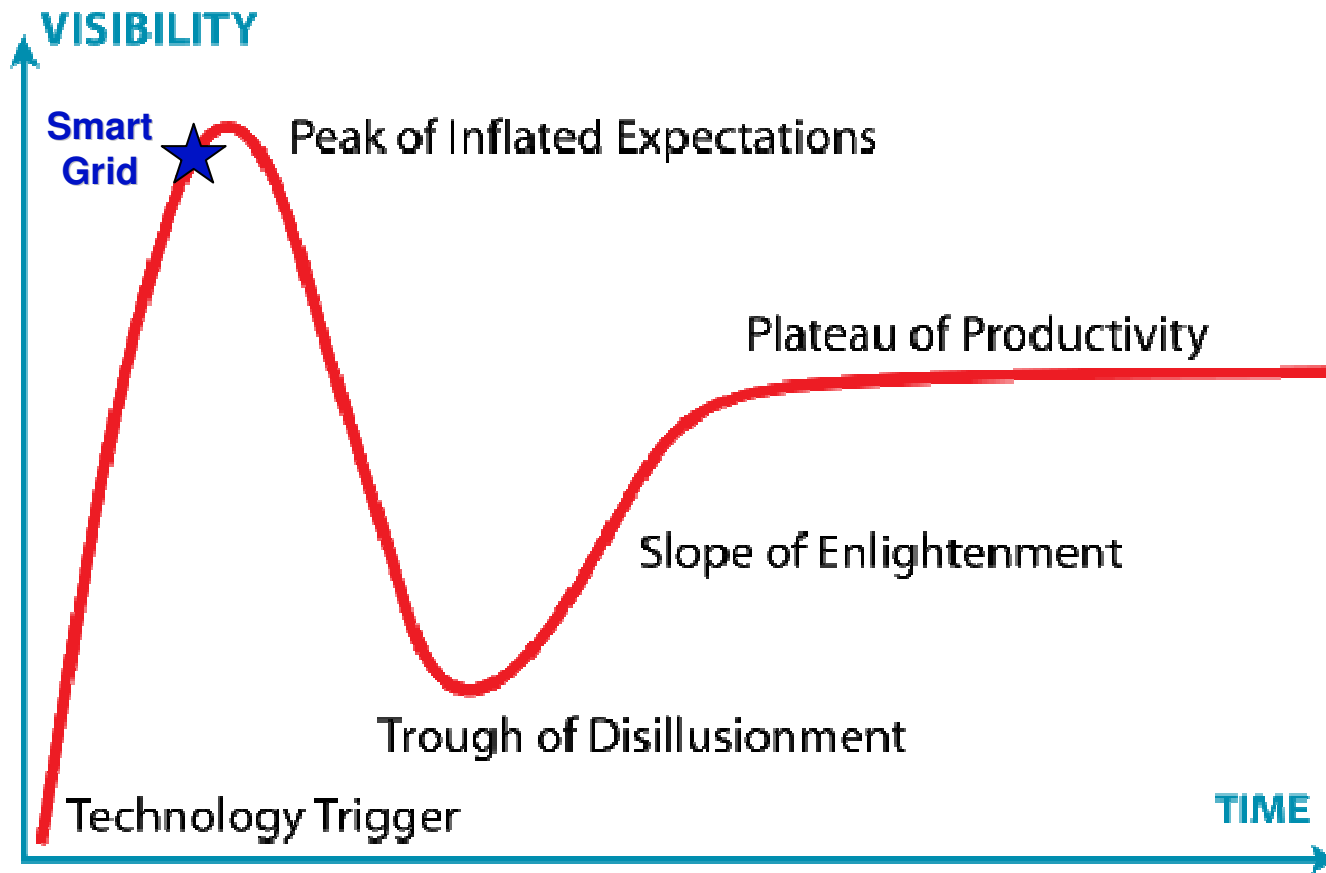
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Smart Grid: Hype Cycle

VISIBILITY

Smart Grid

Peak of Inflated Expectations

Plateau of Productivity

Slope of Enlightenment

Trough of Disillusionment

Technology Trigger

TIME

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

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Current State – System Operations
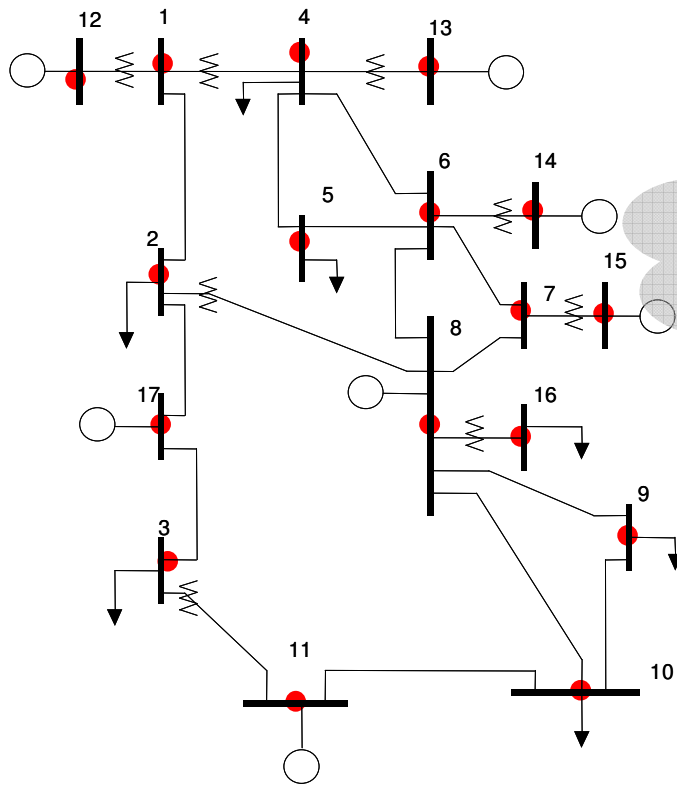
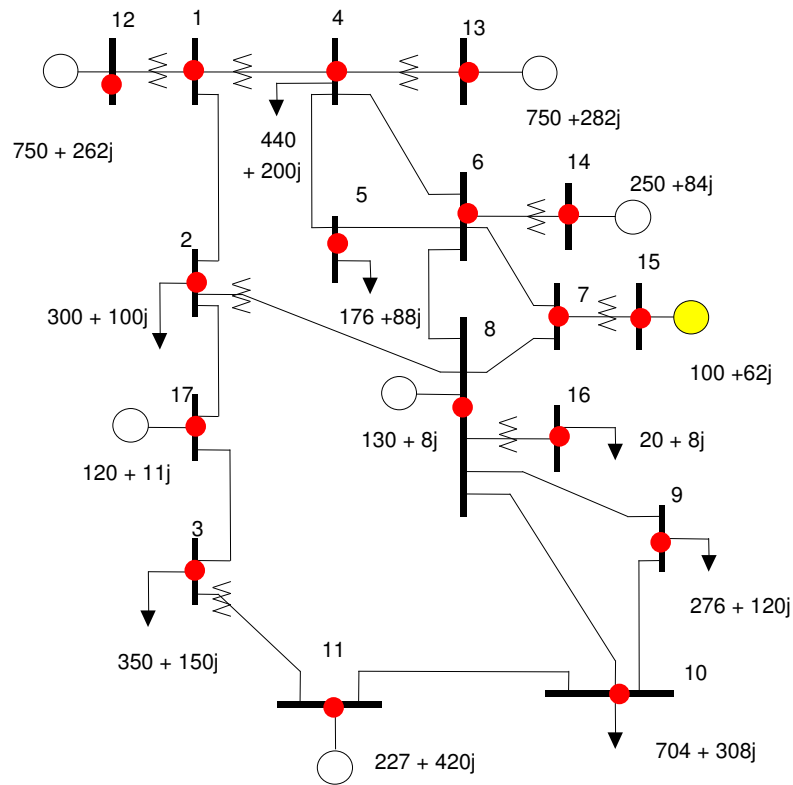**Limited Grid Visibility**

2-4 Sec scan rates

Limited to info from lines and transformers at substations

MW, MVAR, KV breaker status

Credit to

- Paul Myrda for animation of the dots
- Steve Lee for the cloud

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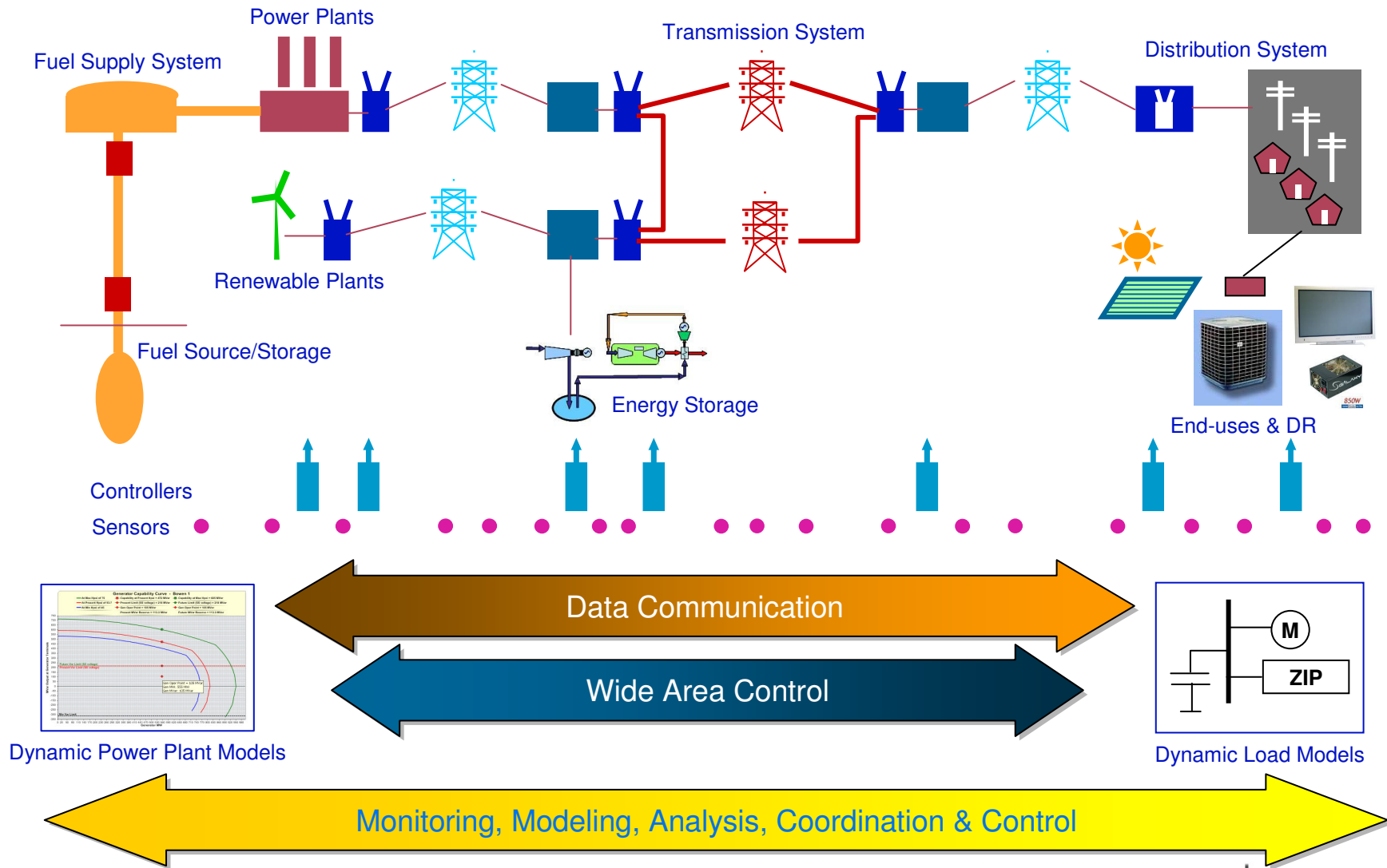# Smart Transmission State – System Operations

Enhanced Grid Visibility

Higher speed scan rates

Allows more frequent analysis of system state

Credit to Paul Myrda for animation of the dots

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# EPRI's End-to-End Power Delivery Chain Operation & Planning

New Challenges for a Smart Grid

- Need to integrate:
  – large-scale stochastic renewable generation
  – electric energy storage
  – distributed generation
  – plug-in hybrid electric vehicles
  – demand response (smart meters)
- Need to deploy and integrate:
  – Synchronized measurement technologies
  – Sensors
  – System Integrity Protection Schemes (SIPS)

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Foundations Still Deficient

- End-to-End Situational Awareness
- Alarm Management and 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

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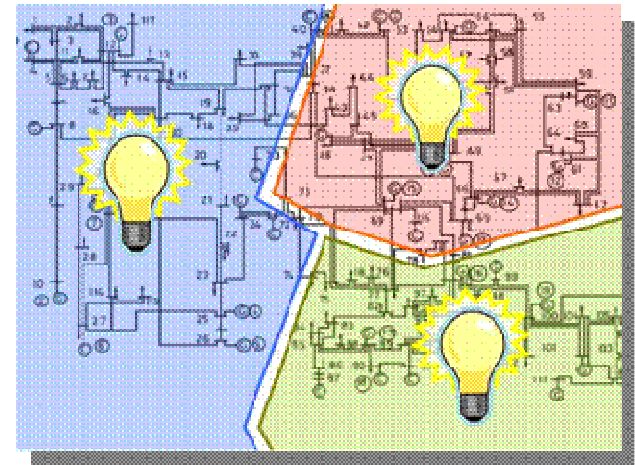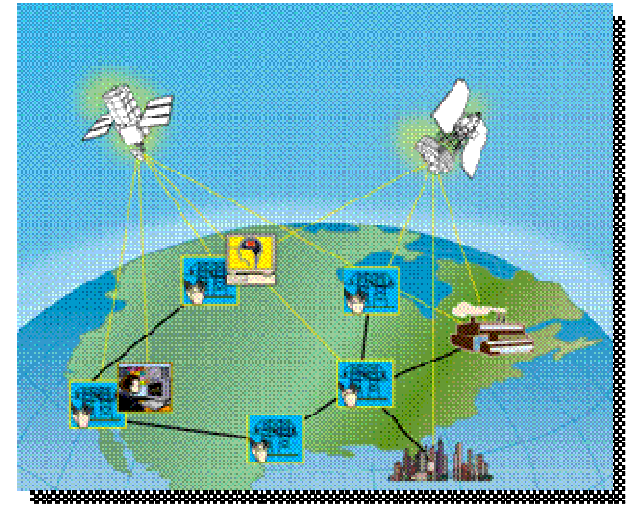
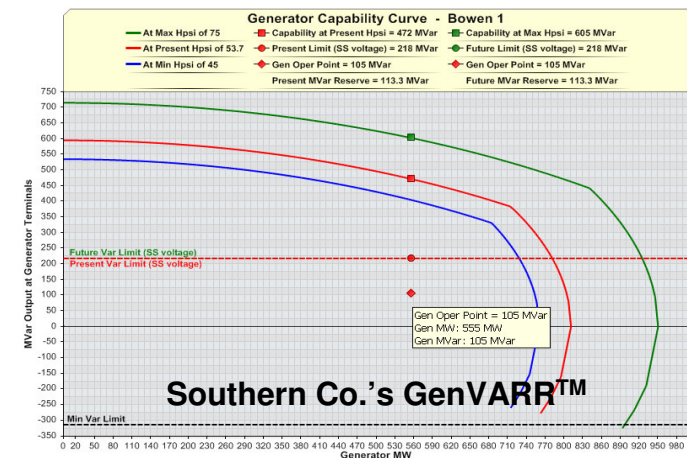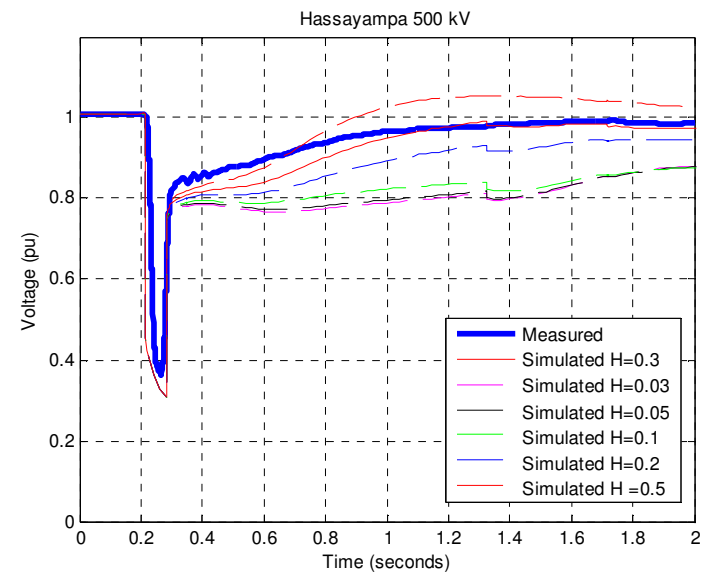# Alarm Management and Real-time Root-Cause Diagnosis

Alarm Management

- Need to diagnose root-cause of alarm messages

- Need to link diagnosis to operator procedure

- Current EMS alarm management uses technologies of the 1970s

- Need to integrate all sources of data and messages, through a hierarchical approach

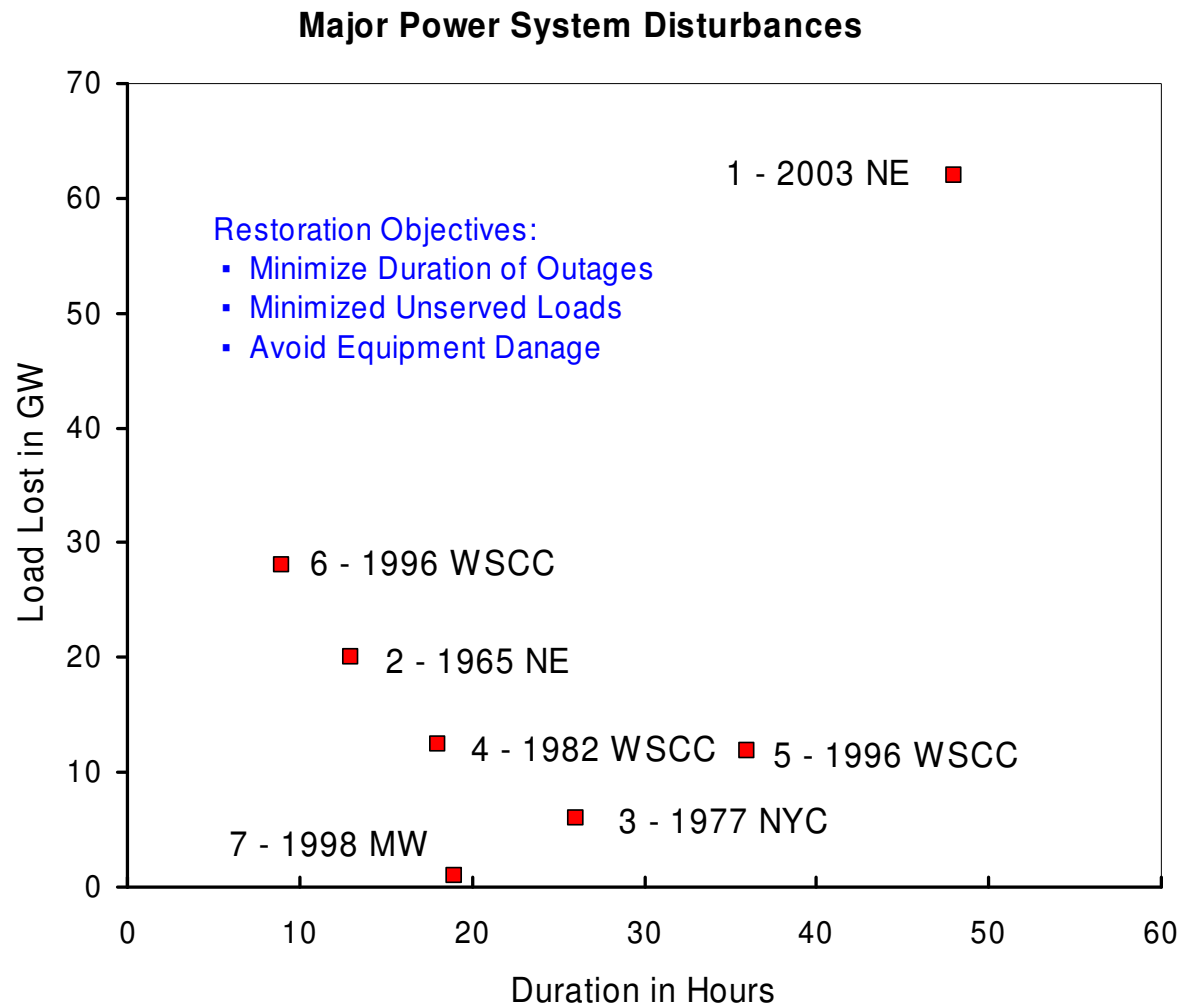EPRI | ELECTRIC POWER RESEARCH INSTITUTE
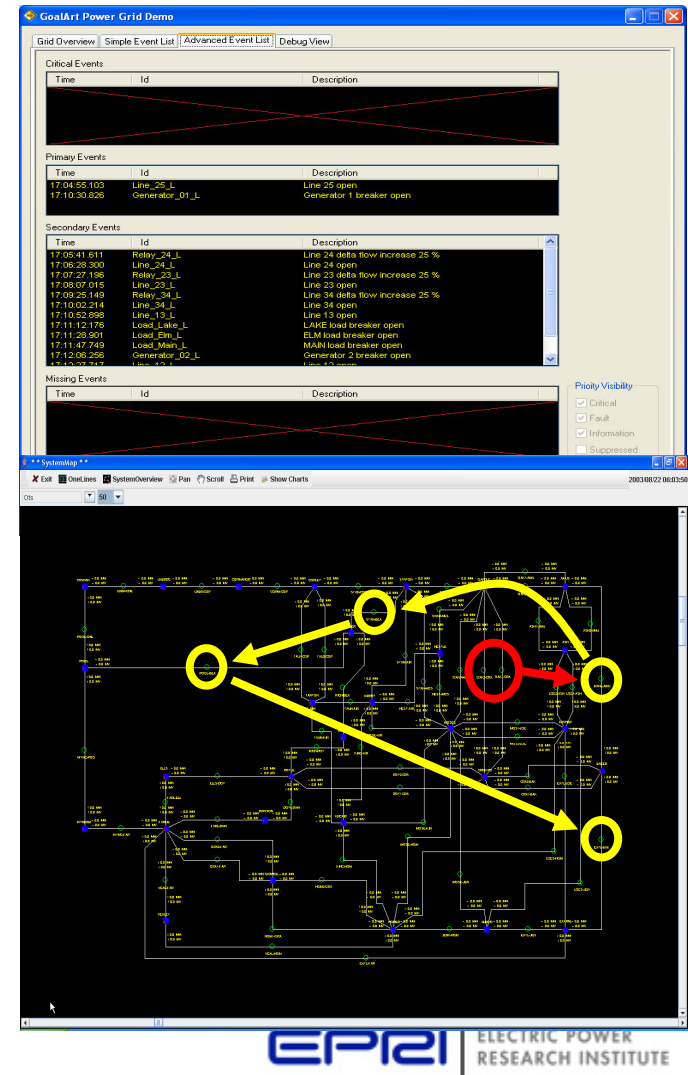
Why Accurate Load and Generator Models Are Needed?

- 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
  - Unaware of real risk of cascading blackouts or voltage collapse, or
  - Under utilization of available stability margin for greater economic benefits

Hassayampa 500 kV

Legend:
- Measured
- Simulated H=0.3
- Simulated H=0.03
- Simulated H=0.05
- Simulated H=0.1
- Simulated H=0.2
- Simulated H =0.5

Generator Capability Curve - Bowen 1

Southern Co.'s GenVARR™

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Effective System Restoration Can Reduce The Societal Impact Of Widespread Blackouts

Major Power System Disturbances

Restoration Objectives:
- Minimize Duration of Outages
- Minimized Unserved Loads
- Avoid Equipment Danage

1 - 2003 NE

6 - 1996 WSCC

2 - 1965 NE

4 - 1982 WSCC   5 - 1996 WSCC

3 - 1977 NYC

7 - 1998 MW

Load Lost in GW

Duration in Hours

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

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New Solutions Are Needed

- 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
- Optimal end-to-end commitment and dispatch by ISO/RTO as backstop for system reliability
- CO2 Cap-and-Trade Market Monitoring

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Potential Role of the Virtual Service Aggregator

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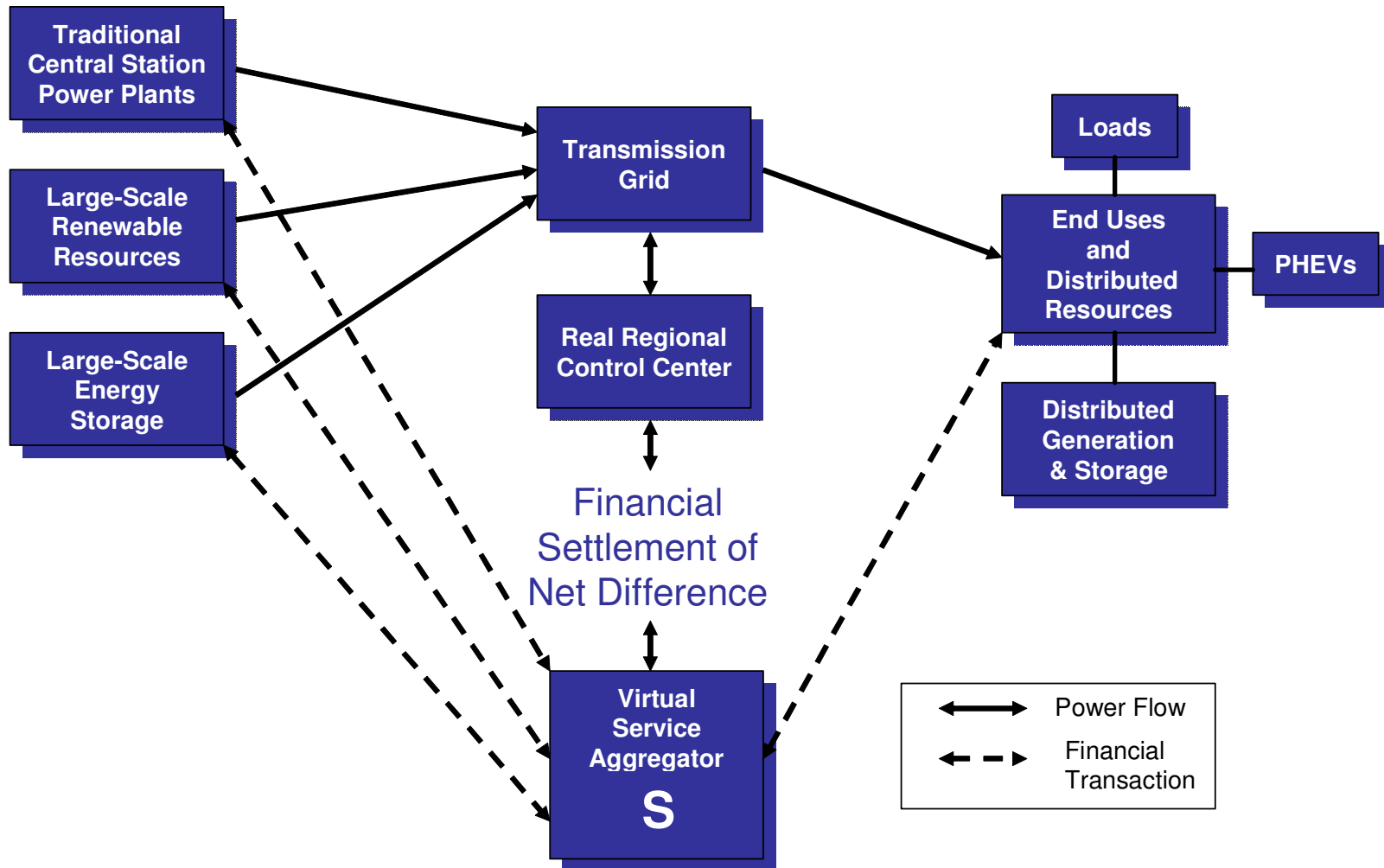
Conclusions

- 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

- Strengthening the Foundations is Indispensable

- Introducing New Solutions is critically needed

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Discussions

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