



– Smart Grid –
**Context and Candidate Outcomes to Shape National
Electric System Transformation**
Annual NARUC Meeting
November 2008

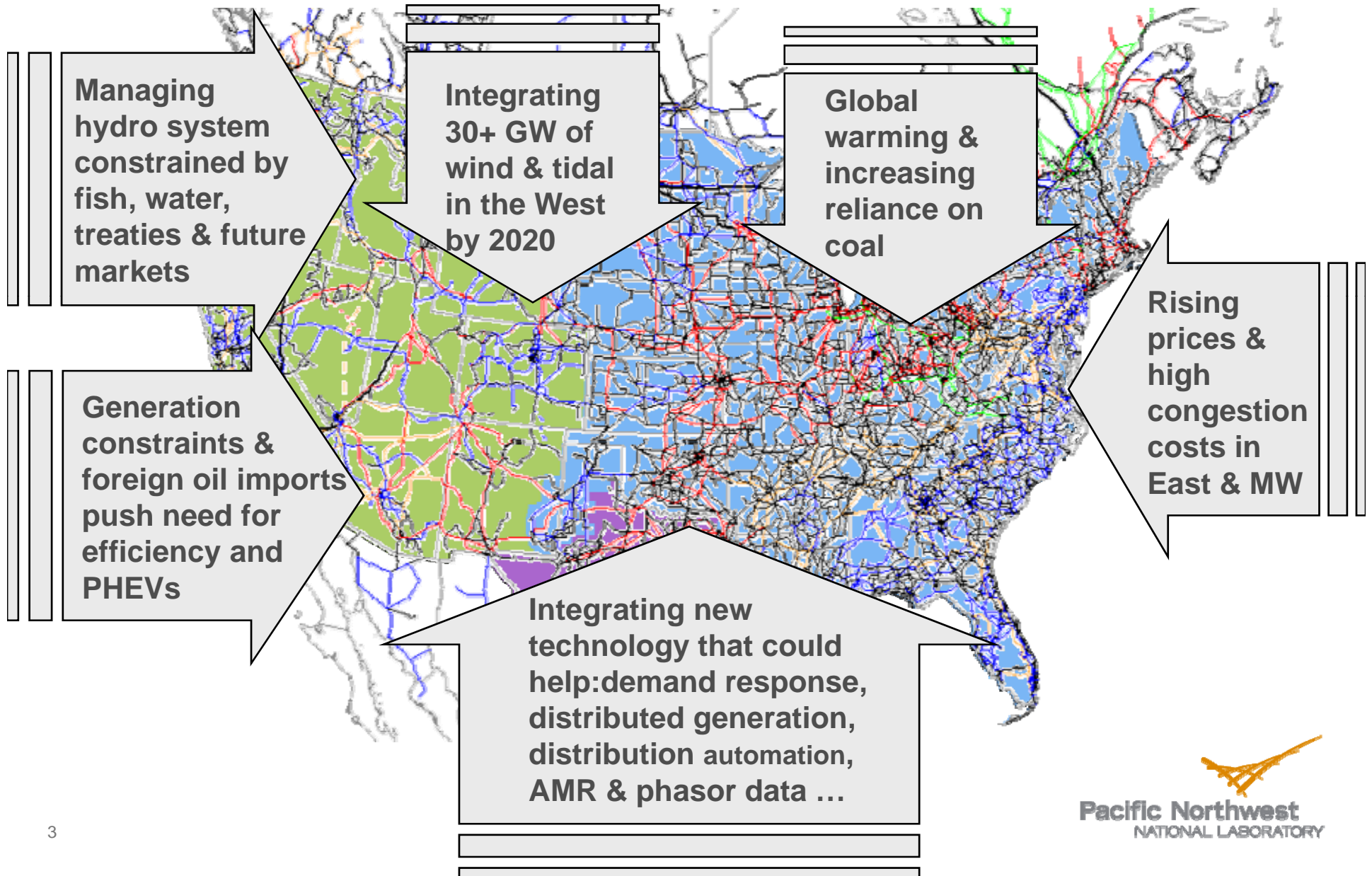
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DISCUSSION TOPICS

- ▶ Context / Definitions of Smart Grid
- ▶ Update on Demonstrations and Lessons Learned
- ▶ Status of EISA 2007 directives
- ▶ Path Forward
 - Gaps in Knowledge
 - Candidate Outcomes to Frame Directions and Priorities
 - Next Steps to Consider

Electric Grid In Transition



Energy Independence and Security Act (2007)

It is the policy of the United States to support the modernization of the Nation's electricity transmission and distribution system to maintain a reliable and secure electricity infrastructure that can meet future demand growth and to achieve each of the following, which together characterize a Smart Grid:

- 1. Increased use of digital information and controls technology to improve reliability, security, and efficiency of the electric grid.**
- 2. Dynamic optimization of grid operations and resources, with full cyber-security.**
- 3. Deployment and integration of distributed resources and generation, including renewable resources.**
- 4. Development and incorporation of demand response, demand-side resources, and energy-efficiency resources.**
- 5. Deployment of `smart' technologies (real-time, automated, interactive technologies that optimize the physical operation of appliances and consumer devices) for metering, communications concerning grid operations and status, and distribution automation.**

Energy Independence and Security Act (2007)

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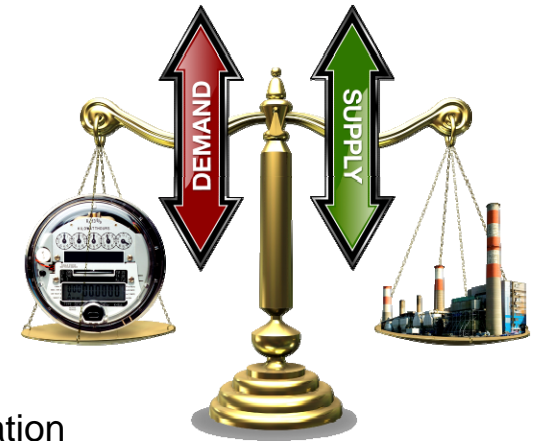
It is the policy of the United States to support the modernization of the Nation's electricity transmission and distribution system to maintain a reliable and secure electricity infrastructure that can meet future demand growth and to achieve each of the following, which together characterize a Smart Grid:

- 6. Integration of `smart' appliances and consumer devices.**
- 7. Deployment and integration of advanced electricity storage and peak-shaving technologies, including plug-in electric and hybrid electric vehicles, and thermal-storage air conditioning.**
- 8. Provision to consumers of timely information and control options.**
- 9. Development of standards for communication and interoperability of appliances and equipment connected to the electric grid, including the infrastructure serving the grid.**
- 10. Identification and lowering of unreasonable or unnecessary barriers to adoption of smart grid technologies, practices, and services.**

What is the “Smart Grid” and how can it help?

Add substantial IT “smarts” to bring digital intelligence and real-time communications and control through-out the power system to see and operate the grid as never before.

- ▶ Demand-side resources participate with distribution equipment in system operation
 - Consumers engage to mitigate peak demand and price spikes
 - More throughput with existing assets; reduce need for new assets
 - Enhanced reliability: bounds impacts, local resources self-organize to manage contingencies
 - Provide demand-side ancillary services – a boon to wind integration
- ▶ The transmission and generation resources get smarter too
 - Improve the timeliness, quality, and geographic scope of the operator’s situational awareness and control
 - Better coordinate generation, balancing, reliability, and emergencies
 - Utilizing high-performance computing, sophisticated sensors, and advanced coordination strategies

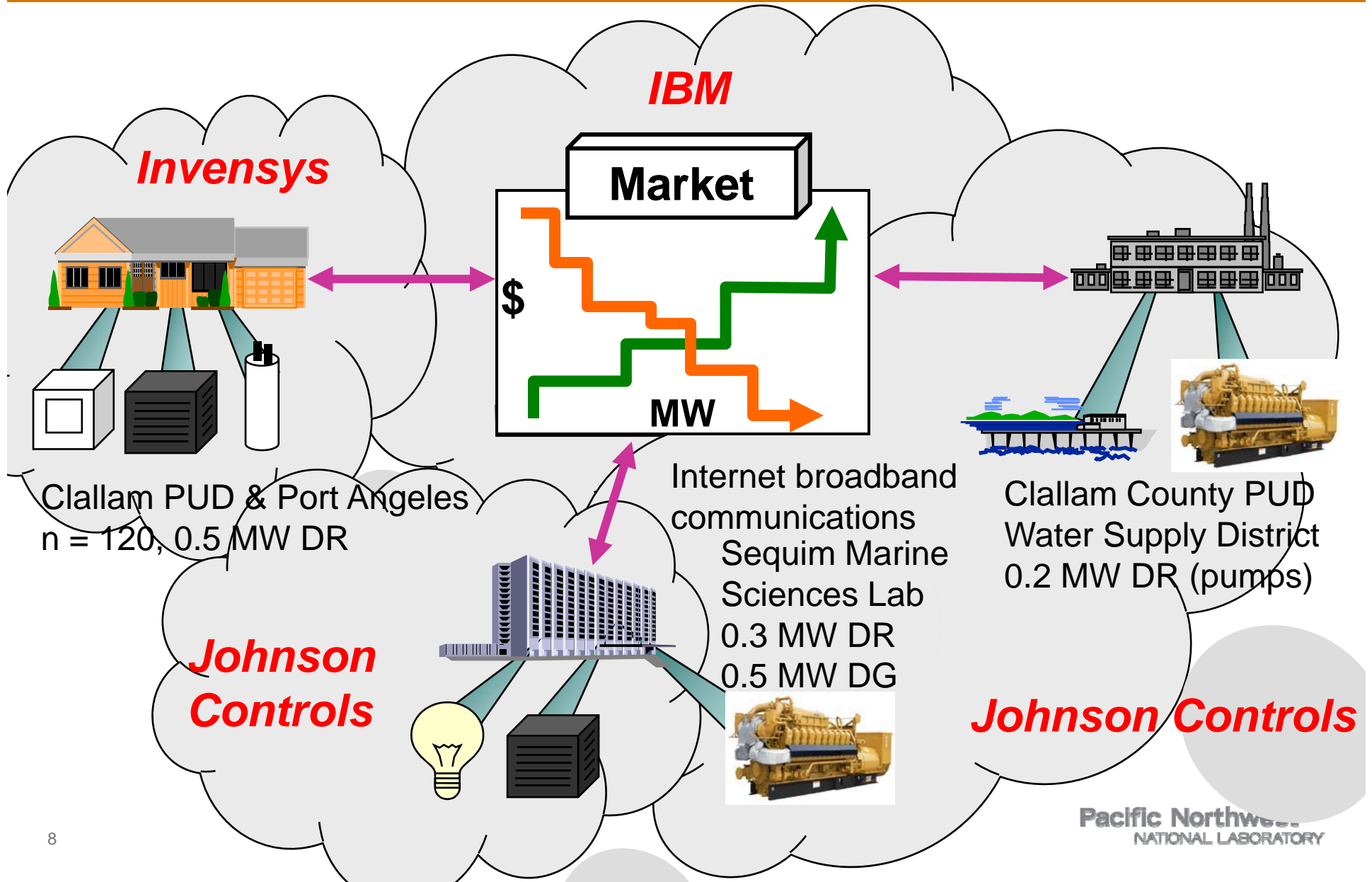


GridWise Demonstration Projects

- ▶ Olympic Peninsula GridWise demonstration
 - Explored how consumers respond to real-time pricing
 - Tested smart appliances in 112 homes for one year
 - Real-time, two-way market with real cash incentives
- ▶ Grid Friendly™ Appliance demonstration
 - Tested device response to stress on grid and consumer acceptance of device in appliances
 - Installed in 150 dryers for one year



Olympic Peninsula GridWise Demonstration

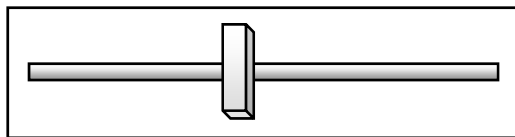


Customer Friendly Demand Response

Being customer friendly means customers ...

- ▶ Maintain control of their demand response
 - prevents *fatigue* (i.e., reduced participation if called upon too often)
- ▶ Are offered a **winning proposition** compared to a fixed rate
- ▶ Are provided a **simple** interface to automate their response

More Comfort ↔ More Savings



Automatically translated to thermostat control temperature/price elasticity

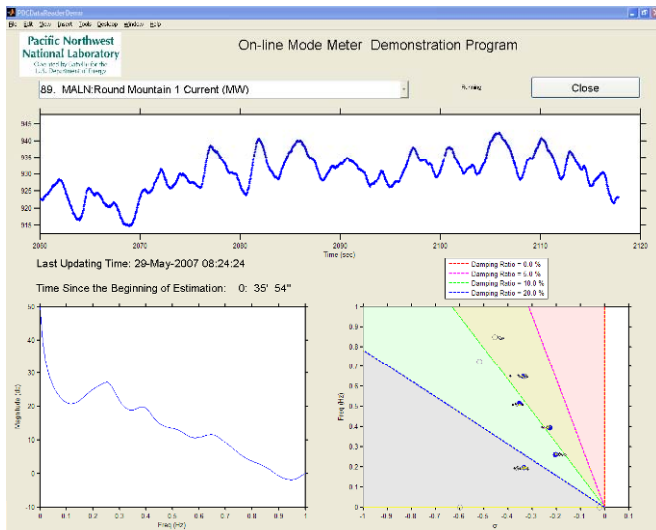
- ▶ Are presented a unified value proposition for DR & efficiency programs

Olympic Peninsula Demonstration

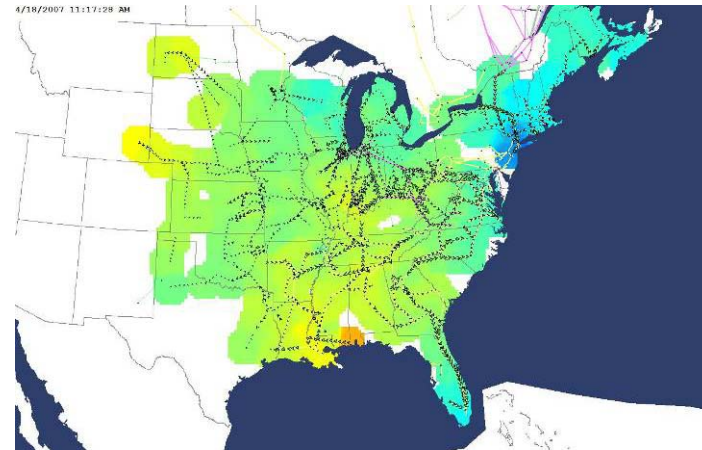
Important Insights

- ▶ Customers (including residential) will respond to 5-minute, real-time prices
- ▶ Able to cap net demand 15% less than normal peak by auctioning available capacity to customers
- ▶ Real-time engagement of customer demand response (DR) is key
 - focus incentives in proportion to DR value they deliver
 - enable use of DR for ancillary services (regulation, spinning reserve)
 - backup generation “firms” DR on local peak conditions for displacing distribution capacity (40% of total grid investment)
- ▶ DR rates can be implemented with “no losers”
 - by debiting for actual load shape against an up-front billing credit

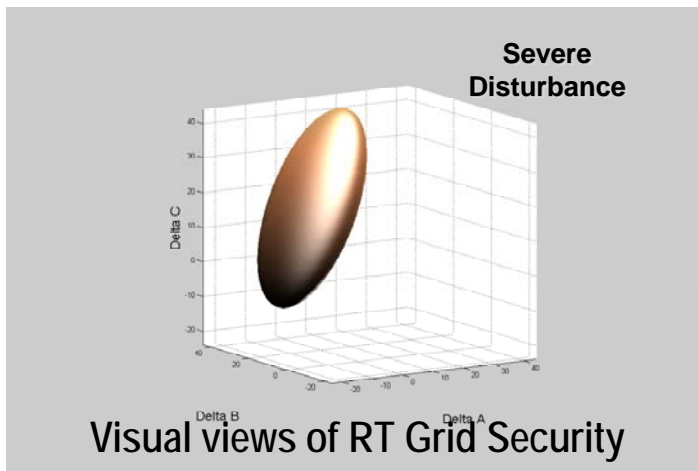
Advanced Phasor Visualization and Decision Support Tools R&D



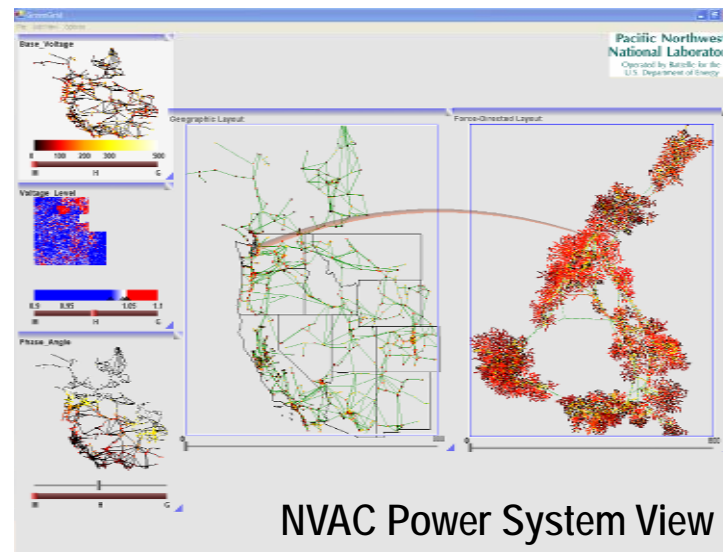
Small Signal Analysis Tool



Wide Area Hybrid Grid Health Tool



Visual views of RT Grid Security



NVAC Power System View

Other Emerging Demonstrations

- ▶ Austin Energy
- ▶ Sempra Energy
- ▶ Oncor
- ▶ Xcel Energy
- ▶ Various COOPS/NRECA
- ▶ PG&E
- ▶ AEP
- ▶ BPA
- ▶ North American Synchro Phasor Initiative (NERC, DOE)
- ▶ PNM
- ▶ Others

Recent Federal Response to Legislation

Energy Independence and Security Act of 2007

- ▶ Organizational authority
 - Smart Grid Advisory Committee (by Apr 08)
 - Reports to DOE
 - Smart Grid Task Force (by Apr 08)
 - Inter-agency, managed by DOE Office of Electricity
 - Smart Grid Interoperability Framework
 - NIST primary responsibility (progress report Dec 08)
- ▶ Smart grid status report (by Dec 08)
- ▶ Security implications report (by Jun 09)
- ▶ Smart grid R&D and regional demonstration
- ▶ Funds for smart grid investments *
- ▶ Accelerated depreciation Emergency Economic Stabilization Act 2008

Reports to Congress: Section 1302 Smart Grid System Report

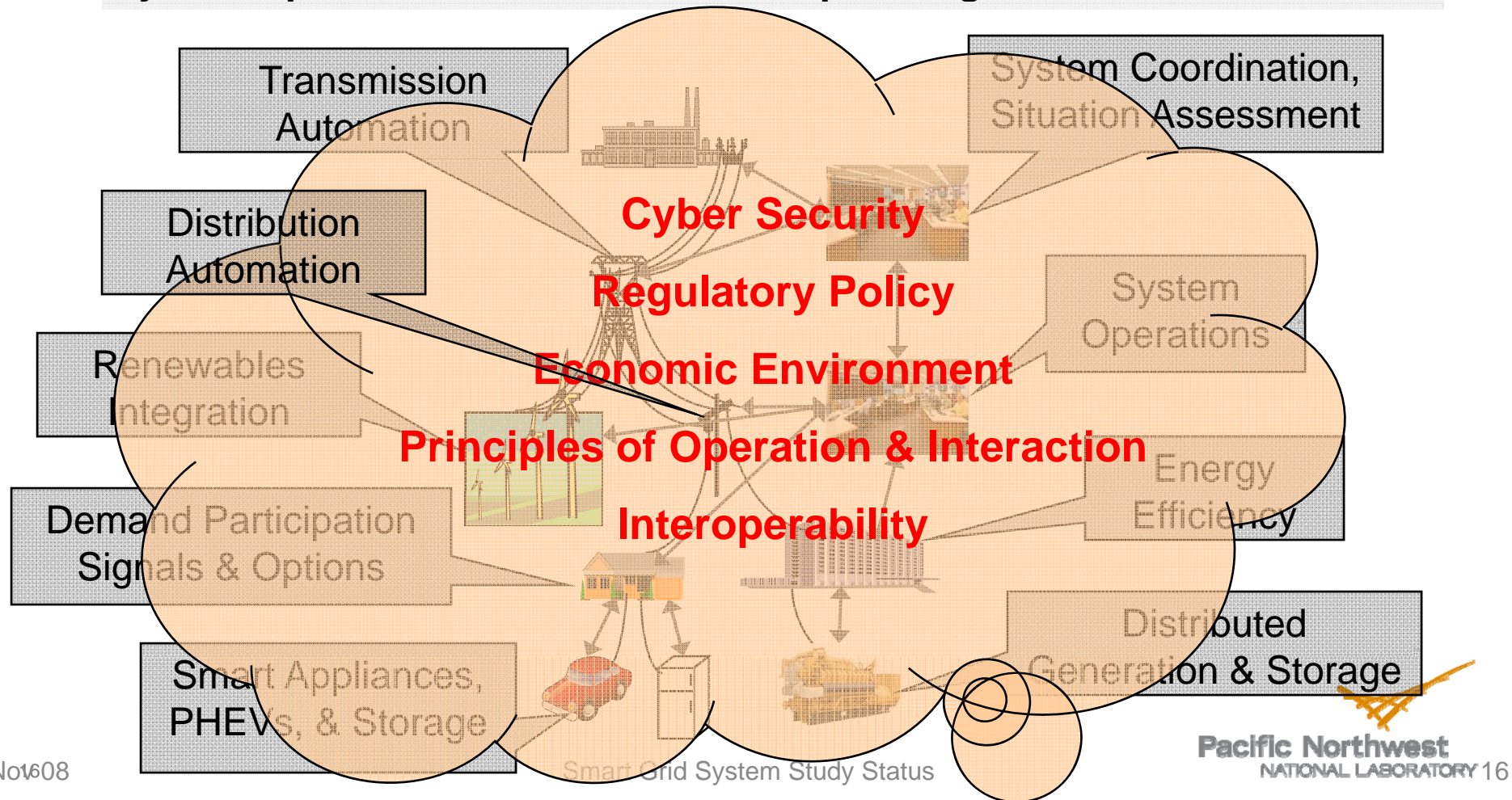
Requirements	Approach
<ul style="list-style-type: none">- Current status and prospects of smart grid deployment- ID of any regulatory or government barriers- Recommendations for State/Federal policies or actions (optional)- Analysis taking a regional perspective	<ul style="list-style-type: none">- Building on Implementation Workshop findings (characteristics & metrics) to guide smart grid status and projection analyses- Leveraging the APQC maturity model to assess key performance indicators of smart grid functions/practices- Coordinate with FERC/NARUC Smart Grid Collaborative on regulatory policies and on suggested recommendations

Status

- Draft submitted to DOE for review; delivery December 2008 to Congress
- Lead Contractor: PNNL

Scope of the Report

Use of digital technology to improve reliability, security, and efficiency of the electric system. Applications for dynamic optimization of system operations, maintenance, and planning.



Report Status

- ▶ Synthesized SG Implementation Workshop results into 20 metrics
 - Area, regional, and national coordination
 - Distributed energy resource technology
 - Delivery (T&D) infrastructure
- ▶ Metric investigations drafted
- ▶ Completed interviews with 22 service organizations
- ▶ Reviews
 - Preliminary draft of document sent to DOE 11/1/08
 - Draft review (EAC SG Subcommittee, SG Task Force) 11/24/08
 - Support final report from Secretary to Congress 12/08

Reports to Congress: Section 1309 Security Attributes of Smart Grid Systems

Requirements	Approach
<ul style="list-style-type: none">- Assess and determine impact of smart grid deployments on infrastructure security and operations- Recommend on how smart grid can help in:<ul style="list-style-type: none">- Reduced vulnerability- Restoration- Coordinated emergency responses- Recommend on risk mitigation	<ul style="list-style-type: none">- Work in coordination with DHS/FERC/NERC on SOW development

Status

- PNNL-led team performing the work
- Report due 6/27/09

The National Electric Energy System is at a Crossroads

- ▶ Convergence of IT revolution, demand growth, RPS/EPS drivers put nation at critical point to move forward. Going forward, making the entire power system smarter has compelling value to the nation.
- ▶ Adding Demand to the toolbox and making the entire grid smarter opens up a new “resource” to transform the efficiency, reliability, and strategic value of the power system.
- ▶ National needs for transmission to serve renewable generation AND carbon dispatch over next 50 years How do we get the nation’s transmission planning, siting and funding done properly?
- ▶ And, if done with the long-term view, this same infrastructure is central to delivering on carbon policy ... taking efficiency to dramatically higher levels and providing the monitoring and verification for carbon program delivery.

RENEWABLES A DRIVER FOR TRANSMISSION UPGRADES

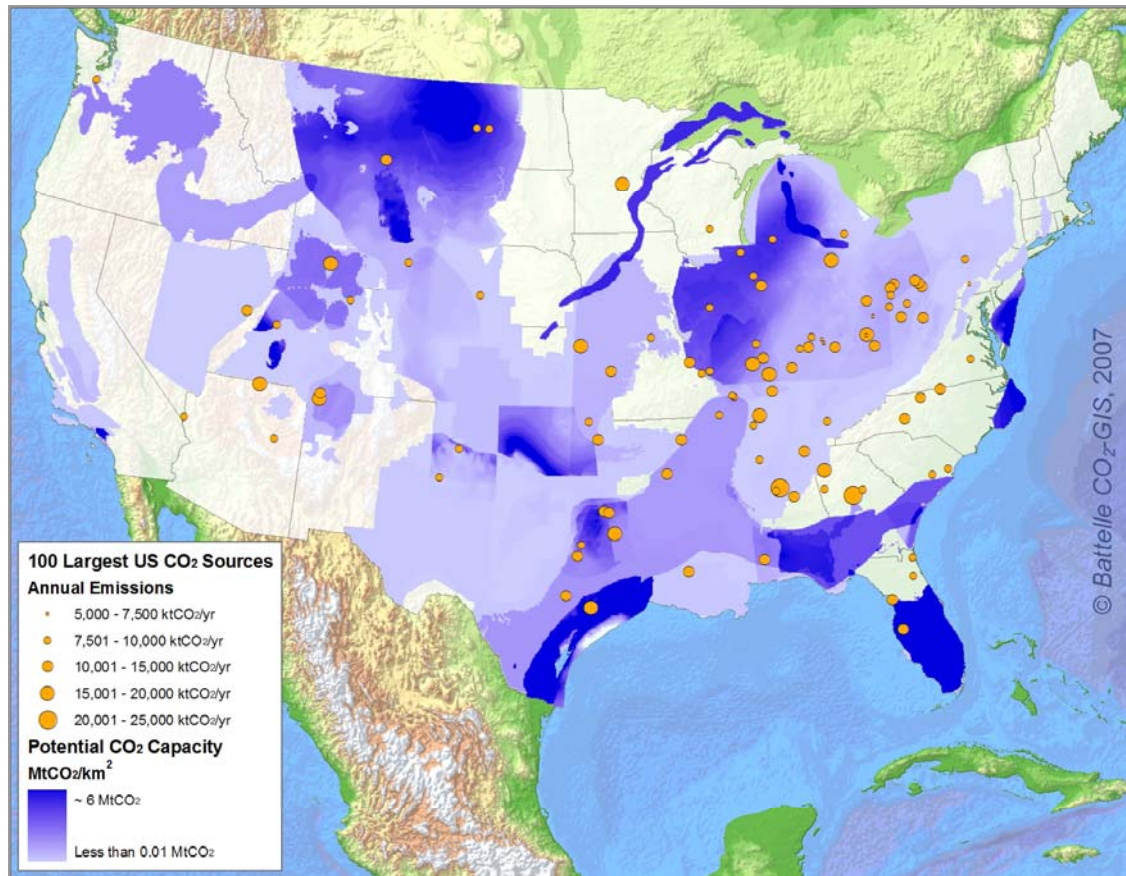
Industry Challenges

- ▶ **Interconnection planning for transmission expansion emerging**
- ▶ **R&D Challenges**
 - **Predicting wind ramps**
 - **Meeting regulation/load following needs**
 - **Managing over generation conditions**
 - **Impact of regulation requirements on hydro units**
 - **Better prediction of “tail” events such as Texas in spring 2008**



OTHER NATIONAL DRIVERS FOR SMART GRID AND TRANSMISSION PLANNING

Air / Water Neutral Fossil w CCS



POWER SYSTEM PLANNING FACES PROFOUND CHANGE AND COMPLEXITY

Gen & Load Characteristics

Today's Grid Planning Basis 2008

- < 5% responsive demand
- < 2% renewables (ex hydro)
- 85% baseload from coal and nuclear

Additional Characteristics

- Reduced system inertia with more use of capacitor banks
- Minimal real-time grid view

Emerging Smart Grid With Renewables, PHEVs and Carbon Policy Emerging Planning Basis 2012

- 10% responsive demand with emerging market coverage
- 10% renewables penetration
- 70% coal/fossil
- 20% nuclear

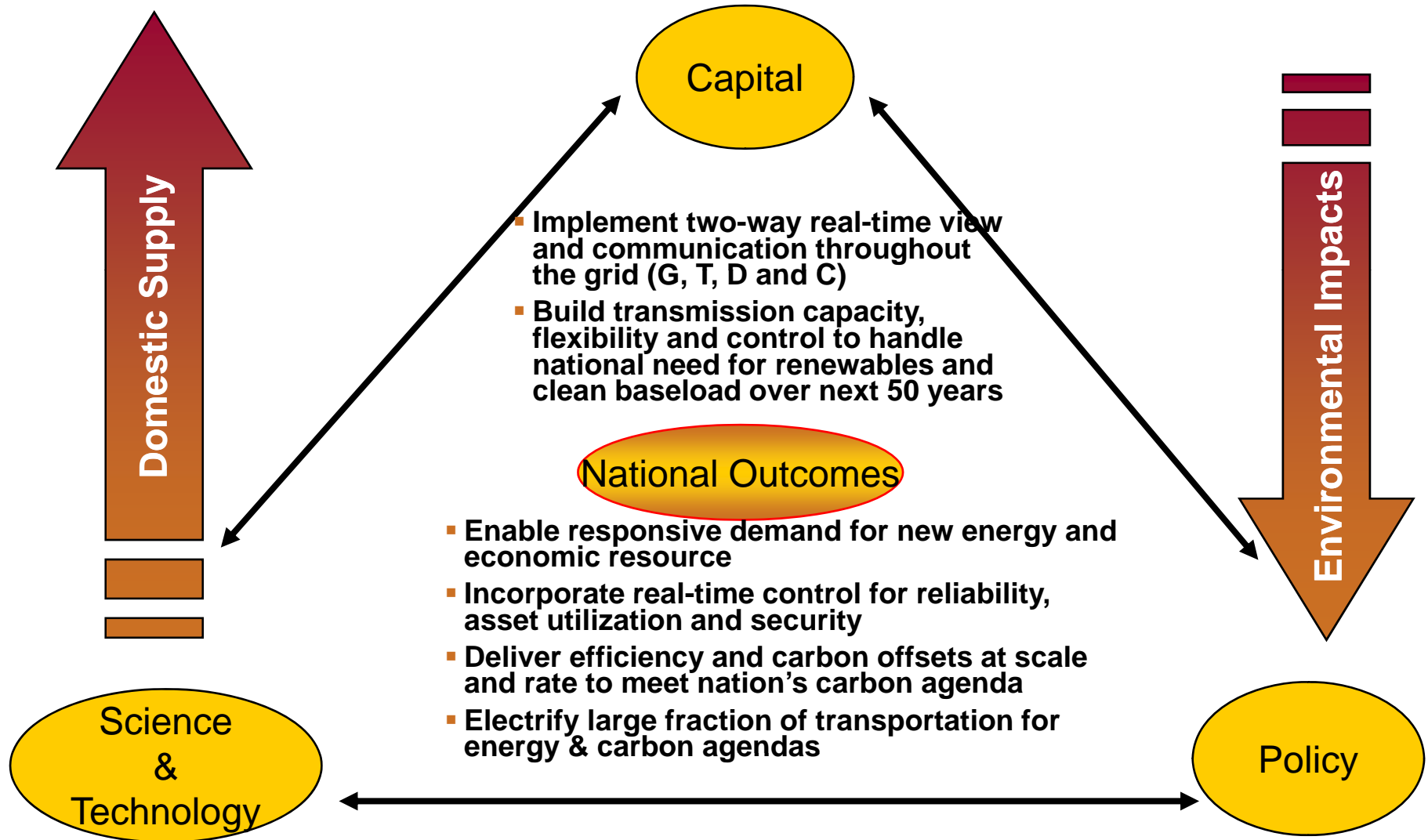
- Carbon policy drives efficiency thus changes in load characteristics
- Carbon policy incents initial carbon dispatch changes
- Basic NA phasor situational awareness network in place
- Modest consumer access to price signals

Smart Grid with Full Real-Time View, Clean Gen, PHEVs Security Planning Basis 2020

- 15% responsive demand
- 20% renewables
- Emerging real-time operational paradigms
- PHEVs becoming a meaningful share of demand
- Storage entering T&D to assist complex gen portfolio

- Real-time two-way monitoring and comms prevalent across entire grid
- Efficiency/demand response have substantially changed end use characteristics
- CCS impacting location of new G and T siting
- Substantial consumer access to price signals

National Outcomes and Requisite Levers to Frame and Deliver a National Transmission Strategy



PRIORITY SMART GRID KNOWLEDGE GAPS

Drafted by Gridwise Alliance (awaiting Board Approval)

1. Consumer elasticity to Demand Response incentives
2. Test/verify “distributed agent” concepts
3. Evaluate alternate rate structures, blends & links to wholesale & ancillary services markets
4. Validate benefits to distribution system performance (cost, efficiency, reliability)
5. Test interoperability frameworks across SCADA, DMS and EMS
6. Develop and validate tools to verify DR resources available to transmission operations
7. Validate value of DR as fast regulation to support renewables integration
8. Demonstrate models to provide customer privacy while maintaining data exchange
9. Demonstrate time synchronized real-time monitoring systems to engage real-time control and adaptive islanding
10. Demonstrate ability of WAMs tools to aid real-time operations in detecting and avoiding imminent outages.

NEXT STEPS TO CONSIDER

1. NARUC/FERC guide evaluation framework for substantial smart grid demos in key regulatory footprints
 1. Validate consumer benefits, acceptance
 2. Validate economic and energy impacts upon distribution systems
 3. Validate performance of alternate rate structures and incentives to deliver value 24/7/365
2. FERC/DOE initiate high level transmission planning agendas that set a long time-frame and focus on integrated infrastructure to deliver clean intermittent AND base load generation for the next 50 years.
3. Define roadmap to complete full coverage and communications across North American grid
 1. Work with NERC/DOE to complete the phasor network coverage (sensors, communications).
 2. Frame strategy to get coverage to consumer premises that is flexible for future value streams
4. Emphasize benefits that cross-cut G-T-D-C