



# Modern Grid for a Clean Energy Future

Washington State Academy of Sciences

CARL IMHOFF, MANAGER ELECTRIC INFRASTRUCTURE RESEARCH

Pacific Northwest National Laboratory

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# Discussion Topics

- ▶ Overview of Modern Power System
- ▶ National and Pacific Northwest Clean Energy Agenda
- ▶ Role of Electricity in Support Clean Energy Agenda
- ▶ PNW Smart Grid Demo
- ▶ PNW / Washington State Clean Energy and Grid Futures



# Future Power Grid Must Meet New Expectations and Technical Challenges

## *Historical Expectations*

**Affordable Power**

**Reliable Power**

**Secure Power**



## *Emerging Expectations*



**Integrate renewable generation**



**Increase grid-scale storage**



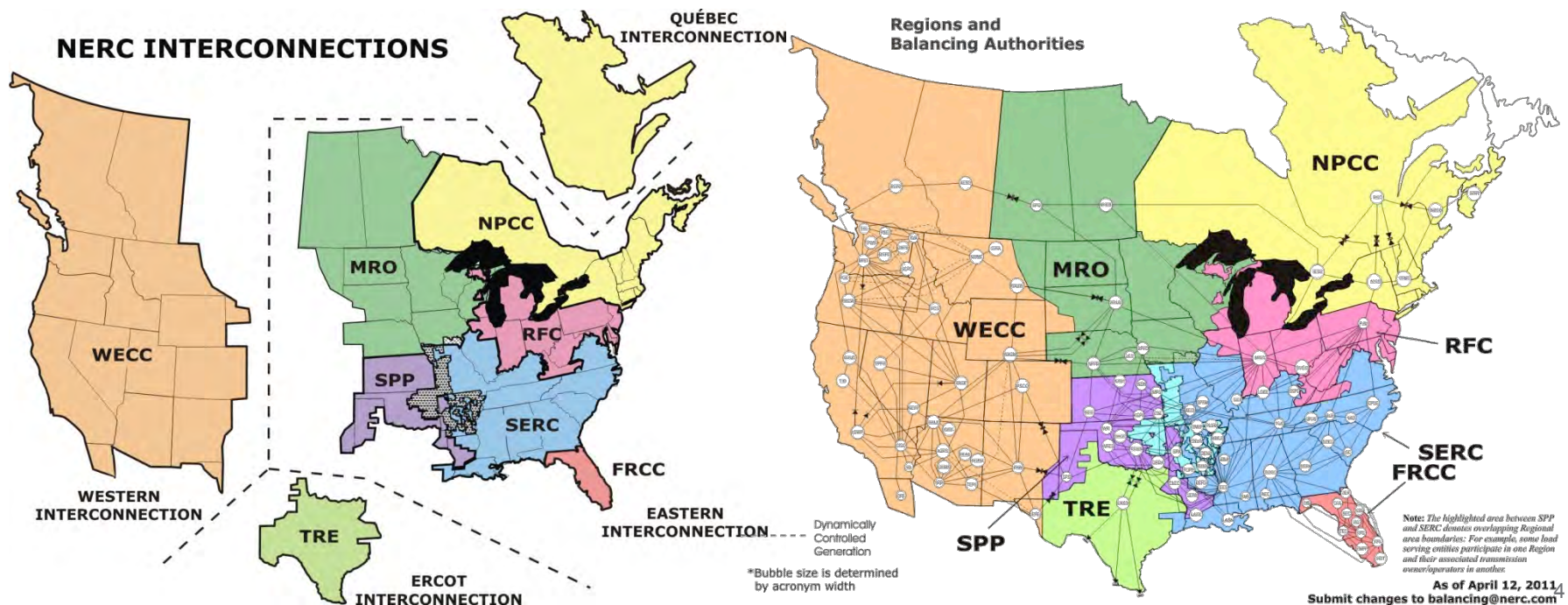
**Electrify transportation**



**Dynamic and responsive loads**

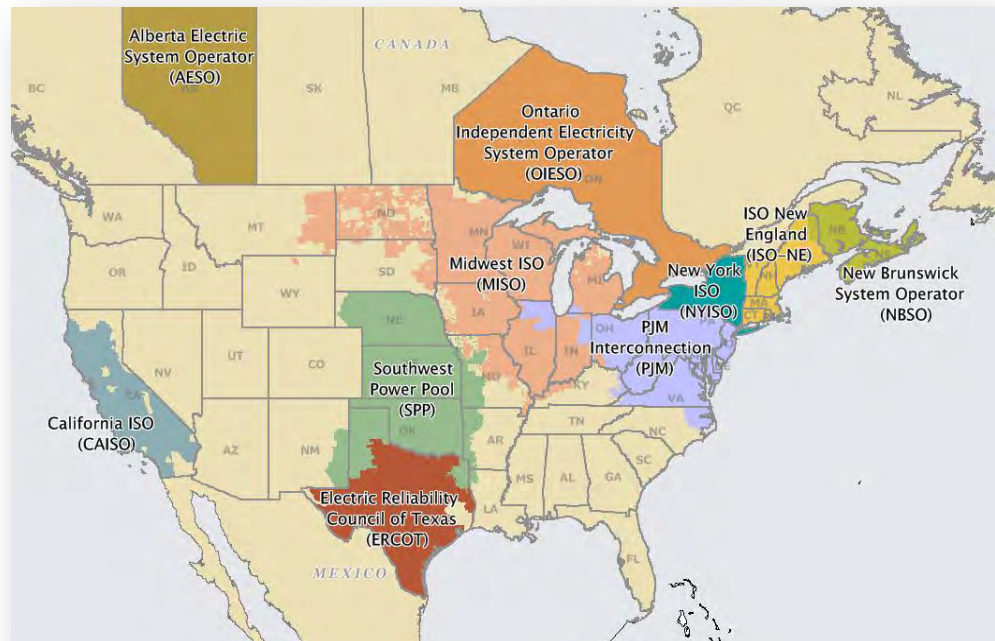
# Power System Realities

- ▶ Over 3,500 operating utilities
- ▶ Blend of business models
- ▶ 50 state regulators, Federal Energy Regulatory Commission (FERC) at federal level
- ▶ Reliability and security managed at multiple levels



# Power System Transitions

- ▶ Market structures fragmented in U.S.
- ▶ Information revolution driving changes in operations and incentives
- ▶ New policy and consumer drivers challenging the “utility business model”
  - Barriers to energy efficiency
  - Need for incentives to get full value of new clean generation concepts
  - Traditional models to fund reliability challenged
- ▶ Power system increasingly vital to emerging national and state agendas
  - Environment
  - Economy
  - Security



## National

- ▶ Federal goal of 80% clean electricity by 2035
  - Renewable
  - Nuclear
  - Clean Coal
  - Natural Gas
- ▶ Reduce oil imports 1/3 by 2025
- ▶ Improve building efficiency 20% by 2020
- ▶ Reduce greenhouse gas emission
  - 17% by 2020
  - 83% by 2050

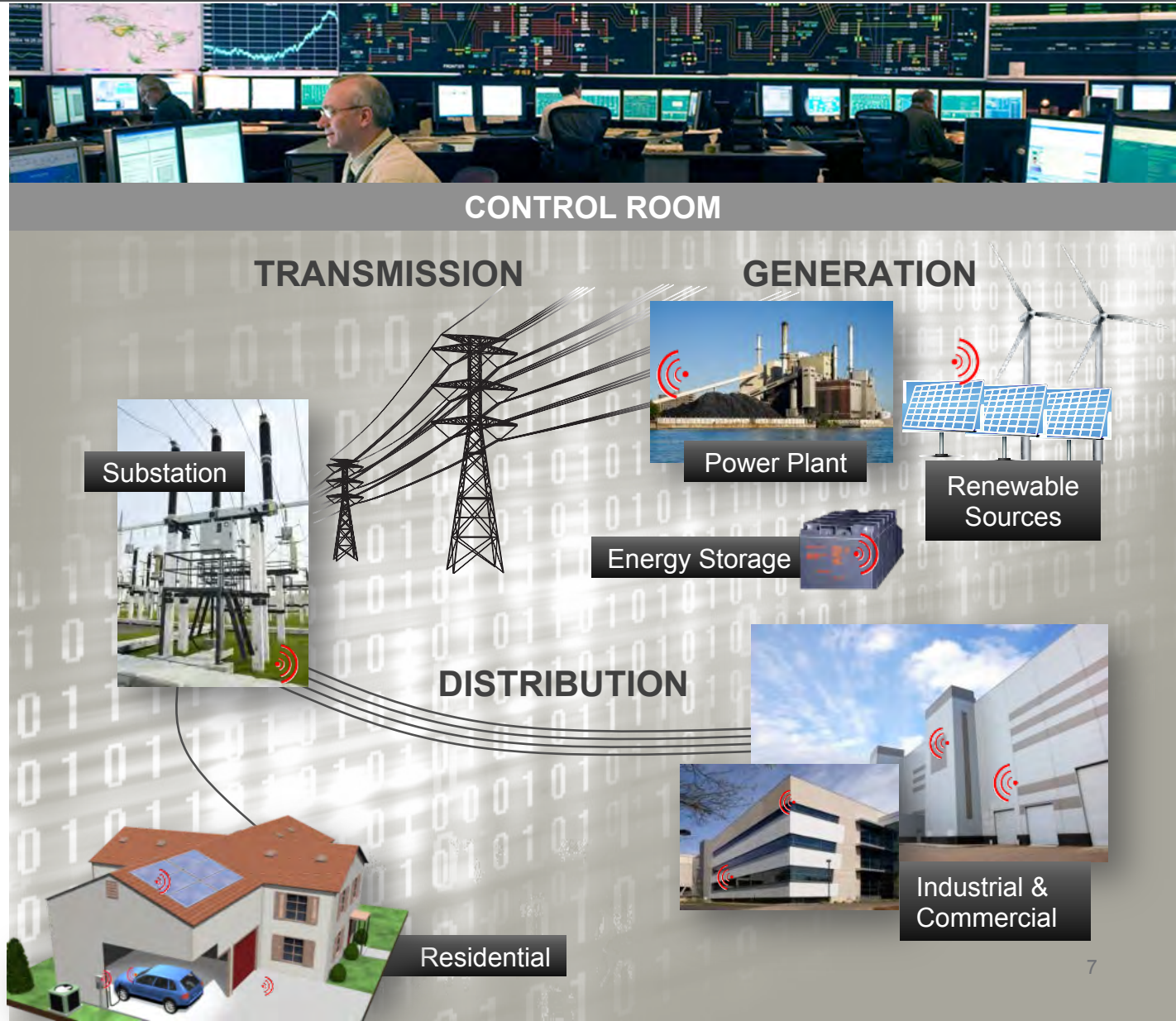
## PNW / Washington State

- ▶ 4.5GW of wind generation in Bonneville Power Administration (BPA) territory (18GW peak, 9 GW average load)
- ▶ Very low carbon footprint from electricity generation
- ▶ Regional plan to meet future growth predominantly with efficiency
- ▶ Natural gas turbines fossil generation of choice
- ▶ Transportation largest source of regional carbon emissions
- ▶ Hydro system exceptional asset but over subscribed

# A Transformation is Underway

New real-time measurement devices and communications provide a view of the power system that offers benefits in grid performance and economic benefit.

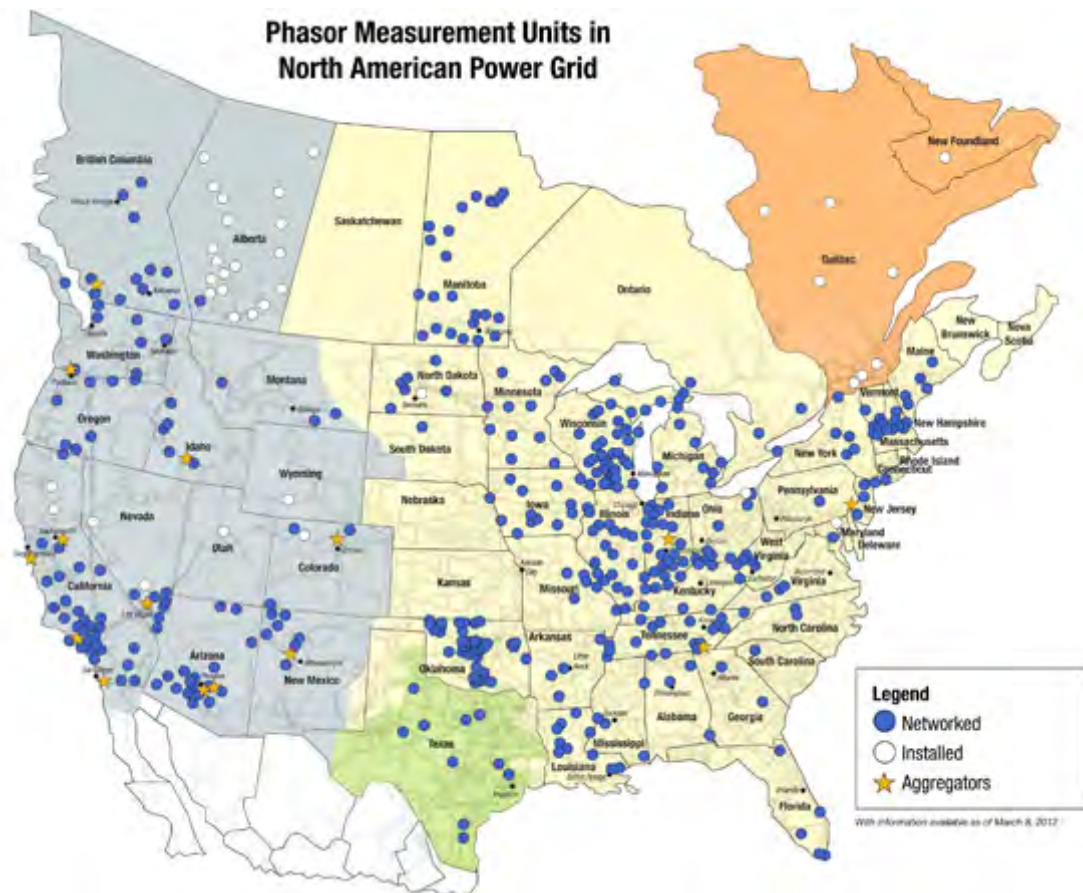
***Power, load, communications & markets increasingly coupled!***



# Deployment of a Vast New Sensor Network is Generating Rich New Data Streams

## North American SyncroPhasor Initiative

- ▶ Power companies, utilities, vendors, labs and universities
- ▶ High-resolution, time-stamped data (with phase angles at 30-60 Hz)
- ▶ ~500 Phasor Measurement Units (PMU) currently deployed in US/Canada
- ▶ Exceeding 1,000 PMUs by 2014
- ▶ Complete US/Canada network ~50,000 PMUs



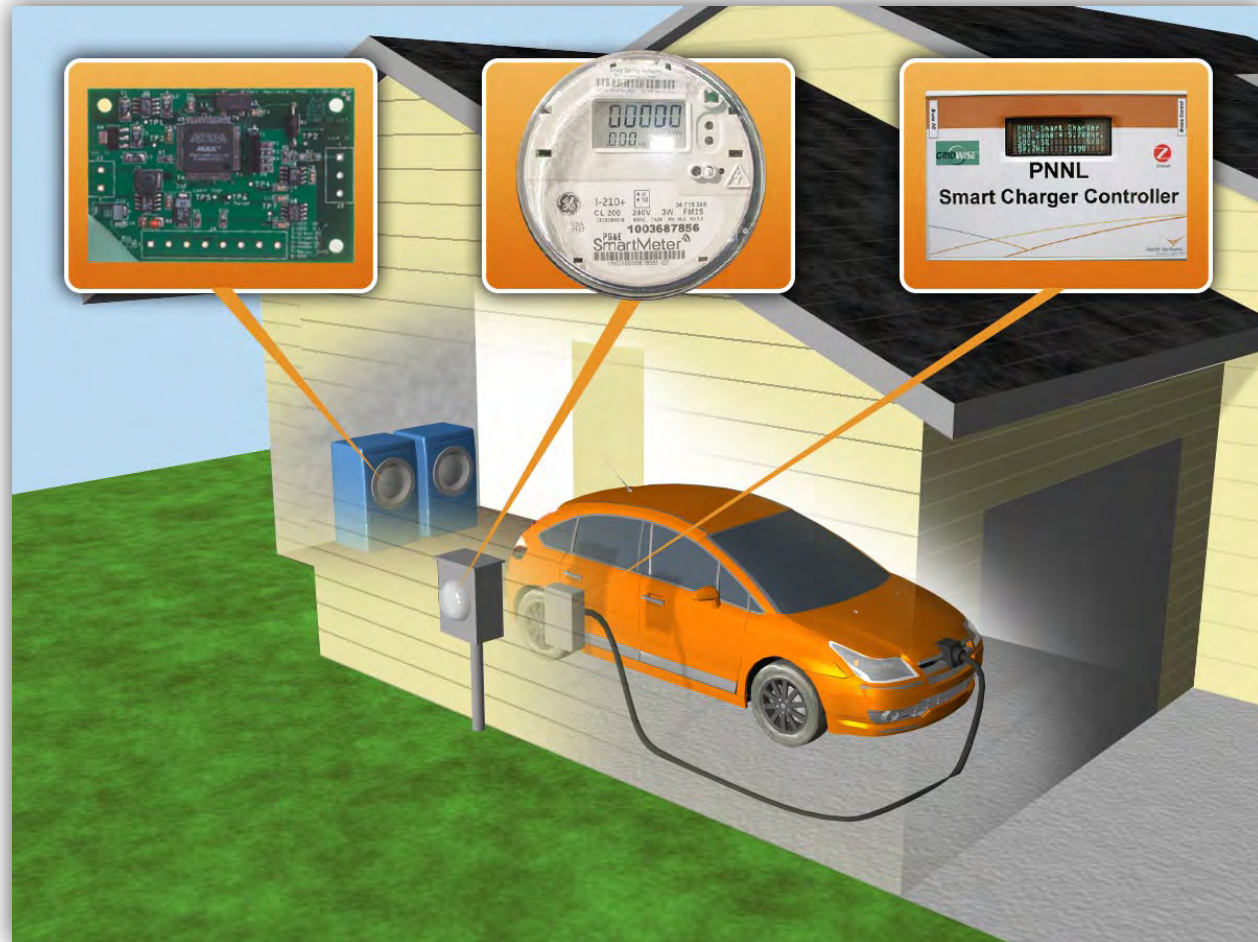
# Smart Meters, 2-way Communications Offers New Opportunities with Greater Complexity



Pacific Northwest  
NATIONAL LABORATORY

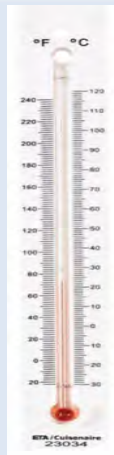
Proudly Operated by Battelle Since 1965

- ▶ Actionable data enables end-use choice and control
- ▶ Planning and operations merged for improved reliability
- ▶ Allows implementation of demand response for improved performance
  - **Efficiency**
  - **Reliability**
  - **Economic**



# Rich New Data Streams are Transforming View and Management of the Grid

	Today – SCADA data	Tomorrow – Phasor data	Improvement
Variety	voltage + current	+ phase angle	more information
Velocity	1 sample / 4 seconds	30-120 samples / second	~200x faster
Volume	8 terabytes / year	1.5 petabytes / year	~200x more data
Veracity	unseen ms-oscillations	oscillations seen at ms	greater accuracy



**thermometer**

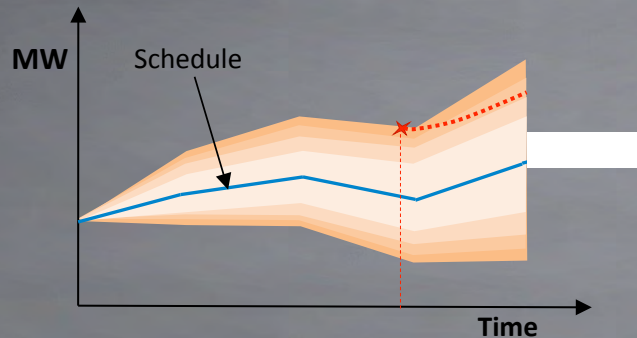
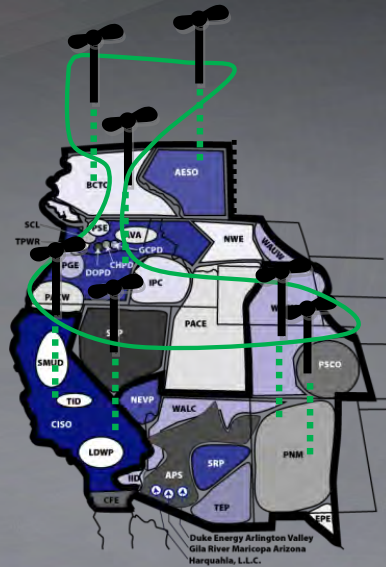


**weather station**

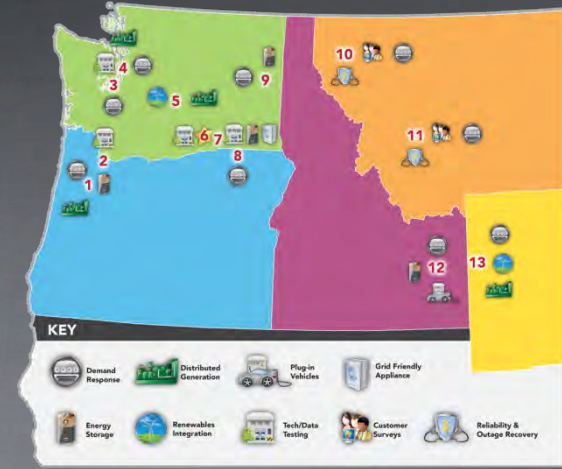
## Enabling Renewable Integration

# Developing and Implementing Grid Operational Methods and Technologies

- ▶ *New business models to accommodate clean generation*
- ▶ *Methods to accommodate renewable uncertainty*



## California Independent System Operator & DOE - Ramping and Transmission Capacity Uncertainty Tool



## Regional and Utility Studies

- ▶ ***New models to develop/operate a different grid***



**GridLAB-D High-resolution  
distribution simulator – Design  
Tool for the Smart Grid**

# Game-changing Advanced Grid Modeling

## Massive Contingency Analysis:

High performance computing improving reliability and efficiency of power systems operations

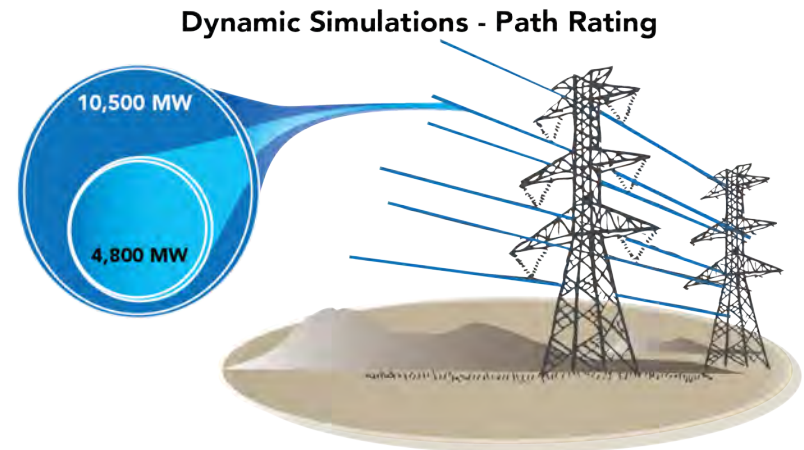
# of processors	Speedup
1024	1004
1536	1498
2048	1920

**Currently running 10k processors, achieved 10,000x speed up**

- ▶ Parallelization dramatically increases computational speed
- ▶ Enables evaluation of a large number of scenarios
- ▶ Revolutionizes grid operations and planning

## Fast Dynamic Simulation:

New model improving system efficiency



Oregon to California Intertie

- ▶ Full topology model
- ▶ Real-time performance rating
- ▶ Enables improved asset management

# Example Energy and Reliability Benefits from Grid Modernization

## ► Distribution automation benefits

### ■ Volt-VAR optimization (annual energy saved)

■ 2% – 4% Reclosers & sectionalizers (SAIDI improved)

■ 2% – 70% Distribution & outage management systems (SAIDI improved)

■ 7% – 17% Fault detection, identification, & restoration (SAIDI improved)

■ 21% – 77% Demand response Instantaneous load reductions

■ 25% – 50% Sustainable (e.g., 6-hour) load reductions

■ 15% – 20% Thermal storage (commercial buildings) Peak load reduction @ 10% penetration

■ up to 5% Residential photovoltaic generation 3 kW-5 kW each, 0% – 6% penetration (annual energy saved)

0.1% – 3%

# Pacific Northwest SG Demonstration Project

## What:

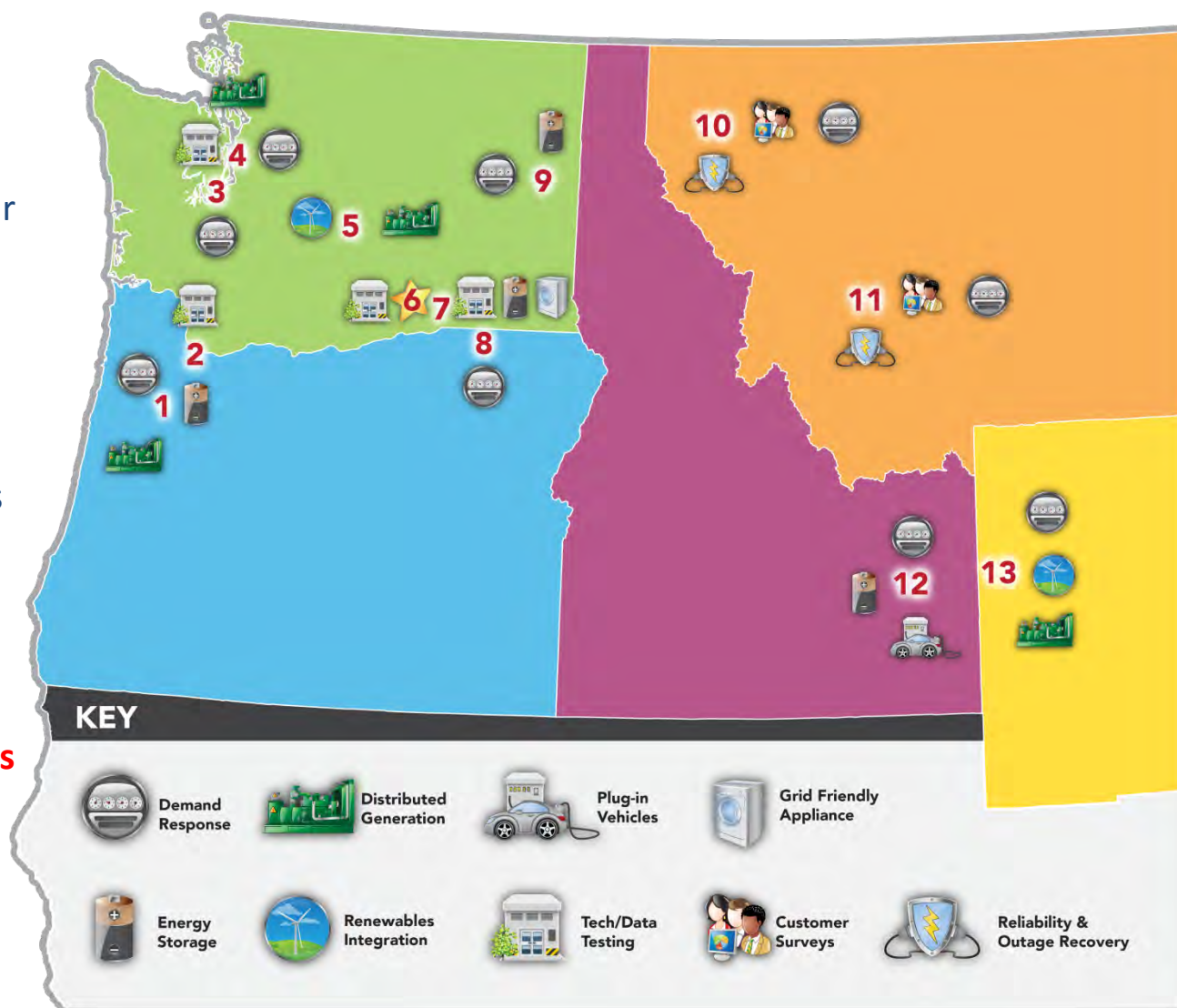
- \$178M, (\$89M private, \$89M ARRA-funded), 5-year demonstration
- 60,000 metered customers in 5 states

## Why:

- Quantify costs and benefits
- Develop communications protocol
- Develop standards
- **Facilitate integration of wind and other renewables**

## Who:

Led by Battelle and partners including BPA, 11 utilities, 2 universities, and 5 vendors



# Washington State Clean Energy/ Grid Perspectives

- ▶ Decades of regional / state leadership
  - Energy Efficiency
  - Renewable Power (hydro, wind)
  - Power system innovation
  - Smart Grid energy policy
- ▶ Home to leading power system stakeholders
  - Innovative public, investor-owned and federal utilities
  - PNNL is leading DOE national laboratory in electric grid R&D
  - Leading vendors and innovators for U.S. and global markets
  - Strong university and community college engagement

Challenge: How to frame state / regional outcomes to frame requisite energy strategy

Energy efficiency  
Demand response  
Clean generation  
Clean transportation

