DOE OE Electric Transmission System Reliability Program

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Topics
DOE OE Transmission System Reliability Program

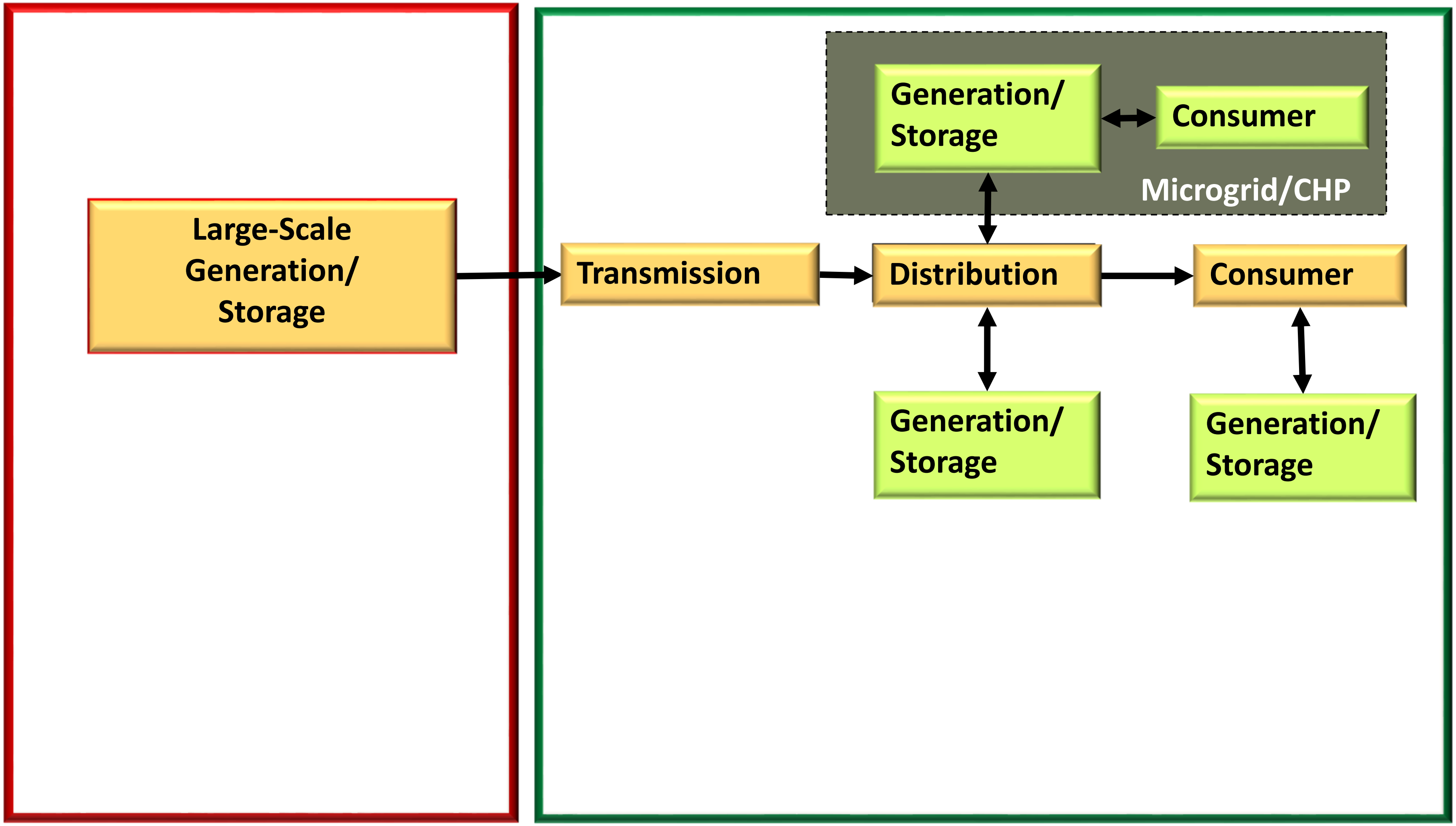
- **Background**

- **DOE OE Transmission Program**
  - OE ARRA Transmission Projects
  - OE Core Transmission Projects

Background

How can Wyoming best apply smart grid technologies in new and existing transmission planning to integrate and increase value of local (end-user) utility smart grid investments?

Electric Power System Transition to a Modern Grid



Smart Grid in Transmission

- **Synchrophasors (a.k.a., Phasor Measurement Units)**
  - Voltage, phase angle, current, frequency, time, location
  - Current Use: Wide area awareness, post-event analysis, planning model validation
  - Future Use: Real-time control, state estimation, self-healing
- **Phasor Data Concentrators**
- **Dynamic Line Rating**
  - Ambient conditions (e.g., temperature & wind)
  - Line conditions (e.g., temperature, tension)
- **Equipment health monitors (e.g., transformers)**
- **Weather forecasting important for renewable energy farms**
- **Higher DC and AC transmission voltages**
  - Reduce line losses
- **Low loss cables**
- **Cyber security**
- **Physical security and robustness**

Future modern grid
Greater interaction between T & D

- Distributed assets alleviate transmission congestion
- Transmission and main grid distribution assets alleviate microgrid congestion
- Better communication between T&D operations
- Changing wholesale and retail markets
- Optimization of entire power system
- Coordinate GT&D to gain efficiency
- More highly networked T&D systems
- Move power between circuits

Transmission Planning Impacted By

Increase in DER

- Renewable energy, energy storage, distributed generation

Increase in consumer participation

- Demand response, photovoltaic, electric vehicles, community storage, microgrids

Increase in renewable energy farms

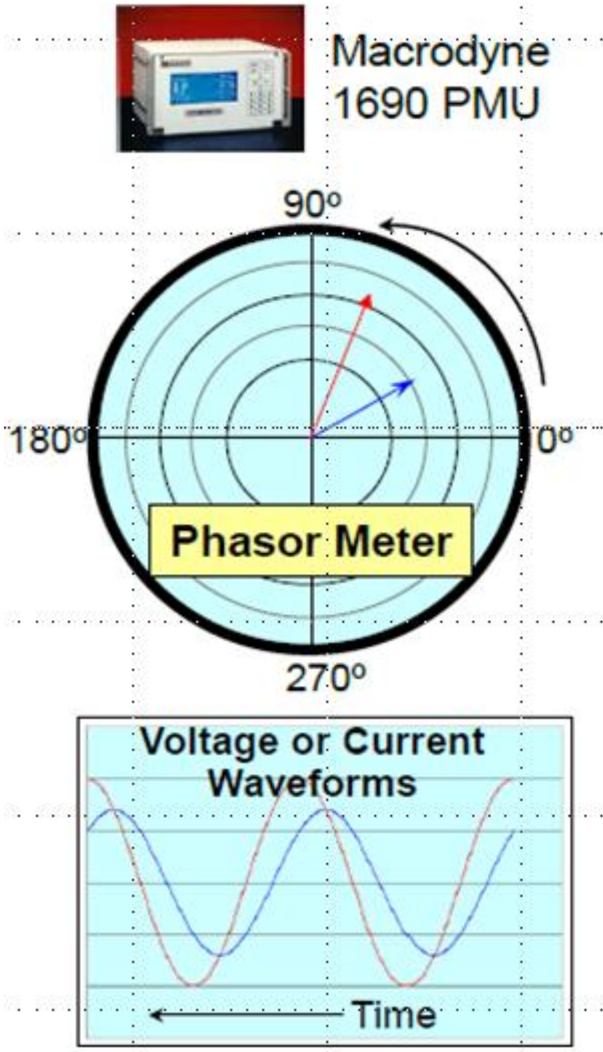
Stronger import and export capabilities between regions

Trend to defer large G&T investments and increase utilization of existing assets

OE ARRA Transmission Projects

Synchrophasors

- **Vectors represent the magnitude & phase angle of voltage and current**
- **Magnitude is the amplitude of ac voltage or current waveform**
- **Angle is shift in voltage or current waveform from reference waveform**
- **Sample voltage and current 30-60 times per second and send to phasor data concentrator**
- **Each PMU is time-synchronized using GPS to allow widely separated locations to record data at same instant of time**
- **Addresses current industry problems**
  - Wide area situational awareness
  - Systems dynamic monitoring
  - Improved modeling and model validation
  - Blackout prevention and mitigation
  - Congestion and bottlenecks
  - Common data and common displays
  - Monitor reliability standards



SGIG Electric Transmission Systems Projects

• American Transmission Company, LLC (PMU)	$2.7*
• American Transmission Company, LLC (SCADA)	22.9
• Duke Energy Carolinas, LLC	7.8
• Entergy Services, Inc.	9.2
• Midwest Energy	1.4
• Midcontinent ISO, Inc	34.5
• ISO New England, Inc	18.1
• New York ISO, Inc	75.7
• PJM Interconnection, LLC	27.8
• Western Electricity Coordinating Council	107.8
	307.9

* Total cost in millions

SGIG Transmission Technologies Deployed

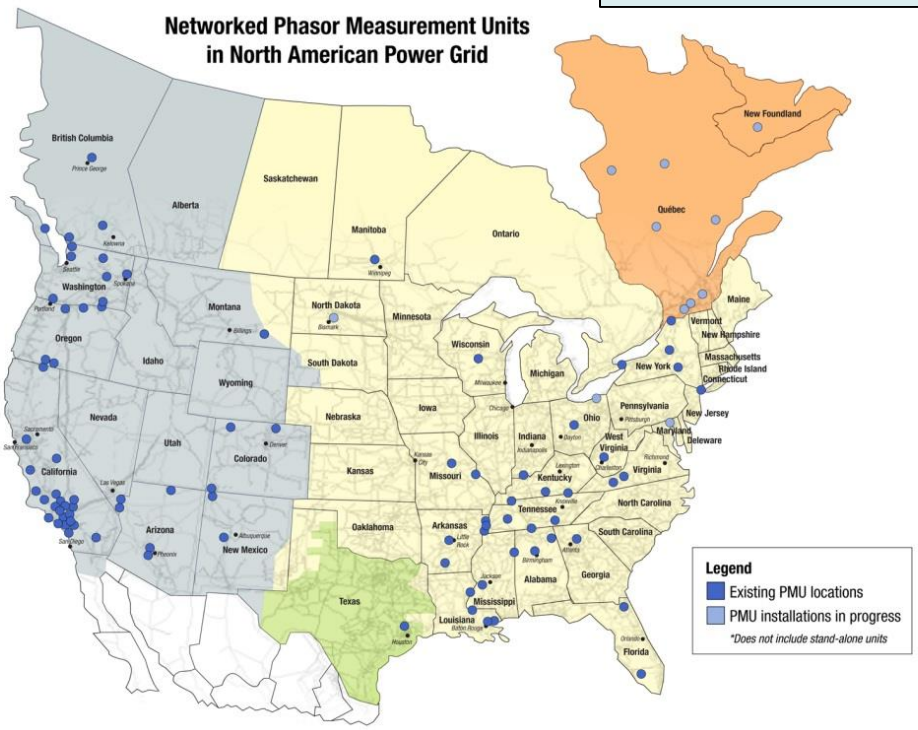
Data through June 30, 2014
Installed synchrophasors – 1,111
Installed PMU data concentrators– 164

Synchrophasor Technology for Transmission System Operations

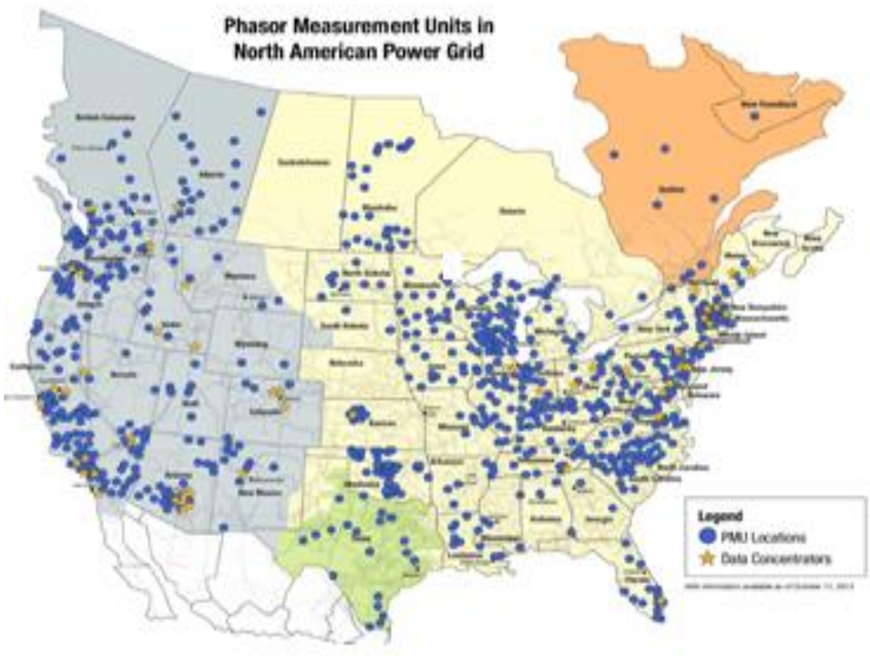
Improved reliability, capacity and operational efficiency – Energy flows on the California-Oregon Intertie can be increased by 100 MW or more reducing energy costs by an estimated $35 - $75 million over 40 years without new capital investments

2009: About 200 PMUs
2014: About 1700 PMUs

April 2007



October 2013



Dynamic Line Rating Technology

- **Adjust transmission capacity ratings in real-time**
  - Sensors and communications devices
    - Wind speed, ambient temperature, solar radiation
    - Line temperature, sag, tension, clearance
  - Conductor characteristics
  - Software

- **Comparison is <u>static line ratings</u> which are usually conservative based on windless, sunny, hot days**
- **Benefits: congestion relief, improved efficiency, defer capital costs, improved asset utilization, improved situational awareness**
- **Two DLR projects in SGDP program**
  - New York Power Authority/EPRI – R&D
  - Oncor – Demonstration and deployment

Oncor Dynamic Line Rating Project

Key Project Elements	Oncor's DLR Project
Project partners	♦ Nexans ♦ Promethean Devices ♦ EDM International, Inc. ♦ Southwest Research Institute (SwRI) ♦ Siemens Energy Inc. ♦ Chapman Construction Company ♦ Electric Reliability Council of Texas (ERCOT)
Total installed cost	$4,833,000
Total project budget	$7,279,166
Project duration	1/1/10 – 5/4/13
Project location	Five 345 kV and three 138 kV transmission line circuits in Texas
DLR equipment	♦ 27 Nexans CAT-1 units, including 45 load cells ♦ 5 Video Sagometer systems ♦ 2 Real-Time Transmission Line Monitoring Systems (RT-TLMS)
DLR software	♦ Nexans' proprietary IntelliCAT software
Average increased real-time capacity	♦ 8%-12% above ambient-adjusted rating (138 kV lines) ♦ 6%-14% above ambient-adjusted rating (345 kV lines)

Although Oncor could not quantify the congestion-related economic benefits of deploying DLR technologies, it was able to estimate the savings associated with the deferral of other transmission upgrades.

Line Type	Alternative Description	New Rating (% Static)	Cost per Mile
138 kV Lattice, Wood H-Frame	Reconductor Aluminum Conductor Composite Core (ACCC) cable	193%	$321,851
	DLR	**110%**	**$56,200**
138 kV Wood H-Frame	Rerate 125 °C Modify structures	130%	$10,561
	Rerate 125 °C Replace structures Rebuild	130% 209%	$6,919 $750,000
	DLR	**110%**	**$29,471**
138 kV Wood H-frame	Rebuild	140%	$237,871
	DLR	**110%**	**$16,767**
138 kV Wood H-Frame	Reconductor	212%	$750,000
	DLR	**110%**	**$28,323**

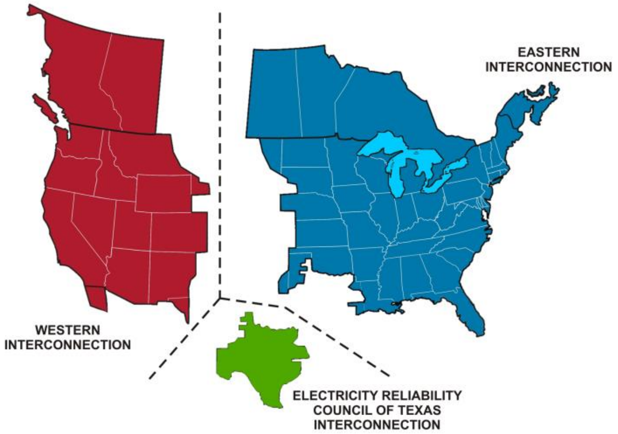
Interconnection Transmission Planning and Analysis Program

- Strengthens capabilities in three interconnections serving the lower 48 states
- Prepares analyses of transmission requirements under alternative futures
- Develops long-term interconnection-wide transmission expansion plans

Benefits:

- Improve regional, interregional, and interconnection-wide coordination
- Improve quality of information to industry planners and policymakers
- Create of long-term transmission requirements under a wide range of futures
- Facilitate development of new transmission facilities that will foster development of renewable or other low-carbon generation capacity

- Six awards, two per each interconnection for $60M
- Two awards to state policymaker groups for $20M



OE Core Transmission Projects

Academic – Industry Collaboration for Synchrophasor Education

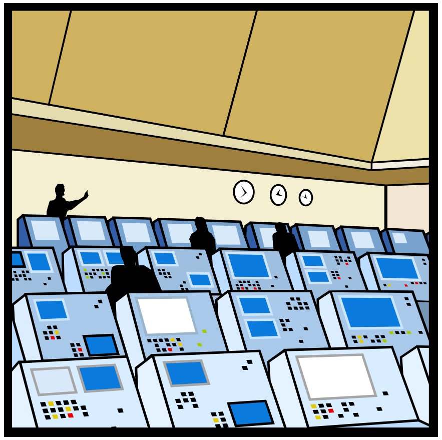
- Program helps universities train workforce to understand and analyze high-speed, time-synchronized data generated by Phasor Measurement Units (PMUs)
- Award recipients use real PMU data provided by partner utilities
- Curriculum on synchrophasor applications
- Seven $200K awards made to the following partner universities:
  - Washington State University
  - North Carolina State University
  - Illinois Institute of Technology
  - University of Wyoming
  - Virginia Tech
  - Texas Tech University
  - Clemson University

PROGRAM VALUE
$2,965,721
(Awards total $1.4 million)

Pre-Commercial Synchrophasor R&D

- **Advance development of production-grade software that uses synchrophasor data to improve reliability and economic efficiency of the bulk power system**

- **Aimed toward planning, operations, and ultimately real-time control**
  - Real-time and offline applications
  - Monitoring and visualization of control room operations
  - Wide-area control and protection
  - Power system restoration
  - Power system model validation
  - Wholesale market efficiency



Awards

Approximate Funding: $23.2M

- **6 awards; $10.6 M DOE; $12.6 awardee**

- **Pacific Gas & Electric**
  - Improve data quality validation and security, strengthen system wide indicators, speed system restoration, improve post event analysis
- **Quanta Technology**
  - Combine PMU data with other sensors to provide fast, reliable and detailed visibility in NY Power Authority area
- **Electric Power Group**
  - Expand grid operator training by developing simulator software to teach operators how to use PMU data
  - Demonstrated by ERCOT and SCE

Awards (continued)

- **Burns & McDonnell Engineering Company**
  - Develop software to monitor and analyze grid conditions in real-time
  - Test software at Southern Company
- **Hawaiian Electric Company**
  - Incorporate PMU data into its T&D modeling and system-wide data analysis
  - Evaluate new visualization techniques
- **Peak Reliability**
  - Develop automated controls and improve grid condition data delivery and quality
  - Serves as reliability coordinator in 14 western states, British Columbia, and northern Baja California, Mexico

Phasor Applications Roadmap

Research Areas

- Visualization
- Monitoring
- Planning
- Phasor Infrastructure Management
- Control
- Protection
- Switching

Near-Term(1-2 Years)

- Wide-area visibility with common situational awareness screens
- Baseline normal operating conditions, limits and alarms for EI
- Demonstrate improved state estimation with phasor measurements
- Model validation for better system understanding
- Identify human factors & visualization needs for phasor based operations tools
- Define best practices for enhanced grid "forensics"
- Design next generation data and communications infrastructure
- Define research and demonstration approach for real-time control
- Identify research needs for federal investment

Mid-Term (2-5 Years)

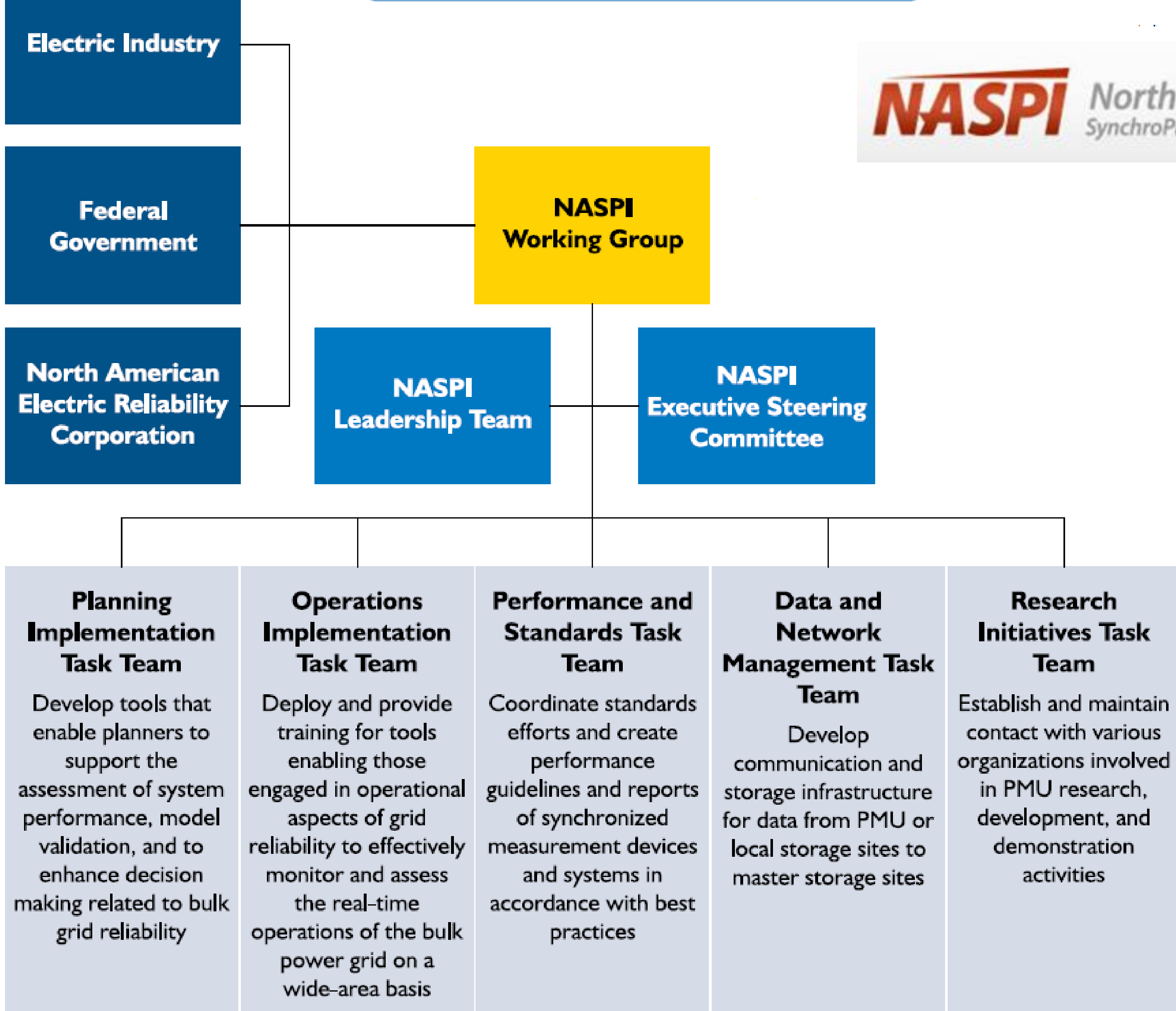
- Wide-area visibility with full coverage
- Approaching real-time state measurement for operators
- Dynamic system security assessment tools
- Common operator tools deployed
- Congestion management
- Dynamic ratings
- Improved LMP
- Work with industry to initiate major demonstration of real-time control for dynamic security
- Work with industry to demonstrate adaptive islanding protection concepts to improve protection from wide-area blackouts
- Develop strategy for next-generation operational tool concepts

Long-Term (5-10 Years)

- Real-time protection
- Distributed closed loop control
- Automatic smart-switchable networks

CERTS

NASPI Organizational Structure



NASPI North American SynchroPhasor Initiative

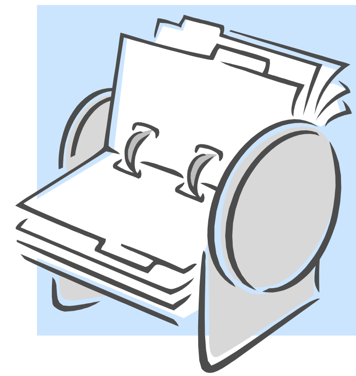
NASPI Accomplishments and Issues

Accomplishments	Outstanding Issues
Development of PMU communications framework (known as NASPInet Architecture)	Improving and expanding communication system architecture and integration
Development of several key technical interoperability standards	Developing independent interoperability testing and certification methods
Maturing PMU functionality, including successively higher measurement speeds	Defining production-grade systems
Identifying the baseline performance of relationships across an interconnection	Improving the baseline for further understanding of normal grid conditions, thus aiding identification of disturbances
Development of educational materials to facilitate deployment	Delivering widespread industry training on synchrophasor technologies
	Mainstreaming NASPI by migrating activities to other organizations
	Further improving data quality and availability

https://www.naspi.org/

Contact Information

North American SynchroPhasor Initiative: www.naspi.org



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