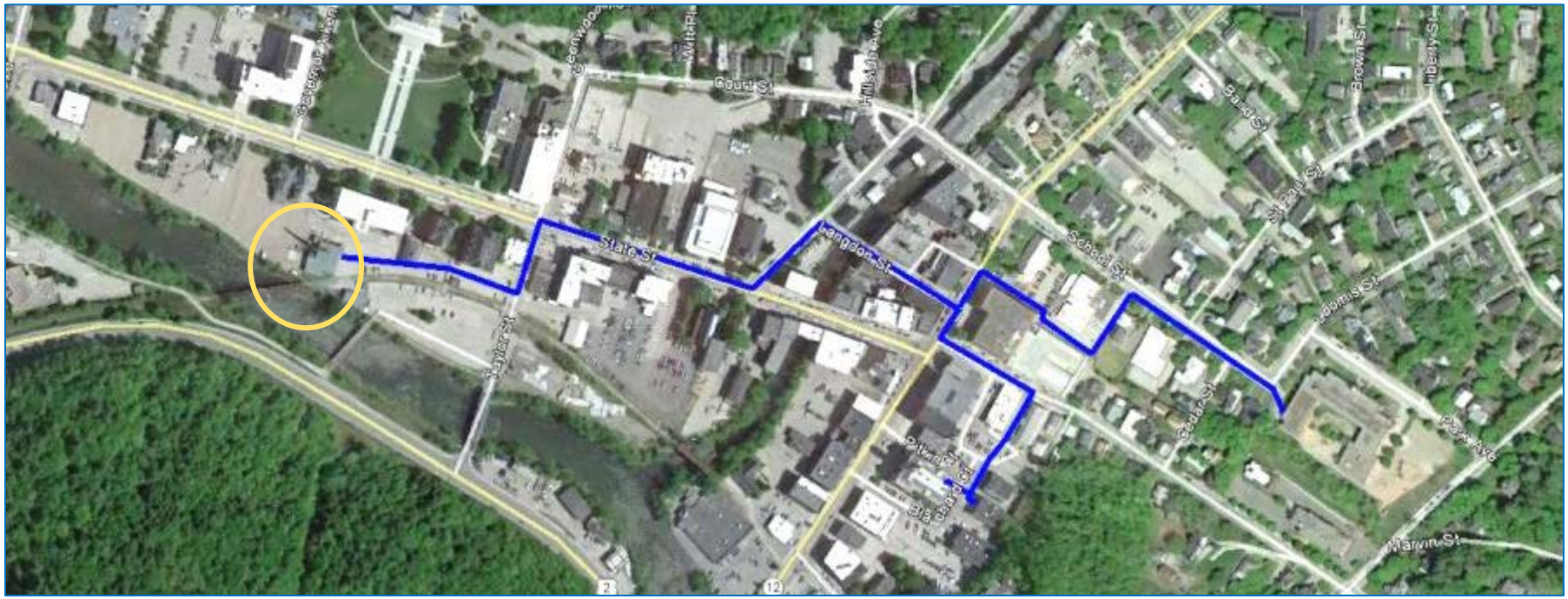
Energizing Communities with Renewables through Grid Modernization

Steve Lindenberg

July 29, 2015

City of Montpelier, VT



Project Financial Summary	
Total project cost	$25,784,973
Total cost share	$17,784,973
DOE funding share	$8,000,000

The State central heat plant was rebuilt with two new biomass boilers. Construction of the central heat plant in 2013 achieved initial operation in March of 2014 with 1,000 tons of woods chips consumed. City hot water distribution constructed in 2013 and was in 100% operation by May 2014.

Forest County Potawatomi Community, WI

Final Projects Accomplished

- *Milwaukee Solar Project Overview* – A locally sourced 30 kW rooftop solar installation located at the Community's Administrative Building in Milwaukee, Wisconsin.
- *Milwaukee Digester Project Overview* – A 2.0 MW anaerobic digestion and biogas CHP electric generation facility located in Milwaukee, Wisconsin.
- *Forest County Small-Scale Biomass Investigation Overview* – The investigation of a packaged biomass cogeneration system or syngas or syndiesel production system at the Stone Lake Campus.
- *Forest County Solar Investigation Overview* – The investigation of solar PV and potentially solar heating systems on residences and other buildings on the Tribe's Reservation in Forest County.

Project Financial Summary	
Total project cost	$42,768,994
Total cost share	$40,168,994
DOE funding share	$2,600,000

Scale of projects and locations make the financial viability possible. First proposed efforts on the Tribal lands were found to lack appropriate scale. Projects in Milwaukee and the presence of a Tribal utility to negotiate electric supply arrangements were critical to success.

Phillips County, CO

Project Plan and Objectives

- Develop a 30 MW community owned wind farm in NE Colorado and sell electric service to local utility under a PPA approach
- Retained an experienced small project developer with a focus on working with community ownership model
- Transmission connection was not available to transport across the WECC region causing expense of upgrades to be part of project cost depending on buyer
- Several attempts made with local and regional utilities to arrange sale of power
- Small scale of wind farm drove cost of electric service to slightly exceed regional market and RPS or other environmental drivers were not sufficient to motivate PPAs
- Ending of the Federal Production Tax Credit incentive period caused major cost increase

Project Financial Summary	
Total project cost	$64,566,398
Total cost share	$62,016,398
DOE funding share	$2,550,000

The ultimate result of five years of planning, evaluation, marketing of power and community investment into the project resulted in canceling the project in late 2014.

University of California, Davis, CA

Project Financial Summary	
Total project cost	$5,000,000
Total cost share	$2,500,000
DOE funding share	$2,500,000

A Northern California supplier, Clean World, designed and built the West Village Energy Initiative anaerobic digester which supplies the UC-Davis with 10MWe from waste collected on campus.

Sacramento Municipal Electric District, CA

SMUD Project Accomplishments

- The Simply Solar project resulted in significant additional photovoltaic (PV) generation in SMUD territory, addressing challenges of installing solar technology on brownfield landfill sites. Excellent for community education on PV.
- SRCSD's Biogas Enhancement resulted in the implementation of FOG collection and liquid food waste co-digestion at the Elk Grove Plant with biogas delivered to SMUD for electric power operations.
- The New Hope and Van Warmerdam Dairy implementation of two dairy digester projects resulted in avoided carbon dioxide equivalent (CO2e) emissions of 10,536 MT/yr and helped meet or exceed the California Air Resources Board (CARB) oxides of nitrogen (NOx) requirements.

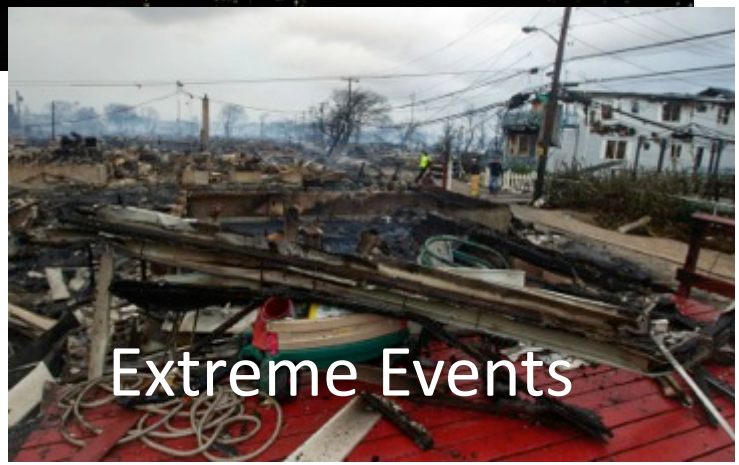
Project Financial Summary	
Total project cost	**$13,574,876**
Total cost share	$8,524,876
DOE funding share	**$5,050,000**

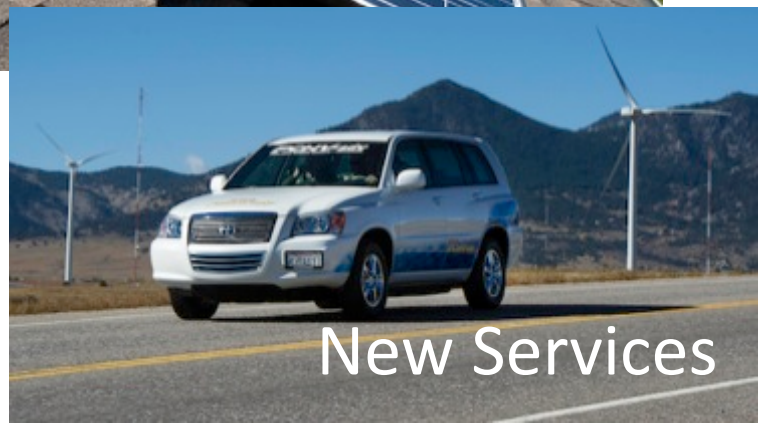
This group of projects were able to be accomplished with some significant delays. The experience and professional skills of the SMUD staff were evident in all phases and across various departments of SMUD. The conclusion we draw is that 3-5 years from concept to commissioning should be expected for community renewable deployment.

Why Grid Modernization?

The existing U.S. power system has served us well…

but our 21st Century economy needs a 21st Century grid.





Grid Modernization Vision

The future grid provides a critical platform for U.S. prosperity, competitiveness, and innovation in a global clean energy economy. It must deliver ***reliable, affordable,*** *and* ***clean electricity*** *to consumers where they want it, when they want it, how they want it.*

Achieve Public Policy Objectives

- 80% clean electricity by 2035
- State RPS and EEPS mandates
- Access to reliable, affordable electricity
- Climate adaptation and resilience

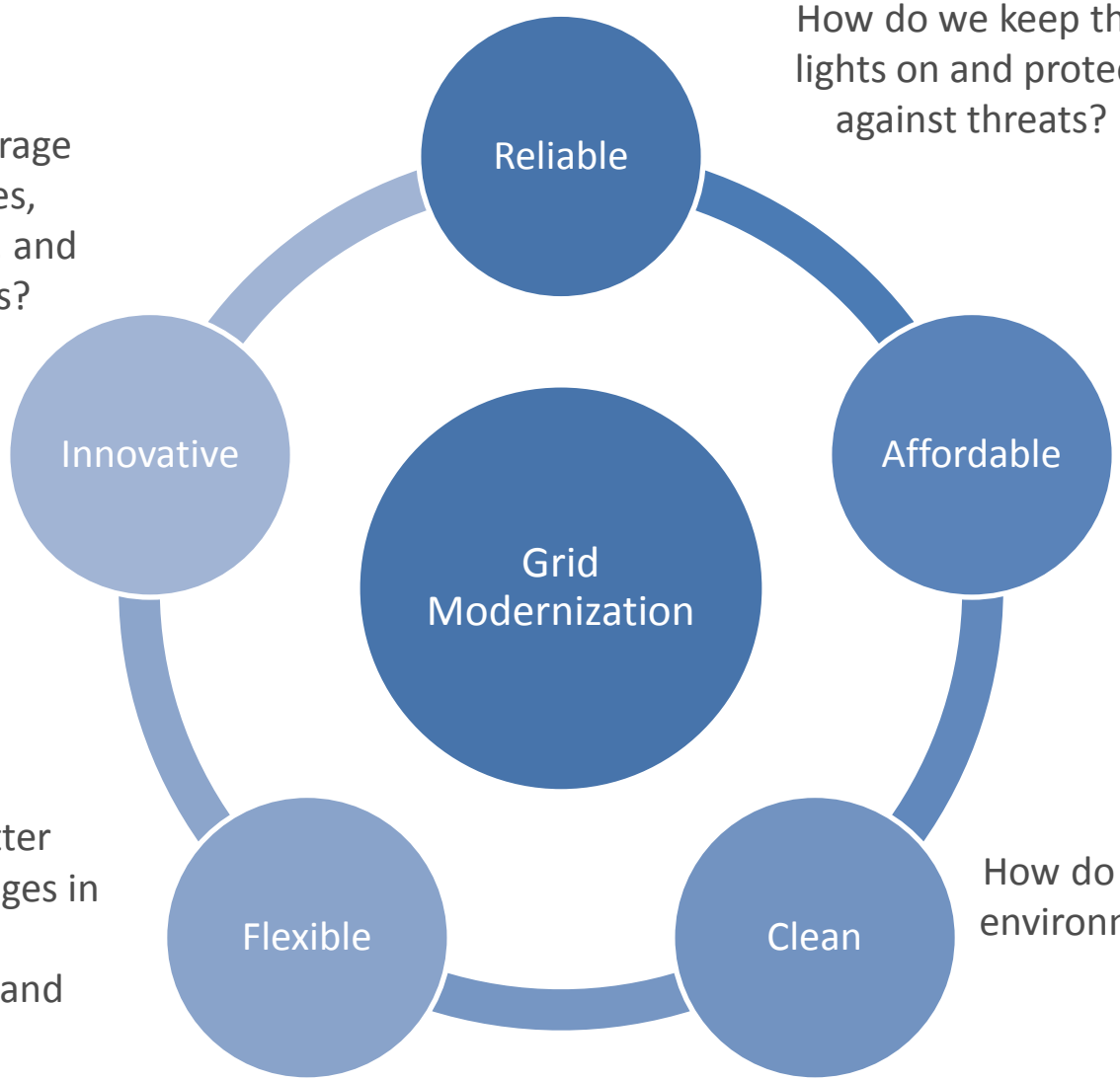
Sustain Economic Growth and Innovation

- New energy products and services
- Efficient markets
- Reduce barriers for new technologies
- Clean energy jobs

Mitigate Risks and Secure the Nation

- Extreme weather
- Cyber threats
- Physical attacks
- Natural disasters
- Fuel and supply diversity
- Aging infrastructure

Key Attributes of a Modernized Grid



How do we keep the lights on and protect against threats?

How do we keep costs reasonable for consumers?

How do we reduce our environmental impact?

How do we better absorb rapid changes in supply, delivery or demand conditions?

How do we encourage new technologies, products, services, and business models?

Technical Areas

Sensing and Measurements	• Visualization tools that enable complete visibility of generation, loads and grid dynamics across the electric system
Devices and Integrated Systems	• Establish common test procedures and inter-operability standards for devices that can provide valuable grid services alone and/or in combination
System Operations and Power Flow	• Develop advanced real-time control technologies to enhance the reliability and asset utilization of T&D systems
Design and Planning Tools	• Create grid planning tools that integrate transmission and distribution and system dynamics over a variety of time and spatial scales
Security and Resilience	• Develop advanced security (cyber and physical) solutions and real-time incident response capabilities for emerging technologies and systems
Institutional Support	• Provide tools and data that enable more informed decisions and reduce risks on key issues that influence the future of the electric grid/power sector

Goals and Outcomes

- This new crosscutting effort will build on past successes and current activities to help the nation achieve at least three key outcomes within the next ten years:

  > 10% reduction in the societal costs of power outages

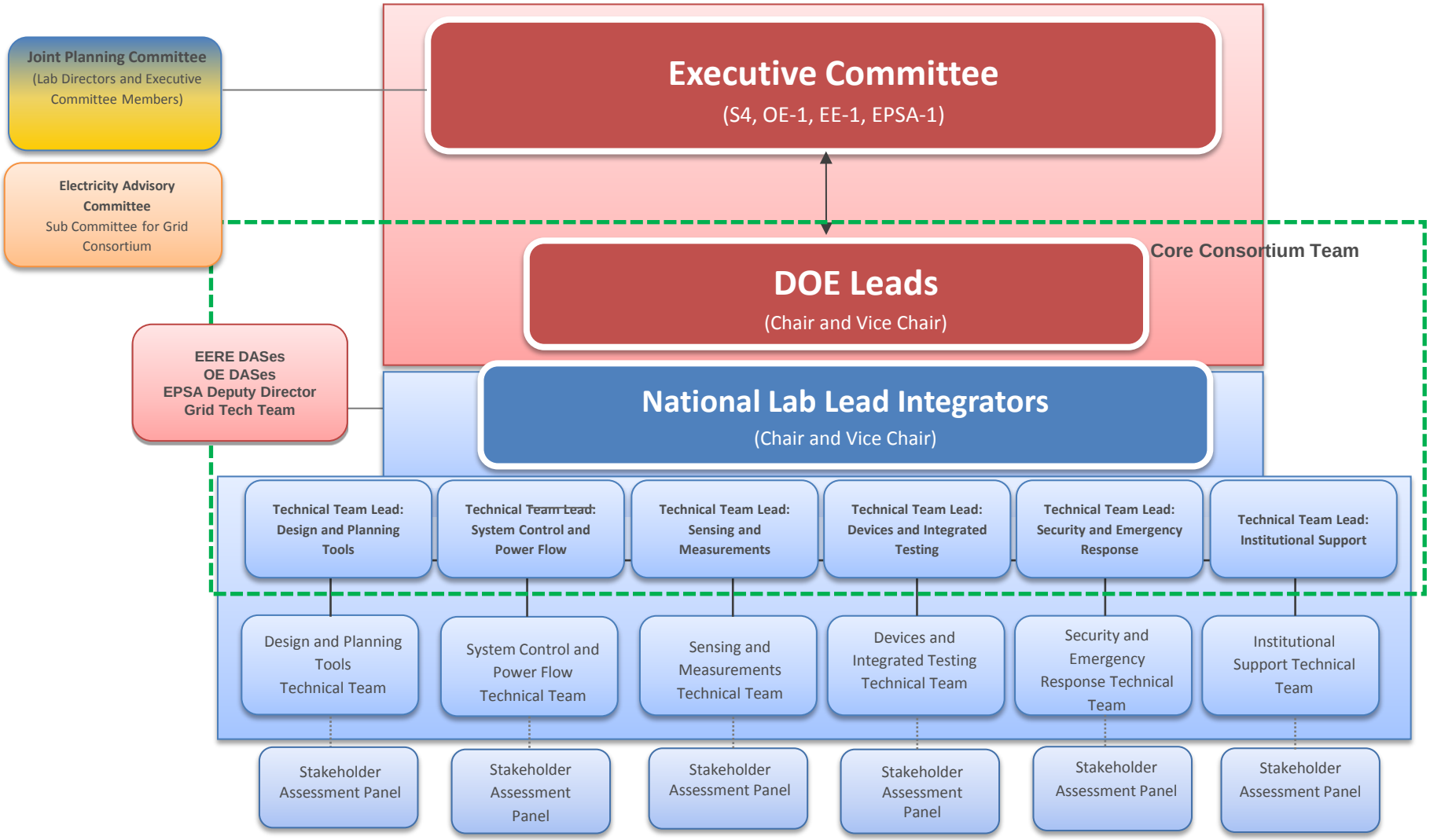
  > 33% decrease in cost of reserve margins while maintaining reliability

  > 50% cut in the costs of wind and solar and other DG integration

- If achieved, these three key outcomes would yield more than $7 billion in annual benefit to the U.S. economy

- In addition, our efforts will ensure the future modernized grid is a flexible platform for innovation by entrepreneurs and others who can develop tools and services to empower consumers and help them make informed energy decisions.

Grid Modernization Laboratory Consortium



Devices and Integrated Systems

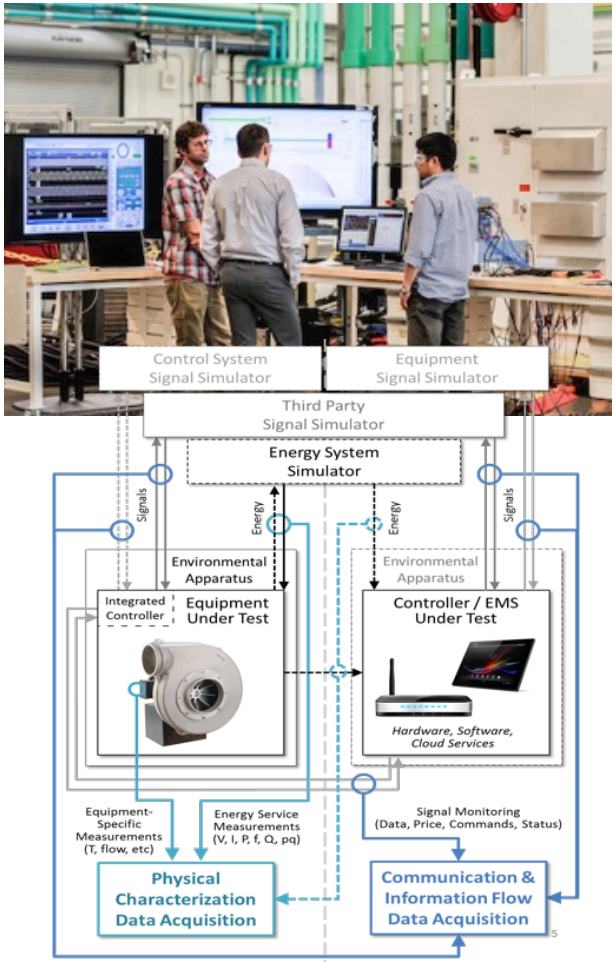
Characterization and testing of energy technologies for providing grid services to improve system affordability, reliability and clean energy use

Expected Outcomes

- Develop new grid interface devices to increase ability to provide grid services and utilization
- Coordinate and support the development of interconnection and interoperability test procedures for provision of grid services
- Validate secure and reliability grid operation with high levels of variable generation at multiple scales

Federal Role

- Common approach across labs and industry test-beds for effective validation of emerging technologies
- Develop common interoperability and interconnection standards and test procedures for industry / vendor community



Sensing and Measurements

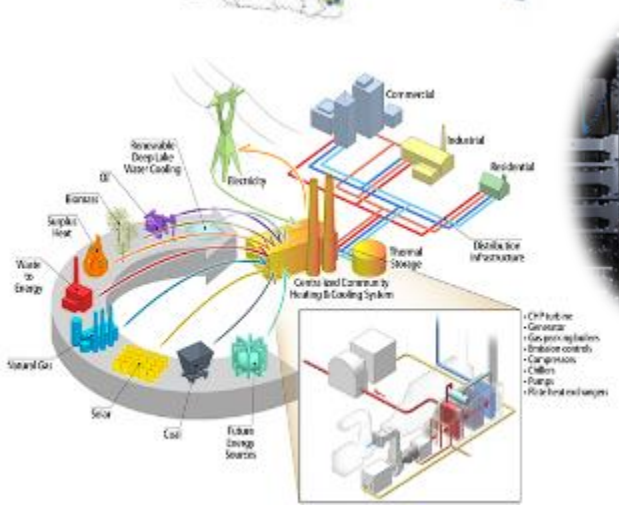
Sensor development and deployment strategies to provide complete grid system visibility for system resilience and predictive control

Expected Outcomes

- Advance and integrate novel, low-cost sensors to provide system visibility
- Incorporate new data streams (e.g. weather
- Develop real-time data management and data exchange frameworks that enable analytics to improve prediction and reduce uncertainty
- Develop next-generation sensors that are accurate through disturbances to enable closed-loop controls and improved system resilience

Federal Role

- Common approach across labs and industry test-beds for effective validation of emerging technologies
- Develop common interoperability and interconnection standards and test procedures for industry / vendor community



System Operations and Power Flow

Advanced real-time control technologies to enhance the reliability and asset utilization of transmission and distribution systems

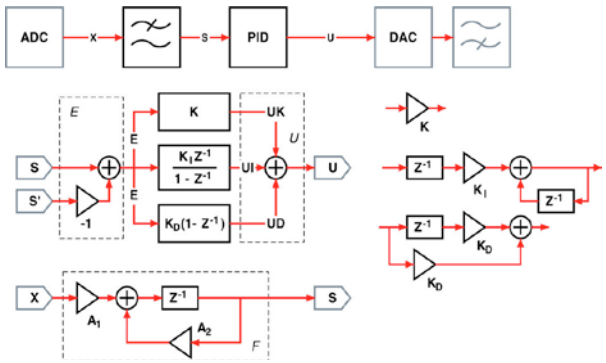
Expected Outcomes

- Deliver an architecture, algorithms, and next-gen control framework for a clean, resilient and secure grid
- Third generation of operations software platform for predictive operations & real-time adaptive control
- New class of power flow control device hardware and concepts
- Advance fundamental knowledge for new control paradigms

Federal Role

- Convening authority to shape vision of advanced grid architecture
- Advance fundamental knowledge for new control paradigms for emerging grid to support industry transformation
- Deliver computational science, materials science & mathematics from Natl. Lab System to develop integrated faster-than-real-time software platforms and power electronics control schemes

Conventional *controls*



Distributed *controls*

Design and Planning Tools

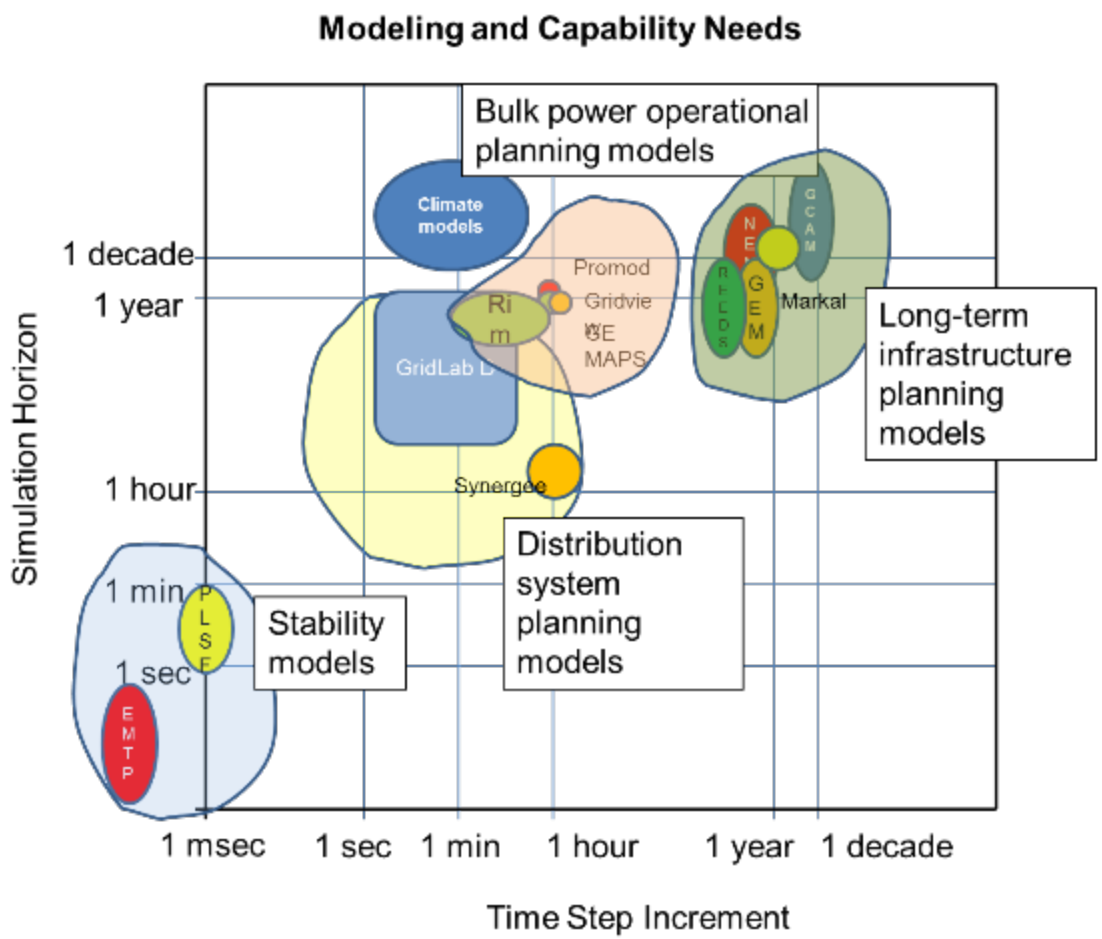
Drive next generation of tools to accurately perform cost-benefit trade-offs and improve reliability of design for deployment new smart grid and renewables

Expected Outcomes

- Incorporate uncertainty and system dynamics into planning tools to accurately capture effects of renewable generations
- Computational tools, methods and libraries that enable 1000X improvements in performance for analysis and design
- Coupling grid transmission, distribution, and communications models to understand cross-domain effects

Federal Role

- Apply Natl. Lab advanced computing expertise and capabilities to develop new tools for stakeholder utilization



Security and Resilience

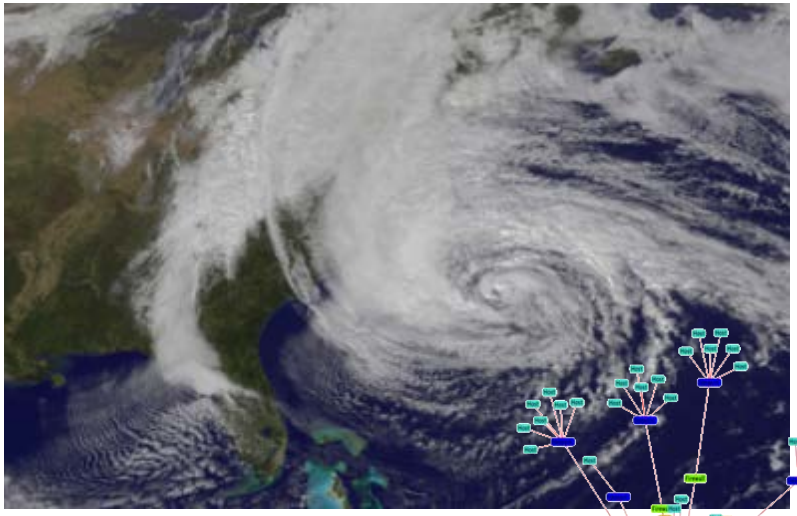
Providing a pathway to holistic and comprehensive security and resilience for the nation's power grid

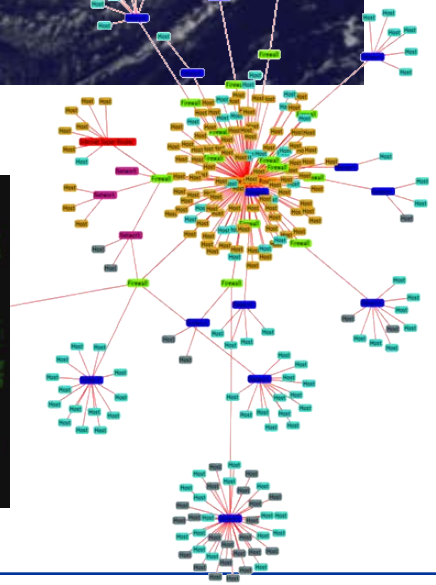
Expected Outcomes

- Holistic grid security and resilience, from devices to micro-grids to systems
- Inherent security designed into components and systems, not security as an afterthought
- Security and resilience addressed throughout system lifecycle and covering the spectrum of legacy and emerging technologies

Federal Role

- Lead and establish security and resilience research programs to develop technology solutions and best practice guidance
- Improve adoption of security and resiliency practices, and provide technology-neutral guidance
- Inform stakeholders of emerging threats and help address threats appropriate for government response





Institutional Support

Enable regulators and utility/grid operators to make more informed decisions and reduce risks on key issues that influence the future of the electric grid/power sector

Expected Outcomes

- Accelerated state & federal policy innovation due to enhanced State and Regional technical assistance
- States adopt changes to their regulatory model that better align utility interests with grid modernization and/or clean energy policy goals
- Methods for valuation of DER technologies and services are defined and clearly understood by stakeholders to enable informed decisions on grid investments and operations

Federal Role

- Provide independent, unbiased technical assistance (e.g., information and analysis tools) that address key grid-related policy, regulatory, and market issues
- Create an over-arching stream of grid-related "institutional" analysis, workshops, and dialogues to raise awareness of the need for grid modernization

Outputs to Deliver Outcomes

> 10% reduction in the societal costs of power outages

- Deliver new grid architecture that enable controllability across emerging fleet of microgrids and end use devices
- Deliver next gen sensing and data management platforms that enable full system visibility for adaptive wide area control
- Deliver new control theory and algorithms to enable adaptive measurement based control and faster restoration
- Deliver real-time N-K contingency tools to inform and predict outages in the face of threats

Outputs to Deliver Outcomes

> 33% decrease in cost of reserve margins while maintaining reliability

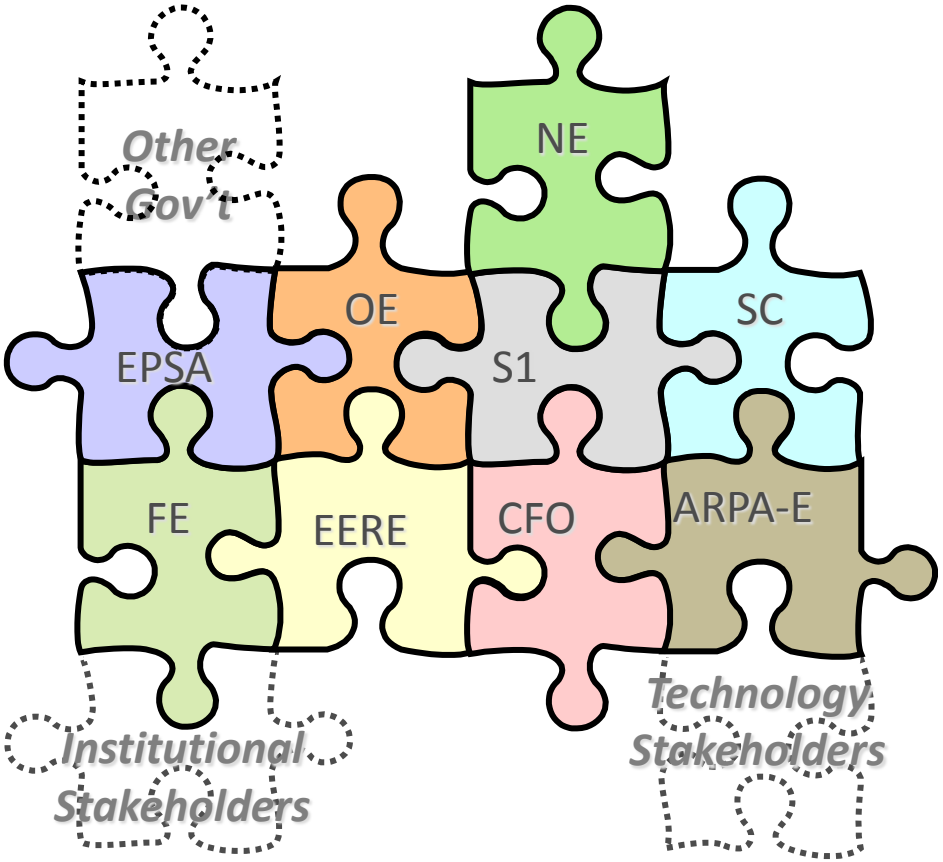
- Deliver a next gen EMS/DMS platform with attributes enabling HPC implementation, algorithms that handle uncertainty, and co-coordination across transmission and distribution
- New grid architecture that enables real-time wide area controls NOT dependent on traditional contingency analysis
- Ultra-fast state estimation (< 1sec) and state measurement to arm real-time controls
- Sensing and data management to enable real-time model validation of distribution circuits under high penetrations of microgrids and distributed resources
- Demos at LSE and balancing area levels to validate concepts

Outputs to Deliver Outcomes

> 50% cut in the costs of wind and solar and other DG integration

- Deliver next gen EMS/DMS platform with controllability to engage responsive loads in balancing variable gen (HPC, full system transparency for model validation and restoration)
- Planning tool platform with HPC and capacity to handle uncertainty to enable fast, risk-based planning at industry and state levels
- Deliver power flow devices (power electronics) to enable flow management at T and D levels to mitigate need for system transmission expansion
- Define and evaluate alternate market-based control concepts that enhance efficiency of variable gen integration

Grid Modernization Initiative

An aggressive grid modernization strategy for the Department of Energy that includes

- Alignment of the existing base activities among the Offices
- An integrated Multi-Year Program Plan (MYPP)
- New activities to fill major gaps in existing base
- Development of a laboratory consortium with core scientific abilities and regional outreach