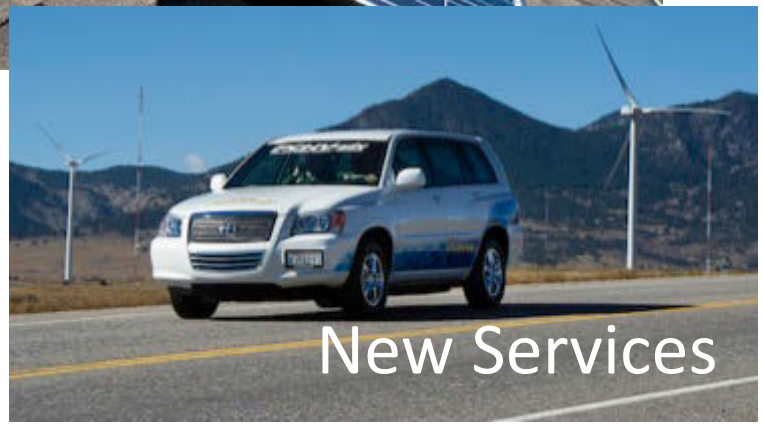
Grid Modernization Initiative

March 2015

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

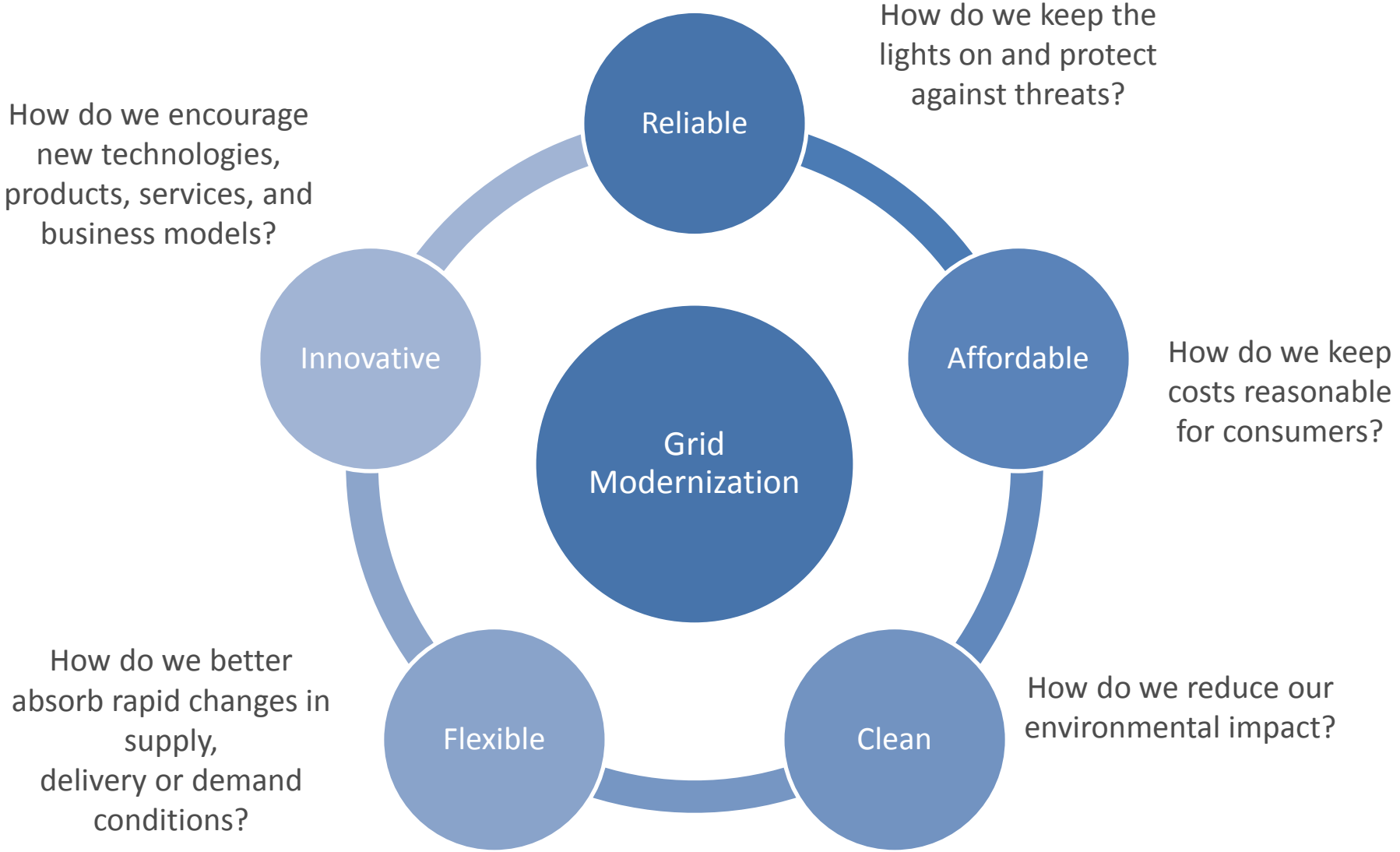
Sustain Economic Growth and Innovation

- 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

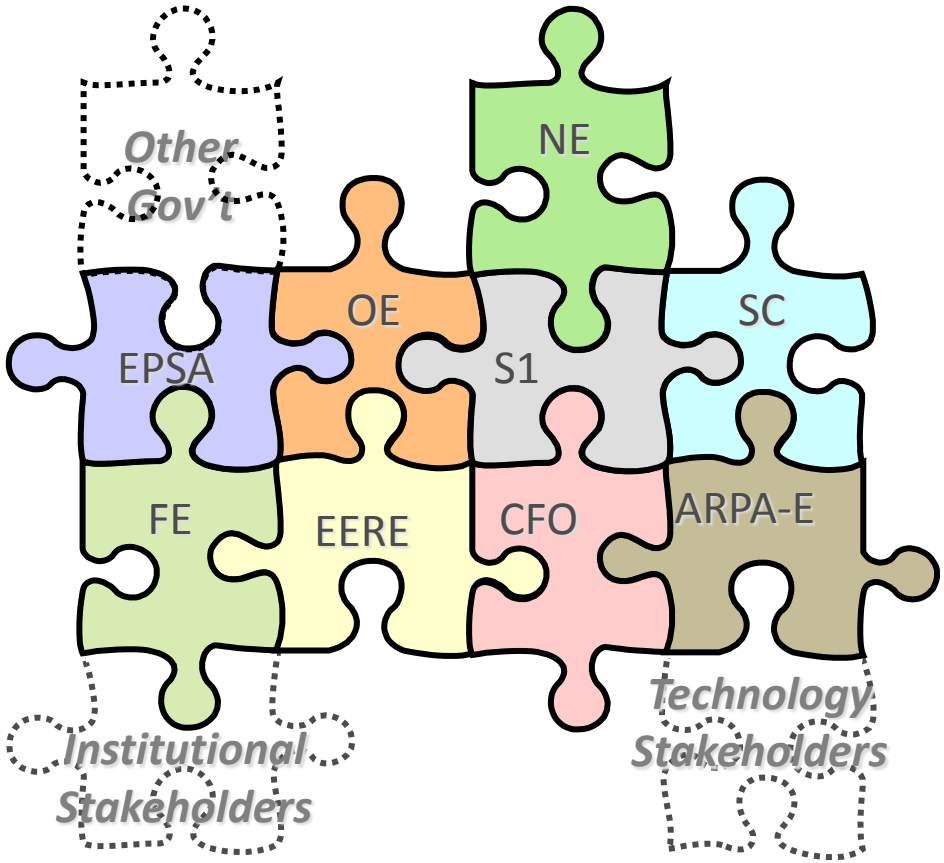
Key Attributes of a Modernized Grid



Grid Modernization Initiative

An aggressive five-year 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



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.

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

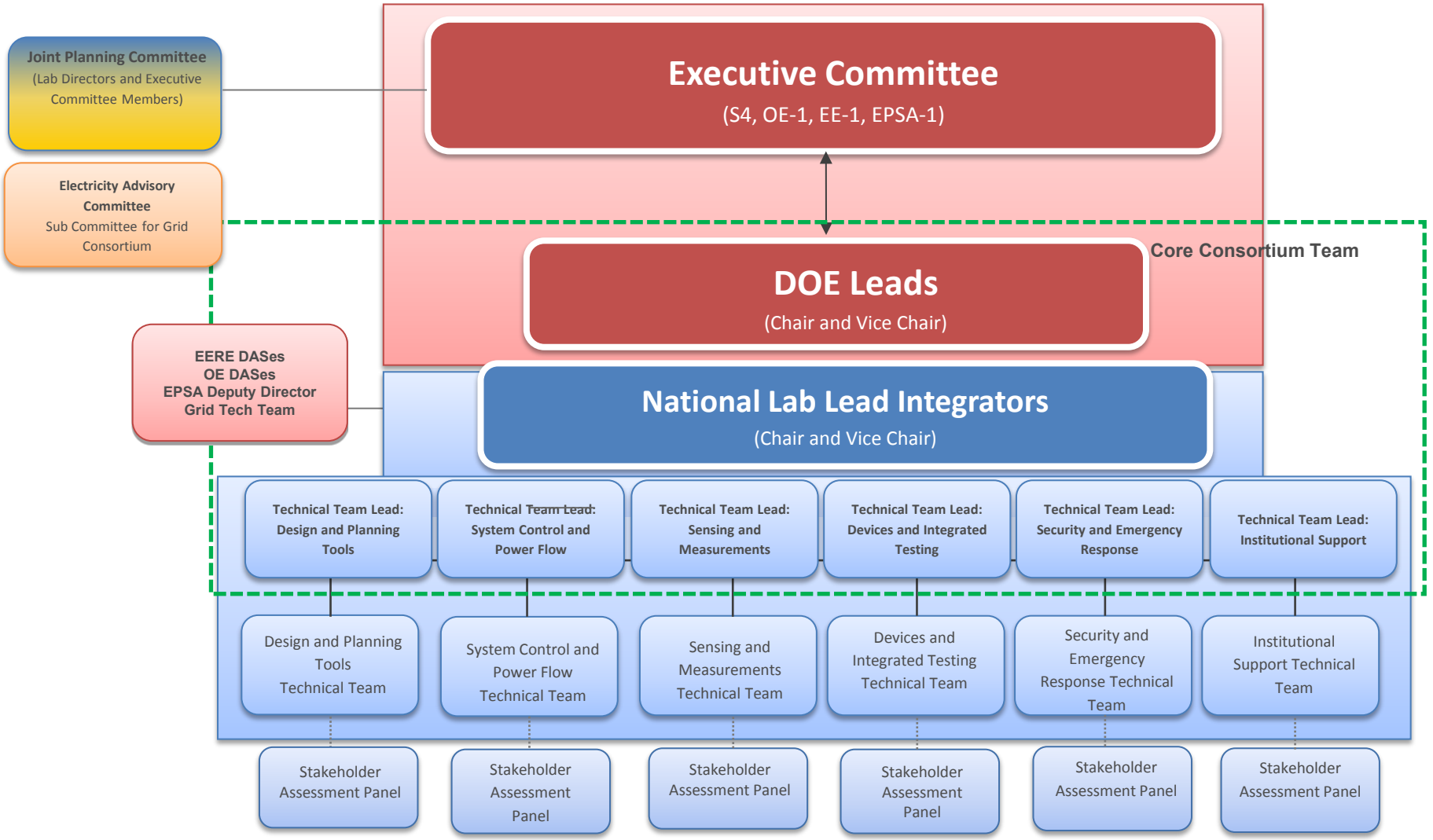
- Deliver next gen EMS/DMS platform with controllability to engage responsive loads in balancing variable gen (HPC, full system transparency for model validation and restoration)
- Planning tool platform with HPC and capacity to handle uncertainty to enable fast, risk-based planning at industry and state 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

Implementation

We will accomplish this by

- Coordinating grid related research across the DOE, better leveraging the $300 million DOE funding (FY2015 request, actuals being assessed)
- Using the Grid Modernization Laboratory Consortium to coordinate the existing $100M+ in activities of the National Labs associated with grid research into a single, efficient and well coordinated portfolio
- Prudently applying DOE investment in Grid Modernization over the next five years and directing these new resources into gaps identified as part of a new Grid Modernization Multi-Year Program Plan (MYPP); and
- Supporting regional, state, and local groups of stakeholders from industry, academia, communities, and local regulators, that will help translate the tools and knowledge from Grid Modernization R&D into actual deployments of modernized grids.

Grid Modernization Laboratory Consortium



Charge to Technical Teams

1. Develop a multi-year program plan for grid modernization through a collaborative laboratory effort combined with DOE HQ strategic direction and outside support from industry, academia, states, consumers and other affected parties;

2. Recommend areas of improved coordination across Offices in the FY15 AOP based on the work breakdown structure (WBS);

3. Propose a holistic, grid modernization AOP for FY16 that cuts across all DOE Offices in conjunction with DOE programs;

4. Establish a DOE-Lab culture that builds on collaboration, inclusivity, transparency and communication across the entire grid portfolio.

FY 2015 Schedule

Activities	Nov/ Dec 2014	Jan 2015	Feb 2015	Mar 2015	Apr 2015	May 2015	Jun 2015	Jul/ Aug 2015
Grid Modernization Laboratory Consortium Kickoff • Hosted by S4, EE-1, OE-1 • Attended by ~70 Lab Members representing the 6 technical areas • Start of the Grid Modernization Multi-Year Program Plan (MYPP)								
First Draft of the Grid MYPP • Lab Leads present the first draft of the MYPP to the Directors at DOE • Meetings between Lab Team Leads and Program Directors across OE, EERE, and EPSA								
Draft Grid MYPP Released for Public Comment								
Outreach and Workshops with External Stakeholders								
Grid Modernization Multi-Year Program Completed								
Framework for DOE-wide FY16 Grid Annual Operating Plan • Based on Grid MYPP, start developing an AOP across DOE and the National Laboratory complex								
Write Body DOE-wide Grid Annual Operating Plan for FY16								
Grid Modernization Summit								

Accomplishments to Date

DOE Business Model Transformation

- Six Lab Technical Teams have been established and are working effectively since the November 6 launch
- GMLC developed rev 1 messaging for DOE program engagement during the week of January 19
- EAC positively engaged and examining adjustments to its agenda to enhance engagement
- Initial discussions with selected stakeholders indicate significant interest and willingness to engage
  - NRECA and EPRI
  - Senate National Lab Caucus staff
  - House Grid Caucus staff
  - One on One discussions

Accomplishments to Date

Programmatic Benefits

- Conducted first-ever AOP review across all DOE grid programs; identified FY15 program synergies to position for FY16 launch
- EERE/BTO and OE, 4 Labs established joint transactive control agenda
- EERE/BTO, OE and BPA framing a regional campus demonstration agenda and leveraging 50% cost share from WA State
- EERE/WWPTO/SETO/OE are working together on Eastern Renewable Generation Integration Study to understand the impacts of 30% wind and solar on the Eastern Interconnect
- EERE/WWPTO/SETO/OE are working together to research the implication of stochastic unit commitment on power system operations
- FE/WWPTO/OE are performing a fleet transition study to understand flexibility needs/capabilities in coal, nuclear, and gas generation
- Four labs developing a framework for federated testing and evaluation leveraging “best in class” physical and virtual assets for enhanced grid test and evaluation (INL, ORNL, PNNL and NREL)

BACKUP SLIDES

Sensing and Measurements

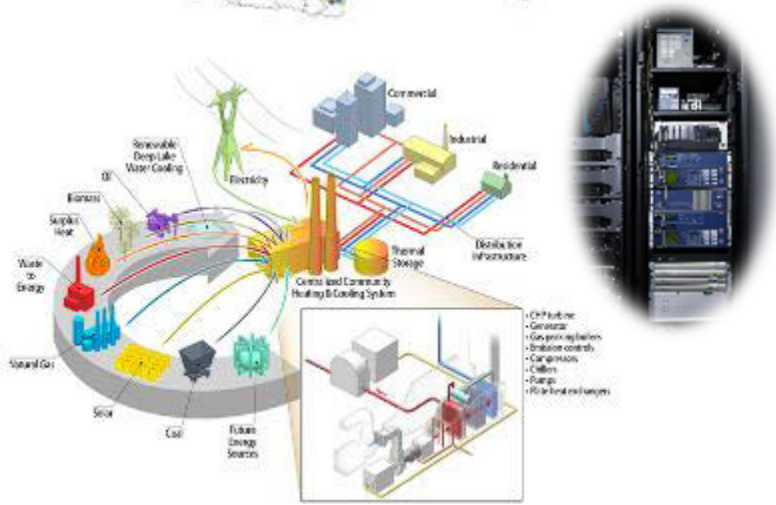
Sensor development and deployment strategies to provide complete grid system visibility for system resilience and predictive control

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



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

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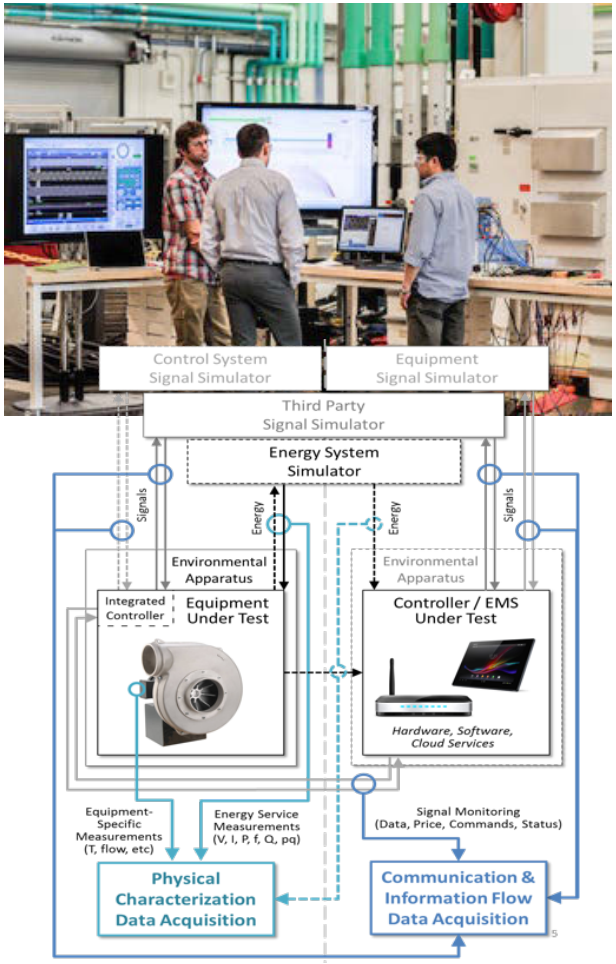


System Operations and Power Flow

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

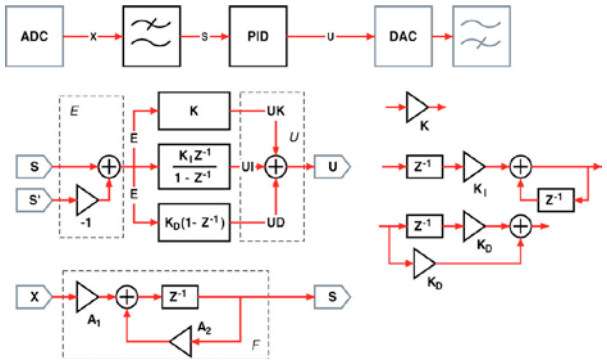
Expected Outcomes

- 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

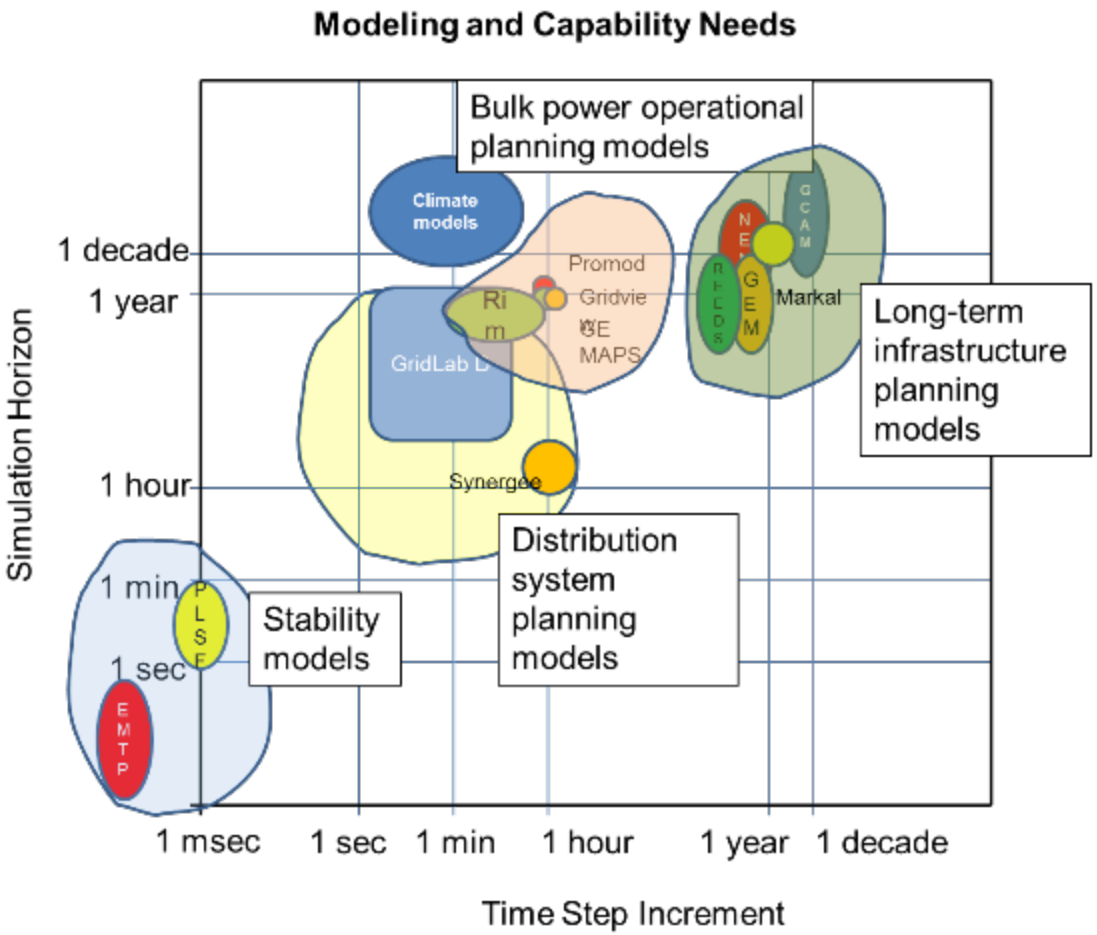
Drive next generation of tools to accurately perform cost-benefit trade-offs and improve reliability of design for deployment new smart grid and renewables

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