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Filer:	Doris Yamamoto
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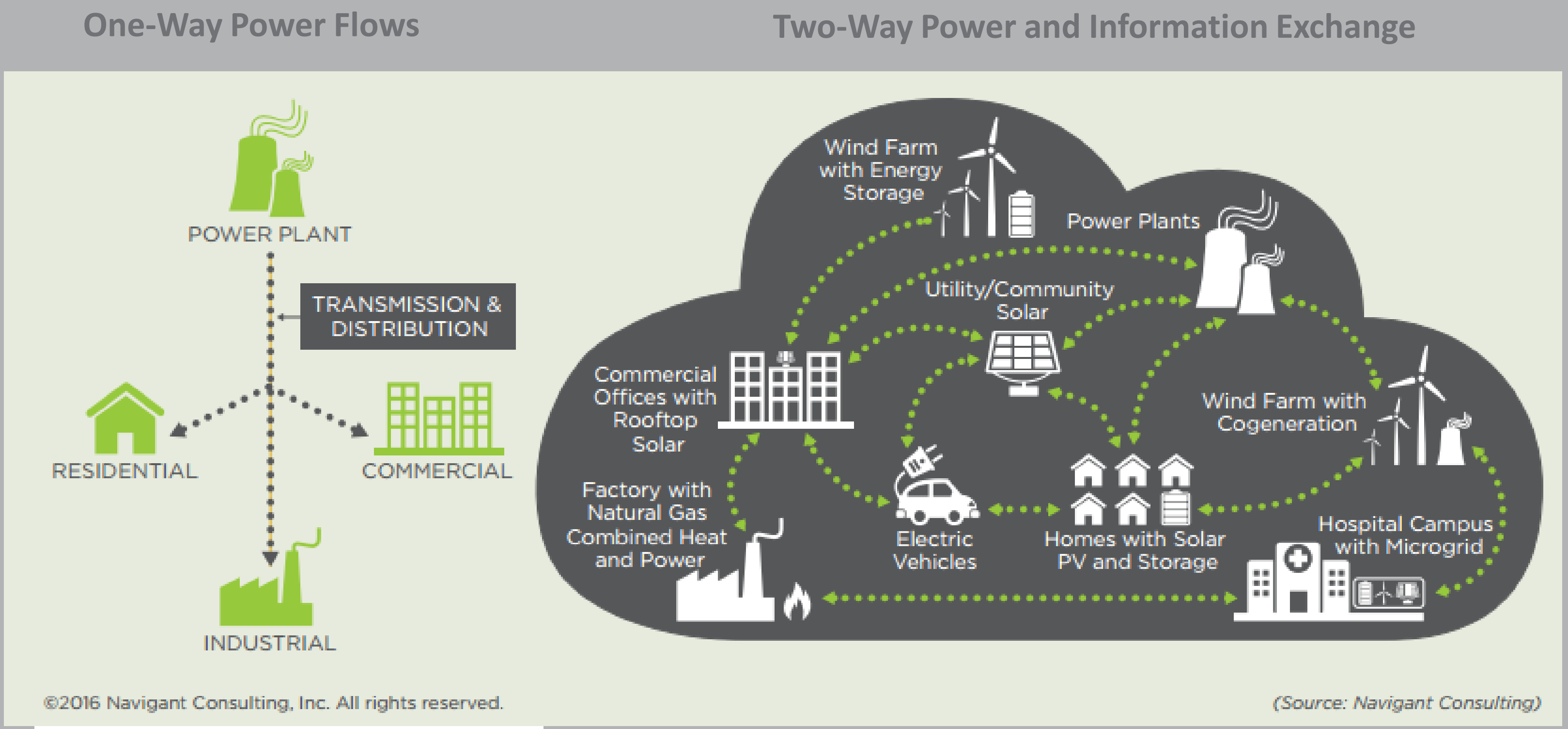
Grid Modernization Update

WILLIAM PARKS, CHAIR GMLC
U.S. DEPARTMENT OF ENERGY

JOHN GROSH, GMLC LEAD FOR DESIGN AND PLANNING TOOLS
LAWRENCE LIVERMORE NATIONAL LABORATORY

March 13, 2017

The Nation is facing an increasingly dynamic electricity system that demands solutions to efficiently match supply and demand.



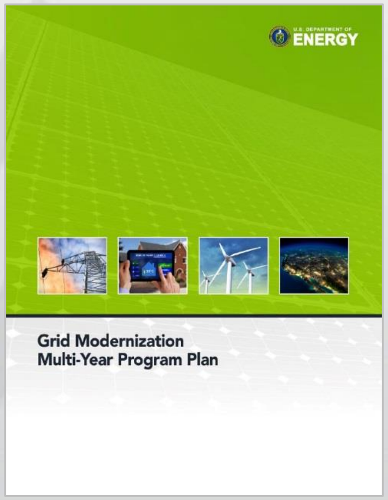
- Large, centrally located generation facilities
- Designed for one-way energy flow
- Utility controlled
- Technologically inflexible
- Simple market structures and transactions
- Highly regulated (rate base) and pass through

- Distributed energy resources
- Multiple inputs and users, supporting two-way energy flows
- Digitalization of the electric-mechanical infrastructure: smart grid and behind the meter energy management systems
- Flexible, dynamic, and resilient
- Complex market structures and transactions
- Regulation changing rapidly around renewables, distributed generation (solar, micro-grid, storage), net metering etc.

NAVIGANT

Grid Modernization Initiative Approach

- Devices and Integrated Systems
- Sensing and Measurement
- System Operations and Control
- Design and Planning Tools
- Security and Resilience
- Institutional Support



MYPP Integrated Technical Thrusts

Technology Innovation

Thrust	Description
Design and Planning Tools	• Create grid planning tools that integrate transmission and distribution and system dynamics over a variety of time and spatial scales
System Operations, Power Flow, and Control	• Design and implement a new grid architecture that coordinates and controls millions of devices and integrates with energy management systems
Sensing and Measurements	• Incorporates information and communications technologies and advances low-cost sensors, analytics, and visualizations that enable 100% observability
Devices and Integrated Systems	• Develop new devices to increase grid services and utilization and validate high levels of DER at multiple scales
Security and Resilience	• Develop resilient and advanced security (cyber and physical) solutions and real-time incident response capabilities for emerging technologies and systems
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

Grid Modernization Laboratory Consortium

Move from a collection of DOE and lab projects to a DOE-Lab Consortium Model that integrates and coordinates laboratory expertise and facilities to best advance DOE Grid Modernization goals.

Efficiency, Synergy, Collaboration, Acceleration

Grid Modernization Lab Call

- New Grid Modernization Crosscut enacted in FY16 at $296M (+$105M)
  - Structure and content reflected MYPP
  - Codified DOE and Lab roles and responsibilities per GMLC Charter
- DOE issued Lab Call July 2015
  - “Foundational” projects to be administered by GMLC
  - “Regional Partnerships” to address specific regional challenges
  - “Program-Specific” projects per usual FOA process
- Full proposals submitted September 2015
  - Multi-Lab teams, over 100 industry/academic partners
- MYPP released, Lab Call awards announced January 2016
  - 88 projects, $220M in new funding over FY16-18

A Sample of Our Project Partners

ALASKA ENERGY AUTHORITY
Department of Energy Federal Energy Regulatory Commission
U.S. Department of Homeland Security
Public Utilities Commission State of California
United Technologies
NERC North American Electric Reliability Corporation
GE
NIST
EPRI Electric Power Research Institute
OMNETRIC Group A Siemens & Accenture Company
National Association of Regulatory Utility Commissioners
SGIP Smart Grid Interoperability Panel
California ISO
GRIDWISE
epb
IEEE
GSA
IEC Independent Electrical Contractors
NRECA
TRANE
NM State University
Georgia Tech
PSERC
TVA
Southern Company
BURNS McDONNELL
Kentucky.gov
CLEMSON UNIVERSITY
OSIsoft.
Entergy
nyserda Energy. Innovation. Solutions.
City of New Orleans Louisiana
Dominion
ComEd.
EIPC Eastern Interconnection Planning Collaborative

Grid Modernization Activities: Working Across the Country

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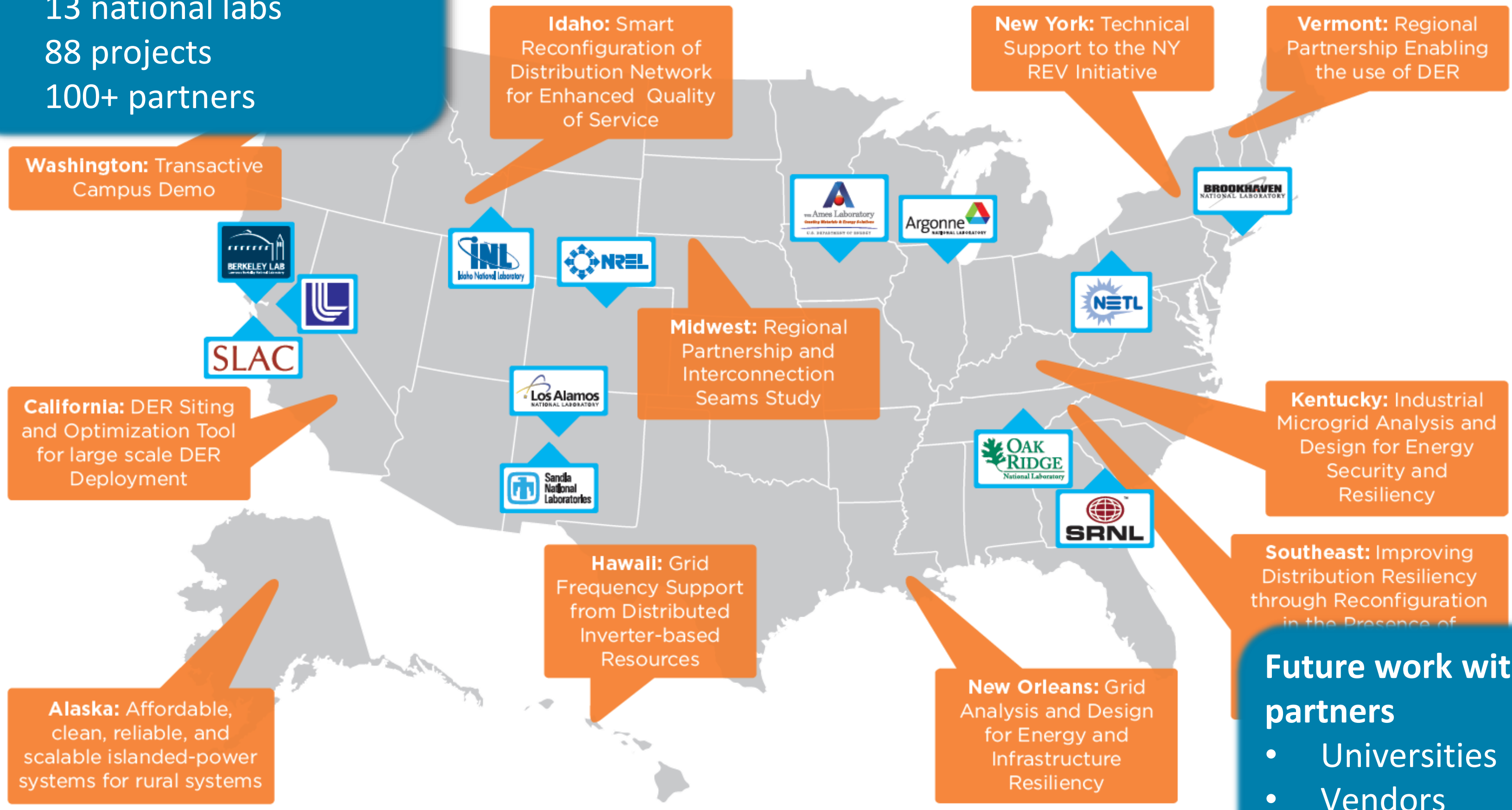
U.S. Department of Energy

Grid Modernization Lab Call

- $220M
- 13 national labs
- 88 projects
- 100+ partners



Future work with other partners

- Universities
- Vendors
- Utilities
- National labs

Planning and Design Tools
Summary

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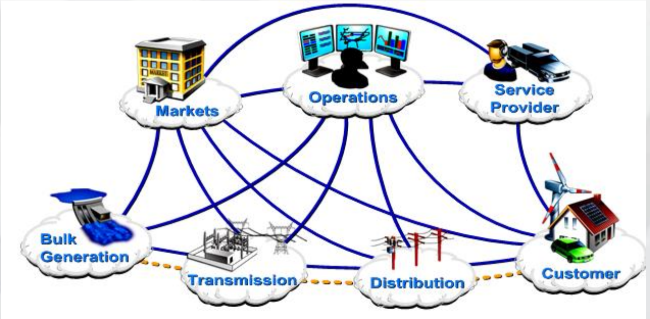
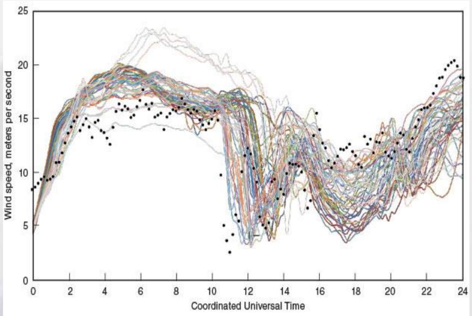
Goals:
- Drive industry and research community to develop next generation tools that address evolving grid needs

Approach:
- Develop scalable open source math libraries, computational methods, and innovative planning and design tools
- Work with software vendors to help integrate new methods into commercial and open source products
- Partners with utilities, ISOs, RTOs, and PUCs to focus research and demonstrate value

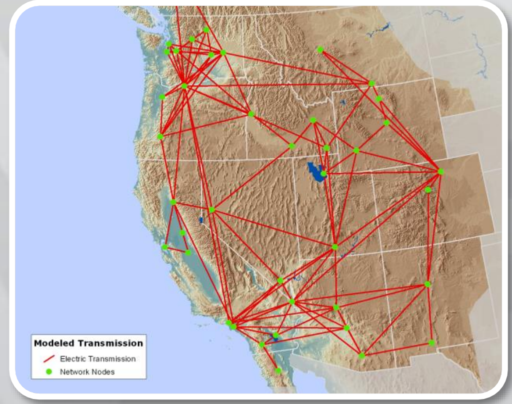
Challenges



Simulating Interactions Across Domains



Modeling Uncertainty

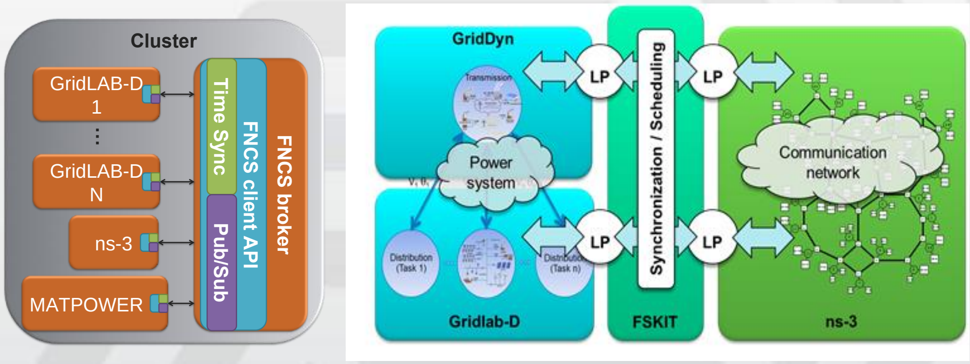


Increasing Resolution, Fidelity, and Time Window

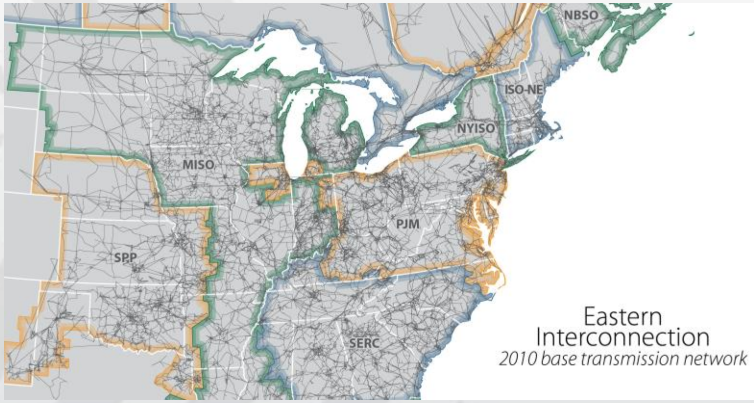
Time to Solution

Foundational Projects

Design and Planning Tools



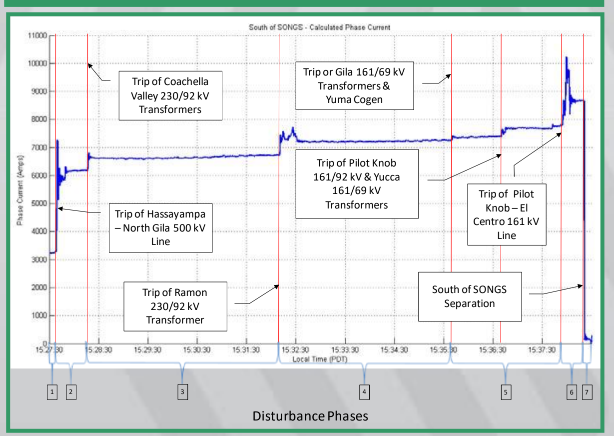
1.4.15 - Development of Integrated Transmission, Distribution and Communication Models (Lead: PNNL)



1.4.26 – Development of Multi-scale Production Cost Simulation (Lead: NREL)

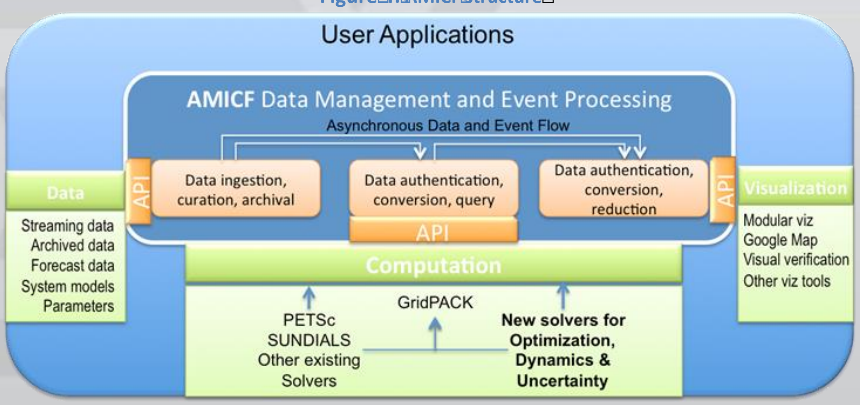
Arizona / So Cal Outage FERC/NERC April 2012

Figure 4: Seven Phases of the Disturbance



1.4.17 - Extreme Event Modeling (Lead: LANL)

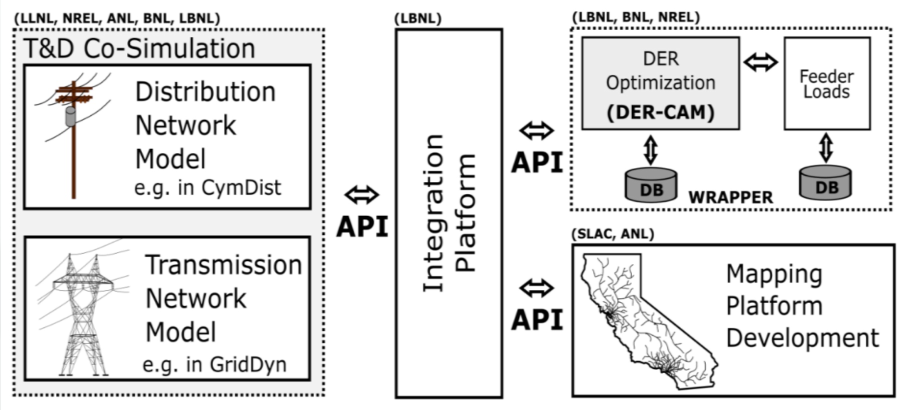
Figure 4: AMICF structure



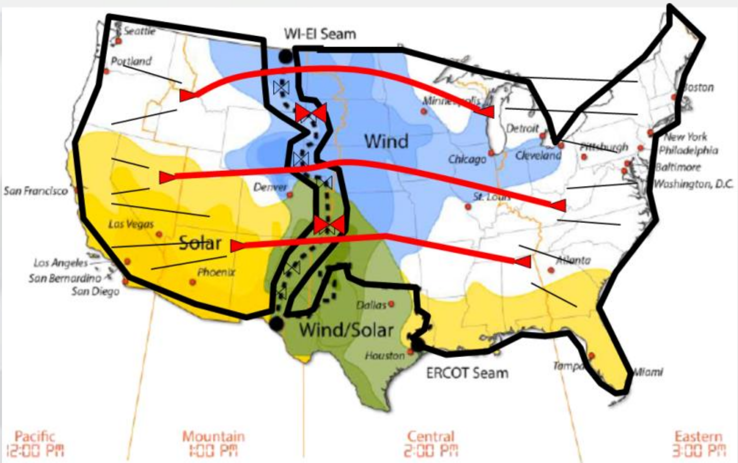
1.4.18 - Computational Science for Grid Management (Lead: ANL)

Regional Demonstration Projects

Design and Planning Tools



1.3.05 DER Siting and Optimization Tool for California (Lead: LBNL and LLNL)



1.3.33 Midwest Interconnect Study (Lead: NREL)

1.3.21 Alaska Microgrid Partnership (Lead: NREL)

DER Siting and Optimization tool for California

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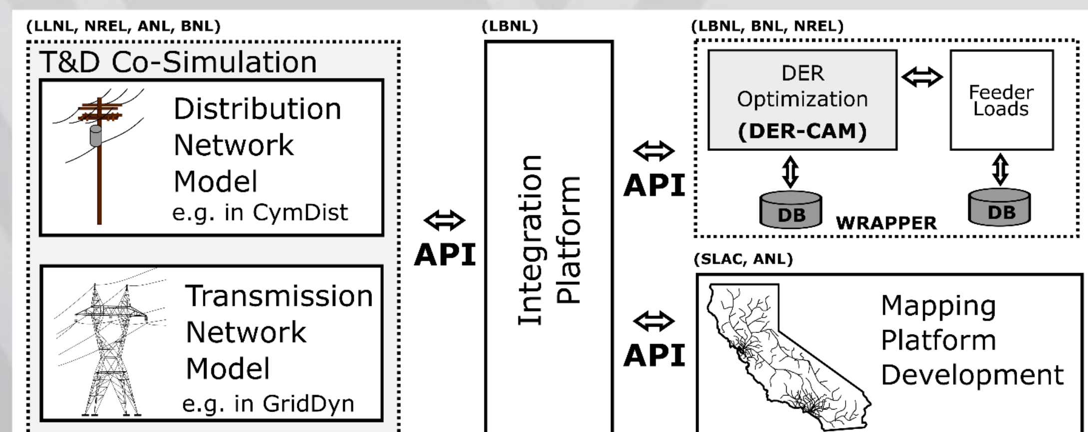
California is moving rapidly towards very aggressive DER implementation: 15GW by 2020

<u>Need for robust distribution planning tools</u>

Project Description
Prototype framework for integrated **distributed resource planning and optimization tool** able to identify **DER adoption** patterns, **microgrid sites**, and evaluate **DER impacts** on the distribution and transmission grid.

Project Participants and Roles
LBNL, LLNL, SLAC, NREL, BNL, ANL
+
CPUC, PGE, SCE, External Advisory Committee

<u>Expected Outcomes</u>
- ✓ DER penetration patterns and operational strategies
- ✓ identify sites with economic potential for microgrid/DER
- ✓ address policy incentives and value of DER as grid assets
- ✓ consider network constraints in the DER location problem
- ✓ evaluate impacts of DER on the bulk electric grid system
- ✓ California as starting point for wider application (e.g NY)



Project Summary: Distribution System Decision Support Tool Development and Application

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Project Description
Identify strategies and provide technical assistance to state regulators and utilities that focus on advanced electric distribution planning methods and tools, with a focus on incorporating emerging grid modernization technologies and significant deployment of DER

Expected Outcomes

- ✓ Develop training course(s) for state PUCs on emerging issues in distribution system planning in partnership with NARUC
- ✓ Identify Gaps in Existing and Emerging Planning Practices & Approaches
- ✓ Review & analyze existing planning tools, identify gaps and make recommendations

Project Participants and Roles
Michael Coddington – NREL (Utility Practices)
Lisa Schwartz – LBNL (TA to state PUCs)
Juliet Homer – PNNL (Tools & Regulatory)

Project Summary: Functional Requirements for a Distribution System Platform

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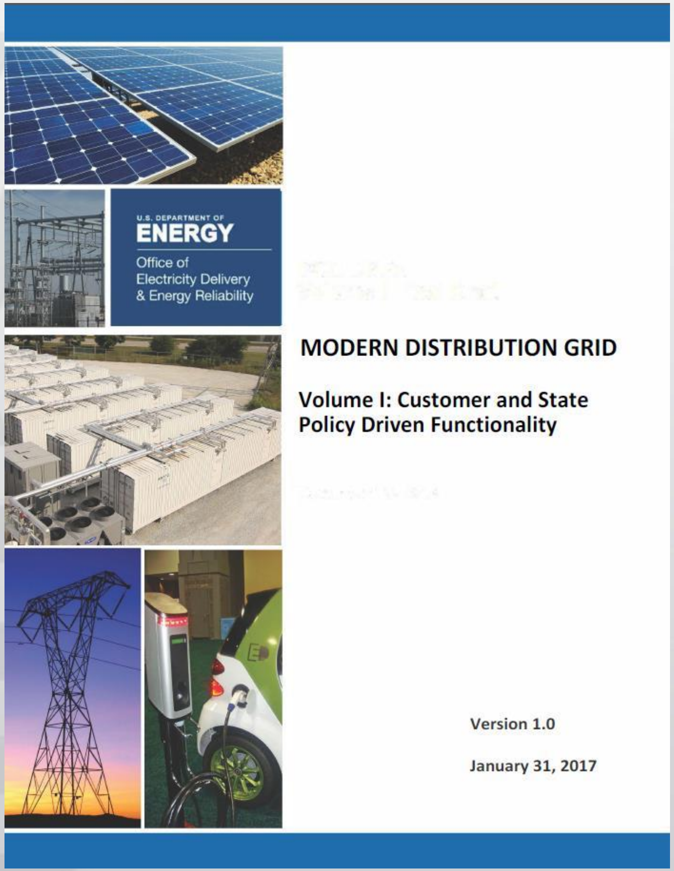
- DOE and the national labs are working with CPUC, CA utilities, technology developers and service providers to determine the functional requirements for a next-generation distribution system (DSPx) that would enable the full participation and value realization of DERs. Phase 1 (complete by May 2017) includes:
  - Mapping state policy objectives to grid capabilities and functions needed to support planning, grid operations, and market operations, and develop a consistent taxonomy of terms (Volume 1)
  - Determining the maturity of analytical capabilities and tools needed to enable the functions (Volume 2)
  - Applying systems architecture to identify core technologies/systems and other considerations to enable rational implementation of DSPx functionality (Volume 3). For example, providing guidance for implementing:
    - Integrated distribution system planning
    - Operational communications networks
    - DER aggregation and operational coordination

- Phase 2 (2017 and beyond) includes:
  - Working with state commissions, industry experts and the national labs to develop and implement a strategy to address gaps in the needed analytical capabilities and tools
  - Applying DSPx concepts to assist targeted regulatory decision processes
  - Developing a reference manual for implementing coordination and communication frameworks and other reference materials



See www.doe-dspx.org

Other Grid Modernization Initiative activities related to California interests

Energy Storage

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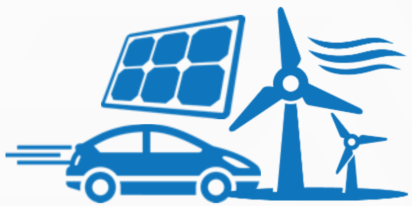
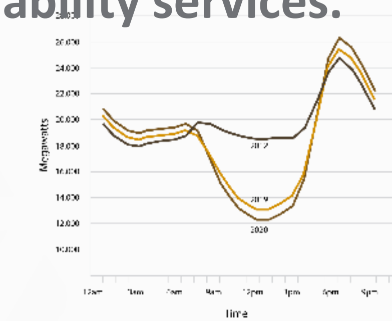
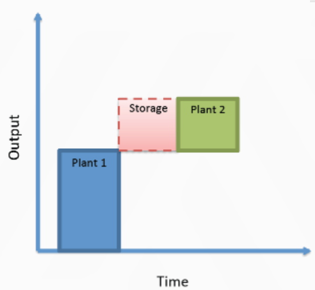
A breakthrough in grid-scale energy storage would unlock a wide variety of new grid reliability services.



The installation of variable generation sources places a strain on grid reliability.



Significant ramping events could cause energy disruptions.



Market driven uptake in demand response services is seeking low cost solutions.

The grid could be more flexible to allow it to improve resilience and maintain efficiency, while remaining generation neutral.

Advanced Power Grid Components

Power grid components are costly to replace, aging rapidly, and potential targets for malicious actors.

Grid components are reaching a critical point of increasing asset retirement.

Consumer demand for reduced disruptions after major weather events is on the rise.

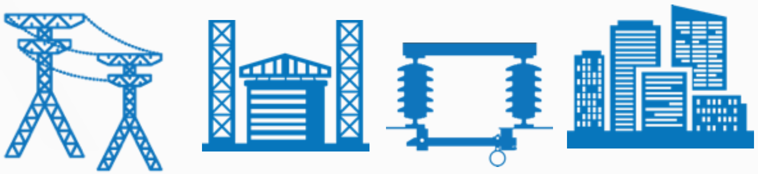
Policy makers are seeking opportunities for added resilience and physical, cyber, and natural threats.

Electricity disruptions are getting more expensive with the increased interdependence of major infrastructure.

Advanced Distribution Controls

The current grid does not know enough about the new technology that is being attached to it.

Significant additions of distributed energy resources could threaten grid reliability.



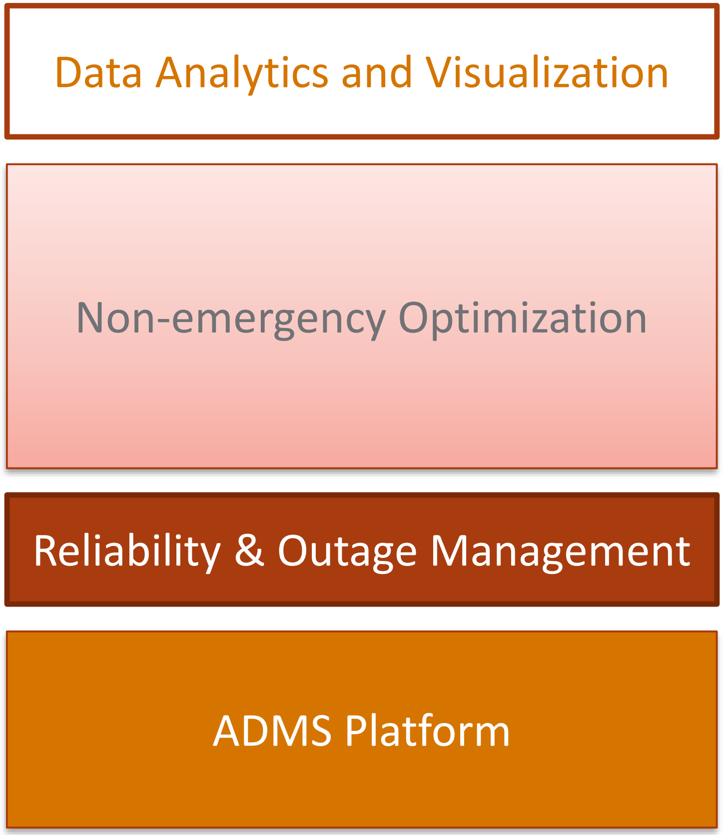
Unsynchronized connection among systems on the grid hurts efficiency.

Increased customer participation and consumer energy management opens new low-cost opportunities.

Interaction of new systems and new technologies adds complexity.

ADC Applications

Develop an integrated suite of ADMS applications that includes non-emergency optimization, reliability and outage management, as well as data analytics and visualization.



- **Non-emergency optimization:** Voltage and VAR Optimization, Distributed Energy Resource Management, Demand Response, and transactive energy
- **Reliability and Outage Management:** Fault Location, Isolation, and Service Restoration, Workforce management, risk-based tools, predictive maintenance, reliability-as-a-service
- **Data Analytics and Visualization:** State estimation, load/distributed generation forecasting, switch plan management, and analysis tools based on sensors

Transactive Energy

Information and communication technology is not leveraging the potential of economic incentives to reduce grid operation costs.

The flexibility of distributed energy resources are not accessible enough in traditional control systems.

Current operational models are not capturing the efficiency potential of new technology.

Energy management systems and building operations are missing out on additional revenue streams.

Traditional utility models are not fully capturing potential new sources of cost recovery.

Microgrids

The current grid needs more redundancy to protect critical infrastructure and open new value streams.

Critical infrastructure is vulnerable to major disruptions.

Grid infrastructure should be neutral to generation sources while maintaining system reliability.

Intentional physical attacks could cause major damage.

Customers are seeking new opportunities to provide grid services to operators and tenants.

Advanced Grid Modeling

The deployment of new technology opens the opportunity to leverage data science to unlock grid system efficiencies for improved reliability and security.

Third party vendors and distributed energy resources are capturing and producing valuable grid data.

Grid operation decision-making has not utilized new analytical tools or big data modeling power.

Grid operators do not have enough understanding of the effect that rapid technology deployment has on the system.

Utilities and regulators need standardized data and grid models to utilize into their operational and planning decision-making processes.

Cybersecurity for Energy Delivery Systems (CEDS)

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Long- Term, Foundational Projects

- Core and Frontier National Laboratory Research Program
- Academia Projects

Mid-Term Projects

- National Laboratory Led Projects

Shorter-Term Projects

- Energy Sector Led Projects

Partnerships

GOAL: Transition R&D to Practice in the Energy Sector

- Funds innovative R&D in areas critical for national security where the industry lacks a clear business case
- Builds R&D pipeline through partnerships with energy sector utilities, suppliers, universities and national laboratories

- **Successfully transitioned more than 30 tools and technologies used TODAY** to better secure U.S. energy infrastructure
- **Over 990 utilities in 50 states have purchased technologies developed by CEDS**

Regional Demonstrations

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The core technologies, tools, and analyses that will be developed in the six technical areas will feed into Integrated Regional Demonstrations designed to accelerate research outputs to widespread deployment. Three specific types are envisioned:

Lean Reserve Bulk Power Systems

Goals:

- Reliable operations with <=10% reserve margin;
  >33% variable wind, solar
- New capability for grid operators to leverage and manage distribution-level grid services
- Data-driven tools for precise, predictive real time grid operations

Target Partners:

- Transmission Utilities
- System Operators

Cleaner Distribution Systems

Goals:

- Demonstrate reliable and affordable feeder operations with >50% DER penetration
- Coordinated microgrid(s) control for resilience (20% fewer outages, 50% shorter recovery time)
- Distributed, hierarchical control for clean energy and new customer-level services

Target Partners:

- Distribution utilities
- Cities and municipalities with ambitious clean energy goals

Grid Planning and Analytics

Goals:

- Use coupled T&D grid planning models with 1000x speed-up to address specific grid-related issues
- Work with states to evaluate new business models, impacts of policy decisions

Target Partners:

- States and local regulators
- Distribution utilities
- New market participants

Grid Modernization Will Have National Impact

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Drivers of change

- Changing Electricity Supply Mix
- Threats to Resilience and Reliability
- New Market Opportunities for Consumers
- Information and Control Technologies
- Aging Infrastructure

MYPP

- Devices and Integrated Systems
- Sensing and Measurement
- System Operations and Control
- Design and Planning Tools
- Security and Resilience
- Institutional Support

Regional Demonstrations

- Low Reserve Margin Demo
- Clean Distribution Feeder
- Grid Analytics Platform

Modernized Grid

Our path to a modernized grid to power American leadership in the 21st Century