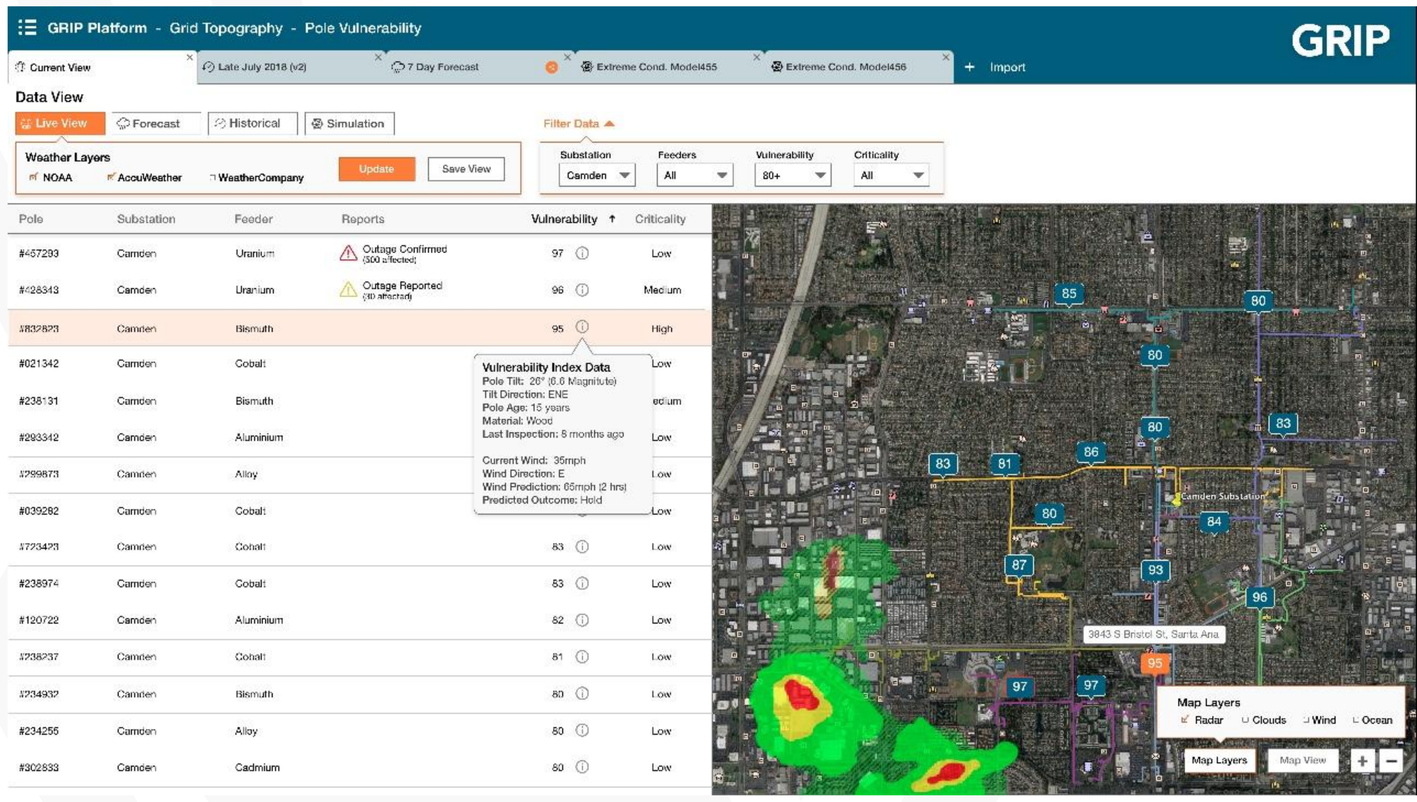
Grid Resilience & Intelligence Platform (GRIP)

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Project Description

In this project we will develop and deploy a suite of novel software tools to enable utilities to anticipate, absorb and recover from extreme events. The innovations in the project include application of artificial intelligence and machine learning for distribution grid resilience (ie. using predictive analytics, image recognition, increased “learning” and “problem solving” capabilities for anticipation of grid events).

Platform UI/UX



Expected Outcomes

- Develop an AI-enabled software platform that will significantly improve ability for utilities to anticipate, absorbs and recover from extreme events such as storms and cyber attacks.
- **Impacts**: Provides valuable insights to reduce recovery time during extreme events, more resilient architectures, improved operating procedures and better utility investment planning for resilient grid infrastructures and resources.

Significant Milestones	Date
Demonstrate predictive analytics capabilities	12/2018
Demonstration of virtual islanding	09/2019
Demonstrate extremum seeking	06/2020
Demonstrate integrated GRIP platform	09/2020

Progress to Date

- GRIP Kick-off workshop
- Utility Resilience Surveys + Interviews
- Technical Advisory Group Y1 Annual Meeting
- Data Management & Platform Architecture Workshop
- Platform Design (UI/UX) Workshop
- Stakeholder Workshop at Southern California Edison

Increasing Distribution System Resiliency using Flexible DER and Microgrid Assets Enabled by OpenFMB (GMLC 1.5.03)

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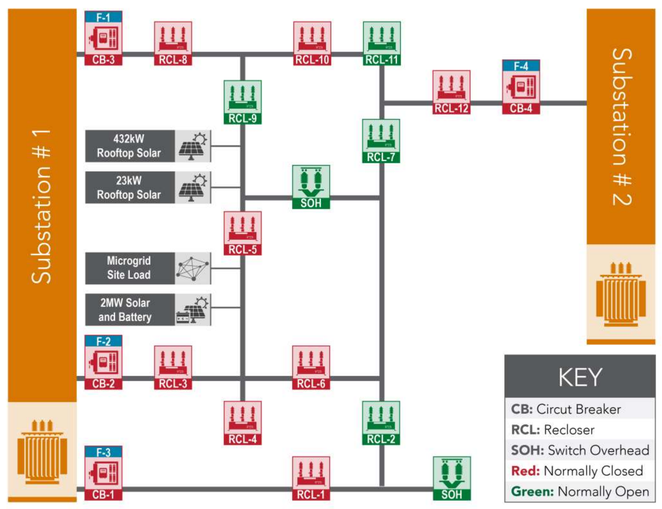
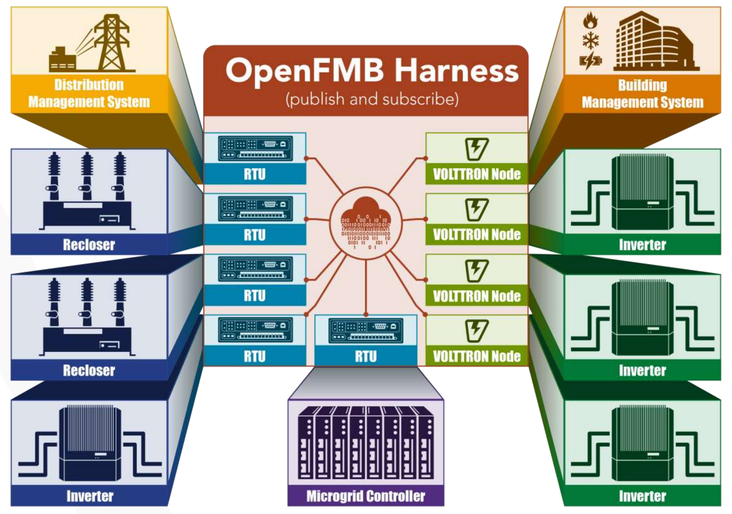
Project Description

Problem: Duke Energy has halted some self-healing systems deployments due to concerns regarding their interactions with moderate-to-high penetrations of DERs.

Objective: To increase distribution resiliency through flexible operating strategies which actively engage utility and non-utility assets as flexible resources, during normal and abnormal events. While this project is focusing on one instance of centralized self-healing system and distributed solar PV, the work is applicable to any system where centralized and distributed controls interact.



One-line diagram of field deployment



Structure of OpenFMB Harness

Expected Outcomes

- This work will produced a standards-based open framework to actively engage DERs as assets, and not as obstacles.
- An operational example of the system deployed and validated with Commercial Off The Shelf (COTS) equipment, using containerized open-source software.
- A quantifiable improvement in distribution system reliability and resiliency, in addition to benefits for DERs.
- The developed framework will be extensible to any combination of centralized and decentralized controls, making it applicable to many of the utilities in the nation.
- Close collaboration with an active Industry Advisory Board (IAB) is ensuring that the work conducted is applicable to the largest possible number of industry stakeholders.

Significant Milestones	Date
Held 2 in-person meetings of the Industry Advisory Board	1/25/18 & 4/22/18
Completed draft of initial Concept of Operations (CONOPS) document	6/30/18
Duke Energy electrical infrastructure models converted into models for co-simulation, hardware in the loop, and emulation	8/1/18
Preliminary integration of Commercial Off the Shelf (COTS) relays into OpenFMB Harness	9/1/18

Progress to Date

- Architecture and controls:
  - Developed layered control architecture for resiliency
  - Evaluated potential to integrate laminar control structures
  - Initial transactive scheme to engage non-utility inverters
  - Completed CONOPS document, with 12 use-cases
- Simulation/HIL/Emulation:
  - Worked with Duke Energy to model physical Remote Terminal units (RTUs)
  - Converted, and validated, Duke planning models into time-varying models for multiple platforms (co-simulation, HIL, and emulation)
  - Finalizing all software and hardware development facilities
- OpenFMB Harness:
  - Identified/developed all necessary OpenFMB adaptors and models
  - Conducted initial work to integrate COTS RTUs to OpenFMB Harness
  - Conducted initial work to integrate VOLTTRON nodes to OpenFMB Harness
- Multiple IAB and project coordination meetings:
  - Bi-weekly telecons with the extended team
  - 2 in-person project meetings
  - 2 in-person IAB meeting
  - Planning for in-person year 2 kick-off meeting

1.5.4 - Integration of Responsive Residential Loads into Distribution Management Systems

ORNL: Teja Kuruganti, Michael Starke, Alex Melin, Mohammed Olama, Helia Zandi, Sonny Xue, Jin Dong, Fran Li (UTK), Xiao Kou (UTK)
PNNL: George Hernandez
EPRI: Chuck Thomas, Doni Nastasi
Utilities: Justin Hill (Southern Company), Sam Delay (Tennessee Valley Authority), George Gurlaskie (Duke), Amy Bryan (Jackson EMC), Hunter Ellis (Electric Power Board, Chattanooga)

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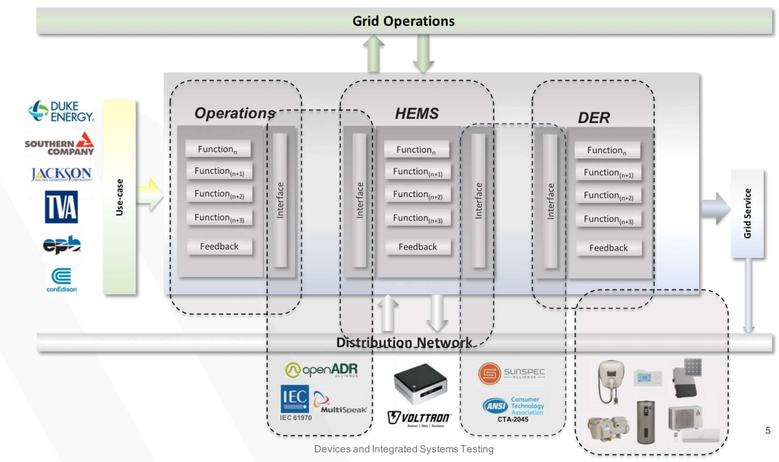
Project Description

The goal of the project is to engage residential loads and distributed energy resources (DERs) to increase distribution system resiliency. This will be achieved through interoperable end-to-end system architecture employing hierarchical control and optimization technology to demonstrate coordinated response from large number of assets in time and magnitude.

Expected Outcomes

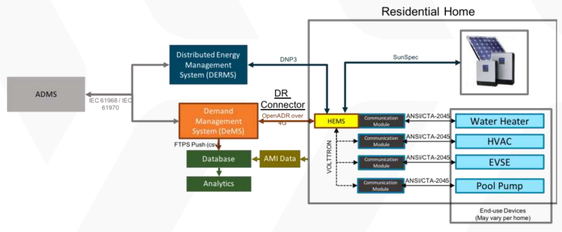
- **Establish HEMS as an interface for demand/DER management**
  - Interoperable interface with DeMS – reliably support data exchange
  - Engage residential loads – control execution and provide feedback
  - Reliable estimation of load potential in real-time – Data-driven models
- **Transactive control system to co-optimize Loads/DER performance to satisfy grid requirements and residential needs**
  - Scalable formulation with minimal communication overhead
  - Embed fault-tolerance and fail-safe mechanisms
  - Centralized and decentralized methods
- **Improve distribution-level grid resilience**
  - Field validation to demonstrate the SW, HW, and Algorithms demonstrate response in time and magnitude
  - Demonstrate this capability to be expandable to multiple deployment architectures

Significant Milestones	Date
Report detailing the software and hardware architecture for end-use load control using VOLTTRON and CTA2045 to demonstrate the ability of load control in response to a grid incentive signal with response times between 0-10 minutes.	6/30/2018
Draft Report detailing the dispatch signal structure and software implementation of the dispatch top node in conjunction with the specific utility architectures	9/30/2018
Draft report detailing the cybersecurity and interoperability plan for the system developed for deployment in collaboration with utility	9/30/2018
Deliver field test plan and deployment use cases to demonstrate the responsive residential loads to provide distribution-level grid resiliency services	9/30/2019



Devices and Integrated Systems Testing

Project Overview



Architecture Overview

Testing Overview

Progress to Date

- End-to-end system architecture to support hierarchical control of demand side assets - 14 use cases developed in collaboration with utilities
- Developed an approved design of CTA-2045 Cellular/Wi-Fi Raspberry PI Zero Communication Module with frequency and voltage monitoring capabilities to the HEMS system
- Developed VOLTTRON-based HEMS software prototyped to meet requirements including CTA-2045 and OpenADR agents to manage DER(Loads)
- Evaluated and formulated online optimization schemes required for accessing DERs to provide grid services targeted at distribution resilience – Open-source solvers
- Establishing M&V capabilities at device-level for advanced use cases
- Laboratory-Level test setup established at Yarnell Station Research Home
- Published thee papers and currently authoring two publications

CleanStart DERMS (1.5.5)

GRID MODERNIZATION INITIATIVE
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Project Description

- ► Develop and implement a DER Management System integrated application which provides a separate communications, analytics and control layer, purely for a black-start and restoration application
- ► Solution will demonstrate the start of a microgrid following an outage (cyber or physical)

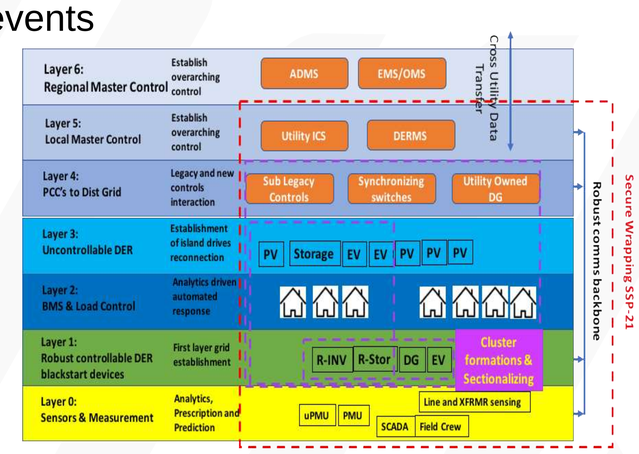
Minimize the outage time for the maximum number of customers with the greatest contribution from distributed and clean energy resources

Team

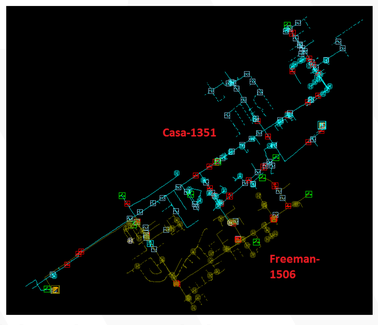
Lawrence Livermore National Laboratory; Pacific Northwest National Laboratory; Los Alamos National Laboratory EST. 1943; City of Riverside Public Utilities; UC Riverside; smarter grid solutions; PingThings; Xendee; Southern California Edison; Hawaiian Electric Company; PG&E

Expected Outcomes

- ► DER controls as a mechanism for black start and restoration
- ► Cross-utility coordination and effective useful information/resource transfer
- ► Product will be transformational to utilities experiencing a rapid DER influx, considering both controlled and uncontrolled resources as part of the resilient resources to be utilized in widescale events



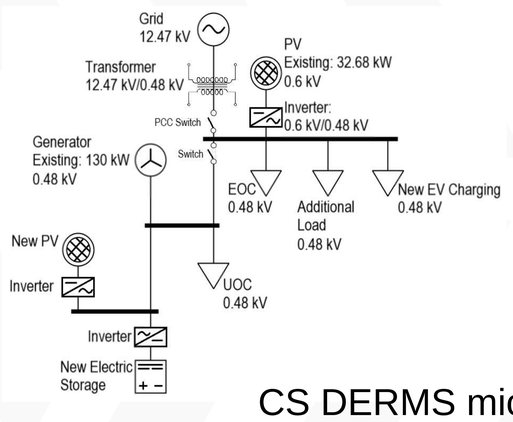
CS DERMS architecture

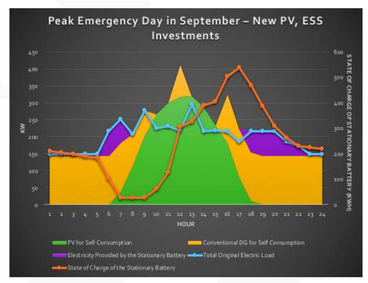


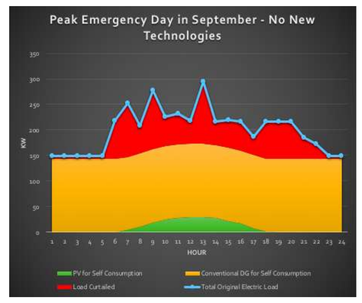
CS DERMS demonstration site and feeder models

Progress to Date

- ► Demonstration site, data collection, and model validation
  : 2-feeder location with EOC, UOC, and commercial loads with some existing PV (mix of critical and non-critical loads)
- ► Design and technology selection
  : new and existing technology required to meet the critical and/or non-critical loads

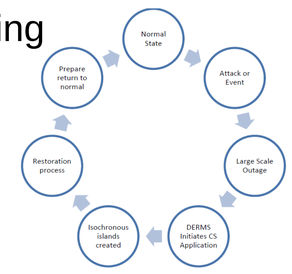




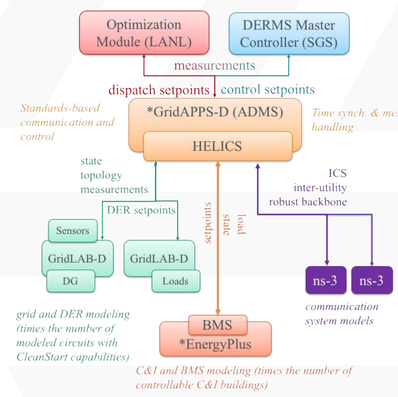


CS DERMS microgrid design and planning

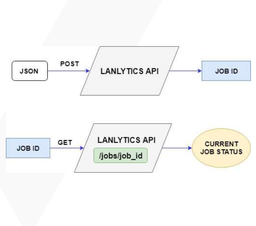
- ► Use cases definition
  : 5 cases from best to worst for generation dispatch



- ► Co-simulation
  : Added a remote federation layer in HELICS between LANL's optimization tools, SGS's DERMS controller, and PNNL's simulations using a RESTful API



- ► Control integration
  : Optimize restoration accounting for cyber compromised devices and capturing stochasticity of DER



Significant Milestones	Date
Data Collection, Cyber and Data plan delivered	3/31/18
Calibration and testing of models	6/30/18
Utility approval of scheme	6/30/19
Functional acceptance testing	12/31/19
Testing and project validation	6/30/20

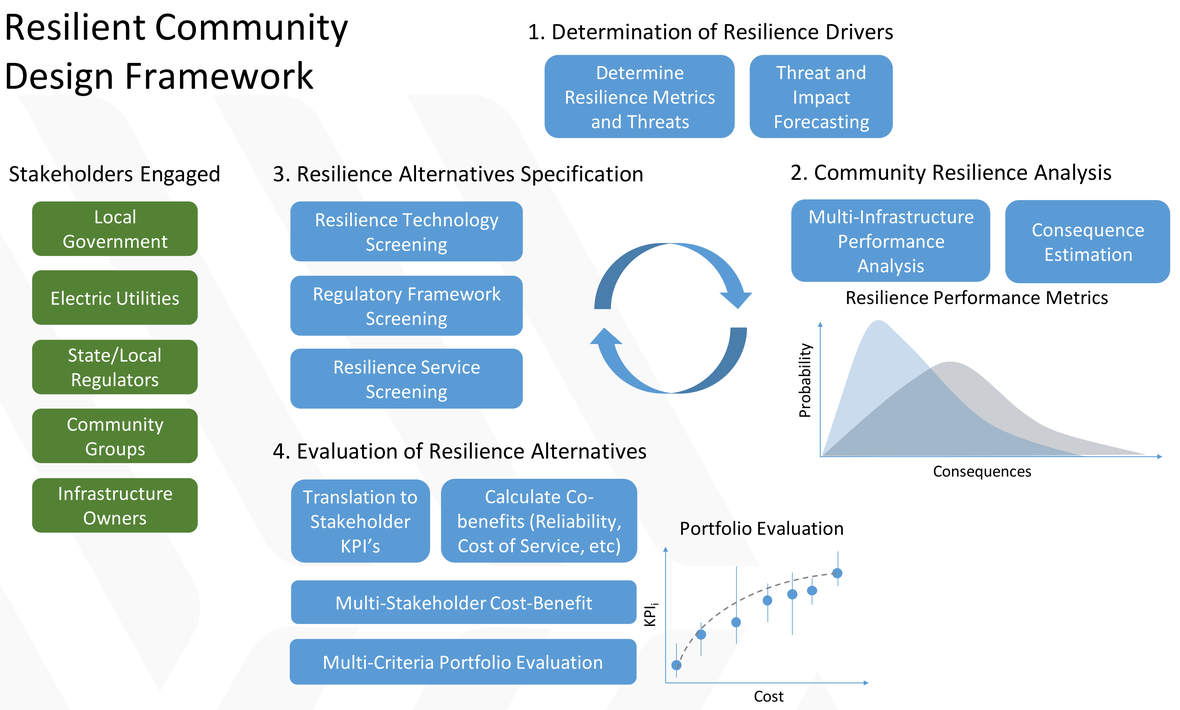
Prepared by LLNL under Contract DE-AC52-07NA27344

GMLC 1.5.06
Designing Resilient Communities
A consequence-based approach for grid investment
Robert Jeffers, PI (Sandia)

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Project Description

- The high-level goal of this project is to demonstrate an actionable path toward designing resilient communities through consequence-based approaches to grid planning and investment, and through field validation of technologies with utility partners to enable distributed and clean resources to improve community resilience.



Expected Outcomes

- A nationally-applicable process – including data and tools – for integrating community/city resilience planning with grid investment planning
- Demonstration of the **Resilient Community Design Toolset** used to support two grid investment planning processes with focus on community resilience value – with CPS Energy and National Grid
- Analysis of alternative regulatory structures and utility business models that can internalize for utilities the value of a more resilient grid
- Utility-scale demonstration of a resilience node enabled by clean distributed energy resources

Progress to Date

- Held first semi-annual stakeholder advisory group (SAG) meeting, July 24-25 2018
- Began assessment of tool landscape for Resilient Community Design Toolset
- Began baseline resilience analysis for San Antonio, TX and Potsdam, NY
- Project awarded plus-up on Aug 16, 2018

Significant Milestones	Date(s)
Semi-annual SAG meetings	7/2018, 1/2019, 7/2019, 1/2020
Baseline community resilience analysis for two cities	3/2019
Resilience impact analysis of grid improvement alternatives	6/2019
Case study report for Potsdam/Buffalo and San Antonio	9/2019
Final design of resilience node, Release final SAG-informed Resilient Community Design Framework document	9/2020
Implementation and field validation of resilience node on utility system	7/2021

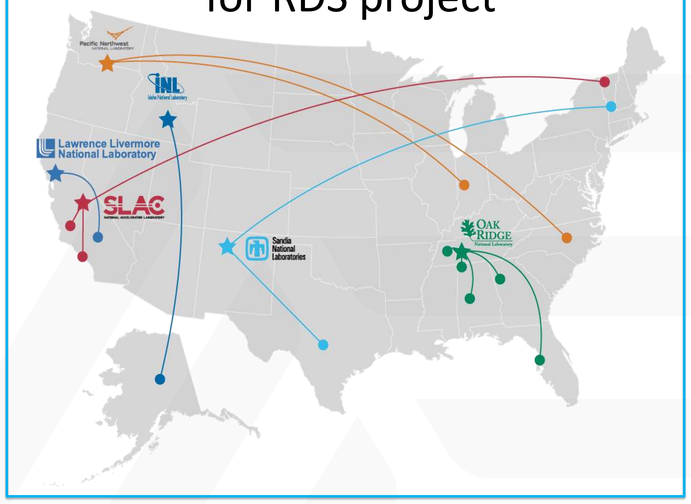
GMLC 1.5.7: Laboratory Value Analysis of Resilient Distribution System (RDS) Projects

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Project Description

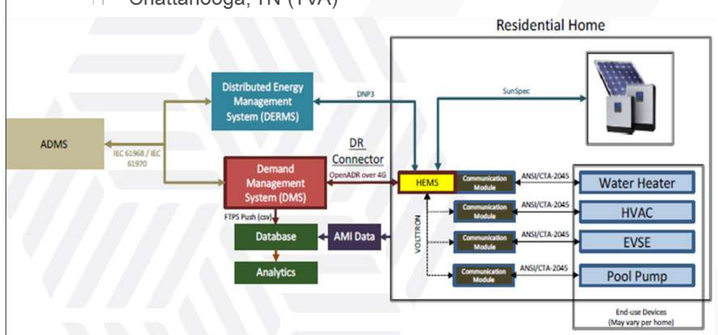
- Develop methodology for estimating value of resilient distribution system and perform value analysis of 5 RDS projects
- Engage with state policymakers/regulators and key stakeholders to communicate lessons learned

Lead Labs and expected test sites for RDS project



Example: ORNL-Led RDS project

- Objective:
  - Validate low-cost, open-source, interoperable home energy management system (HEMS) in residential homes to provide grid-services
- Innovation:
  - Low-cost hardware and software for connecting and controlling end-use devices in homes (DMS/DERMS)
- Test sites:
  - Chattanooga, TN (TVA)



Use-cases

1. Reduce critical peak load
2. Improve disaster preparedness through real-time situational awareness and distribution operations planning
3. High penetration of renewables energy in distribution system
4. Virtual networked Microgrids in distribution circuits to enable resilience
5. Improved asset utilization through locational pricing
6. Reduce outage and recovery times through intelligent COLD LOAD PICKUP
7. Nano-grid: residential-level islanding with assets sensing grid events
8. Distribution feeder-level battery for transmission-level grid services and enabling distribution resilience
9. Inverter control to prevent power generation curtailment due to control of distribution level voltage control assets
10. Adaptive control of DERs on a distribution radial line to stabilize voltage sag across the line
11. Powerflow and congestion management
12. Load control to support frequency regulation

U.S. DEPARTMENT OF ENERGY

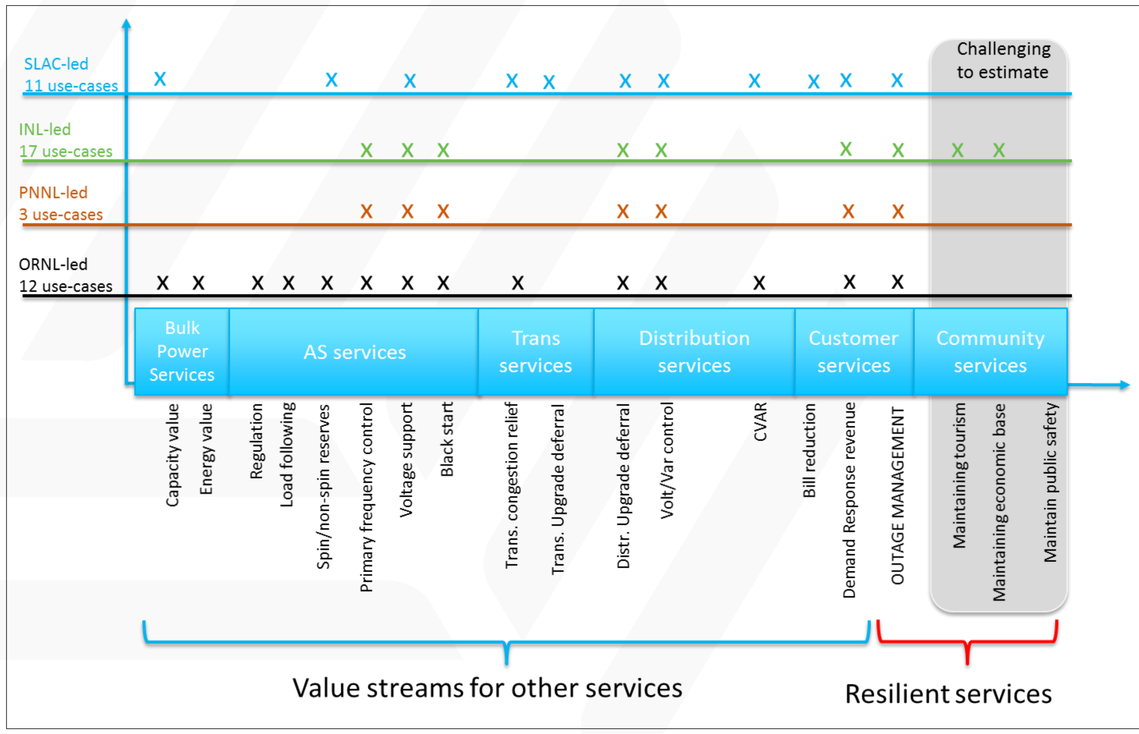
Institutional Support

Expected Outcomes

This work will be the first authoritative valuation study of resilience field demonstrations under diverse use-case scenarios that include different technologies, threats, value streams and regions with different market and regulator structures

FUNDING: Total: $1500			
	FY18 $	FY19$	FY20 $
total	610	380	510

Value Streams to be estimated



Accomplishments

- Embedded with technical RDS teams to influence use-case definitions and metrics selection
- Developed methodology for estimating value of resilient distribution system

Next steps

Engage with state policymakers/regulators and key stakeholders to understand potential business cases and regulator options for resilience investments