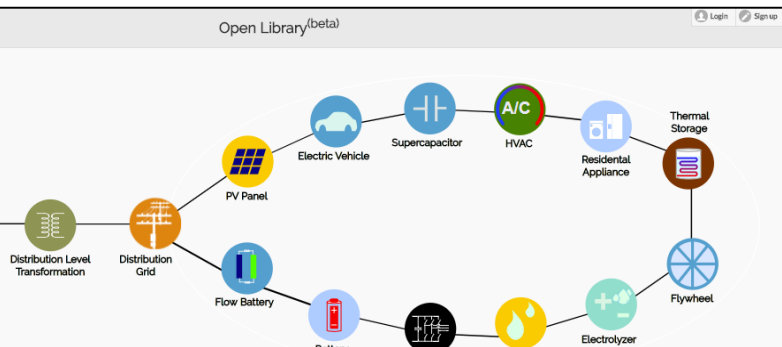


*Exceptional service in the national interest*



Facilities

The facilities summary table identifies the national laboratory facilities that house grid device testing resources. It also shows the applicable technology areas for each facility.

Lab Name	Facility Name	Energy Storage	EV & EVSE	Power Quality	Grid Storage	Grid Scale	Control & Protection	Power Electronics	Power
ANL	Advanced Materials Research Facility								
ANL	Battley Research Facility								
ANL	30 MW Low and Intermediate Power								
ANL	Midsize Solar Energy Storage Center								
ANL	Power and Energy Test Area Laboratory								
ANL	Working Technology Test Center								
ANL	Compass Grid Lab								
ANL	Transformation of Substation Laboratory								
ANL	Facility for Low Voltage Superconducting in Buildings								
ANL	Hydrogen Test Center								
ANL	Hydrogen Test Center								
ANL	Energy System Integration Facility								
ANL	Hydrogen Infrastructure and Research Facility								
ANL	National Wind Technology Center								
ANL	Advanced Grid Technology Center								
ANL	Control for Technology Industrial Systems								
ANL	Advanced Energy Conversion and Control Lab								



# Overview of DOE Grid Modernization Lab Consortium (GMLC) and Details on GMLC 1.2.3 (Testing Network and Open Library)

Matthew Lave

October 12, 2017

UVIG Fall Meeting, Nashville, TN

SAND2017-11188 C



Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

# Grid Modernization Initiative (GMI)

- The Grid Modernization Initiative (GMI) works across the U.S. Department of Energy (DOE) to create the modern grid of the future.
  - primary funding support comes from the Office of Electricity Delivery and Energy Reliability and Office of Energy Efficiency and Renewable Energy, with the Office of Energy Policy and Systems Analysis providing policy recommendations.
- GMI focuses on the development of new architectural concepts, tools, and technologies that measure, analyze, predict, protect, and control the grid of the future, and on enabling the institutional conditions that allow for more rapid development and widespread adoption of these tools and technologies.

# Grid Modernization Lab Consortium (GMLC)



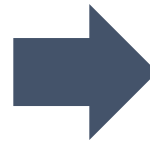
- <https://gridmod.labworks.org/>
- Strategic partnership between DOE and the national laboratories to bring together leading experts, technologies, and resources to collaborate on the goal of modernizing the nation's grid.
- Grid Modernization Lab Call provided funding to GMLC through a comprehensive effort of eighty-eight projects managed by the national laboratories.
- Benefits of GMLC include more efficient use of resources; shared networks; improving learning and preservation of knowledge; enhanced lab coordination and collaboration; and regional perspective and relationships with local stakeholders and industry.



# Grid Modernization Lab Consortium (GMLC)

*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



# GMLC Projects

- **Core Activities**—These projects (**1.1-1.2.5**) provide the fundamental knowledge, metrics, and tools needed to support all the Cross-Cut R&D and regional partnerships.
- **Pioneer Regional Partnerships**—These partnerships (**1.3.01-1.3.99**) involve technical assistance to states, utilities, or other stakeholders that are facing key emerging grid modernization challenges.
- **Crosscutting R&D**—These integrated projects (**1.4.01-1.4.29**) will further advance grid modernization by coupling multiple hardware, software, and institutional solutions into integrated and modernized grids at a scale and a pace necessary to meet national goals.

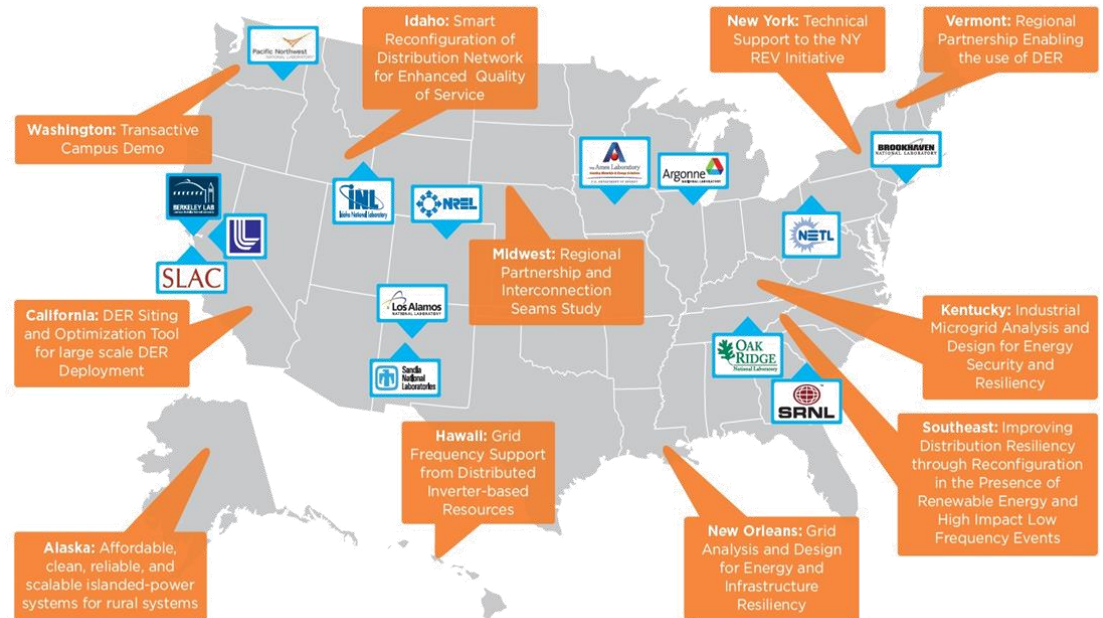
# GMLC Core Activities

PROJECT NAME	DESCRIPTION	LABS
1.1 Foundational Analysis for GMLC Establishment / Analysis	<ul style="list-style-type: none"> <li>• Suite of grid modernization metrics that leverage current industry practice</li> <li>• New metrics that reflect emerging grid attributes and architectures</li> <li>• Baseline modernization assessments and ongoing dashboard</li> </ul>	<b>PNNL</b> , LBNL, LANL, BNL, ORNL, NREL, SNL, LLNL, and LANL
1.2.1 Grid Architecture	<ul style="list-style-type: none"> <li>• Stakeholder-driven architecture for grid modernization</li> <li>• Provide it to the industry along with the tools they need to adapt it to their needs</li> <li>• Inform the playbook for GMLC program managers</li> </ul>	<b>PNNL</b> , ORNL, ANL, NREL, LANL, LBNL, LLNL, SNL
1.2.2 Interoperability	<ul style="list-style-type: none"> <li>• Strategic vision for interoperability</li> <li>• Tools to measure interoperability</li> <li>• Overarching roadmap for stakeholder endorsement.</li> </ul>	<b>PNNL</b> , LBNL, NREL, ANL, LBNL, SNL
1.2.3 Grid Modernization Laboratory Consortium Testing Network	<ul style="list-style-type: none"> <li>• Testing Network (GMLC-TN): federated lab-based resource for testing of grid devices</li> <li>• Open Library (GMLC-OL): public repository for validated models, tools, and testing resources</li> </ul>	<b>SNL</b> , INL, NREL, PNNL, ORNL, ANL, LBNL, SRNL, BNL, LLNL
1.2.4 Grid Services and Technologies Valuation Framework	<ul style="list-style-type: none"> <li>• Valuation methodological framework for value streams (net benefits) provided by different grid-related technologies and services.</li> </ul>	<b>ORNL</b> , PNNL, NREL, LBNL, ANL, SNL, LANL
1.2.5 Grid Sensing and Measurement Strategy	<ul style="list-style-type: none"> <li>• Measurement requirements, data management, communication to enable full visibility of grid system state</li> <li>• Define grid state, roadmap, framework to determine sensor allocation for optimal results.</li> </ul>	<b>ORNL</b> , NETL, PNNL, NETL, LLNL, ANL, NREL, SNL, LBNL, LANL

# GMLC Regional Partnerships

PROJECT NAME	DESCRIPTION	LABS
1.3.04 Industrial Microgrid Analysis and Design for Energy Security and Resiliency	<ul style="list-style-type: none"> <li>Risks, costs, and benefits of a microgrid utilizing renewable energy at the UPS WorldPort and Centennial Hub facilities</li> <li>Roadmap to help industries evaluate microgrid adoption</li> </ul>	ORNL, SNL
1.3.10 Vermont Regional Partnership Enabling the Use of DER	<ul style="list-style-type: none"> <li>Assist Vermont utilities in meeting the state's ambitious goal of obtaining 90% of its energy from renewable sources by 2050</li> <li>(1) DER integration, (2) DER control, (3) validation of wind and solar forecasting, and (4) techno-economic analysis of energy storage.</li> </ul>	SNL, NREL

... and 9 more regional partnerships



# GMLC Crosscutting R&D

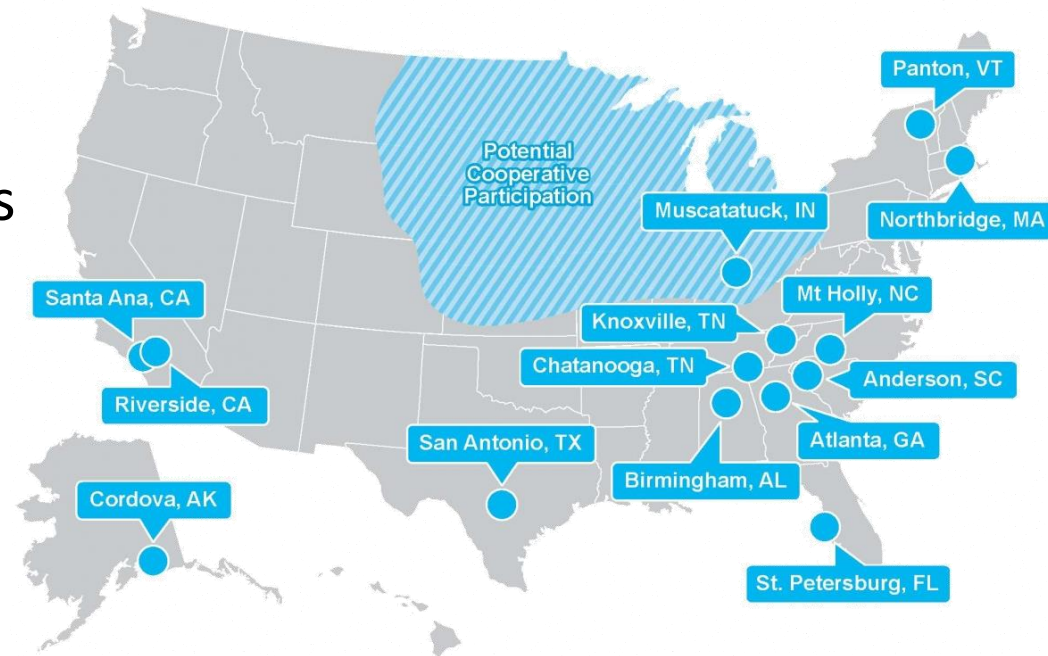
PROJECT NAME	DESCRIPTION	LABS
1.4.01 Standards and Test Procedures for Interconnection and Interoperability	<ul style="list-style-type: none"> <li>• Harmonize requirements across jurisdictions</li> <li>• Eliminate conflicting requirements across technology domains</li> <li>• Streamline conformance test procedures to the fullest extent possible</li> </ul>	<b>NREL</b> , PNNL, LBNL, SNL, ANL, ORNL, INL
1.4.02 Definitions, Standards and Test Procedures for Grid Services	<ul style="list-style-type: none"> <li>• Test protocol to characterize DERs ability to respond to grid signals</li> <li>• Standard set of grid services and "drive cycles" to describe the capabilities that DERs must have to provide them</li> </ul>	<b>PNNL</b> , NREL, ORNL, SNL, LBNL, ANL, INL, LLNL
1.4.04 Advanced Sensor Development	<ul style="list-style-type: none"> <li>• Developing low-cost, accurate sensors</li> <li>• Next generation asset monitoring devices will help determine state of grid components prior to failure</li> </ul>	<b>ORNL</b> , PNNL, NETL, NREL, SNL, LBNL
1.4.09 Integrated Multi Scale Data Analytics and Machine Learning for Grid	<ul style="list-style-type: none"> <li>• Integrating disparate high fidelity data sources</li> <li>• Machine learning methodologies will be used to assist in transforming data into actionable intelligence</li> </ul>	<b>LLNL</b> , LANL, SNL, LBNL, ORNL, NREL, ANL

... and 9 more crosscutting projects



# GMLC Resilience Call

- 7 projects recently awarded (September 2017)
- Develop and validate innovative approaches to enhance the resilience of distribution systems
- Rigorous field validations
- Advancements in cybersecurity technologies
- Technical and economic viability of integrated solutions
- Regional focus



# GMLC 1.2.3: TN and OL

## *Project Description*

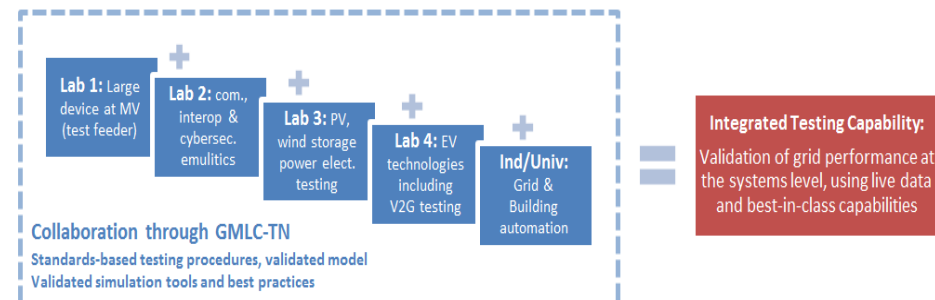
Accelerate grid modernization by **improving access to National Lab testing infrastructure for grid devices and systems, and related models and tools**. Enable national labs to drive innovation more effectively and synergistically.

## *Project Objectives*

- ✓ Establish a Testing Network (GMLC-TN) as a federated, lab-based resource for testing and performance validation of grid devices and systems
- ✓ Establish an Open Library (GMLC-OL) as a public repository for validated models, simulation tools and testing resources

## *Value Proposition*

- ✓ Access to testing resources and validated models is vital to grid modernization
- ✓ Make optimal use of vast and growing set of grid-related testing and simulation resources at National Labs and beyond.
- ✓ Major opportunities to make an impact by improving information, accessibility, and collaboration



# GMLC 1.2.3: Capabilities Catalog

## Catalog of National Laboratory Test Facilities and Capabilities

- To facilitate better understanding of laboratory capabilities
- 10 National Labs, 39 distinct facilities
- 168 capability/application technology pairs
  - e.g., **hardware in the loop testing** of **dist. sys. components**
- Matrices; but also paragraphs describing facilities and capabilities
- public release forthcoming imminent
- Searchable online version soon; periodic updates

### Test Facility

- Energy Systems Integration Facility (NREL)
- Distributed Energy Technologies Laboratory (Sandia)
- ...

### Test Capability

- Communications Interoperability
- Cybersecurity
- Hardware in the Loop
- Grid Compatibility and Interconnection
- Reliability / Safety / Failure Analysis
- Systems Integration and Control

### Application Technology

- Building Technologies
- Dist. Sys. Components
- Electric Vehicles
- Energy Storage
- Fuel Cells
- ICT and AMI
- Integrated Energy Systems
- Microturbines and Gensets
- PV
- Trans. Sys. Components
- Wind

**Facilities**

The facilities summary table identifies the national laboratory facilities that house grid device testing resources. It also shows the application technology areas for each facility.

Lab Name	Facility Name	Energy Storage	Electric Vehicles	Grid	Power and Energy	Smart Grid	Trans. Systems	Wind
ANL	Advanced Protonic Research Facility							
ANL	Nature Research Facility							
ANL	DF Energy Grid and Interoperability Center							
ANL	Advanced Protonic Research Facility							
ANL	Power and Energy Test Area Laboratory							
ORNL	Building Technologies Test Center							
ORNL	Composites Grid Lab							
ORNL	Microstructural Interactions Laboratory							
ORNL	Facility for Low-Temp. Superconductor & Bulky							
ORNL	Physics and Test Center							
ORNL	Reliability Test Center							
ORNL	Energy Systems Integration Center							
ORNL	Systems Interactions and Research Facility							
ORNL	National Wind Technology Center							
ORNL	Advanced Grid Test/Development Facility							
ORNL	Center for Technology Evaluation Systems							
ORNL	Characterized Energy Conversion and Control Lab							
ORNL	DF Operations Research Facility							
ORNL	Multi-Scale Interconnectivity System							

**Battery Abuse Testing Laboratory (BATLab)**

The BATLab provides comprehensive abuse testing platform for safety and reliability of cells, battery and systems from 10Wh to 100k. It includes cell, module, and battery system hardware calorimeters for testing. Testing areas include mechanical abuse (e.g., penetration, crush, impact, compression), thermal abuse (e.g., over temperature, flammability measurements, thermal propagation, calorimetry), and electrical abuse (e.g., overvoltage/overcharge, short circuit, overdischarge/voltage reversal). BATLab's R&D projects focus on:

1. Understanding the mechanisms that lead to energy storage system safety and reliability incidents
2. Developing new materials to improve overall energy storage system safety and abuse tolerance
3. Performing abuse testing
4. Advancing testing techniques
5. Performing detailed failure analysis
6. Developing strategies to mitigate energy storage cell and system failures

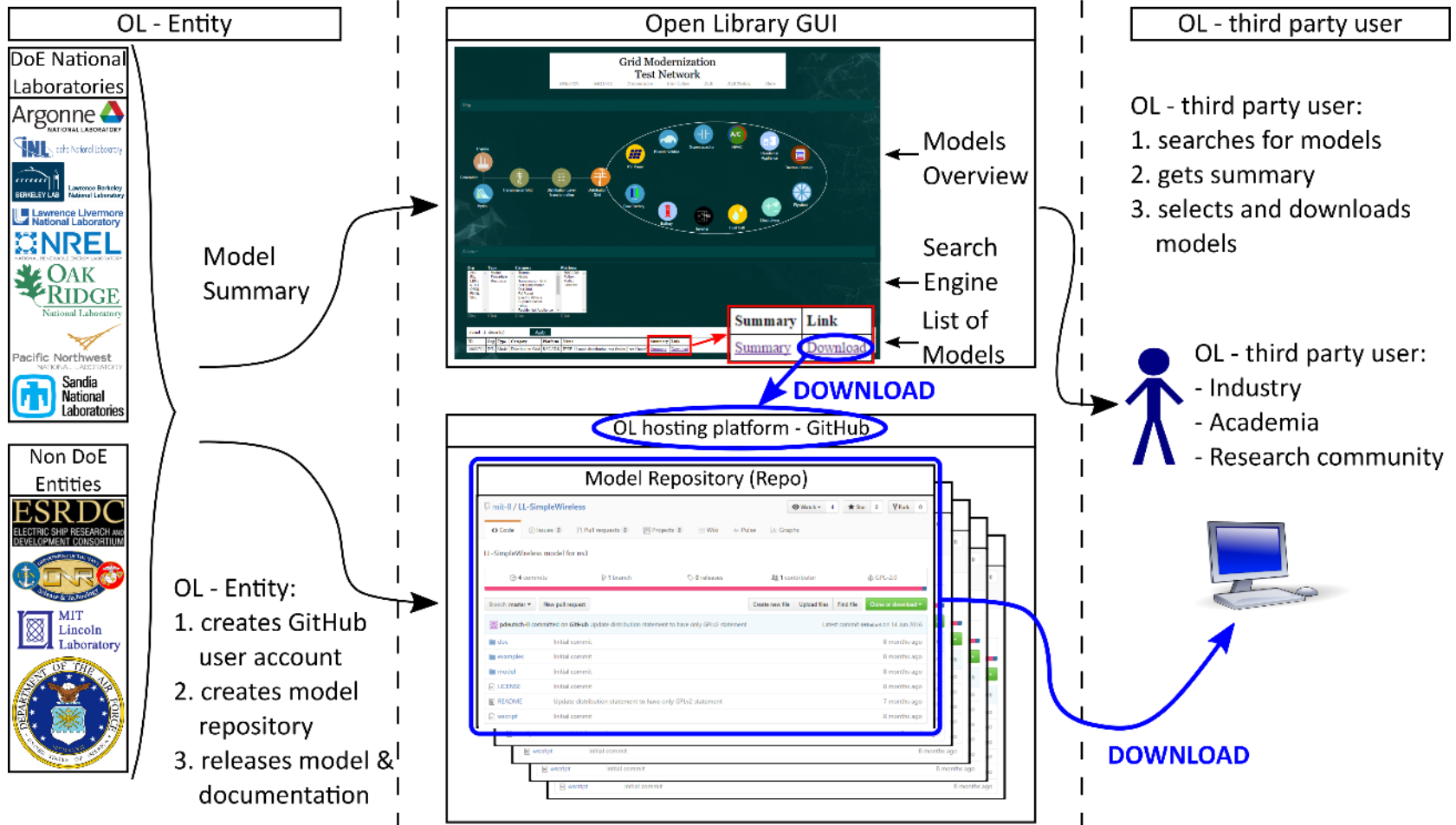
BATLab is also home to one of the world's largest and most comprehensive battery calorimetry laboratories, which uses a variety of calorimetry techniques to characterize energy storage systems. Activities include evaluating materials and strategies to minimize the severity of runaway reactions (i.e., analyzing the degradation products, mechanisms, and potential hazards associated with batteries; and modeling, designing, and testing the performance of a battery's thermal management system. Equipment includes six accelerating rate calorimeters (ARC) for materials and cell-level measurements such as:

- Gas volume measurements for decomposition gas products
- Quantitative gas analysis capabilities from ARC samples
- Performing measurements on 1-100 Ah cells

The facility also includes two isothermal battery calorimeters, a modulated differential scanning calorimeter, microcalorimetry for materials analysis, and cell prototyping equipment.

# GMLC 1.2.3: Open Library Platform

## Open Library Platform



# GMMLC 1.2.3: gridCONNECT

- To address project goals, established gridCONNECT consortium
- gridCONNECT Charter defines members, users, operation, goals, etc.
  - Adopted by the 5 National Lab team members on October 3<sup>rd</sup>, 2017
    - SNL, INL, LBNL, ORNL, LBNL
  - Modeled after other successful DOE consortia
- gridCONNECT will establish a website with:
  - A dynamic database of member test facilities and capabilities
  - An Open Library that serves as a repository for models, simulation tools, and testing resources
  - Information on partnering with the laboratories including methods to simplify partnerships
  - Ability to connect member capabilities with user needs





# GMMLC 1.2.3: gridCONNECT

- Example of information presented on website

**GRID MODERNIZATION INITIATIVE**  
U.S. Department of Energy

HOME ABOUT RESOURCE CATALOG OPEN LIBRARY PARTNERING MEMBERSHIP CONTACT

Protected: Resource Catalog

The information contained in the capabilities and facilities sections of the gridCONNECT website focuses strictly on resources for testing and characterization of devices and systems that are connected to, or interface with, the electric grid. The terms "capabilities" and "facilities," as well as "technology areas" are used in an effort to better convey the value and applications of each resource. These terms are defined as follows:

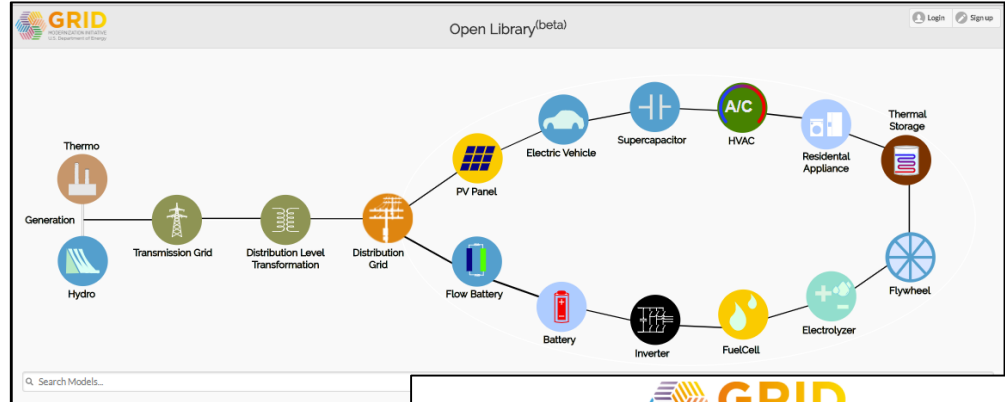
**Facility:** a physical building or laboratory that houses testing equipment and other infrastructure. Capabilities may be housed within a single facility or spread across multiple facilities.

**Capability:** a type of test that can be completed through the combination of available expertise, experience, equipment, and other resources. The catalog outlines six (6) capabilities which are defined in the table below.

Capability Name	Definition
Communications Interoperability	The capability to measure and assess the communications performance of devices, networks, and systems as they interact with the grid, including device to device interactions
Cybersecurity	The capability to measure and assess a device's ability to protect itself against attacks which result in the theft and compromise of information or controls
Grid Compatibility and Interconnection	The capability to assess a device's performance when operating within grid-specified parameters and its reactions to grid-state changes
Hardware-in-the-loop	The capability to provide a software simulation of the electric grid through which a physical device can be tested as if connected to an actual electric grid
Reliability/Safety/Failure Analysis	The capability to evaluate how, when, and in what way a device might fail
Systems Integration and Control	The capability to measure and assess the performance of integrated systems of several devices and their associated controls

**Technology Area:** the application space for a device, system, test, etc. as defined by a specific energy technology. The catalog outlines eleven (11) specific technology areas which are defined in the table below.

Technology Area	Examples of Devices/Systems of Test
Building Technologies	HVAC, lighting, appliances, building control systems, heat pumps, inverters, and converters
Distribution System Components	DERMS/ADMS, cables, bushings, terminations, transformers, and switches
Electric Vehicles	Battery charging controls, power transfer systems (including wireless), and EV supply equipment
Energy Storage	Electrochemical batteries, flow batteries, grid-scale storage systems, and chargers
Fuel Cells	Fuel cells, electrolyzers, and hydrogen storage systems
ICT and AMI	Communications protocols/equipment, SCADA, synchrophasors, fiber networks, and control rooms
Integrated Energy Systems	Microgrids, Hybrid Energy Systems, and microgrid management systems
Microturbines and Generators	Microturbines, natural gas generators, diesel generators, and controls
PV	Inverters and controllers
Transmission System Components	Conductors, transformers, line sensors, power lines, and controllers
Wind	Generators and controllers



**GRID MODERNIZATION INITIATIVE**  
U.S. Department of Energy

HOME ABOUT RESOURCE CATALOG OPEN LIBRARY PARTNERING MEMBERSHIP CONTACT

Partnering

The Department of Energy's national laboratories and facilities combine decades of experience and billions of dollars in research and development to address national security matters, environmental surety, economic viability, and energy sustainability. The technologies and capabilities developed and maintained to support core mission work can have concomitant benefits to industry, academia, and non-profits through technology transfer mechanisms. The information on this page provides a high-level overview of the most common methods utilized in working with the DOE laboratories. While there is a common operating framework through legislation and administrative law, each laboratory/facility may have uniqueness requirements and regulations and any prospective partner should contact a specific laboratory/facility of interest for detailed information.

- User Facilities
  - Each national laboratory has state-of-the-art facilities that are open to industrial and academic users for conducting research in diverse technology areas, including biology and medicine, chemistry and environmental sciences, physics and material science. It is possible to perform proprietary or non-proprietary research at the Designated User Facilities. There is typically no charge for users who are performing non-proprietary research with the understanding that they are expected to publish their results. For proprietary research that is not intended for publication, access to facilities is available on a full cost recovery basis. The submission process for individual or collaborative research may differ at each laboratory; however, access generally begins with an invitation from an employee or through a submitter and approval of a peer-reviewed proposal. More complete descriptions and models of these Agreements are found in the [Class Waiver for Non-Proprietary Users](#) and the [Class Waiver for Proprietary Users](#).
- Strategic Partnership Project (Non-federal)
- Agreement for Commercializing Technology
- License Agreement
- Cooperative Research and Development Agreement
- Funding Opportunity Announcements (and other solicitations)
- Learn More

# Next Steps

- Updating Testing Capabilities Catalog
  - Pushing to public release of catalog and accompanying website database ASAP
- Populating Open Library
  - Collecting models from other GMLC projects and from team member Labs
  - Expect library to be publicly accessible in ~6 months
- Simplifying and educating on partnerships
  - Anticipate a pre-approved CRADA/NDA among all members
- Stakeholder Outreach
  - End goal is value to industry, academia, other national labs, etc.
  - Intend to form industry advisory board as part of gridCONNECT
  - Planning webinars, conferences, direct outreach
  - Input is always welcome!

# Discussion / Questions

Contact: [mlave@sandia.gov](mailto:mlave@sandia.gov)

