gridPULSE: Public User Library for Systems Evaluation to Accelerate Grid Modernization

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***Abstract* — The method for creating synthetic high-frequency solar simulations with unique profiles for each interconnection point on a distribution system feeder using low-frequency input data is presented, including recent improvements which have made it more accurate at matching measured irradiance statistics. These synthetic cloud fields can them be implemented into distribution grid simulations to model irradiance profiles for locations around the feeder. Without unique PV inputs at each interconnection point the number of voltage regulator tap change operations is significantly overestimated. In the final paper, we will present several implementations of the cloud fields into distribution grid simulations, showing the impact of using cloud fields in various scenarios such as different amounts of solar variability, different PV penetrations, and different clustering of PV installations.**

***Index Terms* — power grids, power system modeling, system integration.**

I. Introduction

The electric power grid is a complex system that involves a wide variety of evolving technologies, and requires access to testing resources and validated models for planning and optimization. However, the availability of these testing resources continues to be a challenge. Vast testing capabilities are available within the Department of Energy (DOE) National Laboratories and beyond (e.g., other government labs, universities, and industry); but there is currently no central information repository of up-to-date information regarding these capabilities. This makes them difficult to identify and, without an overarching coordination framework, difficult to integrate into more effective multi-institutional test beds that can handle systems-level testing and validation with live data.

As part of the broad Grid Modernization Laboratory Consortium (GMLC) which is part of the DOE Grid Modernization Initiative, the GMLC 1.2.3 project team formed the gridPULSE consortium to address the goals of accelerating grid modernization by enabling access to a comprehensive testing infrastructure and model library. This is critical to improve the efficiency of development, validation, standardization, and adoption of new grid technologies. A related goal is to enable the National Laboratories to drive innovation more effectively and synergistically by establishing a testing network that functions as a federated lab-based resource for standards-based testing and validation of grid devices and systems. The network will not only provide insight into individual laboratory resources, it will encourage the National Laboratories to collaborate with the intention of providing new capabilities that leverage the unique features from each lab.

II. Main Objectives

There are two main objectives of gridPULSE

- Objective 1 – Establish a Grid Modernization Laboratory Consortium Testing Network (GMLC-TN) that will function as an agreement-based association to maintain and disseminate information related to testing capabilities, information about models and testing-related resources.
- Objective 2 – Develop and establish a Grid Modernization Laboratory Consortium – Open Library (GMLC-OL) that serves as a public repository for component models tools and testing resources. The GMLC-OL will be designed in a manner such that it is self-maintained through user inputs and feedback.

III. Team and Organization

This work takes place under GMLC project 1.2.3. The project team consists of employees of 5 DOE National Labs: Idaho National Laboratory, Lawrence Berkeley National Laboratory, National Renewable Energy Laboratory, Oak Ridge National Laboratory, and Sandia National Laboratories. The overall project and the testing network thrust (related to Objective 1) is led by Sandia National Laboratories. Idaho National Laboratories leads the open library thrust. Together, the testing network and open library efforts combine to form the gridPULSE consortium, as illustrated in Fig. 1.

IV. Major Achievements

Major achievements to date are discussed in this section.

A. gridPULSE Consortium

The gridPULSE consortium was established to improve access for industry, university, and national laboratory partners to: (a) electric grid-related testing resources at the national laboratories and (b) to electric grid-related, validated models and simulation tools. These are critical to accelerate the development validation, standardization, adoption, and deployment of new grid technologies, and will enable the national laboratories to drive innovation more effectively and synergistically. Through this consortium of laboratories organized and accessible via an interactive web environment, and using accelerated partnering mechanisms, gridPULSE will support grid innovation and help identify and bridge gaps in testing and modeling resources.

"Members" of gridPULSE will be those with testing capabilities and/or models to contribute. This initially consists

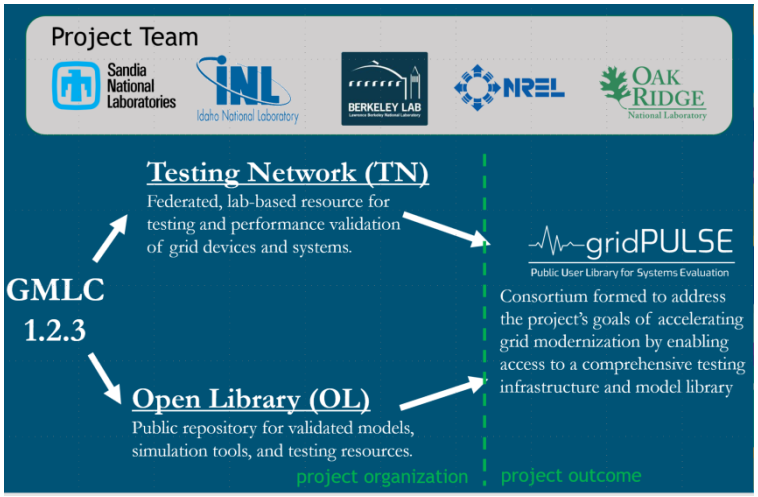

Fig. 1. GMLC 1.2.3 project organization and relation to gridPULSE.

of the five national laboratory team members for the GMLC 1.2.3 project, entities that have testing capabilities and/or modeling tools to deploy. As the consortium advances, membership will expand to include additional national laboratories' resources and capabilities and to include facilities beyond national laboratories (e.g. universities).

"Users" of gridPULSE will be those interested in testing or modeling related to grid modernization, including industry, university, and national laboratory employees. Users do not require special authorization, as information presented through gridPULSE will be available publicly.

B. Testing Capabilities and Facilities Catalog

Through an extensive self-assessment of grid-related test capabilities and facilities, the gridPULSE team assembled the Catalog of National Laboratory Testing Resources. The catalog contains information about testing facilities and capabilities across 12 Department of Energy (DOE) National Laboratories. The catalog has information on both unique test facilities (49 facilities) as well as the test capability and applicable technology area for each (100s of test capability / technology area pairs). This robust information allows the end-user to make decisions about which facility or facilities are best suited for testing his or her device. For example, a user could quickly identify which facilities conduct testing in the PV technology area, and could read details on the specific capabilities of each of those facilities.

The information contained in the catalog focuses on testing and characterization of devices and systems that are connected to, or interface with, the electric grid. Isolated generation systems were considered beyond the scope of this project, but information regarding how generation assets interact with the grid was accepted. The catalog only includes resources where a national laboratory has established capabilities and infrastructure that are actively being used to conduct testing, or that have previously been used to conduct significant testing for a particular technology area and continue to be maintained for such work.

C. Open Library to Collect Public Models

The open library is a collection of open models related to grid modernization. Models are organized into four broad categories: Generation, Transmission, Distribution, and Smart Home. In each category are sub-categories (e.g., within both Transmission and Distribution are sub-categories for PV). Each model entry in the open library has a link to download high-level information such as the ownership, version, contacts, and detailed information such as theoretical basis, specifications, interface opportunities, and validation.

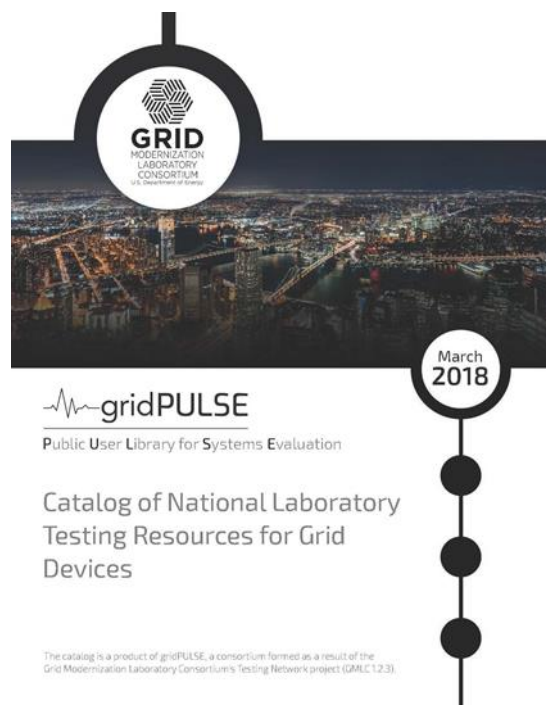

Fig. 2. Cover page for the gridPULSE Catalog of National Laboratory Testing Resources.

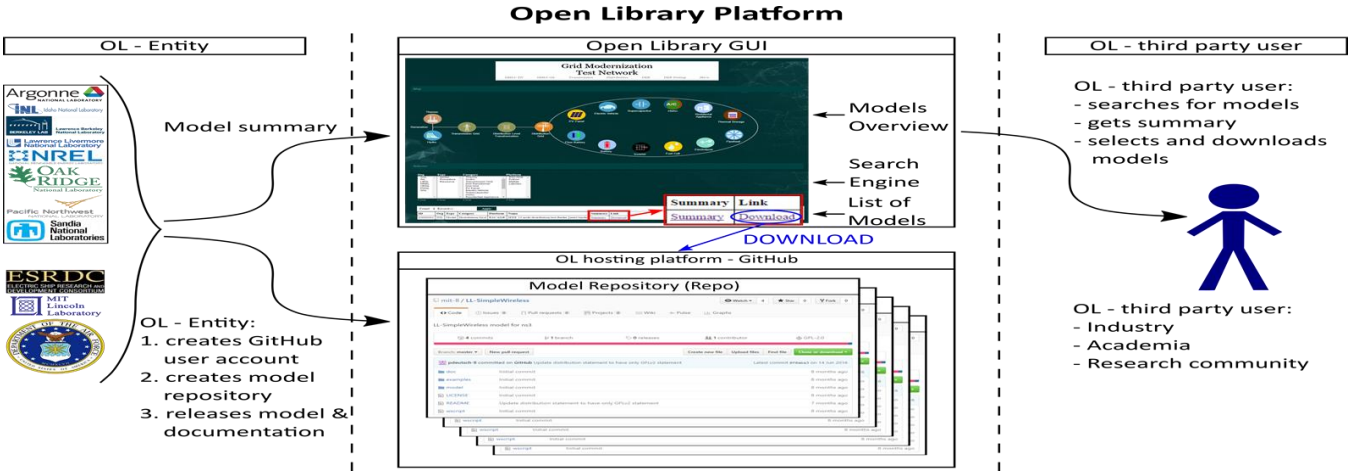

Fig. 3. Open Library implementation showing models in the transmission category.

V. Website to Facilitate User Interaction

The primary tool for both members and users of gridPULSE is the web interface: http://gridmodtools.org. Members will use the website to submit and update information on testing capabilities, provide models to the open library, and list contact details to begin partnerships discussions. Based on this information, users will be able to access detailed information on national test facilities, download useful models, and efficiently establish partnerships in a way that is more streamlined and provides more detailed and useful information than accessing each member's website individually.

Fig. 4. Website home page.

Website taxonomy reflects the major project accomplishments:

- About gridPULSE
- Testing Resources
- Open Library
- Contact Us

A. *About gridPULSE*

The about section contains details on (a) how to use gridPULSE resources and (b) partnering with the DOE National Labs. Step-by-step diagrams showing how to use each gridPULSE testing resources and open library are included in this section. The partnering with DOE Labs section contains information on partnership mechanisms and links to the partnerships offices at each of the National Labs to facilitate partnering.

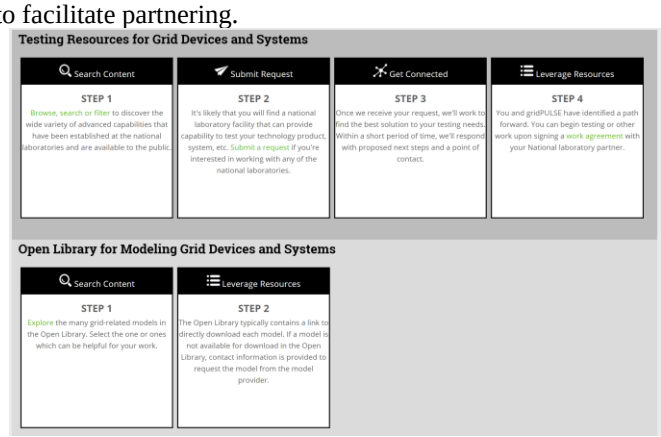

Fig. 5. Step-by-step guide for utilizing gridPULSE testing resources (top) and open library (bottom). .

B. *Testing Resources*

Testing resources are presented in 3 formats: (a) a sortable overview matrix showing facilities and their capabilities, (b) an interactive map showing capabilities geographically, and (c) full details on each National Labs' facilities and capabilities. Sorting in (a) and (b) can be done based on based on national lab, test capability, technology area. And, search results always link to the full information contained in (c). For example, a user could quickly find a test resource or model related to PV cybersecurity by sorting by the PV technology area and the communications test capability.

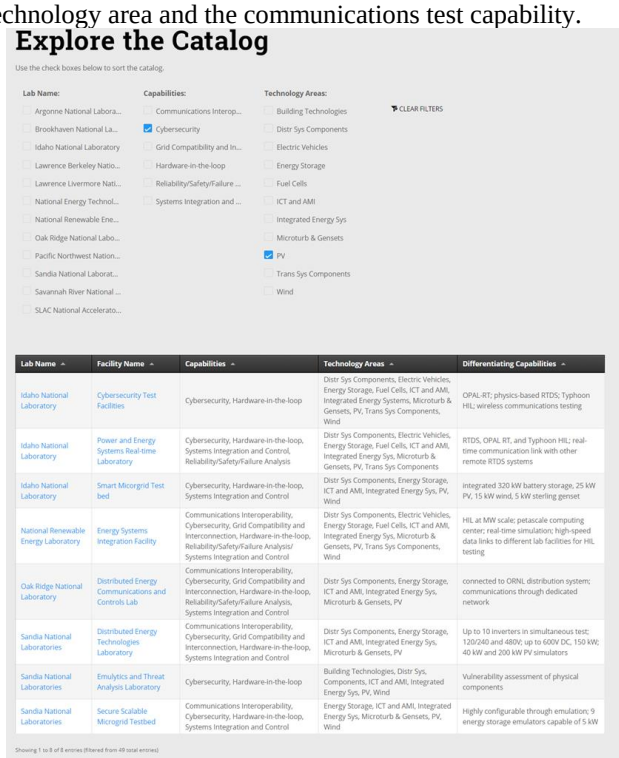

Fig 6. Sortable version of the testing resources.

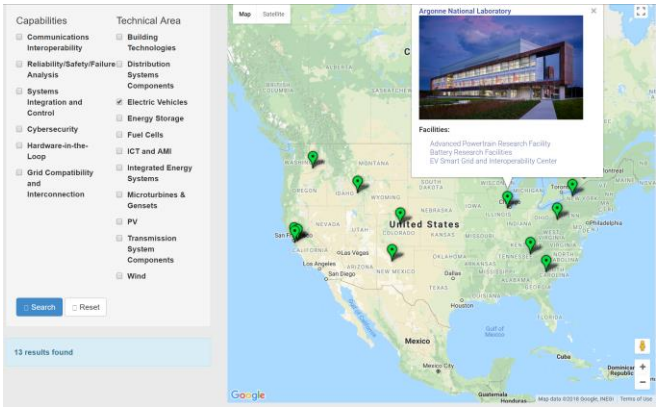

Fig. 7. Map presentation of testing resources.

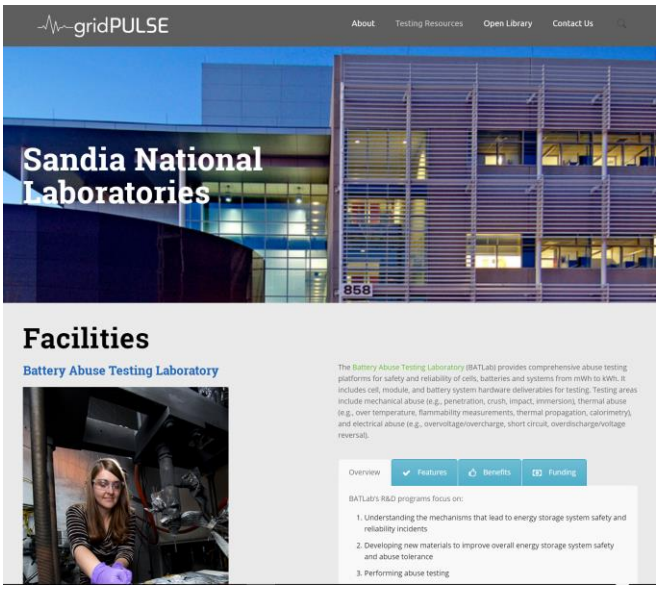

Fig. 8. Full detail on testing resources by National Lab (Sandia shown).

C. *Open Library*

The open library is implemented on the gridPULSE website as a searchable and sortable database of publicly available models, tools, and data sets. For each entry, details on the usability, compatibility, application, and validation are chronicled. Entries are sorted by application (e.g., transmission, distribution, etc.) and by technology area (e.g., wind, EVs, etc.). The open library is currently open to contributions from registrants from *.gov email addresses. Anyone can browse and download models from the open library.

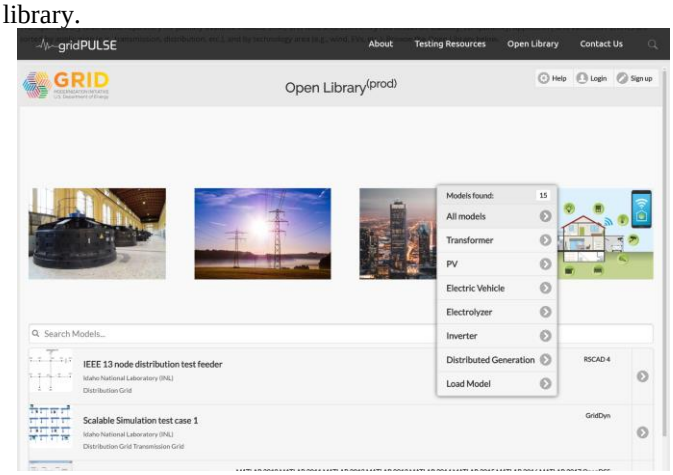

Fig. 9. Full detail on testing resources by National Lab (Sandia shown).

D. Contact Us

The contact us section contains a for through which gridPULSE users can contact gridPULSE members. Contacts requests can include requesting additional information (e.g., a lab contact) on a facility in the testing network, asking for help identifying an appropriate testing facility, suggestions for additions to the open library, etc. Submissions through the contact form are logged and testing requests will be shared with all gridPULSE members to ensure that the best test facility for the user is identified.

VI. Outlook and Sustainability

The main focus of the GMLC 1.2.3 project going forward is stakeholder outreach and sustainability of the gridPULSE consortium. Included in these efforts are:

- Publicity efforts related to the Testing Capabilities Catalog, Open Library, and gridPULSE website.
- Communications outreach including presentations to stakeholders.
- Understanding use cases and what more information might be necessary.
- Enacting a governance structure for gridPULSE which creates value for members.
- Recruiting additional members.
- Suggesting a path forward to fund gridPULSE beyond the GMLC 1.2.3 project, including a detailed understanding of the costs to sustain critical resources (e.g., website) and the incentives that can be leveraged (e.g., funding opportunity announcements that can incorporate gridPULSE).

Through these activities, we intend for the gridPULSE consortium to be self-supporting beyond the lifetime of the GMLC 1.2.3 project. To achieve this, it will be crucial that users see value in the gridPULSE consortium and motivate the members to keep their information up to date and continue to populate new models and testing capabilities.

Acknowledgment

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