

## Category 1 (Foundational/Regional) Project Final Report

### Report Completion Date:

#### Section 1: Project Information

| Project Information                                                                   |                                                                         |
|---------------------------------------------------------------------------------------|-------------------------------------------------------------------------|
| Control #:<br>Title:                                                                  | <b>GMLC 1.4.1</b>                                                       |
| Project Title:                                                                        | <b>Survey of Standards for DER Interconnection and Interoperability</b> |
| Project PI Name and Lab Affiliation:<br>Project Co-PI (plus-one) and Lab Affiliation: | <b>David Narang, NREL<br/>Mary Ann Piette, LBNL</b>                     |
| DOE Project Manager(s):                                                               | <b>Chris Irwin, Guohui Yuan</b>                                         |
| Period of Performance:                                                                | <b>6/1/2016 – 12/31/2019</b>                                            |
| Date Closed:                                                                          | <b>2/28/2020</b>                                                        |

#### Section 2: Project Assessment and Checklist

| Project Assessment and Checklist                                                                                  | Y/N      | Confirmation Date | Comments                                                                            |
|-------------------------------------------------------------------------------------------------------------------|----------|-------------------|-------------------------------------------------------------------------------------|
| Have all quarterly reports been submitted?                                                                        | <b>Y</b> |                   |                                                                                     |
| Have all milestones have been delivered?                                                                          | <b>Y</b> |                   |                                                                                     |
| Are all products finalized (e.g. technical reports, journal articles)?                                            | <b>Y</b> |                   |                                                                                     |
| Have all project products been finalized and presented/submitted to DOE Project Manager(s) and/or GMI Leadership? |          |                   | <b>In process of finalizing with DOE</b>                                            |
| Have all potential sensitivities been identified and addressed with DOE Project Managers and/or GMI Leadership?   |          |                   | <b>In process of finalizing with DOE</b>                                            |
| Has the project team received feedback from Project Stakeholders (e.g. advisory group)?                           | <b>Y</b> |                   |                                                                                     |
| Are there any open or pending costs?                                                                              |          |                   | <b>Final comment resolution of DOE comments and final editing of survey report.</b> |

#### Section 3: Outcomes, Deliverables, Publications

Provide the following:

*\*In addition to titles, provide links to any websites or other repositories where deliverables and/or other information will be available after the project has been completed*

*\*Publications available for public release, URLs, etc. listed here should be uploaded to GMLC Open Point*

##### 1. List of Outcomes:

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- a. *The team identified and evaluated key standards across multiple domains to identify gaps (defined as any activity needed to harmonize requirements among standards development organizations, minimize conflicting requirements among technology domains, or streamline conformance test procedures) preventing effective management of DER grid services.*
  - a. *The team identified challenges posed by interconnection, interoperability, and testing of DERs.*
  - b. *The project team worked to fill identified gaps by working with standards development efforts and validating needed interconnection and interoperability standards and test procedures for DERs at national laboratory facilities*
  - b. *Project team members provided direct input to standards development efforts under various working group efforts across multiple standards development organizations to foster harmonization of requirements across DER technology domains.*
- 2. List of Deliverables:**
- 1) **Standards Gap Analysis:** *The standards gap analysis conducted during this project examined what work is needed to provide unambiguous, reliable connections from a wide range of distributed energy resources to support grid needs and categorized these in terms of what can be done now (or near term) vs. those requiring more work or not yet sufficiently developed to provide grid services.*
    - a) *near term efforts are expected to be productive with*
      - i) *inverter-based systems for energy, frequency regulation, ramping, and voltage management, and*
      - ii) *grid connected microgrids*
    - b) *additional work is needed to allow responsive loads aiming provide needed grid services to reached its full potential*
    - c) *the nascent stage of commercialization of EVs and EV supply equipment suggests that these technologies could have high potential in the future but are not sufficiently developed or deployed to be useful at this time.*
  - 2) **Contributions to updated DER standards:** *The project team provided direct input to standards development efforts. The updated standards will result in 1) enhanced ability of distributed generation and storage to participate in grid energy and power interactions; 2) improved coordination of EVs through harmonization of communications standards with interconnection and interoperability*

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*requirements; and 3) advancement of standards to accelerate participation of responsive loads in energy transactions.*

- 3) **Survey report:** A main deliverable of this project was a survey of DER interconnection and interoperability standards. The report also included a gap analysis and recommendations for specific DER technology domains and associated standards.

3. **List of Publications:**

- a. *National webinar on ESI concept presented by LBNL on May 14, 2018.*
- b. *GMLC Survey of Distributed Energy Resource Interconnection and Interoperability Standards*

4. **List of Awards or Recognition:**

5. **List any ROIs – Software, Intellectual Property, Licensing, Patents, Etc.**

### Section 4: Final Costing

Each Lab Financial POC Completes Final Costing of GMLC Projects for their lab. PIs, Lab Leads will need to assist but not required to report financials with this final report.

### Section 5: Final Thoughts/Comments

| Final Thoughts                                                                            | Comments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|-------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Lessons Learned                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Opportunities for Improvement                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Future Projects:<br>Ideas for future work?<br>Possible next steps and research direction? | <p><b>The project team has identified a number of specific recommendations in the survey and gap analysis report. Highlights include the need for continuing support for industry efforts and for DOE direction and leadership in the following topic areas:</b></p> <ol style="list-style-type: none"> <li>1) <b>Further laboratory testing, field demonstration and development of requirements and specifications for cyber-physical security for DER</b></li> <li>2) <b>Further laboratory testing and field demonstration of grid services from responsive loads</b></li> <li>3) <b>Further laboratory testing, field demonstration and development of requirements and specifications for an energy services interface standard for responsive loads</b></li> <li>4) <b>Further laboratory testing, field demonstration and development of requirements and specifications for grid services from grid-connected microgrids</b></li> </ol> |
| Other:                                                                                    | <b>The project team contributed to updates to some of the most widely adopted standards across the United States for existing</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |

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|  | <p><b>DER. The updates will improve the interoperability of DER such as inverter based DER including PV and energy storage and will also pave the way for increased reliance on these technologies under both normal and abnormal grid conditions.</b></p> <p><b>Looking ahead to the provision of grid services from newly emerging DER technologies such as electric vehicles, and responsive loads, this project has contributed to efforts in these industries to develop widely applicable interfaces such as the energy services interface. Industry efforts are ongoing and could benefit from the reference material and recommendations in the team’s survey and gap analysis report (GMLC Survey of Distributed Energy Resource Interconnection and Interoperability Standards).</b></p> |
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