Category 1 (Foundational/Regional) Project Final Report

Report Completion Date: 28 Feb 2020

Section 1: Project Information

Project Information	
Control #: Title:	**1.2.2** **Interoperability**
Project Title:	**Interoperability**
Project PI Name and Lab Affiliation: Project Co-PI (plus-one) and Lab Affiliation:	**Steve Widergren, PNNL** **Bruce Nordman, LBNL**
DOE Project Manager(s):	**Monica Neukomm (BTO), Chris Irwin (OE)**
Period of Performance:	**3 years 10 months**
Date Closed:	**28 Feb 2020**

Section 2: Project Assessment and Checklist

Project Assessment and Checklist	Y/N	Confirmation Date	Comments
Have all quarterly reports been submitted?	Y		
Have all milestones have been delivered?	Y		See milestone list
Are all products finalized (e.g. technical reports, journal articles)?	Y		
Have all project products been finalized and presented/submitted to DOE Project Manager(s) and/or GMI Leadership?	Y		Presented to DOE and GMI leadership, no comments.
Have all potential sensitivities been identified and addressed with DOE Project Managers and/or GMI Leadership?	Y		There are no sensitivities to address
Has the project team received feedback from Project Stakeholders (e.g., advisory group)?	Y		Held project wrap up meeting with advisors and 2030.5 roadmap group (ESC)
Are there any open or pending costs?	Y		DOE leads approved use of small remaining funds to address interoperability expertise requests

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. Established an interoperability strategic vision for the electric power sector
b. Described the state, challenges, and path forward to advance interoperability
c. Articulated general interoperability requirements, and offered tools and methodology to facilitate gap analysis, develop roadmaps, and demonstrate vision concepts
d. Attracted industry stakeholder attention and incentivized involvement to make interoperability advancement an enduring aspect of grid modernization technology deployment
    i. Brought attention to the importance of addressing interoperability concerns for grid modernization and educated various communities on these concepts
    ii. Inspired an on-going effort in SEPA (ESI Task Force) for developing a universal specification for distributed energy resource information and communications technology integration to improve interoperability of these resources with electric system operation
    iii. Launched an interoperability ecosystem group for integration of DER based on the IEEE 2030.5 standard roadmap that continues in IEEE and SunSpec

2. **List of Deliverables:**
    a. Technical Meetings
        i. September 2016 stakeholder meeting, Chicago, IL: strategic vision early draft document, several project and industry presentations
        ii. May 2017 stakeholder meeting, Gahanna, OH: Interoperability Maturity Model draft document, Interoperability Roadmap Methodology draft document, several project and industry presentations
    b. Public draft reports
        i. April 2017, Interoperability Strategic Vision: Enabling an Interactive Grid, PNNL-26338
        ii. April 2017, A Qualitative and Quantitative Approach for Measuring Interoperability, PNNL-26412
        iii. December 2017, Interoperability Roadmap Methodology V1.1, PNNL-27149
        iv. April 2019, Reference Interoperability Procurement Language, PNNL-28666
        v. October 2019, GMLC 1.2.2 Interop Debrief internal report
    c. Brochures
        i. August 2016, Invitation to Join Interoperability Project, https://gmlc.doe.gov/sites/default/files/resources/Invitation%20to%20Join%20Interoperability%20Project%20Overview.pdf
        ii. Plug & Play DER Challenge – one pager, http://www.plugandplayder.com/
    d. Presentations (a sampling)

      i. 2016, 2017, 2018 GMLC Peer Review presentations
      ii. November 2016, SGIP Grid Modernization Summit
      iii. November 2016 GridWise Architecture Council presentation
      iv. April 2017, IEEE ISGT conference presentation
      v. July 2017, DOE Interoperability briefing
      vi. July 2017, SEPA Grid Evolution Summit presentation
      vii. January 2018, AHR Expo panel presentation
      viii. February 2018, IEEE ISGT conference presentation
      ix. June 2018, Transactive Energy Systems conference presentation
      x. July 2018, SEPA Grid Evolution Summit, 2 presentations
      xi. August 2018, IEEE PES GM presentation
      xii. September 2018, Solar Power International (NASEW) presentation
      xiii. January 2019, AHR Expo presentation
      xiv. January 2019, DOE Innovation XLab presentation
      xv. July 2019, IEEE Transactive Energy Systems conference presentation
      xvi. August 2019, Grid Evolution Summit presentation
      xvii. August 2019, IEEE PES GM presentation
      xviii. September 2019, NCEP training for NARUC presentation
      xix. September 2019, North America Smart Energy Week presentation

   e. Posters
      i. April 2017 GMLC Peer Review poster
      ii. April 2018 BTO Peer Review poster
      iii. September 2018 GMLC Peer Review poster
      iv. July 2018 Plug & Plan DER Challenge poster for SEPA Grid Evolution Summit, Washington, DC
      v. August 2019 Plug & Plan DER Challenge poster for SEPA Grid Evolution Summit, Washington, DC
      vi. September 2018 Plug & Play DER Challenge participant posters for North America Smart Energy Week (SEPA conference), Anaheim, CA
      vii. January 2019 Plug & Play DER Challenge participant posters for DOE Innovation XLab meeting, Seattle, WA
      viii. August 2019 Grid Evolution Summit poster, Plug & Play DER Challenge

   f. Websites
      i. GMLC 1.2.2 Interoperability, hosted by DOE, https://gmlc.doe.gov/projects/1.2.2
      ii. Plug and Play DER Challenge, hosted by SEPA, http://www.plugandplayder.com/
      iii. 2030.5 ESC ICA, hosted by IEEE-SA: https://standards.ieee.org/industry-connections/ieee-2030_5-ecosystem-steering-committee.html

3. List of Publications:
   a. Public whitepapers

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    i. November 2016, Declaration of Interoperability, https://gmlc.doe.gov/sites/default/files/resources/InteropDeclarationV3.pdf
    ii. March 2018, Interoperability Strategic Vision, https://gmlc.doe.gov/sites/default/files/resources/InteropStrategicVisionPaper2018-03-29.pdf
    iii. July 2018, Plug & Play Challenge Call for Concepts, http://www.plugandplayder.com/
    iv. October 2019, Interoperability Maturity Roadmap – IEEE Std 2030.5, published by IEEE https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8894220
    v. Interop Strategic Vision whitepaper that is already on the GMLC 1.2.2 website: https://gmlc.doe.gov/project-highlights/strategic-vision-grid-interoperability-published

b. Final reports
    i. January 2020, Interoperability Maturity Model – A Qualitative and Quantitative Approach for Measuring Interoperability, PNNL-29683
    ii. January 2020, Interoperability Maturity Roadmap Methodology, V1.3, PNNL-2749 1.3
    iii. January 2020, Reference Interoperability Procurement Language, PNNL-28666 Final
    iv. January 2020, Launching Plug and Play Distributed Energy Resources into the Future, http://www.plugandplayder.com/

c. Articles
    i. April 2017, Blurring Lines Between Technical and Cognitive Interoperability, Public Utilities Fortnightly, https://www.fortnightly.com/fortnightly/2017/04/blurring-lines-between-technical-and-cognitive-interoperability
    ii. June 2018, Enabling an Interactive Grid: A Strategic Vision for Interoperability, Smart Grid Newsletter, https://resourcecenter.smartgrid.ieee.org/publications/newsletters/SGNL0255.html
    iii. Sep/Oct 2019, The Plug-and-Play Electricity Era, IEEE Power & Energy Magazine, pp 47-58, https://ieeexplore.ieee.org/document/8802361
    iv. September 2019, Sowing the Seeds of Grid Interoperability: "Plug-and-Play DER Challenge" Seeks Industry Solutions to Address Technology Silos, Christine Stearn (SEPA) and Tim Wolf (PNNL) http://www.plugandplayder.com/

d. Webinars

    i.   August 2018, Plug & Play DER Challenge – Informative Webinar, hosted by SEPA

    ii.   February 2019, Meeting the Plug and Play DER Challenge, hosted by SEPA

    iii.   October 2019, Launching Plug & Play DER into the Future, hosted by SEPA

4. **List of Awards or Recognition:**
    a. Plug and Play DER Challenge Phase 1 Concept Papers recognition
    b. Plug and Play DER Challenge Phase 2 ESI Specifications awards
        i.   October 2019, OpenDEM ESI Specification
        ii. October 2019, openDSRIP Interface Specification
        iii. October 2019, ESI Server Interface Specification

5. **List any ROIs – Software, Intellectual Property, Licensing, Patents, Etc.**
    a. October 2019 Documented and demonstrated ESI specifications: OpenDEM, openDSRIP, ESI Server – participants in the Plug & Play DER Challenge. Ongoing participation in SEPA ESI Task Force
    b. October 2019, Interoperability Maturity Roadmap – IEEE Std 2030.5, being used by the IEEE-SA 2030.5 Ecosystem Steering Committee and SunSpec Alliance for advancing interoperability

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	The follow material summarizes feedback from our project team debriefing Did we accomplish our objectives? • Objectives became clear and commonly held over time • Engaging stakeholders helped clarify needs • Task work brought clarity to addressing the objectives What did we do right to accomplish our objectives? • Strategic Vision work covered the issues and socialized them • Good stakeholder engagement in the tasks, helped shape and better communicate interoperability message and tools • Workshops provided good input and encouraged involvement from industry people and organizations How effective was the GMLC and our team organization?

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	• Leadership, tasks, team assignments worked to deliver on the scope of work • General relationship to other GMLC efforts could be better coordinated across all projects • Interest in other related projects, but no time/opportunity to exchange information • GMLC leadership provided little help or opportunity for internal GMLC project coordination
Opportunities for Improvement	• Electric vehicle interop trial roadmap, a rich area we could not attain liftoff, but should be pursued • Interoperability still seems too complex for broad appreciation, even with progress • Always more work to do on education and socialization • Additional workshops could have been helpful • Deeper attention to grid architecture aspects and interoperability standards development could be beneficial in the future • Consider GMLC inward-facing activities: internal GMLC newsletter, cross-GMLC project sharing/interaction workshops
Future Projects: Ideas for future work? Possible next steps and research direction?	• Ensure continuity of industry engagement with proposed GMLC 2.5.2 Grid Services & ESI project • Future industry workshops to share results and open new opportunities concerning interoperability • Consider an interoperability phase 2 program and opportunities to address non-DER grid integration areas • Engage industry to develop interop roadmaps for EV/EVSE and demand flexibility (buildings, etc.) • Team with 1.2.1 Grid Architecture products and skills to investigate DER architectures and interfaces. Consider the 1.4.2 Equipment Characteristic models and their influence on interoperability. • Consider the Software Engineering Institute's Capability Maturity Model for Integration and how it could be focused on interfaces. • Apply organizing concepts from the interoperability work to help define "best practices" for developing interface standards, including things like modularity in standards and creating structure that allows reference and consistency between standards that build on other standards.
Other:	

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