MIT LINCOLN LABORATORY

ELECTRIC POWER HARDWARE-IN-THE-LOOP COLLABORATIVE

Collaborative Agreement (the "Agreement") by and between the MIT Lincoln Laboratory, a Federally Funded Research and Development Center, having a principal place of business at 244 Wood Street, Lexington, MA 02420, ("MIT LL") and _____, having a principal place of business at _____ (the "Member") effective as of _____, 2016 the "Effective Date."

1. Definitions

As used in this Agreement, the following terms shall have the following meanings and such meanings should be equally applicable to both the singular and plural forms of the terms defined:

a. "Invention" means any invention or discovery (including software-related invention) which is or may be patentable or otherwise protected under Title 35 of the United States Code or any novel variety of plant which is or may be protectable under the Plant Variety Protection Act (7 U.S.C. 2321 et seq.).

b. "Made" in relation to any invention means (a) the conception and (b) either (i) documentation or description in any progress report, final report, or invention disclosure, or (ii) first actual reduction to practice of such invention.

c. "Proprietary Information" means information which, at the time of disclosure, is designated in writing as "confidential" to the owning party and embodies trade secrets or is confidential technical, business, or financial information, provided that such information:

(i) is not generally known, or is not available from other sources without obligation concerning its confidentiality;
(ii) has not been made available by the owners to others without obligation concerning its confidentiality;
(iii) is not already available to the public without obligation concerning its confidentiality; or
(iv) does not include information which is independently created by the receiving party as shown by its written records.

d. "MIT LL Property" means property belonging to MIT or property belonging to the US Government located at MIT LL, for which MIT LL has property management responsibility.

e. "Program" means the work described in Appendix A.

f. "Repository" means the software and model repository described in Appendix A.

2. **PROGRAM DESCRIPTION**. MIT LL agrees to use reasonable efforts to conduct the Program as described in the overview that appears in Appendix A to this Agreement.

3. **TERM OF AGREEMENT.** The term of this Agreement is for a period of one (1) year, commencing on the Effective Date. Thereafter, this Agreement shall automatically renew for successive one (1) year terms. A Party may terminate this Agreement with thirty (30) days written notice of termination to the other Party. Termination shall not, however, affect the rights and obligations contained herein with respect to Proprietary Information disclosed prior to termination. In the event of expiration or

termination of this Agreement, those sections that by their nature are intended by the Parties to survive shall survive and continue in effect to the extent necessary to protect the rights of the Parties.

4. **PUBLICATIONS.** MIT LL and Member will be free to publish non-Proprietary Information about Program activities performed under this Agreement, so long as such publications are also submitted to the Repository.

5. **INTELLECTUAL PROPERTY.**

   a. **Ownership of MIT Copyrights and Patents.** The Member agrees that all right, title and interest in and to any and all software and documentation created or developed, and in and to all patentable inventions conceived or first reduced to practice solely by MIT LL, its personnel, shall be owned by MIT.

   b. **Licenses to MIT Non-Software Patentable Inventions.** In the event an MIT LL non-software invention is made, it shall be handled in accordance with U.S. patent law. In the event that a patent application on such an invention is filed by MIT, for each such invention, MIT hereby grants Member a non-exclusive, royalty-free internal use license. Should Member require additional licenses to such non-software patented inventions these rights will be negotiated through the MIT Technology Licensing Office.

   c. **License to MIT Software and Documentation.** MIT agrees to grant Member a non-exclusive, sublicenseable, royalty-free license to use, reproduce, modify, translate, distribute, publicly display and publicly perform all software and documentation described in Section 5(a), subject to the notices with respect to copyright, trademarks and disclaimer of liability which shall appear on all copies of the software and documentation provided to Member by MIT LL, and which must be reproduced on each copy reproduced or distributed by the Member.

   d. **Joint Intellectual Property.** MIT and Member agree that jointly developed or conceived inventions or copyrightable materials shall be jointly owned. Each joint owner shall be entitled to exercise all rights of ownership as provided by law, without, however, an obligation of accounting from one to the other.

   e. **Government Rights.** The US Government shall receive a non-exclusive, irrevocable, paid-up, worldwide license to use, duplicate or disclose any copyrighted work or patentable inventions conceived or reduced to practice using MIT LL Property or US Government funds, in whole or in part and in any manner, for Government purposes only and to have or permit other to do so for Government purposes only.

6. **MEMBER PROPRIETARY INFORMATION.** Subject to Article 5, any Proprietary Information disclosed in the Repository by Member under this Agreement shall be owned by Member. However, Member agrees to grant MIT LL, the US Government, and all other Members, to the extent necessary, a right to use and duplicate such Proprietary Information in confidence, provided MIT LL and all other members agree that they shall use reasonable measures to protect the confidentiality of all appropriately marked Proprietary Information, unless otherwise required by law.

7. **RESULTS.** The results of EPHCC research will be made equally available to all Members. Ownership of patents and copyrights that result from EPHCC research will remain with the entity that generated the intellectual property, as per the terms of this Agreement.

8. **DUES.** No monetary dues are required of Members. Member agrees to contribute material into the Repository, provide in-kind engineering hours to help maintain the Repository, or provide other support as mutually agreed between Members.

9. **WARRANTY DISCLAIMER.**
THE PROGRAM PERFORMED BY MIT LL AND RESOURCES PROVIDED BY THE MEMBER IN ACCORDANCE WITH THE TERMS OF THIS AGREEMENT ARE WITHOUT EXPRESS OR IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE AND THE PARTIES MAKE NO WARRANTY OR REPRESENTATION THAT THE SAID RESOURCES OR PROGRAM RESULTS DO NOT OR WILL NOT INFRINGE THE INTELLECTUAL PROPERTY RIGHTS OF THIRD PARTIES. ALL MEMBER RESOURCES ARE PROVIDED TO MIT LL "AS IS" AND ALL PROGRAM RESULTS ARE DELIVERED TO THE MEMBER "AS IS." MIT LL AND THE US GOVERNMENT SHALL BEAR NO LIABILITY FOR ANY CLAIM, ACTION, DAMAGE OR INJURY ON ACCOUNT OF THE MEMBER'S USE OF ANY OF THE RESULTS OF THE PROGRAM PERFORMED BY MIT LL HEREUNDER.

   IN NO EVENT SHALL EITHER PARTY, ITS TRUSTEES, DIRECTORS, OFFICERS, EMPLOYEES, AGENTS AND AFFILIATES, BE LIABLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES OF ANY KIND, INCLUDING ECONOMIC DAMAGES OR INJURY TO PERSONS OR PROPERTY AND LOST PROFITS, REGARDLESS OF WHETHER THAT PARTY SHALL BE ADVISED, SHALL HAVE OTHER REASON TO KNOW OR IN FACT SHALL KNOW OF THE POSSIBILITY OF THE FOREGOING. THIS ARTICLE 8 SHALL SURVIVE THE EXPIRATION OR ANY EARLIER TERMINATION OF THIS AGREEMENT.

10. **INDEMNIFICATION**. No party is assuming any liability for the actions or omissions of any other party as a result of this Agreement. Member will indemnify and hold MIT LL and other members harmless against all claims, liability, injury, damages or costs, including reasonable attorney fees, based upon injury or death to persons, or loss of, damage to, or loss of use of property that arises out of the performance of this Agreement to the extent that such claims, liability, damage, cost or expense results from the negligence of the Member's agents or employees.

11. **USE OF NAME.** Member shall not use the name of "Massachusetts Institute of Technology," "Lincoln Laboratory," or any variation, adaptation or abbreviation thereof, or that of any of its trustees, officers, or agents, or any trademark owned by MIT without MIT's written permission. The MIT Technology Licensing Office has sole authority to grant in writing to the Member any approved use of the MIT name, logo, insignia or trademark or the names of any of MIT's trustees, officers, employees, or agents in any press or media announcement.

12. **NOTICES.** Any notices required to be given or which shall be given under this Agreement shall be in writing and be addressed to the parties as shown below. Notices shall be delivered by certified or registered first class mail (air mail if not domestic) or by commercial courier service, and shall be deemed to have been given or made as of the date received.

MEMBER	MIT Lincoln Laboratory
Name	Jayme C. Selinger
Title	Technology & Contracts Administrator
Address	244 Wood Street Lexington, MA 02420

Phone	ph: 781-981-5034
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13. **ASSIGNMENT.** This Agreement shall be binding upon and inure to the benefit of the parties hereto and the successors to substantially the entire business and assets of the respective parties hereto. This Agreement shall not be assignable by either party without the prior written consent of the other party; any attempted assignment is void.

14. **FORCE MAJEURE.** No party shall be responsible to others for failure to perform any of the obligations imposed by this Agreement, provided such failure shall be occasioned by fire, flood, explosion, lightning, windstorm, earthquake, subsidence of soil, failure or destruction, in whole or in part, of machinery or equipment, or failure of supply of materials, discontinuity in the supply of power, governmental interference, civil commotion, riot, war, strikes, labor disturbance, transportation difficulties, labor shortage or any cause beyond its reasonable control.

15. **EXPORT CONTROLS.** Member acknowledges that information disclosed hereunder may be subject to export control, and that compliance with appropriate Government regulations such as the International Traffic in Arms Regulations (ITAR) and Export Administration Regulations (EAR), etc., must be maintained prior to disclosing such information to foreign nationals, business, or governments. The disclosing party shall indemnify and hold all members and MIT LL harmless for all claims, demands, damages, costs, fines, penalties, attorney's fees, and all other expenses arising from failure of the disclosing party to comply with this clause or applicable U.S. export control laws and regulations.

16. **INDEPENDENT CONTRACTORS.** Each Member is acting as an independent contractor and nothing contained in this Agreement is to be construed as creating a partnership, joint enterprise, or any other agency relationship between the parties.

17. **GOVERNING LAW.** The construction, validity, performance, and effect of this Agreement for all purposes shall be governed by the laws and regulations of the United States and applicable Commonwealth of Massachusetts laws that do not conflict with these Federal laws and regulations.

18. **ENTIRE AGREEMENT.** Unless otherwise specified, this Agreement and its Appendix embody the entire understanding between MIT LL and the Member for the Member's support of the Program performed under this Agreement, and any prior or contemporaneous representations, either oral or written, are hereby superseded. No amendments or changes to this Agreement shall be effective unless made in writing and signed by authorized representatives of the parties.

v. 6.24.16

Appendix A

DRAFT (v7 Jan 13, 2016)

White Paper

Electric Power Hardware-in-the-Loop Controls Collaborative (EPHCC)

Statement of Need

The widespread deployment of self-healing distribution systems, distributed energy resources (DER) such as solar photovoltaics and batteries with smart inverters, microgrids, and other distribution-level technologies requires complex device controls with communications interfaces.

Adoption of advanced technologies with complex new controls and interfaces is slowed due to potential safety and system reliability risks. Since the typical tools[1] and engineering methodologies used by power system engineers only perform steady-state load flow and short circuit analyses, they are insufficient for evaluating controls behavior of new devices before installation. For this reason utilities embark on lengthy and costly demonstration projects, but even these cannot provide full test coverage and system validation due to potential damage to expensive power distribution equipment. Progressive utilities, regulators, equipment vendors, and end users are frustrated by the slow rate of technology adoption and implementation of the advanced controls required for modernized distribution systems.

Technical Solution

MIT-LL's power distribution Hardware-in-the-Loop Laboratory Testbed and Open Platform (HILLTOP) can accelerate and reduce the risk of energy technology deployments by enabling utilities to efficiently and rigorously evaluate new technologies to high technical standards in a cost-effective and timely manner. HILLTOP can offer equipment vendors a way to complete most of the required software development and integration work at a much earlier stage in project design and commissioning. A critical mass of industry players must, however, participate in this HIL platform in order for it to achieve the goal of accelerating innovation and standardization for new control and interface technology development.

There is a precedent for this technical solution in the aerospace, automotive, and power transmission industries. These industries have, to varying degrees, adoped real-time simulation, controller hardware-in-the-loop, and open modeling standards to accelerate systems integration, testing, and deployment. The HILLTOP system incorporates the best practices from these various industries.

Figure 1 shows all the elements of the HILLTOP system and EPHCC repository.

Real-time Simulation Repository (bottom row)

This foundational layer contains everything needed to create a model of the power system. It has conversion scripts used to port power system netlists between the various commercially-available real-time simulation. It contains validated models of DER power equipment, along with the unit tests that demonstrate their validity. Since it is not always practical to implement hardware controllers-in-the-loop, these DER models require validated software controllers that can be run in real-time – preferably controllers that have been contributed or validated by industry members.

[1] Typical tools used by the utility industry include OpenDSS (developed by EPRI), PSS/E (Siemens), and EMTP-RV (PowerSys).

Test Repository (top row)
This layer is overlayed on the real-time simulation platform. This layer consists of netlists of real-world feeders, including their electrical and equipment parameters. The feeders require corresponding test stimuli, such as dynamic, high-resolution load and irradiance profiles and transient test events such as grid failures, faults, and motor startups. Lastly, a standard results database and set of post processing scripts make it possible to evaluate the simulated performance against IEEE P2030.8, IEEE 1547, and utility standards.

Controller-in-the-loop Repository (middle row)
These elements increase the realism of the HILLTOP testbed by enabling the actual device controllers to run the simulated power equipment. Each DER device controller that is connected with a real-time HILLTOP simulation will require interface "glue" software and unique interface circuitry, documented with bills of material (BOMs), mechanical schematics, and electrical schematics. Lastly, the repository will contain communication drivers and documentation on register lists for the DER device and data collection communication interfaces.

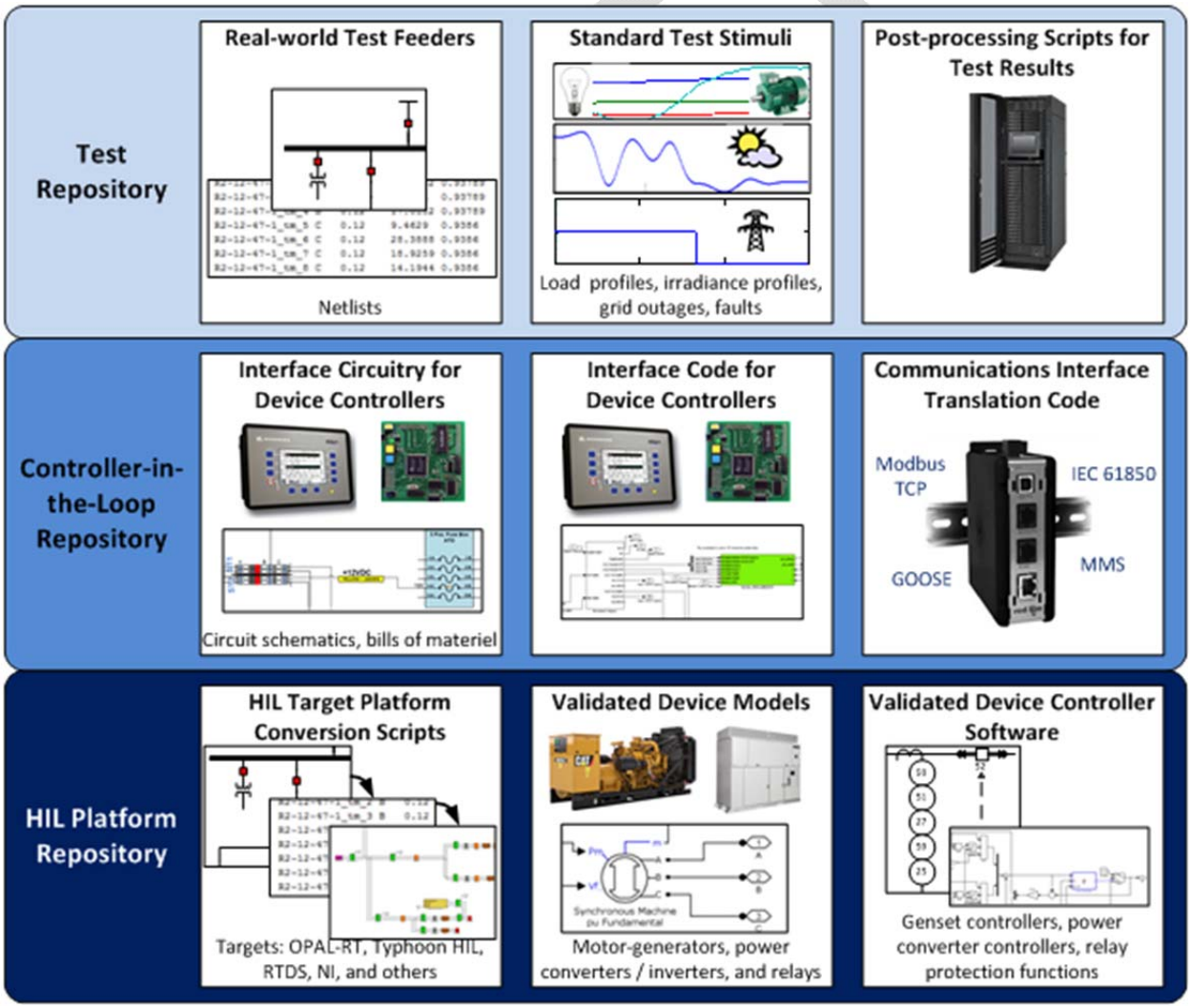

Figure 1: Elements of the shared software repository for the HILLTOP system, organized by EPHCC

Institutional Solution
It will take a substantial period of time – measured in years not months – before power system engineers can accept and adopt new control and interface technologies on their power distribution systems. It will take even longer to reach a consensus among hardware and software vendors, the power industry, utilities, project developers, and systems integrators of power distribution technologies. Such a consensus is necessary for standards.

The solution is to accelerate the process by bringing stakeholders together in a way where technological criteria can be developed through device and system testing. This is a common interest for all the stakeholders: regulators and utilities need a way to evaluate systems for safety and reliability before rate-basing their deployment, vendors want to increase options for customers to evaluate their products and want to streamline system integration work, and the government and research community need a better avenue for testing new concepts.

A Public/Private Collaborative for Power Controls Engineering
Therefore, MIT-LL proposes to facilitate the development of a Electric Power Controls Collaborative (EPHCC). This collaborative will encourage the needed critical mass of industry players and public sector entities to contribute to the HILLTOP system and to collaborate on other initiatives that will accelerate the adoption of distribution system control technologies. The EPHCC will maintain a repository of the elements shown in Figure 1 that vendors and utilities will use to advance their testing of devices individually and in systems, demonstration and evaluation efforts, and systems integration.

Distribution System Applications

• Integration of control systems – Microgrid controller testing and integration with DER and IED sub-systems – Distribution management system testing and integration – Transmission operator dispatch integration and ancillary services testing – Volt VAR control systems testing • Protection system testing, including – Evaluation of automation sequences – Development of automated self-healing systems – Feeder sectionalization studies • Prime mover DG controller testing – Evaluating stability issues due to DG dynamics – Anti-islanding and blackstart testing	• DER controls behavior testing – DG penetration studies – Anti-islanding / intentional islanding controls studies • Detailed power systems analysis – Evaluating electromagnetic transients due to switching or faults – Assessment of symmetrical and non-symmetrical events – Evaluation of transient overvoltage and resonance • Micro-PMU (phasor measurement units) studies • Implementation and evaluation of smart grid concepts • Communications testing and integration • Other distribution-level studies

Purpose
Accelerate the deployment timelines of safe and reliable power distribution technologies through an industry-wide collaboration on real-time simulation tools, equipment models, device controller interfaces, and test protocols.

Tech Transition
Tech transition is inherent in EPHCC. All participants will have access to an shared software repository for immediate use on their projects.

Membership and Stakeholders: Widespread participation will be necessary in order to promote development and adoption of the HILLTOP engineering tools, so MIT-LL will seek engagement and formal membership in the Collaborative by the following types of entities across the US.

Training and Education: Training of utility engineers and education of power systems students is critical to the long-term adoption of real-time simulation and controller-in-the-loop for next-generation power distribution systems. EPHCC's training and education efforts will have two main thrusts:

- Support early adopters: EPHCC must flatten the learning curve for HILLTOP, to enable utility engineers with a nominal amount of training to start using HILLTOP themselves. EPHCC will develop training materials and tutorials to these early adopters, and may also provide technical support and loaner equipment to those who are getting started.
- Foster industry-wide adoption: EPHCC will work with the leading power systems education programs – such as those at NYU Poly, UC Berkeley, WSU, Texas A&M, and U. Wisconsin-Madison – to incorporate this technology and engineering techniques into their distribution engineering coursework. [2] EPHCC will also work with leading industry groups[3] and utilities nationwide to incorporate these engineering practices into their standard workflow. This training will draw from and contribute to the growing EPHCC repository.

Membership

EPHCC will be open to all organizations involved in modernizing the electric power distribution system. Organizations must make a good faith commitment to regular substantive volunteer participation by both engineers and executives, regardless of ability to provide dues or other financial resources.

Membership Cost: Contribution of technical information or in-kind engineering labor

There will be no membership fee to member organizations. Instead, organizations which have technical data or resources that could benefit the HILLTOP system (e.g., validated device model, feeders, test scripts, or device interfaces) will be expected to contribute those data to the shared software repository. Other members will be expected to contribute ___ hours/year of in-kind engineering labor for the development and validation of technical information within the EPHCC shared software repository. Members could meet this obligation by contributing technical information developed in the course of their normal course of business.

Funding for discrete R&D or other technical projects would continue to flow through individual Members of the Collaborative.

EPHCC will also encourage public funding agencies – especially the DOE, DOD, and state agencies – to require their awardees to submit all the relevant technical information developed using those public dollars to the HILLTOP system.

Protection of Intellectual Property: Some of the information shared by industry via EPHCC's repository could be considered sensitive. EPHCC's shared software repository will only be accessible to member organizations via GitHub. Prior to being granted access, new member organizations will be

[2] To start, MIT-LL will create a class through its Beaverworks lab on the MIT campus. Beaverworks educates students through semester-long, project-based courses. Students – guided by MIT-LL Energy Systems staff and power systems professor Marija Ilic and using power equipment donated by MIT industry sponsors and a HIL hardware vendor – will learn power systems engineering topics while integrating numerous DER device controllers, developing realistic test feeders, writing test scripts, and developing demonstrations of next-generation power system deployments. The final class deliverables will be added to the EPCC repository, helping grow the repository rapidly.

[3] The IEEE Power and Energy Society Workforce Collaborative could be a strong potential partner for developing and disseminating training and education materials.

required to agree to use the data for legitimate project development, integration, and testing purposes, not for illegitimate purposes such as reverse-engineering competitors' products.

Operations Expenses: In order to avoid the need to set dues that would reduce participation or slow the initiation of needed work, funding will be sought from DOE and other public funding sources for the out-of-pocket budget to operate the Collaborative, initially estimated to be $__,000/year.

Collaborative Activities: EPHCC will perform coordination and information-exchange functions. Specifically, the functions of the Collaborative may include:

- Maintenance of a shared software repository and bug tracking capability.
- Outreach to stakeholders, especially distribution utilities, regulators, vendors, and government funding agencies.
- Organizing technical working groups and planning sessions with MIT-LL on organization of the technical content and future development of the HILLTOP system.
  - Working groups may develop specialized technical content for the repository in support of specific standards activities, such as IEEE P2030.8 (Microgrid Controller Test Standard)
  - Systematic Model Validation and Model Portability are likely the first two working groups. Staff from LBNL and MIT-LL have expressed interest in participating in and leading these two working groups.
- Sponsorship of an annual Electric Power Controls Engineering Symposium (replacing the Massachusetts Microgrid Controls Symposium), starting in 2017.
- Maintenance of a website to make available information about the Collaborative, its services, achievements, and introductory technical materials.
- Development of education and training materials on the HILLTOP system.
- Development of technical reports and case studies.

Excluded Activities

The Collaborative will not provide formal testing, certification, or vendor equipment evaluation services. Collaborative members – such as owner's engineering firms, national labs, or commercial test labs – could provide testing services using the Collaborative's models. The Collaborative itself will not host a test lab of its own or compete with labs such as UL, TUV, or NREL.

The Collaborative will also not engage in power hardware-in-the-loop testing, due to the expensive laboratory facilities and expertise required. Labs which have the necessary facilities and expertise could, however, use the Collaborative's models and test scripts to advance their power hardware-in-the-loop testing work.

Tentative Milestones

- FY 16 Commitment of the funding required for a minimum budget for at least 2 years
- FY 16: Initial meeting of a Collaborative board or organizing committee
- FY 16: Invitations sent to become a Member of the Collaborative
- FY 16: Initial Member briefing on MIT-LL HILLTOP system
- FY 16: Committee meetings to begin work
- FY 17: Microgrid and DER Controls Symposium
- FY 17: Electric Power Controls Engineering Symposium

Points of Contact:

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