

DEPARTMENT OF ENERGY GRID MODERNIZATION LAB CALL

This lab call constitutes the Department's Activities for the Grid Modernization Initiative in FY2016. Offices contributing to the lab call include the Office of Electricity and Energy Reliability, the Office of Energy Efficiency and Renewable Energy, and the Office of Energy Policy and Systems Analysis.

Since only DOE National Laboratories are eligible to apply as primary recipients under this Lab Call, the ensuing awards will be issued through the Work Authorization System based on a Field Work Proposal (FWP), an Inter Entity Work Order (IWO), an Annual Operating Plan (EERE) or other allowable instrument deemed appropriate by the Government.

*An Integrated and
Coordinated
Approach*

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Introduction

As part of the Department's crosscutting Grid Modernization Initiative, DOE has developed a Grid Modernization Laboratory Consortium (GMLC). The GMLC is a strategic partnership between DOE and the National Laboratories that is focused on achieving DOE's Grid Modernization Initiative's vision, goals, and outcomes. It is intended to complement and strengthen DOE's partnerships with the electric industry, manufacturers, states and other key stakeholders by improving accessibility to this globally-recognized technical expertise. GMLC embodies an integrated and coordinated approach to ensure that DOE-funded activities across multiple DOE offices and National Laboratories will effectively deliver on the outcomes described in the DOE Grid Modernization Initiative's Grid Modernization Multi-Year Program Plan (MYPP).

One key element of accomplishing this new desired level of integration and coordination will be the development and execution of a single Annual Operating Plan (AOP) between DOE headquarters and the National Laboratory complex for grid modernization activities across the Department in FY2016.

The grid modernization activities are represented in two categories:

- 1) **Category 1: Foundational Platform Activities** - In this category, the National Laboratory complex will develop larger, multi-lab, holistic proposals that address well-defined foundational platform activity areas in the Grid Modernization Multi-Year Plan. Because these topics are foundational, the coordination of these topics will occur through the GMLC Management Leadership, in strong collaboration with all key personnel from DOE's offices and programs within the Grid Modernization Initiative. These projects will represent cross-cutting projects where each project will represent a collaboration across and receive support from multiple DOE office and programs. Due to the cross-cutting nature of these topics and projects, the development of all proposals submitted under this category will be coordinated across the National Laboratory complex by the National Lab Lead Integrators.
- 2) **Category 2: Program Office Specific Activities** - Using the framework of the Grid Modernization MYPP, the program offices will develop "Program Specific" lab call topics that address their specific requirements for grid modernization, not covered sufficiently well or specifically in the Foundational Platform Activity Topics. The DOE leads (Parks, Lynn) will work with the program office leadership to develop these topics. Proposals solicited under in the category will undergo a traditional open lab call competition.

Below are guiding principles that should be in mind when developing project submissions:

- **Impact:** Is this a high impact problem?
- **Additionality:** Will DOE funding make a large difference relative to existing funding from other sources, including the private sector?
- **Openness:** Are we focusing on the broad problem we are trying to solve and open to new ideas, approaches, and performers?
- **Enduring Economic Impact:** How will DOE funding result in enduring economic impact for the United States?

- **Proper Role of Government:** Why is this investment a necessary, proper, and unique role of government rather than something best left to the private sector to address?

Funding

This is a multi-office, multi-year lab call for both Foundational and Program-Specific activities. Allocations in tables below represent funding amounts in the different topics. Note that efforts vary by program and office.

Foundational Platform Activity Topics

For Foundational Platform Topics 1, 2, and 3, funding will be allocated equally across EERE and OE as follows:

These areas will be co-funded equally by EERE and OE.

| Topics (\$M) | FY16 | FY17 | FY18 | Total | EERE | OE |
|--------------|-------|-------|-------|--------|-------|-------|
| 1.1 | \$2.0 | \$2.0 | \$2.0 | \$6.0 | \$3.0 | \$3.0 |
| 1.2 | \$5.0 | \$5.0 | \$5.0 | \$15.0 | \$7.5 | \$7.5 |
| 1.3 | \$8.0 | \$0.0 | \$0.0 | \$8.0 | \$4.0 | \$4.0 |

Foundational Platform Activity Topic Area 1.4 will also be co-funded by EERE and OE. It is expected that the GMLC will propose large, coordinated projects that apply to (and can be funded by) multiple program offices at DOE.

For Foundational Activity Topic Area 1.4, the following EERE funds are available to fund crosscutting activities. Crosscutting efforts must be of interest to the program lines the proposals address.

EERE Foundational Funding by Program: Topic 1.4

| Topic 1.4 (\$M) | FY16 | FY17 | FY18 | Total |
|--|---------|--------|--------|---------|
| Building Technologies Office | \$4.13 | \$2.13 | \$2.13 | \$8.38 |
| Fuel Cell Technologies Office | \$2.38 | \$0.71 | \$0.71 | \$3.79 |
| Solar Energy Technologies Office | \$4.13 | \$2.13 | \$2.13 | \$8.38 |
| Vehicles Technologies Office | \$4.13 | \$2.13 | \$2.13 | \$8.38 |
| Wind and Water Power Technologies Office | \$2.25 | \$1.42 | \$1.42 | \$5.08 |
| Total | \$17.00 | \$8.50 | \$8.50 | \$34.00 |

*includes some FY15 dollars

For Foundational Activity Area Topic 1.4, the following OE funds are available. Crosscutting efforts must be of interest to the program lines the proposals address.

| (\$M) | FY16 | FY17 | FY18 | Total Lab Funding |
|--|------|------|------|-------------------|
| National Electricity Delivery Division | 1.0 | 1.0 | 1.0 | 3 |
| Energy Storage | 0.5 | 0.5 | 0.5 | 1.5 |
| Advanced Grid Modernization Research | 0.6 | 0.6 | 0.6 | 1.8 |
| Smart Grid | 0.5 | 0.5 | 0.5 | 1.5 |
| Advanced Distribution Management Systems | 1.5 | 1.5 | 1.5 | 4.5 |

| | | | | |
|---|------------|------------|------------|-------------|
| Energy Systems Risk and Predictive Capability | 0 | 0 | 0 | 0 |
| Cybersecurity for Energy Delivery Systems | 1.5 | 1.5 | 1.5 | 4.5 |
| Transmission Reliability | 2 | 2 | 2 | 6 |
| Transformer Reliability and Advanced Concepts | 1 | 1 | 1 | 3 |
| TOTALS | 8.6 | 8.6 | 8.6 | 25.8 |

Program-Specific Topics

This topical are covers program specific areas of interest. Funding amounts and duration of proposals vary by office and program. Requests from the programs are listed in the document

For EERE programs, the funding levels cover a three-year period as follows:

| (\$M) | FY16 | FY17 | FY18 | Total Lab Funding |
|--|-----------|-----------|-----------|-------------------|
| Building Technologies Office | 3 | 3 | 3 | 9 |
| Fuel Cell Technologies Office | 1 | 1 | 1 | 3 |
| Solar Energy Technologies Office | 14 | 14 | 14 | 42* |
| Vehicles Technologies Office | 3 | 3 | 3 | 9 |
| Wind and Water Power Technologies Office | 2 | 2 | 2 | 6* |
| EERE Total | 23 | 23 | 23 | 69 |

*SETO and WWPTO have already issued their program-specific lab calls. This lab call will NOT be providing any additional funding for these program-specific areas, however the awards from these offices will be coordinated with the broader Grid Modernization Initiative.

For OE programs, the funding levels cover a three year period as follows: **Note that for the OE FY17 and FY18 funding years, separate future lab calls will issue for those years at approximately the same level of total OE funding as FY16; funding levels by program will vary.**

| (\$M) | FY16 | FY17 | FY18 |
|---|-------------|------|------|
| National Electricity Delivery Division | 0 | | |
| Energy Storage | 2.2 | | |
| Advanced Grid Modernization Research | 5.5 | | |
| Smart Grid | 1.2 | | |
| Advanced Distribution Management Systems | 6.2 | 6.2 | 6.2 |
| Energy Systems Risk and Predictive Capability | 2.8 | | |
| Cybersecurity for Energy Delivery Systems | 4 | | |
| Transmission Reliability | 3 | | |
| Transformer Resilience and Advanced Concepts | 4 | | |
| TOTALS | 26.7 | | |

Category 1: Foundational Platform Activity Topics

In this category, the National Laboratory complex will develop larger, multi-lab, holistic proposals that address well-defined foundational platform activity areas in the Grid Modernization Multi-Year Plan. Because these topics are foundational, the development of these topics will occur through the GMLC and DOE GMLC Management Leadership, in strong collaboration with all key personnel from DOE's offices and programs within the Grid Modernization Initiative. These projects will represent cross-cutting projects where each project will represent collaboration across and receive support from multiple DOE office and programs. Due to the cross-cutting nature of these topics and projects, the development of all proposals submitted under this category will be coordinated across the National Laboratory complex by the National Lab Lead Integrators.

Topic 1.1: Foundational Analysis for GMLC Establishment/Framework: (\$6M Total for three years)

While the GMLC has initiated work in developing the MYPP framework and long-term goals for this Initiative, more needs to be done to develop a strong and well-articulated analytical foundation for grid modernization in terms of developing a baseline, defining meaningful metrics, and establishing long-term goals for the GMLC to achieve. Over the course of three years, the National Laboratories will develop refined definitions for these desirable characteristics of the power system (as identified by the QER) and apply them to different regions of the country. This will serve as a baseline against which we can measure improvement. Example metrics are outlined below. Other relevant metrics, such as flexibility, can be considered as well or deferred until years two and three. It is expected in year one, a core set of metrics will be applied across different regions of the country. In subsequent years, more refined approaches may be developed using additional metrics as needed.

- 1) *Reliability*: The ability of a system or its components to operate within limits so that instability, uncontrolled events, or cascading failures do not result if there is a disturbance, whether the disturbance is a disruption from outside the system or an unanticipated failure of system elements. Reliability also means that a system's components are not unexpectedly failing under normal conditions.
- 2) *Resiliency*: The ability of a system or its components to adapt to changing conditions and withstand and rapidly recover from disruptions. To the extent that actions improve a system's ability to withstand disruptions, they might be characterized as enhancing reliability, or resilience, or both. The ability to recover from a disturbance, however, is specific to resilience.
- 3) *Clean*: Energy systems should be efficient and designed, constructed, operated, and decommissioned in a manner that minimizes carbon pollution. They should have a minimal impact on air quality and water quantity and quality, have a minimal land-use footprint, have a low impact on biological resources, and have minimal toxic emissions.
- 4) *Affordability*: Ensures that at both the system and component levels, costs and defined needs (or requirements) of users are balanced with their ability to pay and consider the value created by the energy goods or services for the users or the system.
- 5) *Security*: The ability of the system to operate safely and consistently in the face of all hazards. The system must be able to identify, protect, detect, respond and recover from physical and man-

made situations with minimal loss of service.

Because of the nature of this activity, DOE will ask the GMLC to only submit one proposal for this topic. This proposal will undergo a “pass/fail” external review process. DOE will negotiate with the National Labs to the satisfaction of the Department (based on input for external review process).

Topic 1.2: Core Activities (Total \$15M for three years)

As part of the Grid Modernization Initiative, it is important that the GMLC start focusing on high-level platform activities that cut across multiple program areas. There are five top priority platform activity areas that have been identified. Funding for each activity area should be targeted at approximately \$1M/year (\$3M total) with a minimum funding level of \$500k/year (Total \$1.5M).

- 1) Grid Architecture (Task 4.1.1) - A “grid architecture” refers to a method of providing organized views and insights about “the grid” as a means of highlighting emerging trends and structural constraints to grid modernization, and helping identify issues that may have public policy implications. Please refer to the QER analysis paper on Grid Architecture funded by EPSA. It links the components, structures, and properties of the system (and its functionally diverse and interdependent sub-systems) in a way that desired qualities (e.g. reliability; resilience; affordability) or outcomes can be assessed. Architecture enhances communication and coordination by enabling asset owners, electric utilities, system operators, State and Federal regulators and energy officials, and other stakeholders to share a common set of concepts and terms and to highlight critical relationships. If an entity wishes to reshape their grid, for example, to achieve desired performance requirements or shared policy objectives, “thinking architecturally” (e.g., considering the full range of system impacts given a change in technology, market structures, or policy) will be essential to test the functionality of alternative designs, identify potential areas for interoperability, stage investment decisions, and minimize the risk of inducing unintended consequences.

The GMLC’s work on this subject will lead to outputs and products including:

- Inclusive architectural diagrams or maps of the existing grid and its components, structures, and properties;
- Architecture-Based Tools to make the diagrams and structural detail accessible to a wide range of users and contribute to quantitative evaluation of various architectural elements;
- Application and validation of the architectural principles in at least five diverse geographic areas, in collaboration with regulators, utilities, and stakeholders from the affected areas; and
- Glossary of key terms related to grid architecture, so as to foster the development of a common lexicon on the subject.

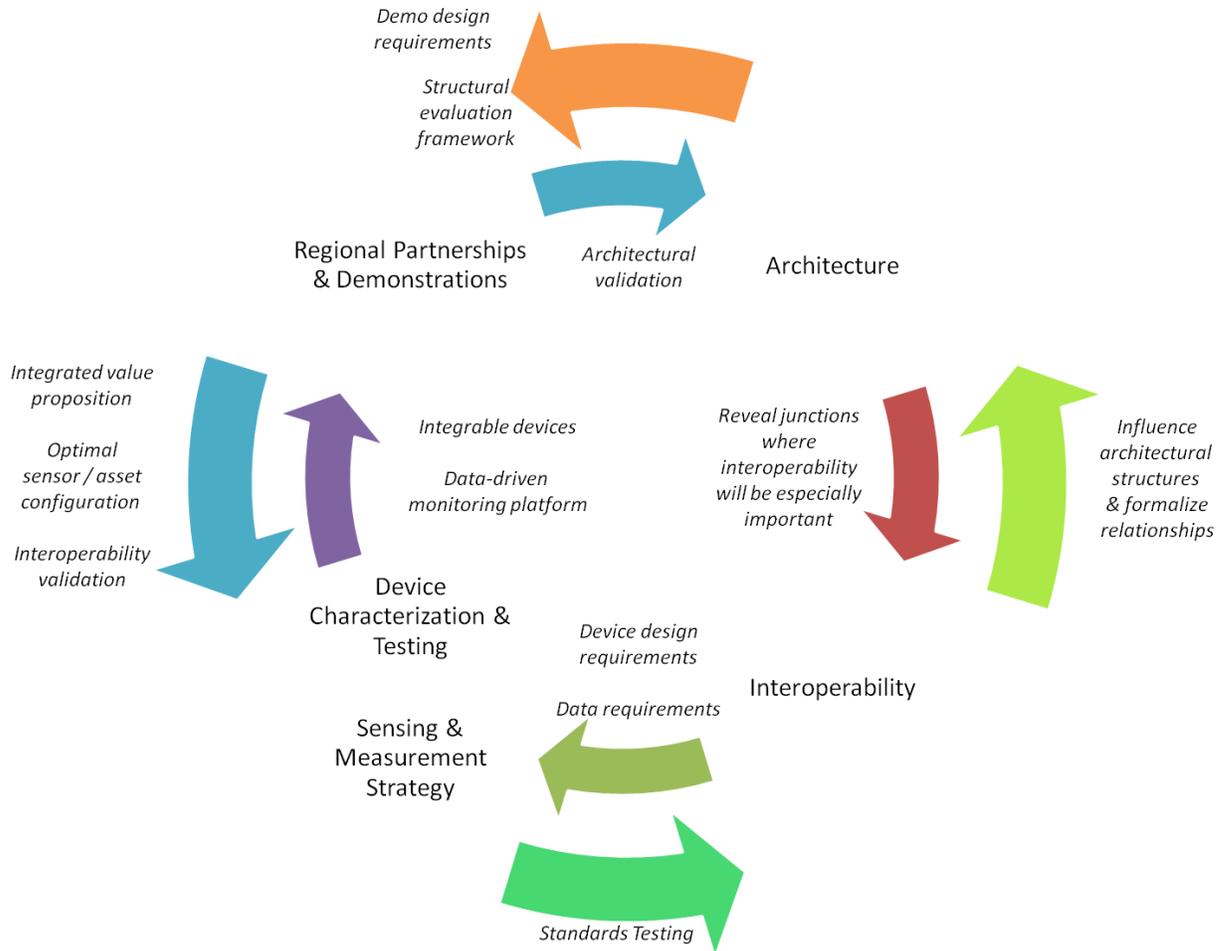
- 2) Interoperability (Tasks 2.2.4, 2.2.5) – As referenced in the MYPP, the National Laboratories will consolidate consensus interoperability standards for the building, distribution, and bulk power systems. Interoperability standards define technical requirements for defining the capability of two or more networks, systems, devices, applications, or components to externally exchange and readily use information securely and effectively. In addition, they will develop testing procedures for interoperability standards.
- 3) Device Characterization and Testing (Tasks 2.3.1-5) – Develop a device and system level testing capability and coordinate standards-based testing activities to evaluate devices’ ability to provide a range of grid services. An open, validated, and accessible component model library will be

developed to host the results from device characterization activities across the lab system, including generation, transmission, distribution, energy storage, and loads.

- 4) Valuation: Efficient characterization and valuation of services provided to the grid by existing and new technologies is important for maintaining reliability and affordability of the rapidly evolving electricity system and providing clear price signals to consumers. Existing methods for establishing rates and policies should appropriately compensate new and existing technologies for the value streams they provide. The national laboratories are in the process of developing a framework to identify values provided by grid services and technologies, and will establish which are monetized in regional markets and which are not. Building on that framework, the labs should:
- Work with stakeholders to refine framework(s) for identifying attributes of services provided to the grid by electricity system components, as well as identify and test approaches to incorporate the valuation of grid service attributes in different regulatory contexts (e.g., pricing or incorporation in planning processes).
 - Evaluate the ability of distinct grid components to provide grid services, and review options for increasing the viability of components to provide grid services—this would allow market operators and regulators to have a more complete understanding of the range of technologies and strategies that can provide grid services.
 - Build on past DOE workshops on the value of storage and distributed energy resources, and continue stakeholder engagement through workshops.
 - Work with stakeholders to develop valuation tools for use by industry and regulators to make investment and pricing decisions.

Based on the QER and the Grid Modernization MYPP, the national labs will develop a comprehensive strategy for valuation that encompasses generation, transmission, distribution, storage, and distributed energy resources (including energy efficiency), and ensure all efforts at the labs, both foundational and program-specific, are coordinated through this effort.

- 5) Sensing and Measurement Strategy – Develop, validate and document a new extended grid state framework and visibility strategy that encompasses power state, asset operational state, thermal states, and other important variables. The extended grid state framework should take in to account sensing capabilities of new and existing devices. As part of this activity, the national labs will define a roadmap for developing complete visibility across the transmission, distribution, and building systems. This will also include environmental parameters for wind and solar forecasting. This should inform the programs on how to invest in a sensing and measurement strategy moving forward.



Because of the nature of these core areas of activity, DOE will ask the GMLC to only submit one proposal for each of the five areas. These proposals will undergo a pass/fail external review process. For those proposals that are selected, DOE will negotiate the selections with the National Labs to its satisfaction (based on input from external review process).

Topic 1.3: Pioneer Regional Partnerships (\$8M in FY16 only)

Technical assistance will target states, utilities, or other stakeholders that are facing key emerging grid modernization challenges. Typical awards will be around \$1M each for up to 18 months. Examples of technical assistance could include the following (*note, these are just representative examples*):

- Hawaii - utility distribution control for high DER penetration distribution feeders
- New York - Reforming the Energy Vision (REV) Smart Grid Design
- California – Meeting the goal of accommodating 12 GW of renewable energy on distribution systems
- Kentucky - Industrial microgrid campus design and planning
- Vermont - Enabling the use of distributed energy resources (DER)
- Midwest ISO – Understanding the benefits of the use of high voltage, direct current (HVDC) transmission lines in the Midwest Independent System Operator
- Southeast – Developing advanced distribution feeders for a more resilient system

- Colorado – System planning and institutional transformation to support municipal goals for carbon neutrality
- New Mexico – Demonstrating the capability of networked microgrids to achieve municipal utility distribution needs

DOE will request multiple National Lab led proposals and select eight through a merit review process. As discussed in the sections below, proposals for technical assistance will be considered using the following criteria:

- Extent to which multiple technologies are integrated at multiple scales;
- How the project supports the MYPP;
- The potential impact of the project on advancing the state of the art;
- How the outcomes of the project will support the industry and real-world applications;
- The general applicability of project outcomes to a wide range of grid modernization scenarios;
- Sufficiency of technical detail in the application to assess whether the proposed work is scientifically meritorious and revolutionary, including relevant data, calculations and discussion of prior work in the literature with analyses that support the viability of the proposed work; and
- Extent to which open standards are used (if applicable).

Topic 1.4: Foundational Technical Areas (Total Funding: \$60M for three years)

The Grid Modernization Multi-Year Program Plan has identified six technical areas that are the core of the Grid Modernization Initiative. Within each technical area, the MYPP has identified tasks that are critical to meeting the Grid Modernization national outcomes. Proposals should identify how they support each of three DOE major achievements. The following are topics in each of the six technical areas. Please refer to the MYPP and the documents referenced within it when developing proposals in these areas. Large, multi-million dollar projects are encouraged. No proposal under \$1.5M will be considered.

Devices and Integrated Systems Testing

1. Standards and Test Procedures for Interconnection and Interoperability (2.2.1 – 3)
2. Definitions, Standards and Test Procedures for Grid Services (2.2.6 – 2.2.9)
3. Use Cases and Procedures for and Implementation of Integrated System Testing with Realistic Communications (2.4.1, 2.4.5, 2.4.7, 2.4.8, and 3.5.3)

Sensing and Measurements

4. Advanced Sensors for Buildings (3.1.1)
5. Advanced Sensors for Distribution Systems (3.2.4, 3.2.5 and 3.3.5)
6. Advanced Sensors for Bulk Power Systems (3.3.1, 3.3.7)
7. Wireless Communications Technologies and Standards (3.1.2)
8. Prototype Wind and Solar Forecasting System (3.3.2 and 3.3.3)
9. Distributed Analytics and Machine Learning Approaches for Dynamic Grid Management (3.4.1 – 3.4.4)

System Operations, Control, and Power Flow

10. Control Theory (4.1.2 - 4.1.3, 6.4.1 and 6.4.4)
11. Development and Multi-Scale Integration of Control Systems (4.2.1 – 4.2.3)
12. Incorporate Sensor and Forecast Data Into Dynamic Grid Management Tools (3.4.3, 3.4.4 and 4.3.1)
13. Incorporate Power Flow Control Devices into Grid Management Tools (4.4.2)
14. Real-Time Coordinated Dispatch of Power Flow Control Devices and Inverter-Coupled Technologies (4.4.3 and 4.4.4)

Design and Planning Tools

15. Computational Science for Grid Management (4.3.3, 4.3.4, 5.3.5 and 5.3.6)
16. Planning Model Development and Validation (5.1.3, 5.1.4, 5.2.6, 5.3.3 and 5.3.4)
17. Development of Integrated Transmission, Distribution and Communication Models (3.5.1 and 5.2.1)
18. Modeling and Analysis of Extreme Events (5.2.3)
19. Coupling of Hardware Testing with Modeling and Simulation (5.2.7 and 5.2.8)

Security and Resilience

20. All-Hazards Risk Management and Assessment Framework (6.1.1 – 6.1.3)
21. Inherently Resilient Communications Standard Development (6.2.1 and 6.2.4)
22. Data Ingest and Dissemination Framework (5.2.5 and 6.3.1)
23. Threat Detection and Response with Data Analytics (6.3.3 and 6.4.3)
24. SCADA System and Network Recovery (6.5.5)

Institutional Support

25. Distribution System Decision Support Tool Development and Application (5.1.7 - 5.1.8, and 7.1.2)
26. Multi-scale Production Cost Model Development and Application (5.1.1 - 5.1.2, and 7.2.5)
27. Valuation Methods for Emerging Technologies (5.1.4 and 7.3.1, 7.3.2)

In responding to this topic area, the GMLC will provide more proposals for the funding available. Proposals will be selected through a merit review process described below.

Timeline: Foundational Topic Areas

| Date | Activity |
|--|---|
| Total Amount to be Awarded | See above for funding guidelines by topic area. |
| Period of Performance | 36 months, beginning in FY'16 contingent upon a Go-No-Go project evaluation and/or meeting SMART during the period of performance. The period of performance for Topic 3: Pioneer Regional Partnerships should be no longer than 18 months. |
| Cost Share Requirement | None required, but industry partnership and cost share is highly encouraged. |
| Identification of Facility/Infrastructure Funding | All proposals that require facility or infrastructure improvements/upgrades should identify these separately, both in terms of funding as well as milestones and activities. Facility/Infrastructure improvements will not be funded through this lab call, but will be considered for funding from other program areas. |
| Submission of Proposals, Review Process, and Required Dates | <p>Lab proposals should be submitted using the forms provided as part of this lab call.</p> <p>Any submissions received after the specified deadlines will be considered late and rejected upon arrival.</p> <p>Project submissions should be emailed to 2016GMLabCall@netl.doe.gov</p> <p>Each proposal should be in the form of a MS Word document with each proposal provided as a separate document.</p> |
| Lab Call Released | <ul style="list-style-type: none"> • 07/02/15 |
| Submission Deadline for Concept Papers | <ul style="list-style-type: none"> • 07/30/15 – Labs submit concept papers <ul style="list-style-type: none"> ○ DUE 3:00 PM EDT |
| Notification of Request for Full Proposal | <ul style="list-style-type: none"> • 08/01/15 – 08/17/15: DOE will review concept paper submissions and notify Labs |
| Submission Deadline for Full Proposals for Merit Review | <ul style="list-style-type: none"> • 09/30/15 – Labs submit full proposals <ul style="list-style-type: none"> ○ DUE 3:00 PM EDT |
| Merit Review Period | <ul style="list-style-type: none"> • 09/30/15 – 10/21/15 – Merit Review Panel will review and score full proposals and release to DOE for final selection |
| | <ul style="list-style-type: none"> • 11/18/15 – Notification to Labs of projects planned for FY'16 funding |
| Partners | While not required, the national laboratory complex is encouraged to partner with states, local governments, utilities, public utility commissions, and other stakeholders that are the forefront of grid modernization efforts. |

Category 2: Program Office Specific Topics

Using the framework of the Grid Modernization MYPP, the program offices will develop lab call topics that address their specific requirements for grid modernization not covered sufficiently well or specifically in the Foundational Platform Activity topics. The DOE leads (Parks, Lynn) will work with the program offices to develop these topics. Proposals solicited under in this category will undergo a traditional open lab call competition and merit review defined below. Where appropriate, proposals in the program specific lab call should be coordinated with activities in the Foundational Topic areas. For example, program-specific activities in interoperability or valuation should be well coordinated with the Foundational activities proposed in Topic 2. This will result in discrete lab calls for the programs listed in the table below.

| Office of Energy Efficiency and Renewable Energy | Office of Electricity and Energy Delivery |
|--|--|
| Buildings Technologies Office (BTO) | Smart Grid |
| Fuel Cells Technologies Office (FCTO) | Advanced Distribution Management Systems (ADMS) |
| Solar Energy Technologies Office (SETO) | Energy Storage |
| Vehicles Technologies Office (VTO) | Cybersecurity for Energy Delivery Systems (CEDS) |
| Wind and Water Power Technologies Office (WWPTO) | Advanced Grid Modeling Research (AGMR) |
| | Energy Systems Risk and Predictive Capability (ESPC) |
| | Transmission Reliability (TR) |
| | Transformer Resilience and Advanced Concepts (TRAC) |

The Grid Modernization Initiative

The vision of the Grid Modernization Initiative is:

A future electric grid that provides a critical platform for U.S. prosperity, competitiveness, and innovation by delivering reliable, affordable, and clean electricity to consumers where they want it, when they want it, how they want it.

The initiative will assess its progress not only by looking at RD&D efforts in individual technical areas but also by looking at three *integrated* demonstrations, referred to in this document as DOE Major Technical Achievements. They are:

- **A transmission and distribution system operating reliably on a lean reserve margin:** full power system visibility from real-time sensor networks enabling new approaches to system design, control, operations, protection and optimization. An integrated effort to demonstrate the

delivery of reliable and affordable grid services with a substantially reduced amount of system reserve capacity.

- **Resilient distribution feeders with high percentages of low-carbon distributed energy resources (50%):** advances in real-time system monitoring, for high penetration of clean, distributed generation, and the proliferation of smart consumer end-use devices. New approaches for distributed control, engagement with bulk system reliability management, and coordination across local intelligent assets, including multiple microgrids, over a range of feeder innovations that meet changing consumer expectations and traditional demand for reliability, resilience, and affordability.
- **An advanced modern grid planning an analytics platform:** a platform of integrated high performance tools that couple transmission, distribution and communications tools, that add the capacity to reflect uncertainty, that substantially increase the speed and productivity of tools to enable stakeholders to achieve timely evaluation of future grid alternatives. This platform will be integrated with vendor products and leveraged into on-going technical assistance with states and regions to substantially improve planning and regulatory assessments of the modern grid.

The demonstrations underpinning these DOE Major Technical Achievements (fully described in Section 8.0), will be multiple and throughout different regions of the country.

Supporting the DOE Major Technical Achievements are six specific technical areas: they are the core of DOE's Grid Modernization Initiative. The six technical areas —equally important and not presented below to suggest sequence or ranking—follow.

Six Technology Activity Areas

Devices and Integrated Systems Testing

New distributed devices and systems will deliver much of the flexibility required by the future grid for managing variable generation and enhancing reliability and resiliency while keeping electricity affordable.

This technical area develops devices and integrated systems, coordinates integration standards and test procedures, and evaluates the grid characteristics of both individual devices and integrated systems to provide grid-friendly energy services. For example, the DOE-funded collaboration between the National Institute of Standards and Technology (NIST) and electric industry stakeholders in developing smart grid interoperability standards, begun in 2009, has laid the technical foundation for more effective grid investments today.

Specific activities that will be included are:

- Develop advanced storage systems, power electronics, and other grid devices
- Develop standards and test procedures
- Build capabilities and conduct device testing and validation
- Conduct multi-scale systems integration and testing

Sensing and Measurements

Measuring and monitoring vital parameters throughout the electric power network is necessary to assess the health of the grid in real time, predict its behavior, and respond to events effectively. Lack of visibility and accurate device- or facility-level information makes it difficult to operate the electricity system efficiently and has contributed to large-scale power disruptions and outages. Additionally, next generation sensors will allow energy management systems to integrate buildings, electric vehicles, and distributed systems.

This technical area focuses on tools and strategies to determine the type, number, and placement of sensors to improve system visibility from individual devices to feeders, distribution systems, and regional transmission networks. This effort includes advanced methods to determine system states not directly accessible by measurement, and estimation methods for broad grid visibility. Finally, it develops frameworks to integrate sensors into grid systems to better determine and forecast solar irradiance and wind generation, integrate and estimate generation and load uses behind the meter, and monitor and predict interfacing infrastructures such as electrified transportation.

DOE's investment in synchrophasor technology development, for example,—in RD&D co-funding for the monitoring devices, technical interoperability standards, communications networks, analytical tools, and community-building—has accelerated the maturity of this technology. This accomplishment demonstrates the impact of small strategic investments in technology.

Specific activities that will be included are:

- Improve sensing for buildings and end-users
- Enhance sensing for distribution system
- Enhance sensing for the transmission system
- Develop data analytic and visualization techniques
- Demonstrate unified grid-communications network

System Operations, Power Flow, and Control

The existing grid control systems were developed over several decades using a set of 20th century design characteristics: centralized dispatchable generation connected to transmission, relatively slow system dynamics that permitted manual control, no significant grid energy storage, passive loads, one-way flow of real power at the distribution level, operation for reliability, and generation-following load for balancing. Several of these design parameters have become outmoded by new technologies, changing economics, and shifting customer expectations.

This technical area focuses on new control technologies to support new generation, load, and storage technologies. This effort develops power flow controllers that will permit fine adjustment and multi-directional power flow as well as flow control devices that can optimize transmission flows. It will also develop system architecture and control theories, coordinated grid system controls, and improved analytics and computation for grid operations and control.

Specific activities that will be included are:

- Develop architecture and control theory
- Develop coordinated system controls
- Improve analytics and computation for grid operations and control
- Develop enhanced power flow control device hardware

Design and Planning Tools

Sound long-term planning and design yields smart capital investment. Electric power grid modeling and simulation applications are fundamental to the successful design, planning, and secure operation of power systems with billions of dollars in capital investments and operations costs. However, existing planning and modeling tools have not kept pace with the complex technology, policy, economics, and outcomes demanded for the electric grid.

This technical area develops the next generation of modeling and simulation tools needed for power system planning. These new tools will handle emerging needs driven by changing technologies and operational capabilities, larger and more complex models, more challenging forecasting, and new types and sources of data.

Security and Resilience

There are ever-increasing natural and man-made threats to the electric grid, including high-impact and low-frequency events, severe storms, fuel delivery failures, and more frequent physical and cyber threats. This technical area aims to meet physical and cyber-security challenges, analyze asset criticality, assess ways to minimize risk, address supply chain risks (specifically for transformers), and provide situational awareness and incident support during energy-related emergencies. New York State's leadership in *Superstorm Sandy* rebuilding and resilience efforts shows that grid modernization is pivotal for protecting citizens and the economy against natural and human attack.

Specific activities that will be included are:

- Improve ability to identify threats and hazards
- Increase ability to protect against threats and hazards
- Increase ability to detect potential threats and hazards
- Improve ability to respond to incidents
- Improve recovery capacity time

Institutional Support

This technical area provides technical assistance to key decision-makers so that they can address the high priority grid modernization challenges and needs identified by electric power industry stakeholders. It gives particular emphasis to working with state policymakers and regional planning organizations, with support for both analysis of issues and creation of information for stakeholders. Analytic, non-prescriptive

workshops and facilitator-led dialogues among stakeholders can build agreement around the value of transforming the grid and the best ways to do that using technology, regulatory, and market tools that meets the unique needs of every region. DOE has already built strong relationships with many institutional leaders through two decades of investments in collaborative work on envisioning the future grid, developing regulatory and planning initiatives, coordinating national action plans for energy efficiency and demand response, and extensive efforts to create regional collaboratives for region-wide resource modeling and planning.

Specific activities that will be included are:

- Provide technical assistance to States and Tribal governments
- Support regional planning and reliability organizations
- Develop methods and resources for assessing grid modernization: emerging technologies, valuation, and markets
- Conduct research in future electric utility regulations

Timeline: Program-Specific Topic Areas

| | |
|--|---|
| Total Amount to be Awarded | See Table above for funding guidelines by program office. |
| Average Award Amount | DOE anticipates funding projects at a minimum value of \$500k/project/year unless otherwise stated. Project submissions should be approximately scoped to this funding level. |
| Period of Performance | 36 months unless otherwise stated, beginning in FY'16 contingent upon a Go-No-Go project evaluation and/or meeting SMART during the period of performance. |
| Cost Share Requirement | None required, but industry partnership and cost share is highly encouraged. |
| Submission of Proposals, Review Process, and Required Dates | <p>Lab proposals should be submitted using the forms provided as part of this lab call.</p> <p>Any submissions received after the specified deadlines will be considered late and rejected upon arrival.</p> <p>Project submissions should be emailed to (see NETL web page).</p> <p>Each proposal should be in the form of a MS Word document with each proposal provided as a separate document.</p> |
| Lab Call Released | <ul style="list-style-type: none"> • 07/02/15 |
| Submission Deadline for Concept Papers | <ul style="list-style-type: none"> • 07/30/15 – Labs submit concept papers <ul style="list-style-type: none"> ○ DUE 3:00 PM EDT |
| Notification of Request for Full Proposal | <ul style="list-style-type: none"> • 08/01/15 – 08/17/15: DOE will review concept paper submissions and notify Labs |
| Submission Deadline for Full Proposals for Merit Review | <ul style="list-style-type: none"> • 09/30/15 – Labs submit full proposals <ul style="list-style-type: none"> ○ DUE 3:00 PM EDT |
| Merit Review Period | <ul style="list-style-type: none"> • 09/30/15 – 10/21/15 – Merit Review Panel will review and score full proposals and release to DOE for final selection |
| Expected Date for DOE Selection Notifications | <ul style="list-style-type: none"> • 11/18/15 – Notification to Labs of projects planned for FY'16 funding |
| Partners | <p>While not required, the national laboratory complex is encouraged to partner with states, local governments, utilities, public utility commissions, and other stakeholders that are the forefront of grid modernization efforts.</p> <p>National labs are also highly encouraged to partner with each other, where appropriate, to develop joint lab partnership projects.</p> |

EERE Program Specific Topic Areas

The sections below provide are the program-specific lab calls for EERE.

Vehicle Technologies Office

This Lab Call is focused primarily on the development of projects in the following areas; however labs are highly encouraged to submit project ideas beyond the possible topics associated with the Technical Areas listed below:

- **Sensing and Measurements**
 - None
- **Devices and Integrated Systems**
 - **Vehicle to Building Integration Pathway (MYPP Task 2.1.3, 2.2.3, 2.4.1)** - Hardware and software development to coordinate and manage the charging (and/or discharging) of groups of vehicles within the commercial building environment. This platform will support the integration of PEV charge control with the building/campus energy management system, enable the integration of variable renewables and charging infrastructure in workplaces to promote greater PEV adoption, and provide for the reduction of peak demand charges resulting from vehicle charging. Efforts should address any associated power quality challenges associated with PEV charge/discharge management in a building environment. Activities should also be coordinated with efforts supported by the Building Technologies Office, such as implementation of the Volttron platform to enable building/vehicles integration.
 - **Export Power Systems (MYPP Task 2.1.3, 2.4.1)** - Systems development to enable vehicle export power in emergency and backup situations without the presence of a grid. More frequent occurrence of extreme weather events impacting electricity availability suggest that a potentially valuable opportunity exists for stand-alone export power from vehicles. These systems should either offer critical load management functions or integrate with external energy management systems. In addition, they should be able to be integrated with renewables and energy storage to serve the local demand efficiently and safely. Application scopes may include residential, utility, and/or commercial/government fleets.
 - **Systems Research Supporting Standards and Interoperability (Tasks 2.1.1, 2.1.3, 2.2.4)** - Technology development, integration and hardware system studies with the ability to link to analytical activities. This activity will prioritize the development of low-cost PEV-grid interface components in a hardware-in-the-loop (HIL) environment and control systems/algorithms to allow verification of component requirements and open communication standards (implemented via technology-specific Volttron agents) in a realistic environment. Such efforts would also be used to define function-specific requirements for vehicles and batteries that are intended to be grid interactive. Establishing the HIL environment and specifying appropriate interface components requirements will enable experiments such as measuring and reporting battery life impacts of V2G functions to support cost and value proposition estimation. Component reliability including power electronics on and off-board the vehicle may also be considered.
- **System Operations and Power, Design and Planning Tools, and Institutional Support**

- ***Simulation and Data Management (MYPP Tasks 7.3.1, 7.3.2, 5.1.2)*** – There is a need for simulation capabilities to be used for the identification of functional market models that allocate value among stakeholders involved in PEV/grid integration. Simulation tools should identify, track, and allocate value among various stakeholders participating in grid services either through wholesale markets and aggregators or individually. Specific scenarios that may be investigated include: bidirectional power flow from vehicles, to quantify the valuation opportunities of V2G including the impact on vehicle batteries, system cost and complexity, and financial value to the individual consumer; the opportunity for transportation electrification to mitigate the variability and cost of distributed solar generation to utilities; and an assessment of the benefit to utility rate payers associated with utility investments in transportation electrification. Outcomes should focus on engaging utilities and regulators in the development of new tariffs and opportunities that enable vehicle participation in grid functions. Additionally, operational tools could provide utilities greater insights in forecasting loads (and flexibility of load) from regional sets of plug-in vehicles so that the most cost effective mix of generation technologies to satisfy demand are scheduled. For example, the availability of real-time renewables data streams could be translated to geographically localized signals to incentivize a desired PEV charging response. Such information transfer would effectively be a way of indirectly scaling the response of the vehicle demand without a utility control interface. Proposals should show coordination with the Foundational work in valuation in Topic 2. Proposals should demonstrate coordination with SETO when addressing the mitigation of solar variability.

Building Technologies Office

This Lab Call is focused primarily on the development of projects in the following areas; however labs are highly encouraged to submit project ideas beyond the possible topics associated with the Technical Areas listed below:

Devices and Integrated System Testing (MYPP Tasks 2.2.7, 2.2.8, 2.4.7) -- Developing market ready Device and Integrated Systems utilizing Volttron: By leveraging the use cases outlined in the Reference Guide for a Transaction- Based Building Controls Framework (Somasundaram, et al. 2014), develop end use, energy market, and grid services that integrate EE and RE technologies and buildings through applications in Volttron with market partners. All proposals must include a business case as to how the solution will be developed, tested, and deployed with the partners in a utility service area or municipality through demonstration(s) and then product launches. All proposals must have clear paths to market and clear partners and clear benefits to the end user, energy market participants, and/or the grid.

1. Volttron in light commercial/C-stores – funds to develop agents for light commercial/C-store applications. Demonstrations must include control of refrigeration, HVAC, lighting, and other connected loads being controlled for EE and Grid use cases. This project must be coordinated and complimentary to ORNL and PNNL’s existing activities.
2. Volttron for Home – funds to develop agents for Home applications leveraging Homekit, Thread, and other emerging residential “standards.” Demonstrations must include utilizing these agents to control clean energy technologies including residential devices and EVs, etc. This project must be coordinated and complimentary to NREL and PNNL’s existing activities.
3. Volttron with DOD – (continued support for demonstrating Transactive Controls with DOD¹) funds to demonstrate transactive controls to fully integrate energy consuming devices with DER into a microgrid on forward operating bases with DOD in resource constrained areas. This project must be coordinated and complimentary to LBNL’s existing activities.
4. Volttron to Vehicles -- funds to develop agents for Volttron applications leveraging the vehicle to building reference guide (pending publishing through NREL). This project must be coordinated and complimentary to NREL and PNNL’s existing activities.
5. Other relevant applications with clear paths to market and clear partners.

Devices and Integrated System Testing (MYPP Tasks 2.1.1 – 2.1.4, 2.2.7, 2.2.8, 2.3.6, 2.3.7) -- Expanding Applications and Agents on Volttron that control DER technologies at Scale: The Buildings Technology Office has been funding the development of an open source controls platform to enable transaction-based energy. In this task, DOE seeks to expand the development of applications and agents across all

¹ This work was originally funded in FY15 at LBNL but does not include other labs involvement as a partner where DOD may current evaluates FOB technologies.

clean energy technologies. Specific agents that are of interest include:

1. Enabling Volttron Functions:
 - a. Volttron for Drivers -- funds to implement one drive (or ballast) specification for both fluorescent and LED lighting solutions in VOLTTRON as specified in the challenge specification. After this reference design is finalized, DOE can issue a SBIR to scale these solutions in the market.
 - b. Volttron for Inverters -- funds to develop a reference design/driver of an inverter/driver-implementing DER related DNP as a Volttron agent. After this reference design is finalized, DOE can provide the reference solution to all inverter manufacturers.
 - c. Volttron for Transformers – funds to develop controlling steel core transformer(s) at the distribution and building level to increase their efficiency to approach amorphous core transform efficiency with lower cost steel core equipment and better device control. This task is an emerging research area and must include participation and engagement with EPA’s Energy Star program as they explore energy star for transformers.
2. Extending Volttron Capabilities:
 - a. Volttron to enable virtual storage – utilizing load control to utilize building assets to perform “virtual storage” while reducing the size of real, electrical storage is required for the grid.
 - b. Volttron to enable distributed cooling/control solutions for buildings comprised of mini-split heat pumps – funds to develop a Volttron agent for mini-split heat pumps that are controlled through IR codes. This solution is an emerging international need to deal with resource constraint utilities. This project must have an identified and engaged international partner like India or China.
 - c. Volttron to enable economic dispatch of EE and RE technologies – funds to develop the fundamental control and economic components to support economic dispatch of EE and RE technologies including small scale CHP systems and Fuel Cell technologies.
3. Other foundational applications that enable building loads/devices to perform EE and grid applications – such as right sized, virtual storage utilizing buildings.

Design and Planning Tools -- NA

Security and Resilience - - NA

Institutional Support -- NA

Fuel Cell Technologies Office

Fuel Cell Technologies Office 2015 Grid Lab Call

Topics 1a and 1b address the dispatch and system planning for distributed generation (e.g. stationary fuel cell systems) integrated into buildings with thermal or electrical storage to serve a building's electrical and heating loads. These systems, when planned and designed accordingly, may also be coupled with other renewable energy generation technologies to offer a comprehensive solution. Topic 2 addresses the capacity of hydrogen infrastructure to support the grid through demand response at hydrogen stations and hydrogen plants (ramping up and down production) and the capacity for fuel cell vehicles to provide backup power to buildings during a grid outage.

FCTO Topic 1a: Building Manager Dispatch Tool for Integrated Fuel Cell/ Building/ Energy Storage

The tool developed under this topic builds on existing capability such as the open-source software, DGBEAT (Distributed Generation Build-out Energy Assessment Tool) or developed by NREL, DERCAM (Distributed Energy Resource Computer Aided Modeling) tool by LBL, or equivalent open-source software. New capabilities include interfacing with building networks (e.g. Volltron) to provide the capability to communicate and transact with the grid for energy services and demand response, determining cost to provide grid services based on projected local electrical and thermal demands, optimizing and executing a dispatch solution for fuel cell systems and energy storage accounting for grid service rates as well as projected building electrical and thermal loads. Proposals should describe the design and characteristics of a dispatch tool that provides "smart," real-time dispatch strategies that make use of building power/heat demand, available renewable resources, available electrical and thermal energy storage, state of the grid, costs, emissions, and similar factors. This tool will be able to interface and manage the various integrated components of building energy systems.

The software tool will include a graphical operator interface allowing a building manager to easily provide the characteristics of the building's energy systems, sensors and controls. Additionally, the software will include an intuitive interface for setting up and reviewing the results of energy optimizations, taking into account factors such as efficiency and dynamic performance characteristics of fuel cell power generation and energy storage devices, projected electrical and heat demand, projected renewable energy resources, current weather and projected weather conditions, grid price signals, in addition to limits or operation schedules the operator may provide. Energy optimizations will include the calculation of GHG and criteria pollutant emissions, and account for depreciation of assets with cycling/use. Energy optimizations will minimize net present value (operation and capital cost) or operation costs including, optionally, the cost of emissions (or credit for emissions reductions).

The software tool will accommodate fixed rates, time of use rates, net metering, partial net metering, and notional market-based rates. The software will facilitate or automate the response to live pricing signals (for both energy and ancillary markets). The operator will choose and adjust the parameters/ algorithms for bidding into day ahead and spot electricity markets. The resulting control schedule will be displayed for confirmation by the operator. The operator's interface will allow the operator to monitor and track the system's performance against the control schedule. The software may also include learning

algorithms that will determine attributes such as thermal loss for various outdoor environmental conditions detected through building or HVAC sensors.

The tool may import device characteristic from and communicate control algorithms or control parameters to “smart” devices (fuel cells, water heaters, HVAC systems, sensors), but it must also have means to support legacy equipment by providing options for inputting characteristics and outputting manual control schedules.

Proposals should discuss the rationale for the selection or design of the building network interface, show the designs of the user interfaces to be programmed, and describe the numerical algorithm used for optimizing the system, including the range of dynamic characteristics for fuel cell or other distributed generation devices and thermal energy storage. Hardware and software platforms should be discussed as well as the coordination and partnership with developers of embedded controllers for devices, system planning tools, building network platforms, distributed energy resource management systems, and supervisory controllers for building energy systems.

To encourage wide-spread adoption to realize national-scale benefits, the software must be deployable to a user’s computer without the need for a paid software license, and operated without the need of an internet connection. The entire code base, including code for functions that are included but funded outside of this topic area shall be shared with industry users/co-developers through open source tools (e.g. Github).

FCO Topic 1b: Optimal Planning of Integrated Fuel Cell/ Building/ Energy Storage

The tool developed under this topic builds on existing capability such as the open-source software, DGBEAT (Distributed Generation Build-out Energy Assessment Tool) or developed by NREL, DERCAM (Distributed Energy Resource Computer Aided Modeling) tool by LBL, or equivalent open-source software. An open-source software tool will be developed for engineering fuel cell power generation and electrical and thermal energy storage systems with optimal system characteristics, size, and control strategies needed to meet building demand, while reducing costs, improving reliability, leveraging use of renewables, and meeting environmental goals. This tool will serve in developing the best strategy for integrating fuel cells and other technologies, along with related controls, into a “smart grid” capable building. The primary emphasis of this topic is to incorporate transactive control capabilities into an open-source fuel cell generation and energy storage planning tool. The tool should also accommodate vehicle to grid options for electrical energy storage..

Current tools (e.g. DGBEAT) include an intuitive user interface for inputting building thermal and electrical load characteristics, fuel cells, combined heat and power (CHP), thermal or electrical storage (TES or EES) specification. Alternatively, the tool can automatically select the optimal fuel cell, TES or EES sizes and options from scalable system models or a library of off-the-shelf systems. Existing tools include building libraries, for example five commercial building vintages consistent with publications of ASHRAE 90.1, sixteen climate zones, and sixteen building types that are derived from CBECS and residential building profiles. Building load profiles are calculated in 15-minute increments or better.

The tool should leverage dispatch software algorithms (as developed in topic 1a) to simultaneously optimize the control strategies and algorithms in addition to energy system component sizing. Thus the planning tool incorporates all the capabilities developed in topic 1a above in addition to fixed rates, time of use rates, net metering, and partial net metering. DOE will not fund the development of dispatch software under this topic. Proposals must describe coordination or partnership to integrate the optimal dispatch algorithms into the planning tool.

To encourage wide-spread adoption to realize national-scale benefits, the software must be deployable to a user's computer without the need for a paid software license, and operated without the need of an internet connection. The entire code base, including code for functions that are included but funded outside of this topic area shall be shared with industry users/co-developers through open source tools (e.g. Github).

FCTO Topic 2: Capacity for Hydrogen Infrastructure and Fuel Cell Vehicles to Support the Grid.

Latest designs in FCEVs have embedded capabilities that may allow them to be used as backup power systems during emergency power outages. Renewable hydrogen stations and hydrogen production plants have hydrogen energy reserve capacity which provides flexibility for providing demand response. Quantitatively understanding the energy and monetary interactions between hydrogen systems for mobility and electric grid systems requires a comprehensive simulation framework that can consider the dynamics of each of these systems. Some of the primary factors include vehicle fueling and vehicle parking behavior, and the changing balance between vehicle rollout vs. hydrogen infrastructure.

Proposals should investigate to what extent these capabilities may be utilized, what would be required, and what benefits may be provided. The performance characteristics, adequacy of infrastructure, and costs vs. benefits should be evaluated. Potential effects on the grid and the degradation of fuel cell or electrolyzer stacks should be considered. The work should quantify available grid resources as hydrogen infrastructure and fuel cell vehicle fleets grow over time. The work should also investigate the cost and benefits of intentionally adding incremental capacity (electrolyzer power and hydrogen storage) to renewable hydrogen stations for the purpose of providing grid services.

For vehicle-to-building backup power, determine the potential flexibility in fuel cell vehicles or vehicle fleets to provide building power with an acceptable compromise of fuel needed for mobility. Quantify the value/cost of effects on the grid from vehicle-to-building implementation such as non-spinning reserve capacity that the grid may not need to support as a result of fuel cell backup power. Quantify how much capacity is available at different times of day for aggregated plug-in fuel cell vehicles to provide grid services, without compromising the mobility needs of individual drivers.

For renewable hydrogen stations, determine how much hydrogen fueling resource (e.g. hydrogen generation and fuel tank capacity) is needed at a hydrogen fueling station to meet vehicle needs while reliably providing grid services. Quantify the flexibility there is in ramping rate of hydrogen generation resources (e.g. electrolyzers) at fueling stations to ensure vehicle fueling needs are met while still being able to provide grid services. Finally, quantify how much capacity is available at different times of day for fueling station resources to offer grid services and how sensitive the grid service capacity is to the adoption of increased numbers of fuel cell vehicles that require fueling.

Solar Energy Technologies Office

The Lab Call for SETO (SUNLAMP) has been released already. No additional program-specific funds will be released for this lab call, however the awards from these offices will be coordinated with the broader Grid Modernization Initiative.

To achieve the Solar Energy Technologies Office's SunShot Initiative goals, the Systems Integration (SI) program within SunShot seeks to enable the widespread deployment of safe, reliable, and cost effective solar energy on the nation's electricity grid by addressing the associated technical and regulatory challenges. The installed cost of solar photovoltaics (PV) and concentrating solar power (CSP) have fallen significantly in recent years, spurring significant growth and accelerating deployment of solar energy systems. The anticipated proliferation of solar power at the centralized and distributed scales emphasizes the need for timely and cost effective interconnection procedures, accurate prediction of solar resources, and monitoring and control of solar power. Moreover, the impact of solar energy on the performance and reliability of transmission and distribution power systems is becoming a larger challenge.

To proactively anticipate and address potential challenges under a scenario in which hundreds of gigawatts (GW) of solar energy are interconnected to the electricity grid, the Systems Integration program has identified the challenges to be addressed in four broad, inter-related topic areas:

- Topic 1: Grid Performance and Reliability: Maintain and enhance the efficiency and reliability of electric transmission and distribution systems in a cost-effective, safe manner with hundreds of gigawatts of solar generation deployed onto the nation's power system.
- Topic 2: Dispatchability: Ensure that solar power is available on-demand, when and where it is needed and at the desired amounts, in a manner that is comparable to or better than conventional power plants.
- Topic 3: Power Electronics: Develop intelligent devices that maximize the power output from solar power plants and interface with the electric grid (or end use circuits), while ensuring overall system performance, safety, reliability, and controllability at minimum cost.
- Topic 4: Communications: Create infrastructure that is used to inform, monitor and control generation, transmission, distribution and consumption of solar energy effectively under broad temporal and spatial scales.

The four topic areas along with their specific metrics are described in Topics 1–4 in "Section 4. Focus Area: Systems Integration" of the [SuNLaMP](#) call for proposals document, which may be downloaded from <https://eere-exchange.energy.gov/FileContent.aspx?FileID=d1052fd7-26bb-4fe9-be14-718fd4addf7d>. To be relevant to SunShot goals, proposals to the Grid Modernization Lab Call must specifically address the goals and all the metrics set forth in the relevant topic from Section 4, Topics 1–4 of the SuNLaMP call for proposals document. Proposals that do not address all of the relevant metrics will be deemed non compliant and may be returned without review.

Wind and Water Power Technologies Office

The Wind and Water Power Technologies Office issued a Program specific Lab Call in March and has reviewed a set of concept papers and provided feedback to the summing labs indicating which concept papers should move forward to full proposal submissions and which concept papers should be submitted to this broader Grid Modernization Lab Call. Labs who received feedback to move forward with full proposal submissions for the WWPTO specific activities should do so based on the timeline and procedures contained herein. The following areas of interest were provided in that lab call.

- **Sensing and Measurements** – For this focus area, the program is primarily interested in concepts of how wind energy forecasting information can be visualized and presented for use by power system operators. Other topics of interest include how any new sensing equipment can be used to provide useful information to grid operators to enable more efficient use of existing grid infrastructure.
- **Devices and Integrated Systems** – Project submissions in this area may include ideas of how distributed wind and small wind technologies can be tied to other technology areas such as building management systems, microgrids, and other interoperability related topic areas. Additionally, labs are encouraged to use this topic area to explain how existing facilities (such as NREL’s CGI, PNNL’s EIOC, and others) can be used to perform integrated tests.
- **System Operations and Power Flow** – This focus area is centered on project submissions related to helping to develop new and novel operational practices for grid operators, develop/demonstrate new operational capabilities from wind turbines (such as active power control), analysis related to providing better access to system flexibility supply options, new system dispatch and commitment tools (such as Stochastic Unit Commitment), and other operational related concepts. Additionally, WWPTO is interested in analysis of how power flow control can be applied to support broader wind deployment.
- **Design and Planning Tools** – The WWPTO is interested in project proposals to demonstrate how wind related information can/should be included into system design and planning tools (both new and existing) to aid in the development of new grid infrastructure that supports wind development. Additionally, submissions related to potential scoping of next generation wind integration studies are highly encouraged.
- **Security and Resilience** – WWPTO is highly interested in submissions related to a wind industry cyber security threat assessment and technology solutions. Additionally, the Program is interested in project proposals that seek to evaluate how wind can improve grid resilience and overall reliability.
- **Institutional Support** – Submissions related to technical information sharing between the national labs and industry, regulators, standards setting bodies, other decision makers and the broader wind integration stakeholder community are of interest to the Program. Furthermore, submissions related to tool development that support the evaluation of how wind related investments impact the power grid are welcome.

OE Program Specific Topic Areas

The sections below provide are the program-specific lab calls for OE.

Smart Grid

Resilient Distribution Grid R&D

The goal of the Resilient Distribution Grid R&D activity, within the Smart Grid R&D Program, is to enhance the ability of the nation's electric distribution grid to prepare for, withstand, and recover rapidly from disruptions caused by extreme weather events. The Program held a stakeholder workshop in 2014 and synthesized the workshop findings² into the two topic areas below. These two areas closely align with one of the GMLC's MYPP outcomes.

An integrated and coordinated approach by national labs is sought for each topic area. This approach must leverage collective capabilities of national labs and build on advances made by DOE (ARRA Grid Modernization, SC, ARPA-E), DHS, and DoD programs as relating to electric infrastructure security and resilience. Each national lab can participate as a member in multiple proposals that consist of different lab teams in response to each technical area. Each proposal must have a lead lab identified; the awarded projects will have different national labs serving as the respective project leads. It is planned for one multi-lab project to be awarded for each of the two technical areas of interest. As with all program-specific proposals, proposals in this area should be closely coordinated with the Foundational activities proposed. For example, activities in grid-architecture, interoperability, and devices characterization and testing found in the Foundational Activities under Topic 2 should be considered in any proposals.

- **Design and Planning Tools and Security and Resilience**
 - **Resilient Distribution Grid Design Tool (MYPP Task 5.1.7, 5.1.8, 6.3.3, 6.4.1)** – This topic area is to seek proposals to develop a tool for use by distribution utility designers in designing a resilient electric distribution grid. The scope involves developing and integrating damage prediction models into a closed-loop design tool in which optimization methods with user-defined multi-objective metrics will be used to perform cost-benefit analyses and to suggest the most effective upgrades to existing grids, communications, and control systems, as well as for full system designs for new grids. Each proposal should structure the project into three phases, providing an adequate description for each phase. Phase I is to complete, in 18 months or less, development of the alpha version of the prototype tool for enhanced distribution grid resilience to withstand all major, extreme weather events. Phase II is to conduct testing and demonstration of the developed prototype, coupled with commonly used distribution engineering analysis tools, to perform simulation/optimization analysis on historical extreme weather events to compare modeled vs. real damage data for tool refinement. Phase II will

² The 2014 DOE Resilient Electric Distribution Grid R&D Workshop report is available at <http://energy.gov/oe/articles/final-report-and-other-materials-2014-resilient-electric-distribution-grid-rd-workshop>.

conclude with completion of the beta version of the prototype in 12 months. Phase III is a 6-month effort to provide technical assistance to two distribution utilities in their use of the beta version of the tool. At the end of Phase I, a go/no-go decision will be made for Phase II, based on DOE acceptance of technical performance of the alpha version of the tool and the test/demonstration plan for Phase II. Similarly, a decision on Phase III will be made at the end of Phase II, based on DOE acceptance of the technical performance of the beta version of the tool and evidence of agreements with two distribution utilities for assisting in their individual uses of the beta version of the tool.

- **System Operations, Power Flow, and Control and Security and Resilience**
 - **Distribution System Restoration Tool (MYPP Task 4.3.1, 4.3.2, 6.2.2)** – This topic area is to seek proposals to develop a tool for system restoration and recovery with response optimization for use by distribution utility operators. The scope involves developing and integrating advanced data analytics, improved situational awareness capabilities, and advanced control schemes into a closed-loop decision support tool in which optimization methods with user-defined multi-objective metrics will be used to make decisions on routing repair crews, scheduling network component repair, conducting logistical operations, and allocating resources. Each proposal should structure the project into three phases, providing an adequate description for each phase. Phase I is to complete, in 12 months or less, development of the alpha version of the prototype tool for enhanced distribution system resilience to quickly recover from two extreme weather hazards (among the following: hurricane, flooding, nor'easter, ice storm, wildfire, etc.). Phase II, spanning 12 months, is to expand the capabilities of the alpha version of the prototype tool to provide optimal recovery from all known extreme weather hazards. Phase III, in 12 months, is to conduct testing and demonstration of the developed prototype to model restoration of physically damaged power systems from historical extreme weather hazards to compare modeled results, in terms of recovery time and other user metrics, against current and then-current restoration schemes. At the end of Phase I, a go/no-go decision will be made for Phase II, based on DOE acceptance of technical performance of the alpha version of the tool. Similarly, a decision on Phase III will be made at the end of Phase II, based on DOE acceptance of technical performance of the full capabilities of the alpha version of the tool against all known extreme weather hazards and the test/demonstration plan for Phase III.

Advanced Distribution Management System (ADMS)

Traditional distribution management systems (DMS) have been deployed by U.S. distribution utilities to manage the operations of electricity delivery from the distribution substations (<50 kV) to end-use customers. The deployed DMS ranges from a basic system composed of a supervisory control and data acquisition (SCADA) system integrated with a graphical information system (GIS) and a visualization layer for operators, to those with additional functionalities for applications such as outage/asset/workforce management; volt-VAR optimization; fault location, isolation, and service restoration (FLISR); demand response; distributed renewable/non-renewable resources integration; integration of advanced metering infrastructure (AMI) and automatic meter reading; and customer information management. The

challenge with these DMS deployments is that they are generally one-off deployments where utility-specific interfaces have to be developed to integrate the various functions, and each interface may be supplied by a different vendor. Further, the individual functions are rarely integrated at a level that allows them to support one another to realize the full benefits.

The ADMS activity, within the Smart Grid R&D Program, is to develop an integrated software platform capable of integrating a full suite of applications for distribution management and optimization. This full suite includes existing and new applications mentioned above, other advanced applications (such as distribution grid resiliency and integration of microgrids, building management systems (BMS), and electric vehicles), and emerging applications (such as transactive control, and a next generation, integrated energy management system [EMS]/DMS/BMS).

- **System Operations, Power Flow, and Control**

- **ADMS Platform Development (MYPP Task 4.2.1, 4.2.3)** – This topic area is to seek development of an integration software platform—based on open source interoperability standards and advanced mathematical models—to integrate a full suite of distribution management/optimization applications. The laboratory project is required to assemble an industry stakeholder panel, which should involve a critical mass of diverse vendors and distribution utilities for DMS and DMS-related applications to provide input to the state of existing ADMS technology, gaps in current and next generation ADMS applications, and the ADMS framework. Each proposal must include a list of organizations sought for participation on the panel and describe how the ADMS framework will be defined and built. An initial set of the prototype ADMS capabilities and applications to be developed in this project should include, but are not limited to: SCADA, AMI, outage management, asset management, workflow management, and customer information systems. The prototype ADMS should be targeted for completion in 2.5 years, followed by a 6-month period to validate the benefits of ADMS capabilities to help utilities and vendors justify investments in ADMS technology. Go/no-go criteria include: acceptance by the DOE of a fully assembled industry stakeholder panel (within 6 months from the project start date); acceptance by the DOE of a delivered report that describes the then-current state of ADMS, its gaps/next generation applications, the ADMS framework, and the initial set of applications/capabilities for the ADMS prototype, all of which are agreed to by the panel (by the end of year one); a validation plan describing the overall approach to verify the benefits of the ADMS platform.

- **Devices and Integrated System Testing**

- **ADMS Testbed Development (MYPP Task 2.3.5, 2.3.9, 2.4.1, 2.4.2, 2.4.12)** – This topic area is to seek establishment of a testbed to test and evaluate existing ADMS products in a realistic, complex utility environment. The testbed with associated capabilities is aimed at addressing common challenges associated with current DMS/ADMS implementation, such as the difficulties of integrating with legacy systems, sharing data between various applications across the utility enterprise, and realizing full benefits from a fully integrated system. The laboratory project is required to assemble an ADMS Testbed Industry Steering Group, which should be comprise of utility engineers responsible for DMS/ADMS deployments within their

organizations. Together with the Steering Group, the project team will define the testbed capabilities and testing requirements to be performed for ADMS products. The testbed of interest must allow simulation/emulation testing to be conducted to evaluate ADMS applications and their interoperability with existing distribution utility equipment and systems (such as outage management system, GIS, distributed energy resource management system [DERMS), FLISR, and feeder reconfiguration). The testbed should leverage, to the greatest extent, existing capabilities at national labs and the private sector for functional testing of ADMS along with utility equipment/systems from multiple vendors. Go/no-go criteria include: acceptance by the DOE of the assembled ADMS Testbed Industry Steering Group (within 6 months from the start date); acceptance by the DOE of a test plan specifying tests to be conducted in year two, developed jointly with the Advisory Group (by the end of year one); successful completion of the year-two test plan and acceptance by the DOE of a test plan specifying tests to be conducted in year three, developed jointly with the Advisory Group (by the end of year two).

Energy Storage

The OE Energy Storage Program is focused on advancing the performance, safety, reliability, and value proposition of stationary energy storage technologies for utility-scale applications. The program is designed to work with key stakeholders (states, communities, industry, etc) to develop, demonstrate, and deploy energy storage technologies that can reduce power disturbances, improve system flexibility to better incorporate growing use of variable renewable resources, reduce peak demand, and provide resiliency to advance the modernization of the electrical utility grid.

This Lab Call is primarily focused on activities to: 1) impact the acceptance of energy storage by elucidating the benefits and values storage provides to the grid; and 2) develop tools for states, regulators, and utilities to enable storage to be accurately assessed and valued in the planning process. Specific information on requested proposal activities in the 6 GMLC areas is provided below.

- **Sensing and Measurements**
 - *None*
- **Devices and Integrated Systems**
 - *None*
- **System Operations, Power Flow, and Control**
 - *None*
- **Design and Planning Tools,**
 - **Design Tools incorporating Energy Storage Flexibility (MYPP Task 2.1.3, 2.2.3, 2.4.1)** – For energy storage to be successful in the utility marketplace, it will be necessary to optimized multiple value streams across ancillary services and energy markets, as well as grid infrastructure investment. Current grid planning models lack the fidelity to accurately value energy storage as a flexible asset in a smart grid framework. To optimize the value of energy storage in distribution or transmission systems, the full range of ancillary services, including regulations services, load following and automatic generation control, need to be modeled on a time scale from seconds or minutes over a period of a year, by a comprehensive energy storage model. A new modeling tool with these capabilities could change how the grid is used, stimulate regulatory changes, and

radically improve the value proposition for energy storage. Proposals are sought for the development of new models for industry standard planning tools that can optimize the size, location, and use of energy storage assets. These models must enable a wide range of energy storage applications to be considered in order to fully capture the value proposition of energy storage. Proposals should be coordinated with the activities in Foundational Topic 2 under Valuation.

- **Security and Resilience**

- *None*

- **Institutional Support**

- **Collaborative Demonstrations and Use-Case Validation (MYPP Tasks 7.3.1, 7.3.2, 5.1.2)**

Field-deployed energy storage demonstration in collaboration with states, utilities, and storage providers help to elucidate storage benefits and integration challenges, and to build confidence regarding the safety and performance of deployed technologies.

Combined with use-case analyses that detail the cost and benefits of energy storage, field demonstrations can help guide the development of the regulatory environment and accelerate acceptance of energy storage. Proposals are sought focusing on collaborative efforts with states, regional entities, and utilities in which detailed cost-benefit analyses are conducted on field deployed energy storage systems in order to provide the value proposition of energy storage under local pricing structures. The studies should provide owners with algorithms for the most cost effective deployment of the storage assets.

Cybersecurity for Energy Delivery Systems

This Lab Call is focused primarily on the development of projects in the following areas; however labs are highly encouraged to submit project ideas beyond the possible topics associated with the Technical Areas listed below:

Security and Resilience

- **Detect Compromise of Hardware, Firmware or Software in the Supply Chain and Restore Integrity (MYPP Task 6.2.3, 6.3.1, 6.3.3)** - Research, develop and demonstrate technology or techniques to detect the presence of undesired functionality inserted in the supply-chain then restore the integrity of the compromised energy delivery system or component. The research can consider one or more of hardware, firmware or software, including third party. The technology and techniques developed are to be used, by one or more of, the supplier during component development, the system integrator, and/or by the energy asset owner or operator following procurement of the component or system.
- **Design Innovative Cybersecurity Solutions into Current or Anticipated Projects Related to Energy Delivery (MYPP Task 6.2.3, 6.3.1, 6.3.3, 6.4.1, 6.4.3, 6.4.4)** - Research, develop and demonstrate innovative cybersecurity technology or techniques that address next-generation cybersecurity needs associated with a current or anticipated project that involves energy delivery systems, regardless of the funding source(s) for that project. This topic is not intended to deploy existing cybersecurity technologies or techniques.
- **Cybersecurity for Renewable and/or Distributed Energy Resources (MYPP Task 6.2.3, 6.3.3, 6.4.1, 6.4.3, 6.4.4)** - Research, develop and demonstrate technology or techniques that strengthen cybersecurity for renewable energy, such as solar or wind, and/or distributed energy resources. For the purposes of this research call, distributed energy resources include “behind-the-meter” power generation, energy storage systems, the interface where plug-in hybrid vehicles interact with the utility, the interface where building management systems interact with the utility to support, for instance but not limited to, energy efficiency or demand response, and microgrids that separate from, and reintegrate with, the bulk power grid as needed for reliability.
- **Cybersecurity for Cloud Use in Energy Delivery (MYPP Task 6.2.3, 6.3.1, 6.3.3, 6.4.1, 6.4.3, 6.4.4)** - Research, develop and demonstrate technology or techniques that enhance cybersecurity for energy sector personnel who access energy delivery infrastructure using the cloud, as defined in <http://csrc.nist.gov/publications/nistpubs/800-145/SP800-145.pdf>. The research can consider cybersecurity technology or techniques that protect against a cyber attack that intends to compromise the use of the cloud for efficient management, maintenance or operation of energy delivery infrastructure. This could include, but is not limited to, cyber-defenses that detect, contain and eradicate attempts to compromise use of the cloud for energy delivery infrastructure.

Transmission Reliability

The Transmission Reliability (TR) subprogram of the Energy Infrastructure Modeling and Analysis Division of OE performs R&D and demonstration regarding electricity transmission systems. This program is best known for its management of the synchrophasor demonstration projects under the American Recovery and Reinvestment Act. Historically, this program has fostered collaboration among national laboratories, industry, and academia.

This laboratory call is an open competition for R&D projects at the national laboratories previously funded under the TR program lines for Advanced Applications Research and Development (AARD), Reliability and Markets/Load as a Resource (LaaR), and Reliability Technology Issues and Needs Assessment (RTINA). The Department welcomes project proposals that continue R&D currently sponsored under those programs with the understanding that the focus of the laboratory call is new R&D in the areas described below. Preference will be given to new projects in the focus areas described below. The period of performance for projects is two years (or three years, at the discretion of the proposer) for new projects and one year for continuation of prior projects. Pending available funding, the TR program expects to release an annual laboratory call in this program area to begin new two-year R&D projects. The expected funding available for these projects is \$3.0 million.

Advanced Synchrophasor Technology Research (ASTeR) (MYPP Tasks 3.4.1 and 3.4.2)

The goal of this research call is to develop and advance applications of PMUs and synchrophasor data. For FY16, the focus of new projects for the program will be: (1) to use real-time synchrophasor data to improve electricity market operations, and (2) to use real-time synchrophasor data to actively control electricity system response so as to maintain reliability and/or system efficiency. Responding laboratory teams are expected to propose a set of two-to-three year projects to beginning in FY16 that collectively achieve the focus areas above.

Responding laboratory teams should build off the prior R&D funded by the TR and Advanced Modeling Grid Research Program and should incorporate of the national sensing strategy being developed in Foundational Topic 2. This R&D included R&D and application development covering the following areas, among others:

- Oscillation detection and damping
- Synchrophasor standards development
- Using Synchrophasors to facilitate compliance with reliability standards
- Event and anomaly detection and intelligent alarming
- Model validation (load, system, generator)
- Identifying equipment misoperations

Proposals for continuing existing R&D should indicate how it contributes to the goals listed above, either directly or as a building block.

Responsive proposals must include utility, industry, and stakeholder partners to ensure relevance, access to data, and engagement with users.

Advanced Grid Modeling Research

The Advanced Modeling Grid Research (AMGR) subprogram supports research and development of more sophisticated, model-based analytical tools, which are necessary for effective planning and operations of the electric system. When a reliability or security event occurs, model-based decision support tools are essential to identify opportunities for operational flexibility that help guide operators along a path to recovery.

The AMGR subprogram focuses research on the modeling, computational, and mathematical advancements that are the foundation of software systems used by operators to monitor, analyze, and control the electric system. It will enhance reliability and enable advanced mitigation and recovery strategies, by:

- Accelerating performance—improving grid resilience to fast time-scale phenomena that drive cascading network failures and blackouts;
- Developing advanced decision-support capabilities—relying on high-fidelity measurements and improved models to represent the operational attributes of the electric system, improving prediction of system behavior and identification of system anomalies, assessing uncertainties, and proactively informing operator decision-making; and
- Integrating model platforms—capturing the interactions and interdependencies that improve operational planning, facilitate development and validation of new control and protection techniques, improve insight into the delicate balance between generation and load, and enable dynamic reconfiguration of electric system elements to achieve both technical and economic objectives.

Proposals submitted in response to this Research Call must adequately address pathways to innovation in one of the following power flow and dynamics modeling areas:

- Load Models
- Protection System Models

Projects must comprise two (2) Phases of endeavor:

- Phase I (lasting up to 24 months) shall result in the development of improved model structure(s). These model structures should be scalable, open source, and integrate into a variety of commercially-available software tools, as applicable. Methods for model validation should be outlined in the proposal. Note that the open source requirement applies to the mathematical model structure, not model representations of specific systems. Selected performers shall prepare a detailed literature review, and deliver a final technical report for Phase I describing the model structure, validation approach, and results.
- Phase II of this project shall last up to 12 months and consist of integrating the model structure into a commercially-available software tool and demonstrating the tool within an operational context, preferably in coordination with a utility and/or software vendor. The final report for Phase II should describe and quantify the operational benefits of the model-based improvement.

The expected funding available under this lab call is \$4.0 million

Load Models (MYPP Task 5.1.3, 5.1.4, 5.2.2)

Effective control requires understanding dynamic behavior across a variety of temporal and spatial domains. Previous AMGR modeling activities focused on the dynamics associated with the bulk electricity system. These models established a foundation for analyses contributing to the understanding of both electric grid stability questions and economic factors facing the regional system. However, little attention was placed on understanding the local system, especially load dynamics. Yet, more and more customers are becoming empowered to make decisions that will influence how the grid is operated in response to either price or control signals in near real time. Furthermore, load characteristics are changing, with growing use of distributed generation and accelerated use of electronics converters in buildings, industrial equipment, and consumer equipment. [DOE and the Buildings Technologies Office are actively researching new ways loads can work together to provide services to the customer and the grid using transactive energy.](#) DOE is also working on new methods to measure load's potential response to grid and other signals. Thus, the traditional modeling assumptions around loads may no longer be appropriate.

Proposed activities under this Lab Call should contribute towards development and validation of mathematical model structures capturing emerging load dynamic behaviors. Research is required to develop physics, math, and economic (if applicable) representations suitable for analytical assessments that run on a range of computational platforms from desktop to high-performance computing systems. Temporal fidelity of load dynamics model should be compatible with latest system measurements, e.g., fnet, synchrophasor.

Price-responsive load models should assume 5 minute market periods, with scalability to finer periods preferred. “Challenges include the multitude of decision-making criteria/objectives and capabilities of consumers, the many types (and latencies) of information that will inform these decisions, and the degree of automation and/or sophistication of the technologies through which these decisions will be translated into actions.”³ Assumptions with respect to these market-based challenges should be outlined in the proposal. Research characterizing changing behavioral response characteristics over repeated dispatch or price requests should also be considered.

Protection System Modeling and Analysis Capabilities (MYPP Task 5.2.1, 5.2.3, 5.1.4)

Protection system misoperations has been identified by NERC as a critical reliability issue. “Nearly all major system failures, excluding those caused by severe weather, include misoperations of relays or automatic controls as a factor contributing to the propagation of the events.”⁴ A significant number of reliability standards related to the analysis and reporting of relay system misoperations have been issued to highlight the concern. In a similar vein, the AMGR subprogram has supported development of

³ U.S. Department of Energy, Quadrennial Technology Review Technology Assessment (2012), <http://energy.gov/downloads/first-quadrennial-technology-review-qtr-2011>, p. 160.

⁴ M. Lauby, Training Webinar – Consistent Protection System Misoperation Reporting (February 10, 2011), [https://www.npcc.org/Compliance/Misoperation%20Reporting%20and%20PRC004/Ref8.8 Consistent Protection System Misoperation Reporting Webinar 2-10-2011.pdf](https://www.npcc.org/Compliance/Misoperation%20Reporting%20and%20PRC004/Ref8.8%20Consistent%20Protection%20System%20Misoperation%20Reporting%20Webinar%202-10-2011.pdf), slide 6.

capabilities for consolidated planning and system protection modeling. Yet, a myriad of protection-related modeling and analysis challenges remain.

This research area seeks to enhance protection system modeling capabilities, as a platform for the study and coordination of protection devices and approaches. Applications could include regional system concerns (e.g., cascading event mitigation, special protection systems/remedial action schemes) or local objectives (e.g., feeder-level adaptive protection, intentional islanding/microgrids). Research should consider, where applicable, node-breaker modeling, as well as capabilities for analysis of single-phase faults. Proposal should include a thorough outline of the model validation approach; advancement in model validation techniques for rare events (such as single-phase faults where historical data may be lacking) could be considered a substantive research achievement.

Open Source Library of Algorithms and Solvers for Power System Applications (MYPP Task 4.2, 4.3, 5.3.5, 5.3.6)

The overarching goal of this Lab Call is to create, maintain, and enhance a scalable math solver library for grid planning and operations tools that work on a variety of computational platforms.

Considerable resources are invested each year by the electric industry into software system improvements. Historically, proprietary software offerings and resulting vendor lock-in have been typical for the industry. Yet, open source software has shown potential to foster innovation, reduce development costs, and enhance overall security; and now, organizations like EPRI are trending towards more use of open source software.

The fundamental premise of this Lab Call is that sharing software enhancements through an open source library of algorithms and mathematical solvers could accelerate application development, enhance system reliability and flexibility, and improve software interoperability within the electric industry. Proposals are sought which support the creation, maintenance, and enhancement of a scalable math solver library for grid planning and operations tools that works on a variety of computational platforms, i.e., from laptop to HPC. Responses may propose additional research into computational architectures and hardware, which offer potential for significant performance improvements when compared to the state of the art.

The proposal should clearly describe a framework for applications to be considered, the underlying mathematical and computational needs (e.g., what solvers are required, and when), and how the proposed team has appropriate expertise and resources to solve the problem. This description should include a pathway towards long-term self-support.

The proposal should also outline a strategy for building awareness of the work. The “library” should include documentation and examples to facilitate use, acceptance, and adoption of the algorithms and solvers by targeted users, e.g. software vendors and developers, electric utilities, and system operators.

Energy Systems Risk and Predictive Capability

The Energy Systems Risk and Predictive Capability (“ESRPC”) subprogram of the Clean Energy Transmission Reliability program (“CETR”) funds research and development to advance predictive

modeling and risk analyses on a system-level basis to assess how interdependent energy infrastructure systems are impacted by forecasted and unforeseen events. ESRPC funds projects to more accurately assess energy system risks from both natural and man-made threats.

Strategic Transformer Research (Task 6.5.4)

The goal of this Lab Call (“Call”) is to evaluate the size, scale, and scope of a potential strategic reserve of bulk power system transformers. This work is intended to support the recommendation found in Chapter 2 of the Quadrennial Energy Review, which directed the Department to analyze the policies, technical specifications, and logistical and program structures needed to mitigate the risks associated with the loss of transformers.⁵

This project is expected to be an exceptionally high profile project undertaken by the Department of Energy, with interim work product subject to feedback from an inter-agency technical panel comprised of representatives from the Department of Energy, the Federal Energy Regulatory Commission (who will be acting in a non-regulatory role), the Department of Homeland Security, and others.

Project submitted in response to this Research Call must comprise two (2) Phases of endeavor. Phase I (lasting up to six (6) months) shall involve the development of an initial draft product, comprising scientific and technical analysis of strategic reserve of transformers. This draft product will then be submitted to the inter-agency technical panel for a 45 day review period, upon which, all comments will be consolidated into a single response back to the project awardee to address. Phase II (lasting up to four (4) months) shall involve the development of the final report for submission to DOE which addresses all comments received from the inter-agency technical panel, as well as incorporates the latest data and industry knowledge.⁶

The final report provided by the Project awardee will need to demonstrate both technical acumen of this topic as well as full accounting of all data and simulation resources used in the development of technical results.

Proposals submitted in response to this Lab Call must adequately address the following topics:

- The appropriate number of spare large power transformers and total capacity in megavolt-amperes necessary to maintain the current level of reliability of the Bulk Electric System;
- Tradeoffs regarding the level of reliability and the number of spares transformers;
- The potential locations of a spare transformers based upon engineering alternatives analysis and taking into account current system operational parameters;
- A review of common substation designs and identification of the types of transformers to be maintained in a Strategic Transformer Reserve;

⁵ Quadrennial Energy Review, U.S. Department of Energy, Page 2-42, May 2015

⁶ This analysis will need to include the current status of industry based equipment sharing initiatives, including the Edison Electric Institute (EEI) Spare Transformer and Equipment Program (STEP), the North American Electric Reliability Corporation (NERC) Spare Equipment Data (SED) program, and the American Electric Power (AEP) Grid Assurance Program.

- An engineering cost estimate of the cost of the Strategic Transformer Reserve alternatives evaluated;
- An Operational Research analysis which examines the logistics of transportation, installation, and energization of spare large power which allows for the greatest efficiency;
- Comparisons among alternative criteria for withdrawal of spare large power transformers from the Strategic Transformer Reserve to replace critically damaged large power transformers, including consideration of related existing industry programs;
- A review of State-based electric distribution equipment reserves and evaluation of the criteria which which equipment from these reserves is drawn down and replaced;
- Other considerations for designing, constructing, stocking, and managing the Strategic Transformer Reserve

Results should be stated in terms of risk-return tradeoffs among the content and location of a reserve of spare transformers and the magnitude of a disruption to the bulk electric system that could be mitigated.

The final report developed under this Lab Call is expected to be fully documented regarding the use of all data sources, analysis methods, and simulation techniques applied. The final document shall be copyedited, formatted, and published by the awardee. All of the final report conclusions shall be fully documented and be able to be reproduced for independent validation and verification purposes if necessary.

This scope of work will be initiated with FY 2015 funding of \$0.5 million and augmented with an expected amount not to exceed \$1.3 million of funding in FY 2016.

Risk and Decision Science for Energy Systems (MYPP Task 6.2.2)

The goal of this Lab Call (“Call”) is to fund research activities to improve forecasts of electric outages and identify infrastructure at risk for tropical cyclone events affecting U.S. territory in the Caribbean, Atlantic seaboard, and Gulf of Mexico regions.

The web-based tool developed as a result of this Call shall improve the precision of forecasts of potential electric distribution outages from the current scale of county level resolution (which is roughly on the order a 50 kilometer by 50 kilometer square) to a resolution on a county block level (which is roughly on the order of a 250 meters by 250 meters). The web-based tool will also identify energy system infrastructure at risk while applying the latest advances in both statistics and operations research to quantify risk and uncertainty of the forecasts provided.

The web based tool is expected to be used to support Mission Support activities within DOE Headquarters and across the Federal Government in the preparation for and the response to tropical cyclone events. The web based application is expected to be housed on Internet-connected servers at the Project awardee’s location during the prototype and testing phase of development. A transition plan to the Department of Energy Office of the Chief Information Officer (“OCIO”) is required as part of the project proposal.

Projects submitted in response to this Research Call must comprise two (2) Phases of endeavor. Phase I (lasting up to 12 months) shall advance the state-of-the-art in forecasting electric outages and identify

infrastructure at risk, as well as potential interdependent system effects of the loss of the infrastructure at risk on a repeatable and consistent basis.

Selected performers shall prepare a detailed literature review, deliver a final technical report describing the methodology, data, and results in Phase I. Additionally, the first Phase will also require that the performer develop a prototype tool which demonstrates the proposed capabilities. The prototype tool will only need to be operated on internal systems to demonstrate completion of Phase I.

Phase II of this project shall also last up to 12 months and consist of testing the web based tool (for at least six [6] months) to validate performance against previous tropical cyclone events as well as synthetic tropical cyclone events. At the completion of Phase II the tool will then be transitioned to the Department of Energy Office of the Chief Information Officer. The entire effort (Phase I and Phase II) is expected to last up to 24 months.

While the DOE anticipates selecting up to two projects for Phase I, only one of the Phase I projects will be allowed to continue into Phase II. The DOE will make this down-selection based on the performance/progress of each selected project and review of information provided in the Phase I report and the Phase I project briefing.

This report must be submitted not later than 30 days after the end of Phase I, and must describe the progress and accomplishments to date and outline the planned work, objectives and expected results for Phase II. The project briefing will be scheduled soon after delivery of the Phase I report to the DOE. During the briefing, the principal investigator of the project (with or without participation of other team members) will present the Phase I progress/results and Phase II plan to the DOE.

The web-based tool developed by this Research Call is expected to leverage existing peer-reviewed research. The tool should provide decision makers with the appropriate fidelity of results which can decisions can be refined and improved based upon the output of the tool.

Proposals submitted in response to this Research Call must adequately address the following topics:

- How electric system outages are currently forecast in peer-review literature
- How at-risk assets to tropical cyclone events are currently identified in peer-reviewed literature
- What are the necessary data sources to forecast outages and uncertainties regarding the forecasts and identify at risk infrastructure
- How this work will advance the state of knowledge in the field

The web-based tool developed under this Lab Call is expected to be rigorously documented, including documentation on not only how the tool calculates and forecasts potential outages and impacts, but also from a technical standpoint of how the tool works, including training and use documentation.. One requirement is that it be expandable to include additional data inputs or changes to existing data inputs. The framework of the tool must be flexible to allow and accommodate the future integration of data and additional applications on that data.

The web-based application tool developed under this Research Call must be capable of the meeting the performance specifications described in Table 1. Each proposal must adequately describe how each performance specification will be addressed and met; and explain additional assumptions, limitations, and outcomes.

Table 1: Necessary Attributes of the Tool

| | |
|---|---|
| At Risk Infrastructure Identified | Electric Generators over 25 MW Bulk Electric Transmission System and related facilities (substations) Electric Distribution System and related facilities (substations) |
| Electric System Outage Forecast Resolution / Fidelity | 250 meters x 250 meters (approximately the resolution of a city block). |
| Outage Forecast Output | Geographic Map of Forecasted Outages and the Uncertainty of those forecasts, as well as list of potential system effects caused by these outages. |
| Frequency of computation | Forecast results are generated approximately every three hours, as data regarding the tropical cyclone risk is updated |
| Tool Run Time | Generation of results less than 30 minutes after the issuance of a tropical cyclone forecast issued by the National Hurricane Center. The tool should also allow playback of past hurricanes and forecast outages and system effects. |
| Statistical Accuracy | Each outage forecast shall appropriately characterize the statistical accuracy of the forecast outages as well as the uncertainty with forecast system effects. ⁷ |
| Coverage Basins | Caribbean Sea (all U.S. territories in this area) Atlantic Ocean (all U.S. States bordering this Ocean) Gulf of Mexico (all U.S. States bordering this Basin) |
| Possible Data Sources | The Tool places a preference on the use of non-proprietary data sources where possible, both in identification of weather locations, as well as the calculation of forecast of outages and system effects. Possible non-proprietary data sources include: NOAA National Weather Service NOAA National Hurricane Center National Corporation for Atmospheric Research Energy Information Administration Federal Energy Regulatory Commission Department of Energy Department of Homeland Security U.S. Census Bureau |

⁷ The research team selected shall also propose performance metrics, such as performance against a generic estimate of customer outages based on scaling customers to wind speeds and demonstrate quantitative improvement over forecast predictions in current peer-reviewed literature.

In addition to addressing the performance specifications in Table 1, proposals must include a preliminary test plan (up to five (5) pages in length) and a transition plan (up to 3 pages in length) for Phase II. At a minimum, the test plan should contain discuss of the following elements:

- How the prototype tool will be tested
- What combinations of energy assets will be included in testing
- What test data sets will be collected and how the data will be analyzed; and
- How validity of the tool analysis will be assessed.

The transition plan should encompass the following:

- Providing a user manual
- A description of the planned training to instruct users of the tool, segmenting users into different categories, such as emergency response planners and emergency responders.
- A planned pathway to transition the tool from hosting at the Phase II awardee to the Department of Energy Office of the Chief Information Officer.

The tasks initiated under this research call will be funded using \$1.5 million of FY 2015 dollars.

Transformer Resilience and Advanced Components

Security and Resilience

- Transformer Testing and Modeling [MYPP Task 6.5.6] – Transformers are critical components of the electric power system and are susceptible to the impacts of GMD and EMP. Through multi-physics modeling and reduced order testing, this \$3 Million activity will help to improve the understanding of transformer vulnerabilities to these events and inform mitigation options.

Design and Planning Tools

- HVDC and MVDC Analysis [MYPP Task 5.1.4] – As the generation mix changes and shifts in location, HVDC and MVDC may play a greater role in the future grid. Currently, the models and methods for assessing the value of these technologies have been limited. This \$1 Million activity will improved models and focus on exploring scenarios and use cases, such as accelerated siting from undergrounding and the provision of virtual inertia. *This activity may be combined with other analysis to explore system flexibility more holistically.*

Institutional Support

- Not applicable

Sensing and Measurement

- Not applicable

Systems Operation, Power Flow, and Control

- Not applicable

Proposal Content and Submission Requirements

Concept Papers

To be eligible to submit a Full Proposal, Applicants must submit a Concept Paper by the specified due date and must use the attached Concept Paper Template. Each Concept Paper must be limited to a single concept, technology or area of research. Unrelated concepts, technologies or research areas should not be consolidated into a single Concept Paper. Concept papers are limited to a maximum length of 3 pages and should succinctly describe salient features of the proposed project as delineated in the Concept Paper Template. Applicants may provide an Addendum to the Concept Paper Template, not to exceed 2 pages, that includes graphs, charts, or other data to supplement their Project Description.

DOE will perform an independent assessment of each Concept Paper based on the criteria delineated for concept papers in the Evaluation and Selection section that follows. DOE will encourage a subset of Applicants to submit Full Proposals. Other Applicants will be discouraged from submitting a Full Proposals. An applicant who receives a “discouraged” notification may still submit a Full Proposal. DOE will review all eligible Full Proposals. However, by discouraging the submission of a Full Proposals, DOE intends to convey its lack of programmatic interest in the proposed project in an effort to save the Applicant the time and expense of preparing an application that is unlikely to be selected for award negotiations.

In order to provide Applicants with feedback on their Concept Papers, DOE will include general comments provided from reviewers on an Applicant’s Concept Paper in the encourage/discourage notification sent to Applicants at the close of that phase.

Full Proposals

Applicants must submit a Full Proposal by the specified due date to be considered for funding under this Lab Call. Applicants must use the Lab Call Proposal Template and provide the requisite information in accordance with the instructions contained in each section. It is requested that the completed Lab Call proposal not exceed 25 pages (excluding the resume file.)

Provide a resume for each key person proposed, including sub-awardees and consultants if they meet the definition of key person. A key person is any individual who contributes in a substantive, measurable way to the execution of the project.

Applicants will have approximately 30 days from receipt of the Concept Paper Encourage/Discourage notification to prepare and submit a Full Proposal. Regardless of the date the Applicant receives the Encourage/Discourage notification, the submission deadline for the Full Proposal remains the date stated on the Lab Call cover page.

DOE will perform an independent assessment of each Full Proposal based on the criteria delineated for Full Proposals in the Evaluation and Selection section that follows.

Evaluation and Selection

DOE Review of Concept Papers

Concept Papers submitted in response to this Lab Call will be evaluated and scored in accordance with the criteria and weights listed below.

Criterion 1: Technical Merit, Innovation, and Impact (50%)

– This criterion involves consideration of the following factors:

- Degree to which the current state of the technology and the proposed advancement are clearly described;
- Degree to which the proposed technology or process has significant impact in reaching the goals stated in the Grid Modernization MYPP
- Extent to which the proposed technology or process is innovative, has the potential to advance the state of the art, and involve appropriate stakeholders

Criterion 2: Project Plan and Resources (50%)

– This criterion involves consideration of the following factors:

- The proposed approach is without major technical and management flaws, and
- The capability of team members is adequate to address all aspects of the proposed work with a good chance of successfully accomplishing project objectives.

- Reviewers will assign an overall score to each Concept Paper based on the following scoring system:

| | |
|----|--|
| 1 | Applicant has strong potential to meet the objective(s) of the Lab Call |
| 0 | Applicant might have the potential to meet the objective(s) of the Lab Call |
| -1 | Applicant does not have the potential to meet the objective(s) of the Lab Call |

DOE Review of Full Proposals

Full Proposals submitted in response to this Lab Call will be evaluated and scored in accordance with the criterias and weights listed below.

Criterion 1: Technical Merit, Innovation, and Impact (50%)

Technical Merit and Innovation

- Extent to which the proposed technology or process is innovative and has the potential to advance the state of the art;
- Degree to which the current state of the technology and the proposed advancement are clearly described;
- Degree to which the proposed technology or process has significant impact in reaching the goals stated in the Grid Modernization MYPP;

- Extent to which the project supports the overall goal of addressing the three DOE Major Achievements (due to be complete in five years) stated in the MYPP; and
- Extent to which the application specifically and convincingly demonstrates how the applicant will move the state of the art to the proposed advancement;

Criteria Specifically for Technical Assistance

- Extent to which multiple technologies are integrated at multiple scales;
- How the project supports the topic area objectives and target specifications and metrics;
- The potential impact of the project on advancing the state of the art;
- How the outcomes of the project will support the industry and real-world applications;
- The general applicability of project outcomes to a wide range of grid modernization scenarios;
- Sufficiency of technical detail in the application to assess whether the proposed work is scientifically meritorious and revolutionary, including relevant data, calculations and discussion of prior work in the literature with analyses that support the viability of the proposed work; and
- Extent to which open standards are used (if applicable).

Criteria Specifically for Foundational Activities

- Extent to which national stakeholders are involved in the process;

Criterion 2: Project Research and Management Plan (30%)

Research Approach and Work Plan

- Degree to which the approach and critical path have been clearly described and thoughtfully considered; and
- Degree to which the task descriptions are clear, detailed, timely, and reasonable, resulting in a high likelihood that the proposed work plan will succeed in meeting the project goals.

Identification of Technical Risks

- Discussion and demonstrated understanding of the key technical risk areas involved in the proposed work and the quality of the mitigation strategies to address them.

Criterion 3: Team and Resources (20%)

- The capability of the Principal Investigator(s) and the proposed team to address all aspects of the proposed work with a good chance of success. Where appropriate, the GMLC should ensure the best personnel and infrastructure within the National

Laboratory Complex are used to address the challenges proposed in the proposals. Qualifications, relevant expertise, and time commitment of the individuals on the team;

- The sufficiency of the facilities to support the work;
- Degree to which the proposed consortia/team demonstrates the ability to facilitate and expedite further development and commercial deployment of the proposed technologies;
- Level of participation and involvement in the project by stakeholders including industry, states, standards organizations, and electric utilities;
- Level of participation by project participants and how well they are integrated into the Workplan; and
- Reasonableness of budget and spend plan for proposed project and objectives.

Other Selection Factors - Program Policy Factors

In addition to the above criteria, the Selection Official may consider the following program policy factors in determining which Full Proposals to select for award negotiations:

- It may be desirable to select project(s) with collaborative efforts among national laboratories, academia, states and regions, energy sector suppliers and utilities that provide a balanced program portfolio.
- It may be desirable to select project(s) that demonstrate solutions that are scalable and cost-effective with a clear industry acceptance for commercialization that provides a balanced program portfolio.
- It may be desirable to select complementary project(s) and/or duplicative efforts or projects, which, when taken together, will best achieve the program research goals and objectives.
- It may be desirable to select a group of projects that represent a diversity of technologies, applications and approaches in order to provide a balanced programmatic effort and a variety of different technical perspectives.
- It may be desirable to select project(s) of less technical merit than other project(s) if such a selection will optimize use of available funds by allowing more projects to be supported and not be detrimental to the overall objectives of the program.

SUBMISSIONS FROM SUCCESSFUL OFFERORS

If selected for award, DOE reserves the right to request additional or clarifying information for any reason deemed necessary, including, but not limited to:

- Indirect cost information;
- Other budget information;
- Name and contact information of the Applicant's Contracting Officer.
- Other supporting documentations