Grid Modernization Initiative

Department of Energy's Grid Modernization Lab Call (2019)

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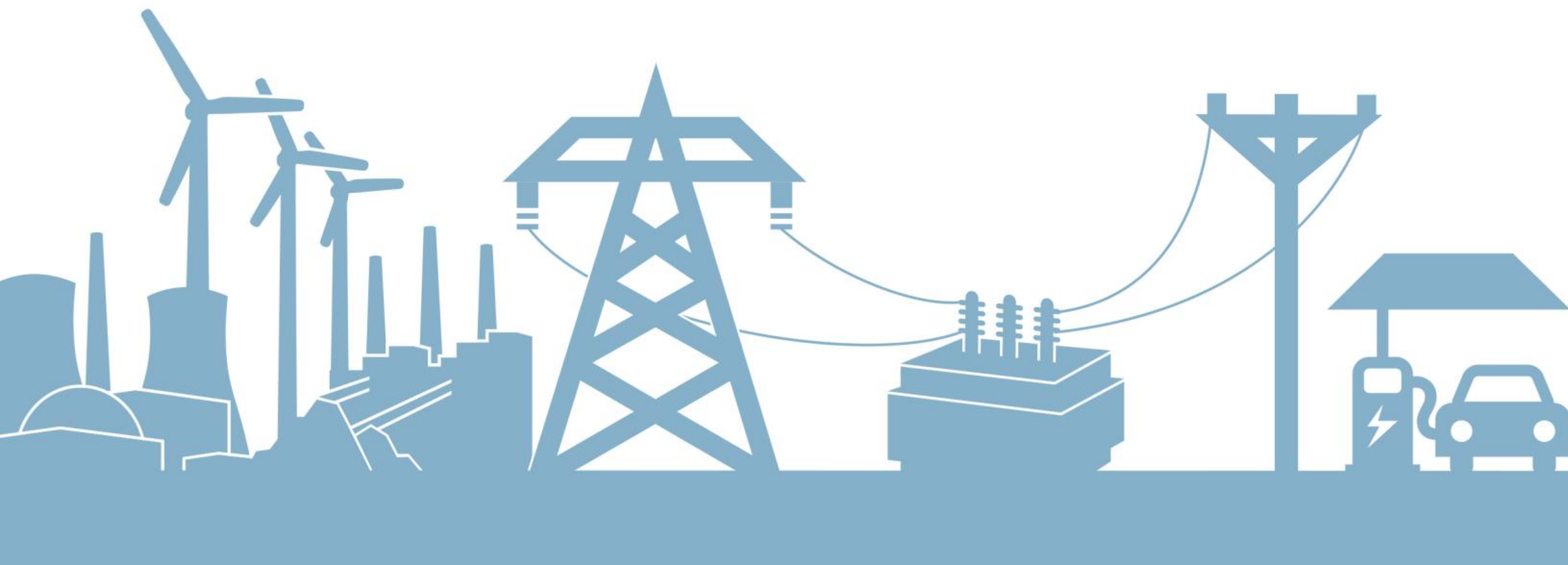

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Introduction

The Grid Modernization Initiative (GMI) works across the U.S. Department of Energy (DOE) to create the modern grid of the future. The GMI focuses on developing new architectural concepts, tools, and technologies that will better measure, analyze, predict, protect, and control the grid, as well as enable the institutional conditions that allow for rapid development and widespread adoption of these tools and technologies.

In 2016, DOE announced the first Grid Modernization Lab Call—a comprehensive, $220M, three-year plan to mobilize 87 projects across the country, bringing together DOE and the National Laboratories with more than 100 companies, utilities, research organizations, state regulators, and regional grid operators to pursue critical research and development in advanced storage systems, clean energy integration, standards and test procedures, and a number of other key grid modernization areas. In 2017, DOE announced up to $32M over three years for seven projects to develop and validate innovative approaches to enhancing the resilience of electricity distribution systems, focusing on the integration of distributed energy resources (DER's), advanced controls, grid architecture, and emerging grid technologies at a regional scale. Additionally, several Offices within DOE have successfully conducted Lab Calls on Office-specific Grid Modernization topics.

New Vision for the Grid Modernization Initiative

With the first Grid Modernization Lab Call (2016) coming to an end, GMI's second Grid Modernization Lab Call (2019) will expand on the work started in 2016, with several major changes:

- Fully Integrated Vision: This effort will focus on a fully integrated vision of the energy system from fuel to generation to load, including interdependent infrastructures.
- Reliability and Resilience: This effort will strengthen, transform, and improve the resilience of energy infrastructure to ensure access to reliable and secure sources of energy. The complexity of the electricity grid and its interconnection with other critical systems can accentuate the risk of cascading failures. As a result, it is paramount that the grid is reliable and resilient against all malicious threats, natural disasters, and other systemic risks such as human error or the grid's dependence on other critical systems.
- Participation: The GMI reflects a collaborative partnership of five DOE Offices (the Applied Offices) including the Office of Fossil Energy (FE), the Office of Nuclear Energy (NE), the Office of Electricity (OE), the Office of Energy Efficiency and Renewable Energy (EERE), and the Office of Cybersecurity, Energy Security, and Emergency Response (CESER).

Principles for the 2019 Grid Modernization Lab Call

As identified in the *Worldwide Threat Assessment of the US Intelligence Community* presented to Congress by the Director of National Intelligence in January 2019, threats to US national security will expand and diversify in the coming year. The development and application of new technologies will introduce both risks and opportunities across the US economy, and the energy sector has been identified by the Department of Homeland Security (DHS) as one of 16 critical infrastructure sectors in the nation. As a result, this Lab Call will focus on security challenges of the electric power system. Key elements of the projects must address:

- *Impact on the Bulk Power System*: Proposals must focus on the bulk power system impacts. Any proposals including DER must show impact on the bulk power system.
- *Demonstrated Near-term Success*: To increase likelihood of industry implementation and increase potential impact, it is critical that selected projects provide meaningful results within 18 months to two years that address clear, immediate challenges. Note that this does not mean the period of performance is capped at two years (i.e., selected projects may have a three-year period of performance).

Based on the principles identified above, the lab call will focus in the following six topic areas:

1. Resilience Modeling
2. Energy Storage and System Flexibility
3. Advanced Sensors and Data Analytics
4. Institutional Support and Analysis
5. Cyber-Physical Security
6. Generation

The grid modernization activities over the next three years will be organized in two broad areas: foundational work resulting from this Lab Call and Office-specific activities organized by individual Offices.

Foundational Lab Call

Multi-lab, holistic proposals are sought that address well-defined foundational platform activities in the six topic areas outlined above. Because these topics are foundational, the coordination of these topics will occur through the Grid Modernization Lab Consortium (GMLC) Tech Team Leads and Integrators, in close collaboration with all key personnel from DOE's Offices and programs within the GMI. These projects will be crosscutting projects, where each project will represent a collaboration across, and receive support from, multiple DOE Offices and programs.

Future Office-Specific Activities

DOE Offices will develop separate efforts (both funding opportunity announcements (FOA) and lab calls) that address their specific requirements for grid modernization. The solicitations issued by the Offices will support the broader holistic GMI vision, and approaches will be developed to enhance project awareness and coordination across the entire portfolio (both foundational and office-specific). DOE Offices conduct their office-specific lab calls on Office-specific schedules with the oversight of the GMI Executive Committee.

Foundational Lab Call

Multi-laboratory, holistic proposals are sought that address each of the six foundational topic areas. These projects will be crosscutting projects, where each project will represent a collaboration across and receive support from multiple DOE Offices and programs. Based on priorities identified by the Administration, Congress, and DOE staff, the GMI will focus on the following six topic areas:

1. Resilience Modeling
2. Energy Storage and System Flexibility
3. Advanced Sensors and Data Analytics
4. Institutional Support and Analysis
5. Cybersecurity and Physical Security
6. Generation

Note that innovative proposals that do not specifically address the subtopics of the six topic areas as defined in the following sections will be accepted for consideration. However, all proposals must broadly address one of these six topic areas above.

To ensure the work and results of the selected proposals provide the most benefit, the Grid Modernization Lab Consortium (GMLC) will provide coordination, information exchange, and knowledge sharing through an annual review and quarterly updates.

Funding

DOE expects to make up to $80M of Federal funding available in this GMI Foundational Lab Call over three years, subject to the availability of appropriated funds. To initiate this three-year investment, over $40M will be committed in FY19 to build core competencies for the future, in collaboration with industry. To increase stakeholder engagement, all proposed projects will reflect non-laboratory partner participation equivalent to at least 20% of the total allowable project costs. In addition, providing federal funding for team members (industry, academia) and development of consortia is permissible as well. The funding breakdown for these efforts is below:

Topic Area	Proposed Foundational Funding ($M)	Anticipated Number of Awards
Resilience Modeling	15	2 – 5
Energy Storage and System Flexibility	20	2 – 5
Advanced Sensors and Data Analytics	10	2 – 5
Cyber-Physical Security	20	2 – 5
Institutional Support and Analysis	5	5 - 10
Generation	10	2-5
Total	**80**	**20 - 35**

Composition of Project Team

Each proposal submitted to this Foundational Lab Call must include at least two (2) National Laboratories and an electric utility (e.g., investor owned utility, electric cooperative, public power, etc.) that owns and/or operates electric power system facilities. An integrated, multifaceted team approach including cooperation and active collaboration with members of utilities, product and service suppliers, end users, state and municipal governments, Independent System Operators/Regional Transmission Organizations (ISOs/RTOs), universities, and others is strongly encouraged.

Technical Criteria

Proposals will be evaluated using the following criteria. All sub-criteria are of equal weight.

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

Technical Merit and Innovation

- Extent to which the applicant clearly, specifically, and convincingly describes how the proposed technology or process is innovative and will advance the state-of-the-art;
- Degree to which the current state of the technology and the proposed advancement are clearly described; and
- 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.

Impact of Technology Advancement

- Potential impact of demonstrated success within the first 18 months to two years of project initiation;
- Clarity of the description of how the project supports the topic area objectives and target specifications and metrics;
- Potential impact of the project on the grid including near-term and long-term benefits and risks;
- Extent to which the research investment helps the national laboratory complex build appropriate, coordinated core expertise and capabilities for the future;
- Degree to which the project incorporates outputs from the activities of the FY16 GMI Lab Call to validate foundational principles; e.g., architecture, interoperability, integration testing, valuation, cybersecurity, etc.; and
- Degree of impact across the five applied Offices including FE, OE, EERE, NE, and CESER.

Criterion 2: Research Approach and Adoption (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 Risks

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

Baseline, Metrics, and Deliverables

- Degree of clarity in the definition of the baseline, metrics, and milestones; and

- Relative to a clearly defined experimental baseline, the strength of the quantifiable metrics, milestones, and a mid-point deliverables defined in the proposal, such that meaningful interim progress will be made.

Transformation Plan

- Clarity of adoption potential for proposed technology along with known or perceived barriers to transformation, including a mitigation plan.

Criterion 3: Team and Resources (20%)

- Clarity of the description of the Principal Investigator(s) (PIs) and the proposed team to successfully address all aspects of the proposed work;
- Appropriateness of qualifications, relevant expertise, and time commitment of the individuals on the team;
- Sufficiency of facilities to support the proposed work;
- Ability of the proposed team to facilitate and expedite development and deployment of the proposed technologies;
- Level of substantive participation by non-laboratory; i.e., industry, academia, consortia; project participants as evidenced by non-laboratory leadership roles within the project, type and amount of non-laboratory cost share, letter(s) of commitment from non-laboratory partners, and distribution of the critical path activities beyond the PI and the PI's institution within the Work Plan; and
- Reasonableness of budget and spend plan for proposed project and objectives.

Timeline and Process for Foundational Lab Call

The following is a timeline for the Foundational Lab Call review and selection process:

Lab Call Milestone	Date
Foundational Lab Call Released	May 29, 2019
Concepts Submission Deadline	June 21, 2019
Concept Presentations	June 24 – June 28, 2019
Full Proposal Submission Deadline – by invitation only	August 9, 2019
Full Proposal Presentations:	
• Resilience Modeling, Energy Storage and System Flexibility, Advanced Sensors, Cybersecurity, and Generation	August 19-23, 2019
• Institutional Support (Virtual)	August 26, 2019
Selection Announcement by DOE	August 27 – September 6, 2019
Funding Released to GMLC	September 9, 2019

Concept Specifications

Applicants will submit project concepts as a Microsoft PowerPoint presentation to DOE for evaluation. No more than 30 slides are to be presented, but backup slides are acceptable within the file. In addition to the concept presentation, the Applicant must submit a one-slide summary identifying the lead organization, the PI(s), the project title, the objectives of the project, a brief project description, the potential impact of the project, and major team participants. Submissions must be emailed to GMI@hq.doe.gov.

Applicants will present their concept presentations to DOE **in person** in Washington, DC during the week of June 24, 2019. The GMLC technical team leads will briefly introduce each topic area to outline the vision and collaborative priorities. Concept presentations submitted for Resilience Modeling, Advanced Sensors and Data Analysis, Energy Storage and System Flexibility, Cyber-Physical Security, and Generation will be 30 minutes, which includes a 15-minute presentation and a 15-minute question and answer session. Concept presentations submitted for Institutional Support and Analysis will be 20 minutes, which includes a 10-minute presentation and a 10-minute question and answer session.

Based on evaluation of the concepts against the technical criteria, DOE will invite a subset of applicants to submit full proposals. Although each activity within the six topic areas is critical to achieving grid-related priorities outlined by DOE, concepts will be selected based on a holistic, theme-focused perspective for the whole topic area.

Full Proposal Specifications

Each invited applicant will submit its full proposal as a Microsoft PowerPoint presentation to DOE for evaluation. In addition to the full proposal presentation, the applicant must submit a one-page summary for dissemination to the public if an award is made. During this phase of the lab call, the invited applicant has the option to submit a supplemental materials document not to exceed 10 pages in length. If a supplemental materials document is submitted, it may not be a mere restatement of the PowerPoint contents. The full proposal must build upon the previously presented concept and include a plan of engagement with team members, team member commitments, key deliverables, and final financial breakdown across all team members. Submissions must be emailed to GMI@hq.doe.gov.

The invited applicant will present its full proposal presentation to DOE **in person** (except for Institutional) in Washington, D.C., during the week of August 19, 2019. DOE will review proposals from Institutional Support and Analysis via webinar on August 26, 2019. Given the crosscutting nature of this lab call, each project will need to fit within the broader collaborative vision of its relevant topic area. To facilitate this holistic approach, the GMLC Tech Team Lead will present a 45-minute overview of the topic area prior to the invited applicant presentations within that topic area. The full proposal presentations will be 40 minutes which includes a 20-minute presentation, a 5-minute discussion on GMLC coordination related to that particular project, and a 15-minute question and answer session.

Based on evaluation of the full proposals against the technical criteria, DOE will select final projects. Although each activity within the six topic areas is critical to achieving grid-related priorities outlined by DOE, projects will ultimately be selected based on a holistic, theme-focused perspective for the whole topic area.

Topic Area 1 – Resilience Modeling

Developing a coordinated strategy for a more reliable, resilient, and secure electric power system is a challenge. The strategy will have to manage the rapidly changing threat space and the ever-evolving and interdependent energy infrastructure. Advanced modeling provides the opportunity to improve the reliability and resilience of our national electric power infrastructure in the face of a rapidly evolving threat environment and increasingly-complex infrastructure systems. There are several challenges that hinder the broad, cost-effective, and transformative use of resilience modeling:

- Many stakeholders, including those at the DOE and the National Laboratories, are using different models and tools to simulate the various reliability and resilience challenges.
- Relevant data with varying levels of granularity is dispersed and spread across a variety of stakeholders making data collection challenging.
- The power system is becoming increasingly dependent upon other infrastructures including coal delivery, natural gas delivery, communications networks, water, existing transmission, and transportation; and there are other dependencies that are not included or studied in most electricity system models.
- While most efforts have focused on the bulk power system, the electric power distribution system is becoming more influential to the operation of the system.
- New and diverse generation, transmission, distribution, storage, and end-use technologies have increased the complexity of system integration, planning, and operation.
- Weather plays an increasingly significant role in energy generation, end-use, and disaster prevention, and recovery.
- With the increase in complexity of resilience-focused models, the advanced analytics to rapidly identifying system vulnerabilities and enhance decision support is becoming more critical.

Proposals may complement but should not duplicate activities already planned for the North American Energy Resilience Model (NAERM) initiative.

Subtopics

Subtopic 1: Reliability and Resilience Metrics

DOE is seeking proposals to clarify definitions for reliability and resilience as well as develop effective metrics to measure and improve them. The work should proactively provide solutions above and beyond current industry practice by addressing the rapidly changing electric power system in terms of security and the spatial and operational time frame to make the system more reliable and resilient.

Subtopic 2: Data

DOE is seeking proposals that identify, acquire, and assimilate the real-time data for both infrastructure and threats to be used by the grid models. The proposals should include increasing the timeliness, frequency, quality, and resolution of the data, identifying data gaps and proposing innovative ways to address them.

Subtopic 3: Interdependencies Modeling

DOE is seeking proposals that identify the most important interdependencies and incorporate them into existing model sets, and fill gaps where they exist. Interdependencies to be considered for inclusion in the electric power system model are weather, water, communications, transportation, transportation of power generation feedstocks, and other sources of energy (e.g., natural gas; coal; renewables, etc.).

Subtopic 4: Use Cases

DOE is seeking proposals for analytical use cases to provide a better understanding of the role of resilience modeling in improving system performance and/or addressing economic and national security needs such as resilience of critical facilities and infrastructure capital expansion planning.

Subtopic 5: Visualization

DOE is seeking proposals that use advanced interactive visualization technologies and tools to clearly and intuitively present model information and results to users. Proposals should focus on innovative visualization concepts and methodologies instead of software development. This could include visualization of services exchanges between heterogeneous infrastructures.

Topic Area 2 – Energy Storage and System Flexibility

Energy Storage and System Flexibility is the ability of the grid, energy resources, and generation fleet to balance supply and demand over multiple time scales and includes understanding and improving the capabilities of energy storage and system flexibility technologies to improve the reliability, resilience, and security of the distribution and bulk power system.

Many energy technologies have the capability to provide temporal flexibility and grid services that help meet system objectives efficiently and cost-effectively while supporting reliability, resilience, and security. Shifting generation and loads may provide new capabilities that can both mitigate impact from adverse events and hasten recovery efforts. These technologies and capabilities include 1) traditional bi-directional electricity storage such as batteries and pumped-storage hydropower; 2) a wide range of technologies that increase the temporal flexibility of loads; and 3) dispatchable generation such as traditional fossil, nuclear, and hydro generation as well as inverter-based renewable and distributed energy sources.

DOE seeks proposals to improve the capabilities of energy storage and system flexibility technologies such as technology prototyping, lab testing, field demonstration and validation, and modeling and analysis. Our ability to understand and manage grid services and novel capabilities, both at an individual technology level and as an integrated system, requires complex control strategies that can potentially govern millions of heterogeneous devices in the field to collectively support a more reliable, secure, and resilient power system. With continued research and development (R&D), we improve our ability to understand and manage grid services and novel capabilities, both at an individual technology level and as an integrated system. These R&D activities may lead to increased flexibility of utility-side generation resources; advancing the state-of-the-art in DER integration and control[1] with respect to the bulk power system; improving the aggregation, integration, and control of building and vehicle charging loads to maximize their value to the bulk power system; and continued technology advances in storage technologies, including batteries, pumped-storage hydropower, thermal energy storage, combined heat and power (CHP), and behind-the-meter energy storage systems.

[1] Distributed Energy Resources (DER) are generally considered as any generation or load-modifying asset or practice associated with the distribution system. The National Association of Regulatory Utility Commissioners (NARUC) defines a DER as "a resource sited close to customers that can provide all or some of their immediate electric and power needs and can also be used by the system to either reduce demand (such as energy efficiency) or provide supply to satisfy the energy, capacity, or ancillary service needs of the distribution grid. The resources, if providing electricity or thermal energy, are small in scale, connected to the distribution system, and close to load." For the purposes of this lab call, examples of different types of DER can include solar photovoltaic (PV), wind, combined heat and power (CHP), small modular and micro reactors (e.g. nuclear), energy storage, demand response (DR), electric vehicles (EVs), microgrids, and energy efficiency (EE).

Subtopics

Subtopic 1: Flexible Distribution System Platforms

DOE seeks proposals that build on existing work from the 2016 GMI Lab Call, OE, EERE, ARPA-E and others to deliver a step increase in the ability to leverage very large numbers of new DER's for system flexibility and reliability. Proposals must address barriers that impact the reliability, resilience, and/or security of the bulk power system. Example barriers that may be addressed in proposals include, but are not limited to the following:

- *Resource uncertainty:* A system with numerous small resources will inherently exhibit more probabilistic behavior than a system with a few large resources in the absence of innovative resource firming approaches. DOE seeks methods that not only address or reduce such uncertainties, but harnesses them to improve overall grid resilience.
- *Management*: To scale DER aggregation programs, DOE seeks proposals to develop distribution energy resources management systems (DERMS), energy management systems for microgrids operating individually or in a network, and other cost-effective pathways to integrate DERs and microgrids with different communication protocols.
- *Incentives*: To secure customer participation, DOE seeks how to consider how DER aggregation (including microgrids) will impact or align with existing DER incentive structures so that potential customers see a net benefit of participation.
- *Communications*: To obtain anticipated grid services from deployed DERs, utilities may need to pursue methods to increase communication reliability between the utility, aggregators, and/or individual DERs and microgrids.
- *Platform Enabling*: A platform is needed that enables higher-order functions such as open technology integration including the use of Advanced Distribution Management Systems or microgrids, expressions of consumer preferences, and enhanced provision of grid services.

Subtopic 2: Network Microgrids

After an unexpected wide-area grid shutdown; i.e., a blackout or a brownout; utilities must be able to restore power to customers as quickly as possible, particularly given the potential impacts to national security. Historically, bulk system capabilities and stability take priority. However, it is possible through a combination of small modular systems, diesel generators, inverter-based generation, energy storage, and smart loads to have power restored to critical loads and support restarting the grid from "the bottom up." Proposals in this subtopic area may build on work in the Cleanstart DERMS project from the Resilient Distribution System solicitation to build more reliable, resilient, and secure power systems using microgrids and networked microgrids. Novel research should investigate how self-assembling microgrids can support a more resilient power system.

Subtopic 3: Black Start Capability

While a resilient grid is the objective, unexpected events may result in wide-area grid outages. Recovering from such an event as quickly as possible is paramount to national security. Units that are black start capable; i.e., can begin generating without external power; must be available to system operators to enable full system recovery. Research proposed in this subtopic may address challenges to, and sufficiency of, current and future black start requirements to foster rapid, efficient recovery from large disruptions including adequacy of unit location, type, capacity, and/or other criteria needed to ensure black start units ready when needed.

Subtopic 4: Power Electronics and Controls

Multiport power electronics interface that enable a variety of energy resources can serve as an energy hub by providing:

- A single point of communication for transactive control and security
- Energy optimization through real-time control
- Fault-tolerance and grid stability to the bulk power system
- Real-time data to operators for load forecasting and power system monitoring
- A significant cost reduction to consumers with integrated functionality.

Research proposed in this subtopic should develop a single point of interconnection for a heterogeneous set of direct current (DC) devices (including solar, wind, electric vehicles, DC building loads) that can provide a single point of interconnection and control for power system operators and support a more interoperable power system.

Topic Area 3 – Advanced Sensors and Data Analytics

The advanced sensors and data analytics topic supports carrying out the R&D recommendations in the GMLC *Sensing & Measurement Technology Roadmap* that underpin its identified high-value use cases. The objectives of this topic area are to (1) develop and demonstrate novel sensors that improve observability and control of the electric grid at a very high resolution, (2) utilize the sensing and measurement technologies to improve grid planning and operations for reducing outages and improving grid reliability and resilience, and (3) improve the physical security of generating and other grid related assets.

Proposals should describe industry states-of-the-art and may build on related R&D conducted through the previous 2016 GMI Lab Call awards. The proposals must either address sensing and measurement priorities across the entire power system including central generation, transmission, distribution, microgrids, customer load, and all types of distributed energy resources; or address sensors for detecting threats to physical installations important to grid operations. More information on these foundational topics can be found in the recently released DOE document *Sensor Technologies and Data Analytics*.[2]

Subtopics

Subtopic 1: Crosscut Support

This subtopic area seeks support of the successful technology development and deployment of advanced sensing and measurement tools and methodologies throughout the electrical grid infrastructure by:

- Identifying the issues that are common across different sensing and measurement areas;
- Establishing a common set of definitions on data requirements, use-cases, and performance parameters; and
- Establishing sensor and analytical capabilities that will help protect the physical security of the grid.

Subtopic 2: Robust Sensing System

This subtopic area aims to investigate and demonstrate technologies that will enable power systems to better predict, respond to, and recover from natural, man-made, or other disasters, through robust system visibility, diverse and damage-tolerant transport networks, and operational awareness. Proposals may include, but are not limited to, the following:

- Develop a multifaceted, secure sensing system that is inherently resilient to extreme events and capable of distinguishing between outages resulting from man-made events and naturally occurring faults;
- Develop optimal sensor placement strategies to ensure a certain level of redundancy for observability under severe conditions;

[2] https://www.smartgrid.gov/files/Sensor_Technologies_MYPP_12_19_18_final.pdf

- Develop distributed communications architectures with dynamic networking features and a self-healing mechanism that are resilient to natural disasters; and
- Develop robust data analytics integrated with network modeling and reconstruction techniques to provide viable damage assessment results when the data quality is largely impacted by natural disasters.

Subtopic 3: Incipient Failure Detection

This subtopic area aims to investigate sensor technologies and data analytics that enable real-time health monitoring of critical electrical grid assets (from generation to behind the meter) rather than relying on run-to-failure and schedule-based maintenance. Proposals may include, but are not limited to, developing new sensors that can measure indicators of incipient faults and failures with a focus on cost-effective and multi-parameter, passive wireless, and optical platforms (other technologies and platforms possible may also be considered) for compatibility with grid asset deployment. The dominant or critical failure modes of the grid assets must be clearly identified and addressed in the proposal. New sensors must be compatible with deployment on or near electrical grid assets. In addition, data analytics should be based on multi-modal and multi-variate methodologies capable of integrating disperse and disparate data sets into a unified framework to successfully identify incipient failures. Proposals should clearly describe and demonstrate how the proposed research advances the state of the art.

Subtopic 4: Monitoring for Critical Infrastructure Interdependencies

This subtopic area aims to investigate, develop, and demonstrate technologies for an integrated system capable of real-time monitoring of the interconnected critical infrastructure sectors (electrical, oil and gas, communications, water, and transportation) and their interdependencies. Critical in this research is to establish the requirements and protocols for exchanging measurement data across infrastructures to overcome data silos. Close collaboration with related industries is strongly encouraged.

Proposals may include, but are not limited to, the following:.

- Development of low-cost, multi-parameter (including electrical, mechanical, chemical, etc.) sensor agents to provide detailed characterization of the state of the system at a particular location;
- Integration of sensor networks for deployment at different locations within a utility's service area to provide situational awareness for a particular utility system;
- Development of combined sensor networks for deployment to a much larger area covering multiple infrastructure types (e.g., water, communications, and electricity) to provide information about the state of interconnected critical infrastructures for early detection of faults to avoid cascading effects.

Subtopic 5: Detecting and Forecasting Behind-the-Meter Resources

This subtopic focuses on developing a suite of approaches and tools that utilizes highly granular spatiotemporal data from networks of sensors for accurately detecting, characterizing, and forecasting DER behavior and its impacts on the bulk power system. Emphasis is on behind-the-meter and distribution-connected DERs, including demand response, with clear and documented understanding of privacy fundamentals and principles as an essential element. Inclusion of demand response in this definition of DERs is significant in that it involves the need to characterize major end-use loads involved in demand response. By extension, this provides critical information that aids in load forecasting and planning applications, as well.

Proposals may include, but are not limited to, the following:

- Improved capabilities for existing sensor networks—based on improved analytics and/or increased communications network capabilities. This includes leveraging the intrinsic capabilities of many new, grid-connected devices to behave constructively during varying grid conditions.
- New and improved sensors that complement existing commercially available sensor concepts or prototypes with significant leaps in capability.

Topic Area 4 – Institutional Support and Analysis

The electric grid and how it is designed and managed has entered a transformational period brought on by evolving government policies, the rapid pace of technological innovation, and the emergence of utility customers and merchants as participants in the generation and management of electric grid resources. In addition, the interdependent nature of the electric grid with other infrastructures, combined with the rapid evolution of digital networks, has raised concerns regarding the resilience and security of the entire energy system. One of the challenges is how to manage this transition and evolve planning, operational, and market systems through informed institutional decision-making and subsequent infrastructure investment strategies that are both prudent and future-looking.

Advancements in shared understanding and capabilities will help address the institutional challenges associated with the current transitional period. DOE expects that the National Laboratory teams will work closely with DOE program managers to develop and implement strategies to involve key stakeholders in these areas. Technical assistance to support institutional decision-making processes is encouraged across topical areas. In addition, there is a recognition that there are many non-institutional players that will have a significant role in evolving business and market structures; they should be engaged in these activities.

Proposals should focus on practical, near-term applications and consider realistic scenarios; e.g., changing market environments. DOE expects to conduct an annual reevaluation of the portfolio to ensure market-responsiveness, pending available appropriations.

Subtopics

Subtopic 1: Resiliency Planning

Provide technical assistance to regions across the country to address their resiliency challenges as they impact the bulk power system. Challenges of particular interest include interdependencies with other critical infrastructure (e.g., communications, coal, gas, transportation, water, etc.) and potentially include challenges to the distribution system as they impact the broader bulk power system. Relevant programs and GMI efforts include:

- Regional assistance efforts such as the Pioneer Regional Partnerships selected following the 2016 GMI Lab Call (https://gridmod.labworks.org/pioneer-regional-partnerships);
- Technical assistance on wind energy integration;
- Technical assistance on integration of advanced fossil technologies; heat rate improvements; and carbon capture, utilization, and storage
- Pumped Storage Hydropower Technical Assistance Efforts;
- Solar Energy Innovation Network;
- Educational materials on IEEE 1547-2018 Standard;
- GMLC Public Utilities Commission projects; and
- NARUC-NASEO Grid-interactive Efficient Buildings Working Group.

Subtopic 2: Technical Assistance to States and Regions

This subtopic will provide direct technical assistance on innovative and high-impact grid modernization or energy infrastructure challenges facing state policymakers, regulators and regional planning organizations. Technical assistance can include innovative projects that improve the evaluation, testing and validation of new ideas and strategies in order to maximize learning, as well as assistance in using existing tools and knowledge through peer interactions and training to widely disseminate effective strategies. Technical assistance may advance the approaches, options and methods developed in other GMLC efforts.

The objective is to work with policymakers and regulators to test and build an understanding of best practices and evolve methodologies that can be applied generally, but also meet the particular needs of a community, state or region. Partnerships involving a region are envisioned as public-private collaborative projects to address near-term grid modernization issues important to particular localities or regions and its stakeholders. Partnerships must include collaboration from relevant stakeholders, such as state policymakers, state regulators, regional planning organizations, utilities, research institutions, federal agencies, local governments, non-profits, and for-profit vendors.

The types of activities envisioned under this topic include:

- Providing insights on various topics to institutional leaders through analytical efforts and reporting.
- Testing, evaluating, and validating new ideas and strategies.
- Analysis and modeling using existing tools and models.
- Developing best practices and methodologies.
- Conducting peer interactions and trainings in order to maximize learning and widely disseminate effective strategies.
- Informing policymakers and regulators on advanced practices and lessons-learned by conducting workshops and trainings.
- Advancing thinking, methodology, and decision frameworks to address key issues through the use of focus groups with policymakers and regulators.
- Working with utilities PUCs, and other community groups to address the needs of EV charging and grid impacts.

Relevant programs and GMLC efforts include:

- Regional assistance efforts such as the Pioneer Regional Partnerships selected following the 2016 GMLC Lab Call (https://gridmod.labworks.org/pioneer-regional-partnerships)
- Technical assistance on wind energy integration
- Pumped Storage Hydropower Technical Assistance Efforts
- Solar Energy Innovation Network
- Educational materials on IEEE 1547-2018 Standard
- GMLC Public Utilities Commission projects
- NARUC-NASEO Grid-interactive Efficient Buildings Working Group

Topic Area 5 – Cyber-Physical Security

DOE is seeking proposals to develop tools and technologies that prevent, detect, and mitigate cyber-attacks in one or more domains of today's and tomorrow's critical energy infrastructure, e.g., fuels, generation, operations, transmission, distribution, and customer. The tools or technologies will enable control systems or component devices, at their points of integration with the bulk electric grid, to prevent a cyber-attack if possible, then if prevention is not possible, mitigate the attack by adapting to survive while sustaining critical energy delivery functions as response actions are executed. The cyber defense of generation assets is covered in the next topic area on generation.

Subtopics

Subtopic 1: Inherently Secure Field Devices that Provide Observability of Grid Security

Resilient energy delivery systems not only require securing networks, but also building secure and resilient operations and process systems. Maintenance connections to field devices can at times be insecure. DOE is striving to further the development of smarter field devices, with particular focus across different energy sector domains such as fossil, solar, wind, etc. that are inherently secure and provide system-wide observability of grid security posture.

The goal of this subtopic is to develop field devices that can:

- Interface securely with both local and remote connections in accordance with varying operational mode (steady or emergency) requirements;
- Identify activities that may adversely impact operations and maintain system-wide observability of grid security posture; and
- Sustain critical functions while under attack.

It is expected that this research will identify common characteristics – technical, policy and process -- shared across different energy sector domains, as well as unique characteristics that remain specific to particular domains. The proposed technology will address the identified shared cross-domain characteristics, and additionally be tailored to the unique operational characteristics of at least one unique domain.

Subtopic 2: Secure Communications of Information used for Grid Operations, for Normal Operations and/or during Emergency Response

This subtopic focuses on research, development, and demonstration of technology or techniques that build resilience at the generation, transmission, distribution and end-user levels (including DER). The proposed solutions can consider secure communications during normal operations as well as during emergency response to a, potentially concurrent, cyber-incident and/or natural disaster. Generation, transmission, distribution, and end-user technologies (including DER) can provide energy, capacity, and services -- so it is imperative that DER communications are robust, secure and resilient. DOE aims to research novel ways to utilize Artificial Intelligence, based on the underlying physical processes, for preventing, detecting, and mitigating 1) anomalies in DER communications, and 2) deliberate misuse of functions the technology was designed to perform that would not otherwise appear to be anomalous.

It is expected that this research will consider communications that cross the interfaces of energy sector domains such as fossil, solar, wind, vehicles, buildings, etc. Examples include satellite communications, Wi-Fi communications, and other types of communication infrastructure used to transmit information needed for grid operations. The proposed technology should identify common characteristics shared across domains (while respecting privacy at domain-to-domain interfaces), as well as interactions among domains that affect cyber-resilience and that may involve shared as well as domain-specific communications.

Subtopic 3: Malware Analysis Using an AI Approach

This subtopic focuses on building tools and techniques that leverage data sciences and AI to perform rapid analysis of malware. Approaches should utilize both Information Technology (IT) and Operations Technology (OT) data, and allow for collaborative or crowd-sourced analysis that benefits from AI technology advances. The goals of this subtopic include the following:

- Identifying common technologies, policies, and processes -- shared across energy sector domains such as fossil, wind, water, buildings, vehicles etc. – that are needed for system-wide cyber-resilience in the face of malware intended to disrupt energy delivery;
- Identifying domain-specific technologies, policies, and processes needed for cyber-resilience in the face of malware intended to disrupt energy delivery, for at least three energy sector domains; and
- Developing an integration of the shared, and the domain-specific technologies, policies, and processes to achieve system-wide cyber-resilience in the event of malware intended to disrupt energy delivery.

Topic Area 6 – Generation

DOE is seeking proposals to develop tools and technologies that accelerate emerging generation systems and/or maximize the value of existing generation assets as they provide value to the grid. The grid of the future may coexist with the widespread deployment of dedicated off-grid or smaller scale, potentially modular, generating assets in remote areas or dedicated to specific facilities. How the changing generation fleet supports a resilient power system is the focus of this topic area.

Subtopics

Subtopic 1: Hybrid System Portfolio Operations

DOE seeks to enable flexible combinations of generation and storage to work together to become more valuable than standalone operation. Proposals may leverage existing efforts such as Beyond Levelized Cost of Electricity (LCOE). Proposals may include, but are not limited to, the following:

- Development of a framework for hybrid system and portfolio operations that generalizes technology resource classifications, their specific applications, and methodologies for portfolio operations.
- Demonstrations of coordinated portfolio operations across several distinct device types that enable services that would be more difficult or costly to achieve with a single resource type.
- Development of physical or virtual technologies to enable coordinated portfolio operations.
- Investigations of economical applications of combined heat and power to existing and near-term opportunities.
- Impact of cycling on operations and costs.

Subtopic 2: Micro and Small-Scale Generation and Supporting Technologies

This subtopic focuses on the impact of micro and small-scale generators on the future power system. This includes the potential for nuclear micro reactors, small modular reactors, modular coal-fired generation, and enabling technologies such as supercritical CO_2 cycle generators (e.g. concentrating solar power). Proposals are sought that investigate how small-scale generation will provide reliability and resilience in a future power system with other generation and load technologies (e.g. solar, wind (D3T)[3], hydro, smart loads).

Subtopic 3: Security of Generation, Fuel Supply, and Water Supply

Both cybersecurity and physical security are of utmost importance to our nation's generation fleet and its needed fuel and water supplies.

For cyber security, proposals are sought that maximize cyber protection and mitigate cyber consequences. The cyber security goals of this subtopic include the following:

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[3] D3T – Defense and Disaster Deployable Turbine

- Survey existing and proposed architectures for advanced control system security, this includes seeking industry input on its plans for future control system designs;
- Propose innovative concepts and resiliency diagnostics for cyber-resistant digital systems and control architectures; and
- Establish methodologies for testing the security of "cyber resistant" instrumentation and controls (I&C) designs.

For physical security, proposals are sought that promote technologies capable of deterring and detecting physical threats to generating stations, their fuel supplies, and/or their water supplies. Advanced and hardened monitoring instruments and anti-intrusion hardware may be topics for research.

Subtopic 4: Environmental Impacts and Critical Functions

All generators have environmental impacts to water, air, and ground systems. Proposals should investigate how specific combinations of generating assets in targeted regions of the United States can be optimized for economical generation and low environmental impact. Regional issues on water usage play a large role in this topic area.

Subtopic 5: Environmental Resiliency

The ability of generation to maintain operability throughout natural disasters and severe weather events as well as return to operations quickly following an event is necessary. Proposals are sought that aid generators and grid operators to recover from outages and that will provide advanced warnings to generators of likely outages.

Subtopic 6: Generation Interdependencies

Power generation technologies have differing interdependencies that must be fully understood and addressed to ensure a reliable, resilient, and secure system. Potential areas of research may include but are not limited to fuel security and delivery as well as interdependencies with water, transmission, and other supporting system infrastructure necessary for stable generation. Proposals are sought that enhance the security and reliability of fuel supplies, water sources, and supporting infrastructure.