Department of Energy
Washington, DC 20585

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MEMORANDUM TO THE DEPARTMENT OF ENERGY
ELECTRICITY ADVISORY COMMITTEE

From: **Patricia A. Hoffman**
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Subject: **DOE Responses to EAC Work Products**

I want to thank all members of the Department of Energy's (DOE) Electricity Advisory Committee (EAC) for your hard work during 2012.

The work products delivered by the Committee during 2012 are listed below. The purpose of this memo and its attachments is to provide to you in a systematic and inclusive form the Department's responses to your analyses and recommendations.

EAC 2012 products

1. Recommendations on the Development of the Next Generation Grid Operating System, October 2012
2. Recommendations on Non-Wires Solutions, October 2012
3. Recommendations on Strategic Portable Generation Reserve, October 2012
4. Recommendations on the Electricity Workforce, October 2012
5. Recommendations on Next Steps for Smart Grid Outreach and Communications Strategy, October 2012
6. Recommendations on Energy Storage, October 2012

The attachments that follow summarize DOE's actions and responses to these 2012 work products.

I look forward to the future efforts of the EAC and am committed to ensuring a strong and fruitful working relationship between the Committee and DOE.

Electricity Advisory Committee (EAC) Recommendations
Next Generation Grid Operating System
October 2012

1. **Convene a technical conference or webinars with key industry stakeholders to develop the vision and roadmap for the next generation EMS. The starting point for these conferences is a draft vision and roadmap to be developed by DOE's Grid Technology Team.**

DOE recognizes the importance of developing the next generation EMS. DOE is also aware of the work done by other entities on this topic and will leverage ideas and concepts already presented. For instance, EPRI is already in the process of developing a roadmap for the next generation EMS. The DOE Grid Tech Team (GTT) will discuss plans on how to build upon and coordinate existing efforts across the various stakeholder communities. Currently, the GTT is developing a 5-year R&D roadmap for grid modernization and will include elements and components necessary for the next generation EMS.

2. **Assemble a team of computational mathematicians and power systems engineers to assess the available technologies and identify those suitable to dramatically enhance the EMS system capability in a cost effective manner. Specifically, identify technologies that enhance computational and analytic capability that can support real-time situational awareness at the second or sub-second level, and identify technologies that enable real-time analysis of exploratory load flows that represent potential near-future states, including contingency analysis and solutions for potential limit violations.**

Over the past six years, the Office of Electricity (OE) has been working closely with the Office of Science's (SC) Advanced Scientific Computing Research (ASCR) Program to discuss how mathematical and computational advancements could benefit grid modernization efforts. One goal is to enable faster than real-time analysis of real-time load flows for predictive controls and actions. Several workshops were held that include: Modeling, Simulation, and Optimization for the Electric Power Grid Conference (October 2012), Computational Needs for the Next Generation Electric Grid (April 2011), Computational Issues and Challenges of the 21st Century Power System (March 2009), and Mathematical Research Challenges in Optimization of Complex Systems (December 2006).

In February 2013, a workshop on Advanced Grid Modeling was held to begin laying out a research and development roadmap for applying advancements in mathematics and computation to improve the performance and capability of power system software tools and/or operator platforms. This workshop brought together people and activities supported from OE, SC/ASCR, and the Advanced Projects Research Agency – Energy (ARPA-E).These ongoing activities have built a community of power system engineers and computational mathematicians that have the ability to assess technologies available for the next generation EMS and develop new solutions if necessary.

3. **Determine how to integrate new, synchronized, voluminous, detailed and robust real time information such as from phasor measurement units (PMUs) within the next generation EMS for model verification, visualization of system conditions, identification of problem conditions, and other applications. Multiple sources of data should be integrated from applications such as digital fault recorder data and disturbance characterization, while also enabling the move from State Estimation to a State Measurement mindset. Leverage existing foundational elements such as Common Information Model concepts for integration with Geospatial Information Systems and other applications that require significant information exchange.**

OE's Clean Energy Transmission and Reliability (CETR) Program has been actively supporting efforts to integrate data from phasor measurement units (PMUs) and other sources of data, such as DFR's, into system operator tools, developing new grid applications with the data, and assisting industry in facilitating information and data exchange. The Consortium of Electric Reliability Technologies Solutions (CERTS) and the North American Synchro-Phasor Initiative (NASPI) community have been significant contributors to these efforts. The Power Systems Engineering Research Center (PSERC) and the Center for Ultra-Wide-Area Resilient Electric Energy Transmission Networks (CURENT) are academic institutions, with support from industry, DOE, and other federals agencies, that are also working towards new applications and capabilities enabled through the integration and use of new data streams.

OE's Advanced Modeling Grid Research Program is focused on addressing the data management and computational challenges needed to move from state estimation to state observation. A major topic of interest are the advances needed to process and integrate large amounts of diverse data, which includes leveraging CIM standards and the development of new data structures and architectures that focus on the critical pieces of data for key applications. A recent Funding Opportunity Announcement (FOA) from this program resulted in 5 awards totaling $6.8M that generated $1.95M in cost-share.

4. **Develop EMS performance specifications for implementation of EMS improvements to further mitigate the likelihood of blackouts resulting from lack of situational awareness or lack of analytical tools and models to address our grid future. Identify and establish a path forward that accommodates enhanced automated control actions to support grid stability, reduce oscillations and maintain safe operating margins. Specifications should include:**

    - Flexibility required to accommodate a wide variety of new and emerging technologies such as distributed generation, variable generation resources, demand response, growing number of non-utility sources of data and control systems in its operations, nodal distribution markets, micro-grids and other changes in distribution topology and local control, voltage optimization, reactive power management, enhanced automated control for grid stability to reduce oscillations in areas of modeling, simulation, visualization, operation and control.

    - Consideration of the human factor involved inside control centers. Any new EMS designs should provide grid operators with common, understandable real-time displays to enhance grid visualization, which can be shared among operators of neighboring systems.

    - Enhanced and common modeling of the grid, including special protection systems, remedial action schemes, safety nets, automatic separation schemes, and other relay schemes in order to give operators a complete understanding of how the power system components will perform following contingencies.

    - Integration and coordination with SCADA-based Distribution Management Systems (DMS). Information exchange between transmission and distribution control entities becomes crucial for both situational awareness and control. Once the data integration is achieved, application coordination will provide a high level of efficiency.

DOE agrees that appropriate metrics will be important to guide the development of the next generation EMS. These metrics will be developed in part from the outcomes of the February 2013 Advanced Grid Modeling workshop and from subsequent workshops and/or discussions that focus on improving EMS. Human factors, advanced protection and controls, visualization, modeling, and simulation are all topics that are being

explored in DOE offices and programs. Lessons learned and results from these activities will be leveraged to help develop performance metrics.

The flexibility of the next generation EMS to accommodate new technologies and concepts will be based on transparency, interoperability, and standardization. New system and data architectures, a common modeling platform, standardized naming conventions, and data exchange between neighboring entities are all issues that have been identified through the efforts of the GTT. WECC would be a good place to start due to its simpler grid, well known oscillation modes, and the current efforts to collect wide-area data that is forwarded to two upgraded reliability centers. These advancements can also be used to increase the resiliency of the power system.

DOE also recognizes the importance of being able to integrate and coordinate between the transmission and distribution systems. In the 2013 budget, DOE proposed the formulation of an Electricity Systems Energy Innovation Hub that will focus on bridging the transmission and distribution systems to enable a more seamless and efficient grid. Additionally, the CETR program is currently evaluating applications in response to a FOA to place synchronized measurement units in the distribution system.

5. **Ensure the development of the next generation EMS conforms to applicable reliability and cybersecurity standards, and includes provisions for the changes needed for cybersecurity over time.**

Cybersecurity and the impacts on energy systems are at the forefront of DOE's awareness. In May 2012, DOE released the Electricity Subsector Cybersecurity Capabilities Maturity Model that will support the further development of cybersecurity operational capabilities within the electricity subsector. OE's Cybersecurity for Energy Delivery Systems (CEDS) Program has also been actively supporting the development of next generation cybersecurity technologies and capabilities for energy delivery systems. In September 2011, the Energy Sector Control Systems Working Group (ESCSWG) released the DOE-facilitated, sector-led Roadmap to Achieve Energy Delivery Systems Cybersecurity, an update of the original 2006 Roadmap. The Roadmap presents a strategic framework with short, mid, and long-term milestones toward achieving the vision that resilient energy delivery systems are designed, installed, operated, and maintained to survive a cyber incident while sustaining critical functions.

6. **Establish a broad collaborative organization to execute these recommendations that includes DOE, LBNL, Oakridge National Laboratory, NERC, EMS vendors, EPRI, relevant academic experts and industry technology**

leaders. This collaborative would also be responsible to keep all stakeholders, including state and federal regulators, informed of progress. The DOE should consider providing the appropriate funding to ensure the development of foundational technology that can be released to the industry in an 'open-source' manner. The DOE should also consider the merits of establishing a proof of concept center or centers at National Laboratories accessible to stakeholders to test and provide feedback for the next generation EMS prototype.

DOE agrees on the need for a broad collaborative organization of diverse stakeholders to successfully develop the next generation EMS. DOE will leverage partnerships and collaborations that have been established through existing activities to ensure advancements will be transparent and information will be communicated to the broader community. DOE will also utilize the capabilities available at National Laboratories to test and evaluate the merits of components for the next generation EMS. The Energy Systems Integration Facility at NREL, the Electricity Infrastructure Operations Center at PNNL, and the National SCADA Test Bed at INL are among the many capabilities that are accessible to stakeholders.

7. **Engage intelligence outside the industry as well to ensure the proper and elegant solution is developed. These can include companies (and elements within) not engaged with the energy industry such as IBM, Google, CISCO, and Oracle.**

DOE recognizes the importance of engaging experts outside of the energy industry to leverage existing knowledge and to spur innovation. DOE has already been engaging these various groups through invitations to technical workshops, competitive grants, and existing research collaborations. For example, the Advanced Grid Modeling Program held a workshop on Computation Needs for the Next Generation Electric Grid in April 2011 which included participants from outside the energy industry.

Electricity Advisory Committee (EAC) Recommendations
Non-Wires Solutions (NWS)
October 2012

We appreciate the background research and current assessment of "non-wires solutions" in regional transmission planning and permitting that is included in the memorandum prepared by the DOE Electricity Advisory Committee. Much of the noted work has been previously funded by DOE. DOE offers the following response to the EAC Recommendations:

1. **Reach out to key organizations, including existing RTOs, regional transmission entities (e.g., WECC, WestConnect), NARUC, regional subgroups of NARUC (e.g., MACRUC, NECPUC), NRRI, National Conference of State Legislators, industry representatives, NASUC, Council of State Governments and individual state regulatory commissions and siting councils to share the concepts outlined in this paper regarding the consideration of NWS. Conduct in-person meetings and webinars, and share papers on NWS approaches. Develop a plan for NWS outreach that first targets regions and states most active with regard to potential transmission projects. Coordinate with the FERC to ensure lessons learned and best practices can be considered in their regulatory role.**

DOE will continue to participate in industry workshops, meetings, and forums sponsored by the organizations identified in the recommendation and, if requested and as our Congressional appropriations on technical assistance to states allows, will share the concepts on non-wires solutions that are outlined in the EAC memorandum. Some of the listed organizations, such as the National Council of State Legislatures and National Association of Regulatory Utility Commissioners, have received funding from the DOE to provide technical assistance on state electricity policy design. DOE will also coordinate with FERC to ensure that FERC is aware of lessons learned by regional transmission planning entities that are considering and/or implementing non-wires solutions, actions or strategies to defer the need for transmission system upgrade.

2. **Build upon the DOE's current activities and 2009 NCEP report by sponsoring the development of a planning guide in 2013 that presents lessons learned and case studies for incorporating full consideration of NWS into transmission planning. A number of the regional and state examples cited in this paper may be ones to cover in such a document. This planning guide would include such**

principles as conducting a high-level screen of NWS to determine the viability of such approaches before conducting a more detailed analysis.

DOE will scope out the development and cost of a planning guide that includes case studies and lessons learned by regional planning and permitting entities that considered non-wire solutions in their transmission planning. Such a guide could serve as a follow-on to the DOE-funded 2009 "Non-Wires Primer" prepared by the National Council on Electricity Policy, and recognized in the NWS memo. If deemed to be a high priority relative to other work and if funding is available, DOE will initiate work in this or a subsequent fiscal year on a "Planning Guide on Non-Wire Solutions in Transmission Planning and Permitting."

3. **Continue to study, evaluate, document, and report on best practices in transmission planning and seek to integrate the development of integrated approaches that consider the economic value of wires and non-wires alternatives and likely market responses to locational price differentials.**

4. **Continue to study, report on, and document the experience nationwide of NWS options such as Demand Response to help transmission planners and policymakers understand situations in which NWS can be an equally reliable approach as transmission lines to grid stability. Report and engage in discussion of such issues with the organizations identified in the first bullet above.**

DOE agrees with the thrust of these recommendations to study, evaluate and document "best practices" in transmission planning (including integrated approaches that consider economic value of wires and non-wires solutions and demand response). DOE intends to continue supporting the priorities identified by the utility electricity interconnection organizations (EIPC, WECC and ERCOT) and states (EISPC, WGA) involved in the interconnection-level transmission planning processes that have benefited from ARRA grants.

5. **Assess the evolution, operation and track record of specific non-wires techniques such as demand response in relevant markets. Based on the experiences at the state and regional level, share with relevant organization such as those in the first bullet above options for how markets should be structured to ensure they do not obstruct NWS options. Sponsor a study that**

assesses the performance of a range of NWS options and the reliability of such options in utility-specific resource planning.

Analysis of the operation and track record of specific non-wires techniques (e.g., demand response) seems quite similar to the scope proposed in the planning guide, except that this work appears targeted primarily to utility resource planners (rather than regional transmission planners). DOE will address the feasibility of including this target audience as part of the scoping effort for a planning guide (see Recommendation #2), or whether a separate study is merited.

6. **Work with collaborative regional transmission planning initiatives and DOE's State and Local Energy Efficiency Action Network to identify potential solutions and share best practices in addressing existing financial barriers to the implementation of NWS when they are more effective than transmission solutions.**

DOE will continue our efforts to assess and analyze financial barriers to non-wires solutions and analyze options for mitigating those barriers when requested by states (and regional transmission planning organizations) as part of our technical assistance to these entities. DOE has to-date provided significant funding for policy and technical analysis (including development and enhancement of electric utility financial modeling tools, such as the LBNL Benefits Calculator for Ratepayer-Funded Energy Efficiency) that supports requests by state regulators to examine demand-side business models for electric utilities (e.g., energy efficiency and demand response). In addition, DOE has supported and continues to support regional demand response collaboratives led by state officials in New England, the Mid-Atlantic, the Midwest, and the Pacific Northwest that provide forums for examining implementation barriers for non-wires solutions (including financial barriers).

7. **Increase the R&D emphasis on NWS, e.g., use of synchrophasor measurement based tools and real-time thermal rating, to optimize the carrying capacity of existing and new transmission assets by providing better knowledge of the situation of the grid.**

DOE will consider this recommendation as part of its management of its existing synchrophasor R&D effort. That effort includes development of new practical and

operational applications that will use data from over 1,100 new synchrophasor measurement units (PMU) that will be deployed across the U.S. electric grid by 2014 under funding from the American Recovery and Reinvestment Act.

Electricity Advisory Committee (EAC) Recommendations
Strategic Generation Reserve
October 2012

1. **Portable or pre-staged backup generators provide vital power under a variety of circumstances to a host of beneficiaries, from homeowners, hospitals and emergency first responders, to utility maintenance crews, nuclear power stations and Homeland Security Organizations at multiple levels.**

Super Storm Sandy highlighted the problem of backup power in the face of national emergencies and the enormous challenge that the creation of a Portable Strategic Generation Reserve would face.

Critical sectors including defense, treasury, water and health have increasingly recognized their vulnerability to longer term electricity outages. Both the Federal Emergency Management Agency (FEMA) and the U.S. Army Corps of Engineers maintain some backup generators that are deployed when needed.

Unfortunately the size and number of available units as well as the logistical challenges including transportation, and ensuring fuel supply inhibit widespread use.

DOE will continue to encourage critical sectors to plan and to consider investments to mitigate longer term power outages where technology options including micro-grids and backup generators can be used to maintain critical services.

DOE agrees with EAC conclusions and analysis on why a DOE Strategic Generation Reserve could not improve reliability.

Electricity Advisory Committee (EAC) Recommendations
Electricity Workforce
October 2012

The Department of Energy's Office of Electricity Delivery and Energy Reliability (OE) appreciates the time and effort invested by the Electricity Advisory Committee (EAC) in formulating the recommendations regarding the Electricity Workforce. They thoughtfully outline the challenge before us in developing the necessary capacity and capabilities of workers, and the critical role that public-private partnerships play in maintaining a safe, secure, and reliable electrical infrastructure to serve the nation's current and future needs.

The recommendations proposed by the EAC raise many important issues. OE concludes that the most effective response may include working with industry to convene a workshop to further discuss actionable next steps. The goals of the workshop could include: 1) Outline existing workforce development efforts, sharing lessons learned across the breadth of interested stakeholders; 2) Identify critical gaps and the entity most appropriate to address implementation; and 3) Develop coordinated milestones and metrics (where applicable) to determine successful implementation.

In addition to proposing the workshop described above, OE has responded to each EAC recommendation individually. A brief discussion of each can be found below.

I. First-Tier Recommendations: Category #1 – Easier for OE to Implement

Recommendation #1.1: OE should evaluate the ARRA electricity delivery workforce training grants with the objective of identifying scalable solutions and results to be distributed to the greater education community. Leverage the results of each project to the maximum extent possible.

OE agrees that there is tremendous value in sharing project results with broader stakeholders. OE is planning to issue a final report after program completion in 2014. In the meantime, OE will work with the project recipients to disseminate success stories and materials, to the extent practical. The workshop, described above, is an important initial step. OE will also explore capturing progress in an interim program document. The document could provide a mechanism for stakeholder feedback on describing the appropriate content for the final report.

Recommendation #1.2: OE should obtain feedback on workforce needs from smart grid demonstration and investment projects in order to successfully plan, install, maintain, and operate a high penetration of these technologies in the future.

OE agrees that the ARRA-funded smart grid investment projects provide an opportunity to not only understand the technology impacts, but also the implications to workforce skills and competencies. Based on this recommendation, OE has initiated a discussion with Center for Energy Workforce Development (CEWD) to understand how to best capture this knowledge in an efficient and effective manner, and to appropriately disseminate results.

Recommendation #1.3: Incorporate workforce implication elements or statements in technology development, demonstration, and deployment projects funded by DOE going forward.

OE will evaluate use of criteria requiring applicants for Funding Opportunity Announcements (FOA) to describe the workforce implications of their proposals. In addition, OE will explore the role that potential Small Business Innovation Research (SBIR) topics might further workforce-related objectives such as effective training.

Recommendation #1.4: Develop an OE-sponsored annual recognition program on excellence in the state of power system education and training for engineers, technicians and operators in power systems – perhaps called the OE FARADAY Recognition Program. This program should seek out and celebrate excellence in private – public – educational institution partnerships.

While appreciating the desire to seek out and celebrate excellence in private-public-educational institution partnerships, OE is concerned that this process could become politicized. Therefore, it requests EAC to help identify other successful Federal award programs that might be used to model such a recognition program. As a precedent, DOE has used its authority under Section 1106 of the Energy Policy Act (EPACT) of 2005 to designate Bismarck State College as a National Power Plant Operations Technology and Educational Center, and thus is open to further discussion surrounding the possible implementation of this recommendation.

Recommendation #1.5:

- **Convene a cross functional group of experts to include industry, government agencies (DOL, DOE, NSF, DHS) and regulators for the purpose of reviewing current practices in workforce benchmarking and metrics.**

OE agrees with this recommendation and believes a breakout panel or discussion at the proposed workshop could be devoted to reviewing current practices in workforce benchmarking and metrics.

- **Identify short and long term recommendations for OE consideration (Phase 1 of 2.1 below)**

II. Second-Tier Recommendations: Category #2 - Recommendations That May Be More Challenging for OE to Implement

Recommendation #2.1 Facilitate dialog among state regulators and industry on workforce needs, establish metrics and identify policies that facilitate necessary workforce development activities by the regulated companies.

OE respects the independent decision-making process of the States. OE could support those efforts, as appropriate and if requested by the States, by providing awareness of ongoing activities as well as technical assistance.

In addition, OE could help facilitate discussions between organizations such as CEWD and the National Association of Regulatory Utility Commissioners (NARUC) to explore the type of information that might be helpful to state regulators in addressing the workforce issues in their jurisdictions. The proposed workshop could once again provide a forum for initial discussion.

Recommendation #2.2: Increase coordination between NSF and OE to address workforce issue.

NSF exhibits national leadership in integrating research and education to support the development of a world-class scientific and engineering foundation. OE recognizes and supports this role, for example, in co-sponsoring the Center for Ultra Resilient Transmission Networks (CURENT) at the University of Tennessee. Federal resources are limited, and thus coordination is absolutely critical. As new centers of mutual interest to

OE and NSF are potentially identified through competitive processes, OE will evaluate supporting those as well.

Recommendation #2.3: Improve coordination and communication with other agencies at the federal and state levels and with other schools to leverage research, share programs / curriculum, track trends and balance the workforce supply and demand to meet electricity delivery needs.

DOE has engaged other agencies through memoranda of understanding to address the workforce challenge. The Smart Grid Task Force is also addressing some of these concerns. Again, with successful execution of the proposed workshop described above, DOE hope to further foster relationships with other agencies to begin road mapping a path forward on combined and coordinated approaches to address the workforce issue as resources allow.

Recommendation #2.4: Convene a group to do workforce scenario planning utilizing the tools that are available to improve the understanding of workforce risks given the inherent uncertainty. Results will be useful to communicate challenges and plan mitigating strategies. This effort could be done in conjunction with the Department of Labor, Department of Education, NSF, DHS and other interested stakeholder groups.

Benchmarking existing ARRA-based smart grid projects (Recommendation 1.2) could help identify trends in future workforce needs. OE will remain vigilant in working with industry to understand workforce risks given the inherent uncertainty, and to foster general awareness of emerging concerns.

Furthermore, OE proposes to develop an updated analysis similar to the EPACT 2005-Section 1101 workforce trends report. The document would take into account the changing landscape affecting the electricity workforce. OE would work with industry and other agencies to the fullest extent to update this analysis to take into account the changes that occurred since the publication of the last report in 2006.

Recommendation #2.5 Identify and embrace best practices that effectively accelerate the transition of mid-career professionals to meet industry workforce requirements.

OE recognizes the potential role that the transition of mid-career professionals plays in the emerging workforce. In particular, the DOE values the service of our Nation's

military personnel and is dedicated to supporting their accelerated transition to civilian job opportunities, including those in the electric power industry. OE will continue discussions with industry on emerging opportunities, such as the Troops to Energy Jobs Initiative, and explore opportunities for building additional awareness at the Federal level in coordination with Department of Defense.

Recommendation #2.6: It is recommended that OE focus on strategies to retain the experienced and specialized workforce demographic to delay retirements, develop skills, transfer knowledge and facilitate mentoring relationships as needed to meet industry needs. In doing so, there will be a greater ability to balance the supply and demand of workers while providing necessary cross training and knowledge transfer for incumbents.

OE considers that these strategies can begin to be addressed at the proposed workshop. OE recognizes that the industry plays a leadership role in developing and implementing those strategies. OE will work with CEWD, for example, and solidify partnerships that would ultimately lead to developing and retaining skilled workers for the future.

Recommendation #2.7 Increase the visibility of career opportunities to build awareness

OE recognizes its unique position as both a research entity and convener to build awareness of the need for entrants into the electric power industry. While OE believes that it can provide assistance in building awareness of overall energy-related career opportunities, the industry is the natural lead in this effort. OE will consider developing blogs and other website content that further promotes general awareness. In addition, OE will continue to look to its partnerships with universities and national laboratories to foster fellowship and research opportunities for young scientists and graduate students, as well as K-12 outreach.

Recommendation 2.8: Develop an educational road-map that aligns with industry needs.

OE recognizes the value of the recommendation as outlined. However, it does not have the dedicated resources to commit to further implementation at this time. Therefore, OE looks to industry to lead this activity, and will support as deemed appropriate.

Electricity Advisory Committee (EAC) Recommendations
Next Steps for the Department's Smart Grid Outreach and Communications Strategy
October 2012

The U.S. Department of Energy (DOE), Office of Electricity Delivery and Energy Reliability (OE), Smart Grid Investment Program (SGIP) is pleased to present this response to the recommendations provided by the Smart Grid Subcommittee of the Electricity Advisory Committee (EAC) in October 2012[1]. This response describes existing and planned activities to develop and share the results of analysis and lessons learned from the Smart Grid Investment Grant Program (SGIG) with the electric power industry including regulators and consumer advocates to maximize the effectiveness of the investment provided by the American Recovery and Reinvestment Act of 2009 (ARRA). The responses are presented according to the six EAC recommendations in the Executive Summary of the report.

1. **"DOE should focus on developing a process to systematically understand and communicate benefits and lessons learned by supplementing and shifting from its current one-way effort to a two-way Smart Grid outreach and communications program. DOE should solicit feedback from key stakeholders, existing Focus Groups and Partners to improve its outreach and, where aligned with meeting its statutory objectives, refine its research, funding, work force efforts, and policies."**

There has been an extensive and broad-based effort by SGIP to support two-way information exchange with key stakeholders and program participants. SGIP recognizes that the efforts to advance smart grid technologies and systems through the ARRA smart grid projects can inform decision-making regarding future investments in grid modernization and catalyze the electric power industry in this important area. Decision-makers include utility executives, regulators (and their equivalents in local governments and electric cooperatives), and electricity customers. The decisions themselves are complex and influenced by many considerations including determining how to assign value to observed smart grid impacts, developing investment strategies that effectively weigh costs and benefits, and aligning modernization efforts with state and local policies. In addressing these needs, close collaboration between utilities and customers will be needed so that consumers better understand the value of electricity infrastructure investments and how to deploy and manage emerging customer-based systems.

SGIP is working closely with the ARRA recipients, and with selected stakeholders, to understand and address the key questions facing decision-makers who need to better understand the

[1] "Smart Grid Outreach and Communications Strategy: The Next Steps, Recommendations for the U.S. Department of Energy," A report by the Electricity Advisory Committee, October 2012

appropriate policy and technology investment strategies. With this objective in mind, SGIP continues to seek the most effective communications mechanisms to share and advance the knowledge gained from these deployments with key stakeholder groups and decision makers. Following are several of the key questions that SGIP is aiming to address with data from the SGIG projects:

- *How are these smart grid technologies and systems configured, what capabilities do they provide, and how much do they cost?*
- *Given the various smart grid approaches and applications (e.g., advanced metering infrastructure, customer systems, distribution automation systems, and synchrophasor technologies), what tangible benefits do they produce and how do we calculate them?*
- *What are the optimal strategies for deploying smart grid technologies and systems and how are they affected by federal and state policies, utility capital investment plans, and customer acceptance considerations?*
- *How do dynamic pricing programs and technologies affect consumer behaviors and investments, and how are they best engaged in improving the efficiency and flexibility of electricity delivery?*
- *What market, regulatory, and technological issues affect the ability to realize the full potential of smart grid technologies and systems and how should we address them?*

In addressing these questions, OE has been working with several of the key electric industry stakeholder organizations from the inception of the ARRA smart grid programs. As directed by EISA Title XIII and the ARRA, these stakeholder engagement efforts have included working with the National Institutes of Standards and Technology (and the Smart Grid Interoperability Panel) to advance cybersecurity and interoperability standards and leading efforts to transfer knowledge across federal agencies though the Federal Smart Grid Task Force. In addition, SGIP has been working with industry groups, consumer advocates, and regulatory commissioners to get their feedback on a variety of implementation issues including analytical approaches for assessing the benefits of smart grid projects, initial results, and lessons-learned, and with assessing information needs to support smart grid investment decisions.

With respect to industry groups, SGIP has worked intensively with the Edison Electric Institute (EEI), the Electric Power Research Institute (EPRI), the National Rural Electric Cooperatives Association (NRECA), the American Public Power Association (APPA), and the North American Synchrophasor Initiative (NASPI), as they represent the various types of utilities, i.e., investor-owned, municipal (public power), and cooperative utilities, and the regional transmission organizations and independent system operators.

Table 1 summarizes SGIP's collaborative efforts with these groups and provides selected examples of the outcomes. SGIP is interested in working with these organizations because they provide effective platforms for reaching into the industry and many have members who are SGIG project recipients, which provides SGIP with a channel to coordinate with multiple projects at once and address issues of mutual concerns. Collaboration with these organizations has been

essential for addressing issues and sharing information on methods for estimating benefits, deployment progress, lessons learned, and initial results.

As shown in Table 1, OE's current efforts with these organizations involve webinars and face-to-face meetings to advance discussions that have focused on:

- *Improving processes to gather and analyze data and information provided by recipients to support the determination of costs of benefits derived from the ARRA smart grid projects.*
- *Advancing approaches for translating impacts and benefits into business case analysis to justify smart grid investments.*
- *Determining what information from the projects would most benefit the industry.*
- *Identifying analysis priorities and directions for future research and development programs.*

Feedback from these collaborative efforts are being captured and reflected in various reports, case studies, and presentations developed by SGIP and are made available through www.smartgrid.gov, and to a limited extent, through the websites and meetings of the respective organizations. For example, NASPI holds three meetings per year where hundreds of industry participants meet to address issues on the advancement of synchrophasor technologies. Other organizations inform their members through formal meetings, in which SGIP staff are sometimes asked to participate.

Table 1 – Collaboration Activities and Outcomes with Industry Organizations

Industry Organization	Selected Activities and Outcomes
EEI	• OE obtained feedback on issues associated with reporting and benefit analysis and made revisions to the guidance for developing Technical Performance Reports for the Smart Grid Demonstration Program • OE and EEI continue to share information on business case analysis to identify all potential benefit streams and advance the benefits estimation methodology • OE participates in EEI's Smart Grid Value Group to share results and discuss issues
EPRI	• Collaborated to produce a standard methodology for assessing costs and benefits for smart grid projects resulting in two published EPRI reports • Currently developing an Evaluation Protocols report (LBNL/EPRI) that provides guidance for the design, analysis, and coordination of consumer behavior studies involving dynamic pricing pilots. • In the process of planning a joint workshop to share results and lessons-learned from pricing pilots • In the process of developing standard approaches for valuing reliability improvements through the application of a DOE-sponsored, value-of-service research and computational tool
NRECA	• OE obtained feedback on reporting and benefits analysis requirements, including determining what topical reports to produce, and revised Metrics and Benefits Reporting Plans • Joint discussions on interoperability and cybersecurity approaches led to the sharing of NRECA's Cyber Security Guide to a wider audience including SGIG recipients • In the process of developing new methods for assessing the impact of smart grid technologies in distribution systems through the application of PNNL's GridLab-D tool and creation of the Open Modeling Framework by NRECA • Discussions on NRECA's R&D needs has led to two OE-supported efforts: 1) the development of user interface tools to support the widespread use of GridLab-D and 2) advancement of a fault prediction tool
APPA	• Obtained feedback on reporting and benefits analysis issues and revised Metrics and Benefits Reporting Plans • Obtained feedback on the four initial results reports and incorporated comments
NASPI	• OE obtained feedback on reporting and benefits analysis requirements and revised Metrics and Benefits Reporting Plans • In the process of addressing communications and data management issues associated with synchrophasor technologies • In the process of tracking and reporting on the development of applications for use in transmission system operations • In the process of determining the R&D needs of synchrophasor technologies • In the process of articulating the business case for synchrophasor technologies

Another key set of SGIP's stakeholders involves the National Association of Regulatory Utility Commissioners (NARUC), state commissions, and other state and local agencies involved in setting policies and priorities regarding cost recovery and other aspects of smart grid investments. To date, SGIP has met with NARUC staff and various current and former commissioners numerous times to obtain feedback and share initial results. The important outcomes from these activities have included the following findings:

- *Regulators are overwhelmed with a proliferation of information; simple mechanisms for presenting information are important.*
- *Regulators need to understand the costs and benefits of smart grid technologies; DOE neutrality is important.*
- *Beyond understanding costs and benefits, SGIP should help develop the important questions and concerns that a commission needs to address when examining proposals for smart grid deployments (e.g., given the current situation what are possible cost-effective deployment strategies, especially if starting with a "greenfield").*
- *SGIP should understand and be sensitive to the differing drivers and strategies that are unique to States and regions.*
- *SGIP should consider supporting efforts to educate commissioners and their staff; options include developing accredited coursework, offering vouchers enabling individuals to attend courses or purchase informational materials, and making a team of experts available to answer specific questions. In addition, a guide to vendors and product developers would be useful.*
- *Face time with commissioners and their staff will be important; the NARUC regional meetings provide valuable opportunities for presenting SGIG results, raising awareness about SGIG reports and products, and getting feedback on the types of information and formats most desired by commissioners and staff to support smart grid investment decision making.*

OE is considering these findings and planning to enhance activities with NARUC and public utility commissioners and staff including participation in regional meetings beginning in 2013 to share findings observed to date and to extend the dialogue on the smart grid information needs of the state regulatory community.

Consumer groups are another important stakeholder. In reaching out to this group, SGIP has convened meetings with representatives from the National Association of Utility State Consumer Advocates, AARP, and the Conservation Law Center to discuss approaches for conducting consumer behavior studies within the SGIG. SGIP obtained feedback from these groups and made revisions to incorporate comments to the set of questions that are being posed to participating electricity customers in these studies with a focus on obtaining a fair and accurate representation of low-income and elderly participants. SGIP intends to engage further with the consumer advocate community when results from the consumer behavior studies become available.

Related to SGIP efforts, there has been a series of broad-based peer-to-peer information exchange meetings to identify common issues in smart grid deployments and to provide mechanisms for utility practitioners to share lessons learned. To date, there have been seven regional meetings involving more than 400 participants representing about 180 organizations. There have also been two cybersecurity information exchanges involving a total about 500 participants representing the SGIG and SGIPP projects.

One of the identified issues from the peer-to-peer meetings is data privacy and there was an OE-sponsored workshop last year to identify potential actions by the federal government and state agencies to ensure appropriate privacy protections in the development, communications, and analysis of smart grid data. In addition, OE with the Smart Grid Task Force is coordinating a series of multi-stakeholder meetings to support an industry-led process to develop a voluntary "code of conduct" for handling consumer data that result from smart grid deployments. The first such meeting occurred on February 26, 2013.

In addition to the peer-to-peer exchanges, OE has established a customer engagement working group consisting of seven committees and more than 150 participants representing all of the major smart grid stakeholders to assess lessons learned, identify best practices, and develop a model framework for utility-customer engagement efforts. This is an on-going process with regular conference calls and meetings.

Another related effort is the Green Button initiative which is an industry-led, OE-supported activity to provide consumers with information-based tools for managing their power consumption and costs. Green Button is based on a common technical standard developed in collaboration with a public-private partnership supported by the National Institute of Standards and Technology. Voluntary adoption of a consensus standard by utilities across the country allows software developers to leverage a sufficiently large market to support the creation of innovative applications.

Finally, OE has shared the smart grid benefits estimation methodology, which was developed jointly with EPRI, and associated computational tools, with European governments and other member organizations participating in the International Smart Grid Action Network (ISGAN). DOE has an ongoing effort with ISGAN and OE is working directly with its members to advance methods for estimating smart grid costs and benefits. The computational tools have been applied and are being modified as required by ISGAN members.

2. **"Create a matrix of information on smartgrid.gov that enables users of Smart Grid techniques and technologies to quickly find the results and benefits of Smart Grid case studies that are comparable to their situation. Data needs to be classified and categorized to make it easy for users to find, sort, and use."**

SGIP plans to continue to use the Smartgrid.gov website as the primary means for making information available to stakeholders and the public including products developed by SGIP, the SGIG and SGIPP projects, and other relevant documents and tools. In addition, SGIP has initiated the use of electronic mailings with a subscription service to widely disseminate these products.
SGIP understands that it is essential that this information be organized and readily accessible for use by its stakeholders and is in the process of implementing enhanced search functions on smartgrid.gov to enable users to get quicker access to documents and reports. This includes making it easier to get information according to the matrix structure suggested by the EAC and the table format provided in Appendix A.

3. **"To maximize its outreach, DOE should identify Partners that have established Smart Grid outreach infrastructure and collaborate with them to disseminate information through existing communication channels that they have developed with their constituents."**

As mentioned, SGIP plans to continue to use smartgrid.gov and electronic mailings to share reports, case studies, and other products and tools. In addition, DOE plans to expand efforts with existing and new stakeholders to take advantage of their respective outreach infrastructures, as suggested by the EAC. For example, SGIP plans to:

- *Expand activities with EEI, EPRI, APPA, NRECA, and NASPI and utilize their communications channels to reach their constituents,*
- *Work with the Association for Demand Response and Smart Grid (ADS), including participating with in the ADS national town meetings, to report on results and lessons learned from the SGIG consumer behavior studies,*
- *Collaborate with new stakeholders and organize sessions at various industry conferences (e.g., DistribuTech) where SGIG projects and OE program managers can share results and lessons-learned,*
- *Expand activities with ISGAN to share cost/benefit analysis methodologies and results from specific SGIG projects with international partners,*
- *Expand activities with the Federal Smart Grid Task Force to share lessons-learned and results from the SGIG projects with other DOE offices and federal agencies, and*
- *Continue activities with the Smart Grid Interoperability Panel, the National Institutes of Standards and Technology, GridWise Architecture Council, and vendor organizations such as the National Electrical Manufacturers Association to advance interoperability and cybersecurity standards development.*

With respect to new stakeholders, SGIP plans to work closely with the Institute for Electrical and Electronic Engineers (IEEE) Power Engineering Society, PennWell Publishing (organizers of DistribuTech), and others to develop a more holistic strategy to "piggy-back" on their national and regional meetings and provide articles for their publications to reach targeted audiences

more effectively. For example, SGIP recently organized sessions at the DistribuTech and IEEE-PES meetings and published a short article in an IEEE newsletter.

SGIP is also using focus groups of SGIG projects to share and discuss experiences and lesson-learned on specific topics. For example, SGIP has been holding monthly conference calls for the group of nine projects conducting SGIG consumer behavior studies to discuss key questions regarding strategies for undertaking effective dynamic pricing programs. Lessons-learned uncovered from these discussions are posted on smartgrid.gov. In addition, the NASPI meetings have served as an effective platform for SGIG projects and other industry participants to discuss issues affecting the progress and application of synchrophasor technologies. As SGIP continues to work with the SGIG projects, additional areas where focused dialogues such as these will be pursued.

4. **"DOE should develop a series of policy papers focused on the following issues, describing the potential for Smart Grid deployment to contribute to their positive resolution: aging infrastructure and required investment, enhancing grid reliability and resilience, renewables integration, cyber-security, aging workforce and the need to achieve operational efficiencies."**

SGIP believes that the policy papers recommended by the Subcommittee are relevant and is in the process of considering how to address them. While not policy papers per se, SGIP does address the topics identified by the EAC in recommendation #4 in other reports and documents. For example, EISA Title XIII requires SGIP to submit a Smart Grid Systems Report every two years to Congress. This report provides an update on the progress the nation is making in grid modernization and adoption of smart grid technologies, tools, and techniques. The second version of this report is scheduled for release this quarter. The next version is due in December 2014 and will have a stronger focus on the contributions of the ARRA smart grid projects.

In addition, Table 2 provides a schedule of upcoming SGIG studies and reports including publication dates. Many of them address the topics identified by the EAC. The table is not comprehensive and does not include the Smart Grid Systems Report, SGIG Progress Report, the schedule for case studies and articles (which is currently under development), or the list of studies and reports that the project recipients will be publishing (except for those on consumer behavior study efforts). Table 2 will be updated as publication plans are finalized.

Table 2 – Proposed Schedule of Currently Planned SGIG Studies and Reports

	FY2013				FY2014				FY2015			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Customer-Facing Systems (AMI, Customer Systems and Pricing Programs) to Affect Demand Reduction												
DOE (LBNL) Report on Customer Acceptance – examination of factors affecting the acceptance and enrollment in the rigorous consumer behavior studies		**IR**						**R**				
DOE (LBNL) Report on CBP Project Descriptions Including Summaries for their Experimental Designs		**IR**										
DOE (LBNL) Report on Customer Response (including bill impacts) – examination of factors influencing the response to customers of time-based pricing in the rigorous consumer behavior studies					**IR**							**R**
DOE (LBNL) Report on Customer Retention – examination of factors affecting customer retention in the rigorous consumer behavior studies									**R**			
DOE Workshop Proceedings – proceedings of a joint EPRI/DOE workshop on lessons-learned from pricing studies								**W**				
DOE Final Report (interoperability and cost-effectiveness) – examination of technological issues associated with the implementation of pricing programs and customer-based systems												**R**
Interim CBS Recipient Reports – recipient-produced reports providing interim results of their consumer behavior studies			**3**	**2**		**1**		**2**				
Final CBS Recipient Reports – recipient-produced reports providing final results of their consumer behavior studies				**1**		**1**	**2**	**1**		**2**		**2**
AMI-Related Operational Efficiency Improvements												
DOE Mid-Term Report – DOE interim report examining the costs and benefits of advanced metering infrastructure and its impact on operational efficiency improvements						**IR**						
DOE Final Report - DOE final report examining the costs and benefits of advanced metering infrastructure and its impact on operational efficiency improvements												**R**
Reliability Improvements with Distribution Automation												
DOE Mid-Term Report – DOE interim report examining improvements in reliability and operational efficiencies from the application of distribution						**IR**						

automation technology and equipment sensors.												
DOE Final Report - DOE final report examining improvements in reliability and operational efficiencies from the application of distribution automation technology and equipment sensors.												**R**
Volt-VAR Optimization												
DOE Mid-Term Report – DOE interim report on the application of advanced control technology on the optimization of voltage and VAR levels in distribution systems with improvements in both energy and operational efficiencies						**IR**						
DOE Final Report - DOE final report on the application of advanced control technology on the optimization of voltage and VAR levels in distribution systems with improvements in both energy and operational efficiencies												**R**
Application of Synchrophasor Technology												
Status of Projects – DOE (ORNL) reports on the status of synchrophasor projects			**IR**					**A**				**R**
Milestones and Achievements – DOE (ORNL) produced articles on milestones and achievements in the application of synchrophasor technology		**A**			**A**		**A**		**A**			
Challenges and Lessons-Learned – NASPI Workshop proceedings				**W**								
Planning and Operational Benefits – DOE (ORNL) reports on benefits observed in transmission planning and operations						**IR**				**R**		
Reliability Benefits – DOE (ORNL) reports on observed reliability improvements							**IR**				**R**	
Cost Effectiveness – DOE (ORNL) reports on the costs and benefits of synchrophasor technology								**IR**		**W**		**R**

Where: A = article, W = workshop proceedings, IR = interim report, R = report, and numbers indicate the number of reports

5. **"DOE should develop a comprehensive information dissemination strategy covering costs, benefits, risks, and the communication methods that DOE intends to use. DOE should continue to post findings on smartgrid.gov and expand on it. The website will become one component of a much broader public outreach plan to meet constituents' Smart Grid information needs. Near-term outreach efforts should be focused on the states and state commissions (e.g., NARUC, regulators and commission staff) by providing information that will promote their understanding of existing and future Smart Grid technologies and the associated costs and benefits to facilitate acceptance, certainty, and adaptation."**

SGIP is developing a comprehensive communications and outreach strategy, which is currently in draft form. It will be shared with the EAC once it is final. The key objectives of the strategy are to:

- *Align and coordinate DOE communications resources to improve efficiency and effectiveness*
- *Develop a series of communication products provided by SGIP, as well as the ARRA funding recipients*
- *Enhance and leverage smartgrid.gov*
- *Make better use of external partners to more effectively channel and inform stakeholders*

This strategy will continue the current set of activities, but also focus SGIP efforts to effectively reach targeted stakeholders, along the lines recommended by the EAC.

As a part of this strategy, SGIP plans to continue to work with the SGIG and SGIPP projects to report on impacts, benefits, and lessons learned in specific areas. The primary objectives of this are to: 1) advance benefit estimation methods for smart grid technologies, 2) capture and report on the costs and benefits of these technologies as observed in the SGIG projects, and 3) communicate the results to key stakeholders, especially to support smart grid investment decisions. SGIP plans to rely more extensively on the project recipients to produce their own studies and reports and to encourage them to make them publicly available through smartgrid.gov. In addition, SGIP is examining the progress and barriers that the projects are facing in implementing interoperability and cybersecurity measures and the integration of distributed energy resources (including EVs and energy storage) in distribution systems. Specifically, the SGIP topical focus areas include:

- ***Peak Demand and Electricity Consumption –*** *the reduction in peak and overall demand, and changes in consumer behavior, resulting from the deployment of advanced metering infrastructure (AMI), direct load control programs, time-based rate programs, and consumer information and control technologies, such as in-home displays, web portals, and programmable communicating thermostats. This topic includes examining the response of customers in a set of statistically-rigorous pricing studies.*
- ***Operations Improvement from AMI –*** *improvements in operational efficiency, including reduced costs, resulting from AMI-enabled capabilities, such as remote meter reading, tamper detection, remote service connection and disconnection, and enhanced outage management.*
- ***Distribution System Reliability –*** *improvements in the reliability of electric distribution systems, i.e., by limiting the scope, frequency and duration of power outages, through the application of technologies that help automate distribution system operations, such as automated feeder switching, equipment health monitoring, and AMI outage notification systems. This topic*

includes examining reductions in the costs associated with improvements in operational efficiency and business processes.

- ***Energy Efficiency Improvements in Distribution Systems –*** *improvements in the efficiency of energy delivery within distribution systems through the application of automated control technologies to more effectively manage voltage and reactive power requirements. This topic includes examining reductions in the costs associated with improvements in operational efficiency and business processes.*
- ***Applications of Synchrophasor Technologies –*** *the application of synchrophasor technologies to enhance visibility and control within transmission systems and how that might lead to improved reliability, efficiency and flexibility.*
- ***Cybersecurity Solutions –*** *implementation of tools and techniques to address threats and manage activities for improving effectiveness and response.*
- ***Interoperability –*** *support for standards development and documentation of lessons learned and best practices for ensuring effective implementation of new smart grid technologies and systems and their ability to communicate with each other and with legacy systems to provide the full suite of smart grid capabilities.*
- ***Grid Integrated of Distributed and Renewable Resources –*** *technologies, tools, and techniques for integrating distributed and renewable energy systems, demand-side resources such as demand response and energy efficiency, energy storage systems, and electric vehicles.*

SGIP recently issued four reports addressing the first four of the topical areas. These reports present information on the technologies and systems and how they are applied, what the SGIG projects are deploying in each area, and some initial results based on early data submitted by the projects. A fifth report on synchrophasor technologies is expected in the third quarter of 2013, as shown in Table 2. SGIP is considering holding more technical sessions where recipients share lessons-learned and results with wider audiences. Several of these have taken place as part of other conferences such as GridWeek, DistribuTech, and IEEE-PES. These sessions have generated favorable feedback so future ones are being considered. Likely topics for subsequent sessions include the SGIG consumer behavior studies and synchrophasor technology applications.

6. **"DOE's resources should reflect this new outreach focus, with designated staff that has the responsibility for public outreach and message management disseminated through a wide range of mechanisms. It should include sufficient resources to implement a multi-year program."**

OE has recently reorganized and placed management responsibility of the SGIG program within the newly-formed SGIP reporting directly to the OE Assistant Secretary of Energy. The communications efforts of this division have been assigned to one person, and that person is responsible for coordinating communications activities within the division, as well as with OE's communications director, and DOE's Office of Public Affairs. As mentioned, SGIP is developing a comprehensive communications and outreach strategy that will guide all future SGIP communications and outreach activities and strengthen the integration of project reporting and data analysis with stakeholder engagement and website development.

Appendix A – Matrix of Smart Grid Technology Applications with Costs and Benefits

Benefits	Technology Applications					
	Consumer-Based Demand Management Programs (AMI-Enabled	Advanced Metering Infrastructure (AMI) Applied to Operations	Fault Location, Isolation and Service Restoration	Equipment Health Monitoring	Improved Volt/VAR Management	Synchrophasor Technology Applications
	• Time-based pricing • Customer devices (information and control systems) • Direct load control (does not require AMI)	• Meter services • Outage management • Volt-VAR management • Tamper detection • Back-Office systems support (e.g., billing and customer service)	• Automated feeder switching • Fault location • AMI and outage management	• Condition-based maintenance • Stress reduction on equipment	• Peak demand reduction • Conservation Voltage Reduction • Reactive power compensation	• Real-time and off-line applications
Capital expenditure reduction – enhanced utilization of G,T&D assets	✔			✔	✔	✔
Energy use reduction	✔	✔	✔		✔	✔
Reliability improvements		✔	✔	✔		✔
O&M cost savings		✔	✔	✔		
Reduced electricity costs to consumers	✔				✔	
Lower pollutant emissions	✔	✔	✔		✔	✔
Enhanced system flexibility – to meet resiliency needs and accommodate all generation and demand resources	✔	✔	✔	✔	✔	✔

Electricity Advisory Committee (EAC) Recommendations
Energy Storage
October 2012

1. **The EAC strongly encourages that DOE continue basic electrochemical research aimed at exposing the "genome of the periodic table" over time – exploring the potential for energy storage based on new electrochemistries and their practical realization.**

DOE-OE has every intention to continue support of electrochemical research for energy storage, and expand the existing programs as resources allow. As noted by the EAC, the DOE-OE R&D energy storage program has seen significant growth over the past four years, engendered by increases in available resources. Many of these efforts focus on investigating new and alternative materials and structures for electrochemical systems, but also includes advanced materials and lower cost materials for other energy storage technologies including flywheels and capacitors. Furthermore, DOE-OE has been providing input for DOE SBIR/STTR materials research efforts for large-scale storage. The goals of these efforts is principally centered on improving device performance, reducing the levelized cost of energy; and in providing a suite of storage solutions for the many application needs.

2. **Complete detailed studies of the effects of higher penetration of renewable sources on grid operations and the permanent retirement of a large percentage of traditional generation. As noted in section 4, this is an ongoing and open area due to the complexity of the problem and the continuing discovery of issues by researchers. The goals of RPS studies should be modified to consider changing end use penetrations, changing T&D infrastructure capacity utilization, and how these will affect storage economics. Work in assessing the role of storage as part of a portfolio of flexible generation, storage, and demand response for renewables integration is needed.**

DOE-OE has been conducting analyses of the effects of higher penetration of renewable sources on grid planning and operations, with specific emphasis on the potential role of energy storage (e.g. National Assessment of Energy Storage for Grid Balancing and Arbitrage, Phase 1, June 2012, PNNL 21388, The Role of Energy Storage With Renewable Electricity Generation, January 2010 NREL TP-6A@-47187, etc.) As noted by the EAC, the problem is very complex, and storage, as well as other technologies (such as DR, and use of existing conventional generation [both central station and distributed]) have the potential to address grid challenges facing higher renewable penetration. DOE-OE

intends to continue, and if resources permit to expand, its analytic efforts in conjunction with other stakeholders at the Federal and State levels, to better characterize the benefits, impediments and costs of energy storage, as well as other options, for a range of energy scenarios, most particularly those related to higher renewable penetration. Analytic treatments of grid planning and operations that employ much finer granularity and higher fidelity are needed to competently assess the role of storage and the broad suite of potential benefit streams. Such studies will guide technology research, development and demonstration, but will also inform policy makers who may seek to ensure institutional barriers do not inhibit realization of energy storage benefits.

3. **Multiple large scale demonstration projects are underway. Additional projects should be planned following the update of DOE-OE's storage plan identified above and as completed R&D and demonstration projects inform the checkpoints along that roadmap. Short-term progress on larger demonstration projects needs to continue.**

DOE agrees with this assessment and to further the demonstration program, has directed its national labs to develop projects through State Energy offices, utility developers, industry partners, and the Military complex. This initiative has lead to demonstration projects being implemented at FT. Deven's BCIL, Texas Tech University, Ft. Hickam, Duke Energy, and Kodiak Electric as some examples. Also, DOE has initiated an Energy Storage Technology Accelerator program. This program provides educational programs as well as technical consulting support to state energy offices and their affiliates in developing distributed energy and energy storage projects. However, major efforts at field validation of devices is subject to budget limitations.

4. **The Energy Independence and Security Act of 2007 required DOE to establish four Energy Storage Research Centers. An RFP for one storage "hub" was released in February 2012 with an award yet to be made (as of this writing). The EAC recommends that this storage hub should be funded and an award made.**

DOE appreciates the EAC endorsement of the Energy Storage Hub, and is pleased to report that an award has been made to a team led by Argonne National Laboratory for the Joint Center for Energy Storage Research (JCESR). The JCESR, administered by the DOE Office of Science, has the ambitious goal of producing energy storage technology that is 5 times more powerful and 5 times less expensive in 5 years. While the focus of the Hub is on science-based revolutionary advancement in energy storage, DOE-OE and DOE EERE will be monitoring the activity within JCESR, looking for opportunities to accelerate translation of fundamental discoveries by JCESR into technology amenable to

private sector development. This is facilitated by the participation in the Hub of three of the national laboratories, Argonne, Sandia, and Pacific Northwest, prominent in the energy storage R&D for OE, are partners in JCESR)

5. **DOE should develop and make public for discussion and debate its roadmap for technology development for storage from TRL 1-2-3 to TRL 8-9, including checkpoints, signposts, and decision criteria.**

DOE agrees with this assessment, and is pleased report that the latest DOE-OE Energy Storage Roadmap is available for public discussion and debate on the DOE website, at the following link: http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/OE_Energy_Storage_Program_Plan_Feburary_2011v3.pdf. Also available are the recommendations of the research communitya and utilities developed in two workshops whivh form the basis for the strategic plan. DOE - OE plans to update this roadmap in the coming years, given availability of funding.

6. **Provide funding for up to 30% of the cost of energy storage technology investments required to demonstrate the performance of the objectives cited above. More than satisfied – refer to sec 3 and appendices. This activity should be continued following the development of the technology roadmap and utilizing the decision points established in it to identify suitable demonstration projects and technologies.**

In addition to the ARRA funding to Industry, DOE has provided funding to perform technical and economic analysis on select ARRA projects. Also, DOE has provided funding to develop demonstration projects with the ARRA FOA 36 section 2.5 innovative technologies recipients. In order to validate new and existing technologies, DOE has funded Sandia National labs to build and operate an energy storage test pad that provides industry an independent third party testing and analysis service. DOE has supported many additional demonstration projects that are heavily cost shared with utilities and storage technology providers to supplement ARRA projects and sustain industry development of even more advanced technologies. Additional opportunities continue be sought, subject to available resources, to sustain the demonstration of energy storage, and gather additional performance data and insights that will help the storage industry and those who would deploy energy storage to have confidence in such deployment.

7. **Continue Funding of next-step R&D activities based on the results from the "materials genome project" cited above.**

DOE-OE does plan to continue support of "next-step" R&D activities for promising electrochemical systems as resources allow. We recognize that support of "Next-step" R&D activities is essential for Technology Maturation, from early-stage laboratory research to proof-of- concept prototypes, and ultimately to full commercial scale devices and demonstration. We recognize that without this support, innovative energy storage solutions might never be fully realized. At present, DOE-OE does support "next-step" R&D activities (e.g. our many successful demonstrations as well as our unwavering and continuing support of advanced flywheel development), and we expect that this support will continue for other materials development activities. Of course the level of direct DOE support for any given activity must be balanced and leveraged with private sector support - a viable model that we have successfully used in our many demonstration programs.

8. **Develop R&D projects focused on better understanding of storage longevity in different applications for existing and new storage technologies.**

Performance testing for battery systems has historically been accomplished using standardized shapes for charge discharge cycles. These performance tests do not include the attributes of actual operations under an application. DOE has been developing standard testing signals that duplicate various applications such as regulating reserves and diurnal cycling for arbitrage. Testing using these application specific signals provides a much better indicator of performance. Stacked application testing is also being conducted. This type of performance testing reveals battery performance under simultaneous applications. Non application based testing is still conducted, however, in order to provide comparison between current battery test results and historic tests results.

Of critical importance is the development of accelerated testing methods and protocols. The ability to predict failure mode and lifetime of battery using only short term tests lasting months to a year is critical. This work is being started at Sandia under an ARPA-e contract and would be greatly benefited by increased funding. Ongoing DOEOE funded work at ORNL with industry partners is examining the potential conversion of batteries from vehicles into stationary grid related applications.

In addition to batteries, power electronics and other component prognostics are extremely important to the development of the industry and would also benefit greatly if additional budgets were available. The OE program, leveraging SBIR funding has been

extremely successful in its power electronics work garnering two R&D100 awards and helping industry achieve world wide commercialization of wide band gap devices.

New Short Term & Mid-Term Goals

1. **Continue to fund (up to 30%) energy demonstration storage projects of new technologies arising from ARPA-E and other developments targeted at moving technology from TRL 3 to TRL 7-8 that expand the use of storage for grid performance enhancement and show benefits to increasing the use of renewable energy resources.**

DOE managers in ARPA-E and OE track technical progress of ARPA-E projects and, where prudent, programmatic activities in OE are adapted to ensure they address important technical challenges being faced within ARPA-E project technologies. For example DOE-OE will support collaborations between EaglePicher Technologies and PNNL on the development of planar Na-battery technology currently in the final year of funding from ARPA-E. This effort will focus on understanding the key mechanisms responsible for battery degradation in order to improve lifetime and leading to a lower life cycle cost of energy (LCOE) for the battery system. As noted above, Sandia is initiating a project for ARPA-E that will complement OE efforts to understand battery degradation and aging. Likewise, ORNL has initiated a project to evaluate battery state of health with laser/acoustic technologies for battery reuse and remanufacturing in the aftermarket.Besides OE moving along projects originating with ARPA-E, SBIR, and university projects, ARPA-E is also basing new projects on OE technology.

2. **Measure and report the impact of PEVs and on performance of the grid in terms of peak loading and any change in the need for ancillary services, and on the impacts of EV load and charging behavior on the T&D system and on methods to address issues identified**

DOE-OE took the lead for the DOE complex to look at potential impacts of EVs and PHEVs on the electricity infrastructure. From 2007 to 2011, significant analysis work has been performed in collaboration with DOE/EERE, Office of Vehicle Technologies Programs (VTP), EPRI, University of Michigan, Ford Motor Company, General Motors, and DTE to look at impacts of high penetration of EVs/PHEVs on the distribution infrastructure, on wholesale price impacts, transmission congestion, and plant emissions. Furthermore, analyses were performed that explored the opportunity to use smart charging strategies of EVs/PHEVs as a resource to provide balancing services for wind and solar technology integration. Currently, OE's research effort has shifted from primarily analysis to low-cost smart EVSE (EV supply equipment) development and support of standards

development to enable EVs/PHEVs to engage with a smart grid infrastructure. DOE-OE and EERE/VTP support standards development activities through organizations such as SAE, and SGIP. DOE-OE has also provided funding to support the examination of the secondary use of vehicle batteries for grid related applications.

The measurements and reporting of the current ARRA Electrification of Transportation projects are performed by DOE/EERE Vehicle Technologies Programs and reported on a quarterly basis. We agree that there is a role for DOE-OE to observe the impacts of the emerging vehicle fleet and their impacts on the electricity infrastructure. This becomes particularly important with the deployment of DC fast-charging equipment. As new funding resources become available DOE-OE will be more actively analyzing potential impacts of fast-charging and the potential role for stationary energy storage system as a mitigation strategy.

3. **Investigate the integration of EV charging with renewable generation. Consider the use of local energy storage as a way to mitigate the impacts of "fast charging" (Level 3 charging) These measurements and analyses have to be performed in the context of local "pockets" of PEV adoption today as in general PEV penetration is not sufficient to exhibit any impacts on a national or regional basis.**

DOE-OE has analyzed and estimated the potential contribution of the emerging EV/PHEV fleet toward the provision of balancing services for integrating wind energy (central power plants) and residential PV solar technologies in 2010 through 2012. DOE-OE is currently working with utilities in Hawaii to study the role of community energy storage system to mitigate both the voltage issues associated with high penetration of residential rooftop PV installations in distribution feeders as well as their aggregated impacts on the transmission system on selected Hawaiian Islands.

DOE-OE agrees that DC charging capabilities could potentially pose a significant stress onto the distribution systems and that those problems would manifest themselves in localized sections of a distribution feeder. Furthermore, DC charging capabilities have gained interest in the last year as the desire to use EVs for longer distance driving has increased. The opportunities to study the role for stationary energy storage system to mitigation strategy for problems associated with high penetration of PV integration and EV fast-charging capabilities will be studied as part of the Hawaii project.

DOE is also actively supporting SAE standards that particularly focus on DC charging technologies to enable DC charging equipment to be integrated into larger smart grid control strategies.

4. **Evaluate ongoing larger-scale demonstrations of energy storage technologies for transportation to include large truck and rail applications and the effect on T&D systems and grid and market operations of such technologies at scale.**

DOE-OE is monitoring studies of the use of storage to provide multiple benefits to electrified rail systems, such as the Bay Area Rapid Transit (BART) system, particularly looking for opportunities for off-board stationary storage to improve rail system performance, energy efficiency, economics and local interconnected grid performance. Use of platform mounted flywheels in BART stations represents an opportunity for efficient regeneration of high power generated during vehicle deceleration.

DOE's Vehicles Technologies program is working on a number of studies that are investigating how plug-in vehicles can provide ancillary services to the grid, such as frequency regulation by modulating vehicle charge rates using different communications models. Another DOE Vehicles Program study uses simulation methods to assess the grid impact of various plug-in vehicle charge scenarios, and considers the opportunities for the integration of renewables to help offset the impact of fast charging. Currently, much of this work is being done by the DOE vehicle technologies program, but given availability of funding, other programs could seek to expand upon this work.

5. **Develop and conduct an educational outreach program to state regulators and legislators involved in energy issues. Conduct this in on site workshops per the preferences expressed by the ESA survey respondents rather than in webinars, publications, or national conferences. Focus especially on commission and legislative staff assigned to renewable integration, advanced energy technology, and other related areas.**

DOE's Outreach program focuses on communications and outreach strategies demonstrating benefits of Energy Storage using methods expressed by ESA in conveying the value of energy storage to regulators and legislators. Several projects focused on outreach include the development of a PUC Regulatory Analysis guidebook and the DOE/ EPRI, NRECA Energy Storage Handbook which aims to provide additional guidance to regulators, utilities and investors to more fully understand the role, cost and performance of energy storage technologies. Presentations and direct outreach with individual utilities will continue educational efforts of these projects. Tools, such as the Energy Storage Selection Tool help potential owners of storage select energy storage technologies based on costs and performance, and the International ESS Database is database of energy storage projects, and state and federal legislation/policies. These projects provide operational information that will help develop a business case for submission to state regulators in a regulated environment, or to investors in a market environment.

Outreach efforts also include publishing technical and policy papers on a public DOE sponsored storage website, active participation in the Energy Storage Association, the co-sponsorship of the EESAT workshop, and the development of a publically accessible website cataloging US storage project details. Numerous presentations at conferences focused on energy storage, renewable generation, cleantech, electrochemistry and power electronics keep the public informed on OE work and maintain transparency of the results of ARRA efforts.

6. **Consider research into better understanding how different incentive designs and longer term performance guarantees / risk mitigation will actually influence investment behavior and support (or not) underlying policy goals, including better anticipation of unintended consequences.**

This is the essence of several projects currently funded by the DOE Storage Program. New wholesale market designs are being developed to provide incentives to stimulate the appropriate amount of investment while at the same time mitigate risk and support policy goals such as removing barriers to the participation of new technologies. Long term energy and reserve options can provide both the longer term incentive to invest in new capacity and mitigate market price risk for both standard and new technologies. Testing of market designs can be used to examine the potential for the design to result in unintended consequences so that when markets are established in the real world, a successful, economically efficient market is more likely to emerge.

7. **Support studies to expose the emissions benefits of storage as a source of ancillary services and the impact this has on the net emissions benefits of variable renewable resources.**

DOE-OE supports both national assessment studies with more generalizable outcomes, as well as regional studies with very location-specific outcomes and close engagement by grid operators (e.g., WECC, Hawaii, BPA, PSE, Nevada Energy and others) to study cost, emissions, and flexibility benefits that grid-connected energy storage may provide for high renewables integration scenarios. Production cost modeling tools such as PLEXOS are being used for these types of studies. They allow to simulate the unit commitment and economic dispatch of grid assets on a 5 min basis. Additional tools, developed to emulate sub-hourly dispatch and automatic generator control (AGC) are also employed in system analyses. These studies are on-going and are planned to continue, subject to resource availability.

Long-Term Goals (2020 and beyond)

1. **Implement programs to test and analyze vehicle-to-grid (V2G) performance and the impact on grid operations.**

DOE-OE as part of its Smart Grid R&D program has been working on smart charging strategies including V2G applications for several years. DOE-OE, however, acknowledges that there are several market acceptance issues associated with V2G applications that are driven by the OEMs' and transportation battery manufacturers' warranty concerns. DOE-OE's position is to support R&D that clarifies the uncertainties associated with the exposure of transportation batteries to be used for grid applications. For instance, OE had funded a small effort to analyze the statistics of frequency regulation signals in an effort to standardize a protocol that would be representative for V2G applications. DOE agrees that more studies will need to be done to remove the uncertainties among stakeholders in the automotive industry that is associated with how a vehicle battery will be utilized for grid applications. Once this knowledge has been generated, standards for V2G "drive-cycles" can be developed so that the transportation battery industry can perform test to learn the impacts and degradation implication of transportation batteries when used in V2G applications.