Department of Energy
Washington, DC 20585

March 2, 2012

MEMORANDUM TO THE DEPARTMENT OF ENERGY ELECTRICITY ADVISORY COMMITTEE

From: **Patricia A. Hoffman /s/**
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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 2011.

The work products delivered by the Committee during 2011 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 2011 products

1. Recommendations on Electric Vehicle Deployment: Policy Questions and Impacts to the U.S., November 2011
2. Recommendations on US Grid Security, October 2011
3. Interdependence of Electricity System Infrastructure and Natural Gas Infrastructure, October 2011
4. Estimating the Value of Electricity Storage Resources in Electricity Markets, October 2011
5. Update to the 2008 EAC Smart Grid Report, May 2011
6. Policy Questions on Energy Storage Technologies, April 2011
7. Recommendations to Address Power Reliability Concerns, March 2011
8. Energy Storage Activities in the United States Electricity Grid, May 2011

The attachments that follow summarize DOE's actions and responses to these 2011 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.

EAC Recommendations
Electric Vehicle Deployment: Policy Questions and Impacts to the U.S. Electric Grid, November 4, 2011

1. **DOE should provide state utility regulators and stakeholder information on options for EV charging policies and retail rate designs and develop guidelines outlining best practices.** DOE can help to enhance the nationwide visibility of successful state level policies. DOE should facilitate the gathering of best practices and act as a conduit for the distribution of this information among federal, regional, state and local policy makers.

DOE Clean Cities is charged with advancing the nation's economic, environmental, and energy security by supporting local actions to reduce petroleum consumption in the transportation sector. DOE understands the need to identify and promote best practices for policies related to EV charging among utilities and stakeholders. In recognition of this need, Clean Cities offered a competitive funding opportunity in 2011, seeking projects to plan and implement policies, procedures, and incentives to prepare communities for successful deployment and implementation of plug-in electric vehicles.
As a result of this funding opportunity, in September 2011, DOE made 16 awards totaling $8.5 million, involving 24 states to stimulate communities to plan for plug in electric drive vehicles in anticipation of successful larger deployments. The awardees are working within their areas to convene a broad set of stakeholder partners (i.e., regulators, policy makers, code officials, automobile dealers, utilities and others) to develop plans that will lead to local and regional policies, procedures and incentives that will ease the path to market acceptance of electric vehicle technologies. The plans will be made public at the end of the award period (October-December 2012) and may be used as templates for policy and practices that can be replicated by any state or region throughout the United States. DOE will get information from these plans into the public purview by distributing the best ideas included in the final plans.

2. **DOE should analyze the impacts that EV deployment may have on the electric power system (particularly the distribution system) and make recommendations or provide guidelines, on appropriate infrastructure investments.** In doing this analysis, the DOE could create a forum for discussion that will allow the various parties in the industry to bring forward proposals for consideration, so that both the DOE and other federal and state policy makers can be informed on the issues, and the best practices for addressing the issues, arising from EV deployment.

Through the Grid Interaction Technical Team, part of the U.S. DRIVE partnership between the Federal government, the automotive industry, the electric utility

industry, and the fuels industry, DOE collaborates in analyses to understand the impacts of EVs on the electric grid. A number of utilities both within and external to this partnership have studied system impacts from plug-in vehicle (PEV) adoption, including Southern California Edison (SCE), DTE Energy, ConEdison, Duke Power, and the Electric Power Research Institute (EPRI).
DTE studied 100 circuits that might expect to have loading issues due to PEVs, and for the most part sees no immediate concerns. DTE studies show the need to incorporate an EV rate or demand response program to encourage off-peak charging. The effect of PEVs on distribution circuit equipment is regional and location specific. DTE published its modeling results in the trade journal T&D World Magazine and has made a number of presentations on the topic.
In January 2010, SCE completed a study to estimate the impact of varying levels and clusters of PEV penetration on the SCE distribution system (substations, circuits, and service transformers) and incorporated study findings into SCE's annual load growth planning process. As expected, study results indicated that noticeable impacts are tied directly to location and concentration of PEV installations. In addition, system-level impacts are not expected to be a major concern until 2015 and beyond under current SCE projections.
*EPRI is very active in analyzing electric distribution system impacts from PEVs. It has initiated a multi-year study involving 20 utilities in the United States and Europe and has developed simulations and modeling looking at clustering and charging diversity, primarily in the residential segment. Preliminary findings indicate that most systems are adequate for the next 1-5 years, with the possible exception of some older residential distribution circuits in specific locations. This information is available on the EPRI website (**www.epri.com**).*
DTE, SCE, and EPRI are all members of the U.S. DRIVE partnership, and DOE will continue to collaborate with them to understand the grid impacts with increased deployments of plug-in vehicles.

3. **DOE should, to the extent that it is needed, consider promoting the standardization of the physical and information technology/ communications interface between EVs and EV charging stations.** There are a number of forums, including the National Institute of Standards and Technology (NIST), that are addressing this issue but it is of national importance that we achieve standardization in this area as quickly as possible. If, in the assessment of the DOE, the industry is not reaching consensus in this area, the DOE could act as a facilitator to ensure that the appropriate standards emerge.

DOE recognizes the importance of a consistent and appropriate set of standards to govern the physical interface and communications protocols between EVs and charging infrastructure, and supports NIST's position that standardized architectural

concepts, data models, and protocols are essential to achieve interoperability, reliability, security, and evolvability. To this end, DOE is engaged with standards development organizations through the previously described Grid Interaction Technical Team, as well as through leadership and participation in Society of Automotive Engineers (SAE) task forces developing EV communications standards including SAE J2947 ("Communication Between Plug-in Vehicles and the Utility Grid"), J2936 (Use-cases for J2947), J2931 ("Electric Vehicle Supply Equipment Communication Model"), and J2953 ("Plug-in Electric Vehicle Interoperability with Electric Vehicle Supply Equipment"). Additionally, DOE collaborated with the American National Standards Institute (ANSI) in April, 2001, to conduct the "ANSI Workshop: Standards and Codes for Electric Drive Vehicles," which convened numerous stakeholders in the international standards arena. As a result of this workshop, ANSI created the Electric Vehicles Standards Panel (EVSP) Roadmap, with the goals of (1) facilitating the development of a comprehensive, robust, and streamlined standards and conformance assessment landscape, and (2) maximizing the coordination and harmonization of standards and conformance programs domestically and with international partners. DOE continues to coordinate with ANSI as they move forward with implementation of this roadmap.

EAC Recommendations
US Grid Security, October 2011

1. Determine Specific Grid Vulnerabilities to HILF Events and Cyber Attacks

DOE has been an active partner with NERC in addressing Cybersecurity and Space Weather Issues including Geomagnetic Disturbances (GMD). In September 2009, DOE co-sponsored with NERC the High Impact Low Frequency (HILF) Workshop in Washington, DC. The workshop examined high risk but low frequency events and their possible impact on the bulk power system. Physical and cyber coordinated attacks, pandemic and EMP were addressed. The EMP recommendations were followed up by NERC in cooperation with DOE including the creation of several task forces: the Geomagnetic Disturbance Task Force (GMDTF) and the Spare Equipment Databases Task Force (SEDBTF). DOE has participated on the executive group for the GMDTF report which is due in March 2012. DOE has been actively involved in the SEDBTF whose report has been completed. DOE also participates on the Cyber Attack Task Force (CATF).

DOE has also been an active participant on the White House Office of Science and Technology Policy Geomagnetic Induced Currents Interagency Working Group which includes all federal agencies involved in addressing this issue.

DOE's Cybersecurity for Energy Delivery Systems Program supports research in next-generation control systems to accelerate the development and deployment of hardened control systems with built-in security. It also supports system vulnerability assessments that reveal exploitable systems vulnerabilities to encourage development of system fixes, and integrated risk analysis which helps stakeholders assess their security posture and hasten their ability to mitigate potential risks. This work is done in partnership with the national laboratories and stakeholders to encourage collaborative developments and dissemination of critical security information.

DOE and EnergySec are working to establish the National Electric Sector Cybersecurity Organization (NESCO) through a cost-shared cooperative agreement. NESCO serves as a focal point bringing together utilities, federal agencies, regulators, researchers, and academics. This group, along with domestic and international experts, developers, and users help to identify cybersecurity research and development gaps, to identify and disseminate effective common practices, and organize the collection, analysis and dissemination of infrastructure vulnerabilities and threats. NESCO works to identify and support efforts to enhance cybersecurity of the electric infrastructure. NESCO's Tactical Analysis Center will serve as a community-driven effort to provide critical analysis services to the industry, using data sources as varied as NERC's Electric Sector-Information Sharing and Analysis Center's

advisories, vulnerability alerting services, information provided by asset owners, and other partner resources.
DOE participates in NERC's Critical Infrastructure Protection Committee meetings and working groups in order to better share information and identify gaps in national policies, programs, and research and development for both physical and cybersecurity issues.

DOE participated in GridEx 2011, a national level exercise led by NERC. GridEx objectives were developed and tailored to fit the needs of the industry and included validating the current readiness of the electricity industry to respond to a cyber incident and provide input for security program improvements, exercising NERC and industry crisis response plans, and assessing, testing and validating existing Command, Control and Communication Plans for key NERC stakeholders.

DOE is working with NERC on the DHS/FEMA-led National Level Exercise 2012. This cooperation will further test NERC and DOE's information sharing, coordination, and response.
In July 2011, DOE held a technical workshop on GMD with utility industry experts to discuss existing mitigation activities. This was followed by an industry-only workshop sponsored by NERC to develop and release mitigation recommendations based on the experience of several utilities including Hydro-One, Dominion, and ConEd.

DOE is partnering with NERC and EPRI to further research on geomagnetic disturbances and impacts on the power grid to expand the current SUNBURST program to monitor GICs on transformers.

DOE is planning to partner with NERC after release of the GMDTF report for further education and outreach to the utility industry.

DOE has partnered with NERC and NIST and the utility industry to develop a sector specific cyber security risk management process guideline.

2. Development of Grid Component Hardening Guidance and Best Practices

While DOE has not been directly engaged in preparing guidance for industry with respect to hardening of grid components and equipment, DOE through its activities and partnerships with NERC and other trade organizations has been encouraging industry to address vulnerabilities of energy systems and incorporate best practices to make the grid and related systems more resilient.

In 2010, DOE prepared a report entitled "Hardening and Resiliency: US Energy Industry Response to Recent Hurricane Seasons." The Report discussed hardening and resiliency activities that the energy industry has undertaken in response to the 2005 and 2008

hurricane seasons. The report also highlighted numerous technologies including Phasor Measurement Units (PMUs), mobile/modular transformers, composite poles, smart grid integration, and infrared thermography. The report can be found on DOE web site at:

http://www.oe.netl.doe.gov/docs/HR-Report-final-081710.pdf

3. Determine Specific Gaps in Sparing Critical Components

DOE has been concerned about the availability of large transformers (>345kV) which until 2010 were no longer manufactured in the U.S. DOE has held meetings with transformer manufacturers to better understand the issue. Several manufacturers are now producing or building capacity to produce large transformers in Georgia, Alabama, Wisconsin and Mississippi.

With the encouragement of the utility industry DOE has been partnering with DHS on a Recovery Transformers Program with ABB and EPRI that is funded by DHS. These transformers will be smaller and lighter weight and are currently beginning testing at CenterPoint Energy in Texas.

The NERC Spare Equipment Database Task Force is also addressing this issue creating a pilot voluntary program to enhance possible utility sharing of large (100MVA) transformers through a database to match utility needs with available spares. EEI also has a STEP program to share spares in the event of a terrorist incident. The NERC program has no such constraint.

DOE is staying abreast of current activities including the monitoring of possible Congressional action or possible action by FERC to mandate utility industry action.

EAC Recommendations
Interdependence of Electricity System Infrastructure and Natural Gas Infrastructure, October 28, 2011

1. **Given the interdependence of the Nation's electric infrastructure and natural gas infrastructure, the U.S. Department of Energy (DOE) should facilitate:**
    - **Coordination among oversight and policymaking agencies or other regulatory bodies;**
    - **Identification of realistic alternative, redundant, and/or backup systems needed for reliable, continuous operation of the interdependent infrastructures;**
    - **Testing of these systems routinely to ensure they will operate when called upon;**
    - **Inclusion of cost/benefit impacts analyses on other infrastructures when considering policies; and**
    - **Periodic reassessment of the status of interdependent infrastructures to determine whether shifts in technology or policy have changed their relationship with one another. Such assessments should include an evaluation of whether the retirement of existing electric generation will result in the development of additional gas generation and thereby place greater demands on the natural gas system.**

2. **In particular, DOE should focus the coordination/research/facilitation activities that are listed above on:**
    - **Policies to ensure that gas supply and gas pipeline capacity will be available to generation resources on a firm basis when required to maintain power system reliability;**
    - **Policies, market rules, and technologies to enhance the contribution of gas generation as a quick-response balancing resource on power systems that will see an increasing penetration of variable renewable sources; and on**
    - **Evaluating the degree to which aging natural gas pipeline system links may be subject to failure with consequences for the electric sector.**

3. **Such assessments should include an evaluation of whether the retirement of existing generation will result in the development of additional gas-fired generation and thereby place greater demands on the natural gas system.**

While all of the recommendations provided will help to inform DOE's path forward in this area, ongoing and planned analysis activities through DOE's Office of Fossil Energy (FE) and National Energy Technology Laboratory (NETL) are already addressing two of the recommendations:

1. Periodic reassessment of the status of interdependent infrastructures to determine whether shifts in technology or policy have changed their relationship with one another. Such assessments should include an evaluation of whether the retirement of existing electric generation will result in the development of additional gas generation and thereby place greater demands on the natural gas system.

2. Such assessments should include an evaluation of whether the retirement of existing generation will result in the development of additional gas-fired generation and thereby place greater demands on the natural gas system.

Specifically, FE and NETL have been engaged in analyses relevant to the EAC recommendations that would facilitate the exploration of how existing and new natural gas power plants could help meet future electricity demand, including:

- *Analysis of the potential impact of new EPA regulations on existing coal power generation capacity*
- *Cost of different coal and gas power plant options, with and without carbon capture and storage*
- *Dispatch modeling to help understand how changes in available generating assets could impact ability to meet electricity demand in different regions.*

FE/NETL analytical activities have not focused on how the natural gas supply infrastructure might need to evolve to accommodate potential changes in electricity demand, but the value of such a capability is recognized and efforts are being initiated to determine how best to do this.

EAC Recommendations
Estimating the Value of Electricity Storage Resources in Electricity Markets, October 2011
Policy Questions on Energy Storage Technologies, April 2011

1. **What are the operational and reliability implications for grid operators arising from high penetrations of variable energy resources and from other changes in the generating fleet? (Also see question (4) below.) How would the impact of these changes be mitigated by changes in grid operating procedures that allow greater amounts of variability to be accommodated with existing levels of reserves?**

The ESS program is funding the PNNL National Assessment of Energy Storage Systems for 2020, which will conduct a national assessment of the role of energy storage for two individual services: 1) balancing services and 2) arbitrage. This work will estimate the total energy storage deployment potential based on meeting the future balancing requirements for a 2020 future grid with an assumed installed U.S. wind capacity of about 300 GW and a generation contribution of about 20% to the total electricity generation. An economic evaluation will be performed that compares the life cycle cost of key storage systems, demand response, and conventional combustion turbines, as well as hybrid systems that bundle storage systems to technology portfolios. Cost and performance targets for energy storage resources will be determined in conjunction with, and using the results of this work, which will help energy storage become a cost-effective grid asset that addresses the operational and reliability concerns associated with increased renewable energy penetration.
The program also currently has a project to study power grid stability in the WECC region. This is particularly important due to the significant deployment of renewable energy technologies in the BPA balancing authority and in California. This project will study the stability issues for a high penetration of variable generation future WECC scenario in 2020. The ESS program will analyze how the use of energy storage technologies expected to be in place for managing variability and how storage can also be used to improve grid stability. Additionally the ESS program plans to include data from the ARRA demonstration projects to highlight the value streams of energy storage resources in addressing variability on the system.
Future work planned by the ESS program will include the analysis of current and future development of planning and operation methodologies. This work will study the potential for reserve sharing across balancing area borders to potentially unleash existing resources that have remained unused or underused in the past. Coordination or even consolidation of balancing areas will be studied to potentially increase the capabilities of existing assets through optimized use, thereby imposing downward pressure on the need for storage. The development of a new methodology is also planned, one that puts storage in a long-term planning process, or queue, as is the case with transmission planning. This will allow others to plan their generation, transmission, and distribution with the knowledge that energy storage projects can be implemented in a set timeframe. It will also allow for a better use of

storage resources and an increased value proposition for energy storage, while also informing future planning efforts.
Additionally, OE is supporting, in combination with EERE, an evaluation of the merit of increased coordination and potential consolidation of grid operational balancing areas in the Western Electricity Coordinating Council, which, if pursued should also reduce the cost and increase the ability of the grid to incorporate larger amounts of variable renewable generation. The results of the first phase of this study, for incorporation of 11% renewable generation, should be completed in the 2nd quarter of FY-12.

2. **What are the consequent market design implications?**

To study the market design implications of the future grid, the ESS Program is working on an Energy Storage Market Structures project. This project will evaluate current market designs to determine current rule restrictions or biases against storage and other resources and will be especially pertinent as renewable implementations increase, resulting in an increased need for balancing services. This project will develop a new market design in response to FERC order 755, one that will allow any storage resource (including demand response) fair access to compete in markets based on the services it provides. This work will also help FERC as it determines how to account for ancillary services and will help drive its policy on energy storage technologies and the future grid. Based on the results derived from this study, further studies will be undertaken in the 2012–2015 timeframe to evaluate specific market segments and issues.
The Oahu storage study will also likely address some market design implications of high renewables penetration, especially at the distribution level. This analysis will provide insights into how PV technologies at various levels of penetration, impact distribution system operation, assets, and system protection schemes, and how energy storage technology located at the distribution system substation level may mitigate some of the challenging impacts. Through this, any market design implications will also be determined.
Research conducted at PNNL has already been instrumental in shaping market design related to storage, by providing supporting data and analyses cited in FERC Order 755, issued in October, 2011, to differentiate the higher market value of fast storage from other resources.

3. **What incentives could policy makers and regulators create for certain technologies? How can stakeholders better understand the impact of different resource mixes on wholesale production costs and emissions? How can policy makers, regulators, and market participants/investors better understand the relative economic viability of different resources, including different storage technologies, both between technologies and in the context of differing resource mixes? DOE could provide useful, decision-making information by performing "scenario analyses" in which different future resource mixes are modeled (including at least one future that contains a high percentage of electricity storage resources) and production costs, emissions profiles, and infra-marginal revenue contributions to different resource types are analyzed.**

The PUC Regulatory Analysis project will help regulators better evaluate and understand the economic viability of storage resources relative to other grid alternatives in the context of different grid situations around the country. It will also discuss potential incentives for energy storage at the state and federal levels, whether they are necessary, and what types of incentives could be implemented if they are considered necessary.
Other projects are underway for the state of Nevada, the Maui and Oahu islands of Hawaii, and the Southern Company balancing area. These projects aim to help understand the near-term needs of the grid in these regions and determine the potential for energy storage. In these projects, production cost modeling is being used to performing various scenario analyses and model different resource mixes in present and future systems. This modeling is also evaluating scenarios with varying degrees of storage resource deployments. Production costs, emissions profiles, and infra-marginal revenue contributions to different resource types are being studied. This work will help stakeholders understand the technical and economic potential for energy storage and other resources in different grid situations. Future capacity requirements and potential deferments with the use of energy storage are also being evaluated.
The PNNL national assessment of the role of energy storage will estimate the total energy storage deployment potential based on meeting the future balancing requirements for a 2020 future grid with an assumed installed U.S. wind capacity of about 300 GW and a generation contribution of about 20% to the total electricity generation. An economic evaluation will be performed that compares the life cycle cost of key storage systems, demand response, and conventional combustion turbines, as well as hybrid systems that bundle storage systems to technology portfolios. The analysis will provide cost performance targets for storage technology to be competitive. The national assessment will be performed by 22 sub-North American Electric Reliability Corporation (NERC) regions for a 2020 future grid scenario.

4. **Will the current state-of-the art in power system modeling and power system management software (including the optimization software inherent in unit commitment and economic dispatch) be sufficient to cope with a future grid that has to support a significant penetration of variable and limited energy resources? What are the constraints that operators and participants should be aware of and what additional research and development should be done in this area? DOE should perform analysis on specific modeling and software optimization tools as a basis for defining and performing a detailed simulation of the real-time performance of the power system under differing operational conditions. This analysis by DOE will lead to recommendations for further improvements in power system modeling and power system management software and will also inform operators and participants as to where the system stability constraints exist.**

The ESS program, through various research projects, such as the development of Control Systems to Manage Grid Stability, is currently working with tools such as PSLF(Positive Sequence Load Flow), to conduct power flow modeling for grid stability, reliability, and other studies. This process will help identify gaps in available modeling software when considering

scenarios that include high renewables penetration, distributed generation resources, and energy storage resource implementation.
The ESS program is also conducting additional production cost modeling with various modeling software tools such as PROMOD, Plexos, and others. These programs are being used to model various scenarios for unit commitment dispatch with variable energy resources, energy storage resources, and other emerging grid technologies such as smart grid & demand response.
Existing work that PNNL has performed with Nevada Power and on the National Assessment has revealed the methodological optimization issues of currently available production cost models to appropriately optimize energy storage. Current models perform optimal dispatch of all grid assets for one point in time. To optimally dispatch energy limited energy storage, the optimal dispatch must be performed over a period of time (say, one day). Only then optimization over the duration of time (i.e., one day) allows to optimally charge and discharge storage technologies. Currently, heuristics are applied in today's models and tools. Further testing must be performed to evaluate the adequacy of the heuristics or whether or not new algorithms must be developed to model and represent energy storage assets appropriately.
The ESS program plans to begin additional projects to develop planning tools that address these gaps in 2013 and beyond. Additionally, operational tools, such as Market Management Systems, currently do not provide optimal dispatch for energy storage resources.
The ESS program also coordinates with other OE programs related to transmission, renewable integration, and high performance computing, to develop new simulation tools, real-time grid operations analytic tools, and operator information displays that improve planning and operations of the grid in the presence of growing variable renewable generation.

5. **Regulated utilities have a crucial role to play as investors in and portfolio managers of the wide array of integration solutions (including storage) that are needed to accommodate variable output resources and loads. What will regulated utilities need for creating performance-based incentives associated with this crucial role, in addition to the recovery of prudently incurred costs? DOE should lay out these alternatives to help provide guidance to state utility regulators and investors.**

The PUC Regulatory Analysis projects aims to provide guidance to state utility regulators, utilities, and investors to understand the role of energy storage technologies. The project will discuss energy storage from a technological and operational standpoint, especially as it relates to the regulated environment. To assist regulators in fairly evaluating energy storage and other competing technologies, a valuation methodology will be discussed and examples of valuation procedures for different applications will be provided. Additionally, the challenges faced by regulators and utilities in evaluating storage technologies and alternatives will be identified and discussed. Possible solutions to these challenges will be identified. Additionally, potential means of incentivizing storage development at the state and federal levels will be discussed.

The following tools are also being developed by the ESS program to assist users of energy storage:
The Energy Storage Project Database will be a publicly accessible database of energy storage projects, research, and policies around the country and the world. The database would help regulators, utilities, and other potential storage system owners, plan for and evaluate storage technologies based on their performance and value in operational practice. It should also help in considering and evaluating potential incentivization programs for energy storage resources.
The public and web-accessible ES-Select Energy Storage Selection Tool being developed is software that will allow high-level decision makers to facilitate the planning process for ESS infrastructure. It will evaluate, from an economic and performance perspective, different storage technologies for their applications. The tool will assist in the selection of the best-fit technologies for a specific application and help to provide a preliminary business case. This tool will also educate potential owners, electric system stakeholders and the general public on energy storage technologies.
DOE is partnering with EPRI and NRECA to develop an energy storage handbook that will include technology cost and performance information based on data gathered from current technology providers. This Handbook will detail the current state of commercially available energy storage technologies, match applications to technologies and will contain info on sizing, siting, interconnecting. This handbook, in conjunction with the project database and the ES-Select tool, can assist potential storage owners to determine the storage technology and technology vendor, and 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. Additionally, these tools will help regulators to understand different storage technologies, evaluate the value of storage proposals, and aid in determining appropriate cost recovery for these resources while ensuring that ratepayer concerns are addressed.
The ESS Program is also facilitating codes and standards development, including performance testing with advanced testing methodologies. This development activity will help regulators and potential owners to further evaluate and compare the performance potential of storage resources to each other and to alternatives. The development of standards will help to target other areas of concern for energy storage, namely, safety, performance, lifetime, etc. Standards will allow regulators to address their concerns around storage systems with a simplified approvals process that uses these developed standards. The program has expanded this work with the development of a new megawatt-scale test facility as a companion to its cell and string facility.

6. **What is the potential market value and what are the returns to storage under different scenarios, including high renewable penetration, retirements of older/less efficient generation, and the likely effects of future market services resulting from impending FERC rulings? DOE should conduct economic analysis that complements the operational and market design analysis described above.**

Production cost modeling in collaboration with Nevada Energy, Southern Company, Maui, and the grid analysis work on Oahu will \will help to evaluate the value of storage under high

renewables penetration, the retirement of older generation, and the effects of market changes based on impending FERC rulings. It will help to determine the quantity of services (from storage and other resources) needed in the cases of these different scenarios. It can also determine the resource mix of these services, whether it be storage or an alternative. Based on this, targets for storage technologies can be developed that help research and development efforts to improve the business case for storage technologies. Power flow modeling will assist in determining the magnitude of system stability and reliability issues resulting from high-levels of renewable generation and retirements of older generating equipment. This will determine the market potential for energy storage and other resources to address these issues. Additionally, the energy storage market structures project is conducting market development work that will allow storage and other resources to be fairly compensated based on services they provide.

The ESS program has another project that will evaluate the value of using energy storage to provide multiple grid benefits and will determine the value of bundling services. Currently, the potential of a storage system delivering multiple services or benefits is relatively unknown from a performance, lifetime, and cost standpoint. This project will answer questions such as how storage can serve multiple services and will energy storage performance decrease vs. when it is providing just one service.

The ESS program will address the market value issue of energy storage through energy storage technology testing. Specifically, the process of testing different storage systems, developing the test methodologies, and creating codes and standards will result in applying metrics to different storage technologies, which can then be used to judge these technologies from a value standpoint.

The ARRA Project valuation report will establish a methodology to calculate the monetary value propositions for the different ARRA storage projects. This will provide not only predictions for the value of different storage technologies in different applications, but it will also provide a methodology by which other energy storage proposals can be judged to determine their potential value.

The PNNL national assessment will assist in establishing a market valuation for storage technologies under a high renewables penetration scenario. An economic evaluation will be performed that compares the life cycle cost of key storage systems, demand response, and conventional combustion turbines, as well as hybrid systems that bundle storage systems to technology portfolios.

7. **What are the potential effects of storage deployment on reducing emissions from conventional generation? Several published papers) have analyzed the impact of using storage for regulation services on reduced emissions from conventional generation. This reduction of emissions is due to a combination of 1) altered dispatch that requires fewer reserves from conventional resources and 2) potential heat rate improvements by reducing the amount of rate of change imposed on conventional generation. Other authors have speculated that the dispatch impacts of using storage to accommodate system variability could actually shift generation from gas-fired resources to coal-base-load units, thereby increasing emissions. Sandia National Laboratory (Sandia) has recently begun a project to re-assess the**

emissions benefits of storage used for regulation services. Sandia is not, however, examining the value of those emissions savings in economic terms. One possibility to be examined by DOE would be to identify the compliance costs improvements, if any, by reduced regulation duty on conventional plants.

The 2nd Generation Emissions Study being conducted by KEMA Inc. is determining the potential for energy storage technologies to decrease emissions from conventional generation. This is based on the reductions from reduced reserve provision by conventional resources and the heat rate improvements that result from reduced cycling of generators to follow load and provide other ancillary services.
There is a project at DOE to determine the effect of generation cycling on wear and tear of conventional generation units. The results from this project will help measure the impact that energy storage resources have on reducing this wear and tear.
The PNNL national storage assessment will include analysis of emissions reductions opportunities from the deployment of storage in the case of high renewables penetration. These opportunities will have an associated economic value that can help to gauge the benefit of utilizing energy storage resources from an emissions perspective.
Further work will be done utilizing production cost modeling and other tools to utilize the above work in creating an economic evaluation of the benefit of reducing emissions from an environmental standpoint (or compliance cost standpoint).

8. **What is the role of storage at the distribution level?**

- **DOE should survey available distribution planning tools for 1) their ability to consider storage resources on the feeder; 2) their ability to optimally locate same; and 3) their use of assumptions in the planning process and comparison of alternatives as storage is applied to adjust load shapes, increase system utilization, and defer capacity upgrades**
- **DOE should monitor results from Community Energy Storage ARRA projects to better quantify the economic benefits and barriers for entry**
- **As an enabler for storage, DOE should assess the effectiveness of the "Perfect Power Seal of Approval" objectives (Galvin Institute), which establish a reliability rating system, certification utilizing a seal of approval, education to effectively communicate advanced practices and applications, and an engagement between the provider and users to reveal significant gaps in performance**
- **Define and resolve federal/state regulatory "gaps" and "overlaps" to increase investment certainty for financing storage projects, DOE should develop analysis that provides better understanding of the costs and benefits that drive rate recovery for storage located on the distribution system**

The ESS program is working on a methodology to analyze the economic value of the ARRA energy storage projects. This includes the distribution level or community level projects. This methodology can then be used to evaluate the business case for new distribution or community level storage projects.

In addition, the PUC regulatory analysis work being conducted also addresses distributed energy storage resources, as long as they are utility connected. It identifies regulatory issues that can affect the approval and financing of distributed storage resources and provides a methodology for the economic valuation of these resources.
The Oahu energy storage study will analyze the role of energy storage deployed in distribution systems under high penetration of distributed solar photovoltaic resources. This will help to determine the economic valuation of distributed energy storage and will also assist in identifying the regulatory gaps and issues that may exist in the approvals and financing of such projects. This analysis will provide insights into how PV technologies at various levels of penetration impact distribution system operation, assets, and system protection schemes, and how energy storage technology located at the distribution system substation level may mitigate some of the challenging impacts.
Additional work is planned in the next few years to further understand storage deployment at the distribution and community level. Power flow modeling tools, such as GridLab-D, Distribution Engineering Workbench (DEW), or open DSSS, can be used to explore the value and benefits of distributed energy storage systems within the distribution system domain. Issues associated with FERC asset classification such as those requiring an energy storage system to be classified as either a tariff receiving "transmission asset", or a market participating "generation asset" should be explored. Energy storage value propositions are artificially restricted due to this classification requirement.

9. **What are the barriers, incentives, and technical challenges to aggregating distribution and community-based storage facilities?**

- **DOE should conduct analyses on the role of storage "behind the meter" (BTM); determine the distribution system benefits of storage on the customer side of the meter; and**
- **Determine the technical challenges caused by significant penetration of BTM variable energy resources and loads, including PEVs, solar panels, wind turbines, micro-grids, etc.**

The Oahu energy storage study will help to determine the issues involved in utilizing storage systems at the distribution or community level, aggregated to provide value to the system as a whole. It will also explore high distributed PV implementation on what the role of storage could be in such a situation both connected to the utility power system, as well as behind the meter,
Additionally, the standards work being conducted in the ESS program will also address behind the meter energy storage. Again, it will develop performance and operational standards for storage technologies, that if met by the technology, can certify its capabilities and thus provide a clear economic case and thus a much easier approvals and deployment process for BTM resources.
Specific work to address the value of distributed versus central storage system is planned for2013.

EAC Recommendations
Address Power Reliability Concerns Raised as a Result of Pending Environmental Regulations for Electric Generation Stations, March 10, 2011

1. **The Secretary of Energy create a consultative process with EPA and FERC at the senior level in which the three agencies commit to communicate on these issues, while recognizing existing authorities of each agency.**

2. **DOE advance a recommendation to FERC for an improvement to the processes for planning in anticipation of unit replacements. One of the problems facing power system Planning Coordinators is a limitation on planning in anticipation of possible plant retirements, since those plans can only be made once a unit owner has provided a formal notice of its intention to remove the plant from service. Under current practice, this does not provide enough time for the Planning Coordinator, utilities, and regulators to develop and implement the full range of actions to protect reliable service, with both cost and environmental goals in mind.**

   To assure that transmission and power systems can take into consideration the potential impacts of the EPA initiatives, the Electricity Advisory Committee recommends that DOE and FERC support actions by the Planning Coordinators across the country to undertake proactive planning studies to examine what transmission system additions, generation additions, or demand-side actions would be needed if generation resources retire. These studies could take the form of scenario analyses to determine what transmission solutions, or replacement resources, will be required to maintain grid reliability for differing levels of unit retirements. While these studies in and of themselves will not immediately address issues related to potential retirements, the studies will provide greater lead time to deal with likely retirements, and will enable informed decision-making about the options for preserving reliability as environmental regulations are implemented.

   By anticipating possible retirements in advance of formal notifications, a wider range of alternatives and greater lead time for implementation can be provided to Planning Coordinators, system operators, regulatory authorities, utilities and investors.

DOE agrees on the importance of ensuring reliability while achieving environmental goals. We also agree on the need for a structured decision process to ensure that existing generation facilities are not retired or derated before regional planning authorities have confirmed that adequate alternative resources are available.

DOE is aware of the range of conclusions from various assessments and appreciates the initiative taken by others to project the potential impacts on the electric system. Such analyses provide value to planning coordinators and regulators who work to ensure system reliability. DOE is currently discussing potential future analytical needs and their design in an effort to address reliability, especially at the local level.

Since the EAC provided its recommendations to DOE; DOE, FERC and EPA have engaged on multiple occasions to discuss the reliability impacts and strategies moving forward to ensure that EPA's regulations may be implemented with minimal impact on reliability of the electric grid. Both DOE and EPA participated in FERC's Technical Conference on Reliability in November 2011. Additionally, FERC has recently issued a staff-written white paper (see FERC Docket #AD12-1, Jan 30, 2012) seeking comment on the Commission's role regarding implementation of MATS in accordance with EPA's Enforcement Policy Memorandum and the Presidential Memorandum released with MATS in December 2011. Most recently, DOE, EPA and FERC participated in the first NARUC/FERC Forum on Reliability at the NARUC Winter Meeting in February 2012.

DOE will continue to work with EPA, FERC and other agencies and stakeholders to seek ways to ensure that achieving compliance with EPA's regulations will not undermine the reliability of the nation's electric system.