CHALLENGE AND OPPORTUNITY: CHARTING A NEW ENERGY FUTURE

APPENDIX A:

WORKING GROUP REPORTS

MEMBERS OF THE SMART GRID WORKING GROUP

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REPORT OF THE SMART GRID WORKING GROUP

The proposals of the Smart Grid Working Group promise important economic, security, and environmental benefits by promoting substantial upgrades to the performance of the transmission and distribution network that connects electricity generators and consumers. A robust, secure electricity grid that can meet customers' ever-increasing demands is an essential foundation for the growth of our economy.

These proposals, outlined in detail below, contain three key elements: (1) a national vision statement of the capabilities that the 21st century electricity network should deliver, and a program of demonstration projects to field-test those new grid technologies on an expedited basis; (2) a robust set of technical performance standards addressing reliability, availability, security, and power quality as a benchmark for implementation; and (3) a 21st Century Electricity System Security and Modernization Fund and other federal and state incentives to stimulate investments in deployment of the new technologies by transmission and distribution facility owners to meet these new performance standards.

I. Why a Smart Grid?

As the U.S. economy has moved into the digital age, electricity's role as an enabler of economic productivity has become even more important. The transmission and distribution network forms the critical link between electricity generation and consumers. However, the technological sophistication of the electricity grid has not kept pace with the growing demand for high-quality, high-value services to end-users.

The potential benefits of an enhanced power delivery system are enormous. An upgraded grid can support the provision of important new services to consumers, including better ability to manage energy use and energy costs, and better support for use of distributed generation. A scenario prepared by the Electric Power Research Institute (EPRI) suggests that transformation of the power grid over the next 20 years could result in substantial increases in productivity and GDP growth, reduced carbon emission, and increased national security.

A. What is a "Smart Grid"?

The term "smart grid" refers to an electricity transmission and distribution system that incorporates elements of traditional and cutting-edge power engineering, sophisticated sensing and monitoring technology, information technology, and communications to provide better grid performance and to support a wide array of additional services to consumers. A smart grid is not defined by what technologies it incorporates, but rather by what it can do. The key attributes of the 21st century grid include the following:

- The grid will be "self-healing." Sophisticated grid monitors and controls will anticipate and instantly respond to system problems in order to avoid or mitigate power outages and power quality problems.

- The grid will be more secure from physical and cyber threats. Deployment of new technology will allow better identification and response to manmade or natural disruptions.

- The grid will support widespread use of distributed generation. Standardized power and communications interfaces will allow customers to interconnect fuel cells, renewable generation, and other distributed generation on a simple "plug and play" basis.

- The grid will enable consumers to better control the appliances and equipment in their homes and businesses. The grid will interconnect with energy management systems in smart buildings to enable customers to manage their energy use and reduce their energy costs.

- The grid will achieve greater throughput, thus lowering power costs. Grid upgrades that increase the throughput of the transmission grid and optimize power flows will reduce waste and maximize use of the lowest-cost generation resources. Better harmonization of the distribution and local load servicing functions with interregional energy flows and transmission traffic will also improve utilization of the existing system assets.

Without concerted action, the United States will not only forego these types of performance enhancements, but will also risk deterioration of the current system. In recent years, investment in transmission infrastructure, for instance, has steadily declined.

B. Reducing Customer Exposure to Costly Outages and Service Disruptions

The National Academy of Engineering has hailed the U.S. electrical system as the supreme engineering achievement of the 20th century because of its ubiquitous impact in improving the quality of life down to the household level. In the 21st century, its role as a key enabler of the digital society promises equally significant implications. However, the electricity system is in serious need of upgrading if the benefits of interconnection are to be fully realized at both commercial and individual consumer levels. The potential benefits of these grid upgrades are illustrated by the cost of power disturbances to today's economy: EPRI estimates that power outages and power quality disturbances cost businesses in the U.S. more than $120 billion a year.

The lack of critical infrastructure investment and the growing demand for high quality, digital-grade electricity has taxed the electrical infrastructure to its limit. Most credible forecasts predict that this underinvestment in the transmission system will continue. Additionally, microprocessor-based technologies have radically altered the nature of the electrical load, resulting in electricity demand that is incompatible with a power system created to meet the needs of an analog economy. This has led to unprecedented electricity reliability problems, as well as inadequate power quality responsible for tens of billions of dollars in losses to industry and society annually.

Technology upgrades in the areas of transmission system monitors, information systems, and power flow controls will enable the grid to be "self healing" – that is, grid controllers will collect diagnostic information about the grid in real time and will be able to use sophisticated controls to minimize the number of customers affected by any problems, and minimize the duration of any problems. A self-healing grid integrates real-time information from embedded sensors with distributed intelligence and automated control, enabling the system to respond automatically to disruptive events and attacks to the system. Development of a self-healing transmission and distribution system – capable of automatically anticipating and responding to disturbances, while continually optimizing its own performance – will be critical for meeting the future electricity needs of an increasingly digital society.

C. Increasing Security of the Electricity Infrastructure

In the current environment, the nation's concern about terrorism is heightened. The nation's electricity transmission and distribution system is one of the most essential parts of the country's infrastructure, because it supports and powers virtually every other sector of the economy. It is vitally important that the electricity grid be capable of real-time management and instant correction in order to minimize the risk of disruption and the time for recovery, if a terrorist attack on the system does occur. This will require the ability to monitor the status of the grid on a real-time basis, to instantly recognize and diagnose any unusual events on the system, and to respond intelligently with adaptive changes in power flows, generating unit operations, and load management.

The smart grid capabilities described above, including the use of real-time monitors, power flow control technology, and sophisticated communications and information technology, will allow grid controllers to rapidly identify and respond to grid problems caused by intentional damage to facilities or other forces. Sophisticated monitoring will give grid controllers the information needed to identify and assess multiple simultaneous problems on the grid in real time. Solid state power flow control devices and fast simulation computer systems will permit problem areas to be "islanded," limiting the size of the area where service is disrupted, and permit power flows to be redirected around damaged facilities.

D. Supporting Widespread Use of Distributed Energy Resources

The new grid infrastructure must support easy, flexible use of distributed energy resources – fuel cells, microturbines, and renewable generation – in homes, offices and factories. Use of small-scale on-site generation (or storage) can be encouraged through the development of standardized interfaces for both power and communications systems. Such "plug and play" interfaces (similar to the standardized interfaces that allow computer and telecommunications equipment to be connected by consumers) will enable residential, commercial, and industrial customers to use distributed generation for self-generation or sales to the grid with a minimum of technical or regulatory difficulty. Standardized interfaces for both power and communications systems will avoid high costs associated with case-by-case engineering or safety analysis.

A grid that supports widespread interconnection and use of distributed generation by both suppliers and consumers will lead to improved reliability and power quality, reduced electricity costs, and greater customer choice and control. Moreover, use of distributed generation can produce important environmental benefits – distributed generation may reduce the need for construction of new transmission and distribution facilities, and some technologies (e.g., renewable energy resources, fuel cells) have emission and climate benefits relative to typical central station power plants.

E. Enabling Smart End-Use Energy Management

A smart grid will provide both communications and power to enable "smart" buildings, motors, appliances, and other "smart" loads through a customer portal – a set of devices and software that enables intelligent equipment within a facility to communicate with other systems over a wide area access network. Simple, effective interfaces between the grid and the energy management systems of buildings and other loads will enable residential, commercial, and industrial consumers to manage electricity use in a manner that improves efficiency and reduces consumer energy costs, while at the same time enhancing customer control of electrical equipment. Grid-related communications capabilities will allow customers to schedule energy use to take advantage of real-time electricity pricing, incentive-based load reduction signals, or emergency load reduction signals. For example, sophisticated space conditioning equipment will be able to receive a variable electricity price signal and automatically adjust the air conditioning or heating to effectively reduce peak loads and maintain comfort.

Smart grid capabilities are even more valuable to customers who have both energy management systems and distributed generation resources interconnected to the grid. They will, for example, be able to reconfigure workplaces with a combination of fuel cells, energy management systems, and other technology advances to produce economic gains like those produced by the introduction of electricity a century ago.

F. Cost Savings Due to Greater Transmission Grid Throughput

Enhanced grid operation will give customers access to less expensive power sources. The smart grid will increase throughput on existing lines by providing more effective power flow control. This increased line capacity reduces congestion (which requires more expensive units to run instead of lower-cost units) and thereby lowers generation costs to consumers.

The ability to increase grid throughput (and the ability to support widespread distributed generation) also relieves pressure to site and build long-line transmission lines, thus avoiding the environmental and aesthetic problems caused by such projects.

G. Enabling Productivity and Jobs Growth in the Economy

The combined effect of all the benefits cited above is much more than just the sum of the parts. Just as the introduction of electricity to the nation's homes, offices, and factories a century ago transformed the way we live and work, a fundamental transformation of our electricity infrastructure will enable significant advances in the nation's growth and productivity. These changes can support dramatic new flexibility and benefits, just as the national highway system has transformed our transportation patterns, and the Internet and mobile phones have transformed our communications and business practices.

Electricity underpins every aspect of the modern economy. Yet we have allowed a lack of critical investment and surging demand for high quality, digital-grade electricity to stress the electrical infrastructure. There are tremendous potential economic and environmental benefits from the changes described above – from increasing power quality and reliability to homes and businesses, from implementing a secure, self-healing grid, from enabling widespread usage of fuel cells, renewable energy and other sophisticated energy management systems at customer sites, and from eliminating congestion bottlenecks through real-time dynamic management of the grid.

A scenario prepared by the Electric Power Research Institute (EPRI) suggests that transformation of the power grid over the next 20 years could support substantial increases in productivity and GDP growth rates, while at the same time reducing energy intensity and carbon emissions. These productivity and related improvements depend on a highly reliable digital power infrastructure in which workers can perform existing and completely new functions quickly, accurately and efficiently. In this sense, power reliability and quality are enabling technologies – they are necessary to unleashing and expanding the digital economy, and to achieving its manifold economic and quality-of-life benefits for the nation in the 21st century.

II. Proposal

To obtain the benefits of a smart grid, an aggressive research, development, demonstration, and deployment effort is needed. Deployment will be the biggest challenge, because deployment will require an extensive investment. The key, therefore, is to provide ample support and inducement for transmission and distribution facility owners to invest substantial resources in upgrading the performance of the grid using smart grid technologies.

To achieve these goals, the Smart Grid Working Group proposes a three-part program:

- A compelling vision statement and demonstration program for advanced grid technologies. The Department of Energy (DOE) should be charged with leading a multi-stakeholder process to expand and clarify the vision and goals statement for the future system, specifying in clear, customer-oriented perspectives the characteristics of the advanced electricity grid of the 21st century. To support this effort, DOE should conduct a regional and local program of demonstration projects in partnership with the private sector for early deployment of the new technology components of the smart grid throughout the country.

- National performance standards for the future electricity grid. To guide the private sector and the regulatory agencies in supporting investments in innovative technologies, an appropriate technical or reliability standards organization (e.g., the North American Electric Reliability Council) should be tasked with developing grid performance standards that, if implemented, will assure grid security, reliability, availability and power quality.

- A 21st Century Electricity System Security and Modernization Fund and other federal and state incentives to promote deployment of smart grid technologies. Installing these new technologies to meet the recommended performance standards will require investment of tens of billions of dollars. To support the initial deployment of these technologies, a trust fund like the Highway Trust Fund should be established. A process to design the new trust fund must include the participation of the federal and state governments, the industry, customers, and other key stakeholders. The resulting trust fund will have to meet standards of equity in both funding and spending, be competitively neutral, and include a sunset provision. In addition, regulatory policies at both the federal and state levels concerning transmission and distribution rates must provide adequate incentives for investments in innovative technologies.

A. Vision Statement and Demonstration Program for the 21st Century Grid

A key first step in the transformation of the U.S. electricity grid is the development of a widely shared vision and strategy for the grid of the 21st century – a clear and compelling statement for customers, regulators, and utilities of what the new, 'smart grid' is and what benefits it will provide. To support this vision, and to build widespread support and confidence in the component technologies, there should be a public-private partnership program of local and regional demonstration projects of these new, innovative grid technologies and systems.

Recommendation – Articulate a National Vision of the 21st Century Grid

The Working Group recommends that DOE coordinate a process involving the industry and labor, which will have to build and operate the new grid, and customer groups and other stakeholders, including public officials and regulators at local, state, and federal levels, to articulate a common vision and strategy for the grid and a clear statement of system requirements and benefits that will result.

Recommendation – Demonstration Program for Advanced Technologies

A public-private partnership program is needed to support early deployment and demonstration of these innovative technologies. The Department of Energy should coordinate this effort, with appropriate Congressional authorization and funding, in partnership with the utility industry, key customers, labor representatives, and local and state agencies. The demonstration projects will bring real benefits in power reliability, security, and system flexibility that will enhance local and regional economic development. The demonstration program would be designed to field-test the new technologies that will be the building blocks of the smart grid, train the labor force to install and work with these systems, and build a broad base of constituents who are familiar and comfortable with the new technologies and what they can do.

B. National Grid Performance Standards

Establishing a robust set of technical performance standards addressing reliability, availability, security, and power quality can provide an indirect means of fostering investment in innovative grid technologies, since federal and state authorities will turn to these standards in determining the proper measure to embody in pertinent regulations. In the electric power industry, standards bodies such as the North American Electric Reliability Council (NERC) and the Institute of Electrical and Electronics Engineers (IEEE) typically develop such technical standards.

The standards envisioned by the Working Group are performance standards, not technology specifications. This policy proposal is not based on any predetermination about which technologies are the most appropriate for further development or deployment. Those choices will need to be made on a case-by-case basis, with the investors' particular circumstances in mind. Instead, the development of performance standards is intended to specify what capabilities the grid is expected to have, in terms of interconnectivity with energy management systems and distributed resources, ability to respond promptly to facility problems, and to optimize throughput in normal operating conditions.

Thus, for example, a performance standard might require that the grid be able to meet particular performance standards exceeding those now in existence, or that performance be measured in a manner that is more appropriate to 21^{st} century needs. For example, System Average Interruption Frequency Indices (SAIFI) or System Average Interruption Duration Indices (SAIDI) are utilized in some jurisdictions today to measure performance, but higher levels of SAIFI and SAIDI - or a measure other than SAIFI and SAIDI – might be more appropriate for 21^{st} century needs. Some state regulations currently authorize deviations from the SAIFI and SAIDI within certain levels. Recalibrating these indices or requiring tighter deviation standards from existing indices would bolster system performance requirements. The national standards may build on existing state standards for quality of service.

Deployment of a smart grid may actually enable the cost-effective measurement of grid performance in a manner that is not feasible today. A smart grid will be more closely monitored and have an integrated communications backbone, allowing measurements to be made and reported in a manner that is not cost-effective today.

While the standards developed by NERC and IEEE are not binding as a matter of federal law,[1] they do carry great weight in shaping infrastructure planning within the industry. As importantly, state and federal rate regulators are very likely to support utility expenditures to bring its system up to new national performance specifications, thus facilitating recovery of costs through regulated rates. This approach of NERC-developed national performance standards avoids state-federal tensions that might be engendered by, for instance, the establishment of performance requirements in federal regulation.

These organizations use an expert-based consensus process to develop standards, enhancing the legitimacy within the industry of the standards that are developed. One consequence, however, is that the process for developing standards can be quite time-consuming. Also note that NERC activities, to date, have focused on transmission but not distribution issues.

Recommendation – Develop Grid Performance Standards

The Working Group proposes legislation that would encourage NERC to develop specifications for grid performance on a specified schedule (e.g., within 2 years), with input from the National Association of Regulatory Utility Commissioners and its members. Appropriations would be made available to fund the work by NERC. The model for the legislation would be the Congressional practice of requesting the National Academies to undertake analyses with appropriate funding.

NERC is fundamentally a transmission organization today, working with the regional reliability councils. It is possible that transmission performance standards may be developed readily through that established system of consensus. The development of distribution-level performance standards should be accomplished by the same body to ensure compatibility. NERC, however, may require time to develop collaborative, consensus-building models for working with states, utilities, and other stakeholders on distribution issues, and therefore may require more time to develop distribution system performance standards.

C. 21st Century Electricity System Security and Modernization Fund and Investment Incentives

To obtain the substantial economic and security benefits of widespread deployment of smart grid technologies throughout the nation will require tens of billions of dollars in capital investment in the nation's transmission and distribution systems. However, currently the owners of those systems are under financial pressure from their lenders and shareholders to limit spending and minimize cost exposure, and from regulators and

[1] Congressional energy legislation currently under consideration would transform NERC and give the standards it develops the force of federal law.

ratepayers to concentrate their investments in areas that resolve relatively near-term concerns.

Given these limitations, which will continue to confront the electricity sector for the foreseeable future, a major new investment vehicle must be developed to spur the deployment of the new, smart grid technologies and thereby deliver the longer-term economic and productivity benefits and jobs that will result from a transformed, 21st century electricity infrastructure for the nation. In many respects, this priority is analogous to the circumstances confronting the country in the 1950s when a national approach to financing the interstate highway system was adopted. That decisive event transformed the nation's transportation infrastructure and brought immense economic benefits to the country. We now need a National Electricity Superhighway and are proposing a parallel way to begin the investment to deploy it.

Various proposals for specific mechanisms to fund such a trust fund for the electricity infrastructure have been explored. These have included approaches such as: fees to electricity customers on the power delivered at the ultimate point of sale; fees on electricity transported through the transmission and distribution system; funds raised through emissions fees and auctions; monies raised by special government-backed financial instruments; and general government revenues.

The Working Group has not recommended any one specific mechanism for financing the 21st Century Electricity System Security and Modernization Fund, but rather recommends that the key government and stakeholder groups engage to develop the details of a program that will fulfill the goals of establishing and funding the trust fund that will benefit the nation. The recommendation below identifies some of the key issues of equity and administration that must be addressed in that process for the trust fund to ultimately be broadly supported and successful.

In addition, it is important that other regulatory and economic incentives also support the widespread deployment of smart grid technologies. In virtually all cases, rates for transmission and distribution are set pursuant to a cost-of-service regime, under which utilities are authorized to recoup investment costs and earn an allowed return by customarily seeking rate authority to reflect substantial new investments in transmission and distribution upgrades. Despite this authority, however, transmission investment levels have declined over the past two decades. Accordingly, the Working Group includes recommendations below regarding federal and state rate incentives.

Recommendation – 21st Century Electricity System Security and Modernization Fund

The Working Group recommends that a new funding mechanism be established in the form of a "21st Century Electricity System Security and Modernization Fund" to help support the costs of initial deployment of the new, smart grid technologies for the nation's electricity transmission and distribution system. The new smart grid system will bring great benefits to the nation in terms of energy reliability, homeland security, economic development, productivity, and jobs. The deployment costs, while dwarfed by the benefits, will also be significant, potentially running into tens of billions of dollars. Hence, this program requires a national priority and broad, public support for its initial deployment.

The Smart Grid Working Group recommends that federal and state governments work with the electricity industry, customers, and other stakeholders to develop a specific funding mechanism for the 21st Century Electricity System Security and Modernization Fund. These discussions should consider the full range of viable options, including a customer fee on electricity delivered at the ultimate point of sale, and broader-based general sources of government funding. The final decisions on a funding mechanism and on the design of the trust fund must meet a number of tests of equity and fiscal discipline, including the following:

- The funding mechanism for the trust fund must be equitable in raising funds from various government sources, customers, or other entities in some general proportion to the benefits that various stakeholders will ultimately receive from the new electricity infrastructure and associated economic gains;

- The funding mechanism for the trust fund should be competitively neutral (e.g., applying comparably to all ownership classes of utilities or utility customers, and to wholesale and retail market participants equitably);

- The funding flowing from the trust fund must be available to all types of owners of transmission and distribution facilities;

- The uses of the fund must be focused on the strategic investments needed to significantly improve the electricity infrastructure's security, reliability, and power quality for customers;

- The use of monies flowing from the trust fund should be overseen by appropriate State or local officials, so that investments reflect the local and regional needs of the system;

- The use of monies from this fund should not be impeded by regular budget and appropriations processes, so whatever funds are obtained for this purpose will be dedicated and fully available; and

- The trust fund must contain a sunset provision – its purpose is to support the initial deployment of the new technologies, not to serve as a permanent funding system.

Recommendation – Incentive rates at FERC for grid enhancement

FERC, either by direction of Congress or on its own initiative, should adopt ratemaking standards for jurisdictional transmission rates that provide incentives for investment in the transmission grid. If feasible, these incentives should be structured as performance-based rates, with a utility's return based on specified grid performance criteria. In areas where such performance measures cannot be developed, the policy could be framed as an incentive return on equity for grid investments, in the context of a rigorous evaluation of technology upgrades and demand-side options.

Both FERC and Congress have expressed recent interest in such incentive rates. FERC has recently proposed to adopt new rate incentives (1% added to return on equity) for investment in transmission facilities approved through a regional transmission organization's planning process. Pending energy legislation also includes a requirement that FERC conduct a rulemaking on incentive rates for transmission investments.

Recommendation – Incentive rates at State commissions for transmission and distribution system enhancement

State regulators should adopt ratemaking standards for the transmission and distribution components of rates under their jurisdiction that provide sufficient incentives for system enhancements reflecting innovative technologies, using performance-based rates keyed to meeting specified performance criteria where possible. Congress should enact a new federal rate standard through an implementation scheme similar to that adopted in the Public Utilities Regulatory Policy Act (PURPA), requiring each state to conduct a public proceeding to decide whether or not to adopt incentive rates for transmission and distribution system enhancements.