**ATTACHMENT A TESTIMONY OF SECRETARY ERNEST MONIZ, 03/22/21**

QER 1.1 and 1.2 Recommendations Related to Infrastructure Development

This memo summarizes a subset of recommendations from the first and second QERs that directly relate to clean energy infrastructure deployment and infrastructure resilience. An appendix includes the entirety of the recommendations from both QERs, color coded to highlight relevant recommendations included in this roll-up.

## QER 1.1: Transforming U.S. Energy Infrastructure in a Time of Rapid Change

### Increasing the Resilience, Reliability, Safety, and Asset Security of TS&D Infrastructure

- Develop comprehensive data, metrics, and an analytical framework for energy infrastructure resilience, reliability, safety, and asset security.
- Establish a competitive program to accelerate pipeline replacement and enhance maintenance programs for natural gas distribution systems.
- Support the updating and expansion of state energy assurance plans.
- Establish a competitive grant program to promote innovative solutions to enhance energy infrastructure resilience, reliability, and security.

### Smart Grid of the Future

- Provide grid modernization R&D, analysis, and institutional support.
- Conduct a national review of transmission plans and assess barriers to their implementation.
- Provide state financial assistance to promote and integrate TS&D infrastructure investment plans for electricity reliability, affordability, efficiency, lower carbon generation, and environmental protection.

### Improving Shared Transport Infrastructures

- Assess energy component transportation.

### Integrating North American Energy Markets

- Partner with Canada and the Arctic Council on energy delivery to remote areas.
- Promote Caribbean energy TS&D infrastructure.

### Addressing Environmental Aspects of TS&D Infrastructure

- Expand R&D programs at DOE on cost-effective technologies to detect and reduce losses from natural gas TS&D systems.
- Work with states to promote best practices for regulating and siting CO2 pipelines.
- Enact financial incentives for the construction of CO2 pipeline networks.

### Siting and Permitting of TS&D Infrastructure

- Allocate resources to key Federal agencies involved in the siting, permitting, and review of infrastructure projects.
- Prioritize meaningful public engagement through consultation with Indian Tribes, coordination with state and local governments, and facilitation of non-Federal partnerships.
- Enact statutory authorities to improve coordination across agencies.
- Adopt Administration proposals to authorize recovery of costs for review of project applications.

## QER 1.2 Transforming the Nation's Electricity System

- **Protect the Electricity System as a National Security Asset.**
    - Amend Federal Power Act authorities to reflect the national security importance of the Nation's electric grid.
    - Collect information on security events to inform the President about emergency actions, as well as imminent dangers.

- Adopt integrated electricity security planning and standards.
- Assess natural gas/electricity system infrastructure interdependencies for cybersecurity protections.

- **Increase Financing Options for Grid Modernization.**
  - Expand DOE's loan guarantee program and make it more flexible to assist in the initial deployment of innovative grid technologies and systems.
- **Increase Technology Demonstrations and Utility/Investor Confidence.**
  - Significantly expand existing programs to demonstrate the integration and optimization of distribution system technologies.

### Maximize Economic Value and Consumer Equity

- **Increase Electricity Access and Improve Electricity-Related Economic Development on Tribal Lands.**
  - Support the achievement of full tribal land electrification
  - Support advanced technology acceleration and economic development opportunities for tribal lands.
- **Strengthen Rural Electricity and Broadband Infrastructure.**
  - Leverage utility broadband build-out to expand public broadband access in rural areas
  - Increase opportunities for small and rural utilities to utilize the Department of Agriculture's electricity financing programs.

### Enable a Clean Electricity Future

- **Address a Range of Power Plant Siting Issues.**
  - Evaluate and develop generation-siting best practices
  - Modernize electricity transmission permitting procedures.

### Grid Operations and Planning for Electricity System Reliability, Security, and Resilience

- **Support Industry, State, Local, and Federal Efforts to Enhance Grid Security and Resilience.**
  - Develop uniform methods for cost-benefit analysis of security and resilience investments for the electricity system
  - Provide incentives for energy storage
  - Support grants for small utilities facing cyber, physical, and climate threats
  - Support mutual assistance for recovering from disruptions caused by cyber threats
  - Support the timely development of standards for grid-connected devices
  - Require states to consider the value of DER, funding for public purpose programs, energy and efficiency resource standards, and emerging risks in integrated resource or reliability planning under the Public Utility Regulatory Policies Act.
- **Encourage Cost-Effective Use of Advanced Technologies that Improve Transmission Operations.**
  - Promote deployment of advanced technologies for new and existing transmission.

### Enhancing Electricity Integration in North America

- **Increase North American Cooperation on Electric Grid and Clean Energy Issues.**
  - Increase U.S. and Mexican cooperation on reliability
  - Advance North American grid security
  - Modernize international cross-border transmission permitting processes.

# APPENDIX: Full Recommendations from Both QERs

The following are the full suite of recommendation from QER 1.1 and QER 1.2, color coded as follows:

- **Green**: directly related to supporting clean energy infrastructure deployment (including reducing emissions from fossil energy infrastructure)
- **Blue**: related to improving infrastructure resilience and reliability; when both resilience and clean energy deployment are relevant, the recommendation is color coded green
- **Gray**: may not be directly relevant to clean energy infrastructure or resilience

## QER 1.1: Transforming U.S. Energy Infrastructure in a Time of Rapid Change

### Increasing the Resilience, Reliability, Safety, and Asset Security of TS&D Infrastructure

**Develop comprehensive data, metrics, and an analytical framework for energy infrastructure resilience, reliability, safety, and asset security.** DOE, in collaboration with the Department of Homeland Security and interested infrastructure stakeholders, should develop common analytical frameworks, tools, metrics, and data to assess the resilience, reliability, safety, and security of energy infrastructures.

**Establish a competitive program to accelerate pipeline replacement and enhance maintenance programs for natural gas distribution systems.** DOE should establish a program to provide financial assistance to states to incentivize cost-effective improvements in the safety and environmental performance of natural gas distribution systems through targeted funding to offset incremental costs to low-income households and funding for enhanced directed inspection and maintenance programs.

**Support the updating and expansion of state energy assurance plans.** DOE should undertake a multi-year program of support for state energy assurance plans, focusing on improving the capacity of states and localities to identify potential energy disruptions, quantify their impacts, share information, and develop and exercise comprehensive plans that respond to those disruptions and reduce the threat of future disruptions.

**Establish a competitive grant program to promote innovative solutions to enhance energy infrastructure resilience, reliability, and security.** DOE should establish a program to provide competitively awarded grants to states to demonstrate innovative approaches to TS&D infrastructure hardening and enhancing resilience and reliability. A major focus of the program would be the demonstration of new approaches to enhance regional grid resilience, implemented through the states by public and publicly regulated entities on a cost-shared basis.

**Analyze the policies, technical specifications, and logistical and program structures needed to mitigate the risks associated with loss of transformers.** As part of the Administration's ongoing efforts to develop a formal national strategy for strengthening the security and resilience of the entire electric grid for threats and hazards (planned for release in 2015), DOE should coordinate with the Department of Homeland Security and other Federal agencies, states, and industry on an initiative to mitigate the risks associated with the loss of transformers. Approaches for mitigating this risk should include the development of one or more transformer reserves through a staged process.

**Analyze the need for additional or expanded regional product reserves.** DOE should undertake updated cost-benefit analyses for all of the regions of the United States that have been identified as vulnerable to fuel supply disruptions to inform subsequent decisions on the possible need for additional regional product reserves.

**Integrate the authorities of the President to release products from regional petroleum product reserves into a single, unified authority.** Congress should amend the trigger for the release of fuel from the Northeast Home Heating Oil Reserve and from the Northeast Gasoline Supply Reserve so that they are aligned and properly suited to the purpose of a product reserve, as opposed to a crude oil reserve.

## Smart Grid of the Future

**Provide grid modernization R&D, analysis, and institutional support.** DOE should continue to pursue a multi-year, collaborative, and cost-shared research and development, analysis, and technical assistance program for technology innovation that supports grid operations, security, and management; and for analyses, workshops, and dialogues to highlight key opportunities and challenges for new technology to transform the grid.

**Establish a framework and strategy for storage and grid flexibility.** DOE should conduct regional and state analyses of storage deployment to produce a common framework for the evaluation of benefits of storage and grid flexibility, and a strategy for enabling grid flexibility and storage that can be understood and implemented by a wide range of stakeholders.

**Conduct a national review of transmission plans and assess barriers to their implementation.** DOE should carry out a detailed and comprehensive national review of transmission plans, including assessments on the types of transmission projects proposed and implemented, current and future costs, consideration of interregional coordination, and other factors. A critical part of this review should be to assess incentives and impediments to the development of new transmission.

**Provide state financial assistance to promote and integrate TS&D infrastructure investment plans for electricity reliability, affordability, efficiency, lower carbon generation, and environmental protection.** In making awards under this program, DOE should require cooperation within the planning process of energy offices, public utility commissions, and environmental regulators within each state; with their counterparts in other states; and with infrastructure owners and operators and other entities responsible for maintaining the reliability of the bulk power system.

**Coordinate goals across jurisdictions.** DOE should play a convening role to bring together public utility commissioners, legislators, and other stakeholders at the Federal, state, and tribal levels to explore approaches to integrate markets, while respecting jurisdictional lines, but allowing for the coordination of goals across those lines.

**Value new services and technologies.** DOE should play a role in developing frameworks to value grid services and approaches to incorporate value into grid operations and planning. It should convene stakeholders to define the characteristics of a reliable, affordable, and environmentally sustainable electricity system and create approaches for developing pricing mechanisms for those characteristics. The goal should be to develop frameworks that could be used by the Federal Energy Regulatory Commission, state public utility commissions in ratemaking proceedings, Regional Transmission Organizations in their market rule development, or utilities in the operation and planning of their systems.

**Improve grid communication through standards and interoperability.** In conjunction with the National Institute of Standards and Technology and other Federal agencies, DOE should work with industry, the Institute of Electrical and Electronics Engineers, state officials, and other interested parties to identify additional efforts the Federal Government can take to better promote open standards that enhance connectivity and interoperability on the electric grid.

**Establish uniform methods for monitoring and verifying energy efficiency.** Through its Uniform Methods Project, DOE should accelerate the development of uniform methods for measuring energy savings and promote widespread adoption of these methods in public and private efficiency programs.

## Modernizing U.S. Energy Security Infrastructures in a Changing Global Marketplace

**Update SPR release authorities to reflect modern oil markets.** Congress should update SPR release authorities to allow the SPR to be used more effectively to prevent serious economic harm to the United States in case of energy supply emergencies.

**Invest to optimize the SPR's emergency response capability.** DOE should analyze appropriate SPR size and configuration, and, after carrying out detailed engineering studies, DOE should make infrastructure investments to the SPR and its distribution systems to optimize the SPR's ability to protect the U.S. economy in an energy supply emergency.

**Support other U.S. actions related to the SPR and energy security infrastructures that reflect a broader and more contemporary view of energy security.** The United States should continue to consult with allies and key energy trading partners on energy security issues, building on the G-7 principles on energy security.

**Support fuels diversity through research, demonstration, and analysis.** DOE and the Department of Defense should continue research and demonstration activities to develop biofuels that are compatible with existing petroleum fuel infrastructure, especially in aviation and for large vehicles. DOE should provide technical support to states, communities, or private entities wishing to invest in infrastructure to dispense higher-level ethanol blends. DOE should ensure adequate support for data collection and analysis on fuels, like propane, that play an important role in the Nation's diverse energy mix and where delivery is challenged by changing TS&D infrastructures.

**Undertake a study of the relationship between domestic shipping and energy security.** The relevant agencies should conduct a study of the economic, engineering, logistics, workforce, construction, and regulatory factors affecting the domestic shipping industry's ability to support U.S. energy security. The Secretary of Transportation should ensure that the National Maritime Strategy includes a consideration of the energy security aspects of maritime policy in its discussion and recommendations.

## Improving Shared Transport Infrastructures

**Enhance the understanding of important safety-related challenges of transport of crude oil and ethanol by rail and accelerate responses.** Key activities at DOE and DOT should be strongly supported.

**Further analyze the effects of rail congestion on the flow of other energy commodities, such as ethanol and coal.** DOE, STB, and the Federal Energy Regulatory Commission should continue to develop their understanding of how rail congestion may affect the delivery of these energy commodities.

**Analyze the grid impacts of delayed or incomplete coal deliveries.** In assessing these issues, DOE and other relevant agencies should examine whether a minimum coal stockpile for electricity reliability should be established for each coal-fired unit.

**Address critical energy data gaps in the rail transport of energy commodities and supplies.** Congress should fund the President's FY 2016 Budget Request for the EIA to address critical energy transportation data gaps and continued data sharing with the STB.

**Support alternative funding mechanisms for waterborne freight infrastructure.** The Administration should form an ongoing Federal interagency working group to examine alternative financing arrangements for waterborne transportation infrastructure and to develop strategies for public-private partnerships to finance port and waterway infrastructure.

**Support a new program of competitively awarded grants for shared energy transport systems.** A new grant program—Actions to Support Shared Energy Transport Systems, or ASSETS—should be established and supported at DOT, in close cooperation with DOE. This program should be dedicated to improving energy transportation infrastructure connectors. A Federal investment in ASSETS would likely mobilize additional and significant non-Federal investment, based on typical TIGER cost shares.

**Support public-private partnerships for waterborne transport infrastructure.** Developing a set of shared priorities for investment ensures that public and private sector needs are met.

**Coordinate data collection, modeling, and analysis.** DOE should lead an interagency effort with DOT, the Department of Agriculture, the Army Corps of Engineers, and the Coast Guard—in cooperation with other relevant agencies with data regarding marine, rail, and other energy transport modes—to improve and coordinate their respective data collection, analytical, and modeling capabilities for energy transport on shared infrastructures.

**Assess the impacts of multi-modal energy transport.** DOE, working with DOT and the Army Corps of Engineers, should conduct a one-time comprehensive needs assessment of investment needs and opportunities to upgrade the Nation's energy-related shared water transport infrastructure.

**Assess energy component transportation.** DOE, in coordination with relevant agencies, should examine routes for transportation of energy system-related equipment, materials, and oversized components. The assessment would include the capacity of the Nation's transportation infrastructure systems to safely accommodate more frequent and larger shipments where analyses indicate such transport will be required.

## Integrating North American Energy Markets

**Continue advances that have been made in the North American energy dialogue.** The United States, Canada, and Mexico should encourage further business exchanges and regular minister-level engagement.

**Increase the integration of energy data among the United States, Canada, and Mexico.** Provide resources for the EIA to collaborate with its Canadian and Mexican counterparts to systematically compare their respective export and import data, validate data, and improve data quality. In addition, efforts should be taken to better share geographic information system data to develop energy system maps and review forward-looking assessments and projections of energy resources, flows, and demand.

**Undertake comparative and joint energy system modeling, planning, and forecasting.** Enhance comparative and joint modeling, planning, and forecasting activities among U.S., Canadian, and Mexican energy ministries and related governmental agencies. The current scale of activities has aided bilateral and individual goals; however, increasing trilateral engagement on planning, modeling, or forecasting activities would capture greater efficiencies and enhance each country's ability to reach economic, security, and environmental goals. DOE's Offices of Energy Policy and Systems Analysis and International Affairs would lead modeling workshops with their Canadian and Mexican counterparts to share methodologies and collaborate on North American analysis.

**Establish programs for academic institutions and not-for-profits to develop legal, regulatory, and policy roadmaps for harmonizing regulations across borders.** In partnership with universities, qualified not-for-profits, and relevant U.S. energy regulatory authorities, state/provincial, local, and national energy regulations will be compared to identify gaps, best practices, and inconsistencies with regulations in Canada and/or Mexico with the goal of harmonization.

**Coordinate training and encourage professional interactions.** This should involve the technical staff in government agencies of the three North American countries that share similar responsibilities to evaluate and implement cross-border energy projects.

**Partner with Canada and the Arctic Council on Arctic energy safety, reliability, and environmental protection.** Joint work should emphasize research and information sharing on the effects of spills and the effectiveness of countermeasures, the identification and mobilization of the resources necessary to mitigate the effects of a pollution incident, and the development of international guidelines for preparedness and response in this logistically challenging region.

**Partner with Canada and the Arctic Council on energy delivery to remote areas.** This should be done through promoting and disseminating the work of the Remote Community Renewable Energy partnership.

**Promote Caribbean energy TS&D infrastructure.** As part of a larger Caribbean strategy, the United States should support the diversification of energy supplies, including actions to facilitate the introduction of cleaner forms of energy and development of resilient energy TS&D infrastructure in the Caribbean.

## Addressing Environmental Aspects of TS&D Infrastructure

**Improve quantification of emissions from natural gas TS&D infrastructure.** Congress should approve the $10 million requested in the FY 2016 Budget to help update Greenhouse Gas Inventory estimates of methane emissions from natural gas systems. DOE and EPA should undertake a coordinated approach, building on stakeholder input, to ensure that new research and analysis is targeted toward knowledge gaps unaddressed by other researchers.

**Expand R&D programs at DOE on cost-effective technologies to detect and reduce losses from natural gas TS&D systems.** DOE should leverage its R&D efforts in this area to facilitate broader air quality benefits.

**Invest in R&D to lower the cost of continuous emissions monitoring equipment.** To further improve safety and reduce emissions from natural gas systems, additional R&D—as proposed in the FY 2016 Budget—is needed to reduce costs and enable deployment of continuous emissions monitoring technologies.

**Support funding to reduce diesel emissions.** To protect workers and nearby communities through further reductions in diesel particulate matter emissions from ports and rail yards, the Administration proposed, and Congress should provide, funding for the Diesel Emissions Reduction Act and other related programs.

**Collaborate on R&D on the beneficial use and/or disposal of dredging material.** The Army Corps of Engineers and other appropriate Federal agencies should undertake collaborative R&D on treating and then either beneficially using or disposing of dredging material.

**Improve environmental data collection, analysis, and coordination.** DOE should work with other Federal agencies to improve data and analysis on the environmental characteristics and impacts of TS&D infrastructures.

**Work with states to promote best practices for regulating and siting CO2 pipelines.** Building on successful state models for CO2 pipeline siting, DOE, in cooperation with Federal public land agencies, should take a convening role to promote communication, coordination, and sharing of lessons learned and best practices among states that are already involved in siting and regulating CO2 pipelines or that may have CO2 pipeline projects proposed within their borders in the future.

**Enact financial incentives for the construction of CO2 pipeline networks.** Congress should enact the Administration's proposed Carbon Dioxide Investment and Sequestration Tax Credit, which would authorize $2 billion in refundable investment tax credits for carbon capture technology and associated infrastructure (including pipelines) installed at new or retrofitted electric generating units that capture and permanently sequester CO2.

## Enhancing Employment and Workforce Training

**Support an energy-job skills training system through the interagency Skills Working Group.** The training system should include new curricula, apprenticeship programs, industry-based credentialing standards, and innovative online learning systems.

**Expand support for an open-source learning community to develop, facilitate, and expand use of state-of-the art courses in energy-related fields.** These efforts should work to maintain and improve the National Training and Education Resource platform.

**Coordinate efforts to accelerate the development of high-quality energy and manufacturing curricula and apprenticeship programs.** DOE should coordinate with existing Department of Labor and National Science Foundation programs.

**Facilitate national credentials for energy occupations.** DOE should support and facilitate an industry-led process of defining needed skills in a number of emerging occupations.

**Facilitate the transition of military veterans into the energy sector.** DOE should work with the Departments of Labor and Defense and stakeholders to standardize the applicability of Military Occupation Codes to civilian jobs in energy sectors.

**Establish an interagency working group to reform existing energy jobs data collection systems.** DOE should convene a group with the Departments of Labor and Commerce to provide complete and consistent definitions and quantification of energy jobs across all sectors of the economy.

## Siting and Permitting of TS&D Infrastructure

**Allocate resources to key Federal agencies involved in the siting, permitting, and review of infrastructure projects.** Federal agencies responsible for infrastructure siting, review, and permitting have experienced dramatic appropriations cuts and reductions in staff. Many of the components of the overall effort to improve

the Federal siting and permitting processes have been stymied in recent years by appropriations shortfalls. Congress should fully fund these priorities.

**Prioritize meaningful public engagement through consultation with Indian Tribes, coordination with state and local governments, and facilitation of non-Federal partnerships.** Early and meaningful public engagement with affected residential communities, nonprofit organizations, and other non-Federal stakeholders through the NEPA process and other forums can reduce siting conflicts. Federal agency coordination with state and local governments and government-to-government consultation with affected Indian Tribes should remain a Federal Government priority. When possible, Federal agencies should co-locate energy infrastructure environmental review and permitting staff from multiple Federal agencies' regional and field offices.

**Expand landscape- and watershed-level mitigation and conservation planning.** When adverse impacts to the Nation's landscape cannot be avoided or minimized any further, Federal agencies should seek innovative approaches to compensate for adverse project impacts commensurate with the scope and scale of the project and effects to resources. Through mitigation planning at a landscape, ecosystem, or watershed scale, agencies can locate mitigation activities in the most ecologically important areas.

**Enact statutory authorities to improve coordination across agencies.** Congress should authorize and fund the Interagency Infrastructure Permitting Improvement Center in DOT, as set forth in Section 1009 of the Administration's draft legislation for the GROW AMERICA Act.

**Adopt Administration proposals to authorize recovery of costs for review of project applications.** Consistent with the proposal in the President's FY 2016 Budget Request, additional flexibility for certain agencies to accept funds from applicants would be appropriate and could expedite the Federal permitting and review process.

## QER 1.2 Transforming the Nation's Electricity System

1. **Protect the Electricity System as a National Security Asset.** The Federal Power Act provides a statutory foundation for an electricity reliability organization to develop reliability standards for the bulk power system. Pursuant to this authority, the Federal Energy Regulatory Commission (FERC) has certified the North American Electric Reliability Corporation (NERC) as the electric reliability organization. Under this arrangement, NERC and FERC have put into place a comprehensive set of binding reliability standards for the bulk power system over the past decade, including standards on cybersecurity and physical security. However, the Federal oversight authority is limited: FERC can approve or reject NERC-proposed reliability standards, but it cannot author or modify reliability standards.

   The nature of a national security threat, however, as articulated in the Fixing America's Surface Transportation Act (FAST Act), stands in stark contrast to other major reliability events that have caused regional blackouts and reliability failures in the past. In the current environment, the U.S. grid faces imminent danger from cyber attacks, absent a discrete set of actions and clear authorities to inform both responses and threats. Widespread disruption of electric service because of a transmission failure initiated by a cyber attack at various points of entry could undermine U.S. lifeline networks, critical defense infrastructure, and much of the economy; it could also endanger the health and safety of millions of citizens. Also, natural gas plays an increasingly important role as fuel for the Nation's electricity system; a gas pipeline outage or malfunction due to a cyber attack could affect not only pipeline and related infrastructures, but also the reliability of the Nation's electricity system.

   - **Amend Federal Power Act authorities to reflect the national security importance of the Nation's electric grid.** Grid security is a national security concern—the clear and exclusive purview of the Federal Government. The Federal Power Act, as amended by the FAST Act, should be further amended by Congress to clarify and affirm the Department of Energy's (DOE's) authority to develop preparation and response capabilities that will ensure it is able to issue a grid-security emergency order to protect critical electric infrastructure from cyber attacks, physical incidents, electromagnetic pulses (EMPs), or geomagnetic storms. In this regard, Federal authorities should include the ability to address two-way flows that create vulnerabilities across the entire system. DOE should be supported in its development of exercises and its facilitation of the penetration testing necessary to fulfill FAST Act emergency authorities. In the area of cybersecurity, Congress should provide FERC with authority to modify NERC-proposed reliability standards—or to promulgate new standards directly—if it finds that expeditious action is needed to protect national security in the face of fast-developing new threats to the grid. This

narrow expansion of FERC's authority would complement DOE's national security authorities related to grid-security emergencies affecting critical electric infrastructure and defense critical electricity infrastructure. This approach would maintain the productive NERC-FERC structure for developing and enforcing reliability standards, but would ensure that the Federal Government could act directly if necessary to address national security issues.

- **Collect information on security events to inform the President about emergency actions, as well as imminent dangers.** DOE should collect targeted data on critical cyber, physical, EMP, and geomagnetic disturbance events and threats to the electric grid to inform decision making in the event of an emergency or to inform the anticipatory authorities in the FAST Act. DOE should concurrently develop appropriate criteria, processes, and definitions for collecting these targeted data using a dedicated information protection program to safeguard utility data consistent with FERC rules. Reporting will be done on a confidential basis. Updating will be required to address evolving threats. DOE will coordinate the development of analytical data-surveillance and data-protection tools with the National Labs, states, universities, industry, Federal agencies, and other organizations as appropriate.

- **Adopt integrated electricity security planning and standards.** FERC should, by rule, adopt standards requiring integrated electricity security planning on a regional basis to the extent consistent with its statutory authority. Such requirements would enhance DOE's effectiveness in carrying out its responsibilities and authorities to address national security imperatives and new vulnerabilities created by (1) two-way flows of information and electricity and (2) the transactive role of customers and key suppliers (such as those providing stored fuel for strategic generators). Important national security considerations warrant careful consideration of how generation, transmission, distribution, and end-user assets are protected from cybersecurity risks. Vulnerabilities of distribution and behind the-meter assets, which may provide an increasing number of potential entry points for access to utility control systems, are threats that can adversely affect the operation of the transmission system; for these vulnerabilities, a careful review of protections is required. To adequately address and support the security requirements of the FAST Act and DOE's implementation of the FAST Act, this review should be performed on an integrated basis, rather than separating the review into bulk power system and other assets.

  To ensure that there are no unnecessary vulnerabilities associated with state-to-state or utility-to utility variations in protections, integrated electricity security planning should be undertaken to cover the entire United States, including Alaska, Hawaii, and U.S. territories. FERC should consider having existing regional organizations undertake such planning, as it deems appropriate. FERC should evaluate whether the costs of implementing security measures identified in the integrated electricity security plan are appropriate for regional cost allocation, where such measures are found to enhance the security of the regional transmission electric system.

  To the extent necessary, appropriate statutes should be amended to clearly authorize FERC to adopt such integrated electricity security planning requirements. However, FERC should immediately begin to advance this initiative to the maximum extent possible under its current authority by initiating a dialogue, including discussions with DOE and state authorities, and driving consensus on integrated electricity security plans.

- **Assess natural gas/electricity system infrastructure interdependencies for cybersecurity protections.** DOE, pursuant to FAST Act authorities and in coordination with FERC, should assess current cybersecurity protections for U.S. natural gas pipelines and associated infrastructure to determine whether additional or mandatory measures are needed to protect the electricity system. If the assessment concludes that additional cybersecurity protections—including mandatory cybersecurity protocols—for natural gas pipelines and associated infrastructure are necessary to protect the electricity system, such measures and protocols should be developed and implemented. This work should build on existing assessments, including those underway at the Transportation Security Administration.

2. **Increase Financing Options for Grid Modernization.** Estimates of total investment requirements necessary for grid modernization range from a low of about $350 billion to a high of about $500 billion. Grid modernization is the platform for the 21st-century electricity system, bringing significant value associated with lower electricity bills due to fuel and efficiency savings, more electricity choices, and fewer and shorter

outages. The Federal Government currently plays a role in providing tax incentives for deployment of clean energy technologies, as well as Federal credit assistance to facilitate early deployment of innovative technologies.

- **Expand DOE's loan guarantee program and make it more flexible to assist in the initial deployment of innovative grid technologies and systems.** The design of the current DOE loan guarantee program is focused primarily on financing deployment of innovative generation technologies. Most DOE loan guarantee recipients, for example, are structured as special project entities that can raise equity outside of regulated business structures and can provide credit security in the form of power purchase agreements. This financing model is not amenable to grid modernization financing by regulated entities, especially in cases of some technological uncertainty associated with initial commercial deployments. In addition, there will be an ongoing need for innovation in grid technologies beyond the likely availability of current DOE loan guarantee authority. Also, the limitations of the loan program restrict the program to a very small and ever-changing portion of new transmission capacity; more projects and innovation are necessary to transform the grid.

  Modifications to the current DOE Title XVII Loan Guarantee Program are needed to (1) reduce restrictions on numbers/types of projects and time frames (e.g., in order to adequately address innovative transmission capacity needs) and (2) provide clear statutory authority for lending to other public or public/private entities that support transmission and other grid modernization projects (e.g., state agencies, regional power pools) through on-lending or equity investing. By their nature, transmission projects, especially big projects, involve many entities and jurisdictions. Statutory clarification is needed on indirect lending authorities to such entities for multi-jurisdictional projects.

  Some of the benefits of grid modernization will be realized over time as the electricity system itself is changed by technology and market innovations. Additional funding resources would bridge the gap between investment costs and realization of benefits and would enable utilities to invest in grid modernization. A relatively low-cost, permanent Federal financing system could be established by setting up a revolving loan fund with one-time seed capital.

3. **Increase Technology Demonstrations and Utility/Investor Confidence.** The future electric grid will require that utilities deploy a wide range of new, capital-intensive technologies. Primary technologies are needed to support increased reliability, security, value creation, consumer preferences, and system optimization and integration at the distribution level. Demonstrating the technical readiness and economic viability of advanced technologies is needed to inspire the confidence of utilities and investors.

   - **Significantly expand existing programs to demonstrate the integration and optimization of distribution system technologies.** The complexity of the issues facing distribution systems— including new technologies, the need for systems approaches, and geographical differences in markets and regulatory structures—points to a significant need for multiple "solution sets" to enable two way electricity flows on distribution systems, enhance value, maximize clean energy opportunities, optimize grid operations, and provide secure communications. Building on existing demonstration programs and reflecting the Administration's commitment to the doubling of Federal clean energy innovation over 5 years as part of its Mission Innovation initiative, DOE should develop a focused, cost-shared program for qualifying utilities to demonstrate advanced distribution system technologies at the community scale, including advanced voltage control/optimization systems; dynamic protection schemes to manage reverse power flows, communications, sensors, storage, switching, and smart inverter networks; and advanced distribution-management systems, including automated substations.

     Demonstrations supported by the cost-shared, cooperative agreement program would be specifically designed to inform standards and regulations and increase regulatory and utility confidence in key technologies or technology systems. Under this program, utilities would have to make a positive business case for projects and obtain regulatory approvals for their proposed demonstrations. Preference would be given to multi-utility partnerships with diverse customer profiles and to projects that promote education and training in key academic disciplines that are essential for distribution system transformation. Cybersecurity plans for all projects would be required and supported by programmatic review of plans and deployments.

     Existing DOE programs, including advanced distribution-management systems, microgrids, communications and sensors, storage, and cybersecurity, should be leveraged to provide technical

assistance regarding technological issues, planning and performance evaluation, and institutional needs. A percentage of funding could be dedicated to small, publicly owned utilities. The program should be of sufficient size to have a material impact; it should start in fiscal year 2018 and be ramped up over the time period identified in the Mission Innovation initiative.

4. **Build Capacity at the Federal, State, and Local Levels.** The 21st-century electricity system is becoming increasingly transactive, and properly valuing attributes is key to an efficient system. Application of lessons learned that pair economic and system analysis will lead to a power system that cost-effectively serves customers while providing nationally valued public goods (e.g., reliability, resilience, and acceptable environmental performance).

   Advances in electricity technologies (i.e., smart grid processes and solutions) require enhanced capabilities in human resources to ensure the cost-effective selection, deployment, and operations of key technologies.

   - **Provide funding assistance to enhance analytical capabilities in state public utility commissions and improve access to training and expertise for small and municipal utilities.** Federal support should be provided to states and small utilities to enable them to better manage the increasing complexities in the electricity system, such as integrating variable energy resources; incorporating energy efficiency, demand response (DR), and storage into planning; developing competencies in various technologies; and making investment and security decisions within uncertain parameters. These issues are highly technical and require a new knowledge base and skillset often within the domain of computer sciences, economics, and cybernetics. At the same time, these entities are dealing with the workforce issues of outside recruitment or retirement across the electricity industry, which are referenced in the QER 1.2. DOE should build and cultivate much-needed analytical capacity at the state level over a limited period of time by allocating funding to state public utility commissions to allow them to hire new or train existing analysts with more sophisticated and advanced skills and build institutional knowledge. Eligibility for state and local funding should be contingent upon demonstration of consideration for integrated system planning, which is outlined in Chapter VII (A 21st-Century Electricity System: Conclusions and Recommendations). DOE should support these analysts through an online interactive education and training platform with access to nationally recognized experts. This platform would also be available and tailored to the needs of small utilities. On a national scale, these actions will serve to sustain system reliability and security and bolster resilience.

   - **Create a Center for Advanced Electric Power System Economics.** DOE should provide 2 years of seed funding for the formation of a center designed to provide social science advice and economic analysis on an increasingly transactive and dynamic 21st-century electricity system. The center should be modeled after the National Bureau of Economic Research and be managed by a university consortium. The consortium will establish and maintain a network of experts in economics, the social sciences, and the electricity system; these experts should be from academia, industry, nonprofit institutions, and the National Laboratories. The center will develop new methods where appropriate, serve as advisor and consultant to stakeholders preparing germane analyses, and foster the advancement of students and professionals who are developing expertise in these disciplines. The focus of the center will include power systems evaluation (e.g., valuation, benefit-cost, and competition analysis).

5. **Inform Electricity System Governance in a Rapidly Changing Environment.** The rapid rate of change in the electricity sector today often exceeds the ability of institutions and governance structures to respond in a manner sufficient to meet critical national goals and objectives. This is particularly true in the resolution of jurisdictional disputes over responsible price formation and valuation. Clarification and harmonization of roles and responsibilities for developing pricing can reduce market uncertainty, facilitate the achievement of policy goals, and reduce costs to ratepayers.

   - **Establish a Federal Advisory Committee on Alignment of Responsibilities for Rates and Resource Adequacy.** DOE, in collaboration with the National Association of Regulatory Utility Commissioners, should convene a Federal advisory committee that reports to the Secretary or the Secretary's designee to examine potential jurisdictional concerns and issues associated with harmonizing wholesale and retail rates and tariffs. This advisory committee will evaluate and make recommendations (where appropriate) on the way in which the organized markets reflect state policy; pricing mechanisms for maintaining resource adequacy; state and Federal roles in pricing and operation of DER, storage, and

microgrids; the role of aggregators; and mechanisms for implementing consumer protection across the various markets and jurisdictions. The advisory committee will represent a broad cross-section of industry and stakeholders. An annual report will be prepared by this advisory committee for the Secretary that identifies the impact of governance issues and recommends solutions.

In the remainder of this summary, we highlight a few recommendations from a much more extensive set in the full report.

## Maximize Economic Value and Consumer Equity

**Tailor and Increase Tools and Resources for States and Utilities to Effectively Address Transitions Underway in the Electricity System.** States and electric utilities are responsible for making critical decisions regarding how to improve the reliability, affordability, and sustainability of the electric grid, and officials from state agencies and utilities provided comments as part of the QER stakeholder process on the Federal role in informing these decisions. Technical assistance, improved regional consideration in program offerings, and new analysis for decision making will allow the Federal Government to respond to the needs of states and utilities in ensuring consumer value and equity in the electricity system of the 21st century. Recommendations include the following:

- Improve energy management and DR in buildings and industry
- Increase Federal support for state efforts to quantitatively value and incorporate energy efficiency, DR, distributed storage, and distributed generation into resource planning.

**Expand Federal and State Financial Assistance to Ensure Electricity Access for Low-Income and Underserved Americans.** Analysis indicates that electricity costs represent a disproportionate share of total income for low-income Americans. Increased funding for proven, state-administered programs and enhanced data and tools for targeting assistance can reduce this "electricity burden." Ensuring that the costs of the rapid transition of the electricity system are not disproportionately borne by low-income Americans is a top priority; low-income Americans should also be able to share in the benefits from an electricity system transition. Recommendations include the following:

- Encourage public-private partnerships to underwrite and support clean energy access for low- and moderate-income households
- Provide assistance to address rural, islanded, and tribal community electricity needs.

**Increase Electricity Access and Improve Electricity-Related Economic Development on Tribal Lands.** The interdependencies of electricity access, health, economic wellbeing, and quality of life underscore the importance of universal access to electricity. While recent data on electricity access on tribal lands is limited, there are still areas that lack adequate access to electricity despite the Nation's commitment to full electrification dating back to the Rural Electrification Act of 1936. More recent anecdotal evidence suggests that the problem broadly persists. It is a moral imperative that the Federal Government support tribal leadership and utility authorities to provide basic electricity service for the tens of thousands of Native Americans who currently lack access to electricity and to foster the associated economic development on tribal lands. Federal agencies should also support renewable energy acceleration and economic development opportunities through renewable energy incentives, workforce development, financing program improvements, and improved consultation with tribes. Recommendations include the following:

- Support the achievement of full tribal land electrification
- Support advanced technology acceleration and economic development opportunities for tribal lands.

**Strengthen Rural Electricity and Broadband Infrastructure.** The Federal Government has historically supported the expansion of access to affordable electricity and communications services in rural America, with major initiatives continuing today mainly through the Department of Agriculture. The lack of access to broadband in rural areas means that these consumers lack access to DR technologies, such as smart meters, smart thermostats, and other technologies that can reduce pollution, help consumers save electricity, improve overall grid resilience and reliability, and enhance economic development. Broadband expansion into these regions would significantly advance grid modernization goals, while providing significant communications, connectivity, and educational benefits to numerous regions of the country. Supporting broadband access in sparsely populated rural areas, many of which are low-income areas, is not, however, profitable for the private sector.

Federal support would help enhance security, environmental, and economic development goals. Recommendations include the following:

- Leverage utility broadband build-out to expand public broadband access in rural areas
- Increase opportunities for small and rural utilities to utilize the Department of Agriculture's electricity financing programs.

## Enable a Clean Electricity Future

**Transform the Electricity System through Leadership in National Clean Electricity Technology Innovation.** Private-sector investment in clean energy technology faces many barriers. For example, prices do not reflect the costs and benefits of clean energy, investments are made in a highly regulated environment, and there are high capital costs and the long time horizons for research and development (R&D) and capital stock turnover in comparison to many other sectors (e.g., information technology). Increased investments in electricity technology innovation is essential for transformation of the electricity system. Federal investments have a history of success and have been leveraged by the private sector to create significant economic value; case studies on nuclear energy, shale gas, and solar photovoltaic, among many other electricity-related technologies, demonstrate the instrumental role of Federal investment in early-stage R&D. Recommendations include the following:

- Significantly increase Federal investment in clean electricity research, development, and demonstration
- Implement Regional Clean Energy Innovation Partnerships.

**Address Challenges to Large-Scale, Centralized Clean Generation.** Regardless of the energy source, there are a number of challenges to deploying large, centralized power-generation facilities. Lower electricity prices, largely related to low-cost natural gas, are reducing the economic viability of other clean generation resources, especially nuclear energy. Nuclear power currently provides 60 percent of zero-carbon generation in the United States. Hydropower is one of the oldest and most established forms of electricity generation, contributing 6 percent of the electricity generated in the United States in 2015 and 19 percent of zero-carbon generation. Non-hydropower renewables—including wind, solar, geothermal, and biomass—accounted for about 7 percent of electricity generated in the United States in 2015. Each of these technologies faces a range of siting constraints, licensing and permitting processes, or environmental concerns, which can be broad and extensive; this can make new, large-scale deployments difficult—in some cases, taking a decade or more to build. A combination of Federal coordination, licensing support, analysis of financing opportunities, and research, development, and demonstration can help address these barriers. Recommendations include the following:

- Increase funding for the life-extension R&D program to ensure maximum benefits from existing nuclear generation
- Increase support for advanced nuclear technology licensing at the Nuclear Regulatory Commission
- Develop environmental mitigation technologies for hydropower.

**Address Significant Energy-Water Nexus Issues Affecting—and Affected by—the Electricity Sector.** Electricity systems and water systems are in many cases interconnected. Water is a critical requirement for many electricity-generation technologies. Two-thirds of total U.S. electricity generation—including many coal, natural gas, nuclear, concentrated solar power, and geothermal plants—requires water for cooling. In addition, carbon capture, utilization, and storage (CCUS) technologies have significant water demands. Electricity is also required for water and wastewater conveyance, treatment, and distribution. From a full-system perspective, the joint reliance of electricity and water systems can create vulnerabilities (e.g., drought impacts on thermoelectric generation and hydropower), but it can also create opportunities for each system to benefit from well-designed integration. Such challenges and opportunities can be addressed through improved policy integration; data collection; modeling; analysis; research, development, demonstration, and deployment; and engagement with stakeholders. Recommendations include the following:

- Launch an electricity-related Energy-Water Nexus Policy Partnership with Federal, state, and local partners.

**Provide Federal Incentives for a Range of Electricity-Related Technologies and Systems.** A package of tax incentives targeted at specific market segments can support an all-of-the-above energy strategy by helping to reduce the costs of deploying and using innovative, commercially available energy technologies. The economies of scale and "learning by doing" promoted by such deployments support continued technology cost reductions and greater market competition. Recommendations include the following:

- Expand the time frame and the total capacity allowed under the Production Tax Credit for nuclear generation
- Provide tax credits for CCUS
- Increase power purchasing authorities for the Federal Government from 10 to 20 years.

**Address a Range of Power Plant Siting Issues.** The land-use requirements for different types of power generation reflect significant differences between the various types of infrastructure and their operational requirements. Recommendations include the following:

- Evaluate and develop generation-siting best practices
- Modernize electricity transmission permitting procedures.

## Grid Operations and Planning for Electricity System Reliability, Security, and Resilience

**Support Industry, State, Local, and Federal Efforts to Enhance Grid Security and Resilience.** Some types of extreme weather events are projected to increase in frequency and intensity due to climate change. Cyber threats to the electricity system are increasing in sophistication, magnitude, and frequency. Physical threats remain a concern for industry. These challenges could be mitigated through a combination of cost-benefit analyses, standards, and collaboration across industry, state, local, and Federal stakeholders. The following recommendations build upon and extend current initiatives, such as DOE's Grid Modernization Initiative and Partnership for Energy Sector Climate Resilience. Recommendations include the following:

- Develop uniform methods for cost-benefit analysis of security and resilience investments for the electricity system
- Provide incentives for energy storage
- Support grants for small utilities facing cyber, physical, and climate threats
- Support mutual assistance for recovering from disruptions caused by cyber threats
- Support the timely development of standards for grid-connected devices
- Require states to consider the value of DER, funding for public purpose programs, energy and efficiency resource standards, and emerging risks in integrated resource or reliability planning under the Public Utility Regulatory Policies Act.

**Improve Data for Grid Security and Resilience.** As the Nation increasingly relies on electricity to power the economy and support consumer options and choices, the consequences of electricity outages are rising. The United States currently lacks sufficient data on all-hazard events and losses. Such data would help utility regulators, planners, and communities analyze and prioritize security and resilience investments. Recommendations include the following:

- Enhance coordination between Energy Sector Information Sharing and Analysis Centers and the intelligence communities to synthesize threat analysis and disseminate it to industry in a timely and useful manner.

**Encourage Cost-Effective Use of Advanced Technologies that Improve Transmission Operations.** Permitting and planning are necessary but complex processes that can slow transmission development and increase costs. Other barriers restrain the use of new technologies that can increase transmission system capacity utilization and improve reliability and security, as well as other planning priorities. Recommendations include the following:

- Promote deployment of advanced technologies for new and existing transmission.

**Improve the Energy Information Administration's (EIA's) Electricity Data, Modeling, and Analysis Capabilities.** EIA provides all levels of stakeholders—government, companies, and customers—with data to inform the evaluation and development of policies that affect the electricity grid. More timely and publicly accessible data on how system operations are changing and how efficiency and renewable energy are specifically affecting them would facilitate the development of Federal and state policies and investments needed to ensure the reliability, resilience, and security of the grid. Substantially improved electricity transmission data and related analyses by EIA would support significant improvements in the effectiveness of a broad range of government policies and programs, including market design and transmission planning. Recommendations include the following:

- Expand economic modeling capability for electricity
- Expand EIA data collection on energy end use
- Support EIA's collection of additional data on electricity and water flow for water and wastewater.

## Electricity Workforce of the 21st Century: Changing Needs and New Opportunities

**Support the Electricity Sector Workforce.** The electricity sector is undergoing a number of significant shifts in structure, energy sources, and applications as the industry modernizes and evolves. The full potential of these shifts, however, will only be realized if the electricity sector workforce appropriately adapts and grows to meet the needs of the 21st-century electricity system. The Federal Government has an interest in the development of this workforce. Recommendations include the following:

- Support cyber-physical systems curriculum, training, and education for grid modernization and cybersecurity
- Support Federal and regional approaches to electricity-workforce development and transition assistance.

**Meet Federal Commitments to Communities Affected by the Transformation of the Electricity Sector.** To achieve the transition to the electricity sector of the 21st century smoothly, quickly, and fairly, the Federal Government should offer a synthesized package of incentives that addresses the needs of the most important stakeholders both within and outside of the electricity sector. Many of these needs are addressed through other recommendations on this list, including incentives to reduce the cost of flexible and clean assets, encourage the deployment of new and improved technologies throughout the electricity supply chain, and train workers for 21st-century electricity jobs. Recognizing that the shift to the 21st-century electricity system can impact communities dependent on 20th-century resources, the following recommendations provide transition assistance for communities affected by the multi-decadal decline in coal production. Recommendations include the following:

- Meet the Federal commitment to appropriate sufficient funding to accomplish the mission of the Abandoned Mine Lands Fund.

## Enhancing Electricity Integration in North America

**Increase North American Cooperation on Electric Grid and Clean Energy Issues.** Electric reliability cooperation is needed to strengthen the security and resilience of an increasingly integrated cross-border electricity grid. A clear understanding of the regulatory requirements at the Federal and state levels for the permitting of cross-border transmission facilities, sharing of best practices, and exploration of potential future cooperation on grid security issues will limit uncertainties and improve policy coordination at the multilateral and international levels. Recommendations include the following:

- Increase U.S. and Mexican cooperation on reliability
- Advance North American grid security
- Modernize international cross-border transmission permitting processes.