Overview of the QER

Objectives

- **Integrated view** of short-, intermediate-, and long-term objectives for Federal energy policy.
- **Strong analytical basis** for decision-making.
- **Outline of legislative** proposals to Congress.
- **Executive actions** (programmatic, regulatory, fiscal, etc.) across multiple agencies.
- **Resource requirements** for RD&D and incentive programs.

Building on Previous Work

- **First installment (QER 1.1)** proposed 63 recommendations regarding transmission, storage, and distribution infrastructure.
- **21 recommendations fully or partially implemented into law** through bipartisan support in Congress.
- **16 state and national energy organizations** issued public statements of support.
- **More than 30 countries** received overview briefings.
Central Finding of QER 1.2

The electricity system is the enabler for accomplishing three key national goals: (1) improving the economy, (2) protecting the environment, and (3) increasing national security. As a critical and essential national asset, it is a strategic imperative to protect and enhance the value of the electricity system through modernization and transformation.
QUADRENNIAL ENERGY REVIEW | Second Installment

Framing National Goals

QER 1.1

National Security

QER 1.2

Ensure System Reliability, Security, and Resilience

Maximize Economic Value and Consumer Equity

Enable a Clean Electricity Future
With some of the lowest electricity prices in the developed world, the U.S. electricity sector supports the economic competitiveness of U.S. goods and services in both domestic and global markets.

Almost all economic sectors now rely, in varying degrees, on highly interconnected, data-driven, and electricity-dependent systems to manage operations and provide services.

Three electricity-reliant areas of the economy—online talent platforms, big-data analytics, and the Internet of Things—could increase GDP by as much as $2.2 trillion in 2025.
• The electricity system is the largest source of air emissions impacting public health; it is also one of the largest users of fresh water and the principal source of radioactive waste.
• The electricity system will likely play a significant role in the decarbonization of other sectors of the U.S. economy as electrification of transportation, heating, cooling, and industrial applications continues.

Global CO\textsubscript{2} Emissions and Probabilistic Temperature Outcomes

Source: Fawcett et al., 2015
“Assuring that we have reliable, accessible, sustainable, and affordable electric power is a national security imperative. Our increased reliance on electric power in every sector of our lives, including communications, commerce, transportation, health and emergency services, in addition to homeland and national defense, means that large-scale disruptions of electrical power will have immediate costs to our economy and can place our security at risk. Whether it is the ability of first responders to answer the call to emergencies here in the United States, or the readiness and capability of our military service members to operate effectively in the U.S. or deployed in theater, these missions are directly linked to assured domestic electric power.”

— Center for Naval Analysis, 2015
Federal Policy Shapes Electricity Generation

Findings

- Federal policies can shape investment decisions as much or more than fuel costs and technology development.

- This is currently evident with variable energy resources (VERs) increasing in both capacity additions and generation due to new technologies, cost reductions, and a range of state and Federal policies.

- Regional generation mixes vary significantly from the national generation profile.

<table>
<thead>
<tr>
<th>Source: Energy Information Administration, 2015</th>
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<tbody>
<tr>
<td>Atomic Energy Act</td>
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<td>Price Anderson Act</td>
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<td>PURPA &amp; Fuel Use Act</td>
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<td>Clean Air Act (CAA)</td>
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<td>EPA Act 1992</td>
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<td>PTC for Wind</td>
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<td>ITC for Solar</td>
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<td>CAA Section 111</td>
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<td>States Enact Renewable Portfolio Standards</td>
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<td>Wind</td>
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<td>Solar</td>
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<td>Other</td>
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North American Electricity Integration

**Findings**

- Trade has been increasing across the North American bulk power system, but cross-border flows, especially between Canada and the United States, are now using the full capacity of existing transmission infrastructure.

- U.S.-Canada cross-border electricity trade and coordination of operations, policy, and regulatory planning are extensive, mature, and efficient, as evidenced by the December 2016 *Joint U.S.-Canada Electric Grid Security and Resilience Strategy*.

- One model for power-sector collaboration across national borders is demonstrated by the reliability planning under NERC, but this engagement has been limited to Canada, the U.S., and the Baja California region of Mexico. Notably, Mexico’s ongoing electricity reform could have significant impacts on the future of cross-border integration.
Findings

- Over half of the 230 TWh of total non-hydro renewable electricity generation growth since 2000 was to meet RPS mandates.

- Building energy benchmarking and transparency policies have been implemented by 8 states and 14 cities.

- More than 20 state and Federal policies exist to incentivize the installation of PEV charging infrastructure.

- Net metering has contributed to the deployment of 12,300 MW of installed distributed PV in the U.S. as of Sept. 2016.
Findings

- The widespread integration of VERs at both utility scale and distributed across all consumer segments significantly expands the time dimensions in which grid operators must function and complicates operations.
- Dispatch effectiveness will require the integration of automated grid management with continuing human oversight as well as an increase in the granularity, speed, and sophistication of operator analytics.

System Reliability Depends on Managing Multiple Event Speeds

Source: von Meier, 2014
Findings

• The integration of variable renewables increases the need for system flexibility as the grid transitions from controllable generation and variable load to more variable generation and the need and potential for controllable load. There are a number of flexibility options such as demand response (DR), fast ramping natural gas generation, and storage.
• At high penetration levels, distribution system changes to enhance DER value to grid reliability will require development of advanced distribution circuits and substations that allow for two-way power flows, new protection schemes, and new control paradigms.

Utility-Scale PV Installed Capacity, Top 10 States, as of August 2016

- California: 7,190 MW_
- North Carolina: 1,741 MW_
- Arizona: 1,273 MW_
- Nevada: 951 MW_
- Utah: 566 MW_
- Georgia: 473 MW_
- New Jersey: 460 MW_
- Texas: 419 MW_
- New Mexico: 385 MW_
- Massachusetts: 350 MW_
- Rest of U.S.: 1,054 MW_

Source: Energy Information Administration, 2016
Increasingly Complex Electricity Systems

Findings

- Mitigation and response to cyber threats are hampered by fragmented information-sharing among utilities and with government, the lack of security-specific technological and workforce resources, and challenges associated with the need for multi-jurisdictional responses to threats and consequences.

- Key vulnerabilities include unpatched networks, unvetted vendor access, access to the public Internet, and insider threats.

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<tr>
<th>Many Forms</th>
<th>Incursion Marketplace</th>
<th>Hack Characteristics</th>
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<tr>
<td>Drive-by vs. sustained focus</td>
<td>Denial of service</td>
<td>Average time to detection is 188 days</td>
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<td>Every point is an entry point</td>
<td>Operational disruption</td>
<td>Ransom attacks on the rise</td>
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<td>“Callback dropper” — embedded empty vessel that pings the attacker ready to accept malware</td>
<td>Identity theft</td>
<td>In the long run, the chance of survival drops to zero</td>
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<tr>
<td>Botnets – networks of infected computers or zombie computers; force multipliers of the Dark Net</td>
<td>Ransoms</td>
<td>Use of cyber firing ranges (where simulations are run)</td>
</tr>
<tr>
<td>Pre-positioned assets, like nukes, in an all-out cyber war (sleeper cells)</td>
<td>Intelligence gathering</td>
<td>Piggy backing/use of Trojan horses to deliver payloads</td>
</tr>
</tbody>
</table>

Attacks on National Infrastructure
(Industrial control networks, electric power, telecom systems, and Internet itself)
Examples are illustrative, not comprehensive.
Electricity System Governance Issues

NERC Regions

RTOs/ISOs

FERC Planning Regions

PMAs

States

Munis

Co-ops

IOUs

Co-ops

IOUs

PMAs

Source: SNL Financial

Source: FERC

Source: Oak Ridge National Laboratory 2011

Source: FERC Planning Regions

Source: SNL Financial

Source: SNL Financial

Source: SNL Financial

Source: SNL Financial

Source: SNL Financial
Recommendation Overview

• The analysis conducted for QER 1.2 identified *integrated objectives* that address the needs and challenges to enable the electricity sector of the 21st century.

• Recommendations will provide the incremental building blocks for longer-term, planned changes and activities, undertaken in conjunction with state and local governments, policy-makers, industry and other stakeholders.

**QER 1.2 Proposes 76 Recommendations in Six Focus Areas**

- Key Crosscutting National Security and Reliability Priorities
- Maximize Economic Value & Consumer Equity
- Enable a Clean Electricity Future
- Ensure System Reliability, Security, and Resilience
- Electricity Workforce
- Enhancing Electricity Integration in North America
Accessing the QER

Electronic Version

www.energy.gov/qer