Linking QER 1.1 and 1.2
QER 1.1: 63 Recommendations

- Increasing Resilience, Reliability, Safety and Asset Security
- Modernizing the Electric Grid
- Modernizing US Energy Security Infrastructure
- Shared Transportation
- Integrating N. American Energy Markets
- Workforce
- Siting and Permitting
QER 1.1: Implementation

Implementation Breakdown:
- Executive Action
  - Existing authorities – 43
- Legislative Action (Congress)
  - New appropriation – 13
  - New statute – 10

Highlights:
- 12 recommendations are complete
- 21 recommendations are reflected in law following Congressional action
- $2 billion to modernize the Strategic Petroleum Reserve

QER 1.1 Implementation Report Card
- Provides detailed analysis of the QER’s 63 recommendations
- Assesses progress achieved in the time following the QER’s release
- Determines what additional actions are required for implementation to occur
QER 1.1 documented major transformation of Electricity Sector:

- Changing generation mix
- Low load growth
- Increasing vulnerability to severe weather/climate
- New technologies, services and market entrants
- Cyber/physical threats
- Aging infrastructure and workforce
- Growing overlap between jurisdictions

Given the centrality of electricity to the Nation, this transformation merits a closer examination in the next installment of the QER.
The QER 1.2 Focus

- **QER 1.2 will analyze how the electric power system as a whole is evolving, including:**
  - Integrating new technologies
  - Changing market conditions
  - Grid operations
  - Financing and valuing
  - Changing role of the customer
  - Jurisdictional challenges

- **Physical structures and the roles of a range of actors, institutions and industries:**
  - Maintaining reliability of supply
  - Ensuring electricity affordability
  - Adapting to dramatic changes in technology and services
  - Fuel choice
  - Distributed and centralized generation
  - Physical and cyber vulnerabilities
  - Federal, state, and local policy direction
  - Expectations of residential and commercial consumers
  - Reviewing existing and evolving business models for a range of entities, throughout the system
Stakeholder Meetings: energy.gov/qer

- State-Tribal QER Listening Sessions: NARUC, NASEO, NCSL, STEAB, ICEIWG
- Public Comments
National Academies Workshop:
Electricity Use in Rural, Isolated and Islanded Communities
February 2016

• Incorporating efficiency
• Increasing resilience, reliability
• Rate design
• Generation alternatives for CO2 reduction
• Technology and operational innovation
• Modernization of planning paradigm
• Transportation linkages to electricity system
• Microgrids

FIGURE 3 As of 2015, the Alaska Village Electric Cooperative serves more than 50 small communities dispersed across large distances and in remote regions with harsh climatic conditions. All of these factors contribute to average electricity prices approximately 5 times the U.S. national average. SOURCE: Modified from Meera Kohler, Alaska Village Electric Cooperative, “Alaska Village Electric Cooperative,” presentation to the workshop, February 8, 2016.
## Resources for Timely Answers to Analytical Questions

### Energy Policy Innovation Consortium: State Policy Actions

*State Policy Actions from 2008- June 2016*

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<tr>
<th>Categories:</th>
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<th>Resources:</th>
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<td>• Decoupling</td>
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<td>• Lost Revenue Adjustment Mechanisms (LRAM)</td>
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<td>• Net-metering and Stand-by Rates</td>
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<td>📝 State Clean Energy Actions Database</td>
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<td>• New Solar Tariff</td>
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<td>📝 NCSL (Energy &amp; Environmental and CPP Reactions)</td>
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<tr>
<td>• Straight Fixed Variable Rates</td>
<td></td>
<td>📝 F&amp;C stories (published and internally pitched)</td>
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<tr>
<td>• Performance Based Regulation (includes NY, HI, more comprehensive efforts)</td>
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<td>📝 States’ press release pages</td>
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<tr>
<td>• Performance Incentives for energy efficiency</td>
<td></td>
<td>📝 Executive Orders</td>
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<tr>
<td><strong>Energy System Resilience</strong></td>
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<td>📝 NASEO state news stories</td>
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<td>• State Resiliency Plans</td>
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<td>📝 Public Utilities Fortnightly</td>
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<td>• Cybersecurity Efforts</td>
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<td><strong>Energy Transmission and Distribution</strong></td>
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<td>• Smart Grid Initiatives</td>
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<td>• Microgrid Development</td>
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<tr>
<td>• Transmission Planning and Siting</td>
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<td>• Interconnection Standards</td>
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<td><strong>Energy Storage</strong></td>
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<tr>
<td>• Incorporate Storage into State Energy Resilience Planning</td>
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<td>• Require Utility Procurement of Energy Storage Capacity</td>
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<td>• Clarify storage’s treatment in the state utility regulatory process</td>
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<tr>
<td>• Incorporate storage into energy assurance efforts</td>
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<tr>
<td>• Promote research and development of energy storage</td>
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</table>
New York (38), Virginia (36), Oregon (35), California (34) and Maryland (30) have the most legislation, incentives, and policy directed at clean energy economic development.

**Establishing the Playing Field: Surveying Clean Energy-related Economic Development Policy across the States**

**Case Studies:**
- Nevada GigaFactory
- Oregon Pacific Northwest Manufacturing Partnership
- Maryland Clean Energy Center
State, Local, and Tribal Products

Breakdown of Alternative Energy References by State and Proportion of Municipalities by State to Reference at least One Alternative Energy Keyword
Front-Line Resilience Perspectives

Figure 4. Key Hazards and Vulnerabilities: Electric Power Distribution*

- Thunderstorms, tornadoes, and hurricane-force winds
- Storm surges, flooding, and increased precipitation
- Earthquakes
- Physical attacks
- Aging infrastructure
  - Ice, snow, and extreme cold weather
  - Increasing temperature and extreme hot weather
  - Cyber attacks
- Geomagnetic and Electromagnetic Pulses
- Capacity constraints
- Dependencies and supply chain interruptions

Distribution poles and lines carry electricity to end users

Distribution substation transformers step down voltage for distribution

Electricity received from Transmission system

Distribution control center monitors and manages local electricity

- Cyber attacks
- Human error
- Workforce turnover and loss of institutional knowledge
- Ice, snow, and extreme cold weather
- Thunderstorms, tornadoes, and hurricane-force winds
- Earthquakes
- Storm surges, flooding, and increased precipitation
- Increasing temperature and extreme hot weather
- Dependencies and supply chain interruptions

Electricity transmitted to Consumers

Local transformers step down voltage before it reaches the end user
State, Local, and Tribal Products

Principles and Frameworks for State Energy Resilience (w/ Case Studies)

Figure 2. Proposed State Energy Resilience Framework

Includes Case studies for:
- New York – Fuel New York
- California – Substations
- Oregon – Cascadia Fault
Electricity Emergency Response Capabilities

Figure 1: Local/Regional/National Restoration Escalation Process
Figure 8 (Left) – Resource Availability Summary, depicts regional differences for
- Bulk and Distribution outages
- Impacted customers
- Recovery resources

- Other Figures (Not Shown)
  - Table 12 Representative Catastrophic Events That Could Require a National-Level Response
  - Table 13 Resources and Restoration Time for Representative Catastrophic Events That Could Require a National Level Response
Policy Drives Generation Capacity Additions

Additions (GW) by Fuel Type, 1950-2015

- Coal
- Natural Gas
- Petroleum
- Biomass
- Nuclear
- Hydro
- Wind
- Solar
- Geothermal
- Other

DOE Org Act 1977
PTC for Wind
ITC for Solar 2006

21 states enact Renewable Portfolio Standards
Renewables Capacity Increasing, Costs Declining...

**Distributed Solar, 2008-2013:**
769% increase in capacity

**Utility Scale Solar, 2008-2013:**
1200% increase in capacity

**Utility Scale Wind, 2008-2013:**
245% increase in capacity

Sources: Department of Energy, Office of Energy Efficiency and Renewable Energy analysis, GTM, SEIA, LBNL, NREL
Top 10 Solar Generation States

Source: Energy Information Administration, September 2015
About 43 GW of capacity currently under construction in the United States (as of May 2016)

US capacity under construction: 43 GW

- Gas CC: 53%
- Wind: 18%
- Nuclear: 13%
- Solar: 9%
- Gas CT: 6%
- Other: 1%

Source: IHS and ABB Velocity Suite

US capacity under construction by region

- PJM
- Southeast
- ERCOT
- Mid-Continent
- West
- Northeast

Source: IHS and ABB Velocity Suite
### U.S. Power Plant Retirements, 1995-2025

#### 1996–05:
- Coal retirements: 4 GW
- Total retirements: 36 GW

#### 2006–15:
- Coal retirements: 43 GW
- Total retirements: 98 GW

#### 2016–25:
- Coal retirements: 43 GW
- Total retirements: 90 GW

QUADRENNIAL ENERGY REVIEW | Second Installment

Capacity Additions, 1995-2025

Notes: Additions exclude coal-to–natural gas or biomass conversions.
Source: IHS and ABB Velocity Suite
Distributed Energy Storage

- Continued decreases in storage technology costs, driven by greater production of batteries for electric vehicles and state-level storage mandates, are likely to increase distributed storage growth.

- From an end-use perspective, distributed electricity storage can reduce peak load and facilitate adoption of distributed generation.

Rates Vary by Class and Utility Type

- Generation is by far the largest component of retail rates.
- Industrial customers typically pay the lowest rates, partially determined by cost differentials, but also by policy goals such as economic development or income-rate progressivity.
- Rates for public utilities are slightly lower than those of IOUs for residential and commercial customers, but higher for industrial customers.
- Averaged across consumer classes, IOUs have higher rates than municipal and cooperative utilities. IOUs are for profit entities and include profits as an additional cost.
Lifeline Network Interdependencies

- **Oil**
  - Fuel for Generators, Lubricants
  - SCADA Communications
  - Water for Production, Cooling, Emissions Reduction
- **Telecom**
  - Fuel for Generators, Lubricants
  - SCADA Communications
- **Electricity**
  - Power for Pumping Stations, Storage, Control Systems
  - Power for Switches
  - Power for Pump/Lift Stations, Control Systems
  - Fuel for Generators
  - Water for Cooling, Emissions Reduction
- **Water**
  - SCADA Communications
  - Water for Cooling, Emissions Reduction
- **Natural Gas**
  - Fuel Transport, Shipping
  - Fuel for Generators
- **Shipping**
  - Fuels. Lubricants
  - Fuel Transport, Shipping
  - Power for Compressors, Storage, Control Systems
Growing Digitization

Figure 6: The Growth of Data in the Power Industry

- PMUs
- Smart Homes
- Distribution Automation
- OMS Upgrade
- GIS Integration
- You Are Here
- RTU Upgrades
- Substation Automation System
- Workforce Management
- AMI

Source: EPRI, GTM Research
50 Million Installed Smart Meters

Value of Smart Grid Technology

- Efficiency
- Reliability
- Cost reduction
- Customer empowerment
- Outage recovery

Obstacles to Smart Grid Technology Adoption

- Tech immature
- Funding
- Customer resistance
- Internal expertise

First Most Important | Second Most Important | Third Most Important
Smart grid will rely on processing exponentially more data at exponentially faster speeds.

Source: IEEE, 2014
The smart grid’s evolution is reliant on the build out of the Internet of Things infrastructure.
Policy Implications of Smart Grid

• **Opportunities** More efficient use of infrastructure
• **Opportunities** Development of innovative services
• **Challenges** Expansion of attack surfaces
• **Challenges** Changing privacy concerns
• **Uncertainties** Impact on electricity demand
• **Uncertainties** Increasing interdependencies vs. Increasing resilience to N-1
• **Uncertainties** Changing employment opportunities
QUADRENNIAL ENERGY REVIEW

QER 1.1 and 1.2 Update for NASEO

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US Department of Energy

September 12, 2016 | Washington, DC