INCREASING THE RESILIENCE, RELIABILITY, SAFETY, AND ASSET SECURITY OF TS&D INFRASTRUCTURE
Vulnerabilities and Disruptions

Illustrations of Tornado and Hurricane Tracks, Wildfires, Earthquakes, and Coastal Inundation

- Disruptions of TS&D infrastructures have serious consequences for the Nation and many regions of the country. Extreme weather and climate change is a leading environmental risk to this infrastructure.

Gulf Coast Electricity Substation Facilities’ Exposure to Storm Surge under Different Sea-Level Rise Scenarios

- For example, sea-level rise increases the vulnerability of electricity substations to inundation caused by hurricane storm surge
Selected Findings

- Mitigating energy disruptions is fundamental to infrastructure resilience
- TS&D infrastructure is vulnerable to many natural phenomena, and some extreme weather events have become more frequent; threats and vulnerabilities vary substantially by region
- Cyber incidents and physical attacks are growing concerns
- High-voltage transformers are critical to the grid
- Aging, leak-prone natural gas distribution pipelines and associated infrastructures prompt safety and environmental concerns
Leak Prone Pipes in Local Distribution Systems

Methane Emissions from Natural Gas Distribution Systems in Indianapolis and Boston (2013)

Expected Replacement Horizons for Select Utilities for Leak-Prone Mains (Forecasted Timeframe in Years)

<table>
<thead>
<tr>
<th>Utility Company</th>
<th>Service Territory</th>
<th>State</th>
<th>Forecasted Timeframe (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Philadelphia Gas Works</td>
<td>Philadelphia, PA</td>
<td>PA</td>
<td>84</td>
</tr>
<tr>
<td>ConEd</td>
<td>New York, NY</td>
<td>NY</td>
<td>35</td>
</tr>
<tr>
<td>PECO</td>
<td>Greater Philadelphia, PA</td>
<td>PA</td>
<td>33</td>
</tr>
<tr>
<td>PSE&amp;G</td>
<td>Newark, NJ</td>
<td>NJ</td>
<td>30</td>
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<tr>
<td>Pensacola Energy</td>
<td>Pensacola, FL</td>
<td>FL</td>
<td>30</td>
</tr>
<tr>
<td>Baltimore Gas Company</td>
<td>Baltimore, MD</td>
<td>MD</td>
<td>30</td>
</tr>
<tr>
<td>UGI</td>
<td>Rural Pennsylvania</td>
<td>PA</td>
<td>27</td>
</tr>
<tr>
<td>Consumers energy</td>
<td>Detroit, MI</td>
<td>MI</td>
<td>25</td>
</tr>
<tr>
<td>DTE</td>
<td>Detroit, MI</td>
<td>MI</td>
<td>25</td>
</tr>
<tr>
<td>National Grid</td>
<td>New York, NY</td>
<td>NY</td>
<td>25</td>
</tr>
<tr>
<td>Dominion Hope Gas Co.</td>
<td>Ohio</td>
<td>OH</td>
<td>20</td>
</tr>
<tr>
<td>Yankee Gas Service Company</td>
<td>Rural Connecticut</td>
<td>CT</td>
<td>20</td>
</tr>
<tr>
<td>Peoples Gas</td>
<td>Chicago, IL</td>
<td>IL</td>
<td>20</td>
</tr>
<tr>
<td>National Grid – Niagra Mohawk</td>
<td>Rhode Island</td>
<td>RI</td>
<td>19</td>
</tr>
<tr>
<td>Peoples TWP</td>
<td>Southwestern Pennsylvania</td>
<td>PA</td>
<td>19</td>
</tr>
<tr>
<td>Peoples Natural Gas Co.</td>
<td>Southwestern Pennsylvania</td>
<td>PA</td>
<td>17</td>
</tr>
<tr>
<td>National Grid – Niagra Mohawk</td>
<td>Syracuse, NY</td>
<td>NY</td>
<td>16</td>
</tr>
<tr>
<td>Columbia Gas of Pennsylvania</td>
<td>Southwestern Pennsylvania</td>
<td>PA</td>
<td>15</td>
</tr>
<tr>
<td>Northern Utilities</td>
<td>Maine</td>
<td>ME</td>
<td>13</td>
</tr>
<tr>
<td>CenterPoint</td>
<td>Arkansas</td>
<td>AR</td>
<td>12</td>
</tr>
</tbody>
</table>

Public safety risks from distribution pipelines

- Safety incidents are relatively infrequent, but increase as systems age
- The most leak-prone distribution pipeline materials are cast iron and bare steel
- Many companies, states, and localities have taken action to improve safety by accelerating distribution pipeline replacement
- Methane leak mapping in Indianapolis and Boston show effect of newer vs. older pipelines

States with Most Cast and Wrought Iron Pipelines

- New Jersey
- New York
- Massachusetts
- Pennsylvania
- Michigan
- Illinois
- Connecticut
- Maryland
- Alabama
- Missouri

States With Most Bare Steel Pipelines

- Ohio
- Pennsylvania
- New York
- Texas
- Kansas
- California
- West Virginia
- Oklahoma
- Massachusetts
- New Jersey
Increasing Resilience, Reliability, Safety, and Asset Security

Recommendations

Electricity Outages by Type of Event and Lost Customer Hours

Selected Recommendations

- Establish a $2.5 - $3.5 billion competitive financial assistance program to accelerate pipeline replacement and enhance maintenance programs for natural gas distribution systems.

- Provide $350 - $500 million in support for the updating and expansion of state energy assurance plans.

- Establish a $3.5 billion competitive grant program to promote innovative solutions to enhance energy infrastructure resilience, reliability, and security.

- Analyze the policies, technical specifications, and logistical and program structures needed to mitigate the risks associated with loss of transformers.

- Analyze the need for additional or expanded regional product reserves.

- Integrate the authorities of the President to release products from regional petroleum product reserves (RPPRs) into a single, unified authority.

The Quadrennial Energy Review, April 2015

"Building a resilient, reliable, safe, and secure energy infrastructure is a national priority and vital to American competitiveness, jobs, energy security, and a clean energy future."
MODERNIZING THE ELECTRIC GRID
Key Trends in Electricity

Selected Findings

- Growth in U.S. electricity demand is at its lowest level in decades
- Investments in transmission and distribution upgrades and expansions will grow
- There is increased use of distributed energy resources
- Extreme weather events and risks of widespread power outages have been increasing
- Lack of adequate information/tools impedes resilience
- State RPS and efficiency standards could influence infrastructure needs
Reliability is a key driver for 48 percent of transmission additions (2011 – 2015)

Reported Drivers of Projected Circuit-Miles of Transmission Addition (2011-2015)

As reported voluntarily to NERC and in EIA form 411 by IOUs, coops-munis, state/federal power agencies, ISOs/RTOs, and merchant developers
Findings


Selected Findings

- Flexible grid system operations and demand response can enable renewables and reduce the need for new bulk-power-level infrastructure
- Investments in resilience have multiple benefits
- Innovative technologies have significant value for the electricity system
- Appropriate valuation of new services and technologies and energy efficiency can provide options for the utility business model
- Different business models and utility structures rule out “one-size-fits-all” solutions to challenges
- States are the test beds for the evolution of the grid of the future

The Quadrennial Energy Review, April 2015

“Innovative technologies and services are being introduced to the system at an unprecedented rate, often increasing efficiency, reliability, and the roles of customers, but also injecting uncertainty into grid operations, traditional regulatory structures, and utility business models.”
Selected Recommendations

- Provide $3.5 B in grid modernization research and development, analysis, and institutional support
- Conduct a national review of transmission plans and assess barriers to their implementation
- Provide $300-$350 M in state financial assistance to promote and integrate transmission, storage, and distribution infrastructure investment plans for electricity reliability, affordability, efficiency, lower carbon generation, and environmental protection
- Value new services and technologies
- Improve grid communication through standards and interoperability
Rapidly Changing Supply/Infrastructure Geography

Crude Oil by Train Facilities (2010)

- In 2010, the United States and Canada had six rail loading facilities for crude oil and four offloading facilities.

Crude Oil by Train Facilities (2013)

- By year-end 2013, crude oil by rail capacity had grown to include 65 loading facilities in Petroleum Administration Defense Districts (PADD) 2, 3, and 4. Rail-to-barge facilities also increased.
Modernizing the Strategic Petroleum Reserve (SPR)

Selected SPR Findings

- The SPR was designed to respond to oil embargoes -- to move oil from south to north, and to inland refineries.
- Today, the SPR’s value is to move oil onto the water and into global oil markets in the event of a disruption, thereby lowering world oil prices and reducing economic harm to the US and its allies.
- Congestion in the Gulf of Mexico is significant. Use of the SPR in the Libyan action had limited impact as it displaced some domestic production.
- Design drawdown rate of the SPR: 4.4 million barrels per day.
- The SPR is 40 years old.

SPR Infrastructure in the Gulf of Mexico region
Findings

Highlighted Pipeline Reversals and Expansions Accommodating Increased Domestic and Canadian Supply

Selected Findings

- The United States has achieved unprecedented oil and gas production growth
- The network of oil distribution (“the midstream”) has changed significantly
- The Strategic Petroleum Reserve’s ability to offset future energy supply disruptions has been adversely affected by domestic and global oil market developments coupled with the need for upgrades
- Biofuel production in the United States has increased rapidly over the last decade, enhancing energy security and reducing greenhouse gases from transportation

“The United States is now the world’s largest producer of petroleum and natural gas. Combined with new clean energy technologies, and improved fuel efficiency, and growth in oil and natural gas production, U.S. energy security is stronger than it has been for over half a century.”
**Selected Recommendations**

- Update Strategic Petroleum Reserve (SPR) release authorities to reflect modern oil markets
- Invest $1.5 - $2 B to optimize the SPR’s emergency response capability
- Support fuels diversity through research, demonstration, and analysis
- Undertake a study of the relationship between domestic shipping and energy security

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**The Quadrennial Energy Review, April 2015**

*“Challenges remain in maximizing the security benefits of our resources in ways that enhance our competitiveness and minimize the environmental impacts of their use.”*
IMPROVING SHARED ENERGY TRANSPORT INFRASTRUCTURES
Intermodal Trends

Rail, Barge, Truck Issues

- Between 2009 and 2014, rail shipments of crude oil increased roughly 4,400 percent
- In one year (2011-12), truck shipments of crude oil increased 53%, rail 423%, and barge 38%
- For every new shale well, the Nation’s railroads move approximately 40 rail cars of drilling material
- Ethanol, now displacing 10% of U.S. gasoline demand, moves on rail, barge and truck. 70% of ethanol shipments from production plants to distribution terminals is moved by rail.
Key Rail Findings

- Oil is an attractive commodity for railroad as it is not seasonal
- On average, roughly 1 million barrels of oil were moved by rail per day in 2014—nearly 12 percent of U.S. domestic crude oil production
- 34 states get coal for power generation from the Powder River Basin in Wyoming, almost all by rail. Eight states obtain more than 90 percent of their domestic coal from Wyoming. It is largely transported through regions of rail congestion where much of our oil and agriculture also originate.

A study by USDA’s Agricultural Marketing Service concluded that, for the period from August 2013 through August 2014, “the magnitude and duration of recent unexpected shifts in supply and demand for ... rail service... have exceeded previous events in terms of both magnitude and duration, including Hurricane Katrina, which caused major disruptions throughout the entire agricultural transportation network.”
Ports and Waterways Trends

Selected Waterways Findings

- In 2012, crude oil, refined petroleum products, and coal were 55% of all U.S. waterborne cargo traffic by weight.
- Nearly 15 percent of all petroleum products consumed in the U.S. are shipped on inland waterways.
- DOT’s Beyond Traffic 2045 report concludes that “… several critical trends will have a major impact on the performance of critical marine links in our transportation systems.” They include:
  - Increasing imports and exports and containerized freight will lead to greater congestion on America’s coastal and inland ports.
  - Investment in ports, harbors, and waterways will be essential to meet the demand of increased trade and competition.

Top 10 Port Systems by Total Energy Commodity Shipments (2013, millions of short tons)

<table>
<thead>
<tr>
<th>Port Channel System</th>
<th>Crude and Petroleum Products</th>
<th>Coal</th>
<th>Total Energy</th>
<th>Energy as a Percentage of Shipments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Mississippi (LA)</td>
<td>161</td>
<td>47</td>
<td>208</td>
<td>48%</td>
</tr>
<tr>
<td>Houston/Galveston (TX)</td>
<td>200</td>
<td>3</td>
<td>203</td>
<td>69%</td>
</tr>
<tr>
<td>Beaumont/Port Arthur (TX)</td>
<td>115</td>
<td>-</td>
<td>115</td>
<td>89%</td>
</tr>
<tr>
<td>Port of NY/NJ</td>
<td>80</td>
<td>&lt;1</td>
<td>80</td>
<td>59%</td>
</tr>
<tr>
<td>Delaware River</td>
<td>62</td>
<td>-</td>
<td>62</td>
<td>82%</td>
</tr>
<tr>
<td>Corpus Christi (TX)</td>
<td>58</td>
<td>-</td>
<td>58</td>
<td>77%</td>
</tr>
<tr>
<td>Port of Virginia</td>
<td>2</td>
<td>50</td>
<td>52</td>
<td>66%</td>
</tr>
<tr>
<td>Lake Charles (LA)</td>
<td>49</td>
<td>-</td>
<td>50</td>
<td>88%</td>
</tr>
<tr>
<td>LA and Long Beach (CA)</td>
<td>46</td>
<td>2</td>
<td>47</td>
<td>33%</td>
</tr>
<tr>
<td>Huntington - Tristate (WV)</td>
<td>8</td>
<td>32</td>
<td>41</td>
<td>87%</td>
</tr>
</tbody>
</table>
Findings

Hours of Lock Unavailability on U.S. Inland Waterways (2000-2014)

Selected Findings

- Rapid crude oil production increases have changed the patterns of flow of North American midstream (pipelines, rail, and barge) liquids transport infrastructure
- Limited infrastructure capacities are intensifying competition among commodities, with some costs passed on to consumers
- The ability to maintain adequate coal stockpiles at some electric power plants has been affected by rail congestion
- Funding for the U.S. freight transportation system is complex and involves a combination of Federal, state, local, and private investments
- Multi-modal shared transportation infrastructure is stressed by increased shipments of energy supplies, materials, and components
Findings
Recommendations

Domestic Crude Refinery Receipts by Barge (1981-2013)

Selected Recommendations

- Support a $2 - $2.5 B program of competitively awarded grants for shared energy transport systems.
- Enhance the understanding of important safety-related challenges of transport of crude oil and ethanol by rail and accelerate responses.
- Address critical energy data gaps in the rail transport of energy commodities and supplies.
- Support alternative funding mechanisms for waterborne freight infrastructure.
- Support public-private partnerships for waterborne transport infrastructure.

The Quadrennial Energy Review, April 2015

“Changes in the U.S. energy marketplace are stressing the Nation’s infrastructures... particularly in the case of oil where the rapid increase in U.S. tight oil production is transforming conventional patterns and modes.”
INTEGRATING NORTH AMERICAN ENERGY MARKETS
Selected Findings
The United States has robust energy trade with Canada and Mexico, and increasingly in the Caribbean region. This presents abundant opportunities for increased integration of markets and policies.

There is an opportunity to lower Caribbean electricity costs and emissions

Selected Recommendations
- Continue advances that have been made in the North American energy dialogue
- Increase the integration of energy data among the United States, Canada, and Mexico
- Undertake comparative and joint energy system modeling, planning, and forecasting
- Establish programs for academic institutions and not-for-profits to develop legal, regulatory, and policy roadmaps for harmonizing regulations across borders
- Coordinate training and encourage professional interactions
- Partner with Canada and the Arctic Council on Arctic energy safety, reliability, and environmental protection
- Partner with Canada and the Arctic Council on energy delivery to remote areas
- Promote Caribbean energy TS&D infrastructure

North American Energy Flows

![North American Energy Flows Diagram]
ADDRESSING ENVIRONMENTAL ASPECTS OF TS&D INFRASTRUCTURE
Improving the Environment

Selected Findings

TS&D infrastructure can serve as an enabler for – or barrier to – better environmental outcomes for the overall energy system.

Energy transport, refining, and processing infrastructure contribute to emissions of criteria air pollutants that pose risks to public health and the environment.

Selected Recommendations

- Improve quantifications of emissions and expand R&D for natural gas TS&D infrastructure
- Support funding to reduce diesel emissions
- Enact financial incentives for the construction of CO2 pipeline networks

Current CO₂ - Enhanced Oil Recovery (EOR) Operations and Infrastructure
ENHANCING EMPLOYMENT AND WORKFORCE TRAINING
## Findings and Recommendations

### Age Distribution of Select Transportation Workers (2014)

<table>
<thead>
<tr>
<th>Occupation</th>
<th>16 to 19 years</th>
<th>20 to 24 years</th>
<th>25 to 34 years</th>
<th>35 to 44 years</th>
<th>45 to 54 years</th>
<th>55 to 64 years</th>
<th>65+ years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total employed</td>
<td>5%</td>
<td>9%</td>
<td>22%</td>
<td>21%</td>
<td>22%</td>
<td>17%</td>
<td>5%</td>
</tr>
<tr>
<td>Truck drivers, driver/sales workers</td>
<td>9%</td>
<td>16%</td>
<td>23%</td>
<td>27%</td>
<td>20%</td>
<td>6%</td>
<td></td>
</tr>
<tr>
<td>Ship engineers</td>
<td>13%</td>
<td>38%</td>
<td>25%</td>
<td>25%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ship and boat captains and operators</td>
<td>5%</td>
<td>17%</td>
<td>24%</td>
<td>33%</td>
<td>17%</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td>Sailors and marine oilers</td>
<td>7%</td>
<td>33%</td>
<td>15%</td>
<td>15%</td>
<td>11%</td>
<td>15%</td>
<td>4%</td>
</tr>
<tr>
<td>Railroad conductors and yardmasters</td>
<td>6%</td>
<td>28%</td>
<td>26%</td>
<td>28%</td>
<td>11%</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td>Railroad brake, signal, and switch operators</td>
<td>10%</td>
<td>20%</td>
<td>30%</td>
<td>40%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Locomotive engineers and operators</td>
<td>4%</td>
<td>13%</td>
<td>39%</td>
<td>23%</td>
<td>20%</td>
<td>2%</td>
<td></td>
</tr>
</tbody>
</table>

### Selected Findings

- By 2030, projections indicate that the energy sector overall, including the TS&D segment, will employ an additional 1.5 million workers, mainly in the construction, installation and maintenance, and transportation areas. 200,000 more workers with computer and mathematics skills will be required.
- Defining priorities in the area of jobs and workforce training and establishing effective programs requires good data.

### Selected Recommendations

- 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.
- Establish an interagency working group to reform existing energy jobs data collection systems.
SITING AND PERMITTING OF TS&D INFRASTRUCTURE
Findings and Recommendations

Selected Findings

Close collaboration with tribal, state, and local governments is critical to siting, permitting, and review of infrastructure projects.

Robust public engagement is essential for the credibility of the siting, permitting, and review process.

Selected Recommendations

- Enact statutory authorities to improve coordination across agencies.
- Adopt Administration proposals to authorize recovery of costs for review of project applications.