**Increasing Energy Production**
- Natural gas production growth
- Oil production growth
- Intermittent renewables
- Distributed generation/energy resources
- Increased generation/production/demand efficiency

**Technology Advances**
- Solar (central and rooftop)
- Wind
- Demand-side
- Hydraulic fracturing

**Policy Developments**
- CAFE
- Clean Air Act -111 (d), other
- Clean Water Act/other
- RFS
- RPS (state)
- RGGI (regional)

**Energy Security Changes**
- Decreased N. American energy imports
- Climate change impacts
- Vulnerabilities more evident, including aging infrastructures, physical and cyber threats
- Increased interdependencies
- Increased energy support required by allies

**Fundamental Changes in the U.S. Energy Sector**
Petroleum, natural gas, and coal have made up at least 80% of total U.S. energy consumption for more than 100 years.

Coal became dominant in the late 19th century before being overtaken by petroleum products in the middle of the 20th century.

Since the mid-20th century, use of coal increased again (mainly as a primary energy source for electric power generation).
In 2014, major energy sources and percent share of total U.S. electricity generation included:

- Coal - 39%
- Natural gas - 27%
- Nuclear - 19%
- Petroleum - 1%
- Other gases < 1%
- Renewables - 13%
- Hydropower - 6%
- Biomass - 1.7%
- Geothermal - 0.4%
- Solar - 0.4%
- Wind - 4.4%
FRAMING TS&D INFRASTRUCTURE

- Economic Competitiveness
- Natural Gas
- Liquid Fuels
- Electricity
- Environmental Responsibility
- Energy Security

High Level Goals
Energy Infrastructure Objectives
Crosscutting Issues
VULNERABILITIES AND DISRUPTIONS: NATURAL DISASTERS

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

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

Increased Intense Precipitation Events (Heaviest 1% of All Daily Events, 1958-2012)

Billion-Dollar Disaster Event Types by Year (1980-2014)
**Vulnerabilities and Disruptions: Climate Change**

**Key Energy Sector Impacts**
- Decreasing water availability for cooling at thermoelectric facilities reduces generation capacity
- Decreasing water availability impacts oil and gas production
- Reductions in river levels impedes barge transport
- Changes in precipitation/decreasing snowpack could decrease available hydropower generation capacity

**Climate Trends**
- Changing precipitation patterns cause more frequent and severe droughts
- Snowpack levels have decreased, resulting in lower summer streamflows
- Ground and surface water levels have declined

Source: NETL 2010b
Energy-related Carbon Dioxide Emissions in Five Cases
2000-2040 (million metric tons)

Source: U.S. Energy Information Administration, Annual Energy Outlook 2014
Meeting the U.S. INDC

- Robust action brings U.S. GHG emissions in the range of 26%–28% below 2005 levels by 2025
- Consistent with reductions of ~80% by 2050

Baseline: AEO 2014 with 2014 GHG Inventory Adjustments

Approximate 2025 Emissions trajectory before current Administration (AEO 2008)

Approximate trajectory to U.S. 2025 Target of 26% to 28% below 2005 levels
U.S. COMMITMENTS

Sector Breakdown of 2013 Emissions

- Appliance & Equipment standards
- Building codes
- Green Mortgages
- Other measures

- HFCs including SNAP
- Oil & Gas Methane
- Efficiency programs
- Other measures

- Clean Power Plan
- Building codes
- Appliance & equipment standards
- Other measures

- Fuel economy standards
- Biofuels
- Reduced VMT
- Aviation & Shipping
- Other measures

- Interagency Methane Strategy
- Agricultural policies on N₂O

- Electricity 31%
- Industry 21%
- Transportation 27%
- Commercial & Residential 12%
- Agriculture 9%

- The U.S. is driving substantial reductions in all sectors and gases through existing and new policies
- Enhanced policies to bolster sinks through reforestation and conservation will further contribute to reaching our 2025 goal
VULNERABILITIES AND DISRUPTIONS: ELECTRICITY OUTAGES

Observed Outages to the Bulk Electric System (1992-2012)

Electricity Outages by Type of Event and Lost Customer Hours
NEW INVESTMENT: ELECTRICITY


Reported Drivers of Projected Transmission Addition (2011-2015)

- Reliability: 48%
- Renewables Integration: 26%
- Economics: 13%
- Generation/Interconnect: 3%
- Other: 10%
JURISDICTIONAL LANDSCAPE

NERC Regional Entities and Balancing Authorities

Regional Transmission Organizations (RTO)/Independent System Operators (ISO)

Federally Regulated Power Lines
Crude Oil by Train Loading (red) and Offloading (green) Facilities
Crude by Rail Shipments, 2010-2014
RAIL TRENDS

Coal-Fired Power Plants Supplied by the Powder River Basin

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**

Calcasieu River Ship Channel – Lake Charles, LA - designed for two tankers to pass

Shoaling can force vessels to reduce cargos, idle until high-tide, or, be subject to one-way traffic restrictions

### 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>
SELECT RECOMMENDATIONS

- Grid Modernization* ($3.5B)
- Grants for state and multi-state grid reliability planning* ($300-$350M)
- Value new services and technologies
- Conduct national review of transmission plans and assess barriers to their implementation

Modernizing Global Energy Security Infrastructures
- SPR modernization and life extension ($1.5-$2B)
- G-7 Collective Energy Security Initiative

Resiliency, Recovery, Safety and Asset Recovery
- Implementation Grants for Energy System Hardening ($3-$5B)
- Rate Mitigation for accelerated NG distribution pipe replacement ($2.5-$3.5B)
- State Energy Assurance/Resiliency Planning Grants* ($350-$500M, depending on 2 or 3 year cycle)
- Strategic Transformer Reserve

Improvements to Shared Infrastructure
- ASSETS grants for energy-intensive connector projects ($2-$2.5B)

Integrating North American Energy Markets
- Enhance North American energy integration through cooperative measure with Canada and Mexico
- Caribbean Renewables/LNG project planning support