U.S. Energy Sector Vulnerabilities to Climate Change and Extreme Weather

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Key Takeaways

- Climate Change and extreme weather are already affecting the Nation's energy sector across all regions and energy technologies

- The current pace, scale, and scope of combined public and private efforts to improve the climate preparedness and resilience need to increase, given the challenges identified

- DOE in partnership with other stakeholders can play a critical role in:
    - Enhancing climate-resilient energy technologies
    - Fostering enabling policies at all levels
    - Providing technical information and assistance
    - Convening and partnering with stakeholders

New DOE Report on Climate and Energy Vulnerability

Purpose of report:

- Respond to White House climate change adaptation initiative (E.O 15314); Supports President's Climate Action Plan
- Provide objective analysis of vulnerabilities to the U.S. energy sector - both positive and negative
- Identify opportunities for future actions

Approach:

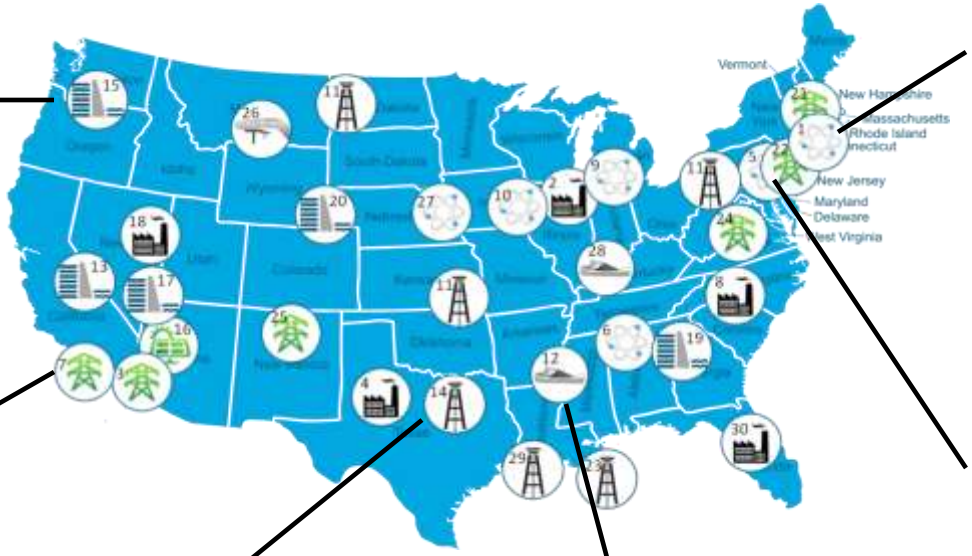
- Use existing peer-reviewed and USG research
- Hosted DOE –Atlantic Council "*Climate Change and Extreme Weather: Vulnerability Assessment of the US Energy Sector*" workshop

Scope:

- Focus on the U.S. energy sector
- Include exploration, production, refining, transport, generation, delivery, and end-use

Recent Events Illustrate U.S. Energy Sector Vulnerability to Climatic Conditions

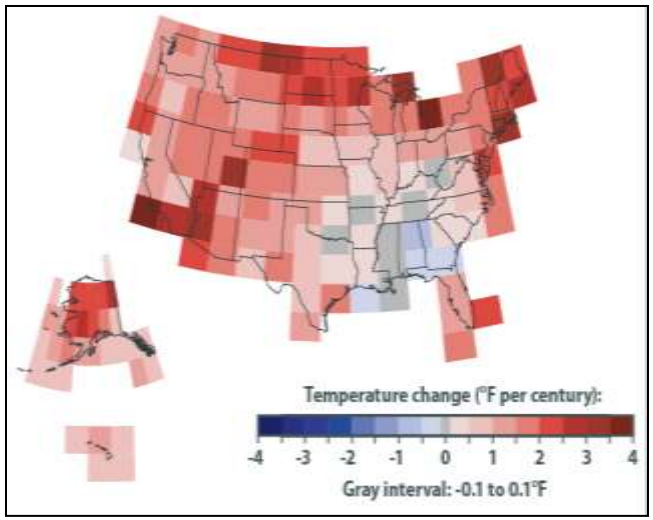
- **Lower water levels**: Reduced hydropower generation
- **Wildfires**: Damaged transmission lines



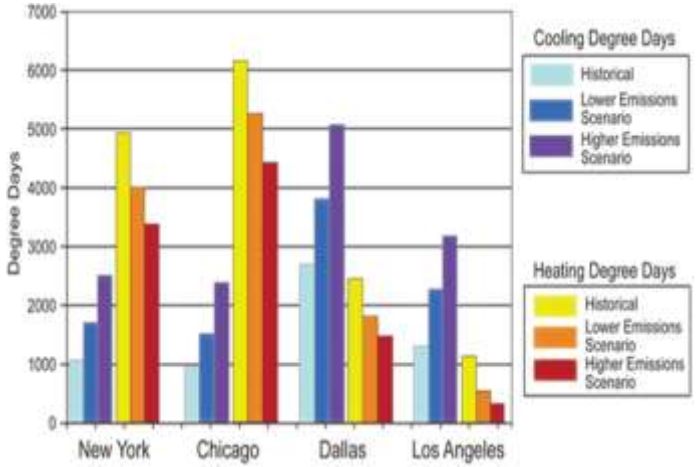
- **Cooling water intake or discharge too hot**: Shutdown and reduced electricity generation from thermoelectric power plants
- **Intense storms**: Disrupted electricity generation and oil and gas operations

- **Water restrictions due to drought**: Potential limits on shale gas production
- **Lower river levels**: Restricted barge transportation of coal and petroleum products

Impacts of Increasing Air and Water Temperatures



Rate of warming in the United States by region, 1901–2011 (EPA 2012a)



Changes in cooling degree days and heating degree days in the United States by 2080–2099 (USGCRP 2009)

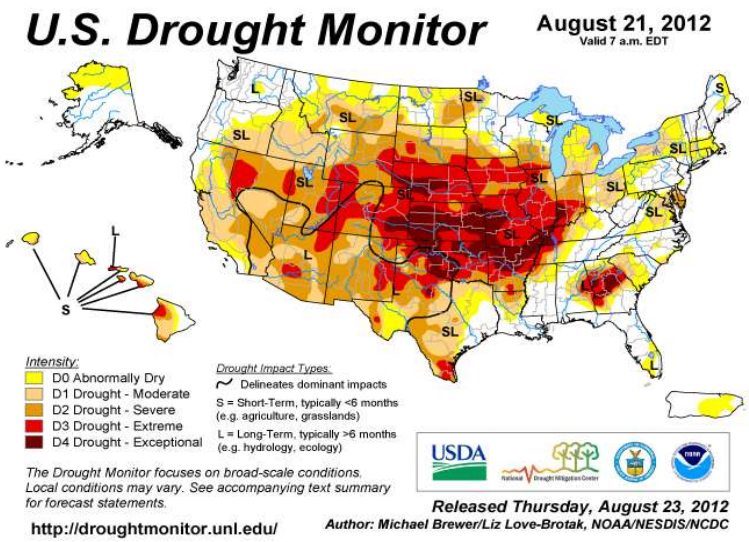
Climate Trends

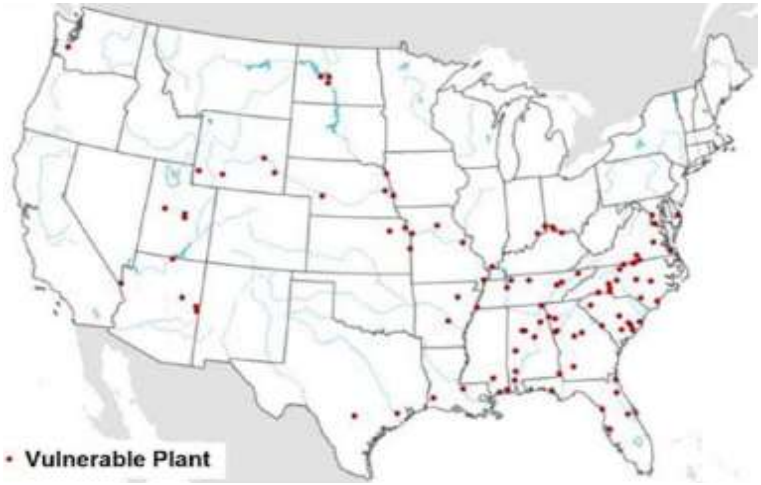
- Average temperatures have increased across the U.S. over the past 100 years
- Heat waves have become more frequent and intense
- Wildfire season and size of fires have increased
- Sea ice cover has decreased in the Alaskan Arctic, and permafrost has thawed

Key Energy Sector Impacts

- Increasing temperatures will likely increase electricity demand
- Thawing permafrost could damage oil and gas infrastructure and impact operations in Arctic Alaska (though decreasing sea ice could generate benefits)
- Increasing temperatures reduce transmission efficiency, and severe wildfires increase the risk of physical damage
- Increasing temperatures could decrease available thermoelectric generation capacity and efficiency

Impacts of Decreasing Water Availability





Water stress: Locations of the 100 most vulnerable coal-fired power plants (NETL 2010b)

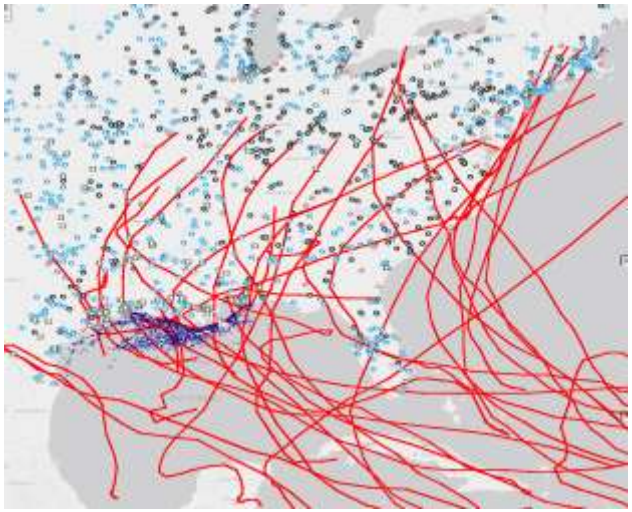
Climate Trends

- Precipitation patterns have changed, causing regional and seasonal decreases and more frequent and severe droughts
- Snowpack levels have decreased, resulting in lower summer streamflows
- Ground and surface water levels have declined

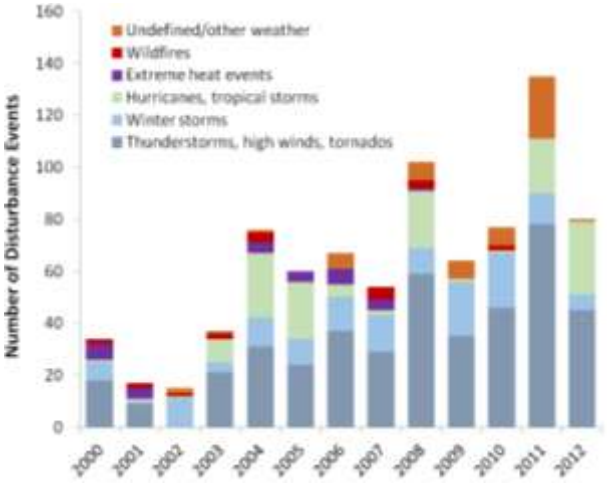
Key Energy Sector Impacts

- Decreasing water availability for cooling at thermoelectric facilities could reduce available generation capacity
- Decreasing water availability could impact oil and gas production
- Reductions in river levels could impede barge transport
- Changes in precipitation/decreasing snowpack could decrease available hydropower generation capacity
- Decreasing water availability could decrease bioenergy production

Impacts of Increasing Storms, Flooding and Sea Level Rise



Hurricane storm paths and locations of
U.S. energy infrastructure 1980-2012
(NOAA 2013a,NOAA 2013d, NOAA 2013h, EIA 2013b)



Weather-related grid disruptions, 2000–2012
(DOE2013b)

Climate Trends

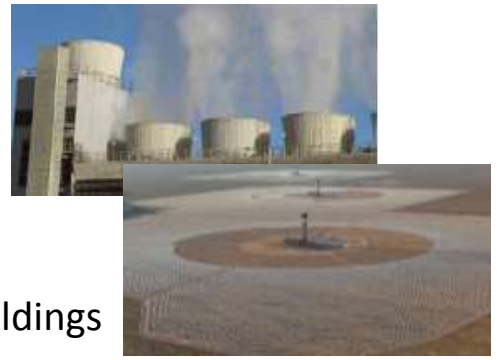
- Relative sea levels rose more than 8 inches in some regions over the past 50 years
- Hurricanes and tropical storms have become more intense
- A larger fraction of precipitation has fallen during intense precipitation events, which has increased flood magnitudes

Key Energy Sector Impacts

- Increasing intensity of storm events, sea level rise, and storm surge put coastal and offshore facilities at increased risk of damage or disruption
- Increasing intensity of storm events increases risk of damage to electric transmission and distribution lines
- Increasing intensity and frequency of flooding increases the risk to inland thermoelectric facilities, and to rail and barge transport of crude oil, petroleum products, and coal

Climate Preparedness and Resiliency Actions

- Effective Actions are underway by public and private sector
  - Development and Deployment of Climate Resilient Energy Technologies and Practices
    - Water capture/reuse, nontraditional cooling waters and dry cooling for thermoelectric power plants
    - Water reuse and dry fracking for oil and gas production
    - Smart Grid, and energy efficiency for transportation, buildings and appliances
    - Storm hardening for coastal energy infrastructure



  - Information and Assessment of Vulnerabilities from National to Local Scale
    - Improved data, tools, and models for characterizing vulnerabilities
    - Federal Vulnerability Assessments including DOE's "Vulnerability Report" and
      - Effects of Climate Change on Federal Hydropower
      - Hurricane Sandy Rebuilding Strategy
      - Economic Benefits of Increasing Electric Grid Resilience to Weather Outages
- Pace, scale, and scope of combined public and private efforts needs to increase and build upon these efforts

President's Climate Action Plan

The President's plan has three major parts:

1. Cut carbon pollution in America

2. Prepare the United States for the Impacts of Climate Change

3. Lead International Efforts to Combat Global Climate Change and Prepare for its Impacts

President's Climate Action Plan - Adaptation

- Developing actionable climate science, launching a climate data initiative and continuing to assess climate-change impacts in the United States

- Providing an information toolkit for climate preparedness and resilience

- Supporting a state, local, and tribal task force on climate preparedness and supporting communities as they prepare for climate impacts

- Promoting insurance leadership for climate preparedness and resilience

- Supporting climate-resilient investment and boosting the resilience of buildings and infrastructure, particularly as we rebuild and learn from Sandy

Hurricane Sandy Rebuilding Strategy

- Rebuilding Strategy released in August will serve as a model for the nation facing greater risks from extreme weather and to continue helping the Sandy-affected region rebuild.
- Contains policy recommendations to help ensure entire communities are better able to withstand and recover from future storms, including energy preparedness and resilience:
  - Making the electric grid smarter and more flexible, and protecting the liquid fuel supply chain
  - Helping to develop a resilient power strategy for telephone and internet communication systems and equipment
  - Providing a forum to coordinate and discuss large-scale, regional infrastructure projects and map the interdependencies between them
  - Establishing guidelines to ensure those projects are situated and built to withstand the impacts of existing risks and future climate change
  - Assisting States and localities to optimize Sandy recovery infrastructure funding and leverage non-federal resources to help build critical infrastructure assets that are climate resilient

Microgrids, Resilience and Developing the 21st Century Infrastructure – State Engagement

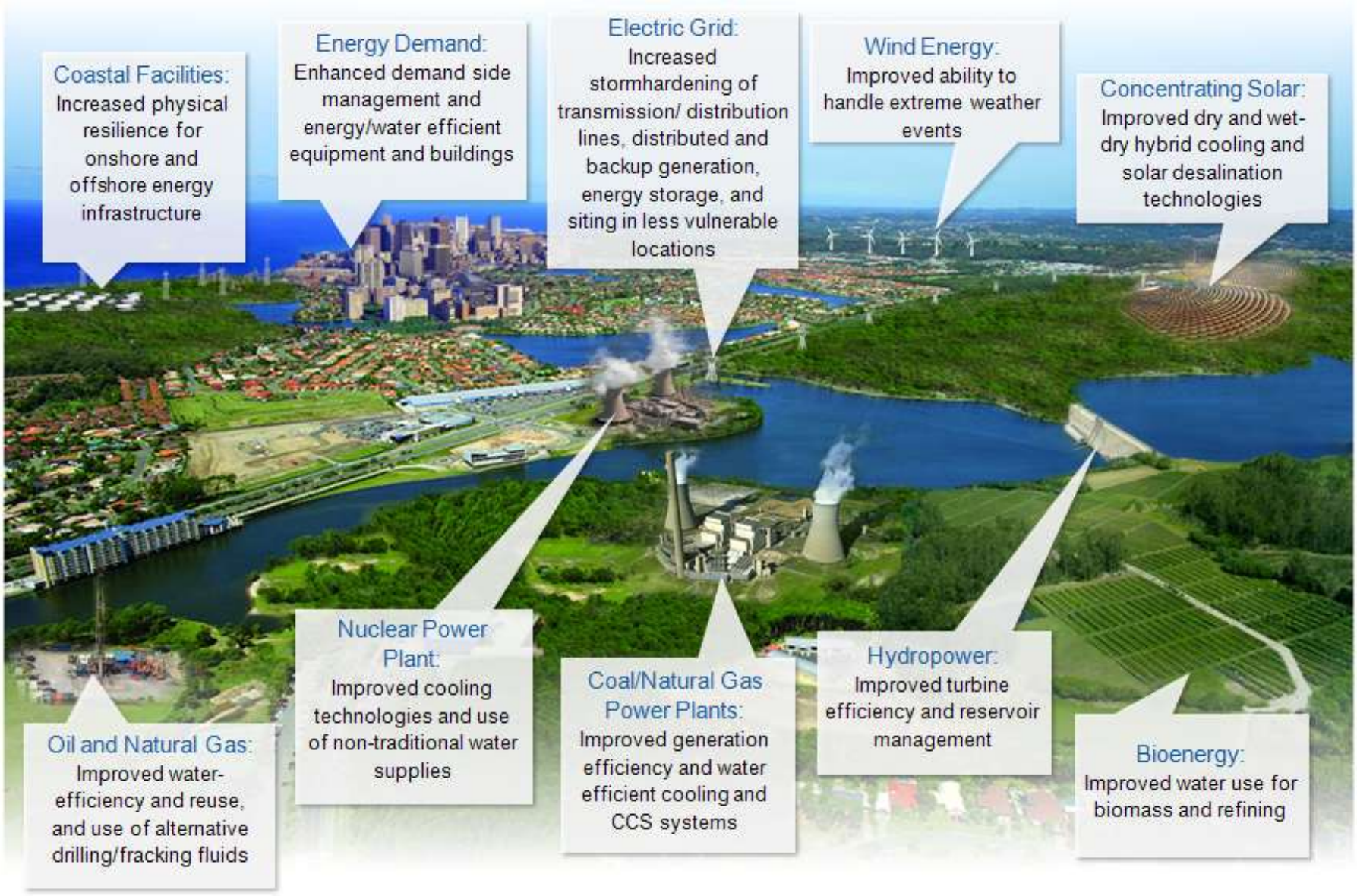
• DOE Secretary Moniz and Governor Christie recently signed a memorandum of understanding (MOU) kicking off the design phase of "NJ TransitGrid," a new project that will provide highly reliable power for a critical transportation corridor when the traditional grid is compromised

•DOE's Sandia National Laboratory will provide initial design work, building on their extensive experience with microgrids for military installations

•This "microgrid" will employ distributed generation technologies such as fuel cells, combined heat and power and solar with storage so that the power system will be less fragile when infrastructure is taken offline

• Important example of 21st century resilience. Project provides first-of-a-kind example for the Nation, while creating jobs and a more competitive economy

Illustrative Opportunities: Twenty First Century Climate-resilient Energy Technologies



Next Steps: DOE Response Framework

- **Enhance Research, Development, Demonstration and Deployment of Climate-resilient Energy Technologies**
  - Use mechanisms, including the Department's National Laboratories, to support efforts to develop 21st Century energy technologies.
- **Foster enabling policies to remove market barriers and encourage building resiliency into energy systems**
  - Examine innovative and effective public policies to support and replicate on a national scale
- **Provide technical information and assistance**
  - Facilitate access to higher resolution data, models and tools, and develop guidance and best practices for energy system preparedness and resiliency
- **Convene and partner with stakeholders**
  - Build robust public-private-partnerships to increase energy system resiliency and to deploy innovative technological solutions and practices.