Overview Of U.S. DOE Report -

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

2013 Energy Assurance and Interdependency Workshop
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Key Takeaways

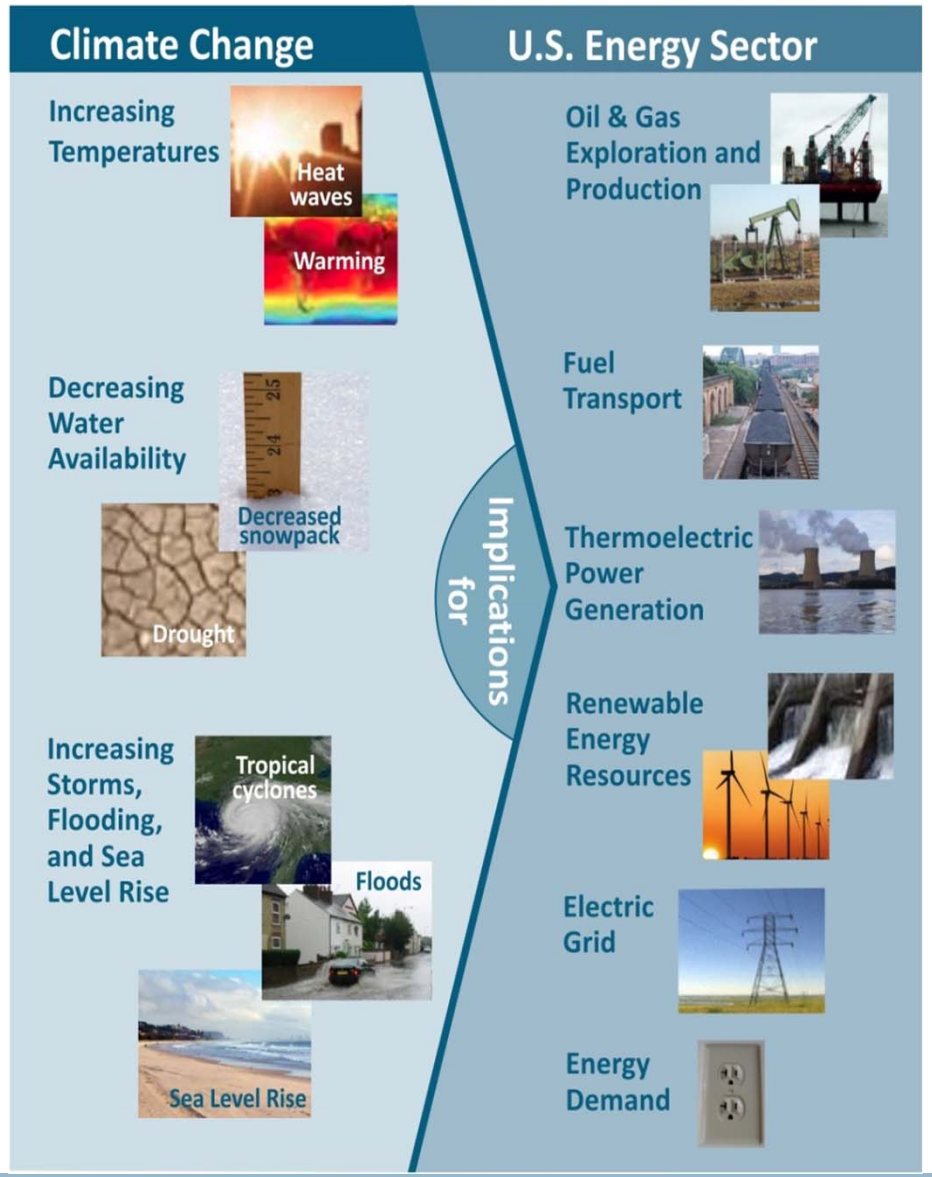
- Climate change and extreme weather are already affecting the U.S. energy sector across all regions and technologies.

- The pace, scale, and scope of public and private efforts to improve climate resilience need to increase.

- DOE 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

Purpose of Report

- Respond to the White House climate change adaptation initiative (E.O 15314)
- Support the President's Climate Action Plan
- Objectively analyze the effects of climate change and extreme weather on the U.S. energy sector
- Identify opportunities for future actions



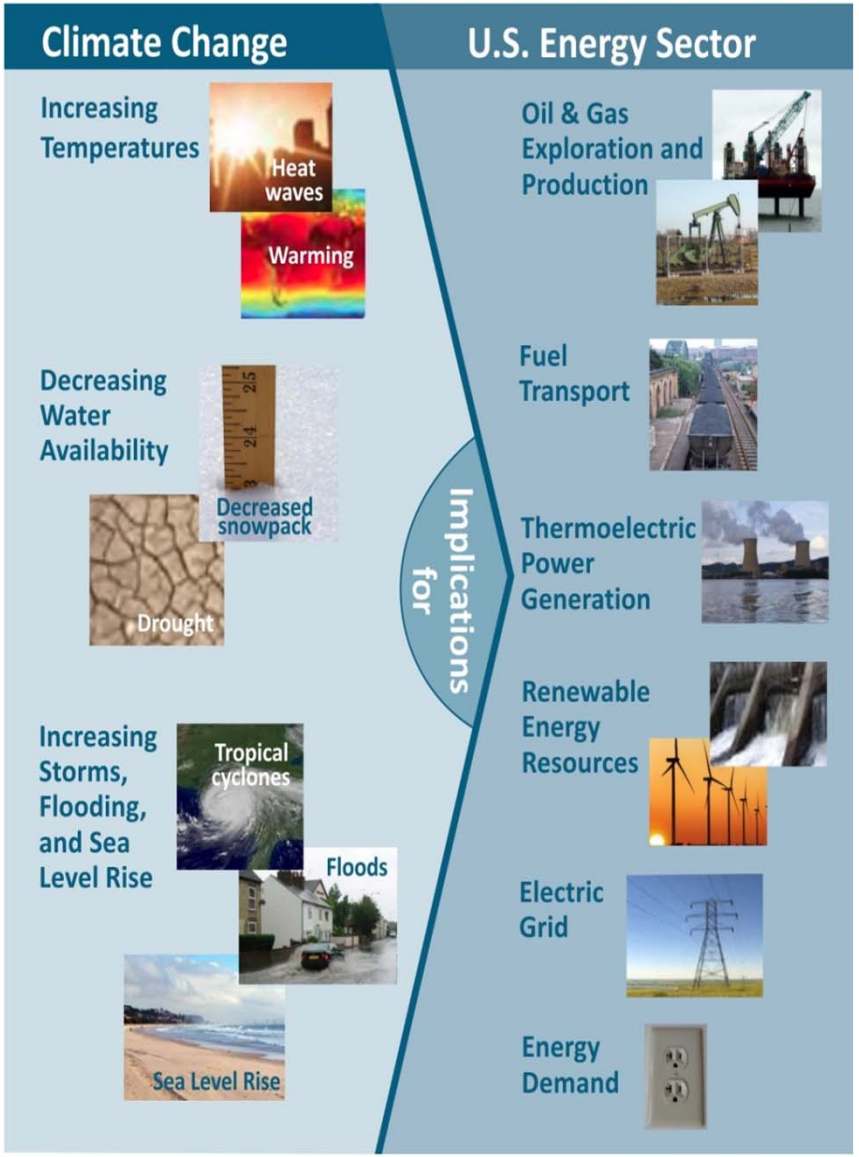
Approach and Scope

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, fuel transport, generation, delivery, and end-use

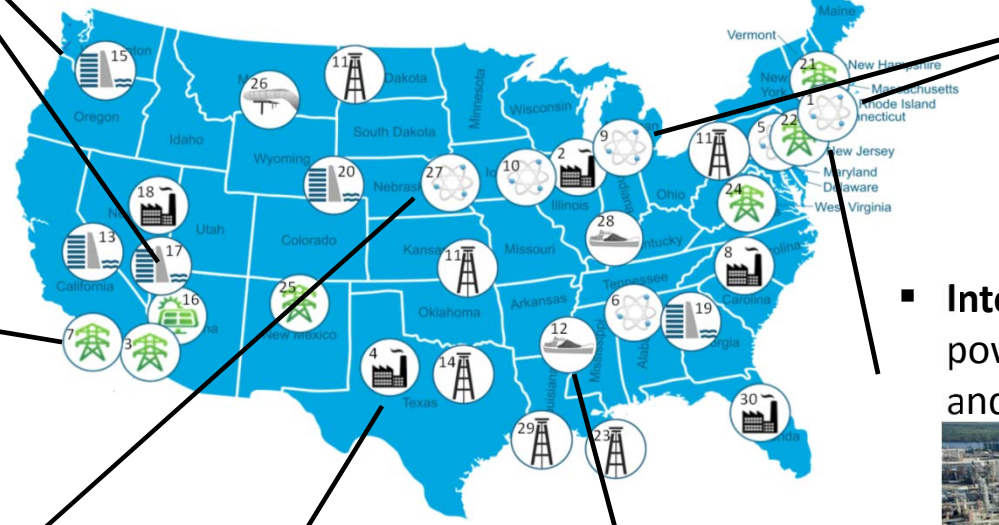


Recent Events Illustrate U.S. Energy Sector Vulnerability to Climatic Conditions

- **Lower water levels**: Reduced hydropower

- **Wildfires**: Damaged transmission lines

- **Flooding:** Impacts on inland power plants



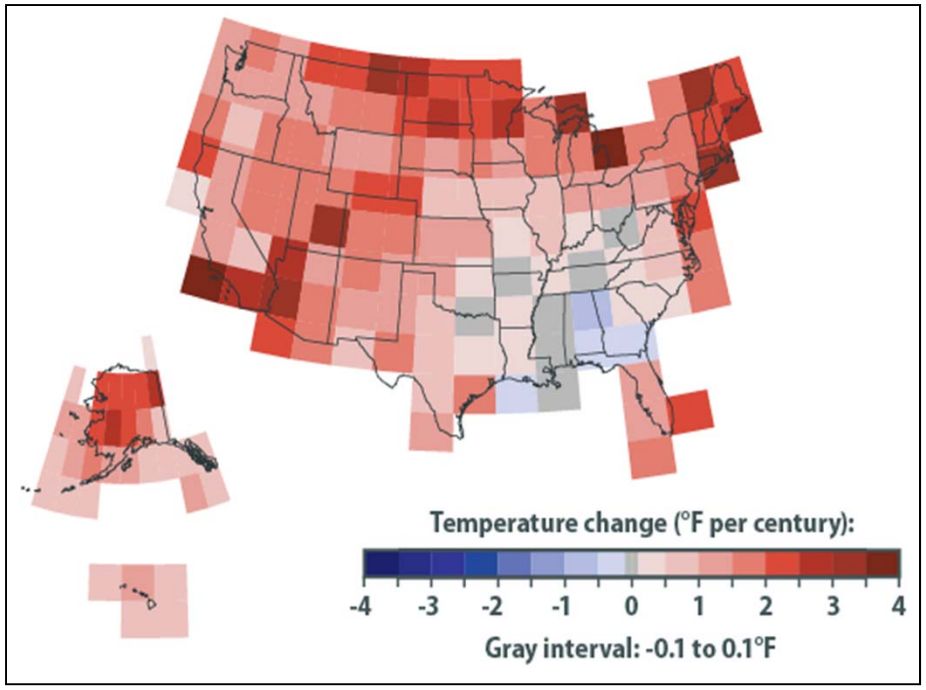
- **Water restrictions due to drought**: Limiting shale gas and power production

- **Lower river levels**: Restricted barge transportation of coal and petroleum products

- **Cooling water intake or discharge too hot**: Shutdown and reduced generation from power plants

- **Intense storms**: Disrupted power generation and oil and gas operations

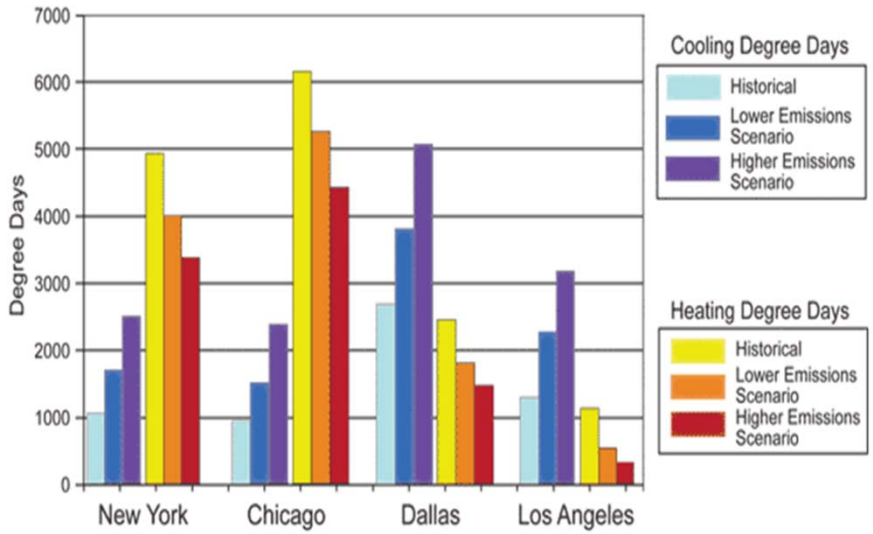
Climate Trend: Increasing Air and Water Temperatures



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

- 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
- Growing season has increased

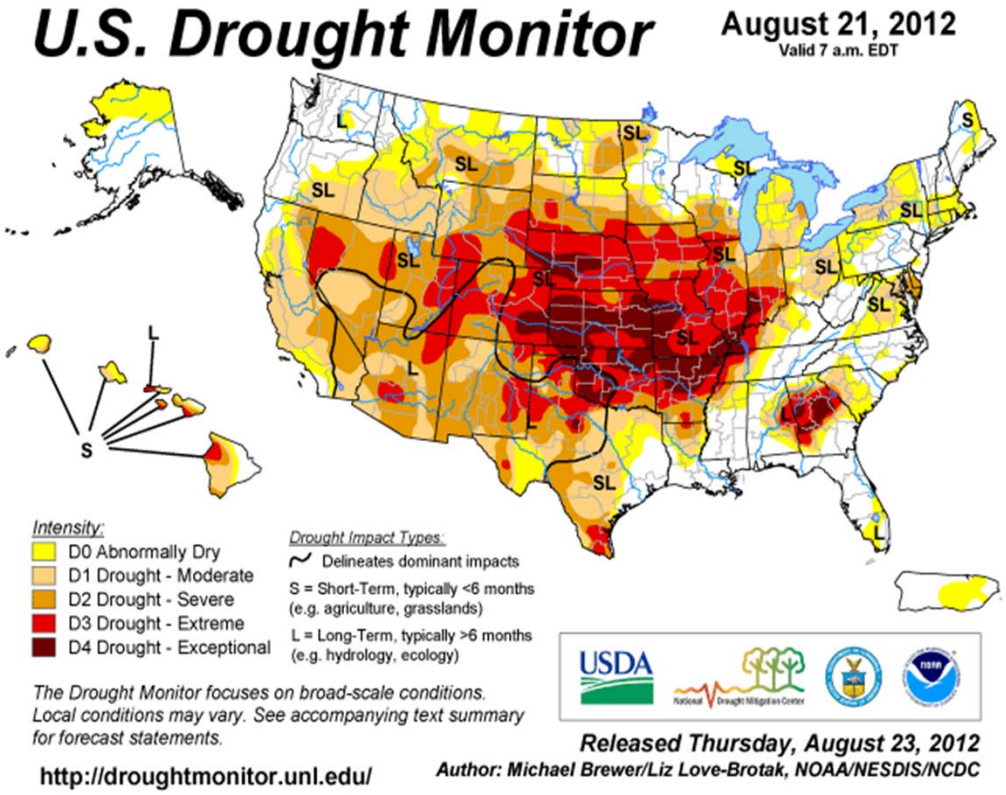
Key Energy Sector Impacts of Increasing Air and Water Temperatures



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

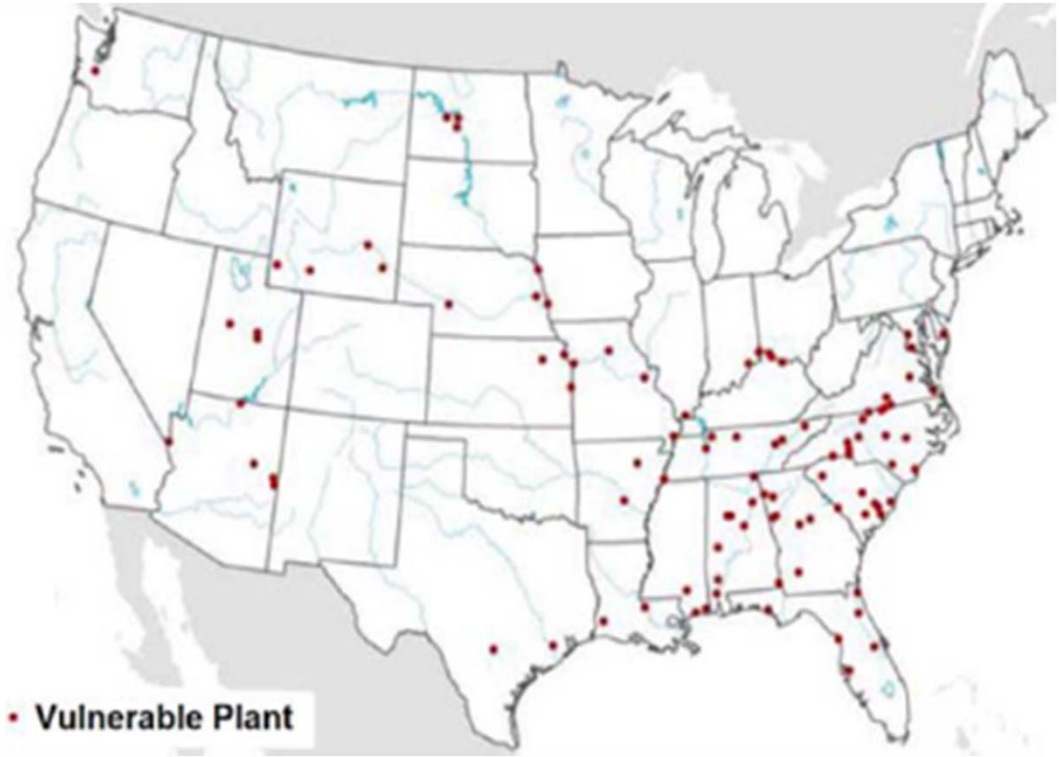
- Increasing temperatures will likely increase electricity demand
- Increasing temperatures reduce transmission efficiency
- Increasing air and water temperatures could decrease available generation capacity and efficiency
- Severe wildfires will increase the risk of physical damage
- Thawing permafrost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

Climate Trend: Decreasing Water Availability



- Precipitation patterns are changing ("wet areas getting wetter & dry areas getting drier") with more frequent and severe droughts
- Snowpack levels are decreasing, lowering summer streamflows
- Ground and surface water levels are declining

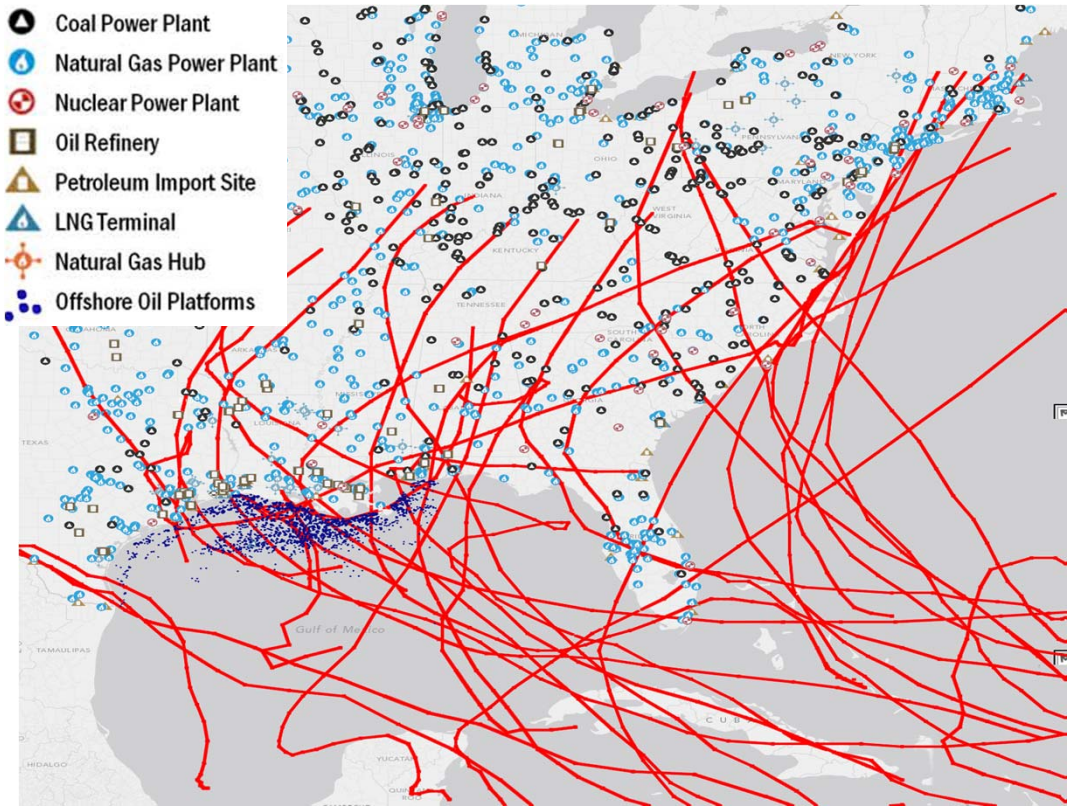
Key Energy Sector Impacts of Decreasing Water Availability



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

- Lack of cooling water could reduce available generation capacity
- Could impact oil and gas and bioenergy production
- Changes in precipitation/decreasing snowpack could decrease available hydropower
- Reductions in river levels could impede barge transport of crude oil, petroleum products, and coal

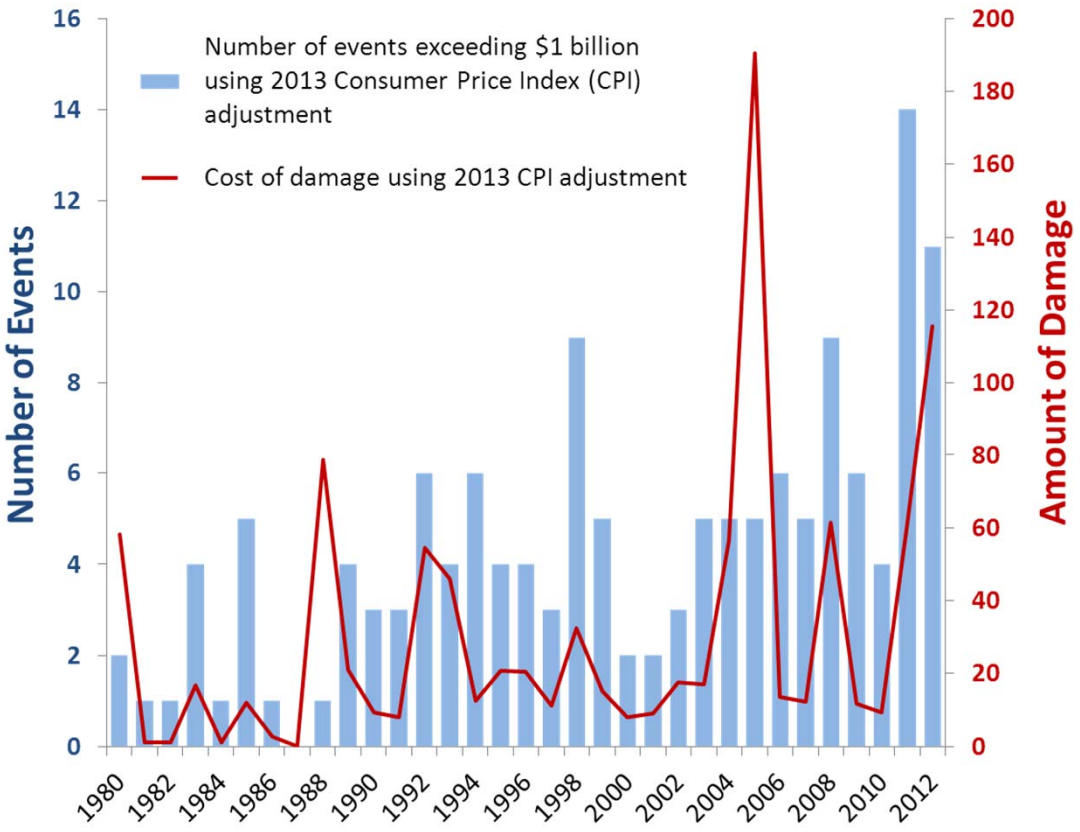
Climate Trend: Increasing Storms, Flooding and Sea Level Rise



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

- 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 of Increasing Storm Intensity, Flooding and Sea Level Rise



Billion-dollar weather and climate disasters, 1980–2012

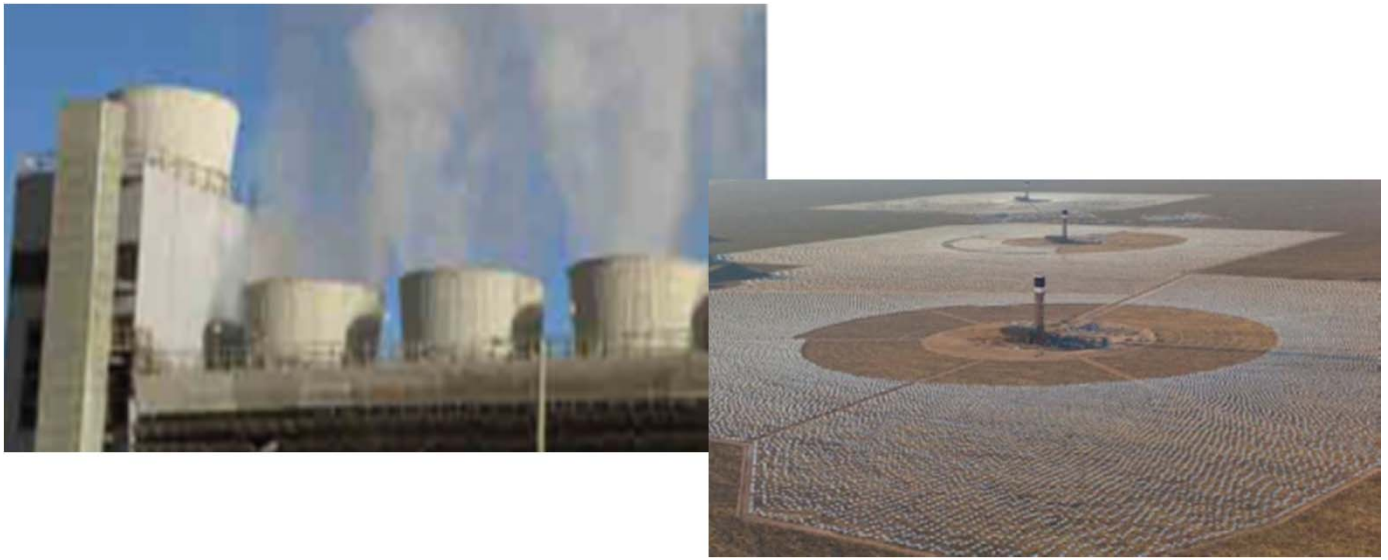
Data source: NOAA 2013a

- Puts coastal and offshore energy infrastructure at increased risk
- Increasing intensity of storm events increases risk to electric transmission and distribution lines
- Increasing intensity and frequency of flooding increases the risk to inland powerplants, and to rail and barge transport of crude oil, petroleum products, and coal

Effective Public and Private Climate Resiliency Actions are Underway

Development and Deployment of Climate-Resilient Energy Technologies and Practices

- Water capture/reuse, nontraditional cooling waters and dry cooling for power plants
- Storm hardening for energy infrastructure
- Backup generation, distributed generation and microgrids

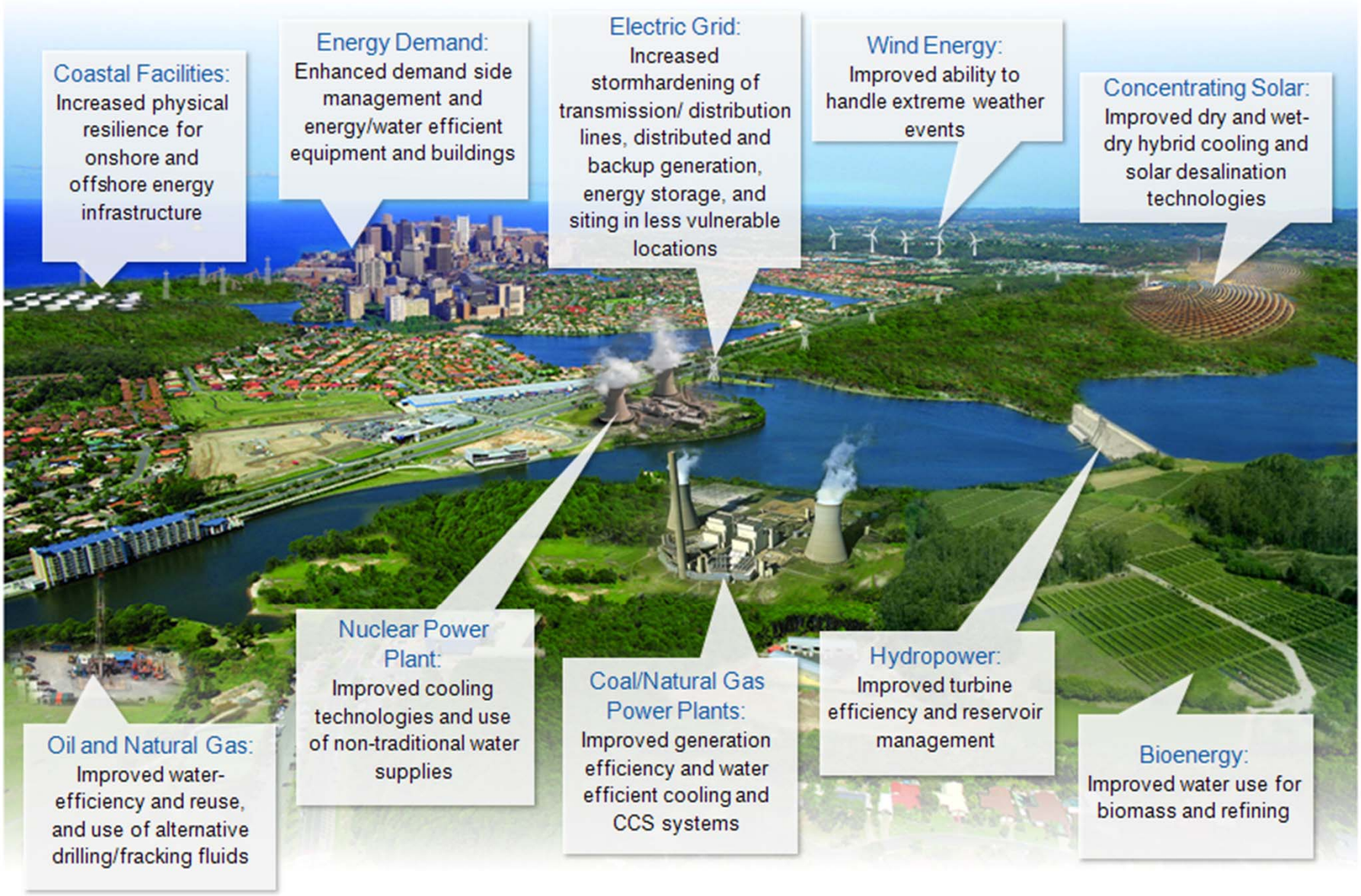


Effective Public and Private Climate Resiliency Actions (cont'd)

Information and Assessment of Vulnerabilities from Global to Local Scale

- Improved data, tools, and models for characterizing vulnerabilities
  - IPCC Fifth Assessment Report *Climate Change 2013: The Physical Science Basis* Summary for Policymakers http://www.climatechange2013.org/images/uploads/WGIAR5-SPM_Approved27Sep2013.pdf
  - Updated National Climate Assessment and regional projections: http://ncadac.globalchange.gov/
  - The Federal Support Water Toolbox: www.WaterToolbox.us
  - Sea Level Planning Tool: http://www.corpsclimate.us/Sandy/
- Federal Vulnerability Assessments including DOE's "Vulnerability Report" and
  - Effects of Climate Change on Federal Hydropower: Report to Congress
  - Hurricane Sandy Rebuilding Strategy
  - Economic Benefits of Increasing Electric Grid Resilience to Weather Outages

Illustrative Opportunities: Building a Climate-Resilient Energy System



President's Climate Action Plan

http://www.whitehouse.gov/sites/default/files/image/president27sclimateactionplan.pdf

The President's plan has three major parts:

- Cut carbon pollution in America
- Prepare the United States for the impacts of climate change
- 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 U.S. climate impacts
- Providing an information toolkit for climate resilience
- Supporting a state, local, and tribal task force on climate preparedness and supporting communities as they prepare for climate impacts
- Promoting insurance industry leadership for climate resilience
- Supporting climate-resilient investment and boosting the resilience of buildings and infrastructure, particularly as we rebuild and learn from Sandy
- DOE and DHS are co-chairing an Infrastructure Working Group under the new White House Council on Climate Preparedness and Resilience.

Next Steps: DOE Response Framework

❖**Enhance Research, Development, Demonstration and Deployment of Climate-Resilient Energy Technologies**

- Use DOE National Laboratories and other mechanisms

❖**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 resiliency

❖**Convene and partner with States and other stakeholders**

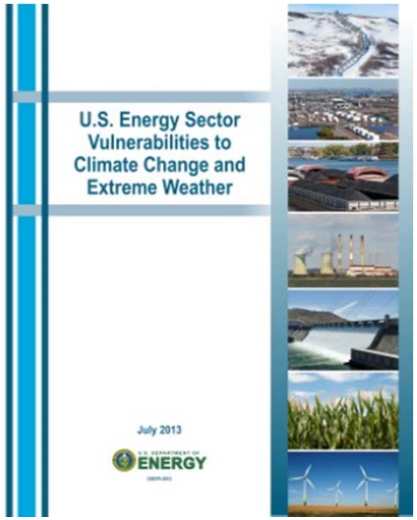
- Build robust public-private-partnerships to deploy innovative technologies and practices to increase energy system resiliency.

For Additional Information

U.S. Department of Energy Contacts:

- ❖ Judi Greenwald - Judith.Greenwald@hq.doe.gov
- ❖ Craig Zamuda, Ph.D. - Craig.Zamuda@hq.doe.gov

- Access to "U.S. Energy Sector Vulnerabilities to Climate Change and Extreme Weather" :



http://energy.gov/articles/climate-change-effects-our-energy