# Overview Of U.S. DOE Report -

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

*RD&D Needs for Energy System Climate Preparedness and Resilience*
IEA Experts' Group on Priority Setting and Evaluation
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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

- Governments 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

# Background

**Purpose of report:**

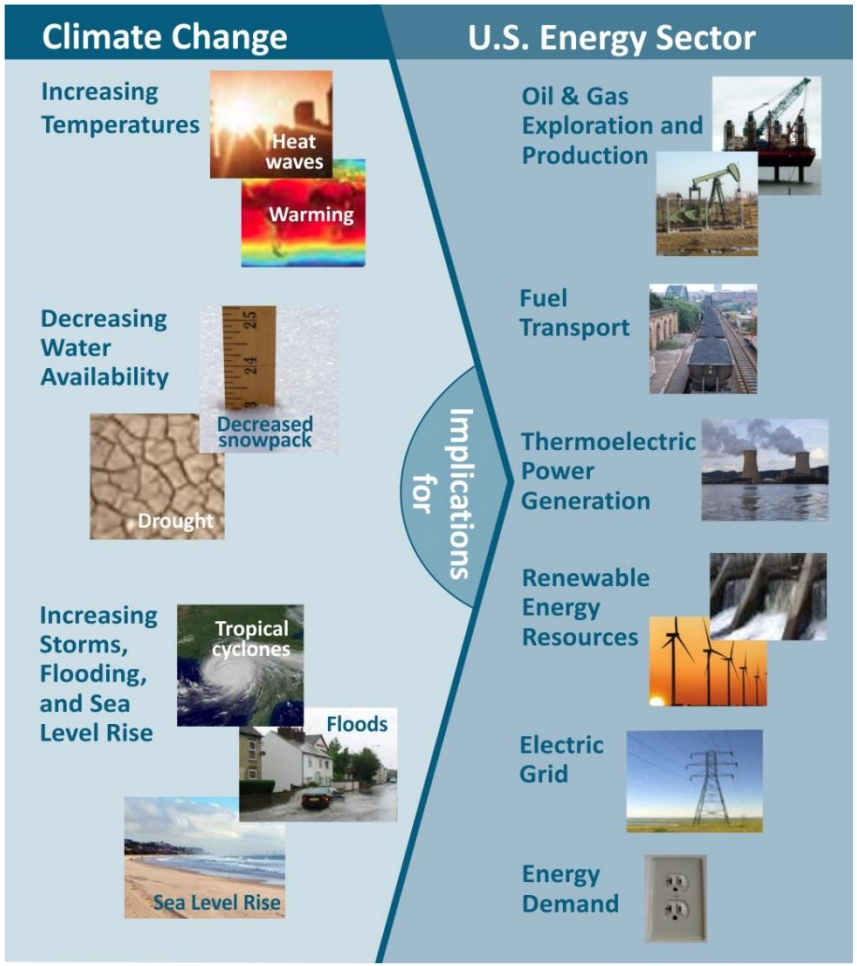
- Support President's Climate Action Plan
- Provide objective analysis of vulnerabilities to the U.S. energy sector - both positive and negative effects
- Identify opportunities for future actions

**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

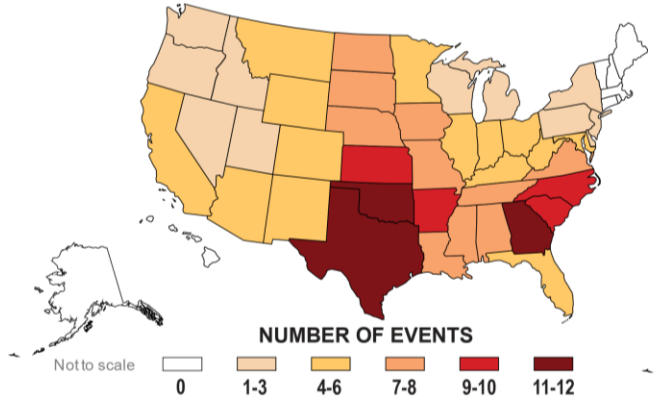
**Scope:**

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

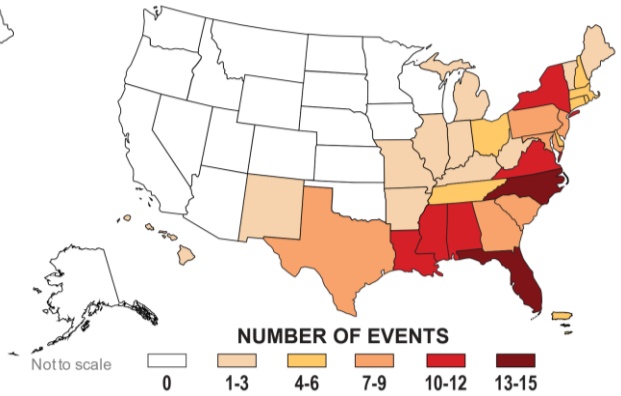


# The Nation Is Climate-Conscious… for Good Reason

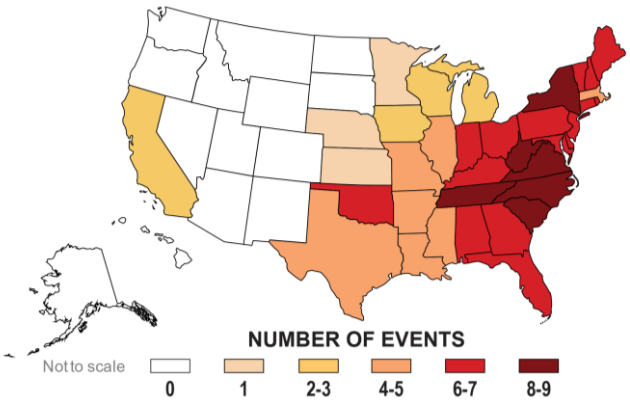
Drought and Heat waves



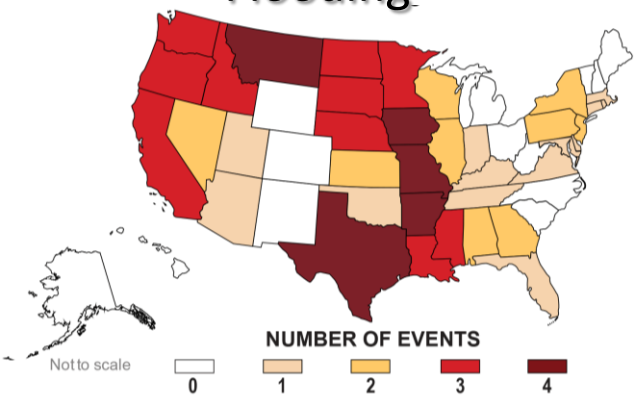

Hurricanes and Tropical Storms



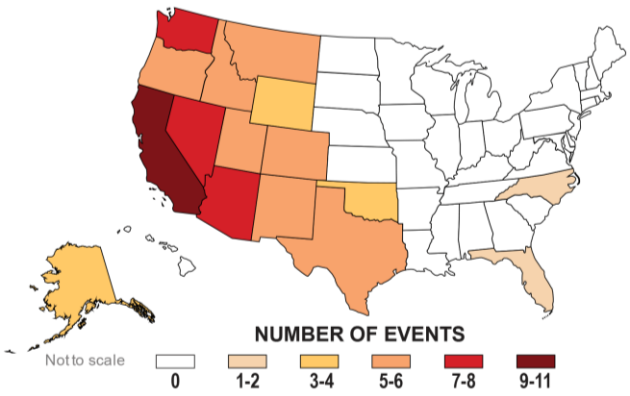

Winter Storms and Crop Freezes



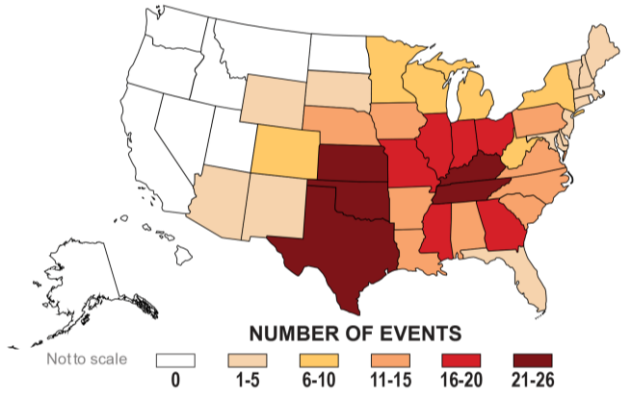

Flooding




Wildfires




Severe Local Storms

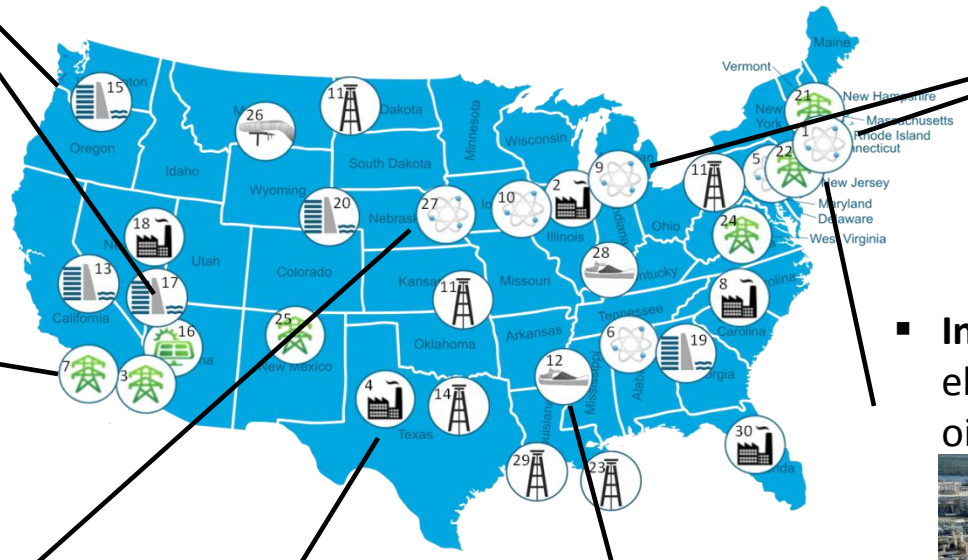


# Recent Events Illustrate U.S. Energy Sector Vulnerability to Climatic Conditions

- **Lower water levels**: Reduced hydropower generation

- **Wildfires**: Damaged transmission lines

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



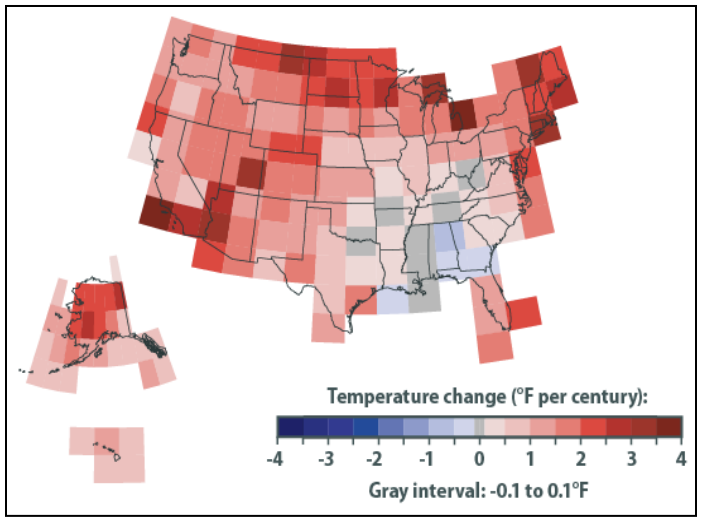

- **Water restrictions due to drought**: Potential limits on shale gas production

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

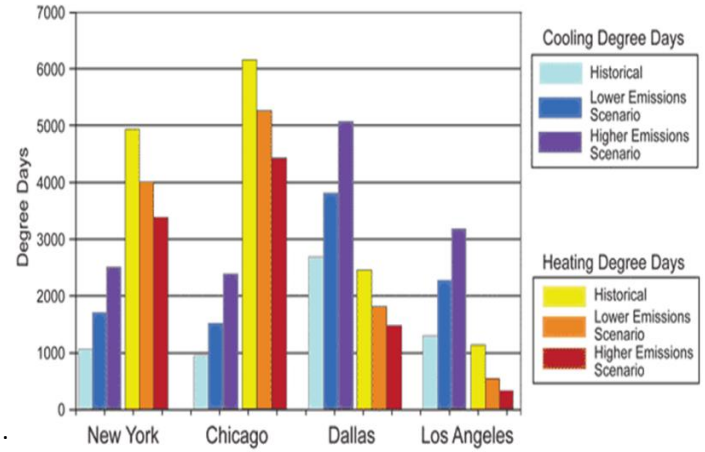
- **Cooling water intake or discharge too hot**: Shutdown and reduced electricity generation from power plants

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

# 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)

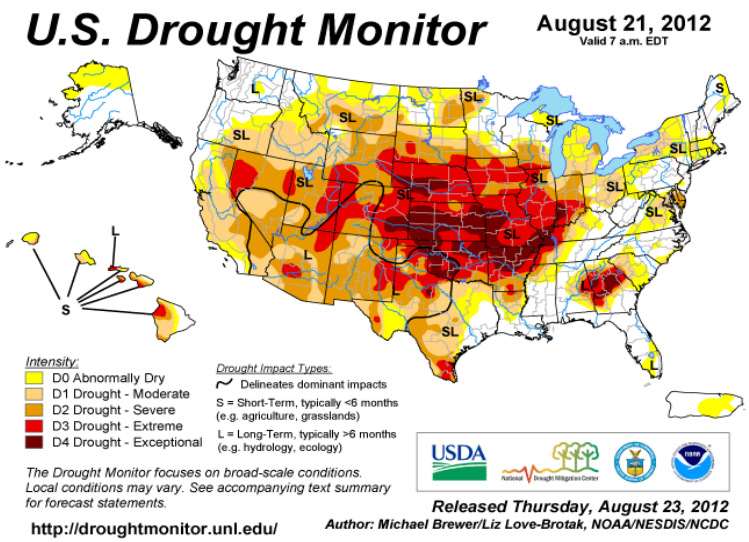
## Climate Trends

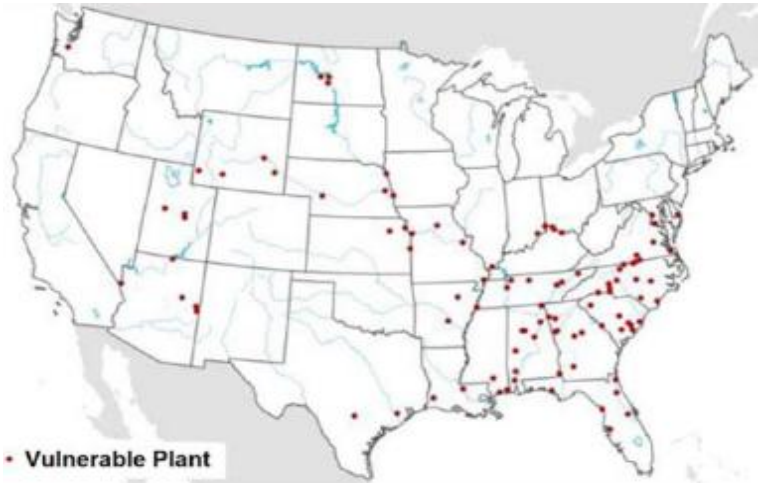
- Average temperatures have increased across the U.S. over the past 100 years
- Heat waves have become more frequent and intense
- Wildfire season and size of fires have increased
- Sea ice cover has decreased in the Alaskan Arctic, and permafrost has thawed

## Key Energy Sector Impacts

- Increasing temperatures will likely increase electricity demand
- Increasing air and water temperatures could decrease available thermoelectric generation capacity and efficiency
- Increasing temperatures reduce transmission efficiency, and 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

# Impacts of Decreasing Water Availability




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

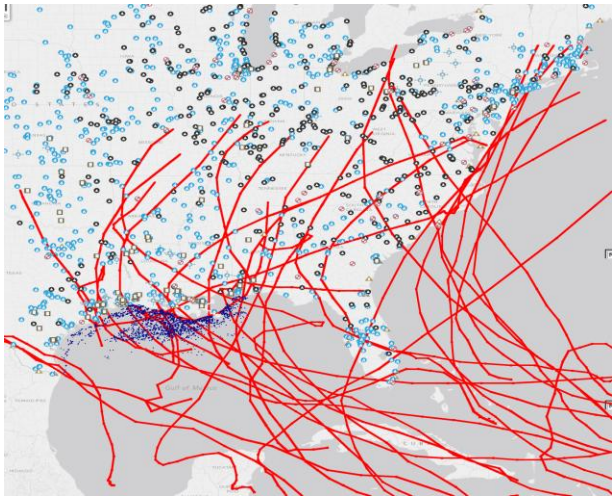
## Climate Trends

- Precipitation patterns have changed, causing regional ("wet areas wetter & dry areas drier") and seasonal changes with more frequent and severe droughts
- Snowpack levels have decreased, resulting in lower summer streamflows
- Ground and surface water levels have declined

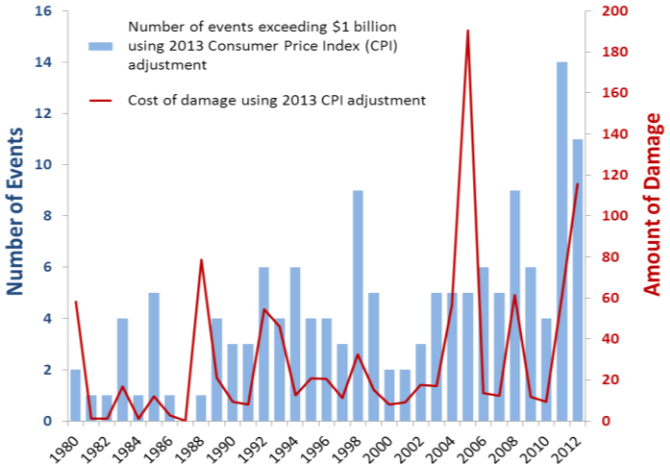
## Key Energy Sector Impacts

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

# 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)




**Billion-dollar weather and climate disasters, 1980–2012** *Data source: NOAA 2013a*

## 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 energy infrastructure 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

# 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 climate resilient 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

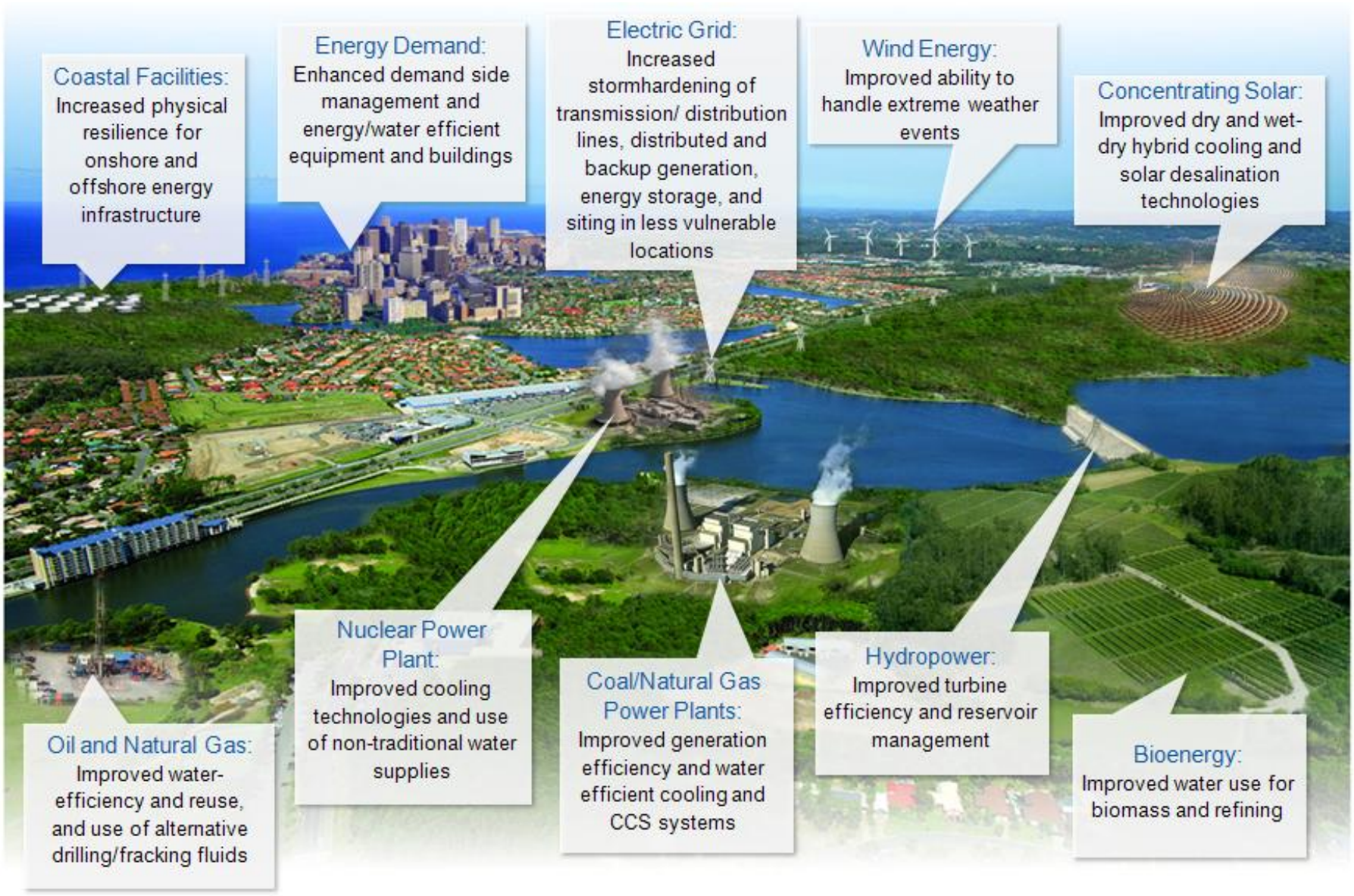
❖**Provide technical information and assistance**

- Facilitate access to higher resolution data, models and tools, and develop guidance and best practices for energy system resiliency

❖**Convene and partner with stakeholders**

- Work with the States and private sector to build robust public-private-partnerships to increase energy system resiliency and to deploy innovative technological solutions and practices.

# Illustrative Opportunities: Building a Climate-resilient Energy System



# For Additional Information

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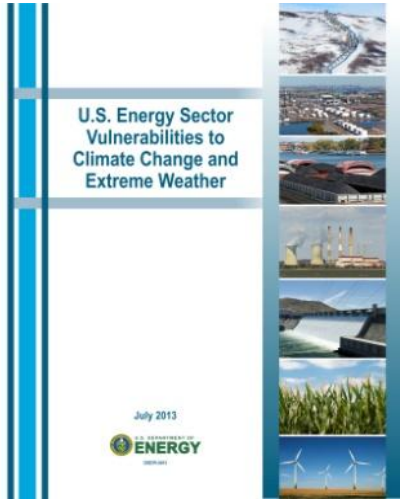
- "Zamuda, C.D., B. Mignone, D. Biello, K.C. Hallett, C. Lee, J. Macknick, R. Newmark and D. Steinberg. 2013. U.S. Energy Sector Vulnerabilities to Climate Change and Extreme Weather. U.S. Department of Energy




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