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CONCORD, MA - WASHINGTON, DC

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978-369-5533
www.mjbradley.com

MJB&A Summary ■ December 2018

Summary of Volume II of the Fourth National Climate Assessment: Impacts, Risks, and Adaptation in the U.S.

On November 23, 2018, the U.S. government released Volume II of the Fourth National Climate Assessment (NCA).[1] NCAs are broadly intended to summarize the effects of climate change on the U.S. Volume I of the Fourth NCA, released in November 2017, focused on the foundational physical science of climate change. Volume II focuses on the observed and projected risks and impacts of climate change on human welfare, the economy, and the environment in the U.S. It also examines impacts at the regional level and details considerations related to risk reduction and implications under various mitigation pathways. Final chapters provide examples of adaptation and mitigation efforts to reduce the risks and costs associated with climate change.

Among its findings, the report concludes, "[w]hile mitigation and adaptation efforts have expanded substantially in the last four years, they do not yet approach the scale considered necessary to avoid substantial damages to the economy, environment, and human health over the coming decades."[2]

Background and Updates Since Previous NCA

The NCA is a Congressionally mandated report the U.S. Global Change Research Program submits to Congress and the President every four years. The Fourth NCA was produced by more than 300 federal and non-federal experts, overseen by a 60-member federal advisory committee and reviewed by thirteen federal agencies.

The Fourth NCA incorporates recent scientific advances and a heightened understanding and experience of extreme events since publication of the Third NCA in 2014.[3] In addition, the Fourth NCA includes enhanced quantification of economic impacts of climate change and new scenario modeling of key environmental variables through 2100. In addition to national-level assessments, the report also divides the U.S. into ten regions to better analyze the observed and projected climate change impacts to each region. State-specific summaries are also available.[4]

The report also includes new chapters evaluating the effects of climate change on U.S. trade and businesses, national security, and U.S. humanitarian assistance and disaster relief (Chapter 16); how traditional air pollutants are affected by climate change (Chapter 13); and how climate change may exacerbate vulnerabilities of human and natural systems that interact between and depend upon each other (Chapter 17). In addition, a new

1 Available at https://nca2018.globalchange.gov

2 NCA, Summary Findings, Section 4: Actions to Reduce Risks

3 The report states that recent scientific advances since publication of the Third NCA include those relating to detection and attribution of human influence, the impact of climate change on extreme events and atmospheric circulations, localized modeling projections, increased understanding of physical processes in ocean and coastal waters, new observations regarding rapid changes in ice loss, and increased understanding regarding large-scale shifts in the climate system ("tipping points").

4 State summaries are available at: https://statesummaries.ncics.org/.

international appendix discusses examples of how other countries have conducted national climate assessments (Appendix 4).

Key Scientific Findings of Climate Change

The following highlights key scientific findings of the report:

Observed and Future Increases in Average Temperature:

- In the contiguous U.S., average annual temperature has increased by 1.2ºF (0.7°C) between 1986 and 2016 and by 1.8°F (1°C) relative to the beginning of the last century.
- Regardless of future emissions, the report projects additional increases in annual average temperature of about 2.5°F (1.4°C) through roughly 2050.
- Significant reductions in emissions could limit global temperature increase to 3.6°F (2°C) or less. Without significant reductions in emissions, annual average global temperatures could increase by 9°F (5°C) or more by the end of this century.

Sea Level Rise: Since 1900, global average sea levels have risen roughly 7 to 8 inches. Almost half of this increase has occurred since 1993. Relative to the year 2000, sea level is very likely to rise 1 to 4 feet by the end of the century.

Rapid Arctic Change. Annual average temperatures in the Arctic have increased more than twice as fast as the global average. These changes are accompanied by thawing permafrost and loss of sea ice and glacier mass. By mid-century, it is very likely the Artic will be nearly free of sea ice in the late summer.

Warming and Acidifying Oceans: Oceans have absorbed roughly 93 percent of the excess heat from anthropogenic warming since the mid-twentieth century. Oceans are also currently absorbing more than a quarter of annual anthropogenic carbon emissions. As a result, the temperature and acidity of the oceans are increasing.

Changing U.S. Precipitation: Average annual precipitation since the beginning of the last century has increased across most of the northern and eastern U.S. and decreased across much of the southern and western U.S. The frequency and intensity of heavy precipitation events are projected to increase with future climate change.

Extreme Climate and Weather Events and Trends. Certain types of extreme events have become more frequent, intense, widespread, and/or of longer duration. From 2015 through April 2018, the U.S. experienced 44 unique billion-dollar weather and climate disasters, incurring total costs of nearly $400 billion. Future climate change is expected to exacerbate these trends:

- **Severe Storms:** Increases in greenhouse gases and decreases in air pollution[5] have contributed to increases in Atlantic hurricane activity since 1970. In the future, Atlantic and eastern North Pacific hurricane rainfall and intensity are projected to increase.
- **Flooding:** While regional changes in sea level rise and coastal flooding are not distributed evenly across the U.S, the frequency, depth, and extent of tidal flooding is expected to increase in the future, as is more severe flooding associated with coastal storms. Since the 1960s, sea level rise has increased the frequency of high tide flooding by a factor of 5 to 10 for several U.S. coastal communities.

[5] Some types of air pollution, especially sulfur aerosols, can have a cooling effect on oceans; therefore, their reduction can lead to warmer waters and increased hurricane activity.

- **Increased Wildfire Risk:** By 2050, the annual area burned in the western United States could increase between two and six times from the present, depending on the geographic area, ecosystem, and local climate. Forest fire risk is projected to increase in parts of the country where is has been more limited to date, such as in the desert Southwest.
- **Heat waves:** The average season length of heat waves across many U.S. cities has grown by more than 40 days over the past half century.

Observed and Projected Climate Change Impacts on Welfare, Economy, and Environment in the U.S.

The report synthesizes observed and projected impacts of climate change at a national and (where applicable) regional level, as well as implications under various mitigation pathways. The following are key takeaways:

Reduced Agricultural Productivity: Food and forage production is expected to decline in regions experiencing increases in the frequency and duration of drought and elevated growing-season temperatures. Agricultural productivity will also be affected by soil degradation and water issues caused by extreme precipitation events. An increased likelihood of extreme heat events can contribute to heat stress in livestock, resulting in economic losses for producers.

Public Health and Air Quality: Climate change is projected to continue to negatively affect human health by increasing exposure to extreme weather events and infectious diseases and by affecting the quality and safety of air, food, and water.

- **Air Quality and Health Impacts**: Many factors affecting air quality are intertwined with the effects of climate change; therefore, overall impacts will likely vary by region. For example, regions that experience excessive periods of drought and higher temperatures will have increased frequency of wildfires, increased ozone production, and more windblown dust from soils. At the same time, changes to temperatures and rainfall affect the types of crops that can be grown and the length of the growing season, the application of fertilizers and pesticides to crops, and ensuing transport and fate of those chemicals into the air, water, and soil. Despite this regional variability, however, there is evidence that climate change will increase the risk of unhealthy air quality in the future across the nation in the absence of further air pollution control efforts. This could lead to increasing incidence of adverse respiratory and cardiovascular effects, including premature death, impairing visibility, and disrupting outdoor recreational activities.
- **Heat-Related Deaths:** Under a high emissions scenario in 49 large U.S. cities, changes in extreme hot and extreme cold temperatures are projected to result in more than 9,000 additional premature deaths per year, amounting to annual damages totaling $150 billion (in 2015 dollars) in 2090. A lower emissions scenario could avoid more than half of these deaths, with damages reduced to $60 billion annually by 2090.
- **Labor Productivity:** Under a high emissions scenario, almost two billion labor hours are projected to be lost annually by 2090 from the impacts of temperature extremes, costing an estimated $160 billion in lost wages (in 2015 dollars).

Outdoor Recreation, Tourism, and Coastal Economies: Climate change damages to ecosystems are harming the quality of fisheries, tourism, human health, and public safety. These changes are expected to reduce the quality of outdoor recreation and other activities that attract tourists and provide income for tourist economies.

Built Environment, Infrastructure, and Transportation: Under a high emissions scenario, it is likely that between $66 billion and $106 billion worth of real estate will be below sea level by 2050 (by 2100, this range could rise to $238 billion to $507 billion). Even under lower emissions scenarios, chronic high tide flooding will lead to higher costs and lower property values for communities and individuals. Increases in heavy precipitation, coastal flooding, heat, wildfires, and other extreme events pose risk to the reliability, safety, and efficiency of the U.S. transportation system. Targeted coordination that addresses interconnected vulnerabilities can build resilience to climate change. Coordination may involve local and state governments, public-private partnerships, and communities.

Effects on U.S. International Interests: The impacts of climate change are virtually certain to increasingly affect U.S. trade and economy, including import and export prices and businesses with overseas operations and supply chains. Climate change is already affecting U.S. military infrastructure.

Impacts to Vulnerable Populations Social and economic consequences of climate change are likely to disproportionately affect marginalized and vulnerable populations, including children, older adults, low-income communities, and some communities of color.

Observed and Projected Climate Change Impacts on Energy in the U.S.

The electric sector is particularly vulnerable to climate change. Furthermore, as explored in Chapter 17 (Sectoral Interactions, Multiple Stressors, & Complex Systems), electricity's central role in nearly all economic activity means that climate change disruptions can ripple throughout multiple sectors. Key impacts discussed in the report are summarized below and are displayed visually in Figure 1.

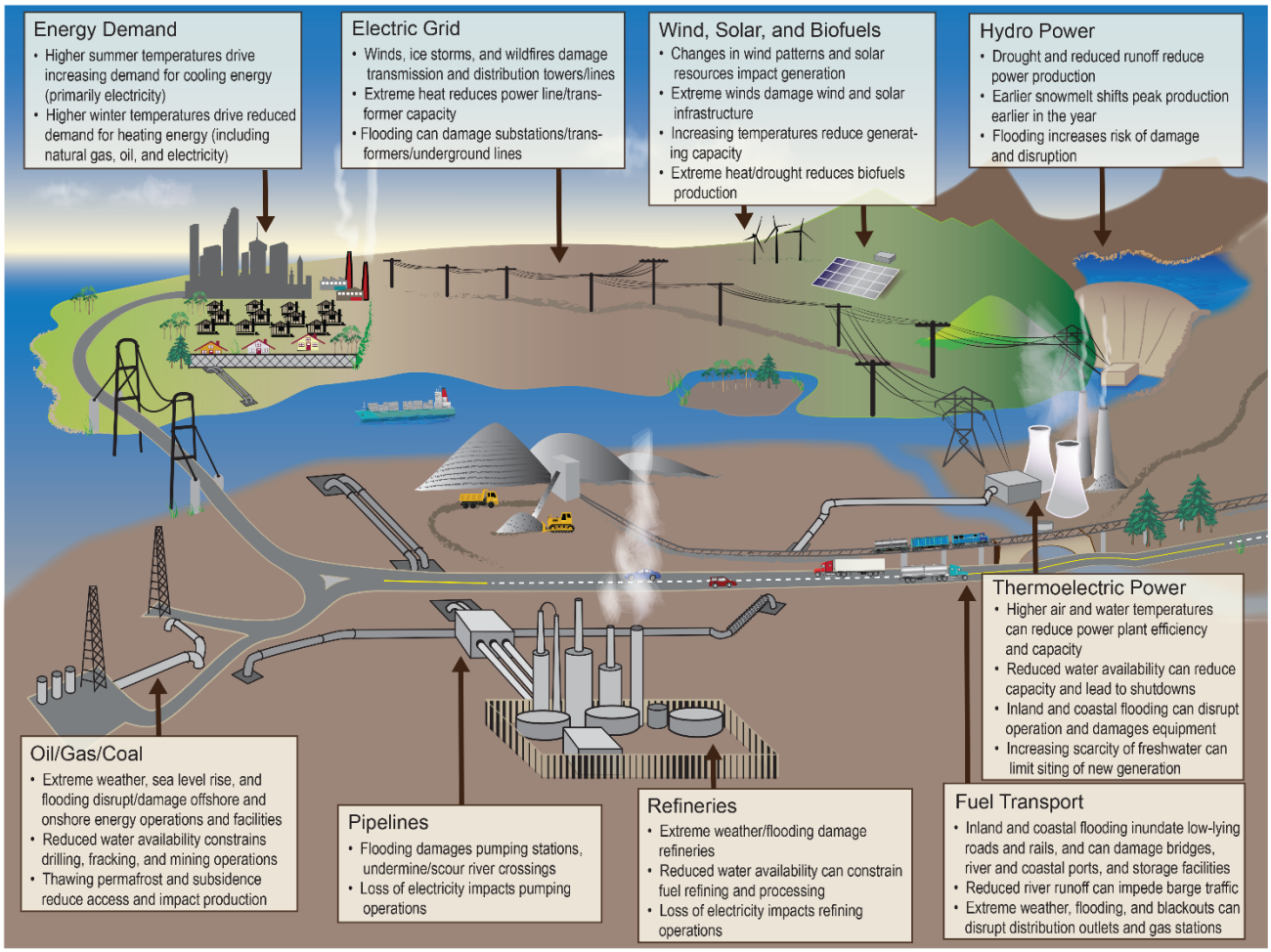
Resilience: More frequent and longer-lasting power outages due to climate change-induced severe weather events are projected to continue to threaten the reliability of critical energy infrastructure and to create fuel availability and demand imbalances. Changes in energy technologies, markets, and policies are affecting the energy system's vulnerabilities to climate change and extreme weather events.

Sea Level Rise Impacts: Nationally, sea level rise of 3.3 feet would expose dozens of power plants, totaling 25 gigawatts of operating or proposed power capacity, at risk to a 100-year flood. Increased flood risk is expected for Gulf Coast refineries.

Energy Demand: Rising temperatures are expected to increase electricity demand by 3 to 9 percent by 2040 under a high scenario and 2 to 7 percent under a low scenario.

Energy Expenditures: Rising temperatures are expected to increase electricity costs by increasing demand, reducing the efficiency of power generation and delivery, and by requiring new generation capacity. By 2040, electricity expenditures are projected to increase by 6 to 18 percent under a high emissions scenario (4 to 12 percent under a low emissions scenario). By 2100, the increase in annual energy expenditures in a high emissions scenario is estimated at $32 billion to $87 billion.

Figure 1: Impacts of climate change and extreme weather events on energy system



Source: Fourth NCA, Volume II, adapted from DOE.

Generation Needs: Compared to a scenario without a warming climate, rising temperatures could necessitate the construction of up to 25 percent more power plant capacity by 2040.

Improving Energy System Resilience: Actions to enhance energy security, reliability, and resilience to climate change effects can include improved data collection, modeling, and analysis to support resilience planning; private and public-private partnerships to support coordinated action; and the development and deployment of new, innovative energy technologies to adapt energy assets to extreme weather hazards.

Figure 2: Projected Changes in Energy Expenditures

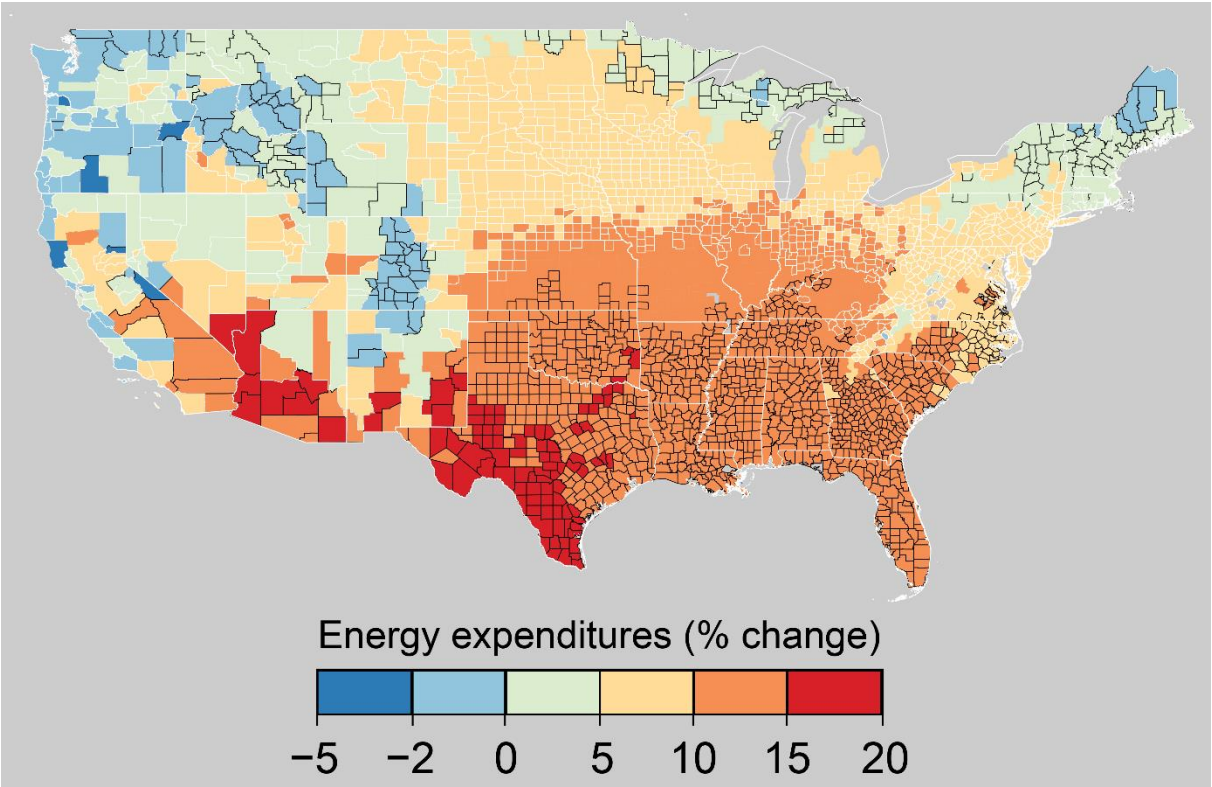


Figure 1: Depiction of county-level median projected increases in energy expenditures for average 2080-2099 impacts under a high emissions scenario. Outline color indicates level of agreement across model projections (thin white outline indicates disagreement of inner 66% of projections in sign; no outline indicates agreement in sign of more than 83% of projections; black outline indicates agreement in sign of more than 95%. *Source:* Fourth NCA, Volume II.

Conclusions

The report finds that impacts of climate change are substantial and wide-reaching, with observed and projected damages to the economy, environment, and human health and welfare. It also finds that while mitigation and adaptation efforts from communities, governments, and businesses have increased, more immediate, substantial, and sustained reductions of greenhouse gas emissions are needed to avoid the most severe consequences. Without these actions, climate change is expected to further damage American infrastructure and property, amounting to substantial economic damages. The final two chapters of the report detail the benefits of and opportunities for mitigation and adaptation. These actions can help reduce the risk of and cost associated with climate change.

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