

# DOE CLIMATE CHANGE ADAPTATION PLAN

2016 INTERIM UPDATE

Department of Energy,  
Sustainability  
Performance Office

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## Introduction

This document serves as an interim update to the 2014 Department of Energy (DOE) Climate Change Adaptation Plan, which is required by Executive Order (EO) 13693, *Planning for Federal Sustainability in the Next Decade*. This update specifies relevant policies and directives that contain language to incorporate climate risk management, and identifies milestones, timelines, and responsibilities for specific DOE offices.

This document is the third interim update of DOE's Climate Change Adaptation Plan. DOE has modified its Adaptation Plan over time in accordance with Executive Order (EO) 13653, *Preparing the United States for Climate Change*, to incorporate knowledge gained from previous adaptation plans and the experiences of the Department and other federal agencies in responding to extreme weather events. The Department's Adaptation Plan also draws from the President's Climate Action Plan of June 2013.

This 2016 update incorporates items discussed at the July 2016 progress review with the White House Council on Environmental Quality (CEQ) and the Office of Management and Budget (OMB), which focused on DOE's progress in climate change adaptation and its responses to the 2016 Strategic Sustainability Performance Plan (SSPP) climate change survey.

This Adaptation Plan considers the national and international context of the DOE mission, as well as the local perspective of DOE facilities and community stakeholders. DOE's refined understanding of climate change enables DOE to more accurately forecast climate change impacts, quantify risk, and identify opportunities to improve resilience to the impacts of climate change. This Adaptation Plan is consistent with DOE's ongoing mitigation activities as outlined in its annual SSPP. DOE maintains a commitment to reducing agency greenhouse gas emissions, using renewable energy technologies, and making its operations sustainable.

## Background

The Department of Energy has identified climate change as a significant threat to future operations, missions, and personnel. Resilience to the impacts of climate change is, therefore, of paramount importance. DOE expects climate change-related severe weather events to increase in frequency and intensity at sites across the DOE complex.

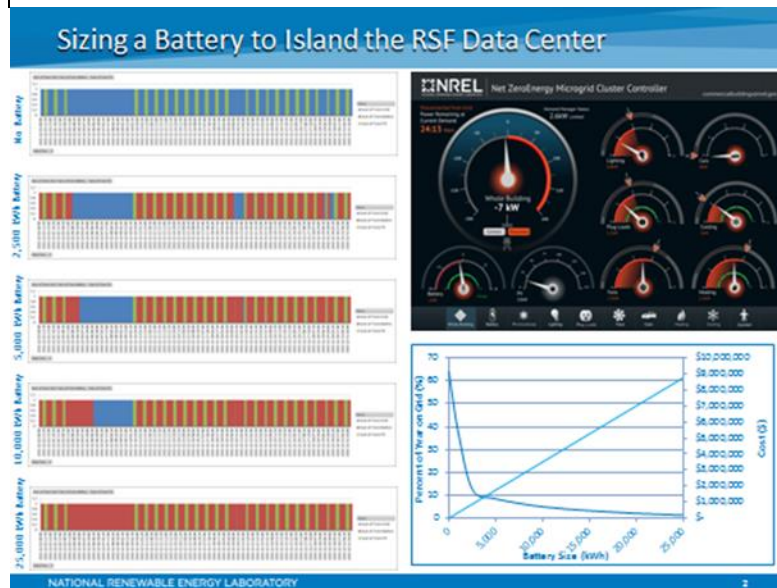
DOE sites have already experienced impacts from climate change. For instance, Los Alamos National Laboratory (LANL) has experienced historic extreme weather events in recent years; the Cerro Grande fire of 2000 resulted in a two week site shutdown, 45 buildings lost, 67 buildings damaged, and damages totaling \$331 million, not including lost productivity. After implementing mitigation and preparation measures, in 2015 LANL experienced the Los Conchas fire. This fire resulted in \$15.7 million in damages and shut down the site for 9 days. LANL is susceptible to drought and flooding, and is currently undergoing a vulnerability assessment to formally assess all climate and severe weather risks, building upon previous laboratory studies.

While climate change and severe weather events may impact every DOE site, not all vulnerabilities have been characterized. The Department is addressing this by implementing new policies as a part of its high-level strategy for resilience to the impacts of climate change. Identifying risks will enable sites to integrate risk management into current processes. While these actions to identify risk may be of little or no cost to a site, they will allow for reduced costs in the long-term. Several laboratories, including the National Renewable Energy Laboratory (NREL) and the Pacific Northwest National Laboratory (PNNL), have already begun implementing resilience action plans, utilizing results from their vulnerability assessments. Action plans are the drivers of change at the site level and are a critical step in the implementation process.

### ***Resilience Planning at NREL***

In FY 2016, NREL initiated three activities associated with the resilience to climate change options identified in the laboratory’s 2015 climate change vulnerability assessment and resilience action plan: (1) development of control technologies and processes to better manage electricity demand; (2) conducting preliminary analysis of adding battery storage on the South Table Mountain (STM) campus to investigate feasibility of islanding facilities--remaining operational even when the grid goes down--during power outages; and (3) designing and constructing slope stabilization for eroding hillsides of the STM campus due to high peak storm events.

#### **Electricity Demand Management and Battery Storage Sizing Analysis**



Reliance on a single electricity supplier is a high-risk vulnerability for NREL. The campus’s Information Technology (IT) infrastructure, buildings and research equipment depend on a reliable source of electricity to meet mission objectives. To reduce the risk associated with this vulnerability, NREL is developing an electricity-shortage contingency plan consisting of pilot project initiatives. NREL determined that acquisition of a large battery would increase the site’s ability to utilize

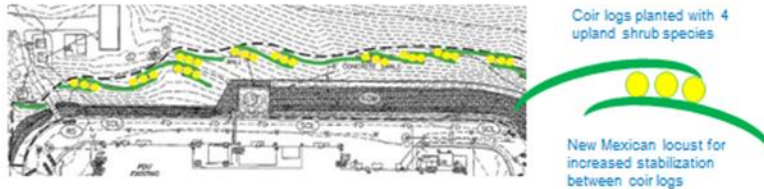
energy from renewable generation during peak demand hours and power outages. NREL evaluated performance and sizing requirements for battery storage to maintain the laboratory’s internal data center operations for 10 business days. In parallel, NREL experimented with various strategies and technologies utilizing the Electric Vehicle Supply Equipment (EVSE) stations in the parking garage, combined with a 30kW battery and the parking garage rooftop

solar PV array, to manage and reduce electrical loads to avoid demand charges and prioritize charging schedules.

### STM Campus Slope Stabilization Design and Construction

NREL's STM campus lies directly adjacent to the South Table Mountain. The proximity of mission critical facilities to the severe mesa slopes creates high impact zones for poor drainage, hillside instability, and erosion. Previous storm events have caused nuisance flooding and

#### Phase 1 Strategies to Mitigate Site Erosion West Campus



erosion issues. More frequent and intense storm events are anticipated in the future, increasing the risk for NREL facilities. Instead of reacting to events with isolated recovery projects, NREL is proactively addressing vulnerabilities across the site in a holistic manner to reduce the overall risk. The development of a site drainage and stability master plan assesses and integrates solutions from a watershed to a basin scale. Several projects for implementation were identified. In one project, NREL is working to

address increased landslides occurring on the west side of its campus. This project's construction is comprised of two phases. The first phase involves restoration through the installation of biologs, a pre-grown 10-foot coconut coir log planted with native shrubs, which will be connected, trenched, and embedded in the upper hillside to dissipate heavier rainstorm flows. This method mitigates slope down-cutting and erosion, slows conveyance of surface waters, and utilizes vegetation root systems to stabilize soil surfaces. The second phase will integrate a 6-foot concrete wall to stabilize the lower tier adjacent to the roadway, outdoor research equipment, and facilities.

In FY 2016, following completion of its vulnerability assessment, PNNL began incorporating new measures into existing procedures and assessments. PNNL created an action plan<sup>1</sup> and will continue implementation efforts through FY 2017. Current measures, new measures identified in FY 2015 to build resilience to climate change impacts, and the FY 2016 status of those new resilience measures, are outlined in the Table 1 below.

**Table 1: Current and Future Actions to Address High Priority Climate Impacts on PNNL Systems**

| <b>Climate Exposure and System Impacts</b>          | <b>High Temperature Impact on Building and Energy Systems</b>  | <b>Intense Precipitation Impact on Building Systems</b>  |
|---|--|--|
| <b>Current Measures</b>                             | <ul style="list-style-type: none"> <li>• Annual review of preventative maintenance plans</li> <li>• Cool roofs are the design default</li> <li>• Maximize use of light-colored materials for roofs and hard-paved areas</li> <li>• Use of shade trees</li> <li>• Optimize building orientation</li> <li>• Plans for a mobile chiller to boost systems stressed by heat</li> <li>• Reduce energy demand with three Energy Savings Performance Contracts (ESPC)</li> <li>• Ensure energy escalation rates reflect risk in facility design and operations planning</li> </ul> | <ul style="list-style-type: none"> <li>• Preventative maintenance procedures to clean roof drains</li> <li>• Current building drain systems are designed for 1” of rain in 24 hours</li> </ul>   |
| <b>New Measures and FY 2016 Status (in italics)</b> | <ul style="list-style-type: none"> <li>• Track equipment life relative to life expectancy and adjust in Life Cycle Cost (LCC) analyses if needed</li> </ul> <p><i>Equipment LCC is tracked via MARS (PNNL’s maintenance program software). Premature equipment failures due to climate is reviewed during annual assessment. Equipment LCC will be adjusted in MARS.</i></p> <ul style="list-style-type: none"> <li>• Use building control systems to alternate operating schedules and reduce power load, if needed</li> </ul>  | <ul style="list-style-type: none"> <li>• Revisit preventative maintenance procedure for building drainage systems for adequate frequency</li> </ul> <p><i>Preventative maintenance measures associated with building drainage were reviewed and determined to be adequate.</i></p> <ul style="list-style-type: none"> <li>• Include drains in five-year facility condition assessments</li> </ul> <p><i>Five-year condition assessment procedure was reviewed and determined to include drainage system integrity.</i></p> |

<sup>1</sup> “Climate Resilience Planning at PNNL.” PNNL. 2016. <http://sustainable.pnnl.gov/climate-resilience/>



|                            |  |  |
|----------------------------|--|--|
|                            | <p><i>PNNL has the ability to reduce power load if needed through its building control system (Johnson METASYS). Operation of this system is captured in a PNNL operating procedure. Additionally, Facility Operation is partnering with R&amp;D to enable automating power load reduction program – VOLTTRON in several buildings.</i></p> <ul style="list-style-type: none"> <li>• Model temperature increases in new building designs and consider trade-offs for changes in envelope and heating, ventilating, and air conditioning (HVAC) design <ul style="list-style-type: none"> <li>• <i>Evaluation to assess the current American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) requirements against the National Oceanic and Atmospheric Administration (NOAA) climate predictions was initiated in FY16 with planned completion in FY17.</i></li> </ul> </li> <li>• Implement continuous commissioning and facility-tuning to reduce energy demand <ul style="list-style-type: none"> <li>• <i>Initiated continuous commissioning and facility-tuning for Energy Independence and Security Act (EISA) “covered facilities” to reduce energy demand.</i></li> </ul> </li> </ul> | <ul style="list-style-type: none"> <li>• Consider flood risk changes in building design and leasing decisions <ul style="list-style-type: none"> <li>• <i>Evaluated the flood risk changes in building design and determined that this is a low risk and no further action is needed at this time.</i></li> </ul> </li> <li>• Assess risk of buildings with below-ground access <ul style="list-style-type: none"> <li>• <i>Evaluated the flood risk for building with below-ground access and determined that this is a low risk and no further action is needed at this time.</i></li> </ul> </li> <li>• Assess building and parking lot catch-basins/storm drains annually to ensure effective infiltration <ul style="list-style-type: none"> <li>• <i>Preventative maintenance measures associated with catch-basins/storm drains were reviewed and determined to be adequate.</i></li> </ul> </li> </ul> |
| <p>Responsible Offices</p> | <ul style="list-style-type: none"> <li>• Sustainability Program</li> <li>• Facilities Strategic Planning</li> <li>• Facilities Engineering</li> <li>• Facilities &amp; Grounds Maintenance</li> </ul>  | <ul style="list-style-type: none"> <li>• Sustainability Program</li> <li>• Facilities Engineering</li> <li>• Facilities &amp; Grounds Maintenance</li> </ul>   |

Additionally, as part of their FY 2015 climate resilience planning effort, PNNL defined metrics that could be tracked over time to help gauge changes in climate risk. The effort to integrate these metrics into the Sustainability Management & Operations Program Management

System began in FY 2016. Based on further conversations with data holders and other stakeholders, PNNL modified some of the indicators to provide more useful information, as reflected in Table 2 below. The revised metrics and the status of the metrics will be provided to PNNL’s internal climate resilience planning team in FY 2017. For the next few years, PNNL will use this information to better understand baseline conditions. Over time, PNNL will be in a better position to understand whether risk thresholds have been crossed, which may necessitate new policies, procedures, or plans for adoption.

**Table 2: PNNL Climate Indicators**

| Risk                              | Indicator   |
|-----------------------------------|---|
| <b>High Temperature Risk</b>      | <ul style="list-style-type: none"> <li>• Number of days over 100°F per year</li> <li>• Premature HVAC equipment failure rates for envelope degradation rate</li> <li>• Cooling season utility costs, sustained year-over-year</li> <li>• Total water use during cooling season for cooling</li> </ul>   |
| <b>Wildfire Risk</b>              | <ul style="list-style-type: none"> <li>• Number of fire events per year in region</li> <li>• Cost of responding to (managing) wildfire events</li> </ul>  |
| <b>Intense Precipitation Risk</b> | <ul style="list-style-type: none"> <li>• Number of rainfall events per year that exceed 1" in 24 hours</li> <li>• Number of flood incidents per year that affect facilities and infrastructure (e.g. vaults)</li> <li>• Cost of responding to flood events</li> <li>• Number of times catch-basins are clogged per year and require maintenance (beyond annual PM)</li> </ul> |

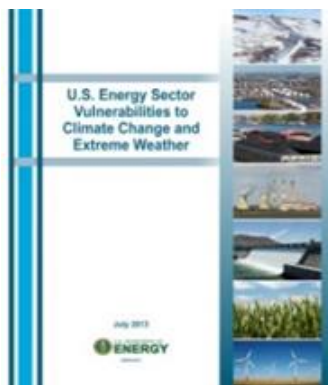
In FY 2016, PNNL partnered with sustainability program personnel from the Hanford Site to facilitate development of the first vulnerability assessment and resilience plan for the adjacent Hanford Site. PNNL leveraged the climate exposure data and analysis from the Hanford Site vulnerability assessment for its own vulnerability assessment. PNNL research scientists helped form the Hanford stakeholder team, facilitated planning workshops, and provided technical analyses of potential climate impacts. The findings from both the Hanford and PNNL assessments were shared at Energy Exchange 2016. Vastly different vulnerabilities were identified across the two sites, even though they share a border, which illustrates how the local context can influence vulnerability and the importance of site-level assessments. In FY 2017, the PNNL and Hanford climate vulnerability assessment teams will continue to collaborate and share data that is of interest to both organizations, such as extreme weather events, high heat days or wet-bulb globe temperature data, and fire risk days. Recording this data will inform future assessments and action plans.



Characterizing climate change, assessing its risks, and reporting on action plans is not only a part of each site's Site Sustainability Plan (SSP) annual reporting process. Climate change is considered when formulating new policies, updating site plans, and modernizing emergency response protocols. DOE plans to release an updated Climate Change Adaptation Plan within a year following the release of the Fourth National Climate Assessment (NCA), scheduled for publication by the United States Global Change Research Program (USGCRP) in 2018.

## Past Documents

Prior to this document, DOE released *A High Level Analysis of Vulnerability to Climate Change* in April 2012. This 2012 report, consistent with EO 13514,<sup>2</sup> *Federal Leadership in Environmental, Energy, and Economic Performance*, established initial findings on the Department's exposure to the impacts of climate change, described its ongoing research and adaptation work, and identified the implications of climate change on DOE missions, programs, and operations. The report highlighted case studies at sites that previously experienced extreme weather events that may become more likely with climate change. In June of 2012, the Department released the *U.S. Department of Energy Climate Change Adaptation Plan*.<sup>3</sup> This plan consisted of a high-level review of possible risks to the Department and its facilities, missions, and personnel. The document also outlined a threefold approach to resilience: reducing greenhouse gas emissions; reducing dependency on limited natural resources; and preparedness through updated emergency response procedures.



underway at DOE sites.

In 2013, DOE's Office of Energy Policy and Systems Analysis (EPSA) released the *U.S. Energy Sector Vulnerabilities to Climate Change and Extreme Weather* report.<sup>4</sup> It summarized potential climate impacts on various components of the energy sector, including thermoelectric power generation, renewable energy sources, hydropower, and energy demand. The types of climate events identified were increased temperatures, decreased water availability, more frequent severe storms, floods, and sea level rise. Adaptation opportunities were identified, as were specific actions already

The Third NCA was released in June 2014 by USGCRP. It was designed to provide federal agencies with climate predictions and impacts by U.S. region. The *2014 DOE Climate Change Adaptation Plan*<sup>5</sup> described potential impacts to physical assets, missions and programs,

<sup>2</sup> Revoked and superseded by EO 13693, *Planning for Federal Sustainability in the Next Decade*.

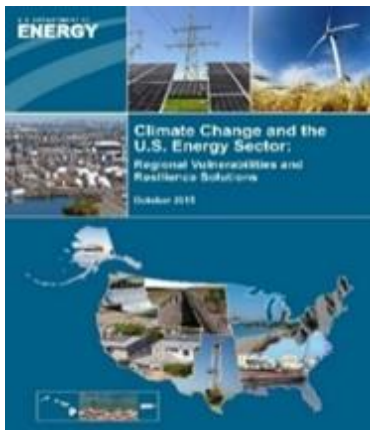
<sup>3</sup> Part of the 2012 SSPP, *U.S. Department of Energy Climate Change Adaptation Plan*. DOE. June 2012. [https://www1.eere.energy.gov/sustainability/pdfs/doe\\_sspp\\_2012.pdf](https://www1.eere.energy.gov/sustainability/pdfs/doe_sspp_2012.pdf)

<sup>4</sup> "U.S. Energy Sector Vulnerabilities to Climate Change and Extreme Weather. July 2013" <http://www.energy.gov/downloads/us-energy-sector-vulnerabilities-climate-change-and-extreme-weather>

<sup>5</sup> *2014 DOE Climate Change Adaptation Plan*. DOE. June 2014. [http://energy.gov/sites/prod/files/2014/10/f18/doe\\_ccap\\_2014.pdf](http://energy.gov/sites/prod/files/2014/10/f18/doe_ccap_2014.pdf)

human health, energy infrastructure and availability, and water availability. Proposed adaptation activities included regional and interagency collaboration, site-level pilot vulnerability assessments, energy grid resilience to climate change impacts, and mission activities advancing climate science. A number of planned activities were described, including policy updates, improved procurement and real property decisions, and modernized Federal programs to support resilient investments. The plan discussed broad strategies and climate impacts. In October 2014, pilot vulnerability assessments were published by Idaho National Laboratory (INL) and Thomas Jefferson National Accelerator Facility (TJNAF). These two sites were the first to complete vulnerability assessments piloted by the Sustainability Performance Office (SPO).

DOE conducted a site survey in 2014 with results documented in a January 2015 report entitled *Climate Extremes and Impacts Survey Results*. The report inventoried participating



sites' climate hazards and the duration and frequency of climate-related severe weather events. In February 2015, LANL released its own case study, *Climate Change and Los Alamos National Laboratory: The Adaptation Challenge*.<sup>6</sup> This study discussed LANL's wildfire risk, wildfire damage, and changes made to LANL's preparedness and response procedures. In September 2015, EPSA released *Climate Change and the U.S. Energy Sector*.<sup>7</sup> This report detailed climate hazards in the U.S. energy sector that impact key infrastructure necessary to operate DOE sites. This extensive document covered each region of the U.S. separately, detailing likely climate impacts named by the

USGCRP, as well as vulnerabilities of significant power types, such as hydroelectric power, and the electric grid. Two additional pilot vulnerability assessments—at PNNL and NREL--were completed by September 2015. Utilizing the findings from the four pilot assessments, a process guide was released by SPO in December 2015 to assist sites in completing a vulnerability assessment. This guide, *Practical Strategies for Climate Change Vulnerability Assessments*, does not promote a single framework, but details pilot vulnerability assessment approaches, best practices, and lessons learned.

In February 2016, PNNL released *Vulnerability Assessments and Resilience Planning at Federal Facilities*.<sup>8</sup> This report outlined a three-tiered approach to climate change adaptation and assessment of climate vulnerabilities for Federal agencies. In May 2016, DOE released its *Strategic Water Management Plan*. This plan examined climate risks associated with water availability across the DOE complex. It found 16 DOE sites located in highly vulnerable watersheds and 11 sites located in watersheds considered vulnerable. Most of the identified sites are located in arid regions of the U.S. at significant risk of drought. These sites are considered

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<sup>6</sup> *Climate Change and the Los Alamos National Laboratory: The Adaptation Challenge*. DOE. February 2015. [http://energy.gov/sites/prod/files/2016/04/f30/CC\\_at%20LANLCase%20Study2-23-15final.pdf](http://energy.gov/sites/prod/files/2016/04/f30/CC_at%20LANLCase%20Study2-23-15final.pdf)

<sup>7</sup> "Climate Change and the U.S. Energy Sector: Regional Vulnerabilities and Resilience Solutions. October 2015" <http://www.energy.gov/epsa/downloads/climate-change-and-us-energy-sector-regional-vulnerabilities-and-resilience-solutions>

<sup>8</sup> *Vulnerability Assessments and Resilience Planning at Federal Facilities*. PNNL. February 2016. Preliminary Assessment available online: <http://www.osti.gov/scitech/servlets/purl/1211559>

good candidates for climate change resilience planning with a focus on water risks. By fall of 2016, the Savannah River Site, Moab Site, and Waste Isolation Pilot Plant completed vulnerability assessments or screenings. As previously mentioned, in October 2016, the Hanford Site completed its vulnerability assessment with assistance from PNNL.

DOE will leverage these past documents and harness available knowledge to build a foundation, through policy changes and key actions, to increase overall resilience to climate change impacts and severe weather events.

## Risks of Inaction

The Department recognizes that changes in the global climate system will have a profound impact on its operations. DOE is committed to reducing greenhouse gas (GHG) emissions and mitigating climate change by developing clean energy and energy efficiency technologies for commercial deployment while providing leadership through its own sustainable operations. As the effects of climate change are felt across the world, it is necessary to characterize potential impacts on the DOE mission, programs, and operations to foster adaptation and resilience to those impacts.

According to the Third NCA,<sup>9</sup> average temperatures in the U.S. will rise another 2°F to 4°F in most regions of the nation over the next few decades, increasing electricity demand for cooling and decreasing generation and transmission efficiency. Sea levels have already risen 8 inches over the past century and will rise another 1 to 4 feet by the end of this century, posing significant risks to coastal energy infrastructure. The Third NCA projects increases in expected hurricane-associated storm intensity and rainfall rates. Dry spells will increase in duration in most regions of the U.S. and longer-term droughts will intensify in large areas of the Southwest, southern Great Plains, and Southeast. The drought over the last decade in the western U.S. represents the driest conditions in 800 years. Hotter weather and increasing dry spells will cause wildfires in the West to start earlier in the season, extend later into the fall, and burn more acreage. More severe hurricanes, winter storms and cold waves, heat waves, floods, and other extreme weather events have negative implications for the energy sector: both increasing energy demand and reducing energy supply for the Nation. A summary of impacts for each U.S. region is included in Appendix B; detailed information about climate impacts for each region is available in the Third NCA.

The impacts of climate change and extreme weather translate into significant costs and threaten the Nation's ability to provide reliable and affordable energy. As described in the Office of Management and Budget's *Analytical Perspectives on the Federal Budget Exposure to Climate Risk for Fiscal Year 2017*,<sup>10</sup> over the past decade, the Federal Government has incurred

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<sup>9</sup> Third National Climate Assessment. USGCRP. 2014. <http://nca2014.globalchange.gov/>

<sup>10</sup> OMB's Analytical Perspectives on the Federal Budget Exposure to Climate Risk for Fiscal Year 2017, Chapter on "Federal Budget Exposure to Climate Risk", [https://www.whitehouse.gov/omb/budget/Analytical\\_Perspectives](https://www.whitehouse.gov/omb/budget/Analytical_Perspectives) ; [https://www.whitehouse.gov/sites/default/files/omb/budget/fy2017/assets/ap\\_24\\_climate\\_risk.pdf](https://www.whitehouse.gov/sites/default/files/omb/budget/fy2017/assets/ap_24_climate_risk.pdf)

more than \$357 billion in direct costs due to extreme weather and wildfires. This represents a small fraction of the overall economic impact of extreme weather. This estimate does not include costs absorbed by the private sector, state and local governments, loss or damage to energy systems and services, and other costs. Thus, these estimates of federal impacts significantly underestimate actual financial exposure to extreme events like droughts, floods, and storms – hazards that are anticipated to grow under future climate-change scenarios.

According to the Third NCA,<sup>11</sup> “Infrastructure around the country has been compromised by extreme weather events and rising sea levels. Power outages and road and bridge damage are among the infrastructure failures that have occurred during these extreme events.” The Third NCA also states, “Climate change impacts will increase the total costs to the nation’s transportation systems and their users, but these impacts can be reduced through rerouting, mode change, and a wide range of adaptive actions.” Similarly, climate change impacts will affect other modes of infrastructure and DOE will address these impacts through adaptation measures and risk management.

DOE plans to analyze and compare costs of completing vulnerability assessments with the costs of inaction. Investments in assessments and implementation of resulting action plans may be smart financial decisions due to increased lifespans of critical site assets and reduced instances and costs from site shutdowns, infrastructure outages and disruptions, repairs and rebuilding post-disaster, and investment risks. As directed by the new Secretarial Memorandum on Climate Change Preparedness and Resilience, SPO will complete a study at one or more representative DOE sites to calculate the potential cost and risk to mission associated with agency operations that do not incorporate climate adaptation measures. Events such as the wildfires experienced by LANL and Superstorm Sandy serve to remind DOE that costs and risk to mission are genuine and need to be addressed.

The effects of climate change—including rising average temperatures, shifting precipitation patterns, increasing climate variability, and more frequent extreme weather events—can alter the availability and predictability of water resources. These effects, combined with population growth, could intensify existing competition for water resources and impact energy production and distribution. In addition, the future of the water-energy nexus depends on a number of other factors, including changes to the mix of fuel sources used in power plants, deployment of advanced generation and cooling technologies, expansion of natural gas and renewable energy production, and increased utilization of biofuels. The evolving U.S. energy portfolio combined with advances in technology and modeling creates an opportunity to effectively manage the interdependency of the U.S. water and energy systems and construct a future energy sector that is more resilient and equipped to manage uncertainties in climate impacts.

The 2011 Las Conchas wildfire at LANL serves as a warning to the Department about the costs and ongoing challenges of not addressing climate change with respect to mission-related

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<sup>11</sup> From “2014 NCA Highlights.” USGCRP. Pg. 38 and 40. <http://nca2014.globalchange.gov/highlights>

activities. The fire accelerated major changes to the site's soil composition, groundwater hydrology, and biota, revealing other major climate-related vulnerabilities.

## Lessons Learned

The Department recognizes that climate change and extreme weather events have already affected its sites, mission, and operations. As a result of lessons learned in recent years and from a recent review with CEQ and OMB, this document solidifies DOE's path toward a more resilient future. While progress has been made already, DOE has lacked a cohesive plan or policy driver to establish climate change resilience as a priority across the complex.

In December 2015, SPO released a process guide to assist sites in completing vulnerability assessments.<sup>12</sup> This process guide outlines previous pilot assessments and their frameworks, while providing useful information on lessons learned from those assessments. These lessons cover a broad range of topics, such as the need to consult climate experts, engage a broad range of stakeholders, and set expectations for the end-product. This document builds upon previous studies to better inform sites looking to complete assessments in the future.

Currently, Strategic Petroleum Reserve (SPR) is undergoing a vulnerability assessment guided by NREL. NREL has set up a timeline and will construct a set of final deliverables, as well as assist in consultations with regional climate experts. NREL will create a final report summarizing the assessment findings including possible resilience actions. This technical assistance, available from various partner laboratories, builds upon prior knowledge from completed vulnerability assessments and successful frameworks. Leveraging this expertise reduces cost while still offering the opportunity to tailor an assessment to site needs.

## Strategy, Governance, and Actions

The Department has initiated a high-level strategy to identify risk-prone sites and ascertain adaptation actions for identified risks. This effort started with a policy change by the Secretary: a Department-wide memorandum that directs sites to complete vulnerability assessments and integrate resiliency into site plans. The Secretarial Memorandum on climate change resilience was signed on October 21, 2016. This memorandum, to be enforced pursuant to DOE Order 436.1A, requires all sites and offices that manage real property to complete screenings, in order to assess their vulnerabilities and determine the need for additional study. Any site deemed to have significant risks will be required to undergo a full vulnerability assessment. Sites with low risks will be re-assessed every four years. Likewise, vulnerability assessments will be re-evaluated every four years. Four year updates to vulnerability screenings and assessments will follow the release of future NCA iterations and allow for updated climate

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<sup>12</sup> *Practical Strategies for Climate Change Vulnerability Assessments*. SPO. December 2016.



science to be utilized. Also under the memorandum, climate-resilient design will be integrated and design standards will be updated for renovations and new construction, to ensure resilience in these buildings.

Currently, DOE is developing screening guidance for release in January 2017. As a result of this new policy, DOE will complete screenings at all DOE sites by January 21, 2018 and vulnerability assessments will, thereafter, be completed at sites with significant risks identified. Sites found to have the most vulnerabilities will be prioritized within their respective Program Office. Vulnerabilities identified will guide site action plans and inform future construction and renovations and new construction and renovations will incorporate climate-resilient design.

In order to carry out this new policy, a steering committee--the Climate Risk Management Steering Committee--will oversee related tasks, report quarterly to management, provide guidance, review plans, schedules, and implementation, and determine related training requirements. This committee will serve as a forum for challenges and barriers to be recognized and mitigated, while also determining timelines and implementation of the new policy. This Climate Risk Management Steering Committee will assist Program Offices within the Department in completing vulnerability screenings and assessments and the Sustainability Performance Office will coordinate a technical assistance team to align with this effort. Climate-resilient design guidance will be also be approved by the committee and will be integrated into site plans and campus strategies along with results from vulnerability assessments and screenings.

As DOE identifies its vulnerable sites and completes all of the necessary assessments, information will be shared with states, tribes, and local communities. This is consistent with President Obama's 2015 Progress Report, which highlights key Federal government actions to support the State, Local, and Tribal Leaders Task Force on Climate Preparedness and Resilience. DOE will inform neighboring communities as they strive to prepare for climate change by sharing climate data, possible impacts, planning changes, adaptation actions, and other resilience activities.

## Resilience Policies

The Department is in the process of reviewing and updating internal policies. DOE has identified DOE Order 150.1A, Continuity Programs, as an appropriate platform to integrate climate change adaptation. This order outlines the requirements for DOE sites when completing continuity planning to ensure that DOE programs are prepared to respond to incidents or events with minimal disruption to operations. The 2014 update of the order now includes climate change as one of the elements to consider during the required All Hazard Risk Assessment. This update and future similar orders will ensure DOE sites retain operational abilities in the face of emergencies associated with climate change.

DOE has identified DOE Guide 413.3-6A, High Performance Sustainable Buildings, as a document in need of an update to include climate change resiliency language. The guide provides implementing instructions for DOE Order 413.3B, Program and Project Management for the Acquisition of Capital Assets. An update would also contribute to the agency's ongoing effort to consider climate resilience in procurement, real property, and leasing decisions. Additional opportunities to further this priority are under consideration.

DOE Order 436.1, Departmental Sustainability, is a key driver for sustainability planning and integration. DOE is in the process of updating the order to "ensure consideration of, planning, and adaptation to the effects of climate change on the Department's operation and programs," among other updates. This order will also serve to enforce the new Secretarial Memorandum on climate change and will include language pertaining to this new policy therein. The Environmental Management System (EMS) process is a coordinating and planning mechanism for climate planning at DOE sites. As identified in DOE Order 436.1, DOE sites use EMS as the primary planning framework to manage sustainability efforts. EMS is well-suited for addressing climate-related programs, and many DOE sites are already using their EMS for this purpose.

DOE technical design standards and safety directives, such as DOE Order 420.1C, Facility Safety, and DOE-STD-1020-2012, Facility Analysis and Design Criteria for Department of Energy Facilities, are key documents to be investigated and incorporated into the DOE climate planning process. DOE Order 420.1C establishes facility and programmatic safety requirements for nuclear safety design criteria, fire protection, criticality safety, natural phenomena hazards mitigation, and System Engineer Programs. DOE-STD-1020-2012 provides criteria and guidance for the analysis and design of facility structures, systems, and components (SSCs) that are necessary to implement the requirements of DOE Order 420.1C and to ensure that the SSCs will be able to effectively perform their intended safety functions under the effects of natural phenomena hazards (NPHs). DOE-STD-1020-2012 is currently under revision, in part to consider including climate change modeling data in the Natural Phenomena Hazard design criteria.

In 2016, DOE revised DOE Order 430.1, Real Property Asset Management, to include a requirement that DOE manage its real property using a life cycle asset management approach that incorporates consideration of climate change resilience and adaptation in planning and budgeting. The revision, DOE O 430.1C also requires, at section 4(a)(1)(b) and 4(b)(1)(c), that Departmental Elements meet federal sustainability requirements for new construction that themselves include climate change resilience.



## Climate Change and the DOE Mission

**The Department of Energy’s mission includes actively increasing resilience to climate change risks and engaging resources to advance national energy resilience and security.** DOE leads climate science research and technology development while collaborating with Federal agencies and regional partners, establishes climate resiliency through training opportunities for staff and key stakeholders, advances information collection concerning severe weather events, and examines impacts on the U.S. energy sector. The Department also commits resources to research development, demonstration, and deployment for clean and efficient energy technologies, participates in outreach opportunities, supports coordination within and outside the agency through working groups, and partners with energy companies and major cities to enhance their resilience planning and implementation. These activities culminate in advancing the Nation’s resilience to climate change impacts.

**DOE leads research and technology development to create a climate smart and resilient future that enhances our nation’s sustainability and security.** DOE’s Office of Science supports fundamental research to understand the energy-environment-climate connection and its implications for energy production, use, sustainability, and security—considering the potential impact of increased anthropogenic emissions as they interact with natural climate variability. DOE’s ultimate goal is to advance a robust predictive understanding of Earth’s climate and environmental systems that can guide sustainable solutions to the Nation’s energy and environmental challenges.

Two DOE research areas focus on uncertainty in Earth systems models: Atmospheric System Research (the science of aerosols, clouds, and radiative transfer); and Terrestrial Ecosystem Science (the role of terrestrial ecosystems and carbon cycle observations). DOE invests in advanced techniques to model the climate-earth-human system, including collaboration with the National Science Foundation to develop the widely used Community Earth System Model. These DOE investments support methods to obtain regional climate information, integrate analysis of climate-change impacts, and analyze and distribute large climate datasets through the Program for Climate Model Diagnosis and Intercomparison and the Earth System Grid. The Department also supports the ARM Climate Research Facility, to measure evolving cloud, aerosol, and precipitation characteristics.

Additionally, DOE supports development and application of models to study how different patterns of socioeconomic and technology development lead to emissions and land cover change that, in turn, can cause human-induced climate change. These models can also be used to guide development and deployment of clean energy technologies and policies, including development of world-class integrated assessment models (IAMs) and a new complex systems modeling framework that will integrate IAMs with high-resolution models of Earth and human systems at the energy-water-land nexus.

A new modeling framework that combines Earth System models with IAMs for application to DOE’s Legacy Class Computers is under development in DOE in order to provide

high resolution climate information with uncertainty characterization. The framework draws on complex systems theory, climate and related impacts research, integrated assessment, and developments in computer and information sciences to understand the co-evolution of interdependent infrastructure, natural resources, and communities as they are affected by rapidly evolving demographic, economic, and environmental stresses, including more frequent and intense climate extremes. The capabilities developed will support evaluation of infrastructure investment and adaptive management decisions that will affect electric grid stability, water availability for energy production, site selection of the next generation of renewable energy infrastructure, and many other long-term challenges. DOE's Office of Science is collaborating with other Federal agencies, through the U.S. Global Change Research Program, with the expectation of rolling out regional test beds to evaluate framework components in FY 2017.

**DOE has consistently worked to advance climate science as a part of its mission and collaborates with numerous Federal agencies and regional partners on a number of projects,** including providing basic science that can be used by the Intergovernmental Panel on Climate Change (IPCC) and the NCA. The mission of DOE's Biological and Environmental Research (BER) program is to support fundamental research and scientific user facilities to achieve a predictive understanding of complex biological, climatic, environmental, and human/socioeconomic systems, with increasing emphasis on their interdependencies and complex, coupled behaviors. Particularly relevant for sustainability assessments, the program strives to describe and explain how the Earth's dynamic, physical, and biogeochemical systems (the atmosphere, land, oceans, sea ice, and subsurface) interact and cause future climate and environmental change and, subsequently, impacts and changes involving energy and connected infrastructures and sectors. With a considerable focus on modeling and analysis tools, DOE and other agencies are able to explore deep uncertainties, including decision-driven uncertainties, and systems dynamics, like the energy-water-land nexus. Understanding of climate and simultaneous stressors on the nexus is a major sustainability challenge for DOE, the Nation, and the international community.

BER research seeks to uncover nature's secrets from microbes and plants to understand how biological systems work, how they interact with each other, and how they can be manipulated to harness their processes and products. For example, research is dedicated to evaluate potential applications for next generation, sustainable biofuels, ecosystems services, or remediation of sites.

BER is also a major contributor to the Nation's climate science research atmospheric circulation studies in the early 1950's that were the forerunners of modern climate models. BER research currently contributes to model development and analysis using community-based models, such as the Community Earth System Model (CESM), the Advanced Climate Model for Energy (ACME), and the Global Change Assessment Model (GCAM). These leading U.S. models are used to address the largest contributors to uncertainty in contemporary climate science, including the impacts of clouds and aerosols on regional and global climate change. With data provided by the Atmospheric Radiation Measurement Climate Research Facility (ARM), a DOE user facility serving hundreds of scientists worldwide, BER archives data and

makes available usable products for model development and analysis. Also, BER has been a pioneer of ecological and environmental studies in terrestrial ecosystems, seeking to describe the continuum of biological, biogeochemical, and physical processes across multiple scales that control the flux of climate and environmentally-relevant compounds between the terrestrial surface and the atmosphere. BER's Environmental Molecular Sciences Laboratory (EMSL) provides the scientific community with powerful suites of instruments and a high performance computer to characterize biological organisms and molecules, related to its missions involving biological, climate, and environmental science.

A particularly important capability for sustainability assessments, Climate and Earth System Modeling consists of three main components: 1) Earth System Modeling; 2) Regional and Global Climate Modeling; and 3) Integrated Assessment Research.

Earth System Modeling (ESM) seeks to develop physical, chemical, and biological model components, as well as fully coupled Earth system models that combine with sophisticated representations of human activities. This research includes the interactions of human and natural Earth systems needed to simulate climate variability and change from years to decades and centuries, at regional and global scales. The research specifically focuses on quantifying and reducing the uncertainties in Earth system models based on more advanced model development, diagnostics, and climate system analysis. Priority model components include the ocean, sea-ice, land-ice, aerosols, atmospheric chemistry, terrestrial carbon cycling, multi-scale dynamical and physical interdependencies, and dynamical cores. This research also supports the USGCRP interagency priority in intra-seasonal to centennial predictability, predictions and projections, including focus on extreme events and the water cycle. In a large and dedicated effort, DOE is developing the ACME, as a computationally efficient system of models adaptable to emerging computer architectures and with greater sophistication and fidelity for high resolution simulation. This system of models provides a critical capacity for regional climate projections, including information on how the frequency of occurrence and intensity of storms, droughts, heat waves, and regional sea-level will change as climate evolves. The scientific priorities for improvement of the community models are based on efforts to quantify uncertainties relative to specific scientific questions; and the outputs of the intercomparison and validation resource allow one to determine best features of all global models that can be considered for incorporation into DOE's ACME modeling platform.

Regional and Global Climate Modeling (RGCM) applies climate and Earth system modeling and analysis tools to increase the robust predictive understanding of climate change, including efforts to develop regional simulations. RGCM activity conducts scientific analyses to study the predictability of statistical distributions of future weather extremes; causes and distributions of droughts; biogeochemical controls on abrupt climate change; the role of the highly resolved patterns of carbon budgets on regional and global climate change; energy water interdependencies; and the roles of cryospheric phenomena (sea ice, glaciers, ice sheets, and permafrost thaw) on Arctic climate, sea level rise, and large scale modes of variability. Also, research explores model derived analogs that combine historical and projected climate changes, with an objective to validate and improve the uncertainty characterization of future climate

projections based on prediction successes using existing data testbeds. To rapidly and efficiently advance model capabilities, BER supports a unique and powerful intercomparison resource, the Program for Climate Model Diagnosis and Intercomparison (PCMDI), for global climate model development, validation, diagnostics, and outputs, using over 50 world-leading climate models. This set of diagnostic and intercomparison activities combined with scientific analysis, ensures that BER funded researchers can exploit the best available science and practice within each of the world's leading climate research programs.

Climate modeling, simulation, and analysis tools, both through RGCM and ESM, are essential for understanding the drivers, magnitude of changing weather patterns, and extremes, from global to regional to local scales. This is critically important information for planning sustainable infrastructure and energy systems of the future.

Integrated Assessment Research (IAR) helps shape our fundamental understanding of anthropogenic climate change drivers as well as the impacts of climate change and simultaneous stressors. Integrated Assessment Models (IAMs) such as GCAM are essential tools for understanding climate change mitigation options and sustainable development pathways. They simultaneously address vulnerabilities arising from climate change and stressors that include changes in population/demographics, natural resource depletion, transmission/network disruptions, and socioeconomic shocks of various causalities. Previously, work focused on drivers, specifically sources of greenhouse gas emissions, within a common economic and risk-based framework. Increasingly, efforts are aligned with modeling and understanding cascading vulnerabilities and the interactive effects of consequences, that is, cross-sectoral impacts, adaptations, and corresponding dynamics. Such models reflect that all systems are changing and co-evolving with time, and while climate change is one driver of change, it is just that, one driver. Most recently, priority attention has been given within BER activities to the development and demonstration of a novel high resolution IAM-IAV hybrid model system, improving not only resolution but the detailed process representations for autonomous elements and coupled energy-water-land system interdependencies. Such advances are seen as potentially transformative and there is great interest in this multi-scale, multi-sector, multi-model framework, not just for the basic research investigations undertaken by BER but by DOE's applied energy programs and a broad range of other agencies interested in long-term risk and sustainability research.

**The Department is committed to establishing climate literacy through training opportunities.** Since 2014, several climate adaptation training events have been held at DOE sites nationwide. The focus has been on basic climate science, available data and tools, and vulnerability assessments. The primary goals have been to make attendees aware of the cross-cutting nature of climate change impacts and to provide a solid foundation for building a climate change community of practice. DOE is working closely with an outside vendor to tailor training curricula to fit DOE's specific mission requirements.

Climate change is a significant part of the ongoing sustainability training that is provided when requested by DOE sites. DOE is working with its training partners at the DOE National Training Center/HAMMER Federal Training Center Partnership (Hammer) to provide online

training for DOE personnel. DOE has conducted several site visits and formal trainings to discuss and train managers and staff on sustainability and climate change adaptation and resilience. In 2016, site visits and trainings were offered at the Hanford Site, Los Alamos National Laboratory, and the Savannah River Site.

DOE conducted a two-day climate change adaptation training on June 21-22, 2016 at Hanford in Richland, Washington for DOE managers, Federal and contractor staff, regulators, Tribal Nations, and regional stakeholders. The training addressed climate science, impacts from severe climate events, tools to screen and assess vulnerabilities, and strategies to lead organizational change. DOE is exploring the development of an online, on-demand training in FY 2017.

DOE visited Los Alamos National Laboratory on January 26-28, 2016 to hear concerns and discuss sustainability strategies, including climate change adaptation as an element of its pollution prevention program. DOE also gave a training at the Savannah River Site on October 25-27, 2016, which covered climate change adaptation and meeting complementary sustainability requirements on energy efficiency, waste management, and high performance sustainable buildings.

Most recently, NREL and the Colorado Water Conservation Board hosted a Climate Fundamentals Academy taught by an outside vendor on November 7-8, 2016. The training is part of a regional series of workshops that support a climate certification process. Participants learned about the implications of climate change with a regional focus added for Colorado and the Rocky Mountain region of the United States. A second workshop is scheduled for March 6-7, 2017 at NREL. Participants will learn about greenhouse gas management and accounting, the energy-water-food nexus, organizational change, stakeholder engagement and basic adaptation planning frameworks again with a regional focus added for Colorado and the Rocky Mountains. A third workshop in this series is currently being planned.

**The U.S. Energy Information Administration (EIA) is engaged in efforts to advance information collection related to severe weather events.** EIA has several tools to help collect and disseminate pertinent energy data to help interested parties evaluate the energy market after significant weather events, including collecting hourly electric system operating data and enacting emergency surveys on gas to monitor supplies following natural disaster disruptions. EIA also tracks and reports on selected significant storms that impact or could potentially impact energy infrastructure, through the use of real-time storm tracking with energy infrastructure maps.<sup>13</sup>

**DOE is examining the impacts of climate change on the U.S. energy sector** and associated economic implications. DOE estimates that weather-related energy blackouts in the United States doubled between 2003 and 2012. In that same period, 679 widespread power outages occurred due to severe weather, at an annual cost of between \$18 billion and \$33 billion. Vulnerabilities to energy infrastructure are visible in the aftermath of extreme weather events. New York City identified approximately 50 substations and 33 power plants located in areas that

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<sup>13</sup> Energy Disruptions. EIA. Real time data. <http://www.eia.gov/special/disruptions/>

could be affected by rising seas and storms; many of which were impacted during Superstorm Sandy. The Office of Energy Policy and Systems Analysis (EPSA), working in collaboration with the private sector, is identifying, developing, and applying methodologies for assessing the costs and risks of resilience strategies. EPSA, in collaboration with Tennessee Valley Authority (TVA) and Oak Ridge National Laboratory (ORNL), is also assessing the costs and benefits of investments in climate resilience using a TVA case study. The analysis conducted by ORNL developed a general approach for assessing climate change vulnerabilities of an electricity system and evaluating the costs and benefits of climate resilience investments. EPSA is also collaborating with the Rhodium Group to assess the cost of climate change to the U.S. power sector, specifically related to rising temperatures using the National Energy System Model (RHG-NEMS).

**DOE has committed significant resources to research, development, demonstration, and deployment (RDD&D) for innovative clean and efficient energy technologies to address reductions in greenhouse gas emissions and climate mitigation.** Increasing climate change and extreme weather events can affect many sectors of our society, including energy security, human health, transportation, communication, agriculture, and food security. DOE is developing approaches to harden energy infrastructure, conserve and reuse water, reduce energy needs, increase renewable and clean energy and storage capacity- including expanding the use of electric vehicles that can serve as backup energy storage - and deploy smart grid and microgrids to better monitor, manage, and respond to outages.

The Office of Energy Efficiency and Renewable Energy (EERE) funds a diverse range of renewable power, sustainable transportation, and energy efficiency RDD&D activities including work on combined heat and power (CHP), which offers the opportunity to improve resilience and mitigate the impacts of extreme weather events by continuing to provide electricity and thermal service in the absence of grid electricity.

The Office of Fossil Energy (FE) is working on programs to advance technologies, processes, and infrastructure for more sustainable operations and to utilize cleaner energy. One such effort, involving FE, the City of Pittsburgh, and the National Energy Technology Laboratory (NETL), seeks to develop the City's microgrids and upgrade and retrofit energy facilities. Another program, the Solid Oxide Fuel Cell (SOFC) program, by FE and NETL, is focused on developing efficient, low-cost SOFC systems with near-zero emission of CO<sub>2</sub> and air pollutants and minimal use of water that can be employed as a standalone distributed energy resource (DER) and/or integrated into energy districts and microgrids.

DOE's Office of Nuclear Energy (NE) is also developing nuclear fuels and materials for use in higher temperature reactors that will provide for improved electricity generation efficiency, process heat production, and operation in higher temperature climates. NE is also supporting an ongoing program, the Water Technology Innovation Program, with EERE, FE, and EPA to recycle and reuse industrial, agricultural, and municipal wastewaters, addressing the climate threat of reduced water availability and drought.

**DOE participates in outreach opportunities and supports agency internal and external coordination through working groups.** The Department continues to include regional stakeholders and planning for potential climate-related events. DOE has begun to integrate climate change modeling information into technical standards, orders, policies, and guidance. DOE is also working to expand climate-related training opportunities in FY 2017 and hosted training events at its Hanford site and NREL in 2016, which included local and regional stakeholders.

Utilizing internal working groups, DOE provides guidance and best practices for climate adaptation activities across the Department, identifies common vulnerabilities, develops coordinated adaptation plans and strategies, identifies projected climate impacts to mission critical activities, and recommends procedures to incorporate these impacts into planning, budgeting, management, and operations of DOE facilities. DOE and its employees also participate in partnerships and working groups on the local, regional, and interagency level. Many DOE sites are engaged in research partnerships to further their understanding of climate change related risks and vulnerabilities.

The Department will continue to leverage internal working groups, like the Climate Adaptation Collaborative (CAC) and the Climate Risk Management Steering Committee, to provide guidance and best practices for adaptation and resilience activities across the Department. The CAC is a headquarters/field cross-programmatic forum established to identify common vulnerabilities, share best practices and case studies, take advantage of potential synergies, and develop coordinated adaptation plans and strategies. The newly formed Climate Risk Management Steering Committee is comprised of senior leaders from the Program Offices and will provide the Chief Sustainability Officer with quarterly briefings on the progress of all climate change resilience actions and barriers to resiliency efforts. As outlined in the Secretary's Climate Change Memorandum, the Climate Risk Management Steering Committee also reviews plans, schedules, guidance, and implementation of vulnerability screenings and assessments. Additionally, this group determines training requirements for sites and develops training, as necessary.

DOE is collaborating with other Federal agencies to advance climate change understanding in the following areas: wildfire management (U.S. Forest Service); stormwater modeling (U.S. Geological Survey); and climate science (U.S. Department of Homeland Security, U.S. Environmental Protection Agency, and National Aeronautics and Space Administration). In FY 2017, DOE will continue to focus on strengthening agency internal missions, programs, policies, and operations to incorporate climate change resilience and adaptation.

**DOE is updating policies and assessing internal risks and vulnerabilities to climate change.** Many Program Offices (POs) have already begun assessing vulnerabilities. DOE has conducted site vulnerability assessments and additional assessments are in progress. In order to accelerate the pace of these assessments, Secretary Moniz signed a memorandum on October 21, 2016 requiring all POs to prepare DOE facilities for the risks associated with climate change by requiring all sites to conduct vulnerability screenings. As a result, DOE is developing screening guidance with a scheduled release of January 2017.



As stated in individual site SSPs, many sites are undertaking individual efforts to increase resilience beyond internal assessments. DOE's Pantex Plant in Texas has pursued activities to reduce depletion of the local Ogallala Aquifer water source (depletion of the waters are caused by increased temperatures and drought). Brookhaven National Laboratory (BNL) scientists study the interaction of urban environments and the atmosphere and have presented internationally on improving modeling of severe storms around urban centers and modeling the contribution of waste heat in the city to an urban heat island, based on case studies of BNL's nearest metropolis, New York City.

**DOE is expanding its partnerships with energy companies to enhance climate resilience planning and implementation.** DOE is tackling shared climate impacts across the energy sector, enabling the public and private sector to advance their resilience priorities, and assisting the private sector in the management of impacts on the energy system. DOE established the Partnership for Energy Sector Climate Resilience in 2015, to provide continued leadership and support for collaboration with the private sector and the coordination of a strategic approach. Communities and businesses look to the Federal Government for authoritative information on climate resilience. DOE has made significant progress in collaboration with nearly 20 electric utilities nationwide. These partners have conducted vulnerability assessments, developed resilience solutions, and produced resilience planning guides that can assist others.<sup>14</sup>

**DOE has been working directly with several major cities on pilot programs to increase resilience.** In addition, DOE is working with states, local and tribal communities, and the private sector to stimulate resilience planning and pre-disaster mitigation through incentives that, for example, leverage existing programs and efforts that either directly or indirectly benefit climate resilience. DOE is supporting community efforts--locally and regionally--to address shared challenges. EERE provides competitively awarded financial assistance to U.S. states and territories to advance policies, programs, and market strategies that accelerate job creation and reduce energy bills while achieving energy and climate security for the nation. Federal Energy Management Program and NREL developed the Climate Change Resilience Roadmap,<sup>15</sup> an interactive web tool that walks government entities through a three-step process and offers guidance and checklists to ensure the development of effective multi-jurisdictional weather and climate disaster plans. To mitigate the hazards and risks associated with climate change and environmental disasters, the Climate Change Resilience Roadmap offers comprehensive guidance for federal, state, and local entities to effectively convene at the regional level for

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<sup>14</sup> DOE's Partnership for Energy Sector Climate Resilience. May 2016. <http://www.energy.gov/epsa/partnership-energy-sector-climate-resilience>

*Climate Change and the Electricity Sector: Guide for Assessing Vulnerabilities and Developing Resilience Solutions to Sea Level Rise.* July 2016. <http://www.energy.gov/epsa/downloads/climate-change-and-electricity-sector-guide-assessing-vulnerabilities-and-developing>

*Climate Change and the Electricity Sector: Guide for Climate Change Resilience Planning.* September 2016. [http://www.energy.gov/sites/prod/files/2016/10/f33/Climate%20Change%20and%20the%20Electricity%20Sector%20Guide%20for%20Climate%20Change%20Resilience%20Planning%20September%202016\\_0.pdf](http://www.energy.gov/sites/prod/files/2016/10/f33/Climate%20Change%20and%20the%20Electricity%20Sector%20Guide%20for%20Climate%20Change%20Resilience%20Planning%20September%202016_0.pdf)

<sup>15</sup> Climate Resilience Roadmap. NREL. [http://www.nrel.gov/tech\\_deployment/resilience-planning-roadmap/](http://www.nrel.gov/tech_deployment/resilience-planning-roadmap/)

comprehensive and sustainable planning. DOE also participates in the Resilience Dialogues,<sup>16</sup> an online service that allows community leaders to engage in facilitated, expedited, and tailored consultations with scientists, resilience practitioners, and other subject-matter experts on increasing resilience. Dialogues expand on a number of resilience topics, such as how to identify locally relevant information, tools, and connections, expectations on climate change, facilitators that help communities launch or advance their climate adaptation plans, and ways to reach experts and other resources for resilience planning.

## Conclusion

The Department recognizes that climate change and extreme weather events have already affected its sites, mission, and operations. Climate change-related severe weather events are expected to increase in frequency and intensity at sites across the DOE complex. DOE recognizes that changes in the global climate system will have a profound impact on the Department. As the effects of climate change are felt across the world, it is necessary to characterize potential impacts on DOE's mission, programs, and operations to foster adaptation and resilience. The Department has initiated a high-level strategy to identify risk-prone sites and ascertain adaptation actions for identified risks.

This Adaptation Plan considers the national and international context of the DOE mission, as well as the local perspective of DOE facilities and community stakeholders. DOE's refined understanding of climate change enables DOE to more accurately forecast climate change impacts, quantify risk, and identify opportunities to improve resilience. This Adaptation Plan will work in concert with DOE's ongoing mitigation activities outlined in its annual SSPP. DOE maintains its commitment to reducing agency greenhouse gas emissions, utilizing renewable energy technologies, and making its operations sustainable. In light of recent changes in policy, as well as the summer progress review with CEQ and OMB, this document solidifies DOE's path toward a more resilient future.

Assessing the risk of climate change and reporting on action plans is not only a goal of each site's Site Sustainability Plan (SSP) annual reporting process. Climate change also is included when writing applicable new ordinances, updating site plans, and modernizing emergency response protocols. DOE is examining and updating internal policies. DOE will leverage past documents and harness available knowledge to build a foundation, through policy changes and key actions, to increase its overall resilience to climate change and severe weather events. DOE leadership remains important to understanding climate change and severe weather event risks, to improving the resilience of its missions, programs, and operations, and supporting communities in their efforts to enhance resilience.

DOE plans to analyze and compare costs of completing vulnerability assessments with the costs of inaction. Investments in assessments and implementation of resulting action plans

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<sup>16</sup> Resilience Dialogues. USGCRP and American Geophysical Union's Thriving Earth Exchange. 2016. <http://www.resiliencedialogues.org/>

may be smart financial decisions due to increased lifespans of critical site assets and reduced instances and costs from site shutdowns, infrastructure outages and disruptions, repairs and rebuilding post-disaster, and investment risks. As directed by the new Secretarial Memorandum, SPO will complete a study at one or more representative DOE sites to calculate the potential cost and risk to mission associated with agency operations that do not incorporate climate adaptation measures. Events such as the wildfires experienced by LANL and Superstorm Sandy serve to remind DOE that costs and risk to mission are genuine and need to be addressed.

The EIA is engaged in efforts to advance information collection related to severe weather events. DOE is also examining the impacts of climate change on the U.S. energy sector. The Department of Energy is leading fundamental research and technology development to create a climate smart and resilient future that enhances our nation's sustainability and security. DOE is committed to reducing greenhouse gas (GHG) emissions and mitigating climate change by developing clean energy and energy efficiency technologies for commercial deployment while providing leadership through its own sustainable operations. DOE has consistently worked to advance climate science as a part of its mission and collaborates with numerous Federal agencies and regional partners on a number of projects including supporting the Intergovernmental Panel on Climate Change (IPCC) and the NCA. DOE has committed significant resources to research development, demonstration, and deployment (RDD&D) for innovative clean and efficient energy technologies to address reductions in greenhouse gas emissions and climate mitigation.

DOE participates in outreach opportunities and supports agency internal and external coordination through working groups, while being committed to establishing agency internal climate literacy through training opportunities. DOE is expanding its partnerships with energy companies to enhance climate resilience planning and implementation. DOE has been working directly with several major cities on pilot programs to increase resilience. As DOE identifies its vulnerable sites and completes all of the necessary assessments, information will be shared with local communities and tribes. DOE will prioritize sharing information gathered from vulnerability screenings and assessments with local communities, Native American tribal groups, and government agencies.

The efforts presented in this *2016 DOE Climate Change Adaptation Plan* set DOE on a path to resilience. Through its multitude of actions - internally, locally, and internationally - DOE will continue to lead the U.S. energy sector and the nation to a more resilient future in the face of a changing climate.

## Appendix A: Resources

The following resources are provided to assist sites in completing vulnerability screenings and assessments, as well as to inform the reader of some of the widely available climate science and risk management resources.

### *Tools*

#### **[Federal Emergency Management Agency \(FEMA\): Hazus program](#)**

Hazus is a methodology that contains models to determine losses (from earthquakes, floods, and hurricanes) and the most beneficial mitigation approaches. It estimates the physical, economic, and social impacts of disasters.

#### **[Georgetown Climate Center \(GCC\) – Adaptation Clearinghouse](#)**

GCC provides this website as a state and federal policy data center on which case studies, tools, groups, resources, and reports can be located.

#### **[The Nature Conservancy: Climate Wizard](#)**

The University of Washington and the University of Southern Mississippi partnered with the Nature Conservancy to create this website that allows users to view maps of climate impacts anywhere on Earth. Historic temperature and rainfall maps, updated future predictions of temperature and rainfall, and climate change maps are available.

#### **[National Oceanic and Atmospheric Administration \(NOAA\): Vertical Datum Transformation Guide \(VDatum\)](#)**

VDatum is a free software tool from NOAA that assists with transforming geo-spatial data.

#### **[The U.S. Climate Resilience Toolkit](#)**

NOAA, in partnership with Federal agencies and other organizations, developed this toolkit to enable decision-makers to take action to improve their climate resilience using data-driven tools, information, and subject-matter expertise.

#### **[U.S. Department of Transportation: Vulnerability Assessment Scoring Tool \(VAST\), Userguide and other Tools](#)**

The VAST tool walks users through a step-by-step process to conduct an indicator-based vulnerability screening and allows users to use any indicators, data sources, and climate stressors desired. Other resources on this website include a Sensitivity Matrix Excel file and much more. This resource is tailored to the transportation sector, but can be applied elsewhere with some reconfiguration.

#### **[Vulnerability and Consequences Adaptation Planning Scenarios \(VCAPS\)](#)**

These scenarios are a Sustainable Europe Research Institute (SERI) developed modeling process that offers climate change adaptation planning by local decision makers from coastal communities.

## *Historical Climate Data and Guides*

### **[Carbon Dioxide Information Analysis Center \(CDIAC\): U.S. Historical Climatology Network](#)**

CDIAC provides free long-term data in a daily or monthly format from 1218 observing stations across the 48 continental United States. Daily data includes observations of maximum and minimum temperature, precipitation amount, snowfall amount, and snow depth. Monthly data consists of monthly-averaged maximum, minimum, and mean temperature and total monthly precipitation.

### **[Climate Source: Climate Normals](#)**

Climate Source, in agreement with the Spatial Climate Analysis Service (SCAS) at Oregon State University, offers spacial climate data sets in GIS format, including climate normals for 1961-1990.

### **[National Center for Atmospheric Research \(NCAR\) Climate Data Guide](#)**

The Climate Data Guide is a website devoted to the ins and outs of obtaining and analyzing various existing climatic data sets. NCAR envisioned the Climate Data Guide as a focal point for users to find not only data, but also expert-user guidance, commentary, and questions and advice on appropriate data applications.

### **[NOAA National Climatic Data Center \(NCDC\)](#)**

The NCDC is the world's largest archive of weather data. The center offers access to data, maps, publications, and services, such as data resource consultations. The [NCDC monitoring section](#) provides records of variations in various aspects of climate, including drought, wildfire, storms, snow and ice, etc.

### **[NOAA NCDC - U.S. Climate Normals](#)**

Every 10 years, NCDC computes new 30-year climate normals for selected temperature and precipitation elements. The 1981-2010 normals were released on July 1, 2011.

### **[Parameter-elevation Regressions on Independent Slopes Model \(PRISM\) Climate Normals](#)**

PRISM Climate Group, established at Oregon State University and part of the Northwest Alliance for Computational Science and Engineering, offers climate normals for 1981-2010 for precipitation, temperature, and mean dewpoint.

### **[World Meteorological Organization: Climate Normals](#)**

Climate normals are available for years 1961-1990 for a fee.

## *Climate Model Output, Downscaled Data, Guides, and Model Evaluation*

### **[Cal-Adapt](#)**

This is a web-based climate adaptation planning tool for the state of California that contains statistically-downscaled data for the state, which can be downloaded or manipulated in an embedded Google maps viewer.

## **The Federal Highway Administration (FHWA): Coupled Model Intercomparison Project (CMIP): CMIP3, CMIP5, and Userguide**

FHWA offers this Excel tool that processes downscaled climate data at the local level into temperature and precipitation variables relevant to transportation agencies. It relies on statistically downscaled climate data from the U.S. Bureau of Reclamation's Downscaled CMIP3 and CMIP5 Climate and Hydrology Projections website and data is available at the 1/8 degree resolution (about 56 square miles) covering the contiguous United States. This climate model output is from the model projections used in the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4).

## **IPCC AR4, Chapter 8: Climate Models and their Evaluation**

This chapter details model evaluation. It is a high-level, technical discussion of the state of climate modeling and an evaluation of the models used by the IPCC.

## **NCAR – Earth System Grid**

This website hosts a portal for many outputs from a variety of models, both those used by the IPCC and those under development

## **NCAR: GIS Program: Climate Change Scenarios**

This page contains a guide on statistical downscaling, tutorials on using Community Climate System Model (CCSM) projections in GIS formats, and more. The CCSM model was used for the IPCC AR4.

## **North American Regional Climate Change Assessment Program NARCCAP)**

NARCCAP is an international program that systematically investigates the uncertainties in regional scale projections of future climate and produces high resolution climate change scenarios using multiple regional climate models (RCMs) and multiple global model responses to future emissions scenarios. This website hosts a portal for dynamically downscaled climate model output; output can be requested in various formats (ASCII, GIS, ArcGIS).

## **North American Climate and Hydrology Projections**

This resource features downscaled output from CMIP3 models and scenarios; output can be requested in NetCDF or ASCII formats, climate projections are valid for the continental U.S., and hydrologic data are available for the western U.S.

## **PRISM Climate Data**

PRISM Climate Group gathers climate observations, applies quality control measures, and develops spatial climate datasets to reveal short- and long-term climate patterns. Maps are available using the PRISM model, which maps difficult situations (high mountains, rain shadows, temperature inversions, coastal regions, etc.). Datasets incorporate various modeling techniques and are available at multiple spatial/temporal resolutions, with a timeline from 1895 to the present. Climate normals are also available and data is available for free or a fee, case dependent.

## *Sea Level Rise Guidance, Data Sources, and Models for Inundation Mapping*

### **[Army Corps of Engineers: Guidance on Managing and Planning for Sea Level Rise](#)**

This 2009 document, entitled *Water Resources Policies and Authorities Incorporating Sea Level Change Considerations in Civil Works Programs*, provides guidance on calculating sea level rise and incorporating projections into planning efforts.

### **[NOAA: Coastal Inundation Mapping Guidebook](#)**

In 2009, NOAA's Coastal Services Center developed a mapping guidebook for mapping coastal inundation. This document lists resources for sources of data, including bathymetry, Light Detection and Ranging (LiDAR), topobathy, airborne laser mapping, floodplain mapping, and more.

### **[NOAA: Technical Considerations for Use of Geospatial Data in Sea Level Change Mapping and Assessment](#)**

This 2010 document provides updated guidance for Federal and state agencies, and coastal planners using geospatial data when conducting sea level change assessments and mapping.

### **[NOAA National Hurricane Center \(NHC\): Sea, Lake and Overland Surges from Hurricanes \(SLOSH\)](#)**

NHC's SLOSH is a useful computerized model that estimates storm surge heights and winds resulting from historical, hypothetical, or predicted hurricanes. This resource is useful for inundation mapping, data, or sea level rise risk assessment.

### **[NOAA National Ocean Service \(NOS\) Sea Level Map](#)**

NOS partnered with the Center for Operational Oceanographic Products and Services to provide maps of land lost by projected sea level rise.

### **[U.S. Climate Change Science Program \(CCSP\) and the Subcommittee on Global Change Research: Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region](#)**

This 2009 report by the CCSP details Mid-Atlantic sea level rise effects, examples of regional and local planning and policy changes, and other adaptation opportunities.

### **[CCSP and the Subcommittee on Global Change Research: Impacts of Climate Change and Variability on Transportation Systems and Infrastructure, Gulf Coast Study: Phase 1](#)**

This 2008 report gives examples of regional or local inundation mapping.

### **[United States Geological Survey: National Assessment of Coastal Vulnerability to Sea-Level Rise](#)**

This document provides relative risks due to future sea-level rise for the U.S. Atlantic, Pacific, and Gulf of Mexico coasts. Through the use of a coastal vulnerability index, sea-level rise is quantified based on the following criteria: tidal range, wave height, coastal slope, shoreline change, geomorphology, and historical rate of relative sea-level rise. This resource can also be used as guidance to analyze exposure to sea level rise.



## *Climate Projections, Tools, and Models*

### **Climate Central**

This independent organization of scientists and journalists researches and reports about climate and climate impacts.

### **Department of Interior Regional Climate Science Centers**

This resource that can provide technical assistance regarding climate information focused on issues related to ecology and public lands.

### **Environmental Systems Research Institute: ArcGIS Emergency Management Mapping Software**

this resource contains many different applications of interest, including ArcGIS and mapping software (including historical impact maps) tailored to Emergency Management.

### **IPCC - Climate Change 2014: Impacts, Adaptation, and Vulnerability: Summary for Policymakers - IPCC Working Group II Fifth Assessment Report (AR5)**

AR5, with contributions from over 800 scientists, and discusses new results since the fourth report as well as climate change adaptation and mitigation.

### **IPCC- AR4 Climate Change 2007: Working Group 1: The Physical Science Basis**

Working Group 1 contains the work of 152 coordinating lead authors from over 30 countries and was reviewed by over 600 experts, including a large number of government reviewers. It discusses climate science, modeling, projections, and more.

### **National Park Service (NPS): Using Scenarios to Explore Climate Change: A Handbook for Practitioners**

This handbook from NPS's Climate Change Response Program describes the five-step process for developing multivariate climate change scenarios. Detailed instructions are provided on how to accomplish each step. Appendices include a hypothetical scenario exercise that demonstrates how to implement the process, some early examples of how climate change scenarios are being used to inform planning and decision making, and advice on designing and facilitating scenario workshops.

### **NOAA Climate Program Office (CPO)**

CPO strives to facilitate more and more effective partnerships in support of adaptation and mitigation services and has a goal to develop and deliver climate mitigation and adaptation information, products, and services for use in climate-related decisions.

### **NOAA Earth System Research Laboratory, Physical Sciences Division**

This division of NOAA provides integrated expertise in weather and climate physical observations, modeling, analysis and applications. This website features many interesting ways to access and display data, including an interactive plotting and analysis feature.

### **NOAA Regional Climate Centers**

This resource can be used for technical assistance and expertise and focuses more heavily on historical observations of climate.

### **SERI: VCAPS**

SERI has developed a modeling process to inform scenario-building and planning for coastal management. The VCAPS tool allows users to represent information about pathways that link hazards, impacts, vulnerabilities, and management actions. The tool allows for creating influence diagrams that represent vulnerability and consequence scenarios.

### **U.S. Army Corps of Engineers and the Joint Airborne LiDAR Bathymetry Technical Center of Expertise (JALBTCX)**

The U.S. Army Corps of Engineers and JALBTCX provide LiDAR data useful for elevation data.

### **USGS LiDAR Data from the National Elevation Dataset (NED)**

High resolution LiDAR data is available from USGS, including elevation data needed for model calibrations.

### **U.S. Global Change Research Program (USGCRP): National Climate Assessment (NCA)**

The Third NCA report, release in 2014 by USGCRP and National Science and Technology Council and entitled "Climate Change Impacts in the United States," details climate impacts per U.S. region and sector.

### **USGS: Derived Downscaled Climate Projection Portal**

A new USGS funded project provides a comprehensive web-based dataset of high-resolution (downscaled) climate change projections for the entire U.S. The Derived Downscaled Climate Projection Portal allows visualization and downloading of future climate projections from a group of "statistically downscaled" global climate models (GCMs). Temperature and precipitation projections from these models have been used to calculate derivative climate indicators that measure the number of days that exceed certain thresholds.

### **USGS: National Assessment of Coastal Vulnerability to Sea-Level Rise**

This is quick-glance map highlighting U.S. coastal areas most vulnerable to sea level rise.

### *Scientific Experts*

#### **EcoAdapt: Climate Adaptation Knowledge Exchange (CAKE)**

Managed by EcoAdapt, a non-profit organization, CAKE offers a virtual library of guidebooks, adaptation plans, directory, tools, community forums, and searchable vulnerability assessment case studies, including a map search feature. The site also hosts a directory of organizations and climate change professionals, and climate change tools.

#### **State/Local Scientists**

Many states have a climatologist that serves as a resource for acquiring and interpreting regional historical climate data, and in some cases, future projected data. For a few states, the state climatologist position, which is often unpaid, may be occupied by an individual without advanced training in climatology.

### **[U.S. Climate Resilience Toolkit: Find Experts](#)**

This toolkit features a U.S. map with links to Regional Integrated Science and Assessment Centers (RISA), NCDC Service Directors, river forecast centers, and regional climate centers.

### *Information on Climate Impacts to Various Sectors*

### **[DOE Energy Infrastructure: U.S. Energy Sector Vulnerabilities to Climate Change and Extreme Weather](#)**

This 2013 DOE publication details power supply susceptibilities to climate change impacts in the energy sector. This is useful in researching the energy security of facilities and assessing possible weaknesses in off-site energy supplies.

### *Additional Guides to Conducting Vulnerability Assessments*

### **[FHWA: Vulnerability Assessment Framework](#)**

FHWA provides a framework for a vulnerability assessment based on their pilot studies and information learned.

### **[National Wildlife Federation \(NWF\): Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment](#)**

This NWF document gives detailed advice on how to frame and complete a climate change vulnerability assessment. Key components of this guide include assistance with identifying vulnerability, understanding why certain resources or systems are vulnerable, and advice for prioritization of susceptibilities.

### **[United Nations Environment Programme \(UNEP\): Handbook on Methods for Climate Change Impact Assessment and Adaptation Strategies](#)**

This guide provides an explanation of modeling climate change scenarios including types of models, issues, downscaling, explanation of climatological baselines, reasons to select a GCM, and integration of climate change impacts into an assessment. Socio-economic scenarios are also discussed.

### **[University of Washington: Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments](#)**

This guidebook, from the University of Washington's Center for Science in the Earth System and the Joint Institute for the Study of the Atmosphere and Ocean, was designed to help governments prepare for climate change by assessing vulnerability and risk through implementation.

### **[United States Department of Agriculture: Responding to Climate Change in National Forests: A Guidebook for Developing Adaptation Options](#)**

This guide uses a science-based approach to develop tools to evaluate climate threats and adaptation options, identify key resource issues, and develop improved management options to mitigate effects of climate change.

*Prior DOE Site Vulnerability Assessments*

**Idaho National Laboratory (INL)**

[Climate Change Vulnerability Assessment for Idaho National Laboratory, October 2014](#)

**Thomas Jefferson National Accelerator Facility (TJNAF)**

*Climate Vulnerability Screening at Thomas Jefferson National Accelerator Facility: October 2014.* Please contact the Sustainability Performance Office (SPO) directly to obtain a copy of the TJNAF pilot assessment.

**National Renewable Energy Laboratory (NREL)**

[A Climate Change Vulnerability Assessment Report for the National Renewable Energy Laboratory, May 23, 2014-June 5, 2015](#)

[A Resiliency Action Plan for the National Renewable Energy Laboratory, May 23, 2014-June 5, 2015](#)

**Pacific Northwest National Laboratory (PNNL)**

[Climate Resiliency Action Planning at Pacific Northwest National Laboratory, September 2015](#)

*DOE Vulnerability Assessment Guidance:*

**Sustainability Performance Office**

[Practical Strategies for Climate Change Vulnerability Assessments](#)









Please note this is an internal document to DOE and has not been released publicly.

*For more information:*

If you require further information please contact SPO at [sustainability@hq.doe.gov](mailto:sustainability@hq.doe.gov).

## Appendix B: National Climate Assessment U.S. Regional Projections and Potential Resilience Actions for the U.S. Energy Sector

The [Third National Climate Assessment](#) (NCA), released by the U.S. Global Change Research Program (USGCRP) in June 2014, is an excellent resource for decision-makers to understand climate change impacts in eight U.S. Regions.

|   |                             |   |
|---|-----------------------------|---|
|    | Northeast                   | Communities are affected by heat waves, more extreme precipitation events, and coastal flooding due to sea level rise and storm surge.  |
|    | Southeast and Caribbean     | Decreased water availability, exacerbated by population growth and land-use change, causes increased competition for water. There are increased risks associated with extreme events such as hurricanes.                            |
|    | Midwest                     | Longer growing seasons and rising carbon dioxide levels increase yields of some crops, although these benefits have already been offset in some instances by occurrence of extreme events such as heat waves, droughts, and floods. |
|   | Great Plains                | Rising temperatures lead to increased demand for water and energy and impacts on agricultural practices.  |
|  | Southwest                   | Drought and increased warming foster wildfires and increased competition for scarce water resources for people and ecosystems.  |
|  | Northwest                   | Changes in the timing of streamflow related to earlier snowmelt reduce the supply of water in summer, causing far-reaching ecological and socioeconomic consequences.   |
|  | Alaska                      | Rapidly receding summer sea ice, shrinking glaciers, and thawing permafrost cause damage to infrastructure and major changes to ecosystems. Impacts to Alaska Native communities increase.  |
|  | Hawai'i and Pacific Islands | Increasingly constrained freshwater supplies, coupled with increased temperatures, stress both people and ecosystems and decrease food and water security.  |

The table below, which is featured on page 121 of the Third NCA, summarizes possible adaptation actions to consider for energy systems. For each possible action listed, one or more key challenges are addressed. These challenges are a result of one or more projected climate impacts, which may be unique to each U.S. region.

| Possible Climate Resilience and Adaptation Actions in Energy Sector  |                          |                               |  |                |
|--|--------------------------|-------------------------------|--|----------------|
| Possible Actions   | Key Challenges Addressed |                               |  |                |
|  | Extreme Weather Events   | Increase in Peak Energy Loads | Water Constraints on Energy Production | Sea Level Rise |
| <b>Supply: System and Operational Planning</b>   |                          |                               |  |                |
| Diversifying supply chains   | X                        | X                             | X                                      | X              |
| Strengthening and coordinating emergency response plans  | X                        | X                             | X                                      |                |
| Providing remote/protected emergency-response coordination centers   | X                        |                               |  |                |
| Developing flood-management plans or improving stormwater management   | X                        |                               |  | X              |
| Developing drought-management plans for reduced cooling flows  |                          |                               | X                                      |                |
| Developing hydropower management plans/policies addressing extremes  |                          |                               | X                                      |                |
| <b>Supply: Existing Equipment Modifications</b>  |                          |                               |  |                |
| Hardening/building redundancy into facilities  | X                        | X                             |  |                |
| Elevating water-sensitive equipment or redesigning elevation of intake structures  | X                        |                               |  | X              |
| Building coastal barriers, dikes, or levees  | X                        |                               |  | X              |
| Improving reliability of grid systems through back-up power supply, intelligent controls, and distributed generation                 | X                        | X                             | X                                      |                |
| Insulating equipment for temperature extremes  | X                        |                               |  |                |
| References to technical studies with case studies on many of these topics may be found in Wilbanks et al. 2012. <sup>4</sup>         |                          |                               |  |                |
| Implementing dry (air-cooled) or low-water hybrid (or recirculating) cooling systems for power plants                                |                          |                               | X                                      |                |
| Adding technologies/systems to pre-cool water discharges   |                          |                               | X                                      |                |
| Using non-fresh water supplies: municipal effluent, brackish or seawater   |                          |                               | X                                      |                |
| Relocating vulnerable facilities   | X                        |                               | X                                      | X              |
| <b>Supply: New Equipment</b>   |                          |                               |  |                |
| Adding peak generation, power storage capacity, and distributed generation   | X                        | X                             | X                                      | X              |
| Adding back-up power supply for grid interruptions   | X                        | X                             | X                                      |                |
| Increasing transmission capacity within and between regions  | X                        | X                             | X                                      | X              |
| <b>Use: Reduce Energy Demand</b>   |                          |                               |  |                |
| Improving building energy, cooling-system and manufacturing efficiencies, and demand-response capabilities (for example, smart grid) | X                        | X                             |  |                |
| Setting higher ambient temperatures in buildings   | X                        | X                             |  |                |
| Improving irrigation and water distribution/reuse efficiency   |                          | X                             | X                                      |                |
| Allowing flexible work schedules to transfer energy use to off-peak hours  |                          | X                             |  |                |




## Appendix C: DOE Secretarial Memorandum on Climate Change Preparedness and Resilience



**The Secretary of Energy**  
Washington, DC 20585

October 21, 2016

### MEMORANDUM FOR HEADS OF DEPARTMENTAL ELEMENTS

FROM: ERNEST J. MONIZ   
SUBJECT: Climate Change Preparedness and Resilience

In March 2015, President Obama signed Executive Order 13693, *Planning for Federal Sustainability in the Next Decade*. The Order reaffirms the Federal government's commitment to provide leadership in energy and environmental management, which will drive national greenhouse gas reductions and prepare for climate change impacts.

In June 2015, the Office of Management and Budget issued its annual update to Circular A-11, which included direction to Federal agencies to consider climate preparedness and resilience as part of their Fiscal Year (FY) 2017 construction and maintenance budget requests.

As the Federal leader in energy efficiency, renewable energy, and clean energy research and development, DOE has both a unique opportunity and a clear responsibility to lead by example and integrate sustainability into all aspects of our operations. This includes ensuring the resilience of our facilities and operations in the face of a changing climate. The Department of Energy (DOE) is committed to integrating climate change preparedness into new construction and maintenance as part of the implementation of the FY17 budget. The attachment provides guidance on implementing this requirement at DOE.

I am requiring all Program Offices to ensure that DOE facilities are prepared for the risks associated with climate change. These actions include:

- Initiating climate vulnerability screenings for all sites and offices that manage real property for the Department. These climate vulnerability screenings must be completed no later than one year from the issuance of the guidance for conducting vulnerability screenings from the Sustainability Performance Office;
- Establishing a schedule for more detailed vulnerability assessments for those sites found to have significant risks associated with climate change;
- Updating on a four-year cycle: 1) completed vulnerability screenings for all sites found to have low risks and 2) all vulnerability assessments previously completed;
- Incorporating the cost of these efforts into budget requests.



Additionally, I am directing that a Steering Committee, comprised of senior leaders from the Program Offices, be established immediately. This committee will provide quarterly briefings on the progress of all climate change resilience actions and any barriers to resiliency efforts to the Chief Sustainability Officer.

Further detail on departmental responsibilities are included in the following attachment. Screening criteria and process steps concerning milestones for follow up assessments and planning and policy changes will be issued by the Chief Sustainability Officer. Assessment results will be integrated into site plans, campus strategies, Environmental Management Systems, and associated planning documents at the site level.

DOE will also share information with local communities surrounding DOE facilities, as appropriate, and improve regional partnerships such as those with local municipalities. This is consistent with President Obama's 2015 Progress Report, which highlights key Federal government actions to support the State, Local, and Tribal Leaders Task Force on Climate Preparedness and Resilience. DOE elements should engage neighboring communities and local agencies in their ongoing assessment and planning processes. DOE sites will report on their progress annually through their Site Sustainability Plans.

The Chief Sustainability Officer will monitor the Department's efforts and issue additional guidance. Progress reports will be provided as part of annual sustainability progress reporting.

Attachment

# Climate Resilience Roles and Responsibilities

## VULNERABILITY SCREENINGS AND ASSESSMENTS

Vulnerability screenings and assessments are the responsibility of Landlord Programs (Program Offices). Guidance on assessing vulnerabilities and risk is available from the Sustainability Performance Office (SPO), under the direction of the Department of Energy's (DOE) Chief Sustainability Officer.

### **Under Secretary for Management and Performance will:**

- Immediately create a Steering Committee and convene quarterly meetings on all major climate change resilience actions and any barriers to resiliency efforts
- Task SPO to provide additional guidance to Program Offices in consultation with the Steering Committee

### **Steering Committee will:**

- Report quarterly to the Under Secretary for Management and Performance
- Immediately distribute vulnerability assessment guidance to each Program Office
- Review plans, schedules, guidance and implementation of prior vulnerability screenings and results
- Develop a schedule and priorities for completion of vulnerability assessments
- Determine training requirements for sites and develop training, as necessary

### **Program Offices will:**

- Conduct vulnerability screenings at their respective sites (if the site has not already completed a vulnerability assessment) no later than one year from the issuance of the guidance from the SPO and determine if: 1) no action is required because of a lack of significant climate threats or 2) a more detailed vulnerability assessment is needed
- Utilize the latest National Climate Assessment and other related information provided by SPO to inform vulnerability screenings
- Prioritize sites needing further assessment and identify sites needing further assessment (i.e., with significant mission critical impacts)
- Oversee vulnerability assessments at sites with significant mission-critical climate impacts

- Determine cost-effective actions for sites with significant mission critical threats and implement those actions, with as-needed evaluation of planning and policy changes, by Fiscal Year (FY) 2020
- Identify a senior official as its representative to the Steering Committee created by the Under Secretary for Management and Performance, and report any challenges or barriers to conducting vulnerability screenings and assessments
- Ensure that all project and property managers incorporate climate-resilient design into construction and renovation projects and ongoing facility management activities and planning processes, including site plans and campus strategies
- Identify funding for vulnerability screenings and vulnerability assessments by including funding requirements in future budget requests, beginning with FY18 requests

**SPO will:**

- Develop and issue guidance, to be approved by the Steering Committee, for conducting vulnerability screenings within 90 days of issuance of this memorandum
- Staff the Steering Committee
- Coordinate a technical assistance team to assist Program Offices in carrying out vulnerability screenings
- Provide National Climate Assessment and related climate and assessment information to Program Offices
- Perform a study to calculate the potential cost and risk to DOE mission associated with agency operations that do not incorporate climate adaptation measures; this study will be completed at one or more representative DOE sites
- Amend Departmental Order 436.1 to include implementation and assigned roles and responsibilities detailed in this memorandum

**The Office of Environment, Health, Safety and Security will:**

- Assist SPO in guidance development and coordinating technical assistance
- Develop guidance to support DOE sites with integrating climate resilience into Environmental Management Systems
- Participate on the Steering Committee as a non-voting member

**CLIMATE-RESILIENT DESIGN**

Major construction and renovation projects will begin to incorporate climate-resilient design aspects, as defined by EO 13693, beginning in FY17.

**Undersecretaries will:**

- Develop guidance, to be approved by the Steering Committee, within 180 days of issuance of this memorandum to enable project and property managers to begin to



incorporate climate-resilient design into real property projects and activities, as per DOE Order 430.1C, including construction and renovation projects and ongoing facility management activities and planning processes, including site plans and campus strategies.

## **COST ESTIMATION**

Cost estimates shall be developed, maintained, and documented in a manner consistent with methods and the best practices identified in GAO-09-3SP *GAO Cost Estimating and Assessment Guide* (current version), and, as applicable, with the Federal Acquisition Regulation (e.g. *FAR Subpart 15.4 – Contract Pricing*; *FAR Subpart 17.6 – Management and Operating Contracts*); Office of Management and Budget Circular A-11, *Preparation, Submission, and Execution of the Budget*; and Department of Energy Acquisition Regulation (DEAR) Subpart 915-4 – *Contract Pricing*.