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Testimony

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Introduction

Thank you, Chairman Stewart, Ranking Member Bonamici and other members of the Subcommittee for the opportunity to testify on the very important topic of climate science and policy options to address climate change. My name is Bill Chameides and I am the Dean of the Nicholas School of the Environment and Nicholas Professor of the Environment at Duke University and a member of the U.S. National Academy of Sciences. I am by training an atmospheric scientist, having spent much of my research career studying the chemistry of the lower atmosphere and the impacts of regional air pollution, trying to understand the causes of environmental change and identify pathways toward a more sustainable future.

I recently served as the vice-chair of a report entitled *America's Climate Choices* [1] (ACC) issued by the National Research Council of the National Academy of Sciences (NAS) at the request of Congress. That report, the capstone in a 5-report series, brought together more than 90 experts from around the country to think collaboratively about the causes and consequences of climate change and the choices for responding. I believe the ACC reports hold special credibility because they were prepared according to the stringent NAS guidelines for balance, objectivity, and peer review, and because they were developed by volunteer experts, including top climate, social, and economic scientists, as well as leaders from the private sector, and former office holders at the federal and state level.

KEY MESSAGES OF NAS REPORT

The ACC report series summarized what we know about climate change and what kinds of response choices we face as a nation. Some key take home points included:

- Climate change is occurring. The preponderance of scientific evidence suggests that the emissions of greenhouse gases from human activities are the primary cause of global warming over the past 50 years. Climate change poses significant risks for a range of human and natural systems. Greenhouse gas emissions are continuing to increase, which will result in further change and greater risks.

- Some projected future impacts of most concern to the United States include more intense and frequent heat waves, risks to coastal communities from sea level rise, greater drying of the arid Southwest, and increased public health risks. Impacts occurring elsewhere in the world can also deeply affect the United States, given the realities of shared natural resources, linked economic and trade systems, migration of species and disease vectors, and movement of human populations.

- The environmental, economic, and humanitarian risks of climate change and its impacts indicate a pressing need for substantial action to limit the magnitude and rate of climate change and to prepare to adapt to its impacts.

- We can expect always to face some uncertainties about future climate risks, but uncertainty is not a reason for inaction. Indeed uncertainty cuts both ways– while climate change could ultimately prove to be less severe than current best estimates indicate, it could also prove to be more severe. This uncertainty argues for approaching the problem though a process of iterative risk management.

- Current response efforts of local, state, and private sector actors aimed at both mitigation and adaptation are significant, but not likely to yield the degree of progress that could be achieved with the addition of strong federal policies that establish coherent national goals and incentives and that promote strong U.S. engagement in international-level response efforts.

Today, a little less than two years since the report was released, the conclusions of the report remain solid; indeed have been largely strengthened by recent events and scientific findings.

WHAT IS KNOWN ABOUT CHANGES IN THE CLIMATE SYSTEM

John Adams once said, "Facts are stubborn things; and whatever may be our wishes, our inclinations, or the dictates of our passion, they cannot alter the state of facts and evidence." Much of what we know about the climate and the phenomenon commonly referred to as global warming is the product of more than a hundred years of research, founded on the most basic laws of science such as the First Law of Thermodynamics, grounded by ever-improving observations of the climate system and supported by the paleoclimate record. While climate models play an important role in climate research, it would be incorrect to characterize global warming as conjecture solely based on climate models or simulations.

As context for today's discussions, here are some scientifically documented facts about the climate system:

- Thermometer measurements show that Earth's average surface temperature has risen substantially over the past century, and especially over the last three decades. The first decade of the 21st century was the warmest during the instrumental record, 9 of the 10 warmest years on record occurred since 2001, and the two warmest years on record occurred in 2010 and 2005.[2]
- These data are corroborated by a host of independent observations showing warming in other parts of the Earth system, including the oceans, the lower atmosphere, and ice-covered regions. Further corroboration comes from shifting seasonal patterns, melting glaciers and permafrost, and rising atmospheric absolute humidity.
- How unusual are current temperatures? Two examples: 1. Extreme hot summertime temperatures[3] around the globe now occur more than 10 times more frequently than earlier in the 20th century;[4] and water that had been frozen in the Peruvian Quelccaya Ice Cap for over 6000 years has recently melted.[5]
- The climate in the U.S. has become more variable and extreme. Over the past 50 years we have seen "an increase in prolonged stretches of excessively high temperatures, more heavy downpours, and in some regions more severe drought." [6]
- Carbon dioxide concentrations are higher today than they have been for at least the past 800,000 and we know from isotopic data that most of the increase over the past century has come from burning fossil fuels. A dubious milestone was reached in April 2012, when the first measurement of carbon dioxide concentrations in excess of 400 ppm was recorded at a remote site.[7]
- Greenhouse gases such as carbon dioxide warm the atmosphere and the full impacts of greenhouse gas emissions on the climate do not fully manifest themselves for decades or centuries after they are added to the atmosphere. Some of the carbon dioxide emitted to the atmosphere from the first Model T remains there today and some of the carbon dioxide we will emit into the atmospheric on our trip home today will be warming the atmosphere of our great-great-grand children, and beyond.
- Most of the recent decadal-scale warming can be attributed to fossil fuel burning and other human activities that release carbon dioxide and other heat-trapping greenhouse gases into the atmosphere. Changes in solar radiation and volcanic activity can also influence climate, but observations show that they cannot explain the recent warming trend.

- Human activities have also resulted in an increase in small particles in the atmosphere, which on average tend to have a cooling effect, but this cooling is not strong enough to offset the warming associated with greenhouse gas increases.
- Natural climate variability, for example caused by the El Nino-Southern Oscillation or ENSO, leads to year-to-year and decade-to-decade fluctuations in temperature and other climate variables that can produce significant regional differences and temporarily mask longer-term global climate trends.[8]
- Much has been made by some of the so-called recent “pause” in global warming. It is important to view this phenomenon in the following context: (1) As noted above, the past decade was the warmest on record; (2) There is precedence for warming pauses in the era of human-induced climate change - between 1980 and 2000 there were two periods when global warming halted for a period of years only to resume, and there was the extended warming halt between 1940 and 1970; and (3) The cooler years of the current millennium, which have given rise to the pause, coincided with la Nina phases of ENSO, just as our understanding of the climate system predicts. Indeed Foster and Ramstorf [6] conclude that once ENSO and other short-term influences are accounted for, the global warming signal continues unabated.
- Human-caused climate changes and impacts will continue for many decades and in some cases for many centuries. The precise nature of these impacts cannot be predicted with great certainty. In part because we are not yet able to predict exactly how the climate will respond to increasing levels of greenhouse gases and in part because we are unable to predict how our energy and economy will evolve in the coming decades. However, we do know that the risks for human well-being from climate change are considerable.

In summary, the vast array of climate research, taken together, clearly indicates that climate change is occurring, is very likely caused primarily by the emission of greenhouse gases from human activities, and poses significant risks for a range of human and natural systems. How should we as a nation respond? Borrowing from the earlier mentioned report on America’s Climate Choices, some recommendations are presented below.

AN EFFECTIVE NATIONAL RESPONSE

There is, of course, much room for debate about what policies should be implemented to respond to climate change and its impacts, but uncertainty is not a reason for inaction. We, as individuals and as a society, often act in the face of uncertainty. And often we choose to take a conservative path, and rightly so. I, for example, cannot predict if, let alone when, there will be a fire in my house, but I pay for fire insurance. Similarly in the face of uncertain but substantial risks from climate change, a prudent course of action is to develop and implement a risk-based and flexible response to the climate change challenge.

Such a response should have the following elements:

(1) Substantially reduce greenhouse gas emissions. In order to minimize the risks of climate change and its most adverse impacts, the nation will need to reduce greenhouse gas emissions substantially over the coming decades. The exact magnitude and speed of emissions reduction depends on societal judgments about how much risk is acceptable and at what cost. However, given the long lifetime associated with infrastructure for energy production and use (among other factors), the most effective strategy is to begin ramping down emissions as soon as possible.

An optimal response will be one that adopts a portfolio of approaches and policies. Economists[9] find that the most effective way to achieve a national emissions reduction target while minimizing overall costs is with a comprehensive, nationally-uniform price on CO_2 emissions, with a price trajectory sufficient to drive major investments in energy efficiency and low-carbon technologies. This suggests that such pricing mechanisms should be part of the portfolio. Complementary policies to ensure progress in key areas of opportunity where market failures and institutional barriers can limit the effectiveness of a carbon pricing system should also be included.

(2) Begin mobilizing now for adaptation. Prudent risk management involves advanced planning to deal with possible adverse outcomes—known and unknown—by increasing the nation's resilience to both gradual climate changes and abrupt disaster events. Initial steps could include improved early warning and evacuation plans, rezoning to account for the fact that past climatological norms may no longer apply, and shifting incentives to encourage development in less vulnerable regions. Longer term, effective adaptation will require the development of new tools and institutions to manage climate-related risks across a broad range of sectors and spatial scales. Adaptation decisions will be made by state and local governments, the private sector, and society at large, but those efforts will be much more effective with national-level coordination, for instance, to share information and technical resources for evaluating vulnerability and adaptation options.

(3) Invest in science, technology, and information systems. Scientific research and technology development can expand the range, and improve the effectiveness of, options to respond to climate change. Systems for collecting and sharing information, including formal and informal education, can help ensure that climate-related decisions are informed by the best available knowledge and analyses, and can help us evaluate the effectiveness of actions taken. Many actors are involved in such efforts. For instance, technological innovation will depend in large part on private sector efforts, and information, education, and stakeholder engagement systems can be advanced by non-governmental organizations and state/local governments.

(4) Participate in international climate change response efforts. America's climate choices affect and are affected by the choices made throughout the world. U.S. emissions reductions alone will not be adequate to avert dangerous climate change risks at home, so it is in our country's interest to advance efforts to reduce emissions abroad. A strong effort to reduce our own emissions may enhance our ability to influence other countries to do the same. Similarly the United States can be greatly affected by impacts of climate change occurring elsewhere in the world, so it is in our interest to help enhance the adaptive capacity of other nations, particularly developing countries that lack the needed resources and expertise.

(5) Coordinate national response efforts. An effective strategy requires coordination among a wide array of actors. This includes balancing rights and responsibilities among different levels of government (vertical coordination), assuring clear delineation of roles among many different federal agencies and other types of organizations (horizontal coordination), and promoting effective integration among the different components of a comprehensive climate change response strategy (e.g., all of the various types of efforts discussed in the previous recommendations).

ACT SOONER RATHER THAN LATER

The risks of not taking action to deal with climate change seem to far outweigh the risks of taking action:

- The faster that emissions are reduced, the lower the risks, and the less pressure to make steeper and potentially more expensive reductions later.
- Current energy infrastructure investments could "lock in" a commitment to substantial new emissions for decades to come. Enacting relevant policies now will provide crucial guidance for investment decisions.
- Policy changes can potentially be reversed or scaled back if needed, whereas adverse changes in the climate system are likely difficult or impossible to "undo."

STAY FLEXIBLE

Because we cannot predict the exact path the climate will take with a high degree of confidence, we are unable to prescribe a response to climate change today that we know will be optimal for decades to come. And so, we need an iterative risk management approach that systematically and continuously identifies risks and possible response options, advances a portfolio of actions that emphasize risk reduction and are robust across a range of possible futures, and revises responses over time to take advantage of new knowledge, information, and technological capabilities. Flexibility and adaptability are key.

PURSUE "WIN-WIN'S"

There are many "win-win" opportunities, where actions that would help in climate change mitigation or adaptation will also bring other substantial societal benefits, such as increasing energy independence, mitigating air pollution and the resulting health impacts, taking measures to make buildings and population centers more resilient to storms and more energy efficient, and reducing vulnerability to natural weather extremes.

FINAL THOUGHTS

America has choices to make about climate change; choices that we must make in the face of risks that are growing with every new ton of greenhouse gases emitted into the atmosphere. We cannot avoid these choices. I would urge in your deliberations to bear in mind that electing to do nothing is indeed making a climate choice – a choice that our children and their children and their children after them will face increased risks from human-induced climate change.

Thank you for your attention. I will be happy to answer your questions.

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[1] "America's Climate Choices" published by the National Academies Press. Committee Members included: Albert Carnesale (*Chair*), University of California, Los Angeles; William Chameides (*Vice-Chair*), Duke University, VA; Donald F. Boesch, University of Maryland Center for Environmental Science, Cambridge; Marilyn A. Brown, Georgia Institute of Technology; Jonathan Cannon, University of Virginia; Thomas Dietz, Michigan State University; George C. Eads, CRA Charles River Associates, Washington, DC; Robert W. Fri, Resources for the Future, Washington, D.C.; James E. Geringer, Environmental Systems Research Institute, Cheyenne, WY; Dennis L. Hartmann, University of Washington, Seattle; Charles O. Holliday, Jr., DuPont (Ret.), Nashville, TN; Diana M. Liverman, University of Arizona and University of Oxford, UK; Pamela A. Matson, Stanford University, CA; Peter H. Raven, Missouri Botanical Garden, St. Louis; Richard Schmalensee, Massachusetts Institute of Technology; Philip R. Sharp, Resources for the Future, Washington, DC; Peggy M. Shepard, WE ACT for Environmental Justice, New York, NY; Robert H. Socolow, Princeton University, NJ; Susan Solomon, National Oceanic and Atmospheric Administration, Boulder, CO; Bjorn Stigson, World Business Council for Sustainable Development, Geneva, Switzerland; Thomas J. Wilbanks, Oak Ridge National Laboratory, TN; Peter Zandan, Public Strategies, Inc., Austin, TX; Laurie Geller (*Study Director*), National Research Council.

[2] National Climate Data Center, "Global Analysis-Annual 2012, http://www.ncdc.noaa.gov/sotc/global/2012/13

[3] Defined as 3 sigma above the climatological mean; for a normal distribution that would have a probability of 0.27% of occurring.

[4] J. Hansen, et al. Perception of Climate Change, Proc. Natl. Acad. Sci., 1205276109, 2013.

[5] L.G. Thompson, et al. Annually Resolved Ice Core Records of Tropical Climate Variability over the Past ~1800 Years, *SciencExpress*, 1234210, 2013.

[6] National Climate Assessment, U.S. Global Change Research Program, 2012.

[7] National Oceanic and Atmospheric Administration, Carbon dioxide reaches milestone at Arctic sites, http://researchmatters.noaa.gov/news/Pages/arcticCO2.aspx, 2012

[8] G. Foster and S. Rahmstorf, Global temperature evolution, 1979 – 2010, *Environ. Res. Lett.*, 6, 044022, 2011.

[9] W.D. Nordhaus, To Tax or Not to Tax: Alternative Approaches to Slowing Gobal Warming, Review of Environmental Economics and Policy, volume 1, pp. 26–44, doi: 10.1093/reep/rem008, 2007.