AUTHENTICATED
U.S. GOVERNMENT
INFORMATION
GPO

S. HRG. 110–522

CLIMATE CHANGE IN COASTAL REGIONS

HEARING

BEFORE THE

COMMITTEE ON ENERGY AND NATURAL RESOURCES UNITED STATES SENATE

ONE HUNDRED TENTH CONGRESS

SECOND SESSION

TO

EXAMINE THE IMPACTS OF CLIMATE CHANGE ON THE RELIABILITY, SECURITY, ECONOMICS, AND DESIGN OF CRITICAL ENERGY INFRASTRUCTURE IN COASTAL REGIONS

MAY 13, 2008

Printed for the use of the
Committee on Energy and Natural Resources

U.S. GOVERNMENT PRINTING OFFICE

44–709 PDF WASHINGTON : 2008

For sale by the Superintendent of Documents, U.S. Government Printing Office
Internet: bookstore.gpo.gov Phone: toll free (866) 512–1800; DC area (202) 512–1800
Fax: (202) 512–2104 Mail: Stop IDCC, Washington, DC 20402–0001

COMMITTEE ON ENERGY AND NATURAL RESOURCES

JEFF BINGAMAN, New Mexico, *Chairman*

DANIEL K. AKAKA, Hawaii
BYRON L. DORGAN, North Dakota
RON WYDEN, Oregon
TIM JOHNSON, South Dakota
MARY L. LANDRIEU, Louisiana
MARIA CANTWELL, Washington
KEN SALAZAR, Colorado
ROBERT MENENDEZ, New Jersey
BLANCHE L. LINCOLN, Arkansas
BERNARD SANDERS, Vermont
JON TESTER, Montana

PETE V. DOMENICI, New Mexico
LARRY E. CRAIG, Idaho
LISA MURKOWSKI, Alaska
RICHARD BURR, North Carolina
JIM DEMINT, South Carolina
BOB CORKER, Tennessee
JOHN BARRASSO, Wyoming
JEFF SESSIONS, Alabama
GORDON H. SMITH, Oregon
JIM BUNNING, Kentucky
MEL MARTINEZ, Florida

ROBERT M. SIMON, *Staff Director*
SAM E. FOWLER, *Chief Counsel*
FRANK MACCHIAROLA, *Republican Staff Director*
JUDITH K. PENSABENE, *Republican Chief Counsel*

CONTENTS

STATEMENTS

	Page
Bingaman, Hon. Jeff, U.S. Senator From New Mexico	1
Burkett, Virginia, Chief Scientist for Global Change Research, Geological Survey, Department of the Interior	9
Corker, Hon. Bob, U.S. Senator From Tennessee	3
Craig, Hon. Larry E., U.S. Senator From Idaho	2
Drevna, Charles T., President, National Petrochemical & Refiners Association	23
Edgar, Lisa Polak, Commissioner, Florida Public Service Commission, Tallahassee, FL	3
Falgout, Ted, Port Director, Port Fourchon, LA	21
Landrieu, Hon. Mary L., U.S. Senator From Louisiana	21
Martinez, Hon. Mel, U.S. Senator From Florida	4
Wallace, Terry, Principal Associate Director For Science, Technology and Engineering, Los Alamos National Laboratory, Los Alamos, NM	16
Wilbanks, Thomas J., Oak Ridge National Laboratory, Oak Ridge, TN	5

APPENDIX

Responses to additional questions	51

CLIMATE CHANGE IN COASTAL REGIONS

TUESDAY, MAY 13, 2008

U.S. SENATE,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Washington, DC.

The committee met, pursuant to notice, at 9:47 a.m. in room SD–366, Dirksen Senate Office Building, Hon. Jeff Bingaman, chairman, presiding.

OPENING STATEMENT OF HON. JEFF BINGAMAN, U.S. SENATOR FROM NEW MEXICO

The CHAIRMAN. I'd like to go ahead with the hearing at this point, welcome everyone here today, and thank the witnesses who are testifying before the committee.

This is an oversight hearing on climate-change impacts on our energy infrastructure.

Over the last 4 years, the world has witnessed, through numerous tragedies, the vulnerability of low-lying coastal regions to natural hazards, including, of course, the tragedy that happened in Burma last week. It's expected that within the next 50 years, we will see accelerated sea-level rise, increased storm intensity, and significant coastal erosion. The consequences of these events should not be underestimated.

As a Nation, we've begun to consider mitigation efforts aimed at reducing greenhouse gas emissions, as it's now generally accepted that some level of climate change is occurring. While much of our attention has been focused on how our current mix of energy resources and technologies contributes to climate change, there has been little focus so far on how changes in climate will affect our current and future energy needs. I'm concerned that in many communities facilities are being developed without adequate consideration of the potential cost of protecting or relocating them from sea-level-rise-related erosion and flooding and storm damage. Much of our energy infrastructure has been built based on our knowledge of historical climate conditions, but since our climate is changing, energy infrastructures which are optimal today may not be, in the future.

The longevity of our infrastructure argues for us to look long-term in the planning and design of new systems. Decisions made today for the creation of new infrastructure need to occur in ways that ensure that such infrastructure is robust enough to cope with or adapt to changing climate conditions.

In the latest report that it issued, the Intergovernmental Panel on Climate Change states that it's very likely that we will see

stronger, more destructive hurricanes and typhoons, accelerated sea-level rise, and changing weather patterns in coming years. A significant portion of our Nation's critical energy infrastructure is concentrated in coastal areas that are vulnerable to natural hazards and changes in climate. This infrastructure forms the heart of a nationally and globally interdependent energy system.

Our own experience with the Gulf Coast hurricanes in 2005 demonstrated the vulnerability of our energy systems and the magnified nationwide effects that a localized disruption can create. Nearly a third of our Nation's refining capacity was closed. That was in 2005. There was a significant loss of natural-gas supplies in the Gulf of Mexico. The disruptions increased United States energy prices and threatened to create significant shortages of fuel for home heating and electric power generation in New England. There's currently a need to consider how to incorporate future changes in environmental conditions as new infrastructure expansion plans are developed and implemented. Today, we'll hear testimony on what's needed to create a more resilient and adaptable infrastructure in response to the inevitable impacts and challenges that climate change will present.

Let me just see if Senator Craig wished to make an opening statement before we go to the witnesses.

[The prepared statement of Senator Domenici follows:]

PREPARED STATEMENT OF HON. PETE V. DOMENICI, U.S. SENATOR FROM NEW MEXICO

Good morning, I want to thank Chairman Bingaman for holding this hearing and I thank the witnesses for being here today.

There is no question that we must strengthen our infrastructure and expand our ability to produce energy. Whether it is climate change, population growth, global economic growth, or a combination of those factors, the need to invest significantly in our future energy security is apparent. It is clear that the coastal States can and should play a significant role in this effort—many of them already are.

We must reduce greenhouse gas emissions, and I believe we have taken several steps in the right direction on this front. That having been said, we must do more. I remain unconvinced that cap-and-trade is the right policy option to achieve our goals, however.

Consistently, every single analysis done of legislation to cap carbon dioxide emissions concludes that it will increase the cost of energy for Americans. At a time when Americans are suffering daily from the consequences of high energy bills, policies that add to this burden are exactly the type we must avoid.

There are alternative approaches, and some of them have been signed into law—including the 2005 Energy Policy Act and the 2007 Energy Independence and Security Act. Those bills created first-of-a-kind incentives for nuclear power, renewable sources of electricity, and strengthened our efficient use of everything from automobiles to dishwashers.

We can do more, and it is for that reason that I have introduced legislation to create the Clean Energy Investment Bank of the United States. I am hopeful that we can continue to move forward on proposals that achieve our goal of reducing greenhouse gas emissions without harming the American economy. This effort is of paramount importance, not only to our coastal states, but to the entire country.

I thank you again, Mr. Chairman, for scheduling this hearing and I look forward to hearing from the witnesses.

STATEMENT OF HON. LARRY E. CRAIG, U.S. SENATOR FROM IDAHO

Senator CRAIG. Mr. Chairman, thank you very much. Most importantly, thank you for doing the kind of oversight on this issue that is so very, very necessary.

You've said it well. Today, our energy is delivered on an energy system that was built between 1947 and 1975, after World War II. Increasing growth in energy demand will just put more pressure on our old, badly deteriorated, and, in some instances, obsolete infrastructure. The Energy Information Agency forecasts that total energy consumption will increase by 19 percent over 2030—or, by 2030. We consistently have blackouts. Recent blackouts in the Northeast and in California highlight how fragile our Nation's existing power grid is. Generation capacity has been added, mainly by natural gas, but there has been little expansion in the transmission network. Here, they tell us the average age of power transformers in service is 40 years. This aging transmission infrastructure is also of some concern, as its vulnerability relates to terrorist attacks. I know we're going to hear from some of our lab people today. New Mexico and a lab in Idaho are working with DOE and Homeland Security to identify and fix these vulnerabilities. Limited domestic refinery capacity is impacting gasoline prices. It goes on and on, at a time when our country isn't in the business of needing less energy, it is in the business of needing more energy, not only to sustain our lifestyles, but to sustain our growth and now to sustain an ever-growing desire to have a cleaner environment. All of that requires energy in somewhat different forms than what's currently being produced today, and all of that infrastructure services those needs as it relates to greenhouse gas emissions, climate-change concerns, and a cleaner environment.

Thank you, Mr. Chairman.

The CHAIRMAN. Before I introduce the panel, let me call on—Senator Corker would like to introduce one of the witnesses, and Senator Martinez, as well, and Senator Landrieu, when she arrives.

So, Senator Corker, why don't you go ahead.

STATEMENT OF HON. BOB CORKER, U.S. SENATOR FROM TENNESSEE

Senator CORKER. Mr. Chairman, thank you. Thanks for your leadership on this committee.

It is my pleasure to introduce the distinguished witness from the Oak Ridge National Laboratory who's here to testify. I know all of us have some great talent in our States. He's one of the best. He is a corporate research fellow and scientist, Dr. Tom Wilbanks. Tom leads the lab's Global Change and Developing-Country Programs. Tom shared in the 2007 Nobel Peace Prize as a coordinating lead author in the Working Group, too, of the Intergovernmental Panel on Climate Change, a project I'm sure that many of you have heard a lot about. Tom is a past president of the Association of American Geographers, one of only three non-academics in the last 100 years. I don't know what that says about the organization or you, Tom, but we're certainly glad that you led it. He's been awarded a number of honors in that field.

Tom, we thank you for being here today and representing, not just our State, but our country, in this world the way you do.

Thank you very much.

The CHAIRMAN. Thank you very much.

Senator Martinez.

Senator CRAIG. Mr. Chairman, before you got to Mel, let me apologize. I mentioned New Mexico, Los Alamos, Idaho, the INL, and I failed to recognize that Tom, with the phenomenal lab at Oak Ridge, was here. Welcome.

The CHAIRMAN. Senator Martinez.

STATEMENT OF HON. MEL MARTINEZ, U.S. SENATOR FROM FLORIDA

Senator MARTINEZ. Mr. Chairman, thank you very much. This is a timely and important topic, and I appreciate you holding this hearing.

I'm very pleased today to introduce Lisa Edgar, from the wonderful State of Florida. She is with the Florida Public Service Commission. Ms. Edgar is a former chairman of the PSC, and she's currently serving on the Governor's Action Team on Energy and Climate Change, where our Governor has taken a very forward-leaning position, and obviously Florida is leading the way. Unfortunately, Florida has had a long history of dealing with natural disasters, but our State also has been a leader on emergency preparedness and prevention efforts. Just yesterday, we had terrible wildfires that seem to have taken a number of homes in Brevard County and coastal area on the Atlantic Coast of Florida. Terrible situation. But, the PSC has taken a strong multifaceted approach through requiring utilities across the State to submit hurricane-season preparedness briefings, perform regular inspections on infrastructure, and implement a ten-point storm preparedness initiative.

We've been blessed in Florida to have talented people and public servants like Ms. Edgar leading our regulatory agencies. She's held numerous other positions throughout the State, in State government, before joining the Public Service Commission, and she also served as deputy secretary of the Florida Department of Environmental Protection.

On a really side and personal note, of great importance to me is the fact that she is a graduate of Florida State University, as an undergraduate and law grad, where we happened to have been walking on similar hallways. So, we're delighted that you would have the good judgment to bring up a Seminole to testify up here.

So, Lisa, we're glad to have you and welcome you to the committee.

Ms. EDGAR. Thank you.

The CHAIRMAN. All right. Let me just introduce the rest of the panel, and then we'll hear from the witnesses.

Virginia Burkett is here, and she's the chief scientist of the Global Change Programs with the United States Geological Survey. Thank you for coming.

Terry Wallace, from—who's a regular witness here at our committee, and a good friend, and does a great job at Los Alamos National Laboratory as the principal associate director for science, technology, and engineering at Los Alamos National Laboratory.

Ted Falgout—and Ted is the executive director with Port Fourchon in Galliano, Louisiana.

Charles Drevna is here, the president of the National Petrochemical and Refiners Association in Washington, DC. You've been a witness before us before, and thank you for being here again.

Lisa, you were already introduced, as were you, Dr. Wilbanks.

So, why don't we start with Dr. Wilbanks and just go across the table with each of you giving us 5 or 6 minutes of the highlights of your testimony. We'll include your full statement in the record.

We do have 4 votes that begin at 11 o'clock, and so, if you folks could summarize your testimony, and then we will hopefully have some time for at least a few questions before we have to conclude the hearing and do those four votes.

Dr. Wilbanks, thanks for being here.

STATEMENT OF THOMAS J. WILBANKS, OAK RIDGE NATIONAL LABORATORY, OAK RIDGE, TN

Mr. WILBANKS. Thank you, Mr. Chairman, Senator Corker—my Senator—distinguished members of the committee.

As you know very well, we've heard a lot over the past decade and a half about the energy sector as a reason for the large share of the carbon emissions that are a cause of climate change, but we've heard very little about how the energy sector might be impacted by climate change when those impacts could be considerable.

A couple of years ago, the Interagency Climate Change Science Program commissioned the first comprehensive assessment of these climate-change risks and vulnerabilities for the energy sector in the United States I'm going to summarize what this assessment found out about implications of climate change for critical energy infrastructures in coastal regions. But, let me first update the context for thinking about these kinds of risks and vulnerabilities.

In the past several years, scientists observing what's happening with global climate change have noticed two things. Number one, physical impacts of climate change are emerging faster than was projected even 7 or 8 years ago. Number two, greenhouse gas emissions worldwide are increasing faster than what had been assumed in any climate-change scenario we've ever taken seriously. When we put these two observations together, our conclusion is that risks of relatively severe climate change are greater than we've been projecting. These two facts suggest that the kinds of implications I'm going to mention could, by the mid to longer terms at least, become pretty serious.

Okay, the main impact concerns, aside from Alaska, are two. First, severe storms, along with some sea-level rise, and second, water availability. But, the big issues differ according to the coastal region. For the Gulf Coast, Florida and the rest of the Coastal Southeast, the main concern is with the intensification of severe weather events, along with severe—with sea-level rise, which threaten the reliability and security of critical oil, gas, and electricity infrastructures, both onshore and offshore.

Other important concerns for this region are significantly higher demands for electricity for cooling as temperatures rise, and possibly some seasonal water shortages for cooling of power plants inland to supply electricity for coastal areas.

For the Coastal Northeast, the main concern is with coastal flooding from severe weather events, along with increased demands for air conditioning and electricity for cooling.

For the West Coast, the main concern is with decreasing freshwater availability from spring and summer snowmelts in the western mountains, increasing competition for scarce water between energy and other uses, possibly affecting electricity availability for coastal development, the energy-water nexus that this committee knows a lot about.

For Alaska, the main effects, not all necessarily negative, depending on one's point of view, include effects on energy infrastructures of the thawing permafrost, which are already being observed, effects on oil and gas exploration and production, which might get easier in some ways, and effects of ice-cap melting on energy transport along the North Slope, which could be interesting.

These very brief comments just touch on the high points of what we think we know, but I hope they're a useful start for the rest of the hearing.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Wilbanks follows:]

PREPARED STATEMENT OF THOMAS J. WILBANKS, OAK RIDGE NATIONAL LABORATORY, OAK RIDGE, TN

Mr. Chairman, distinguished members of the Committee, I thank you for your interest in the issues being discussed at this hearing, and I appreciate the invitation to join you this morning.

INTRODUCTION

As you know very well, we have heard a lot over the past decade and a half about the energy sector as a driver of climate change: the reason for a large share of the carbon emissions that are a cause of climate change. But we have heard very little about the energy sector as a target of impacts of climate change. The fact is that energy production and use in the United States and the world are going to be affected by climate change, and our objectives of assuring the reliability, affordability, and security of energy services for the American population depend partly on recognizing possible risks and vulnerabilities and taking actions to reduce those risks and vulnerabilities.

In the summer of 2005, as one element of producing 21 summaries of what we know and don't know about issues for climate change science, the nation's Climate Change Science Program (or CCSP) commissioned the first comprehensive assessment of these climate change risks for the energy sector in the U.S. I had the honor of leading the team that prepared it, under the auspices of DOE's Office of Science, along with serving as Coordinating Lead Author for the chapter of the recent IPCC Fourth Assessment report that dealt with energy sector impact issues, also supported by DOE. The CCSP report was completed last fall (see http://www.climatescience.gov/), and I briefed the Senate and House staffs about its conclusions last October.

What I would like to do, to serve as a foundation for the other testimony to come, is to summarize what this assessment found out about effects of climate change on energy production and use in the United States, including but not limited to energy infrastructures in vulnerable coastal regions. Before I move on to that, let me observe that our knowledge about impacts of climate change on energy production and use is limited by the fact that this topic has not been the focus of very much research to date, beyond a few issues such as effects of warming on energy use in buildings; so what I will say is only a beginning. But I think it does point us toward some issues that need further attention as a basis for our risk management strategies.

The CCSP energy sector impact assessment has been labeled Synthesis and Assessment Product (SAP) 4.5; it was charged with answering three questions as best we could with currently available knowledge:

- How might climate change affect energy consumption in the United States?

- How might climate change affect energy production and supply in the United States?
- How might climate change have other effects that indirectly shape energy production and use in the United States?

Here is a summary of the answers to those questions, paying particular attention to issues for coastal infrastructures:

EFFECTS ON ENERGY CONSUMPTION AND USE

About effects on energy consumption and use, it is clear that warming will reduce total U.S. heating requirements and increase U.S. cooling requirements for buildings. The research done so far indicates that the demand for cooling will rise 5 to 20% for each one degree Centigrade of average warming. The demand for warming will drop 3 to 15% for each degree of warming. The ranges reflect different assumptions about such things as the rate of market penetration of improved energy-use technologies.

Overall, because we use more energy for heating than for cooling in the U.S., the two effects roughly cancel each other out in terms of total energy requirements at a national scale, but this hides an important effect. Because nearly all of our cooling is supplied by electricity, while our warming comes from a combination of natural gas, fuel oil, and electricity, the warming associated with climate change will increase demands for electricity, especially in areas with a lot of demand for cooling and areas which have not historically done a lot of space cooling.

Other effects of climate change on energy consumption, for instance for water pumping or for fuel in vehicles doing more interior cooling, are less clear, because that research has not yet been done.

Obviously, in coastal areas of the U.S. Southeast, the projected increase in needs for electricity is an infrastructure issue. Recall that the first U.S. national assessment of climate change impacts, published in 2001 and based on relatively modest estimates of possible climate change, projected an increase in the July heat index in the Southeast by the year 2100 of between 8 and more than 20 degrees Fahrenheit. The increase in coastal areas would be less than the regional average, because of the moderating effect of the seas; but energy costs for comfortable living can be expected to increase and, combined with such other factors as greater discomfort in summer outdoor activities, higher risks of severe storms, and higher costs for private property insurance, could add stress to coastal economies and societies.

EFFECTS ON ENERGY PRODUCTION AND SUPPLY

About effects of climate change on energy production and supply, the knowledge base is more limited, and—except for Alaska, where impacts are already being observed—our conclusions are based mainly on extrapolations from recent experience with climate variability, combined with relatively high-confidence projections of temperature and precipitation associated with climate change.

Aside from Alaska, the main concerns are with:

(1) increased exposure to severe weather events, especially in storm-prone coastal areas, along with possible long-term effects of sea-level rise that could have consequences for facility siting, and

(2) reduced water supplies for hydroelectric power and/or thermal power plant cooling in regions that become drier or that depend on diminished mountain snowfall for surface water supplies

Another effect of some concern is that, with warmer air and water temperatures, the overall efficiencies of thermoelectric power plants (fossil and nuclear) will be reduced. Although the percentage change for a particular power plant might be small, the aggregate impact could be significant: note that a one percent reduction in power generation nationally would mean a need to supply 25 billion kWh of additional electricity each year.

Electricity transmission and distribution systems may also be affected by climate change, both in terms of the total demands for power movement (see above) and effects of weather on their reliability. The most familiar example is effects of severe weather events on power lines (e.g., from ice storms or tornadoes as well as hurricanes), but in the summer heat wave of 2006 electric power transformers failed in several areas, such as St. Louis and Queens, NY, due to high temperatures, causing interruptions of electric power supply.

Finally, climate change could have effects on renewable energy alternatives other than hydropower, such as biomass energy, windpower, and solar energy. Currently available research does not tell us enough to draw firm conclusions about this topic,

but it is important for us to improve the information available for energy decision-making in this regard.

INDIRECT EFFECTS ON ENERGY PRODUCTION AND USE

The issue of possible indirect effects on energy production and use is an interesting one. It includes both impacts of climate change on other systems and infrastructures that in turn relate to energy demands, such as transportation and agriculture, and also impacts of climate change policy responses on energy systems and infrastructures. As you are acutely aware, some of these connections—such as possible effects on energy institutions, energy prices, and regional comparative advantage—are both politically charged and lacking in objective research; and SAP 4.5 does little more than note the questions. But the possibility of impacts, especially of climate change policies, is an issue that we need to keep in mind. Certainly, some of our energy institutions think that impacts on them of climate change policies could well be greater than impacts of climate change itself.

MAIN CONCLUSIONS

Based on the knowledge available to us when we put SAP 4.5 together, we came up with four main conclusions about effects of climate change on energy production and use in the United States:

First, there is a range of impact concerns, which vary by energy source and region, but the general picture at this point is one of caution rather than alarm. Aside from Alaska, the main risks and vulnerabilities have to do with severe storms, especially in the Southeastern US, and water availability, an issue in most parts of the country but most directly for parts of the West that depend on winter snowfall in the mountains for spring and summer surface water supply.

Second, with climate change effects likely to emerge over a period of some decades, we have time to consider strategies for adaptation to reduce risks of negative effects and take advantage of possible positive effects. The energy sector in this country is accustomed to change, including attention to weather variables, and it has both the fiscal resources and the management skills to incorporate climate change as an aspect of uncertainty in its longer-term strategic planning and investment. Potentials for adaptation are considerable.

Third, we need to pay particular attention to regional implications of energy sector impacts, and I will conclude with a summary of implications for the coastal regions of the U.S.

Finally, we simply need to know more abut these kinds of things than we know now, working through a rich collaboration among government, industry, NGOs, and academia. As with most other areas of interest in climate change impacts and adaptation potentials, we know too little at present to do more than sketch out a general picture of risks and vulnerabilities, when investment behavior needs better information than that. For example, we need to know more about potentials for power plant cooling approaches that are less water-dependent, on technology improvements for affordable space cooling, and approaches for increasing the resilience of coastal and offshore oil and gas production systems to extreme weather events.

SUMMARY OF IMPLICATIONS FOR CRITICAL ENERGY INFRASTRUCTURES IN COASTAL REGIONS OF THE UNITED STATES

Regarding what SAP 4.5 has to say about projected impacts of climate change on critical energy infrastructures in coastal regions in the United States, here is a very brief summary:

Coastal Southeast.—intensification of severe weather events, threatening the reliability and security of critical oil, gas, and electricity infrastructures both onshore and offshore; significantly increased demands for electricity for cooling; possibly occasional seasonal water shortages for power plant cooling for facilities using freshwater systems inland.

Coastal Northeast.—vulnerabilities to flooding from severe weather events, northeasters as well as hurricanes; increased demands for electricity for cooling, along with space heating savings; increased demands for air-conditioning.

West Coast.—decreased freshwater availability from spring and summer snowmelt, increasing competition for scarce water between energy and other uses, possibly affecting electricity availability for coastal development.

Alaska.—effects on energy infrastructures of thawing permafrost; effects on oil and gas exploration and production (possibly positive); effects of polar ice cap melting on energy transport, especially from North Slope development.

This concludes my testimony this morning. Thank you, Mr. Chairman

The CHAIRMAN. Thank you very much.
Dr. Burkett.

STATEMENT OF VIRGINIA BURKETT, CHIEF SCIENTIST FOR GLOBAL CHANGE RESEARCH, GEOLOGICAL SURVEY, DEPARTMENT OF THE INTERIOR

Ms. BURKETT. Yes, sir. Mr. Chairman and members, thank you for inviting me to present highlights from our recent report about Climate Change Impacts on Transportation in the Central Gulf Coast Region. This work was led by the United States Department of Transportation as—and is one of the 21 synthesis products of the United States Climate Change Science Program. The other co-leads for the project, Mike Savonis, behind me, from DOT, and Joanne Potter, as well, from Cambridge Systematics, are here with me today.

The region between Mobile, Alabama, and Galveston, Texas, contains the largest concentrations—concentration of United States ports and thousands of miles of pipelines and onshore infrastructure, like tank batteries and processing plants, that receive and transport two-thirds of the United States oil imports and more than 90 percent of our Outer Continental Shelf oil and gas. These facilities, plus 17,000 miles of highways and 61 airports, are all vulnerable in some way to climate change that is anticipated during the next 50 to 100 years. The four primary drivers are: accelerated sea-level rise, increased air and water temperature, an increase in the intensity of tropical storms, and changes in rainfall patterns.

An acceleration of sea-level rise is due to thermal expansion of heating of the water and the melting of glaciers and ice sheets as one of the most certain and most costly consequences of global warming. This region has very little topographic relief and is highly vulnerable to permanent flooding due to subsidence and/or accelerated sea-level rise, and, in fact, both of these are occurring—sea-level rise and subsidence—from Mobile all the way over to Galveston. This is very common.

As the temperature of the sea surface increases tropical storms are likely to intensify. This coastline is vulnerable to flooding, erosion, and wetland loss during tropical storms. As barrier islands and mainland shorelines erode, human communities and onshore infrastructure and low-lying coastal areas become more susceptible to inundation and destruction.

Climate models indicate an increase in average temperature of the region and extreme high temperatures. Rainfall is expected to come more in the form of heavy downpours, with an increase in the spacing between rainfall events.

All of these changes in the physical climate can directly affect transportation infrastructure and the physical stability of the coast upon which the infrastructure sits. Warmer temperatures may require changes in materials, maintenance, and operation of transportation systems. Some pavements deteriorate more quickly. Rail lines will buckle. Higher temperatures affect the length of runways and aircraft performance. More intense rainfall would increase the short-term flooding of roads, which is already a problem in the region.

We learned, from Hurricane Katrina, that prolonged flooding can damage pavement infrastructure. With a storm surge of 23 feet—and we had 30 feet in the area during Katrina—but, with 23 feet, 64 percent of the interstates, half of the rail, 29 airports, and all of the present port facilities are subject to flooding. Even if storms do not increase in intensity, existing infrastructure will be more likely to flood as sea level rises.

While protective structures, like levees and sea walls, can protect some facilities, flooding of even small segments of a road can make the entire system unusable, which is important, in terms of hurricane evacuation.

Thank you, sir, and we have experts from transportation that can help answer questions.

[The prepared statement of Ms. Burkett follows:]

PREPARED STATEMENT OF VIRGINIA BURKETT, CHIEF SCIENTIST FOR GLOBAL CHANGE RESEARCH, GEOLOGICAL SURVEY, DEPARTMENT OF THE INTERIOR

Mr. Chairman and Members of the Committee, as a Lead Author and Editor of the U.S. Climate Change Science Program assessment of climate change and its impacts on Gulf Coast transportation, I am pleased to present a summary of our findings about trends in the physical environment and the climate variables that have implications for the transportation sector. I would like to acknowledge the other editors and co-authors of the report, with whom I have collaborated over the past four years to develop this broad regional assessment upon which my testimony is based (CCSP 2008):

Editors: Michael J. Savonis (FHWA) and Joanne R. Potter (Cambridge Systematics)

Lead Authors.—Michael J. Savonis, Joanne R. Potter, Robert C. Hyman (Cambridge Systematics), Barry D. Keim (Louisiana State University), Thomas W. Doyle (USGS), Robert S. Kafalenos (FHWA), Kenneth J. Leonard (Cambridge Systematics), Ron Hagelman (Texas State University), Stephen B. Hartley (USGS), Matthew Sheppard (IBM), John H. Suhrbier (Cambridge Systematics), Eric Lindquist (Texas A&M Univerisity), and Jessica E. Tump (Cambridget Systematics)

Contributing authors.—Claudia Tebaldi (National Center for Atmospheric Research), Daniel M. Beagan (Cambridge Systematics), Alan Meyers (Cambridge Systematics), Michael F. Wehner (Lawrence Berkeley National Laboratory), Tamara G. Houston (NOAA), David T. Hunt (Cambridge Systematics), Michael K. Maynard (Wilbur Smith Associates), Barbara Fritsche (Wilbur Smith Associates), Russell H. Henk (Texas Transportation Institute), Edward J. Seymour (Texas Transportation Institute), Leslie E. Olson (Texas Transportation Institute) , Wesley R. Dean (Texas A&M University), Ivor Van Heerden (Louisiana State University), S. Ahmet Binselam (Louisiana State University), and Nanda N. Srinivasan (Cambridge Systematics)

These authors collectively represent three Federal agencies, five universities and research institutions, and two transportation planning and engineering firms. In addition to the contributions from these co-authors, the study was guided by a 16-member advisory committee formally chartered by the Secretary of Transportation under the Federal Advisory Committee Act of 1972. This committee included transportation experts representing the various modes (e.g., rail, ports, highways) and several additional physical scientists and risk assessment experts.

The Gulf Coast project was sponsored by the U.S. Department of Transportation (DOT) in partnership with the U.S. Geological Survey (USGS) under the auspices of the U.S. Climate Change Science Program (CCSP). The study, Synthesis and Assessment Product (SAP) 4.7 titled "Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: Gulf Coast Study, Phase I" is one of 21 "synthesis and assessment" products planned and sponsored by the CCSP with the Department of Transportation as the lead agency. This SAP was completed by the CCSP in March 2008. This project demonstrates how our understanding of climate change and other physical processes can be integrated with knowledge of transportation engineering and planning to produce an assessment of risks and vulnerability that is relevant to this important sector of the U.S. economy.

The ultimate goal of this 3-phased research project is to provide knowledge and tools that will enable transportation planners and managers to better understand climate change and associated risks, adaptation strategies, and tradeoffs involved in planning, investment, design, and operational decisions. The objective of Phase I of this project, which we have now completed, was to conduct a preliminary assessment of the risks and vulnerabilities of transportation in the region, after collecting and integrating the range of data needed to characterize the region—its physiography and hydrology, land use and land cover, past and projected climate, current population and trends, and transportation infrastructure. Subsequent phases will involve a more detailed analysis. PhaseµII will involve an in-depth assessment of risks to transportation in a selected location, reporting on implications for long-range plans and impacts on safety, operations, and maintenance. This phase will also develop a risk assessment methodology and identify techniques to incorporate environmental and climate data in transportation decisions. Phase III will identify and analyze adaptation and response strategies and develop tools to assess these strategies, while enumerating future research needs.

My comments this morning will focus on the major drivers of change in the central Gulf Coast, considering the natural physical setting as well as the historical and projected changes in climate. The Lead Author of the study from the DOT, Mike Savonis, is with me to answer any questions that you might have about potential impacts on the wide range of transportation modes within the regions, such as pipelines, highways and ports.

The Gulf Coast study area (Figure 1)* includes 48 contiguous coastal counties in four States, from Houston/Galveston, Texas, to Mobile, Alabama. This region is home to nearly 10 million people living in a range of urban and rural settings and contains critical transportation infrastructure that provides vital service to its constituent States and the Nation as a whole. It is also highly vulnerable to sea level rise and storm impacts. A variety of physical datasets were compiled for review and use by the project research team. Most of the spatial data was organized in geographic information system (GIS) formats or "layers" that can be used to assess the vulnerability and risks of the transportation infrastructure in the study area and inform the development of adaptation strategies. In cooperation with DOT's Bureau of Transportation Statistics we developed a GIS that allows us to overlay elevation, storm surge, census data, and other attributes of the study area with transportation infrastructure.

The Central Gulf Coast region is a low-lying sedimentary coast with low topographic relief; the great majority of the study area lies below 30 m (100 ft) in elevation (Figure 2). Much of the central Gulf Coast region is prone to flooding during heavy rainfall events, hurricanes, and lesser tropical storms. Land subsidence is a major factor in the region, particularly in the Galveston region and the Mississippi River deltaic plain. Subsidence is influenced by both landform characteristics of specific locations as well as by human activities, such as ground-water withdrawals. Most of the coastline is also highly vulnerable to erosion and wetland loss, particularly in association with tropical storms and passing storm fronts. It is estimated that 56,000 ha (217 mi^2) of land were lost in Louisiana during Hurricane Katrina. Further, many Gulf Coast barrier islands are retreating and diminishing in size. The Chandeleur Islands, which serve as a first line of defense for the New Orleans region, lost roughly 85 percent of their surface area during Hurricane Katrina. As barrier islands and mainland shorelines erode and submerge, human communities and onshore infrastructure in low-lying coastal areas become more susceptible to inundation and destruction.

The central Gulf Coast study area's transportation infrastructure is a robust network of multiple modes—critical both to the movement of passengers and goods within the region and to national and international transport with:

- 27,000 km (17,000 mi) of major highways—about 2 percent of the Nation's major highways—that carry 83.5 billion vehicle miles of travel annually.
- Pipelines, bulk terminals, and other infrastructure that receive and transport two-thirds of all U.S. oil imports. Pipelines traversing the region transport over 90 percent of domestic Outer Continental Shelf oil and gas. Approximately one-half of all the natural gas used in the United States passes through or by the Henry Hub gas distribution point in Louisiana.
- The largest concentration of public and private freight handling ports in the United States, measured on a tonnage basis, which handle around 40 percent of the Nation's waterborne tonnage. Four of the top five tonnage ports in the United States are located in the region.

* Figures 1–9 and tables 1–3 have been retained in committee files.

- The center of U.S. transcontinental trucking and rail routes with one of only four major points in the United States where railcars are exchanged between the dominant eastern and western railroads.
- The Nation's leading and third-leading inland waterway systems (the Mississippi River and the Gulf Intracoastal Waterway) based on tonnage and providing 20 States with access to the Gulf of Mexico.
- 61 publicly owned, public-use airports, including 11 commercial service facilities.

All of these transportation modes are vulnerable in some way to the changes in climate that are anticipated in this region during the next 50 to 100 years. The relative vulnerability of facilities is dependent, in large part, on elevation and distance from the coastline.

The Gulf Coast, like much of the world, has experienced significant changes in climate over the past century and is expected to change even more rapidly during the next century (IPCC, 2007). The four key climate drivers in the Central Gulf Coast region—rising temperatures, changing precipitation patterns, rising relative sea levels, and increasing storm intensity—present clear risks to existing infrastructure. These factors can be incorporated into decisions that enable communities to prepare for and adapt to changing climatic conditions. The research team's assessment of historical and potential future changes in these four variables draws on publications, analyses of instrumental records, and models that simulate how climate may change in the future.

Our assessment of the present climate and 20th century trends was built around climatic data from the United States Climate Division Datasets (CDD) and the United States Historical Climate Network (USHCN). Empirical trends and variability were analyzed for temperature and precipitation at the CDD level for the climate divisions along the Gulf Coast from Galveston, Texas, to Mobile, Alabama, including Texas Climate Division 8, Louisiana Divisions 6-9, Mississippi Division 10, and Alabama Division 8 (Figure 3).

Results from our analysis of temperature variability during 1905 to 2003 indicate that the 1920s or 1930s was generally the warmest decade for the various Gulf Coast climate divisions (Figure 3). After a step down in the temperature in the late 1950s, the coolest period occurs in the 1960s, while a warming trend is evident for all seven climate divisions beginning in the 1970s and extending through 2003. Of the seven climate divisions, LA6, LA8, and MS10 have slight but significant cooling trends over the 98-year period of record. Precipitation variability shows that the 1940s and 1990s were the wettest decades, while the 1950s was generally the driest (Figure 4). Although all of the climate divisions at least suggest long-term patterns of increasing rainfall, only MS10 and AL8 have significant trends.

A water balance model developed for the region suggests a long-term trend of increasing annual runoff (Figure 5). Over the entire record since 1919, there was an increase in rainfall that, combined with relatively cool temperatures, led to an estimated 36 percent increase in runoff. Modeled future water balance, however, suggests that runoff is expected to either decline slightly or remain relatively unchanged, depending upon the balance of precipitation and evaporation. Moisture deficits and drought appear likely to increase across the study area, though model results are mixed. These findings are consistent with the Intergovernmental Panel on Climate Change (IPCC, 2007), which concludes that it is very likely that heat waves, heat extremes, and heavy precipitation events over land will increase during this century and that the number of dry days (or spacing between rainfall events) will increase. Even in mid-latitude regions where mean precipitation is expected to decrease, precipitation intensity is expected to increase (IPCC, 2007).

Sea level has risen more than 120 m (395 ft) since the peak of the last ice age (about 20,000 B.P.) and over the 20th century by 1-2 mm/year (0.04-0.08 in/year). The rate of global sea level rise since 1963 is estimated at 1.8 mm/year (0.07 in/year) (IPCC, 2007). More recent analysis of satellite altimetry data for the period from 1993 to 2003 shows a global average rate of sea level rise of about 3.1 (2.4-3.8) mm per year (0.12 in/year). Whether the faster rate since 1993 reflects decadal variability or a long-term acceleration over the 20th century rate is unclear. There is high confidence, however, that the rate of observed sea level rise was greater in the 20th century compared to the 19th century (IPCC, 2007).

Changes in mean water level at a given coastal location are affected by a combination of changes in sea level in an ocean basin and by local factors such as land subsidence. Gulf Coastal Plain environments, particularly in the central and western parts of the Gulf Coast study area, are prone to high rates of land surface subsidence attributed to soil decomposition and compaction, deep fluid extraction, and the lack of sediment deposition. For example, the Mississippi River delta region

demonstrates relative sea level rates of 10 mm/year (0.40 in/year), five-fold greater than the 20th century rate of global sea level rise. Subsidence rates for several Gulf Coast sites by previous investigators range from a low of 0.27 cm/year (0.11 in/year) in the Big Bend region of northwest Florida up to 2.39 cm/year (0.94 in/year) for coastal Louisiana.

The scenarios of future climate referenced in our report were generated by the National Center for Atmospheric Research (NCAR), a research center lead by a consortium of universities and international organizations, by using an ensemble of 21 different atmosphere-ocean coupled general circulation models (GCM) for the Gulf Coast region. Model results, climatic trends during the past century, and climate theory all suggest that extrapolation of the 20th century temperature record would likely underestimate the range of change that could occur in the next few decades. While there is still considerable uncertainty about the rates of change that can be expected (Karl and Trenberth, 2003), there is a fairly strong consensus regarding the direction of change for most of the climate variables that affect transportation in the Gulf Coast region.

Climate models currently lack the detail needed to make confident projections or forecasts for a number of variables, especially on small scales, so plausible "scenarios" are often used to provide input to decision making (Parson et al., 2007). Output from an ensemble of 21 GCMs run with the three emissions scenarios indicate a wide range of possible changes in temperature and precipitation out to the year 2050. The models agree to a warmer Gulf Coast region of about 1.5 °C ± 1 °C (2.7 °F ± 1.8 °F), with the greatest increase in temperature occurring in the summer. Based on historical trends and model projections, we conclude that it is very likely that in the future the number of very hot days will substantially increase across the study area. Modeled outputs of potential temperature increase scenarios for August are presented in Table 1. Extreme high temperatures could be about 1°C (1.8 °F) greater than the change in the average temperature simulated by the GCMs.

Scenarios of future precipitation are more convoluted, with indications of increases or decreases by the various models, but the models lean slightly toward a decrease in annual rainfall across the Gulf Coast. However, by compounding changing seasonal precipitation with increasing temperatures, average runoff is likely to remain the same or decrease, while deficits (or droughts) are more likely to become more severe. Each of the climate model and emissions scenarios analyzed in our report represents plausible future regional conditions.

Increased tropical storm intensity is likely to accompany global warming as a function of higher sea surface temperatures, which have been observed globally (Webster et al., 2005; IPCC 2007). The kinetic energy of tropical storms and hurricanes is fueled from heat exchange over warm tropical waters. An increase in sea surface temperature (SST) from global climate change is likely to increase the probability of higher sustained winds per tropical storm circulation (Emanuel, 1987; Holland, 1997; Knutson et al., 1998). Sea surface temperature has increased significantly in the main hurricane development region of the North Atlantic during the past century (Bell et al., 2007) (Figure 6) as well as in the Gulf of Mexico (Smith and Reynolds, 2004) (Figure 7).

Recent empirical evidence suggests a trend towards more intense hurricanes formed in the North Atlantic Basin, and this trend is likely to intensify during the next century (IPCC, 2007). In the Gulf region, there is presently no compelling evidence to suggest that the number or paths of tropical storms have changed or are likely to change in the future.

Change in the rate of sea level rise is dependent on a host of interacting factors that are best evaluated on decadal to centennial time scales. Two complementary modeling approaches were applied in this study to assess the potential rise in sea level and coastal submergence over the next century. Both models were used to estimate relative sea level rise (RSLR) by 2050 and 2100 under a range of greenhouse gas emissions scenarios. Both models account for global sea level change as estimated by the global climate models and also incorporate values for land subsidence in the region based on the historical record. One model, CoastClim, produces results that are closer to a simple measure of future sea level change under the scenarios of future climate. A similar model, SLRRP, also incorporates values for high and low tidal variation attributed to astronomical and meteorological causes, which are pulled from the historical record. The SLRRP model is rectified to the NAVD88 (North American Vertical Datum of 1988) that is commonly used by surveyors to calculate the elevations of roads, bridges, levees, and other infrastructure. The tide data used in the SLRRP model is based on a monthly average of the mean high tide (called mean high water) for each day of the month (Table 2). The SLRRP results capture seasonal variability and interannual trends in relative sea level change, while the CoastClim results do not.

The three long-term tide gauge locations analyzed in this study represent three subregions of the study area: Galveston, Texas (the chenier plain); Grand Isle, Louisiana (the Mississippi River deltaic plain); and Pensacola, Florida (Mississippi/Alabama Sound) (Figure 8). For each of these gauges, we examined potential range of relative sea level rise through 2050 and 2100 using the SRES B1, A1B, A2, and A1FI emissions scenarios based on the combined output of 7 GCMs. Results for the year 2100 generated with CoastClim range from 24 cm (0.8 ft) in Pensacola to 167 cm (5.5 ft) in Grand Isle. Results for the year 2100 from SLRRP (Table 3), which as noted above accounts for historical tidal variation, indicate relative sea level rise in the range of 70 cm (2.3 ft, NAVD88) in Pensacola to 199 cm (6.5 ft, NAVD88) in Grand Isle.

Storm surge simulations accomplished basin-specific surge height predictions for a combination of storm categories, track speeds, and angled approach on landfall that can be summarized by worst-case conditions to exceed 6 to 9 m (20 to 30 ft) along the central Gulf Coast. Storm attributes and meteorological conditions at the time of actual landfall of any storm or hurricane will dictate actual surge heights. Transportation officials and planners within the defined study area can expect that transportation facilities and infrastructure at or below 9 m (30 ft) of elevation along the coast are subject to direct and indirect surge impacts. Sea level rise of 1 to 2 m (3 to 6 ft) along this coast could effectively raise the cautionary height of these surge predictions to 10 m (33 ft) or more by the end of the next century.

Changes in climate can have widespread effects on physical and biological systems of low-lying, sedimentary coasts. However, the large and growing pressures of development are responsible for most of the current stresses on Gulf Coast natural resources, which include: water quality and sediment pollution, increased flooding, loss of barrier islands and wetlands, and other factors that are altering the resilience of coastal ecosystems (U.S. Environmental Protection Agency, 1999). Human alterations to freshwater inflows through upstream dams and impoundments, dredging of natural rivers and engineered waterways, and flood-control levees also have affected the amount of sediment delivered to the Gulf coastal zone. Roughly 80 percent of U.S. coastal wetland losses have occurred in the Gulf Coast region since 1940, and predictions of future population growth portend increasing pressure on Gulf Coast communities and their environment. Sea level rise will generally increase marine transgression on coastal shorelines and the frequency of barrier island overwash during storms, with effects most severe in coastal systems that already are stressed and deteriorating. An increase in tropical storm intensity or a decrease in fresh water and sediment delivery to the coast would tend to amplify the effects of sea level rise on Gulf Coast landforms.

The global near-surface air temperature increase of the past 100 years is approaching levels not observed in the past several hundred years (IPCC, 2001). Regional "surprises" are increasingly possible in the complex, nonlinear Earth climate system (Groisman et al., 2004), which is characterized by thresholds in physical processes that are not completely understood or incorporated into climate model simulations; e.g., interactive chemistry, interactive land and ocean carbon emissions, etc. While there is still considerable uncertainty about the rates of change that can be expected (Karl and Trenberth, 2003), there is a fairly strong consensus regarding the direction of change for most of the climate variables that affect transportation in the Gulf Coast region. Key findings from our analysis and other published studies for the study region concerning future climate include:

Warming temperatures—All GCMs available from the IPCC (via the Coupled Model Intercomparison Project 3) used in this study indicate an increase in average annual Gulf Coast temperature through the end of this century. Based on GCM runs under three different emission scenarios developed by the IPCC Special Report on Emissions Scenarios (SRES) (the low-emissions B1, the high-emissions A2, and the mid-range A1B scenarios), the average temperature in the Gulf Coast region appears likely to increase by at least 1.5°C ± 1°C (2.7°F ± 1.8°F) during the next 50 years. Extreme high temperatures are also expected to increase—with the number of days above 32.2°C (90°F) very likely to increase significantly across the study area. Within 50 years the probability of experiencing 21 days a year with temperatures of 37.8°C (100°F) or above is greater than 50 percent (Figure 9).

Changes in precipitation patterns—Some analyses, including the GCM results from this study, indicate that average precipitation will increase in this region while others indicate a decline of average precipitation during the next 50 to 100 years. In either case, it is expected that average soil moisture could decline, due to increasing temperatures and resulting higher

evapotranspiration rates. While average annual rainfall may increase or decrease slightly, the intensity of individual rainfall events is likely to increase during the 21st century.

Rising Sea Levels—Relative sea level is likely to rise between 1 and 6 ft by the end of the 21st century, depending upon model assumption and geographic location. The highest rate of relative sea level rise will very likely be in the central and western parts of the study area (Louisiana and East Texas) where subsidence rates are highest (Table 3). Relative sea level rise (RSLR) is the combined effect of the projected increase in the volume of the world's oceans (eustatic sea level change), which results from increases in temperature and melting of ice, and the projected changes in land surface elevation at a given location due to subsidence of the land surface. The highest rate of relative sea level rise will very likely be in the central and western parts of the study area (Louisiana and East Texas), where subsidence rates are highest (Table 3). The analysis of a "middle range" of potential sea level rise of 0.6 to 1.2 meters (2 to 4 feet) indicates that a vast portion of the Gulf Coast from Houston to Mobile may be inundated over the next 50 to 100 years. The projected rate of relative sea level rise for the region is consistent with historical trends, other published region-specific analyses, and the IPCC 4th Assessment Report findings, which assumes no major changes in ice sheet dynamics.

Storm Activity—The destructive potential of hurricanes is likely to increase as the sea surface temperature of the Atlantic and Gulf of Mexico continue to rise. Rising relative sea level will exacerbate exposure to storm surge and flooding. Depending on the trajectory and scale of individual storms, facilities at or below 9 m (30 ft) could be subject to direct storm surge impacts. Rising relative sea level will exacerbate exposure to storm surge and flooding.

In the near term, the direction and scale of these modeled outcomes are consistent regardless of the assumptions used for level of greenhouse gas emissions. Model outputs are relatively similar across a range of IPCC SRES emission scenarios for the next four decades. However, long-range projections (modeled to 100 years) do vary depending upon emission scenario, with the magnitude of impacts indicated being more severe under higher-emission assumptions.

Based on findings from the USGS-led research team about the physical setting and climatic trends, a regional-scale characterization of impacts on transportation systems and infrastructure was led by the DOT. The following summary of potential impacts is presented in the Executive Summary of the report:

Warming temperatures may require changes in materials, maintenance, and operations. The combined effects of an increase in mean and extreme high temperatures across the study region are likely to affect the construction, maintenance, and operations of transportation infrastructure and vehicles. Higher temperatures may also suggest areas for materials and technology innovation to develop new, more heat-tolerant materials. Some types of infrastructure deteriorate more quickly at temperatures above 32.2°C (90°F). As the number of very hot days increases, different materials may be required. Further, restrictions on work crews may lengthen construction times. Rail lines may be affected by more frequent rail buckling due to an increase in daily high temperatures. Ports, maintenance facilities, and terminals are expected to require increased refrigeration and cooling. Finally, higher temperatures affect aircraft performance and the runway lengths that are required. However, advances in aircraft technology are expected to offset the potential effects of the temperature increases analyzed in this report, so that current runway lengths are likely to be sufficient. The effects of increases in average temperatures and in the number of very hot days will have to be addressed in designing and planning for vehicles, facilities, and operations.

Changes in precipitation patterns may increase short-term flooding. The analysis of future annual precipitation change based on results of climate model runs is inconclusive: some models indicate an increase in average precipitation and some indicate a decrease. In either case, the hotter climate may reduce soil moisture and average run-off, possibly necessitating changes in right-of-way land management. The potential of changes in heavy rainfall may have more significant consequences for transportation; more frequent extreme precipitation events may result in more frequent flooding, stressing the capacity of existing drainage systems. The potential of extreme rainfall events and more frequent and prolonged flooding may disrupt traffic management, increase highway incidents, and impact airline schedules—putting additional strain on a heavily used and increasingly congested system. Further, pro-

longed flooding—inundation in excess of one week—can damage pavement substructure.

Relative sea level rise may inundate existing infrastructure. To assess the impact of relative sea level rise (RSLR), the implications of rises equal to 61 cm and 122 cm (2 and 4 ft) were examined. As discussed above, actual RSLR may be higher or somewhat lower than these levels. Under these scenarios, substantial portions of the transportation infrastructure in the region are at risk: 27 percent of the major roads, 9 percent of the rail lines, and 72 percent of the ports are at or below 122 cm (4 ft) in elevation, although portions of the infrastructure are guarded by protective structures such as levees and dikes. While protective structures will continue to be an important strategy in the area, rising sea levels significantly increase the challenge to transportation managers in ensuring reliable transportation services. Inundation of even small segments of the intermodal system can render much larger portions impassable, disrupting connectivity and access to the wider transportation network.

Increased storm intensity may lead to greater service disruption and infrastructure damage. This study examined the potential for flooding and damage associated with storm surge levels of 5.5 m and 7.0 m (18 ft and 23 ft). These modeled outputs are comparable to potential surge levels during severe storms in the region: Simulated storm surge from model runs across the central Gulf Coast demonstrated a 6.7-to 7.3-m (22-to 24-ft) potential surge for major hurricanes. These levels may be conservative; surge levels during Hurricane Katrina (rated a Category 3 at landfall) exceeded these heights in some locations. The specific location and strength of storm surges are of course determined by the scale and trajectory of individual tropical storms, which are difficult to predict. However, substantial portions of the region's infrastructure are located at elevations below the thresholds examined, and recent storms have demonstrated that major hurricanes can produce flooding miles inland from the location of initial landfall. With storm surge at 7 m (23 ft), more than half of the area's major highways (64 percent of Interstates; 57 percent of arterials), almost half of the rail miles, 29 airports, and virtually all of the ports are subject to flooding.

Other damage due to severe storms is likely, as evidenced by the damage caused by Hurricanes Katrina and Rita in 2005. Damage from the force of storm surge, high winds, debris, and other effects of hurricanes can be catastrophic, depending on where a specific hurricane strikes. This studyI did not examine in detail these effects; the cumulative direct and indirect impacts of major storms need to be further analyzed. However, given the expectation of increasing intensity of hurricanes in the region, consideration should be given to designing new or replacement infrastructure to withstand more energy-intensive, high-category storms.

Mr. Chairman, thank you for the opportunity to present the findings of Phase I of the Gulf Coast study. I will be happy to answer any questions that you and other Members of the Committee may have.

The CHAIRMAN. Thank you very much.

Dr. Wallace, please.

STATEMENT OF TERRY WALLACE, PRINCIPAL ASSOCIATE DIRECTOR FOR SCIENCE, TECHNOLOGY AND ENGINEERING, LOS ALAMOS NATIONAL LABORATORY, LOS ALAMOS, NM

Mr. WALLACE. Good morning, Chairman Bingaman and distinguished members of the committee. It is an honor to be able to appear before you today to discuss the national energy infrastructure and its vulnerability to extreme weather events and climate change.

The United States energy infrastructure is extraordinary, both in the scale and complexity, and this vital network is susceptible to climate change through two phenomena which have already been outlined by other panelists; that is, the vulnerability to storms and the long-term climatic conditions.

I'd like to focus on a couple of specific examples to illustrate this. Carrying on the theme of Senator Craig, we do have an infrastructure which is quite aged. If we look at some of that infrastructure

and the challenges that it will face, particularly with climate change, we have some decisions which need to be made.

The National Laboratories developed infrastructure models to assess the vulnerabilities to domestic infrastructures, and these models are already in wide use within the Federal Government to improve our ability to prepare for and respond to natural disasters. But, let's look at the specific examples, maybe away from the coast, where some of the other panelist members will concentrate their testimony.

I'd like to take an example of California. Using climate science to predict the temperature rise in coastal California, we can evaluate the cascading effects on the electric grid and water availability. The midpoint prediction for a rising temperature in California by the year 2030 is on the order of 2 degrees Fahrenheit. Although this seems like a small number, it will have a dramatic impact. For example, the length of the season for what we call "heat-wave days" grows by about 30 percent, and, further, the demand for electricity will create rolling blackouts. If we put those together, we see that this will increase, by approximately 11 gigawatts, new power capacity that's required just to deal with the climatic changes. This is above and beyond the nearly 60 gigawatts that will be needed for projected growth to California's State economy.

Beyond these power needs, there is a connection to water. Meeting the increased power needs, if it's—for example, use coal—will require an additional 280 billion gallons of water per year. So, in this California scenario, even a slight temperature change will require maybe a 20-percent increase in new electrical energy capacity, have a dramatic impact on water resources, and together this will have a consequence on the California GDP on the order of $20 billion—or $200 billion by the year 2030.

A second example I'd like to show, which are illustrated over here, is, if we—the consequences of shifting to renewables; in particular, wind. There's a new wind study that's out today from EERE. Wind provides a clean, but intermittent, source of energy. If we consider an energy scenario where we want to see wind to grow to be 25 percent of the portfolio in the Western United States region, we can look at the consequence. Wind-generation capacity must be installed in geographic areas that are—where we have sustained wind resources. On this chart, you can see, those are concentrated in the Western United States, on the eastern slope of the Rockies. Getting to a goal of 25-percent wind generation requires an—adding something like 20,000 square miles of wind generation. However, this wind generation is far from the existing grid, and it will dramatically overload the existing grid as it carries power to our population centers. This is illustrated here. The dark blue lines show you where we will have transmission overloads. So, simply increasing the wind power is not sufficient to talk about what the climatic changes will have.

These scenarios illustrate that there are significant tradeoffs in the different choices we need to make when we look at a growing energy portfolio. Climate change provides a set of future constraints with measurable economic impacts. They nearly have as much impact on our energy choices as will our growing population over the next 30 years.

So, in conclusion, I just wanted to give a few of these examples where the National Laboratories are applying science to understanding important vulnerabilities and trying to provide choices or scenarios that public policymakers make when they choices for energy.

So, I thank you for this opportune for testifying, and I'm pleased to answer any questions you may have.

[The prepared statement of Mr. Wallace follows:]

PREPARED STATEMENT OF TERRY WALLACE, PRINCIPAL ASSOCIATE DIRECTOR FOR SCIENCE, TECHNOLOGY AND ENGINEERING, LOS ALAMOS NATIONAL LABORATORY, LOS ALAMOS, NM

INTRODUCTION

Good morning Chairman Bingaman, Ranking Member Domenici, and distinguished members of the Committee. It is an honor to appear before you today to discuss the national energy infrastructure and its vulnerability to extreme weather events and climate change. I will also discuss some of the tools in development at the Department of Energy's national laboratories to guide policymakers on these issues.

I am Terry Wallace, the Principal Associate Director for Science, Technology and Engineering at Los Alamos National Laboratory. Los Alamos' mission is to develop and apply science and technology to ensure the safety, security and reliability of the U.S. nuclear deterrent; reduce global threats; and solve other emerging national security challenges. No emerging challenge is greater than that of energy.

Energy is the cornerstone of our nation's prosperity and the global demand is extraordinary. If the rest of the world's population enjoyed the U.S. standard of living today, it would require an immediate six-fold increase in energy production. Within a generation, energy demand will more than double.[1] The speed of this growth, and its global scale, are unlike anything we have experienced. While energy use in the US will grow more modestly over this period, we are interconnected to global demand through our infrastructure. Our national security vulnerabilities are intimately tied to this infrastructure. In this testimony, I will focus on how we are using today's best science to create tools to understand and mitigate vulnerabilities to our energy infrastructure from increased energy demand and climate change.

THE NATION'S ENERGY INFRASTRUCTURE

The United States' energy infrastructure starts with the generation and delivery systems for our primary energy sources: electricity (dominated by coal and nuclear), liquid fuels (dominated by petroleum), and natural gas. There are 160,000 miles of electrical transmission lines connecting over 600 coal-fired plants and 65 nuclear plants, over 600 major sources of hydropower, and many smaller plants using renewable resources. The electrical backbone delivers power to consumers through 35,000 substations that ultimately reach 140,000,000 individual, commercial and industrial users. For petroleum, there are 180,000 miles of pipelines for oil and 300,000 miles for natural gas, supplying end users through a network of 150 refineries of liquid fuel, and through 1,900,000 miles of natural gas lines to consumers.[2]

However, the infrastructure is much more complex than just this backbone, and I will explore some of the ways that different elements are linked together and interdependent. Beyond the backbone, the energy infrastructure links directly to telecommunications, the banking system, public health, transportation, food, and manufacturing. Understanding the links helps us make better policy choices.

---

[1] Projections from the Energy Information Agency indicate a growth of 57% worldwide by 2030, or doubling in approximately 40 years. Scenario planning from LBL takes this as a lower limit, with an upper limit of 2.8% per year, or tripling in 40 years.

[2] http://www.eia.doe.gov/pub/oil—gas/natural—gas/analysis—publications/ngpipeline/index.html
http://www.referenceforbusiness.com/industries/Transportation-Communications-Utilities/Petroleum-Pipelines-Refined.html
http://www.colpipe.com/ab—main.asp
http://www.eia.doe.gov/basics/quickelectric.html
http://tonto.eia.doe.gov/ask/electricity—faqs.asp
http://www.whitehouse.gov/energy/National-Energy-Policy.pdf
http://www.gasfoundation.org/ResearchStudies/SafetyReport.pdf
http://www.eia.doe.gov/neic/quickfacts/quickoil.html

For example, electric power and water are linked. A 500 MWe coal-fired generating plant typically consumes 1.8 billion gallons of water per year. The use of this water impacts regional choices for farming, industrial, and residential use. The CO_2 emissions from such a plant will accelerate climate change, with both regional and global impacts on temperature. The availability of water will increasingly constrain economic growth. Changes in climate will affect where human populations grow or migrate. The changes in population create shifting demands, in turn, for energy and water, and these demands should guide the investments we are making today in our infrastructure. It is particularly urgent that we develop science-based tools now to inform these investments. While the timescale for climate change is long, today's energy choices will also be felt long into the future, because the lifetime of our capital investments in the energy backbone is more than 50 years.

Global climate change models have been developed with support by the DOE Office of Science, and several national laboratories play a strong role in this science, including Los Alamos. Climate change can lead to specific threats to our energy infrastructure, for example through flooding in coastal areas, and water shortages triggered by temperature rise and regional drought. These effects will be felt most acutely on our coasts, both because most of our population lives near the coast, and because many climate change impacts are concentrated at the coasts. This is illustrated in Fig. 1,* which shows the proximity of electrical lines and substations to flood-prone areas in Baltimore, and the network of electrical generation and transmission facilities near California, which rely directly on water (hydropower and coal).

FRAGILITY AND STORM VULNERABILITY

The national laboratories have developed infrastructure models to assess vulnerabilities in domestic infrastructures (to sudden events such as terrorist attacks or natural disasters). These models include best-in-class infrastructure data on US critical infrastructure sectors. They are already in wide-use by the federal government (such as the Department of Homeland Security's National Infrastructure Simulation and Analysis Center [NISAC],[3]) to improve our ability to prepare for and respond to natural disasters. The models allow predictions of where resources should be targeted to make the backbone more robust. They allow us to run scenarios that help train our emergency responders, and they help the government position disaster response resources at the locations where they can make the biggest difference.

For example, less than a month after Hurricane Katrina, infrastructure modeling was used to position emergency responders, telecommunications and power repair crews, and supplies in Florida prior to Hurricane Rita. This intensive modeling effort by NISAC from several national labs (including Los Alamos and Sandia), incorporated lessons learned from Katrina, and helped the nation bring back the critical energy and communications infrastructure in Florida within two weeks, with a dramatic benefit to the regional population and economy. Similarly, these scientific models today inform a wide range of national security simulations to help us prepare both homeland security professionals and our soldiers. This powerful set of tools for decision makers has been validated using detailed data for our infrastructure today, in all its complexity, and shown to have strong predictive value for natural disasters. The nation can benefit by extending these tools to more broadly inform our national energy policymakers.

ENERGY DEMAND AND CLIMATE CHANGE

Los Alamos researchers recently applied similar models in California and the 14-state western region to highlight the connections between power, water, and infrastructure planning. Using the best global climate science to bracket predictions of temperature rise in coastal California, we evaluated the cascading effects on the electric grid and water availability. The results were dramatic, and illustrated the need for state politicians to begin making changes in their near-term capital investment planning as a response.

The midpoint prediction for rising temperature in California in the year 2030 is between 2 degrees F (winter) and 4 degrees F using today's best climate models.[4] Although this may seem like a small number, looking at its impact on electricity demand, several key predictors of system failure for the electrical grid change dramatically in these scenarios. First, the length of the season for heat-wave days

* Figures 1–4 have been retained in committee files.

[3] http://www.dhs.gov/xabout/structure/gc—1197658542121.shtm

[4] Hayhoe et al, Proc. Natl. Acad. Sci 101, 12422–27 (2004).

grows from roughly 110 days to 140 days. Heat-wave days generate the largest short-term demand for air conditioning. Second, the need for rolling blackouts is triggered when average demand across a region crosses a threshold near the peak delivering capacity of the existing grid. The infrastructure models predict that by the year 2020, there will be 100 hours of rolling blackouts across more than 20 days, triggered primarily by overtaxed capacity in the Bay area, but with effects across the state (Fig. 2). The effects of climate change will trigger a need for approximately 11 GW of new power capacity, in addition to the 57 GW that will be needed from projected growth to the state economy based on current trends. Beyond the increased power needs, the connection to water will be acutely felt in the southwest through both reservoirs in the Sierras and through the Colorado river system. The climate impacts will result in decreases in Sierra snowpack of about 35%, and decreases of total reservoir inflow of about 10%. On the demand side, meeting the increased power need from coal sources would require an additional 280 billion gallons of water per year.

In other words, even modest climate change (2-4 degrees F) is expected to trigger a 20% change in the projected need for new electrical energy capacity, and a dramatic effect on water resources. Together, these effects point to a potential cost to the cumulative California gross state product (the value of all goods and services) of more than $200 billion by 2030. Because these effects will be felt within two decades, the planning for this increased capacity has already started. Luckily, the modeling identifies key failure points (such as those transmission lines in the San Jose-East Bay corridor), and also allows us to test different mitigation strategies, compared to the cost of taking no action. Most importantly, these tools allow policymakers to compare the inter-related impacts of simultaneous adoption of policies across the spectrum of conservation, new infrastructure construction by region and by technology, and the interplay of resources such as water and power. This provides a science-based framework for informing tradeoffs that must happen between different interests in policy discussions at state, regional, and national levels.

IMPACTS OF A PUSH FOR WIND

One of the strongest policy responses being adopted to address this need for new energy sources because of growth and climate change is to require the rapid scale-up of renewable resources such as wind energy. Actions are being taken at the state, regional, and national level to provide both financial incentives and regulatory requirements for utilities to increase wind energy. Wind provides a clean (but intermittent) source of energy, and in the West the water savings for implementing wind energy provide a substantial additional benefit. As one mitigation strategy, this infrastructure modeling approach was used to model the growth of wind energy to 25% of the western regional total. Because the wind generation capacity must be installed in geographic areas where there are sustained wind resources, this has substantial implications for today's electrical grid. Figure 3 shows the intensity of wind in the western region, which is concentrated across four Rocky Mountain states, plus California. Getting to the goal of 25% wind power requires wind generation across about 20,000 square miles (unlike solar panels, the land around wind farms can continue to be used for farming, ranching and resource exploration).

However, this generation capacity occurs far from the existing grid, and the resulting load in getting this power to where it is needed by the growing population centers across the West will result in transmission line overloads across a major portion of the western network (Fig. 4). Interestingly, if conventional power plants continue to be built near existing load requirements, there is much less impact on transmission lines.

Of course, where people live, especially in concentrated population centers such as Phoenix, has a profound influence on regional energy and water use. There is a large body of evidence documenting the effects of urban heat islands (such as Phoenix) in raising the average temperature, especially the nighttime low temperatures, over the entire geographical area of the city. In the case of Phoenix, the average daily low temperature is more than 10 degrees F higher, over an 800 square mile area, than the surrounding undeveloped areas. This has accelerated the use of energy for air conditioning, as well as water. According to a recent estimate, a rise of 5 degrees in the low nighttime temperature led to a 9% increase in residential water usage. This equates to more than 500 million gallons per month just from the effects of the urban heat island in Phoenix.[5] Similar effects are now occurring for Las Vegas and many other cities across the southern U.S. In this way, population growth not only concentrates the use of energy and water, it accelerates the pace

[5] Guhathakurta & Gober, J. Am. Planning Assoc. 73, 317–29 (2007).

of regional climate change in a way that provides positive feedback, or more rapid growth of consumption.

As these scenarios illustrate, there are tradeoffs involved in the different choices we might make to meet a growing energy need. Climate change provides a set of future constraints with quantitative economic impacts that can be bracketed with high confidence, even though there is substantial uncertainty in the range of outcomes. If we choose primarily coal-based power, we can quantify the impacts on water resources; if we choose renewable resources such as wind, we can quantify requirements for improvements in the transmission network. Growth of population centers couples strongly to both intensity of water and energy use, and the need for future infrastructure. Using today's predictive science modeling tools, we can give a balanced view of these tradeoffs to policymakers at a state, national, and global scale. Tomorrow's tools can be targeted to ask the right questions to strengthen our future infrastructure.

CONCLUSION

In summary, I have given just a small number of examples of how our national laboratories are working to apply science to understanding important vulnerabilities in our national infrastructure, and the interdependencies that impact public policy choices. These science-based modeling tools could, and should be much more widely applied in energy security, as we move rapidly into a future where our national security, economy, and lifestyle depend on how we prioritize investments to meet global climate and energy challenges.

Thank you for this opportunity to testify. I would be pleased to answer any questions you may have.

The CHAIRMAN. Thank you very much.

Senator Landrieu, when Mr. Falgout sat down, I went ahead and introduced him. Would you like to make any additional comments?

STATEMENT OF HON. MARY L. LANDRIEU, U.S. SENATOR FROM LOUISIANA

Senator LANDRIEU. I would just like to welcome Ted, who's been, just, a tremendous advocate for not only the expansion of Port Fourchon and energy infrastructure to bring to this Nation the oil and gas resources that we need to keep this Congress moving, but I think he's been a great advocate for the restoration of the coast.

I thank you, Ted, and look forward to your testimony.

I also want to say to Dr. Burkett, it's wonderful to see you, Virginia. She's served our State so well in the capacity of secretary of Wildlife and Fisheries, and is now serving the Nation in a broader capacity.

So, I want to welcome both witnesses with Louisiana roots.

Thank you.

The CHAIRMAN. Right.

Mr. Falgout, go right ahead.

STATEMENT OF TED FALGOUT, PORT DIRECTOR, PORT FOURCHON, LA

Mr. FALGOUT. Thank you, Senator Landrieu, Chairman Bingaman, committee members, for the opportunity to testify.

I'm going to focus my testimony on a former distributary of the Mississippi, the Bayou LaFourche Corridor, its uniqueness, its vulnerability, and why this rapidly eroding piece of real estate should be of great concern to all of us.

The Gulf's key energy support infrastructure is not widely distributed throughout the Gulf. Eighty percent of the oil and 87 percent of the natural gas comes from offshore Louisiana. Port Fourchon has evolved into the most significant energy support fa-

cility on the Gulf of Mexico. It services over 90 percent of the deepwater activity in the Gulf, 45 percent of the Shelf, and is the support base for LOOP, the Louisiana Offshore Oil Port, which handles 13 percent of the Nation's foreign oil. The pipeline infrastructure that connects the 50 percent of the United States refining capacity runs through our port. At the end of the day, this remote piece of real estate plays some key role in furnishing this country with 15 to 18 percent of its total oil supply, both foreign and domestic, as well as a significant part of its seafood production.

The LaFourche Corridor, as a result of being one of the most recent Mississippi River Delta lobes, less than 7,000 years old, is experiencing one of the highest rates of subsidence in the world; therefore, our relative sea-level rise is more than twice what other coastal areas are.

With much of the southern reach of this critical corridor barely above sea level today, the need for action is immediate if not addressed. The vulnerability of this Nation's energy security will increase greatly.

Unreliability plays a big part in today's record gas prices. A recent study determined that in 2006 over $63 billion worth of oil and gas was tied to this port. That was at $66-a-barrel oil. This year, it will exceed $100 billion. It's conservatively estimated that a 3-week loss in services from Port Fourchon would lead to a loss of almost $10 billion in sales, $2.9 billion in household earnings, 77,440 jobs nationwide, just a 3-week disruption. By the way, it would also include an additional 21.6-cents-per-gallon increase in gasoline prices nationwide. Without increased levee protection and infrastructure upgrades, we will simply be unable to sustain ourselves and what we provide to this Nation.

Our greatest vulnerability exists in the 17-mile stretch of Louisiana Highway 1, which connects the port to the hurricane-protection levee system inland. Only by elevating this highway will there be a reduction in the vulnerability of this critical piece of energy infrastructure. The good news is that we've not stood idly by complaining, we have amassed over $300 million, and are in construction. The bad news is, this is only enough money for half of the distance. So, in essence, we have half a bridge to energy security.

There are some very real, very critical components of our energy infrastructure that are at huge risk today. Every day we wait to address them, our vulnerabilities not only continue, but increase, as our coasts and our communities wash away.

Thanks for this opportunity.

[The prepared statement of Mr. Falgout follows:]

PREPARED STATEMENT OF TED FALGOUT, PORT DIRECTOR, PORT FOURCHON, LA

I am Ted Falgout, Port Director of Port Fourchon, Louisiana's southern-most Port sitting on the Gulf of Mexico.

I am going to focus my testimony on a former distributary of the Mississippi River, the Bayou Lafourche Corridor, its uniqueness, vulnerability and why this rapidly eroding piece of real estate should be of great concern to all of us.

As significant as the GOM is to this country's energy supply, one would think its energy support infrastructure would be distributed rather widely across the Gulf Coast. This is simply not so. 80% of the oil and 87% of the natural gas comes from offshore Louisiana. And due to the expansive wetlands and uniqueness of the Mis-

sissippi River delta building process, there are only 3 corridors in all of Louisiana that allow you highway access to the Gulf.

Port Fourchon has evolved into the most significant energy support facility on the GOM. It services over 90% of the deepwater activity in the Gulf, 45% of the shelf activity and is the support base for LOOP, the Louisiana Offshore Oil Port which handles 13% of the nation's foreign oil. The pipeline infrastructure that connects to 50% of the US refining capacity runs through our Port.

At the end of the day, this remote piece of real estate plays some key role in furnishing this country with 15-18% of its total oil supply, both foreign and domestic as well as a significant part of its seafood production.

I hope I have impressed you with the significance of this corridor, now let me get to the true purpose of this hearing, Impact of Climate Change on this obvious piece of critical energy infrastructure.

The Lafourche Corridor, as a result of being one of the most recent Miss. River delta lobes (less than 7,000 years old) is experiencing one of the highest rates of subsidence in the world. Therefore our relative sea level rise is more than twice that of most other coastal areas. With much of the southern reach of this critical corridor barely above sea level today, the need for action is immediate and if not addressed, the vulnerability of this nation's energy security will increase exponentially. A price already being factored in today's record gas prices.

A recent study by renowned economist Dr. Loren Scott, determined that in 2006, over $63 Billion worth of oil and gas was tied to this port. That was at $66 barrel oil! This year it will exceed $100 barrel of oil. He conservatively estimated a 3-week loss in services from Port Fourchon would lead to:

- A loss of almost $10 billion in sales at US firms
- A loss of $2.9 billion in household earnings
- A loss of 77,440 jobs in the nation

Just a 3 week disruption!!!

By the way, it would include an estimated 21.6 cents per gallon increase in gasoline prices nationwide.

Again, the chance of disruption is increasing daily as coastal land loss occurs. Without increased levee protection and infrastructure upgrades, we will simply be unable to sustain ourselves. Our greatest vulnerability exists in a 17 mile stretch of LA Highway 1 which connects the Port to the hurricane protection levee system inland. Only by elevating this highway, will there be a reduction in the vulnerability of this critical piece of energy infrastructure. The good news is that we have not stood idly by complaining. By agreeing to make this a toll road, selling 137 million in bonds, borrowing $66 million from the federal government, and with local, state and federal contributions, we have amassed over $300 million and are in construction. The bad news is, this is only enough money for half of the distance, so in essence we have half a bridge to energy security.

I hope in this testimony that I have been able to point out that there are some very real, very critical components of our energy infrastructure that are at huge risk today and every day we wait to address them, our vulnerabilities not only continue, but increase as our coast and communities wash away.

The CHAIRMAN. Thank you very much for your testimony.

Mr. Drevna, go right ahead.

STATEMENT OF CHARLES T. DREVNA, PRESIDENT, NATIONAL PETROCHEMICAL & REFINERS ASSOCIATION

Mr. DREVNA. Thank you, Chairman Bingaman and members of the committee. It's a pleasure to be back in front of you again today.

The safety and security of our employees, and our facilities, importantly—most importantly, our host communities, is paramount in our operations. We recognize, even more in the aftermaths of Hurricanes Katrina and Rita, the importance of this issue, and we appreciate the opportunity to discuss what the oil and gas community has done to further address the concerns over the past several years.

As Mr. Falgout has already said, if I may summarize what he said, the Gulf Coast is America's energy heartland. The region is

vital to America's ability to receive energy imports and refine oil domestically.

Meteorologists have questioned the relationship between the storm intensity and climate change, but, in this context, it's absolutely appropriate to discuss our efforts to protect infrastructure from the elements.

Katrina and Rita severely damaged the region's infrastructure and economy, to say nothing of the tragic loss of life and displacement of residents. The refining industry was not spared the effects, yet we responded quickly and effectively to the dangers and challenges posed by these storms.

Katrina damaged offshore energy production facilities that were critically important to receiving imported oil supplies; refineries and pipelines that served as the major providers of refined and crude products to large parts of the country, effectively removing, temporarily, 10-plus percent of our Nation's gasoline supply. In spite of this serious damage, no signature long-lived transportation fuel shortage occurred during this period.

The rapid return to service of major portions of the fuels industry may be attributed to two critical factors: quick action by the Federal Government to temporarily wave regulatory requirements, and release of crude oil from the SPR, as it is intended to be used; and, in addition, the effects of the dedicated employees of the oil and gas community, as well as the employers, who managed to return significant assets to service in a short timeframe. They deserve a lot of credit. Many facilities sheltered employees during the recovery process and provided supplemental housing allowances and loans to employees and their families.

Refiners have significantly enhanced their storm preparation procedures in the wake of Katrina and Rita. Gulf Coast refineries have performed process analyses of the time it takes to enact a full facility shutdown procedure, telling them how long it takes to drain the tanks of inventory to prevent leakage, or fill them with water to ensure buoyance, and thus, minimize damage to the tanks and its surroundings.

During the hurricane season, facilities monitor the projected path of the storms—the storm arc, so to speak—and react accordingly. Besides projected storm paths—because projected storm paths narrow as the storm moves closer to shore, facilities have different levels of reaction, depending upon how far the storm is out to sea. The process is based on the idea of a trip wire.

In 2006, NPRA published a valuable crisis planning and response guide, titled "Hurricane Security Operations" for security at refineries and petrochemical facilities, to synthesize and share experiences and insights of personnel in order to inform and approve our preparations for hurricane season. The paper addresses prehurricane planning and recovery operations, and will be updated periodically as we draw from the lessons of the past and improve upon our already impressive ability to get facilities back online and operating safely.

The refining community continues to evolve, and we will strive to face these complex challenges, but we need Congress's help to do so. By implementing sensible strategic policies, Congress can

help guarantee America a secure, reliable, predictable, and, just as importantly, geographically diverse supply of energy.

Necessary and prudent actions include the following: unlocking known reserves of domestic oil and gas resources, resisting the political temptation to manipulate market forces by imposing a harmful windfall profits tax or instituting price controls to address unsubstantiated price-gouging allegations, or repealing LIFO or eliminating foreign tax provisions. Please repeal the renewable fuels mandate, suspend the tariff on imported ethanol, and expedite permitting procedures for new refinery construction and facility refinery capacity additions.

In light of the concerns we've heard today with regard to the concentration of energy-producing complexes in the Gulf Coast, and by following the example of Louisiana, we could clearly diversity our energy resources. By doing so, we have steady access to our own domestic natural resources and also reduce our dependence on foreign imports.

Thank you very much for the opportunity to testify. I look forward to your questions.

[The prepared statement of Mr. Drevna follows:]

PREPARED STATEMENT OF CHARLES T. DREVNA, PRESIDENT, NATIONAL PETROCHEMICAL & REFINERS ASSOCIATION

Chairman Bingaman, Ranking Member Domenici, and members of the Committee, thank you for the opportunity to testify today regarding critical energy infrastructure in coastal regions.

NPRA, the National Petrochemical & Refiners Association, is a national trade association with nearly 500 members, including those who own and operate virtually all U.S. refining capacity and most U.S. petrochemical manufacturers. In addition to producing refined petroleum products such as gasoline, jet fuel, and home heating oil, our member companies provide consumers with a wide variety of products and services used daily in their homes and businesses—products used in making everything from plastics to clothing to medicine to computers.

Our member companies help keep our economy strong through the critical products they provide to American consumers, but also by providing tens of thousands of jobs across the country. The domestic refining industry currently employs more than 65,000 people[1] while supplying our nation with over 350 million gallons of motor gasoline per day, in addition to many other petroleum products.

There are currently 149 refineries operating in the United States. The total number of refineries has decreased by 50 percent over the past 25 years as smaller, less efficient refineries were closed for economic reasons. During that same time period, total refinery output has increased by more than 25 percent. In order to meet the growth in demand for our products, we have added the aggregate equivalent of one new world-class refinery per year for each of the last 15 years through expansion of existing facilities. Petroleum refining is the America's single largest source of energy products, supplying 39% of total U.S. energy demand and 97% of transportation fuels.[2]

Refining industry investments and reinvestments are also significant, and the domestic oil and natural gas sector's investments have actually exceeded earnings in recent years. During the period of 1992—2006, the oil and gas community invested $1.25 trillion dollars, compared with net income of $900 billion.[3] Many of these investments were made to expand refining capacity, and also to make our products and processes even safer, more efficient, and more environmentally friendly than they already are.

---

[1] U.S. Department of Energy—Energy Efficiency and Renewable Energy. Industrial Technologies Program—Petroleum Refining Industry of the Future http://www1.eere.energy.gov/industry/petroleum—refining/printable—versions/profile.html

[2] Ibid.

[3] "Investment and Other Uses of Cash Flow By The Oil Industry, 1992—2006," prepared by Ernst & Young LLP for the American Petroleum Institute.

THE SIGNIFICANCE OF THE GULF COAST

The Gulf Coast is America's energy heartland. According to the U.S. Energy Information Administration (EIA), the Gulf of Mexico, in 2005, produced 1.582 million barrels per day (mmb/d) of federal crude production, about 28.5 percent of the U.S. total crude production, and produced 10.4 billion cubic feet (bcf/d) of natural gas per day, 19.2 percent of the nation's total natural gas production. In addition to production, the Gulf Coast is also vital to America's ability to receive energy imports and refine oil domestically. In 2005, 60.4 percent of America's crude oil imports came through the Gulf Coast (more than 10 percent alone came in through the Louisiana Offshore Oil Port.) The region also contained 8.068 million barrels per day of refining capacity, 47.4 percent of the nation's total refining capacity.

HURRICANES KATRINA AND RITA IN 2005

On August 28, 2005, Hurricane Katrina swept across the Gulf Coast with tremendous impact. More than 1,800 people lost their lives, hundreds of thousands of people were displaced from their homes, and almost three million people lost access to electricity. Katrina was followed by Hurricane Rita on September 24, which also resulted in mass evacuations and significant damage. Both hurricanes severely damaged the region's infrastructure and economy. The refining industry was not spared the effects of these hurricanes, yet we responded quickly and effectively to the dangers and challenges posed by these storms.

According to the U.S. Mineral Management Service (MMS) report of September 2, 2005, 88.53 percent of Gulf crude oil production and 72.48 percent of its natural gas production was "shut-in" or temporarily offline. Hurricane Katrina damaged offshore energy production, facilities that were critically important to receiving imported oil supplies, refineries in the affected states and beyond, and pipelines that served as major providers of refined and crude products to large parts of the country. This damage effectively temporarily removed 10 percent of the nation's gasoline supply by its impact on refining capacity.

Ten refineries constituting 12 percent of America's total refining capacity (producing 2 mm/b/d) were directly affected by Hurricane Katrina and forced to temporarily suspend operations. Many other refineries, while not as badly damaged, were forced to reduce their operations as well.

The effects of Katrina were not limited to the Gulf Coast. Indeed, the widespread electricity outages caused by storm damage affected industry operations through the country. The most serious of these impacts was the temporary closure of three major pipelines:

1. The Colonial Pipeline, 5,500 miles of pipeline originating in Houston and ending in New York Harbor, which carries a daily average of 100 million gallons of gasoline, diesel and other petroleum products from refineries in the Gulf to customers in the Southeast and Eastern United States.
2. The Plantation Pipe Line, 3,100 miles of pipeline, which performs a similar function along a slightly different route, delivering a total of 620,000 barrels (26 million gallons) of refined petroleum products per day to Birmingham, Alabama; Atlanta, Georgia; Charlotte, North Carolina; and Washington, D.C., among other cities.
3. The Capline Pipeline, which carries 1.1 million b/d of crude oil to refineries in the Midwest where it is refined to produce gasoline, diesel and other petroleum products for distribution primarily in the Midwest. The effect of the closure of this pipeline was particularly dramatic, as much of the Midwest's refineries, responsible for 16 percent of America's refining capacity, were unable to secure crude oil supplies and thus unable to function at full capacity.

All three of these pipelines were completely or partially out of service due to the disruption of electricity supplies by Hurricane Katrina. As a result, the major supply lines of refined products to the Southern and Eastern states were unavailable for shipment in whole or in part during the initial period after the storm.

THE AFTERMATH

In spite of the serious damage these storms inflicted on the domestic refining industry, no significant, long-lived transportation fuel shortage occurred during this period. The rapid return to service of significant portions of the transportation fuels industry may be attributed to two critical factors: quick action by the federal government to temporarily waive regulatory requirements and release crude oil from the Strategic Petroleum Reserve; and the efforts of the dedicated employees of the

oil and gas community, as well as their employers, who managed to return significant assets to service in a short time.

Federal authorities took several decisive actions to help relieve the many energy-related problems left in the wake of Hurricane Katrina.

SPR Release

- The Administration released 9 million barrels of crude oil from the Strategic Petroleum Reserve (SPR) to assist refiners who were short crude supplies as a result of hurricane damage. The recipients used this crude to manufacture more gasoline, diesel, jet fuel and home heating oil to supply consumers across the nation. This is precisely the type of event meant to trigger SPR release and demonstrated the importance of careful SPR management.

Waivers to Increase Fuel Flexibility

- EPA provided temporary fuel waivers that made it easier to provide motor fuels to affected areas. This action pertained to both gasoline summer volatility and diesel sulfur specifications, and helped alleviate some of the supply problems in these areas by increasing the available supply of both domestic production and imports.

Jones Act Waiver

- The Department of Transportation temporarily lifted Jones Act requirements to allow non-U.S. flag vessels to transport much needed refined products from one U.S port to another.

IEA (International Energy Agency) Exchange

- IEA made available 60 million barrels of petroleum. This provided relief in the form of refined products (gasoline, diesel, jet fuel, home heating oil) which were much needed due to disrupted supplies from several refineries.

The refining industry also took several steps to recover from the shock of Hurricanes Katrina and Rita.

The safety of employees and their employees' families was the first priority. Many plants sheltered employees during the recovery process and provided supplemental housing allowances and loans to employees and their families. Indeed, many plants that were "shut-in" had employees live on-site for several weeks. The Valero Port Arthur plant housed over 1,000 of its workers while the plant was brought back on-line.[4]

The refining industry also temporarily expanded its workforce at affected plants, bringing in employees from unaffected plants as well as contractors. Restarting a plant is more complex and potentially dangerous than normal operations because it involves increased heat and pressure. Consequently, restarting a refinery requires additional workers to monitor and perform necessary procedures.[5] The restart process was particularly challenging for several plants because flooding ruined the electric pumps that sent crude oil throughout the refinery complex, and therefore had to be rebuilt before the plant could be restarted safely.[6]

In addition to bringing damaged plants on-line as soon as possible, the refining industry also worked to increase the output of its non-damaged plants in order to meet demand. For many plants, this meant delaying planned maintenance in order to continue production. Refineries typically perform scheduled maintenance throughout the year in order to maintain and repair their equipment, but in the wake of Hurricanes Katrina and Rita many refining plants delayed this planned maintenance so they could supplement reduced refining capacity.[7]

HURRICANE SECURITY OPERATIONS

There were numerous lessons learned by those in the industry directly or indirectly affected by the hurricanes. As one security manager said, "We hoped we were as prepared as possible, but as with any emergency, there are always going to be areas for improvement." Indeed, after Hurricane Katrina, many companies reported being better prepared for Hurricane Rita.

---

[4] Herrick, Thaddeus. "Restarting A Refinery Requires It To House Hundreds of Workers." Wall Street Journal. 11 October 2005.

[5] Ibid.

[6] Gold, Russell and Thaddeus Herrick. "Damage to Oil and Gas Facility Pushes US Closer To Energy Crisis." Wall Street Journal. 2 September 2005.

[7] Herrick, Thaddeus. "Refiners' Tough Call: Do Fall Maintenance Or Pump Flat-Out?" Wall Street Journal. 28 September 2005.

Following the 2005 hurricane season, NPRA published a white paper titled "Hurricane Security Operations" to synthesize and share the experiences and insights of security personnel in order to inform us and improve our preparations for the hurricane seasons to come. The paper is divided into two sections: pre-hurricane planning (which constitutes the major focus of the paper) and recovery operations.

The paper serves as a valuable crisis planning and response guide for security at refineries and petrochemical facilities in the event of a major hurricane or other natural or man-made disaster. It will be updated periodically as industry continues to learn the lessons of past crises and improve upon its already impressive ability to get facilities back on-line and operating safely.

NPRA is pleased to have made this paper available on line and free to the public on our website at http://www.npra.org/publications/general/Hurricane__Security__Operations.pdf.

CONTINUED SAFETY IMPROVEMENTS AT U.S. REFINERIES

U.S. refineries have made several changes in their storm preparation procedures in the wake of Hurricanes Katrina and Rita. Almost every refinery in the Gulf Coast has performed process analyses of the time it takes the facility to enact a full shutdown procedure, which tells them how long it takes to drain the tanks of inventory (to prevent leakage) or fill them with water (to ensure buoyancy and minimize damage to the tanks and surrounding equipment.) During hurricane season, the facilities monitor the projected path of the storm, the "storm arc" and react accordingly. Because projected storm paths narrow as the storm moves closer to shore, facilities have different levels of reaction depending on how far the storm is out to sea. The process is based on the idea of a trip wire—if it takes a plant 36 hours to empty its tanks of inventory and fill them with water, and if the plant is in the storm arc 36.5 hours out, shutdown procedures are enacted.

The safety record of American refineries continues to improve. The overall trend is for reduced recordable incidents and greater employee safety. NPRA's compilation of industry statistics shows that the rate of total recordable incidents has declined dramatically in the last two decades, and reached an all-time low last year.[8]

The refining industry's safety record compares favorably to other industries. According to the Department of Labor, private workplace total recordable incidents in 2006 averaged a rate of 4.4 total incidents, compared to the refining industry's 1.1 rate.[9]

PRICE FLUCTUATIONS

Two important factors must be kept in mind when examining the price of refined products: the cost of crude oil and competition.

The cost of crude is the single greatest driver of the petroleum product prices. In June of 2005, the U.S. Federal Trade Commission released a landmark study entitled: "Gasoline Price Changes: The Dynamic of Supply, Demand and Competition." This study determined that "worldwide supply, demand, and competition for crude oil are the most important factors in the national average price of gasoline in the U.S. and the "the world price of crude oil is the most important factor in the price of gasoline. Over the last 20 years, changes in crude oil prices have explained 85 percent of the changes in the price of gasoline in the U.S." Further, according to March 2008 EIA data, crude oil constitutes 72% of the price of a gallon of gasoline, taxes 13%, followed by refining and distribution and marketing, which both account for 8% respectively.[10]

Despite assertions that mergers have reduced competitiveness and led to an increase in fuel prices, the reality is that is that the U.S. refining industry is highly competitive. Fifty-four refining companies, hundreds of wholesale and marketing companies, and more than 165,000 retail outlets compete in the U.S. market. The largest U.S. refiner accounts for just 12% of America's refining capacity. No one company, or group of companies, sets gasoline prices. Rather, in the U.S. refining industry, the laws of supply and demand drive competitive behavior and determine pricing.

---

[8] NPRA Report Of Occupational Injuries And Illnesses For The Year 2007. Total recordable incidence rate is determined by Total Recordable Cases x 200,000 (base number of hours worked for 100 full time employees.)

[9] Department of Labor, Bureau of Labor Statistics. Workplace Injuries and Illnesses in 2006. October 16, 2007. http://www.bls.gov/iif/oshwc/osh/os/osnr0028.pdf

[10] EIA's "Gasoline and Diesel Fuel Update," March 2008, http://tonto.eia.gov/oog/info/gdu/gasdiesel.asp

NPRA and its members understand public and congressional concern regarding high gasoline prices. This is especially the case because refiners must purchase crude and therefore are the first to feel the pinch of high oil prices. Simply put, high crude prices translate into higher costs for refiners and the American consumer.

Policymakers, however, should be cautious about taking any action that suggests that price controls are the answer to today's gasoline market conditions. The nation's ten-year experiment with government intervention into the fuel market during the seventies led to gasoline shortages and long lines at gas stations. Consumers were prohibited from purchasing gasoline on certain days of the week. That history does not suggest that price controls would be an acceptable template for congressional action.

The most effective way to maintain adequate gasoline supplies at reasonable prices is continued reliance on market mechanisms, not price regulation or other actions that interfere with and distort market realities that both refiners and consumers must face.

A recent, but very compelling example of the need to rely on continued market mechanisms was the temporary price increase during the immediate aftermath of Hurricanes Katrina and Rita. These nationwide price increases moderated consumer demand, attracted increased refined product imports, and motivated unaffected U.S. refiners to augment their production. Without the price increase, there would have been little incentive to attract increased supply, and long-lived and widespread fuel shortages may have occurred. Instead, the market acted and moderated the price of gasoline and returned retail prices to pre-storm levels by the end of November 2005.

The Federal Trade Commission investigated charges of post-Katrina "price-gouging" and found "no evidence to suggest that refiners manipulated prices through any of these [illegal] means." Instead, it found that "refiners responded to market prices by trying to produce as much higher-valued products as possible, taking into account crude oil costs and physical characteristics." Although the prices increases might have been surprising and painful to many, they were a natural consequence of the widespread effects of Hurricane Katrina and helped mitigate demand in a supply-short environment.

The charge of "price-gouging" is not new to the refining industry. Dozens of investigations have been launched at the state and Federal levels and in each instance the industry has been cleared of charges of "price-gouging." Then, as now, allegations of price-fixing, price-gouging or other illegal practices are false.

CURRENT STATE OF THE DOMESTIC REFINING INDUSTRY

149 refineries are currently operating in the United States. These refineries, located in 33 states, have a combined capacity of over 17.4 million barrels per day (b/d).[11] Although a new, "green-field" refinery has not been built in the United States since 1976, America's operable refining capacity continues to expand. While there are several factors that contribute to the lack of new refineries—enormous capital costs, rising commodity costs, environmental regulations, and sustained community resistance—America's refining capability continues to grow. The domestic refining industry has increased capacity over the past thirteen years. U.S. refining capacity on January 1, 1994 stood at 15.0 million b/d and at 17.4 million b/d on January 1, 2007. This increase of 2.4 million b/d represents an aggregate growth of 16 percent or, in simpler terms, the addition of a large-scale (185,000 b/d) refinery each year.[12]

The Congressional Research Service reports that domestic refining margins in 2007 declined versus 2006 with several independent refiners experiencing significant losses in the fourth quarter of 2007. "New capacity investments in refineries, one possible source of gasoline price relief for consumers, are likely to be slowed by the poor profit performance of the refining sector. If new capacity does not come on line the need for imported gasoline will remain a key factor in avoiding shortages in the U.S. market."[13]

RECOMMENDED POLICY ACTIONS

The refining industry continues to evolve, and we will strive to face these complex challenges. Yet we need the help of Congress to do so. By implementing sensible,

[11] EIA, July 2007.

[12] EIA: the size of an average U.S. refinery on 1/1/07 was 117,000 b/d.

[13] Congressional Research Service. "Oil Industry Profit Review 2007," RL34437, April 4, 2008, p. CRS-8.

strategic policies, Congress can help guarantee America a secure, reliable and predictable supply of energy. Necessary and prudent actions include the following:

Increase supplies of domestic oil and gas resources

- Refineries and other important onshore facilities have been welcome in limited areas throughout the country, including the Gulf Coast. However, policymakers have restricted access to much-needed offshore oil and natural gas supplies in the eastern Gulf and off the shores of California and the East Coast. Congress should permit oil production in ANWR.
- These areas must follow the example of Louisiana and many other states in sharing their energy resources with the rest of the nation. In light of the concerns regarding the concentration of energy producing complexes along the Gulf Coast, it is becoming increasingly clear that we need to diversify our energy sources. By doing so we ensure steady access to our own natural resources, and also reduce our dependence on foreign imports.
- Simply put, this additional supply is sorely needed.

Repeal of the renewable fuels mandate

- here are serious questions whether to continue a mandate for increasing amounts of corn ethanol and biodiesel in the midst of a global food crisis.
- Recent studies have explained the negative impacts biofuels mandates are having on the environment
- USDA projects that corn production in 2008 will be 7.3% below the record level in 2007, while domestic ethanol plants will use 33% of this year's corn harvest. This "will keep the price of corn in record territory into 2009."[14] This will also contribute to higher costs for ethanol-blended gasoline.

Congress should suspend the tariff on imported ethanol

- Given the significant strain on our nation's fuel supply system associated with the dramatically increased ethanol mandate, Congress should suspend the tariff on imported ethanol in order to maximize the supply of renewable fuels. This is not a new position for NPRA; NPRA advocated this position in testimony before the Senate Commerce, Science, and Transportation Committee in May 2006, before the Senate Energy and Natural Resources Committee in February, and before the House Energy and Commerce Committee last week. Removing the tariff is critical to providing refiners more flexibility that will be desperately needed to comply with the newly expanded ethanol mandate.

Congress should preempt state biofuels mandates

- The present enthusiasm for renewable fuels has resulted in several states and even municipalities adopting local mandates. Local mandates will impose additional strain on the ethanol distribution system and increase costs for shipping and storage.
- The existing federal renewable fuels standard mandate with its credit-trading provisions contains a degree of freedom that allows the distribution system to operate at a low-cost optimum by avoiding infrastructure bottlenecks (such as lack of storage or rail capacity). Mandating biodiesel usage in specific areas forces a distribution pattern that is less flexible, and therefore has less capability to minimize costs.
- Further, these mandates create boutique markets requiring special fuel formulations and transportation logistics, thereby balkanizing the national fuel market. If Congress wishes to allow for as diverse a supply of alternative fuels as possible, and to promote as much flexibility in the system as possible, state and local biofuels mandates should be preempted.

Resist tinkering with market forces, including imposition of "windfall profits" taxes, LIFO repeal or elimination of foreign tax provisions

- Market interference that may initially be politically popular leads to market inefficiencies and unnecessary costs. Policymakers must resist turning the clock backwards to the failed policies of the past.

Experience with price constraints and allocation controls in the 1970s demonstrates the failure of price regulation, which adversely impacted both fuel supply and consumer cost. The state of Hawaii cancelled its less than one-year old gasoline price regulation because it led to higher prices and supply uncertainty. A windfall profits tax would discourage investment in refineries, which is needed to expand do-

[14] Kilman, Scott. "U.S. Corn Production Seen Dropping, Though More to be Used for Ethanol" Wall Street Journal 10 May 2008.

mestic production capacity and produce cleaner fuels. Such a tax would also place domestic upstream producers at a further disadvantage to state-owned oil companies, resulting in more, not less imports of foreign supplies. A recent Congressional Research Service report states that "[t]he combination of high crude oil prices that raised [independent refiners' and marketers'] costs and the inability to quickly pass cost increases on to consumers lowered refining margins, resulting in generally declining profits" in 2007.[15]

Review permitting procedures for new refinery construction and refinery capacity additions

- Seek ways to encourage state authorities to recognize the national interest in increased domestic refining capacity by reducing the time needed to permit expansions and other refinery projects.

CONCLUSION

NPRA, its members, and the entire oil and gas community are dedicated to working cooperatively at all levels to ensure an adequate supply of clean, reliable and affordable petroleum products for America. We stand ready and willing to work with Congress, and are committed to serving American consumers. I appreciate this opportunity to testify today and welcome your questions.

The CHAIRMAN. Thank you very much.

Ms. Edgar, why don't you go right ahead.

STATEMENT OF LISA POLAK EDGAR, COMMISSIONER, FLORIDA PUBLIC SERVICE COMMISSION, TALLAHASSEE, FL

Ms. EDGAR. Thank you. Good morning, Chairman Bingaman, committee members. Thank you, to Senator Martinez, for his introduction and for his support.

On behalf of Governor Charley Crist, I am so pleased to be here today and to share with you the impacts that severe storms have had on Florida's energy infrastructure, and the steps that we have taken to be better prepared.

The 2004 and 2005 hurricane seasons were the most destructive in Florida's history. In a 6-week period in 2004, Florida was hit by four major hurricanes. Charlie, Frances, and Jeanne overlapped in the central part of Florida. Hurricane Ivan crossed the northwest panhandle. The very next year, we had hurricanes Dennis, Katrina, Rita, and Wilma. Ranging in strength from category 2 to category 4, together these eight storms caused more than $25 billion in private property damage and over $2 billion in restoration costs for Florida's investor-owned electric utilities.

The widespread damage to Florida's electrical system provided strong evidence of its vulnerability to hurricanes and also dramatically illustrated how important it is to get the power back on. The sooner that businesses and schools can function, the sooner families and communities can have some normalcy and local economies can recover.

In response, the Florida Public Service Commission initiated a multifaceted approach to address future storm readiness and storm hardening, addressing both lessons learned by individual utilities and a more comprehensive statewide perspective to the grid. For each action, the Commission carefully balanced the need for a robust infrastructure with the need to minimize the rate impact for utility customers.

[15] Congressional Research Service. RL34437, "Oil Profit Industry Review 2007," April 4, 2008, summary.

Our approach includes an annual pre-hurricane-season preparedness briefing, inspection and replacement regime for wooden poles and other facilities, reliability reports, and a 10-point storm preparedness initiative.

Each Florida electric utility—investor-owned, municipal, and rural cooperatives—are required to present an annual hurricane preparedness briefing to the Commission. We just had our briefing for this year, and I am so pleased to be able to tell you that Florida's utilities are well prepared for the upcoming hurricane season.

In response to concerns in past storms that wooden utility poles had not adequately withstood hurricane winds, resulting in more downed lines, the Commission imposed a systematic pole inspection program. In addition, our 10-point plans address vegetation management, joint-use attachments, transmission inspection and hardening, GIS, data collection, and coordination with local governments. A detailed discussion of all of these initiatives is in my written testimony.

The Commission also adopted new rules in three areas: encouraging utilities to exceed minimum engineering standards in vulnerable coastal areas; storm hardening plans to enhance reliability, to reduce restoration costs and outage times, and to make adjustments as data and experience indicated; and also, more cost-effective undergrounding, where appropriate.

As a high-growth State, Florida is assessing generation options to meet future growth in demand. We're looking for reliable, cost-effective, and diverse sources. The PSC recently approved a need petition for two new nuclear units, and we have a request pending before us for two more additional units. Our experience showed little damage to nuclear and other generation facilities. Measures to harden transmission and distribution will benefit all communities.

Three points to end with. The first, and perhaps the most critical, is that we must maintain a high level of storm preparedness. All of us—government, utilities, citizens—must not become complacent after a quiet storm season. We know that intense storms will occur again, and we've learned firsthand that the rapid response of our utilities is critical to the safety of our people and to the recovery of our communities and our businesses. Second, strengthening our electric infrastructure will be an ongoing process. Third, the goal of hardening our electric infrastructure to improve reliability, to reduce storm damage, outages, and restoration time, must include cost-benefit data and analysis. Our customers deserve good financial value as we move forward.

Thank you for this opportunity.

[The prepared statement of Ms. Edgar follows:]

PREPARED STATEMENT OF LISA POLAK EDGAR, COMMISSIONER, FLORIDA PUBLIC SERVICE COMMISSION, TALLAHASSEE, FL

Good morning Chairman Bingaman and members. Thank you for the opportunity to speak before you today and thank you to Senator Martinez from Florida for his support.

On behalf of Governor Charlie Crist, it is my privilege to share with you our experience with the impacts severe storms can have on critical energy infrastructure and what Florida has done to be better prepared.

My name is Lisa Edgar. I am a commissioner on the Florida Public Service Commission, which regulates electric utilities. I was appointed to the Commission in

January, 2005, just after the unprecedented 2004 hurricane season and just in time for the numerous storms of 2005, and I served as Chairman in 2006 and 2007.

THE 2004-2005 HURRICANE SEASONS

The 2004 and 2005 hurricane seasons were the most destructive in Florida's history. During a six-week period, from August 13 through September 25, 2004, Florida suffered from the affects of an unprecedented four major hurricanes. The paths of Hurricanes Charley, Frances, and Jeanne overlapped in the central part of Florida. Hurricane Ivan crossed the northwestern panhandle. Ranging in strength from category 2 to category 4, together these four storms caused more than $17.5 billion in damages to private property (homes and businesses) and $1.3 billion in restoration costs for Florida's investor-owned electric utilities (distribution and transmission).

Similarly, in 2005, Hurricanes Dennis, Katrina, Rita, and Wilma caused over $7.2 billion in private property damage and approximately $1 billion in investor-owned electric utility restoration costs. The widespread damage to Florida's electrical system in 2004 and 2005 provided strong evidence of its vulnerability to a hurricane's fury. In the storms' aftermaths, clean-up and restoration of service was accomplished in record time and involved a peak work force of over 27,000 utility volunteers from as far away as California and Canada. This effort also dramatically illustrated how important it is to get the power back on—the sooner businesses and schools can function, the sooner families and communities can have some normalcy and local economies can recover.

COMMISSION'S MULTI-FACETED APPROACH TO STORM READINESS AND HARDENING

In January 2006, the Florida Public Service Commission initiated a multi-faceted approach to address future storm readiness and storm hardening beginning with a workshop to explore the lessons learned by all electric utilities during the past two hurricane seasons.

- Storm readiness includes the operational plans and procedures to make sure that utilities are prepared—in advance of each hurricane season—with adequate equipment and labor resources to quickly and efficiently restore service to their customers.
- Storm hardening means upgraded design and construction practices, as well as maintenance practices, so that electric facilities are better able to withstand high winds, storm surges, and flooding.

The Commission's multi-faceted approach to storm preparation includes several actions designed to provide a higher level of preparedness and hardening of the state's electric infrastructure. This approach addressed both lessons learned by individual utilities, and a more comprehensive, statewide perspective. For each action, the Commission carefully balanced the need for developing a robust transmission and distribution system with the need to moderate rate impacts to utility customers. The Commission's multi-faceted initiative includes:

Annual Pre-Hurricane Season Hurricane Preparedness Briefing

Each Florida electric utility—including investor-owned utilities, municipal electric utilities, and rural electric cooperatives—is required to present an annual Hurricane Preparedness Briefing at a Commission workshop prior to each hurricane season to gauge their storm readiness. Our briefing this year was held on May 1, and I am pleased to report Florida's utilities are well prepared for the upcoming hurricane season.

Inspections and Replacement of Wooden Poles

In response to concerns that wooden utility poles had not adequately withstood hurricane winds resulting in more downed lines, the Commission imposed a more thorough and systematic pole inspection program. The Commission required an eight-year wooden pole inspection process for all investor-owned electric utilities and local exchange telephone companies. Each company is required to file, by March 1, an annual inspection report.

Annual Distribution Service Reliability Reports

Each investor-owned utility is required to file, by March 1 of each year, a report summarizing its reliability performance data for the distribution services provided to customers. Report requirements include overall system reliability data, as well as storm-related impacts. The results of each utility's storm hardening activities are also to be included in their Annual Distribution Service Reliability Reports.

Ten Point Storm Preparedness Initiatives

On April 4, 2006, the Commission voted to require the investor-owned utilities to file plans and implementation costs for ten ongoing storm preparedness initiatives. After reviewing the plans, the Commission required each IOU to implement programs for each of the ten initiatives, which include:

- A three-year vegetation management cycle for all major distribution circuits.
- An audit of joint-use attachment agreements.
- A six-year transmission structure inspection program.
- Hardening of existing transmission structures.
- A transmission and distribution geographic information system.
- Post-storm data collection and forensic analysis.
- Collection of detailed outage data, differentiating between the reliability performance of overhead and underground systems.
- Increased utility coordination with local governments.
- Collaborative research—between the IOUs, municipals, and co-ops—on the effects of hurricane winds and storm surge.
- A natural disaster preparedness and recovery program.

A detailed discussion of each of the ten ongoing storm preparedness initiatives is contained in the Commission's Report to the Legislature on Enhancing the Reliability of Florida's Distribution and Transmission Grids During Extreme Weather, submitted in July 2007. A copy of this report* is attached as an exhibit to my testimony.

New Construction Standards

As part of the comprehensive storm preparedness initiative, the Commission adopted new rules encouraging investor-owned utilities to exceed minimum accepted engineering practices of the National Electrical Safety Code (NESC) for facilities in areas most vulnerable to the effects of hurricanes. The rule also directs maximum use of easements and road rights-of-way by requiring new and replacement distribution facilities where there is safe and efficient access for installation and maintenance.

Storm Hardening Plans

New rules were also adopted that require IOUs to file storm hardening plans every three years for review by the Commission. The objective is to enhance reliability while reducing restoration costs and outage times, and to make adjustments as data and experience indicate.

Undergrounding Initiatives

Recognizing that, in some situations, it could be appropriate to convert existing overhead electric distribution systems to underground, the Commission adopted new rules for cost-effective installation of underground utilities.

It is generally recognized that construction of underground electric distribution systems is more expensive than a comparable overhead system. Customers who request underground service are responsible for paying the difference between the cost of the underground project and the cost of a comparable overhead project. This cost difference, or contribution-in-aid-of-construction (CIAC), is often a barrier because it's expensive, and because the customer is required to pay the total amount upfront before construction begins.

The Commission amended its rules to:

- Require utilities to compare hardened overhead to hardened underground facilities to ensure comparable costs.
- Require utilities to include the cost differentials in long-term operating costs and benefits, including the costs and benefits of storm restoration in the CIAC.
- Share the costs of undergrounding of a specific location with all ratepayers if it will provide quantifiable benefits to customers outside the immediate area.
- Allow customers to pay the CIAC charges over time, through approved utility tariffs, to address the "sticker shock" often associated with the up-front costs of overhead to underground conversion projects.

Later this year, a new cost model being developed by Florida utilities and universities should be available to assist in the economic evaluation of future underground conversions.

---

*Report has been retained in committee files.

CONCLUSION

I will conclude with a couple of observations. The first, and perhaps the most critical, is that Florida must maintain a high level of storm preparedness, regardless of the level of activity of the most recent hurricane season. The utilities, and citizens, must not become complacent, after a quiet storm season. We know that intense storm seasons will occur again and we've learned first hand that the rapid response of our utilities is critical to the safety of our people and to the recovery of communities and businesses.

Second, strengthening Florida's electric infrastructure to better withstand storm impacts calls for a wide range of hardening activities that, in some cases, may take years to complete. Utilities have taken steps to harden critical infrastructure, such as hospitals and highway crossings, and more projects are planned for the future.

Third, the goal of strengthening the state's electric infrastructure to improve reliability, and reduce storm damage, outages, and restoration time, must incorporate cost benefit data and analysis. Customers deserve good financial value as we move forward.

Thank you again for the opportunity to share Florida's initiatives with this committee.

The CHAIRMAN. Thank you all very much for the excellent testimony.

Let me start—and we'll just do 5-minute rounds here on questions—let me start with you, Dr. Burkett. You talked about the Geological Survey's estimates, as I understand it, with regard to sea-level rise.

Ms. BURKETT. Yes, sir.

The CHAIRMAN. What is the estimate? I mean, is there a consensus as to what we need to expect in the Gulf, on the West Coast, on the East Coast, with regard to sea-level rise at particular periods in our future?

Ms. BURKETT. Yes, sir. The IPCC has this global estimate, but it, of course, depends, like Ted was saying, on the elevation of the land surface. In this particular region, in the Gulf Coast, the land surface is sinking and sea level is rising. In Louisiana, the sea-level rise is a centimeter per year. In the past 100 years, only about a fifth of that is due to global sea-level rise; the rest is sinking. But, in the future, as sea-level rise accelerates two-, three-, or fourfold, depending largely on what happens in the ice sheets, the sea—you know, the land will be submerged much more rapidly.

So, in the study area, between Mobile and Galveston, we had the low end of sea-level rise, which was more toward the Florida Panhandle, which was about 3 millimeters per year, and then you can double or triple that—basically, between 2 and 4 feet, we think, is plausible.

The CHAIRMAN. By what time?

Ms. BURKETT. 2050.

The CHAIRMAN. By 2050. Two——

Ms. BURKETT. Because that includes——

The CHAIRMAN. Two to four feet sea-level rise, and this is——

Ms. BURKETT. Relative sea-level rise, which includes the changes in the land surface.

The CHAIRMAN. Is this in Alabama—Senator Sessions' State—you're talking about, or where is this?

Ms. BURKETT. There are parts—well, it varies from one part of the coast to the other because of the geology. It's a little slower—the rate of sea-level rise is a little slower in the Mobile area compared to south Louisiana, because of the leveeing of the river and the other things that have happened there. In Galveston, the rate

is also higher than it is in Mobile, because of groundwater withdrawals.

The CHAIRMAN. Okay. To what extent is the projected increase in sea level being factored into decisions about location of infrastructure, either public infrastructure or private infrastructure?

Ms. Edgar, is this something that you folks factor in when you give permits to put in new plants or put in new transmission facilities? Do you factor in what's expected to happen to the sea level?

Ms. EDGAR. Certainly. Our Department of Environmental Protection, that would do much of the analysis of the siting issues, would look at future conditions and environmental impacts, and impacts to those communities. Certainly, we have found, with the siting of generation facilities in particular, that the buffer areas that are required provide a good level of protection.

The CHAIRMAN. Okay.

Let me ask Dr. Wilbanks and Dr. Wallace, both, Is it your impression that the Federal Government—I mean, I know both of you work for laboratories that are contracted with the Department of Energy, but is this kind of a expected change being integrated into our planning in the future for Federal facilities and Federal infrastructure?

Mr. WILBANKS. There is growing interest in looking at risks and vulnerabilities that can be addressed at fairly low cost. For example, the Department of Defense has a program that is now starting to look at climate-change implications for military installations in vulnerable areas, where it may be possible, for example, in an area that might be subject to sea-level rise and storms in coastal areas, to assure that new construction is built so that it can handle sea-level rise and storm effects, so that the building stock that's in use 20 or 30 years from now will be much more resilient to that then the building stock that's in place right now. So, there is that kind of thinking ahead that is beginning, but impact and adaptation actions are still at a fairly early stage in this country, compared with attention to mitigation.

The CHAIRMAN. Dr. Wallace, did you have a point of view on this?

Mr. WALLACE. I think that there originally was a program to look at national infrastructure that was an EERE in DOE, and it moved to the Department of Homeland Security. Los Alamos and Sandia, in particular, have a joint program called NISAC to look at infrastructure, and it allows a powerful set of modeling tools in which you can do various scenarios. So, there is a lot of scenario- planning around looking at things like sea-level change. It's not necessarily climatic changes, but, as referenced in Dr. Burkett'—it could be subsidence, it could be what you would expect from a national disaster, should you remove a levee. So, there actually is quite a bit of scenario- planning to look at this. Again, in the end, you still have to make decisions about how you want to invest or not invest, and those aren't the decisions that the technical side actually does, but do give the tradeoffs and also the economic impacts.

The CHAIRMAN. Okay. That's—my time's up.

Senator Craig.

Senator CRAIG. Mr. Chairman, where do we start? I've spent a lot of time, as have you, looking at predictions, projections, modeling as it relates to climate change and impact, rate of sea rise, and all of that. While I express concern about it, I'm as interested in making decisions that are a part of large investment schemes that bring about infrastructure in a way that obviously reflects that, and does so to sustain itself in the future.

You know, living in Idaho, there was always a standard joke about California, when it came, not to climate change, Mr. Chairman, but to earthquakes, that owning property in Idaho was really a pretty good prospect, because ultimately it would become oceanfront property. We now might have to adjust that a bit.

But, while that might be standard humor, certainly looking for higher ground, if you will, in part, is a reality that we ought to be concerned about. When it comes to the low-lying lands of the Gulf Coast and Louisiana, we've got some real problems, and I think you've spelled that out most clearly today, as it relates to what's there now and its capacity and its capability based on any given scenario.

Let me, though, go back to the Pacific Northwest. Possibly you, Dr. Wilbanks, could respond to this. We believe, in the Pacific Northwest this year, we had record snowfall. In many areas of the Pacific Northwest, we recorded the highest snowfall ever in the history of recorded snowfall; not just in total fall, but in actual accumulation at a given point in time. So, it was predicted that we would have substantial runoff for the hydro systems of the Pacific Northwest this year. The runoff isn't coming. It is interesting that the combination of cooler temperatures and warmer days at times—and we were predicting substantial flood scenarios in key areas that had historically had flood scenarios; they are not materializing, as we speak. In fact, some large reservoir systems are now predicting that they will barely fill, when they had expected to "fill and spill."

Are you working with the Department of Energy and the Interior—as it relates to how we look at these water scenarios and how we look at additional capacity in system, as it relates to times of runoff and different kinds of combinations that would impact the hydro system? Certainly, the Bonneville Power Administration was looking at what appeared to be an ample water season, which may now not materialize.

Mr. WILBANKS. I can offer a few comments on that, Senator. It's a very interesting point.

First of all, one of the limitations of climate-change projections is that they tend to focus on averages, not on variability. One of the things we know about nature is that there's a great deal of variability in nature, and it's often the extremes that are the problems, not the averages. So, there's a challenge there in answering questions like this with the existing science.

A second thing is that nature still has the capacity to surprise us, and that ought to make us all humble who think we know the answers to most nature society questions. The climate-change projections that are available to us right now all say that, in the long run, snowfall in the western mountains will decline, on the average. That doesn't mean in every season, but, on the average, they

will decline, which means that meltwater into the dry river basins of the West will decline, on the average. It suggests that, by, say, the last quarter of the century in the Columbia River Basin, there will be less water to go around to meet the needs for agriculture, for energy, and for urban development.

A group at the University of Washington led by Ed Miles is doing a lot of research on regional climate-change implications for the Northwest. He suggests that by the year 2050 or shortly thereafter, the Pacific Northwest will need affordable desalination of seawater to meet needs for water for continued urban development on the Pacific West—the Northwest Coast of the United States So, there are challenges there. We're looking at—we don't know all the answers yet, but the point you're making about surprises is an important one for us to remember.

Senator CRAIG. My time is running out. Let me just offer this as a concern. When we talked about the new study that's out, proposing a—wind energy capacity going up 20 percent of portfolio, it also suggested the need of a $20 billion worth of infrastructure upgrades in transmission to handle that, because wind oftentimes isn't where the current transmission is. You've got to connect it, and oftentimes you have to transport it even further than is current. I look at those combinations, that's a bit of a hurdle.

Thank you all.

The CHAIRMAN. Senator Landrieu.

Senator LANDRIEU. Thank you.

I'd like to start with just showing some graphs, if I could, some charts that I think might put some of this in perspective.

If you could hold up the—this is the toe of the boot, I guess. If Louisiana is shaped like a boot, this is the toe of the boot, and, just to orient the committee members, this is Port Fourchon. Tom, if you could point to that. That's Port Fourchon, right there.

Now, it's just a spit of land—I guess, 100 miles or so down that bayou. The bayou's about 100 miles—Ted, right?—from LaFourche. But you can see that—I mean, it's a—you can't see the road there, but the—Highway 1 starts there and goes all the way up. Actually, does the highway already run to Canada, all the way up to—we don't know. We think it might go all the way up through the country.

Mr. FALGOUT. It's called "the longest street in the world."

Senator LANDRIEU. But, it starts there. It's two lanes, and it basically sits at sea level now. We have been trying to get the Federal Government and the State of Louisiana to recognize the significance of this particular road to connect Port Fourchon, which 20 percent or 25 percent of the energy of the country comes through—if this small little port is shut down, it has huge impacts, as has been outlined.

Mr. Chairman, for the life of me, I can't understand how the country can invest in, you know, "The Big Dig" in Boston and other—you know, in projects, and not realize that lifting this particular road, either with general-fund dollars, which is one option, but the other option that we've provided, which makes a lot of sense, is using a portion of the taxes generated by the industry that uses this port—not additional taxes, but the revenues, which is what revenue-sharing was all about.

The other thing that this graph shows is—the red is the potential—or real land loss that's occurring. We are—have a project—Tom, if you'd point to Morganza, to the Gulf—to protect some of this infrastructure. This is Homer, right here. We're trying to get a levee built right here, and we have, now, several lawsuits pending and some problems with—although the Congress has taken action to build this levee, we've been trying to get this done for 40 years, and it's just one thing after another.

Now, I want to put up the next poster to show you where the infrastructure is, because—the next one, not this one—well, actually, no, this one is the right one. I wish I could do this talking into the mic. But, the R's are where the refineries are, and you'll notice the big refineries are not on the coast, they're up, because they know to move away from the coast for protection. So, they're not on the beach, is what I'm trying to explain. We don't build refineries on the beach. But, we're building them where they need to be. The Mississippi River is that blue line, blue, swirly line. They have to be with a source of water. You have to be by a source of water to build a refinery. So, the industry is doing a pretty good job of siting their refineries where they need to be.

The little F's are other infrastructure that is defined as, sort of, other petrochemical infrastructure. But, as you can see, this is the infrastructure necessary to move oil and gas. These are pipelines. They only exist beneath Louisiana, Texas, and Mississippi. This—there's nothing like this off the coast of Florida or in the West or on the East Coast or on the West Coast. This is the infrastructure that is laid down.

Now, we have two choices. We can protect this, or we can move it. Both are expensive, but I'd suggest protecting it is less expensive than moving it, because, first, there's no other place in the country you can move it to, and the resources are here. If you put wind out in the—if you put wind out in the West, you're going to have to have an infrastructure grid that sort of looks like this. These are pipelines and facilities that can transport—generate and transport the energy.

I want to show you what this supports. This infrastructure supports this distribution system in the country. This is the gas distribution system for the Nation, and it basically comes out of Louisiana. So, that infrastructure that I just showed you supports the distribution of gas that comes all around. The only other trunk even close to the trunk that we have is, you can see, from Canada, is a large amount of gas coming from Canada. The other part of it comes from here.

So, I just want to conclude, not by a question, but just saying, Mr. Chairman, when Dr. Burkett, who's studied this her whole life, says that between Mobile and Galveston we're predicting a 2- to 4-foot sea rise, basically because of subsidence of our land and, of course, the rising temperature of the water, that this is a—truly an emergency right now, and that is why Senator Sessions and others of us are trying to lead this effort on America's energy coast to explain that it's not just for the people of Alabama, Mississippi, and Louisiana that this is a problem for, it's a problem for the whole country.

So, in conclusion, spending a little bit of money to build levees, to raise these highways, to do smart siting of these facilities is going to save us billions of dollars in the long run, and we believe that we're generating the funding right now to do that, which is what revenue-sharing and coastal impact assistance was all about.

In my final minute, I'd just like Ted to add a word or two.

Mr. FALGOUT. I guess a logical question would be, Why not move Port Fourchon further inland, where the refineries are, and not have to protect the coast? That is not what Port Fourchon does. Port Fourchon is the intermodal hub where everything changes modes of transportation, and that has to be on the Gulf of Mexico for the most efficient transportation system that's out there.

If you move Port Fourchon inland 30 or 40 miles, that means 270 large vessels a day that go to this port, bringing these widgets and gadgets back, have to do this 30- or 40-mile stretch further inland, burning more fossil fuels, causing more erosion, doing huge environmental impact. We have to sustain a place on the Gulf of Mexico to do this transfer, and this is your best option.

The CHAIRMAN. Senator Sessions?

Senator SESSIONS. Thank you, Mr. Chairman.

Ms. Burkett, you used the figure "2- to 4-feet sea rise," and some of that is land subsidence. How much do you estimate to be actual sea rise and how much is the sinking on this land?

Ms. BURKETT. The percentage, of course, varies. In Louisiana, the percentage of—that is due to the land sinking is greater than it is in Alabama. In my testimony, we have a table that actually breaks out the amount that is due to sea-level rise versus subsidence. In the Alabama Mississippi Sound area, the subsidence—Mississippi Alabama Sound is .34 millimeters per year. So, the sea-level rise there is much greater, 2.14. So, most of the change in the Alabama coast is due to the sea-level-rise factor, as opposed to the sinking. It's just the opposite in Louisiana and Galveston.

Senator SESSIONS. Mr.—it's Drevna, I believe; is that right?

Mr. DREVNA. Yes, sir.

Senator SESSIONS. Yes. You know, I think a lot of work was done to get those refineries back on after Hurricane Katrina delivered that direct hit on, I guess, our energy coast, but it didn't seem like it was very fast to me and the people in our area whose prices were up and whose shortages existed. Post-Katrina, has the oil and gas industry, including pipelines and refineries—have they learned lessons that could allow their facilities to be hardened? Are there redundant supplies of pipe or other equipment that could be utilized to promptly bring this back online? Finally, what economic interest is there for the oil and gas industry to spend considerable sums of money in merely trying to bring the system back up online quickly?

Mr. DREVNA. Senator, I understand the frustration, back in the summer of—late—early fall of 2005, but if you look at it—if you look at it from the total devastation that your area of the country experienced, but, in relative terms, I think the—again, the oil and gas and refining industry—petrochemical and the electric utility industry—we all—we were all together for those 2 or 3 weeks, working very diligently on getting those facilities back up online. If you look at—if you look at it from the total impact to when we got ev-

erything back online, it—I would just, sort of, disagree with you, Senator, it was a relatively short period of time. Yes, it was a——

Senator SESSIONS. How——

Mr. DREVNA [continuing]. Frustrating——

Senator SESSIONS. How long?

Mr. DREVNA. We were back up within 3 to 4 weeks, in most cases. Now, there were—I know that the one—the one refinery in your State that was—the Pascagoula refinery, that facility was under 5, 6 feet of water for a long time, so that took a heck of a lot longer to get back online.

Senator SESSIONS. I agree that Hurricane Katrina, which almost couldn't have been a more perfect storm——

Mr. DREVNA. Right.

Senator SESSIONS [continuing]. To hit the energy sector—it wasn't the biggest and strongest; it was a category 3, as I recall, and Camille was category 5—but the very nature of the configuration of that storm——

Mr. DREVNA. Right.

Senator SESSIONS [continuing]. The way it moved slowly and pushed so much water, was very——

Mr. DREVNA. Right.

Senator SESSIONS [continuing]. Aberrational and devastating. But, I guess my inquiry would be, What are you going to do about that? Are you—do we need better berms? Can we put better dikes up around the refineries? Can we take other steps to—and utilizing the lesson of Katrina to more quickly recover?

Mr. DREVNA. Senator, we—as I mentioned in my oral remarks and as in my—in the written testimony, we do have a May 2006 publication, "Hurricane Security Operations," and it identifies six critical elements that should be provided in any emergency response plan. It's an emergency management team, it's facility security, logistics, communications, personnel, government and community relations. It's all these things that have to be taken into account and worked together.

I think it's—you should also—we should also understand that refineries and petrochemical facilities, especially along the Gulf—we've been dealing with hurricanes for decades, but you said "the perfect storm," and that—and, unfortunately, that's what Katrina, and then, 2 weeks, followed up by Rita, was—were.

But, I would like to go back and comment, if I may, on Senator Landrieu's point. You know, we have a—we have a group called the Homeland Security Department, and we're diligently working in establishing regulations to protect our refineries and the petrochemical facilities and other critical infrastructure against terrorism, but I think, as Senator Landrieu points out so clearly and so poignantly, it doesn't make a difference, if we don't protect it from Mother Nature. You know, as critical as that area of the country is in providing the whole—the whole country with energy, with those BTUs that keep our economy going, to cavalierly say, "Well, we're going to have an Energy Independence and Security Act of 2007 that doesn't address anything like that"——

Senator SESSIONS Well——

Mr. DREVNA. Now——

Senator SESSIONS [continuing]. My time's up, but I just would follow up on that. That's exactly the point I was raising. Some of this may need to be funded by taxpayers, some of it needs to be funded by the industry. We—the industry funds its protection against terrorism attacks, fundamentally, and——

Mr. DREVNA. That——

Senator SESSIONS [continuing]. So, maybe we need to be asking what kind of standards we need for our critical oil and gas facilities and electric generating facilities in the light of storms. I don't know—the data I have shows that in—since 1900, we haven't seen, based on the mean data, an increase in hurricanes, but there's enough of 'em—too many, far as I'm concerned—and they're will always be, I assume, hurricanes in the future. Whether it's global warming or not, we've got threats from hurricanes, and hopefully we can do better.

Madam Chairman, thank you—

Senator LANDRIEU [presiding]. Yes. Thank you.

Senator SESSIONS [continuing]. For your interest in this subject. Your knowledge of it is valuable to us in this discussion.

Senator LANDRIEU. Thank you.

Senator Salazar.

Senator SALAZAR. Thank you very much, to Chairman Bingaman, for this hearing, and to you, Senator Landrieu, for your leadership on so many issues in the Gulf Coast and on energy.

Let me ask a question to you, Dr. Burkett. You know, I hear you giving us the ominous statistic, which is 2 feet to 4 feet, in terms of the change of the sea level caused by subsidence and also the sea rise. When you look back at the statistic that Senator Landrieu spoke about, which is, over the last 50 years you've seen, I think she said, Louisiana losing 34 square miles a year—34 square miles a year—when you look back at those 50 years, and you look at both of these factors—sea rise, as well as subsidence—how does that compare to looking ahead at the next 50 years?

Ms. BURKETT. The past 100 years, about a fifth of the change in elevation was due to sea-level rise. But, you know, sea level is supposed to accelerate—they call it "latent sea-level rise" in the IPCC report—because it takes the ocean a long time to absorb the thermal energy, the heat energy from the atmosphere, and for the glaciers to retreat. So, the rate of sea-level rise is expected to accelerate, this century. We haven't seen an acceleration yet, even though, during the past 15 years, the rate of sea-level rise is double what it was over last century. But, we don't have a long enough record yet to attribute that to human activity. It might just be natural variability, hopefully. But, we may already be seeing that initiation of the acceleration that would change it from being one-fifth of the cause to being one-half or more of the cause, and largely dependent on——

Senator SALAZAR. How——

Ms. BURKETT [continuing]. Ice sheets.

Senator SALAZAR. Dr. Burkett, how confident are you and your scientific peers of this 2-foot to 4-foot rise by the year 2050? Is it a consensus within the scientific community that this is going to happen?

Ms. BURKETT. We use IPCC models, that were used for the fourth assessment report, to—as input into the sea-level rise, so the sea-level rise, coupled with the actual records that we have of the sinking of the land——

Senator SALAZAR. Okay.

Ms. BURKETT [continuing]. Using tide gauges, the IPCC says they're—you know, they have a high degree of confidence associated with——

Senator SALAZAR. Do you——

Ms. BURKETT [continuing]. Their numbers.

Senator SALAZAR. Do you have a high degree of confidence? Is it going——

Ms. BURKETT. Yes.

Senator SALAZAR [continuing]. To happen?

Ms. BURKETT. We use their numbers.

Senator SALAZAR. So, you believe that it is going to happen, that we're going to have this 2- to 4-foot rise——

Ms. BURKETT. I'd say it——

Senator SALAZAR [continuing]. By 2050.

Ms. BURKETT. Yes, sir, it's likely, but by 2100. That's——

Senator SALAZAR. Okay. So, that—then, you would probably conclude, and most people would be a part of your effort, that, then, we should be doing something about this, whether it's hardening the infrastructure, taking other kinds of actions to deal with this issue. It's a reality. It's coming.

Ms. BURKETT. Yes.

Senator SALAZAR. We should be dealing with it.

Let me ask Dr. Wallace a question. You may pipe into this one, Dr. Burkett, as well. This is not about the coast, but it is related to climate change. You know, for us, in the West, water is the lifeblood of our communities, as we often say. For me, in Colorado, I have great concerns about what happens with the Colorado River and what happens with the ski industry and our agriculture that depends on irrigation from those rivers. Do you have some thoughts, from the Los Alamos perspective, or, Dr. Burkett, you, as the head of geo-survey, climate-change experts, on what's going to happen with respect to global warming and the flow of waters into the Colorado River Basin?

Mr. WALLACE. It's a good question, because I think the—our understanding of global warming, there is a consensus about the—a global rise. But, as Dr. Wilbanks referred to before, you have variability within that, and the grand challenge that stands before us from energy and climate today is to scale that to a regional level. So, we can do a pretty darn good job of understanding what's going to happen in a global sense, but how it—there's winners and losers in climate change, and our climate in New Mexico and Colorado is largely controlled by what happens with what's called the ENSO or the El Nino/La Nina effects. There isn't consensus, to be perfectly honest, with the rise in global temperature, exactly how that will affect La Nina or El Nino. Some models today are suggesting that you will actually get increased rainfall in the Southwest, and presumably, increased snowfall in the Rockies. Other models show that you will have a drought, which may rival the Great Drought of between 1000 and 1200 A.D. in the West, and which changed

civilization there. We just don't know yet. We need to do a lot more modeling, and we realize this is very complicated system.

The fact of the matter is, there'll be a significant change, but the grand challenge is for us to be able to develop the science and the models to take this to small regional scale.

Senator SALAZAR. Dr. Burkett, if you could answer that question, too, in terms of the regionalization of understanding the issue——

Ms. BURKETT. Yes.

Senator SALAZAR [continuing]. Of global warming, down to that kind of basic——

Ms. BURKETT. Right.

Senator SALAZAR [continuing]. Level——

Ms. BURKETT. In general, we expect to see less snow at low altitudes. In addition, we—because of the temperature of these—the expansion of the spring, warming earlier in the year, the timing of runoff to reservoirs will change. If you couple the declining snowfall at low altitudes with the increasing temperature, the propensity for drought in your region is highlighted.

I am an author of a IPCC special report on water that will come out. It was just approved by the governments, the U.N. member governments. I'm going to send you a copy of that. We focus on your region. Also, I want to send you a copy of some output that we're working on now for a report that'll come out from the Climate Change Science Program very shortly, that looks at your region, and I think it'll answer your—a lot of your questions.

But, the regional modeling is where a lot of activity needs to be focused so we can get real definite answers——

Senator SALAZAR. I look forward——

Ms. BURKETT [continuing]. To you.

Senator SALAZAR [continuing]. To receiving and reviewing those reports, Dr. Burkett, and thank you for your good work.

Senator LANDRIEU. Thank you, Senator.

Senator Murkowski.

Senator MURKOWSKI. Thank you, Madam Chairman. I want to thank you. Thank you for your leadership on energy issues. I think you have—you have proven yourself as you talk about the Gulf States, you talk about the development and, just, the production that comes out of your region, and, in terms of an individual that is constantly reminding us all about the energy breadbasket down in the Gulf and how the State of Louisiana, in particular, has for years been supplying this Nation, and, in many cases, not asking for much in return, maybe a little respect, maybe a little funding coming down.

But, the trip that we were able to take when you took me down there to Port Fourchon, we had an opportunity to meet with you, Mr. Falgout, to understand and see firsthand what goes on—it's one thing to look at those charts and see the little spider web of infrastructure there, it's another thing to be flying over, for a long period of time, and looking down—reminds me of Alaska; it's really wet, and——

Senator LANDRIEU. Big.

Senator MURKOWSKI [continuing]. It's huge. So, I appreciate, again, your leadership on this, and an opportunity to talk about what happens to this very, very critical infrastructure.

Now, Alaska wasn't part of this discussion. Our issues are a little bit different up there. But, when we take into account how, really, we have so much of our energy infrastructure concentrated in one area, down there in the Gulf, there's a level of vulnerability. When we're talking about whether—how we protect it from Mother Nature, it is a very dicey issue. We're looking at erosion issues, where we've got communities up north that are literally falling into the Arctic Ocean, into the Bering Sea, and we see how much it's going to cost to move a small village. To move the infrastructure that is literally powering this country will be phenomenally expensive.

So, I guess the question that I throw out to you—it's one thing to provide for protection of existing infrastructure—is there anything out there, in terms of innovative technologies, that you're looking at within the industry that could provide for greater protection?

The example that I'll use up north, when we knew we had to deal with permafrost, we just didn't lay a pipe on the tundra, we had to elevate it, because you couldn't have the warm pipe on the frozen permafrost; you had the ability to move it, or have it be flexible in the event of earthquakes; so, you build in that type of technology. Directional drilling has allowed us to do remarkable things up north without disturbing the surface.

Is there anything that you see, in terms of technology within the industry, that can provide for greater security, greater protection? That's just kind of a general question to you all.

Mr. Falgout and Mr. Drevna.

Mr. FALGOUT. We have a lot of tools in our chest for coastal restoration. Certainly, we have one of the greatest resources sitting there, the Mississippi River, for sediment. But, you have to transport that sediment. It's unrealistic to cut the levees and let everything flood again and try to rebuild the delta. That'll take 1,000 years anyway. So, long-distance distribution of sediment through pipelines and through dredging operations in the Mississippi River, taking that sediment and placing it through the estuary, trying to rebuild the skeleton, at least, of the system to where then, over the longer term, you can start to build onto the skeleton, built meat, so to say, in the estuaries, and bring—to build the friction, to break the storms, to do the things necessary—all of that costs billions of dollars to do. But, certainly when we look at the resources that are out there, what is—you know, what is coming through Coastal Louisiana, I think it just makes sense to approach it in that manner. Then, certainly Senator Landrieu has, you know, overwhelming experience in seeing some of these things. We are starting with the offshore revenue-sharing money, the State has committed 100 percent of it, through a constitutional amendment, to be used for coastal restoration and infrastructure protection. So, we're getting there, but, you know, some of our—we say, you know, we're at ground zero—and what we say, we're at zero ground, actually—down at Port Fourchon.

[Laughter.]

Mr. FALGOUT. You know, some of this is immediate need. If—unless we develop a mechanism to mitigate some of these immediate energy issues, we may not just be able to sustain the ability to do what we do.

Senator MURKOWSKI. Mr. Drevna.

Mr. DREVNA. Senator Murkowski, just to go back to the comment I made before, about Senator Landrieu's charts, absolutely we had the technology to prevent—or, to minimize the damage and—in the critical infrastructure—and, you know—and, of course, we should, naturally, protect what we have and what's there and now, but we also have the technology to be able to expand our horizons, so to speak, and not put all our eggs in one energy basket, as we've done in this country for the past 35 years.

You know, if you only go back, again, a couple of summers ago, in reference—Katrina and Rita—you know, huge offshore platforms were actually toppled over, not one iota of environmental damage. We've learned a lot over the past 25, 30, 35 years. We can effectively and with a very, very, very limited or no environmental footprint, bring resources from the East Coast, the eastern Gulf, the West Coast, and your fair State of Alaska. For some reason, we decide we'd rather tell foreign countries to send more to us, but then tell 'them not to send more to us, and keep our own resources locked up. So, I think what we need is an energy basket that is for everyone, that is for all resources, whether it's coal, nuke, oil and gas, biofuels done in the right way, not trying to create winners and losers or create a false market, but, yes, the long answer to your question, we have the technology available to provide the American citizens with the BTUs they need.

Senator MURKOWSKI. Thank you.

Thank you, Madam Chair.

Senator LANDRIEU. Thank you.

We're going to have a vote called in a few minutes, but I do have a couple of more questions. If the members—Senator Sessions has another question.

But, before I do, a statement. I had the staff calculate that if Katrina and Rita happened again just like it did 3 years ago—it'll be the 3-year mark in August 29 for Katrina, and September 24 for Rita—based on the current price of gasoline today, as it was relative 3 years ago, gas would go to $6.10 a gallon.

Now, we don't know if Katrina is going to hit again, but it could. Hurricane season starts in June. Based on what happened to the price of gas the last time it hit, not factoring in anything else, gas will go to $6.10.

Now, we can't prevent that storm, but we could be taking steps, as following up with what Mr. Drevna said, as to have alternatives. If the Gulf had to shut down, you could open the East Coast or the West Coast, or you could bring in more from Canada, or you could do something. But, right now we're basically sitting ducks, because there is no other place to go to get the capacity. We don't have redundancy in the system. I'm going to say it over and over again. We're happy to continue to do what we can do in the Gulf. We can harden our assets. We want to bring in more energy. We have the capacity to do it. But, that is, in itself, not even enough. We need redundancy.

The example that is most clear, and it's easy for the Gulf to understand—we have two major shipyards in the Gulf where we're building ships: Avondale, in New Orleans, and Gulfport, in Mississippi. Gulfport was completely destroyed. We completely stopped

shipbuilding in Gulfport. But, luckily, Avondale was still standing, and so, you could move your shipbuilding capacity to Avondale until you could get Gulfport back up online.

We don't have that redundancy in the energy—so, if the Gulf shuts down, I can just tell the country, "We told you so."

The only final thing I'll say about it is, had Rita hit Houston the way Katrina hit South Louisiana, I don't know, Mr. Drevna, what would—what would you say? You're closer to it than anybody else at this panel. What would—what are some of the things that you all talked about, had Rita hit Houston and——

Mr. DREVNA. Senator——

Senator LANDRIEU [continuing]. Shut down the Houston ship channel?

Mr. DREVNA [continuing]. We were literally scared to death about the path of Rita. I mean, not that Rita was—not that some facilities, unfortunately, did not dodge that bullet, but the—if it would have hit as projected earlier on, you would have had—you would have had, you know, Katrina-squared, as far as impact. I don't know—honest to goodness, I don't know what the country would have done. I mean, we—I mean, there's only so much more you can bring in from imports. I don't—you know, it was—it would have been—it would have been a real national disaster.

Senator LANDRIEU. Okay. So, let's just factor that into the hearing, not that we can prevent hurricanes, but we could build redundancy into this system, we could be doing some things to protect the assets, and we could be using the revenues that are coming into this country more wisely; i.e.—Senator Sessions, I'll get to you in a minute—but, the revenues generated from the industry, just in the Gulf, are about $10 billion a year. Ten billion just in taxes paid by the current industry. None of that money right now is going to protect this infrastructure. It's all basically going into the general fund to be spent on general operational expenses of this Nation. If some of it was returning, which was what we accomplished in revenue-sharing, but it's perspective, we could be building some of these levees, you know, hardening some of these assets, and protecting ourselves from the shock that will occur if another monster storm hits the Gulf.

Senator Sessions, you had another question, then I think we'll call it a wrap.

Senator SESSIONS. Thank you.

When you say "in revenue," you don't mean jobs and salaries and—but, you mean just the tax revenue—Government——

Senator LANDRIEU. Just the tax——

Senator SESSIONS [continuing]. To the Government of the United States from this production.

Senator LANDRIEU. Just one form of tax revenue. It's the severance and royalties. I'm not even counting the income taxes that people are paying, or the corporate taxes that——

Senator SESSIONS. Those that are——

Senator LANDRIEU [continuing]. Are going to——

Senator SESSIONS [continuing]. Making good salaries.

Senator LANDRIEU. That's in addition. So, it's $10 billion just from revenue—from severance and royalties, basically.

Senator SESSIONS. I couldn't agree more. I'm convinced.

Mr. Drevna, I agree with you, that—what is it that makes us say it's perfectly all right to pay for oil produced off the coast of Nigeria or in the Persian Gulf or in the Caspian Sea or in the North Sea, but we won't allow any of it to be produced off our shore? If we really care about the environment—and T. Boone Pickens, I saw an article where he said, "Our purchase of oil abroad"—he estimated $600 billion a year, maybe, next year; other estimates are about $500 billion—represent the greatest wealth transfer in the history of the world. If anybody thinks that's not affecting our economy, if anybody thinks that's not driving up the average person's gas price, they're from another planet.

That's what people are talking to me about. They're talking about gas prices. They're not telling me they want a cap-and-trade bill that's going to drive up the cost of gas, according to EPA, $1.50 a gallon, and according to the National Association of Manufacturers, about $5 a gallon, depending on how you estimate it. But, I'm just saying, these are really important issues. This infrastructure in the Gulf is critical to our Nation, and we did open up, 2 years ago—under Senator Landrieu and Senator Domenici's leadership, we were able to open up some more potential production in the Gulf, but large parts of it are closed.

I'm—Dr. Burkett, you—I'm trying to get this straight, because if we're talking about—2 to 4 feet in change in water makes me nervous, and just by 2050. But, I think the numbers you gave me, in my homemade mathematics here, show that we're talking about two-point—is it millimeter—2.4—2.14 millimeter rise—yes, millimeters per year.

Ms. BURKETT. Right.

Senator SESSIONS. You add the subsidence in my area, of .34, which is less than 2.5—I multiply that out to say, by 2050, considering both of those factors, we're talking about less—around an inch a year, in common—an inch by 2050. Would you disagree with that number?

Ms. BURKETT. Putting together the—that's the historical trend. The 2.14 there is the historical trend. That's the sinking of the tide gauge, basically, relative—well, that's—that is the actual tide-gauge record there. Basically, we have three long-term tide-gauge records, and you can see them——

Senator SESSIONS. So, you would expect it to increase.

Ms. BURKETT. Yes, sir. We expect it to accelerate.

Senator SESSIONS. How much do you—how much, just from the sea rise, not subsidence? Hopefully, the subsidence won't increase—

Ms. BURKETT. No, sir. We——

Senator SESSIONS [continuing]. But it could, I suppose.

Ms. BURKETT [continuing]. Expect that to be steady, the rate of subsidence to just continue. But then, looking—and you can look at the——

Senator SESSIONS. What would you estimate, then, using——

Ms. BURKETT. On the low end, on your part of the coast, off of—off the Alabama coast—now, Mobile—you know, Mobile has a higher rate of subsidence than does this general average for the area. So, depending even on the—in the Alabama coast where you are, the rate of relative sea-level rise will be greater. In the Upper Mo-

bile Bay area, for example, the land is sinking, so it would be higher there. So, it depends upon where you are.

Senator SESSIONS. Why is that happening?

Ms. BURKETT. Due to human activity.

Senator SESSIONS. We're not producing any significant oil and gas in the upper part of the bay——

Ms. BURKETT. No, sir, but——

Senator SESSIONS [continuing]. To my knowledge.

Ms. BURKETT [continuing]. There are groundwater withdrawals. I'd have to look exactly what the——

Senator SESSIONS. Okay.

Ms. BURKETT [continuing]. Causes are, but there are other factors that are—you have a slightly higher rate in the Northern Mobile Bay——

Senator SESSIONS. Anyway, do you know what the Gulf Coast—regarding subsidence, the actual sea-level rise is projected to be?

Ms. BURKETT. The sea-level rise alone there, you're looking at, basically, the global average, 0.6 meters—0.6 meters, and a meter is 3 feet—over a 100-year period.

Senator SESSIONS. Okay. So, 0.6 meters, and that's about 18 inches, right? That's over 100 years, not by 2050. So, you're saying 100 years, which would be 2106, is 18 inches from the sea increase, and by 2050 you would agree that it would probably be much less than that.

Ms. BURKETT. Right. The actual——

Senator SESSIONS. I just want to be sure——

Ms. BURKETT [continuing]. Estimates——

Senator SESSIONS [continuing]. I'm not having everybody selling their beachfront property and——

Ms. BURKETT. No, sir.

Senator SESSIONS [continuing]. Moving to Ohio or something—

[Laughter.]

Senator SESSIONS [continuing]. Because I'm not sure it's that dramatic. I hope it's not.

Ms. BURKETT. The low end was 1 foot, the high end was 6 foot. For the purposes of this study, we selected 2 to 4 feet as being the range at which we would assess the impacts on transportation infrastructure. So, the low end—you're right in your calculations—would be about 1 foot, and the high end would be as high as 6 feet. Those are conservative, though, because——

Senator SESSIONS. Now you're going conservative. You're going to high and low and—but, Okay.

Ms. BURKETT. Because they don't assume any changes in ice-sheet dynamics.

Senator SESSIONS. All right. I understand, and I'm with you. thank you, Madam Chairman.

Senator LANDRIEU. We're going to wrap up with this. It—I wanted to ask one final question, Ms. Edgar. This—watching the destruction of Katrina and Rita on the electricity grid—you talked about that in your testimony—it occurred to me that we, after every storm season, put those poles back up, try to cut the trees a little more, and every season they go down again and everybody's electricity goes off. Is there any better way to do that? Is—are burying these lines possible, both from a cost-effective manner

and—what do other countries do with their electricity grid distribution that are either in high-wind areas or high-storm areas?

Ms. EDGAR. Senator, thank you for the question. One of the things that we have tried to do is look at the different geographical variations across our State. Certainly undergrounding in some areas does make sense. It is, as we realize, often more expensive, but trying to look at those long-term community benefits and trying to assess where those costs and benefits will be is one of the things that our State has been looking at. We have made some regulatory changes to try to make undergrounding more cost- effective, where, indeed, it does look like it would have long-term benefits.

Senator LANDRIEU. Okay.

Is there anything anyone wants to add, on the panel, that you don't feel——

Mr. Drevna.

Mr. DREVNA. Senator, if you don't mind, I'd just like to respond to your—again, to your earlier comment about, you know, the infrastructure, where we should get the money from.

I think it's—you know, I mean, with some trepidation, I bring this up, but, what the heck—you know, there's been a lot about oil industry profits these days, and if—I don't think the American public knows, and maybe a lot of us in this room don't know, that one company who has made $40 billion last year, their taxes were $60 billion. So, they paid more in taxes than profits. They still employed high-paying jobs that had ripple effects on all towns across the country, as did the whole industry. So, I think there's a story to be told there, that, you know, there—are the resources available out there to fix the problem? Absolutely. It's just the direction of where those resources go. I applaud you, and I urge you to continue to fight to get those resources where they belong.

Senator LANDRIEU. Okay. Thank you very much.

I want to thank the staff for putting a good hearing together, and thank all of our panelists.

The meeting is adjourned.

[Whereupon, at 11:17 a.m., the hearing was adjourned.]

APPENDIX

RESPONSES TO ADDITIONAL QUESTIONS

RESPONSES OF CHARLES T. DREVNA TO QUESTIONS FROM SENATOR BINGAMAN

Question 1. In light of all the changes that petroleum refiners have had to implement to prepare for hazardous weather, such as the hurricanes that occur in the Gulf Coast area, do you feel that the infrastructure is sufficiently 'reinforced' against future extreme weather and other possible impacts brought on by climate change?

Answer. U.S. petroleum refiners have made several significant changes in how they prepare for and react to hazardous weather.µ Almost every refinery in the Gulf Coast has performed process analyses of the time it takes the facility to enact a full shutdown procedure, which tells them how long it takes to drain the tanks of inventory (to prevent leakage) or fill them with water (to ensure buoyancy and minimize damage to the tanks and surrounding equipment.) During hurricane season, the facilities monitor the projected path of the storm, the "storm arc" and react accordingly. Because projected storm paths narrow as the storm moves closer to shore, facilities have different levels of reaction depending on how far the storm is out to sea. The process is based on the idea of a trip wire—if it takes a plant 36 hours to empty its tanks of inventory and fill them with water, and if the plant is in the storm arc 36.5 hours out, shutdown procedures are enacted.

There are additional ways to assist refiners in preparing for extreme weather events that may occur in the future. Congress could signal that investments in energy infrastructure are a national priority with tax incentives. The National Petroleum Council—an advisory group to the U.S. Department of Energy—recently reported that oil and gas will be critical to meeting the global energy needs over the next quarter century. Congress should resist efforts to single out the oil and gas industry with repeal of the Section 199 manufacturing deduction in the IRS Code (by excluding gross receipts of the taxpayer derived from the sale, exchange, or other disposition of oil, natural gas, or any primary product thereof from the term "domestic production gross receipts") or increase the amortization schedule for geological and geophysical expenditures for major integrated oil companies from five to seven years because this would send a message that these industries are not national priorities and would provide a disincentive for domestic investment.

Question 2. Are the other components of the refining infrastructure hardened against sea-level changes, subsidence in the gulf, and shoreline erosion? If not, what else needs to be done to ensure the safety and security of the infrastructure?

Answer. Refiners have made many investments in protecting themselves against the hazards of the Gulf Coast. However, the best way to protect America's energy infrastructure is to permit and encourage the geographical diversification of its energy supply. Refineries and other important onshore facilities have been welcome in limited areas throughout the country and policymakers have restricted access to much-needed offshore oil and natural gas supplies in the eastern Gulf and off the shores of California and the East Coast. Congress should permit oil production in ANWR. By diversifying our energy supply, we ensure steady access to our own natural resources, and also reduce our dependence on foreign imports.

Additionally, tax incentives would promote investments in refining infrastructure both in the Gulf and in more geographically diverse locations. For example, section 1323 of EPAct05 provided a tax benefit such that a refinery can expense 50% of the cost of a refinery expansion. Congress could apply this tax provision to investments in refining infrastructure.

Question 3. You mention in your testimony that 3 major pipelines were shut down in the aftermath of Hurricane Katrina due to disruption of electricity supplies. What mechanisms have been put in place to mitigate such circumstances in the future?

Answer: Since NPRA does not represent the oil pipeline industry, this question could be directed to the Association of Oil Pipe Lines.

Question 4. You state in your testimony that after Hurricanes Katrina and Rita that the restart process for several refineries was particularly challenging due to flooding of electric pumps. What measures have been put into place to mitigate these circumstances in the future?

Answer. NPRA is not aware of any technology that would mitigate this problem.

RESPONSE OF CHARLES T. DREVNA TO QUESTION FROM SENATOR DOMENICI

Question 1. As we seek to address the coastal energy infrastructure impacts associated with climate change, should greater emphasis be placed on strengthening and expanding energy infrastructure in the areas where it is already located, or on diversification of the areas within the United States where energy is produced, refined or otherwise processed?

Answer. Each of these goals are of vital importance, and Congress must work to advance both of them. Congress should encourage an expansion of energy infrastructure through tax incentives and policies that support investment. Congress should enhance our energy security by expanding domestic energy production and permit oil production in ANWR and remove restrictions on offshore oil and gas supplies in the eastern Gulf of Mexico and off the shores of California and the East Coast.

RESPONSES OF LISA POLAK EDGAR TO QUESTIONS FROM SENATOR BINGAMAN

Question 1. It seems that the rest of the coastal areas in the US could learn from the efforts that you have undertaken in Florida to harden the energy infrastructure against extreme weather conditions. How much did these readiness and hardening efforts cost Florida in terms of time and financing? In other words, how much of these program developments and infrastructure hardening efforts were transferred to Floridian energy consumers in the form of increased electricity costs?

Answer. Storm readiness and hardening measures are an ongoing process, with some activities requiring several years to complete. It is important to carefully examine and balance the need for a robust transmission and distribution system with the need to moderate rate impacts to consumers.

Initial storm hardening efforts such as pole inspections will be completed by utilities within 8 years and inspections will continue on an 8 year cycle. Electric utilities are performing vegetation management in cycles of 3 years for major feeders and up to 6 years for laterals. Florida's largest electric utility, Florida Power & Light, estimated costs of between $48.5 million and $61.5 million to implement storm hardening in 2007. Projected costs for 2008 and 2009 are between $75 million to $125 million and $100 million to $150 million, respectively. These costs are for projects to harden infrastructure serving critical customers, crossing major thoroughfares, major planned expansions, rebuilding and/or relocating facilities, and constructing new distribution facilities. The Commission will review the actual expenditures resulting from implementation of storm hardening plans when an investor-owned electric utility makes a formal request for cost recovery thorough a pass-through mechanism or through a request for base rate increase. To date, only one utility has requested cost recovery. A small investor-owned utility, Florida Public Utilities Company, requested an adjustment to base rates. The Commission approved an increase of $19,615 for costs associated with storm hardening activities.

Measures considered to reduce potential storm damage and outages should include cost/benefit data and analysis. Consumers deserve good financial value, short-term and long-term.

Question 2. By taking these preventative measures, how much do you estimate that you are saving the government and consumers by preventing dramatic property damage and energy losses due to extreme weather?

Answer. Estimated benefits of storm-hardening to electric consumers include reduced damage to electrical infrastructure, shorter restoration time, and reduced restoration costs. In addition, there are public benefits which accrue due to reduced disruption to Florida's overall economy. Local businesses and schools need electricity to function; the sooner they can operate after a major disruption, the better for families, communities and state and local economies. However, the exact dollar value of total benefits is difficult to estimate as there is limited historical data available to conduct conventional cost/benefit analyses on many of the new preventative measures.

In order to estimate ratepayer benefits, investor-owned utilities such as Florida Power & Light relied on their experience with the 2004-2005 hurricane season, forensic analysis of damage to facilities, and an independent analysis by a consulting firm to produce an estimate. Assuming a hurricane frequency of once every 3-5 years, FPL estimates a storm restoration cost savings, on a net present worth basis,

of approximately 70% to 45%, respectively, of the hardening costs over a 30 year period. Quantifying the total savings to the government and consumers for preventing property damage and energy losses is difficult because such analysis is, by nature, somewhat subjective and dependent upon how and what data is considered. To aid further analysis, the Commission directed each investor-owned utility to include the methods it would use to collect detailed outage data in its storm-hardening plan. Improving these methods will allow more meaningful analysis and more accurate measurement as we move forward.

As stated in the order approving the plans of Florida Power & Light and other investor-owned utilities, the measures directed meet the requirements of enhancing reliability and reducing restoration costs and outage times in a prudent, practical, and cost-effective manner.

Question 3. Have you worked with any other partners in other states to help them prepare for extreme weather—whether through preparedness measures or through infrastructure hardening, particularly in the area of electricity transmission to areas outside of Florida?

Answer. During the Commission's work with the Florida Emergency Operations Center, information related to storm preparedness and recovery has been shared with Alabama, Mississippi, and Tennessee. The Commission has also shared our experiences with other states through our participation with the National Association of Regulatory Utility Commissioners. The Commission has provided information and material to other states in response to numerous telephone inquiries. All documents and activities associated with the Commission's storm hardening efforts are available on our website at http://www.psc.state.fl.us/utilities/electricgas/eiproject/.

Question 4. How will rising sea-level impact Florida's energy transmission? It is clear that Florida has made an enormous effort in preparing for hazardous weather—but have you done the same for anticipating and preparing for changes in sea level?

Answer. The Florida Public Service Commission has not addressed the impact of changes in sea level on energy transmission. Evaluations after the 2004-2005 storm season revealed that damage to transmission was minimal compared to the damage sustained by coastal distribution lines. The damage to transmission was due more to high winds and localized tornadoes than from surges and flooding.

In Executive Order 07-128, Governor Crist established the Governor's Action Team on Energy and Climate Change. This team will develop an Action Plan to achieve targets for statewide greenhouse gas reduction, including policy recommendations and changes to existing law. As part of this effort, six Technical Working Groups have been established, one of which is looking at potential Adaptation issues.

Question 5. How have sea-level rise projections been factored into your siting decisions for future energy infrastructure?

Answer. Power plants and transmission lines are designed to take into account storm surge and historic flood levels. The Florida Department of Environmental Protection is the state agency that would review the impact of sea-level on transmission line and power plant siting.

RESPONSE OF LISA POLAK EDGAR TO QUESTION FROM SENATOR DOMENICI

Question 1. In the Energy Policy Act of 2005, we created an Electric Reliability Organization to ensure the functionality of electric infrastructure. The North American Electric Reliability Council reached some troublesome conclusions about the diminishing capacity margins across our country in their 2007 Long Term Reliability Assessment.

In your experience, what role does the supply of energy have in the reliability of our electric delivery infrastructure and how does it compare to the threat posed by weather events?

Answer. Based on data from the Florida Reliability Coordinating Council, Florida electric utilities are planning to maintain reserve margins between 20-25%, over the next 10 years. However, Florida is heavily dependent on natural gas as a fuel source for generating electricity. Any interruption to that supply, whether caused by weather events, shortage of fuel supply, or inadequate interstate transmission could be problematic. The severe 2004-2005 hurricane season caused interruptions to the natural gas supply sources; however, Florida electricity generation was not curtailed due to adequate generating capacity and fuel supply reserves.

Achieving a diverse fuel mix is one of the strategic concerns the Commission considers when determining whether a new power plant is needed to meet future energy demands in Florida. On March 18, 2008, the Commission approved the need for Florida Power & Light to build two new nuclear generating units and the Com-

mission recently concluded hearings on a need determination petition filed by Progress Energy, Florida, for two new nuclear units. The Commission has also approved the need for Florida Power & Light to increase the generating capacity at two existing nuclear units. Renewable generation, conservation, and demand-side management programs are also an important part of Florida's approach to maintaining a balanced and reliable fuel supply.

RESPONSES OF TERRY WALLACE TO QUESTIONS FROM SENATOR BINGAMAN

Question 1. How have the NISAC findings been applied in a practical sense—meaning have you worked with public utilities and other state/local entities to implement the results of your modeling?

Answer. LANL has worked and is continuing to work with the following utilities and local governments: Sonoma County (CA), California Energy Commission, Public Company of New Mexico (PNM) and City of Santa Fe. Some of these have resulted in continuing relations.

Question 2. According to the NISAC findings what critical areas/issues have been overlooked in recent climate change impact discussions?

Answer. Present dialogue and analyses tend to overlook,

(-1-) Realistic time and effort necessary for integrating renewable energy into national grid.

In most cases, energy storage and smart grids would be necessary to optimally use power generated by renewable sources. Both the technology maturation and supply chain should be carefully examined. It is our belief that such analyses have not been carried out to the fullest extent.

(-2-) Social and market response to integration of renewable into the national grid.

Most likely social response would be governed by projected increase in costs per kilowatt-hour; and inflationary impacts on national GDP. This may be countered by increase in employment. On the other hand, it is difficult to gauge market response. On one hand, policy impacts such as carbon-emissions trading may make this approach attractive and on the other hand periodicity of wind power introduces major uncertainty in pricing approaches.

Question 3. Are there any severe consequences that we have not yet recognized?

Answer. Land use dynamics. One of the aspects of global warming that is often ignored is impacts of more frequent extreme weather events (such as hurricanes, intense thunder storms, and long stretches of dry seasons). We expect desertification of additional lands in US Southwest land and soil erosion in some coastal regions. This could lead to substantial reduction on energy reliability due to damage to distribution networks (similar to reliability problems encountered due to flooding). We believe commercial, technical and social impacts of this sort could be studied using NISAC type models, but have so far not been analyzed.

RESPONSES OF THOMAS J. WILBANKS TO QUESTIONS FROM SENATOR BINGAMAN

Question 1. In your testimony, you mentioned that there may be reduced water supplies for power generation and cooling capabilities. Have you also considered the impacts to production of liquid transportation fuels?

Answer. This is an interesting question, related to everything from oil refining to biomass liquid fuel production. In our review of published research for the Climate Change Science Program, we did not find open literature publications on this issue, although we know that the industry understands petroleum fuel production connections and research is under way on biomass liquid fuel production connections. Clearly, the question is especially important for regions that are (or are expected to be) liquid transportation fuel producers and are also projected to face greater water scarcity with climate change.

Question 2. Of all of the areas studied in the SAC model, which coastal area(s) do you feel will be most greatly affected by climate change and its impacts? In other words, where should we focus our immediate attention?

Answer. The answer to this question is a matter of personal judgment, of course. The most immediate impacts of climate change are already being experienced in Alaska; in fact, there is no other U.S. region for which weather events will be attributable to climate change for some time yet. For near-term impacts, then, the top priority is Alaska. For mid-term impacts, e.g., in a 2030-2050 time period, my personal judgment is that the region most vulnerable to serious impacts is the coastal Southeast, including but not limited to the Gulf Coast. A combination of Sun-belt growth, more intense storms, sea-level rise, and land subsidence suggests that if

there is any U.S. region at risk of very serious impacts in that time frame, it is this one. For the longer-term, I would add potentials for large-scale flooding in the coastal Northeast and risks of freshwater scarcity limiting coastal development in the West, unless we are successful in developing affordable desalination technologies.

Question 3. What are the foreseen impacts of climate change on Alaska, particularly in regards to oil and gas exploration and production?

Answer. The best current reference on likely impacts of climate change on Alaska is the Arctic Climate Impact Assessment (ACIA: http://www.acia.uaf.edu/pages/scientific.html). According to this authoritative source, climate change is likely to have both positive and negative effects on oil and gas exploration, production, and related markets. Regarding both exploration and production, climate change is likely to improve access to resources in presently ice-covered waters and adjacent land areas. Drawing from Table 18.8, page 1001, of that study, for exploration reduced sea ice is likely to facilitate some off-shore operations but hamper winter seismic work on shore-fast ice. Later freeze-up and earlier melting are likely to limit the use of ice and snow roads. For production, reduced extent and thinner sea ice are likely to allow construction and operation of more economical offshore platforms. Storm surges and sea-level rise are likely to increase coastal erosion of shore facilities and artificial islands. The costs of maintaining infrastructure and minimizing environmental impacts are likely to increase as a result of thawing permafrost, storm surges, and erosion. For transportation, reduced extent and duration of sea and river ice are likely to lengthen the shipping season and shorten routes (including trans-polar routes). Permafrost thawing is likely to increase pipeline maintenance costs.

RESPONSES OF THOMAS J. WILBANKS TO QUESTIONS FROM SENATOR DOMENICI

Question 1. Dr. Wilbanks, you discussed as a Western impact the increasing levels of competition for water. In terms of their individual contributions to the tightening of water supplies, how significant do you believe the impacts of climate change are when compared with population growth?

Answer. As you suggest, it is at least as important to be looking at driving forces for water demand as at possible reductions in water supply. Over the next century, changes in population sizes and distributions, economic patterns, technologies, and institutions are likely to reshape regional economies and the quality of life more than climate change alone. The issue is how climate change will interact with these other forces—for instance, the possibility that growing regional water scarcity might begin to affect job creation and lead to population shifts, or the possibility that significant improvements in technologies for efficient use of water might improve prospects to adapt to some shrinkages in water supply. A significant challenge for climate change science is improving our capacity to project socioeconomic scenarios over time periods equivalent to the available projections of climate change.

Question 2. Dr. Wilbanks, your testimony cites research indicating that a one degree Celsius increase in temperature would result in disproportionate heating and cooling adjustments (5-20 percent increase in cooling and 3-15 percent decrease in heating). Can you explain in greater detail the disparities between these two adjustments?

Answer. Thank you for the question. There might be two issues here. One is the relatively wide range implied by 5-20 and 3-15. The main explanation is that published research studies include a wide range of assumptions about such important factors as trends in building construction and the rate of market penetration of innovative building equipment technologies. Another explanation is that there is some uncertainty about what would actually happen. I believe that these ranges are useful for policy discussions rather than confusing.

The other issue is why cooling demands are somewhat more sensitive to a temperature change than warming demands. The main explanation for this is simply a scale factor: nationally, we consume substantially more energy to warm buildings in the United States than to cool them. An assumed change in a driving force is likely to affect a smaller base more in percentage terms than a larger base. One part of this explanation is that there are many areas in the northern parts of the U.S. where summer air-conditioning of buildings is less universal than in the south. A relatively small increase in summer heat indexes might stimulate a considerable increase in the market penetration of air-conditioning in these areas.

Question 3. Dr. Wilbanks, your testimony alludes to the existence of some positive impacts on energy production and infrastructure that could result from climate change. Can you explain in greater detail what these might be?

Answer. There are several kinds of impacts that might be considered positive. One example is easier access to oil and gas reserves in areas now covered by ice in Alas-

ka, along with easier trans-polar transportation by tanker. Another is actions to reduce vulnerabilities to climate change that also reduce vulnerabilities to impacts of climate variability, such as exposures to coastal hurricanes. A third is that attention to climate change risks and vulnerabilities may increase attention to embedded issues that are important with or without climate change, such as the "energy-water nexus." A fourth is the potential that U.S. responses to concerns about climate change might include the development and demonstration of energy technologies that improve our competitiveness in a greening global energy technology marketplace. One responsibility that we all share as policymakers, scientists, and citizens is responding to challenges such a climate change in ways that create opportunities as well as problems.

RESPONSES OF THOMAS J. WILBANKS TO QUESTIONS FROM SENATOR AKAKA

Question 1. Your testimony states: "Finally, climate change could have effects on renewable energy alternatives other than hydropower, such as biomass energy, windpower, and solar energy. Currently available research does not tell us enough to draw firm conclusions about this topic, but it is important for us to improve the information available for energy decision-making in this regard."

Question 2. Hawaii relies on imported oil for 90% of its energy needs, and is continually seeking alternative, sustainable, and clean energy sources. Marine and hydrokinetic energy is an alternative energy source that is of particular interest to me. Can you elaborate on the aforementioned excerpt? By excluding hydropower, are you implying that it is resilient to climate change impacts?

Answer. Thank you for your question and your interest in this topic. Earlier in my testimony, I indicated that hydropower is the only renewable energy system for which climate change impacts have been projected by a body of published research. Hydropower potentials are almost certain to be affected in some regions by diminished mountain snowfalls, at least in the longer run. This is a significant energy supply issue for the American West.

Marine and hydrokinetic energy is an alternative of particular interest to many island states and nations, and effects of climate change on ocean currents, storm patterns, and the sea level are likely to affect evaluations of potentials for this alternative. In our summary of existing research for the Climate Change Science Program, we did not find analyses of such effects, but I would agree that such analyses should be carried out.

More generally, it appears that in many instances island states and nations have the potential to serve as "test-beds" for innovative uses of renewable energy and energy efficiency improvement strategies, because their energy costs tend to be relatively high and their ability to demonstrate locally-appropriate smaller-scale energy alternatives is also relatively high. We should be working actively with island states and nations to realize their potentials to become the leaders in exploring clean energy pathways for the world's future. I have personally been involved in USAID-supported explorations of this potential in the Caribbean, and the results were very encouraging. Another current target of opportunity might be DOD's current interest in Guam, where local leaders are asking about longer-term benefits to their economy that are not dependent on U.S. defense expenditures. Helping them to develop leadership positions in their region related to clean energy options for island nations might be one answer.

RESPONSES OF TED FALGOUT TO QUESTION FROM SENATOR BINGAMAN

Question 1. In terms of the climate change impacts to coastal wetlands, the stabilization of wetlands in the Port Fourchon area is critical to maintaining a strong and secure energy infrastructure. The subsidence and sediment loss that has occurred in the past several decades has resulted in a fairly significant loss of wetlands in Louisiana's gulf coast. Have any of the restoration efforts been successful in stabilizing erosion in the critical energy corridor that you mentioned in your testimony?

Answer. There have been numerous small scale efforts to protect some of the most vulnerable areas of the corridor. Most have been very successful, but are not nearly to the scale necessary to match the problem. For instance, at the Port, we have installed offshore breakwaters that have performed masterfully along the shoreline. We have also utilized all of our dredge material from channel maintenance for marsh restoration and beach nourishment. We have also conducted our mitigation from Port impacts in a manner that protects the port and helps to insure sustainability. We are quite capable of sustaining the Port well out into the future with the tools we are currently using in this relatively small area.

Where the major problem lies is the 17 mile stretch between the Port and the Hurricane Protection Levee System. This expansive area has limited sources of sediment and is rapidly eroding into open water. It is probably too far deteriorated to save, even with very aggressive restoration efforts will be challenged in this reach. This is the reach that the single road (LA1) is becoming exposed to open water and its vulnerability is increasing daily. All agree that in this particular area, the only cost effective way to insure access to the Port is to build a bridge. This is precisely what we are doing, but have exhausted our funding and are only half way there. What I have tried to convey, is that this highway is one of, if not the most, significant pieces of energy infrastructure in this country and to have it in the condition it is in is flirting with disaster.

From the Hurricane Levee inland, numerous small scale restoration efforts have been successful and prove that this stretch of the corridor is sustainable if we act soon. A multiple lines of defense system will work well in this stretch. This would involve Barrier Island restoration, rebuilding marsh in the mid basin by long distance delivery of dredge sediments, increased levee protection and long term sustainability achieved by major diversions from the Mississippi River into the Barataria and Terrebonne Basins.

RESPONSES OF VIRGINIA BURKETT TO QUESTIONS FROM SENATOR BINGAMAN

Question 1. In your testimony, you mention the two remaining phases to be undertaken related to climate change impacts to infrastructure. When will the next phase commence? Will phase II only focus on roads, or will it also include energy-related transportation, such as pipelines for liquid fuel transportation and electrical transmission lines?

Answer. According to the discussions USGS has had with DOT, the second phase of this work will involve an in-depth study of risks to transportation at one or more selected locations in the central Gulf Coast region. It is expected to include a structural and operational assessment, and socio-economic analysis on the local, regional and national importance of the transportation services. Phase 2 is also anticipated to fully develop the risk assessment approach toward transportation decision-making under uncertain conditions that was begun in phase 1. Yes, this phase is expected to cover all aspects of transportation, and in the Central Gulf Coast region, including the energy sector to the extent possible. Since many of the pipelines and much of the information is proprietary, analysis of specific energy facilities is frequently more difficult. The third phase will identify and analyze adaptation and response strategies and produce tools to help communities and states implement successful adaptation. The timing of phases 2 and 3 is dependent upon funding availability within the US Department of Transportation, but we anticipate that phase two will begin in Fiscal Year 2009.

Question 2. What other regions, coastal or otherwise, have the greatest need for a comprehensive study of climate change impacts?

Answer. The 2007 report of the Intergovernmental panel on Climate Change (IPCC) reveals numerous hot spots of societal or ecological vulnerability in the United States, including the entire state of Alaska, low-lying sedimentary coastlines (such as the Mississippi River Delta and the Gulf and South Atlantic coasts), arid regions (because of the projected decline in rainfall in the southwestern United States), western mountain regions, coral reefs and small islands (including Hawaii and the U.S. protected islands and freely associated states in the Pacific), heavily populated coastal areas (such as New York City and Miami), the Great Lakes region, and several dozen other geographic regions of America. A methodical, comprehensive, routinely updated, border-to-border national assessment program is needed because all areas of the country will be impacted in some way by climate change. A climate change impacts and adaptation program would enable our country to minimize the adverse effects of climate change while allowing us at the same time to take advantage of any benefits that it might offer.

Question 3. Is there any intent or plan to expand these research efforts to other regions of the U.S.?

Answer. Yes, the U.S. Climate Change Science program has a strategic plan that will expand this type of research to other areas of the country. The U.S. Department of Transportation is planning to expand its research efforts to other parts of the United States and is already working on a similar project in the mid-Atlantic region.

RESPONSES OF VIRGINIA BURKETT TO QUESTIONS FROM SENATOR AKAKA

Question 1. Your testimony warns of a rise in sea-level by 2050, which will vary between 2 to 4 feet, on the coastline extending from Mobile, AL to Houston/Galveston, TX. Do you have similar analyses that apply to the islands of Hawaii and the U.S. territories? If so, can you please provide the data?

Answer. We have not conducted the same level of assessment for the islands of Hawaii or the U.S. island territories, though this would certainly be possible. The U.S. Geological Survey has, however, conducted assessments of the vulnerability to sea level rise for the Kaloko-Honokohau National Historic Park (in Hawaii) and the National Park of American Samoa (NPSA) (see attachments).

Question 2. The impact of climate change on the ocean is of particular concern to Hawaii. Hawaii is disproportionately susceptible to increases in sea-level rise and ocean temperature, which jeopardize public safety, economic development, cultural resources, and the health of our unique island ecosystems and wildlife. Are you aware of future studies, either by USGS or other agencies that recognize the unique characteristics of islands (compared to the continental U.S.) and explore the impacts of climate change on the sea-level rise and ocean temperature on Hawaii and the U.S. territories?

Answer. The USGS and the National Oceanic Atmospheric Administration are jointly planning a coastal impacts and adaptation program that will have an island component. Such a program should entail an assessment of impacts for all U.S. coastal areas and potential adaptation strategies, which could widely vary among coastal types. The Small Island chapters of the past two IPCC assessment reports (2001 and 2007) broadly characterize the unique vulnerability of small islands. However, there are still many unknowns concerning the potential impacts of climate change on small islands-even though there is a strong scientific consensus that they are among the most vulnerable regions to climate change.

Currently, the USGS is partnering with NOAA, the University of Hawaii, the University of Colorado, and the International Pacific Research Center to develop high-resolution climate change projections for Hawaii. These projections can then be used to model how native Hawaiian ecosystems, freshwater stream flows, invasive species, and coastal communities might be affected by changes in rainfall patterns, increased sea level, and increasing temperatures.

Data and information results from these research efforts would help stimulate new projects designed to identify management options for decision-makers to mitigate the impacts of future climate change.

○