Texas at a Crossroads

THE CASE FOR ADDRESSING GLOBAL WARMING IN TEXAS

ENVIRONMENTAL DEFENSE FUND

finding the ways that work

An open letter to the Members of the 81st Texas Legislature:

There is no longer serious debate about the science of global warming.[a] The focus is now on what the response should be. And the debate has evolved from scientific issues to one primarily focusing on economic implications and opportunities.

If we fail to act, the cost of anticipated climate change impacts will far outweigh the cost of stabilizing greenhouse gas levels in the atmosphere.[b] Moreover, by not engaging in the policy debate, Texas risks missing economic opportunities. Billions of dollars are being invested across the country in so-called "new," "green" or "clean" energy companies. While some Texas businesses are benefitting, most investment is going to companies in other states that have worked to be leaders in addressing climate change and are creating markets for clean energy technologies.

How Texas responds to the global warming problem and the opportunities created by the clean energy economy will play a large role in the economic future and quality of life of Texans. Thousands of potential jobs, billions in new profits and, ultimately, the economic sway of our state in the world's emerging clean energy economy are at stake. Failing to engage on global warming policy until federal legislation is enacted will continue to put Texas at a competitive disadvantage compared to more proactive states.

Texas is at a crossroads. It can choose to continue to ignore or deny the problem and wait for the imposition of mandates that are crafted by others or it can become more involved in the process to maximize benefits for Texans. The path we recommend is for Texas to constructively engage in the federal policy debate while enacting cost-effective state-based measures to reduce emissions, attracting clean technology industries, and proactively preparing for inevitable carbon regulations and unavoidable climate impacts.

Twelve bills dealing with climate change were introduced and one was passed by the 80th Texas Legislature. Even more climate bills will be filed this session. We hope this report will help persuade you to support legislation that will put Texas on a path to being a leader in responding to global warming and taking advantage of the opportunities of the emerging clean energy economy.

Sincerely,
Jim Marston, Director
Texas Regional Office
Environmental Defense Fund

[a] See, for example, the statements of the Texas A&M Atmospheric Sciences faculty and National Academy of Sciences, reproduced as appendices to this report.
[b] See, for example, "The Stern Review," the current 'state of the art' in analysis of the economics of climate change: http://www.hm-treasury.gov.uk/sternreview_index.htm.

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Our mission
Environmental Defense Fund is dedicated to protecting the environmental rights of all people, including the right to clean air, clean water, healthy food and flourishing ecosystems. Guided by science, we work to create practical solutions that win lasting political, economic and social support because they are nonpartisan, cost-effective and fair.

Cover photos: Hurricane Katrina image from NOAA. Other images from iStockphoto.

The complete report is available online at www.edf.org

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CHAPTER 1

Introduction

Global warming will be one of the defining issues of the 21st century. The Earth is getting warmer, and climate scientists from around the world agree the continental United States will continue to warm. Global land surface temperatures in 2007 were the warmest ever recorded, and seven of the eight warmest years on record have occurred since 2001.[1] Average annual temperatures in the western and central portions of the U.S.—including Texas—could warm by about 7 degrees Fahrenheit by the end of the century.[2]

If nothing is done to curb emissions of the greenhouse gases that contribute to this warming, Texas can expect, among other things, more sizzling summers, more variable precipitation patterns, and potentially catastrophic impacts from sea level rise. Recent evidence suggests that the effects of global warming are happening even faster than the influential and consensus-based Intergovernmental Panel on Climate Change forecasted they would in their 2001 report.[3]

How we respond to this growing problem will define the economic security and quality of life for Texans this century and beyond. The vast majority of climate experts agree that human activity is very likely the cause of the observed changes in the climate, and that federal legislation limiting greenhouse gas emissions is imminent. Texas can and must be prepared to implement such legislation in a way that fosters economic development and job creation. The good news is that many of the measures that reduce greenhouse gas emissions, such as increasing energy efficiency, also save money, enhance energy security and reduce emissions of other health-threatening air pollutants.

The reality of a changing climate is beginning to take root in the American consciousness, and is being reflected in the decisions of both business and consumers. Perhaps the most palpable example surfaced when Fortune 500 companies, including GE and DuPont, joined with environmental groups to form the U.S. Climate Action Partnership in support of federal climate legislation (see, for example, "A Blueprint for Legislative Action" released January 2009, www.us-cap.org). This and other similar actions by industry and state governments are helping spur the federal government to take action.

At least 30 U.S. states are part of state-based or regional climate change initiatives, although Texas—by far the nation's biggest carbon polluter—is not participating in any of these.

Texas, which supplies the country with much of its energy, should strive to become an example of how sustainable energy production can be compatible with efforts to limit global warming and increase energy security. As the nation's leader in wind-generated power, Texas has already shown that it can be a national model. As the nation's leading natural gas producer and petroleum refiner, Texas has many

opportunities to reduce emissions and demonstrate the viability of cleaner energy production. Ignoring these issues until federal legislation is in place will put Texas at a competitive disadvantage compared to more proactive states.

Texas is at a crossroads. It can choose to continue to ignore or deny the problem and wait for the imposition of mandates that are crafted by others. The other path—the one we recommend—is to constructively engage in the federal policy debate while enacting state-based measures to begin reducing emissions, attracting clean technology industries, and proactively preparing for carbon regulations and unavoidable climate impacts.

Some state officials have spoken out on the need for Texas to engage on the global warming issue. During a July 2008 hearing before the state's Senate Committee on Natural Resources, Larry Soward, a commissioner with the Texas Commission on Environmental Quality, urged members to take action. "Given the possibilities that perfectly legitimate, science-based "worst case" scenarios present or imply, I sincerely believe we in Texas cannot continue our failure to act," he told the panel. "As the nation's leading emitter of greenhouse gases, it only seems reasonable and logical to me for us here in Texas to step up, take a leadership role and begin to seriously and meaningfully address our greenhouse gas emissions."

This report summarizes the state of scientific knowledge about climate change, especially its projected impacts on Texas, outlines the policy and economic implications and opportunities for the state, and recommends specific steps for the 81st Texas Legislature.

Much of the factual information in this report comes from a soon-to-be-published update of the 1995 book The Impact of Global Warming on Texas, *hereafter referred to as the* 2009 HARC Assessment*, after the Houston Advanced Research Center, the sponsoring organization. The final draft of the book is available for review at: www.texasclimate.org.*

CHAPTER 2

Climate science: the growing consensus

The Intergovernmental Panel on Climate Change (IPCC), comprising the world's leading scientists in a variety of climate-related disciplines, has been summarizing climate science for policymakers for nearly two decades. Each report has been stronger than the last, reflecting scientists' growing understanding of climate change. The 2007 IPCC assessment concluded that most global warming over the past 50 years was very likely due to human-caused increases in greenhouse gas levels.[4] Furthermore, the 2007 IPCC report made it clear that without action to reduce greenhouse gas emissions, temperatures will continue to rise rapidly and "net damage costs of climate change are likely to be significant and to increase over time."[5]

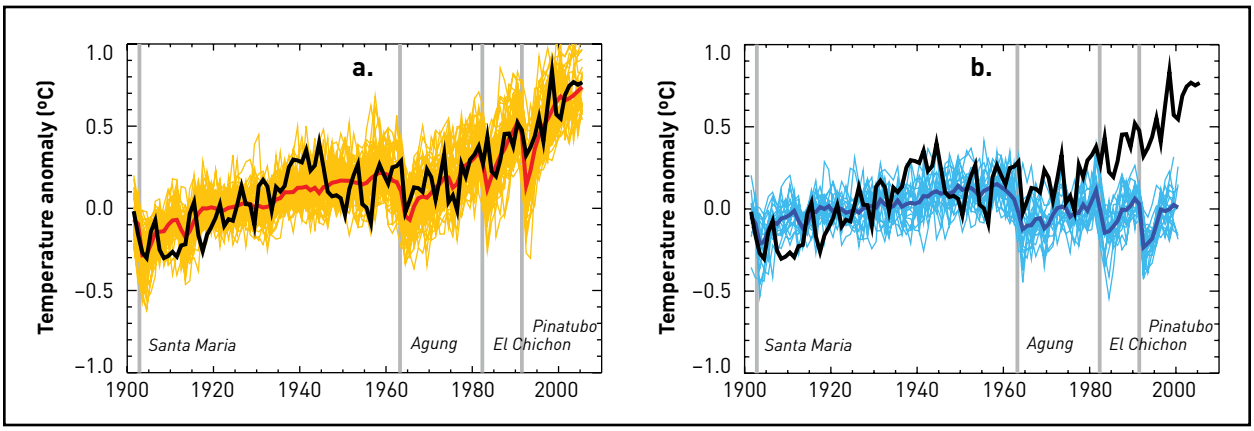
The planet is warming because human activities, especially the burning of fossil fuels, have increased levels of greenhouse gases in the atmosphere. These gases, such as carbon dioxide, methane and nitrous oxide, act like a blanket in the atmosphere, trapping extra heat.

Scientists know that rising levels of greenhouse gases are the primary reason for recent global warming because they have carefully examined and excluded all other plausible sources of the extra heat. Natural factors such as volcanic eruptions and variations in solar energy cannot explain recent rapid global warming (see Figure 1).

Of the various man-made greenhouse gases in the atmosphere, carbon dioxide is contributing most to the recent warming. The levels of carbon dioxide in the atmosphere have increased dramatically since pre-industrial times. Ice-core samples reveal that the global average concentration of carbon dioxide has ballooned from about 280 parts per million (ppm) in the 18th century to 383 ppm in 2007. Ice cores also reveal that the current concentration of carbon dioxide in the atmosphere greatly exceeds the natural range of the last 800,000 years (172–300 ppm).[6]

FIGURE 1

Climate models can reproduce recent global warming



Climate models can only reproduce the observed global average temperature record if they include the effect of greenhouse gases (GHGs). a) The yellow lines show individual models run with natural factors and manmade GHGs, and the red line is the average of all the independent models. b) The light blue lines show simulations with just volcanic eruptions and solar energy levels, holding GHG levels constant (i.e., natural factors only) and the thick blue line shows the model average. In each graph, the thick black line shows actual global average temperature and vertical gray lines indicate major volcanic events. Source: IPCC[7]

Even if greenhouse gas levels stayed fixed at levels measured in the year 2000, there would still be some additional warming due to a lag time between when greenhouse gases are emitted and when temperatures reach equilibrium.[8,9] Yet worldwide emissions of carbon dioxide may double between 2000 and 2030, with most of that increase coming from developing countries like India and China.[10] To minimize the amount of future warming and avoid the worst effects of climate change, we must take immediate action to slash greenhouse gas emissions.

Texas' contribution

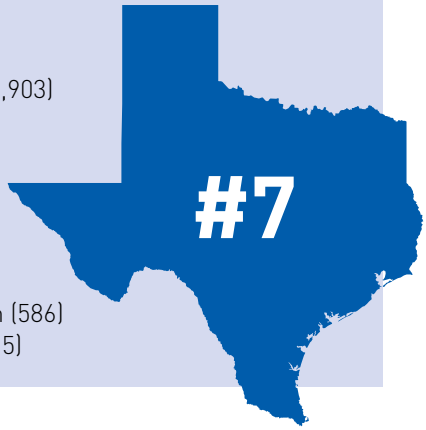
Until recently, the United States has been the world's biggest emitter of carbon dioxide (CO_2) emissions. Texas leads the nation with more than 10 percent of total U.S. emissions.[11] If Texas were a country it would rank 7th in the world.

Texas' large emissions are the result of its large population, its climate and an energy-intensive economy that accounts for more than a quarter of total U.S. natural gas production and oil refining capacity. The state is also home to a number of other energy-intensive industries, such as aluminum, chemicals and forest products.[13]

World's top ten carbon dioxide emitters[12]

Numbers in parentheses indicate carbon dioxide emissions from fossil fuel combustion in million metric tons.

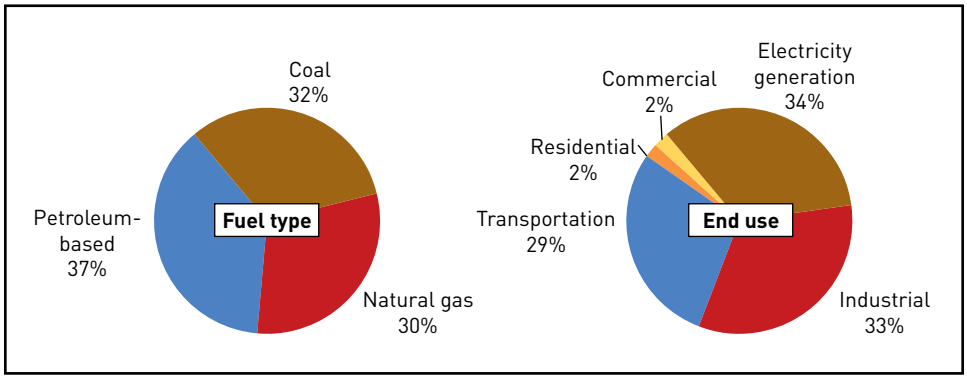
1. China (6,018)
2. United States (5,903)
3. Russia (1,704)
4. India (1,293)
5. Japan (1,247)
6. Germany (858)
7. **Texas (664)**
8. Canada (614)
9. United Kingdom (586)
10. South Korea (515)



Texas' carbon dioxide emissions are subdivided by fuel type and end use in the following charts.[14,15]

FIGURE 2

Carbon dioxide emissions in Texas by fuel type and end use



Source: See endnotes 14,15.

CHAPTER 3

Expected impacts of climate change in Texas

Rising temperatures

According to simulations produced for the Intergovernmental Panel on Climate Change, if no action is taken to curb global warming, annual temperatures in Texas could increase by about 7 degrees Fahrenheit (plus or minus 2 degrees) from the last two decades of the 20th century, to the last two decades of the 21st century.[16] By mid-century, temperatures in Texas are predicted to be roughly 4 degrees Fahrenheit warmer.[17]

"With the first eight years of the 2000–2019 period being the warmest such period on record, the projection for that period is well on its way to reflecting reality," Texas State Climatologist John W. Nielsen-Gammon writes in the *2009 HARC Assessment.*

Though 7 degrees might not sound like much, such an increase will amplify heat waves and is expected to lead to more heat mortalities, higher concentrations of ozone air pollution, a larger number of wildfires, increased evaporation of surface water, and increased damage to roads, rail lines, bridge joints and other infrastructure that could buckle in the searing heat.

Another impact of unchecked global warming will be higher energy demand as Texans increase their air conditioning use. As electricity utilities scramble to meet this demand, they'll be forced to produce more—which could, in turn, increase the greenhouse gas emissions that are driving the warming trend if the utilities continue to rely largely on fossil fuels without capturing carbon emissions. While higher wintertime temperatures would reduce heating demand in colder months, it would not offset the higher electric use during summer in most of the state.[18]

Public health consequences

The higher temperatures will increase concentrations of ground-level ozone—a pervasive lung irritant that results when pollution emitted from vehicles, diesel equipment, power plants and industrial sources chemically reacts in the sunlight and heat. The largest increases in ozone levels are predicted to occur in cities that already have high pollution levels such as Houston and Dallas-Fort Worth, which already violate federal ozone standards.[19] Studies in Los Angeles have estimated that every 1.8 degree Fahrenheit increase in temperature above 71.6 degrees results in a 5 percent increase in ambient ozone concentrations.[20] An estimated 1,000 air pollution deaths per year could occur in the United States for every 1.8 degrees Fahrenheit increase in temperature due to carbon dioxide emissions.[21] The higher temperatures will also lead to more instances of illness caused by ground-level ozone and particulate matter pollution, such as respiratory diseases and cardiovascular problems, according to a recent study coordinated by the U.S. Environmental Protection Agency.[22]

Global warming also poses other threats to public health. The greatest weather-related cause of death in the United States is heat mortality,[23] and global warming will exacerbate that problem. Moreover, a warmer climate will allow mosquito-borne diseases to migrate north from the tropics and may increase the incidence of other diseases. Diseases commonly mentioned to become more prevalent include malaria, dengue fever, West Nile virus, and diseases associated with diarrhea, such as cholera.[24]

With more heat waves, grass and brush will tend to be drier, and wildfires will become a more common concern for a large portion of the state. Wildfires are already a severe problem. Nationwide, they destroyed a total of 9.9 million acres in 2006 and 9.3 million acres in 2007—the most in the United States since 1960.[25] In Texas, fires scorched 2.25 million acres statewide from late 2005 through 2006, destroying more than 730 homes and killing 20 people.[26]

Implications of precipitation variability

Of all the potential impacts of global warming on Texas, perhaps the most difficult to forecast is its effect on precipitation patterns. According to John Nielsen-Gammon, "[climate] models suggest that the odds are tilted in favor of a precipitation decrease, but the models' ability to accurately simulate precipitation changes over a relatively small area such as Texas has not been demonstrated."[27]

What is more certain is that continued climate change would present serious problems for water planners, as the historic hydrological record used to predict supply availability and demand and to plan large infrastructure projects such as reservoirs becomes less and less reliable. Particularly challenging will be the fact that water availability is affected by both precipitation and temperature. A combination of less precipitation and higher temperatures would lead to less runoff into rivers and less recharge of aquifers, coupled with more evaporation into the atmosphere of water in lakes, rivers and streams, according to research by George Ward, associate director of the Center for Research in Water Resources at the University of Texas at Austin.[28]

The implications for Texas are serious. According to Nielsen-Gammon, "Even though precipitation projections are uncertain, it is likely that environmental and human water systems will be under increased stress due to changes in both water supply and water demand."[29]

Given such predictions, Texas would be well-served to implement cost-effective policies to build resiliency and reliability into the state's water system. This should include increasing water use efficiency across the board in agriculture (which accounted for 55 percent of the water used in the state in 2005), industry and municipalities. Unfortunately, if climate change continues unabated, the state could still face difficult water supply issues even with full implementation of advanced conservation measures.

Simply building more surface water reservoirs is not likely to be the answer. As noted above, hydrological patterns may deviate significantly from past patterns, which could undermine the viability of some proposed reservoirs. For example, hotter temperatures will increase reservoir evaporation and larger storm events could increase the rate at which existing (or new) reservoirs fill up with sediment from run-off events. Both of these factors could make new reservoirs economically prohibitive.

Desalination of seawater and brackish water, sometimes proposed as a supplemental source of fresh water, is less likely to be affected by continued climate change.

However, desalination technology requires relatively high energy input which, depending on how that power is supplied, could further contribute to CO_2 emissions.

More severe weather

When Hurricane Ike tore through the southeast Texas coast in September 2008, the storm flattened homes from Port Arthur to Freeport, destroyed offshore oil rigs and severely eroded the coastline. The storm was so powerful it blew out windows on skyscrapers in downtown Houston, and caused as much as $22 billion in damage.[30]

Few aspects of the global warming debate stoke fears like the possibility of intense hurricanes hitting Texas. Such fears are not unreasonable. Despite uncertainties in modeling hurricanes, "one can confidently predict that the likelihood of a major hurricane striking the Texas coast will increase over the coming half-century," writes Nielsen-Gammon.[31] This conclusion is due in part to an unexplained trend wherein Texas has received less than its share of damaging hurricanes in the past half-century.

The U.S. Climate Change Science Program recently warned that extreme weather events "are among the most serious challenges to society in coping with a changing climate."[32] This is particularly true for Texas, which is arguably the worldwide leader in the frequency and variety of severe and high-impact weather.[33] It has been observed that the amount of precipitation produced per storm increases as water vapor content rises with higher temperatures.[34] Though research on the likelihood of other types of severe weather in Texas under global warming is limited, early results suggest an increase.[35]

Damage to coastal areas

The state is blessed with more than 367 miles of coastline along the Gulf of Mexico and more than 3,300 miles of bay-front shoreline. And Texans love living near the

Hurricane Ike

NOAA

water. The 18 counties bordering the Gulf, while constituting only 7 percent of the land in the state, are currently home to nearly a quarter of its population.[36]


Shrimp boat

Sea levels worldwide are predicted to rise with warming temperatures for two reasons: warmer ocean temperatures cause sea water to expand and higher air temperatures melt land-based ice sheets and glaciers.[37]

Most severely impacted will be low-lying coastal areas, like those in Texas and other Gulf states, which are significantly more vulnerable to sea level rise than much of the Pacific coastline that is marked by tall cliffs and other abrupt changes in altitude. Much of the Texas coast and most of its barrier islands are less than five feet above sea level.[38]

The IPCC estimates that the global average sea level will rise by 7 to 23 inches by 2100 relative to 1980–1999 levels, assuming that ice flow from Greenland and Antarctica will continue at the same rates as observed in recent years.[39] Allowing for faster ice flows, projections of global sea level rise reach 19 to 31 inches by 2100.[40] Other studies indicate that a global sea level rise centered near 1.5 meters (5 feet) may be possible.[41] A study focused on the U.S. Gulf Coast predicted that by 2100 relative sea level in the study area is likely to rise between 24 cm to 172 cm (0.8 to 5.6 ft) depending on location (with a projection of 2.3 to 4.2 feet for Galveston, specifically).[42]

A 1-foot rise in sea levels along the Texas coast would cover 402 square miles—an area slightly larger than the city of Dallas.[43] With a 1-foot sea level rise, freshwater marshes and estuaries that provide wintering habitat for many ducks and geese, and act as nurseries for numerous species of aquatic and marine life, would be inundated with saltwater. As the water in these estuaries becomes brackish, populations of shrimp and shellfish, which depend on the salinity balance in the estuary, could decline severely, adversely affecting, for example, the state's multimillion-dollar shrimp industry.

A three foot rise in sea level could submerge 1,000 square miles of Texas coastal land, an area roughly equivalent to Big Bend National Park. South Padre Island would be underwater, and much of Galveston Island would be uninhabitable.[44]

The rising water would also erode hundreds of miles of sandy beaches that line the Texas coast. To date, more than half of the shorelines in Texas and Mississippi have eroded by, on average, as much as 10 feet per year since the 1970s, and the Intergovernmental Panel on Climate Change suggests that sea level rises due to global warming are one reason.[45]

Tidal storm surges will reach farther inland due to higher sea levels. This, combined with the loss of wetlands that help protect the shoreline, will increase flood damage along the Gulf Coast caused by hurricanes and even more modest storms.[46]

A recent study analyzed the effects of sea level rise and other projected impacts of climate change on transportation systems and infrastructure in 48 contiguous coastal counties in four states—from the Houston/Galveston area east to Mobile, Alabama. The report concluded that three out of every four freight facilities in the study area are potentially vulnerable to sea level rise.[47]

The threats associated with sea level rise could persist for a long time even if action is taken to reduce greenhouse gas emissions. The 2007 IPCC report concludes that sea level rise could continue for centuries, even after human-induced greenhouse gases are stabilized in the atmosphere.

Threats to wildlife and ecosystems

Few other states can match Texas' biological diversity. The state is home to a rich array of native wildlife species, including 477 birds, 159 mammals, 149 reptiles, 175 fish and 71 amphibians.[48] According to Packard, Gordon and Clarkson, writing in the *2009 HARC Assessment*, "Texas possesses one of the richest natural heritages in North America because of its location at the continental intersection of forest and desert biomes, temperate and subtropic climates. Effects of climate change are likely to be more pronounced at edges like this."[49]


Texas live oak tree

TREELAND NURSERY

Scientists have long known that plants and animals will shift toward northern latitudes and higher altitudes when the climate warms. Paleontological studies of plants during warmer, interglacial periods thousands of years ago allow scientists to generalize that an increase in temperature is likely to result in shifts in species distribution.

But human land-use patterns may prevent some species from adapting to climate change through migration. Land fragmentation, caused by expanding residential, commercial and other development, breaks migration corridors and makes it more difficult for some species to adapt to a changing climate.

Packard, Gordon and Clarkson predict that "[b]ecause species are predicted to be differentially affected by climate change and their rates of adaptation may differ significantly from one another, it is expected that some ecosystems or species assemblages may be disrupted."[50]

Native trees and plants like the live oak and shin oak could disappear in a warmer climate. And as many as 31 songbird species, including the American redstart and the grasshopper sparrow, could be forced to shift their breeding ranges out of Texas as global warming changes the state's climate.[51]

CHAPTER 4

Economic implications and opportunities

The cost of inaction

It is common to hear concerns about the expense of mitigating emissions to avert the most damaging effects of global warming. But what we do not hear as much about as much is the cost of inaction: How great a burden will be placed on our economy if we do nothing?

If left unchecked, climate change has the potential to harm the Texas and U.S. economies. While few studies have looked specifically at Texas, national-level research concludes that the cost of inaction outweighs the cost of controlling emissions. One study concluded that "[r]educing greenhouse gas emissions and protecting ourselves from those impacts that are now unavoidable will be costly, but a failure to act to address climate change would be even more expensive."[52] This study predicted $1.9 trillion in economic costs (1.8 percent of U.S. GDP) in 2100 from just four anticipated impacts: hurricane damage, residential real estate losses, and increased energy and water sector costs.[53] For Texas, there will likely be additional costs, including higher health care costs from heat-related injury and air pollution, as well as impacts on coastal economies that depend on tourism and capital-intensive investments, such as fuel refining and goods movement.

For comparison, several studies examine the direct private costs of limiting emissions.[54] These studies show consistently that the costs of reducing (or avoiding) emissions will be small relative to both the overall size of the economy and the costs of inaction.

A review of five independent economic analyses of climate policy concluded that in 2030 the median forecasted cost to the U.S. economy of capping greenhouse gas emissions is less than 1 percent of U.S. GDP.[55] The magnitude of this effect on GDP can be thought of this way: under business as usual, the total output of the U.S. economy is projected to reach $26 trillion in January 2030. With a cap on greenhouse gases, the economy will get there by April 2030, a mere three months later.

In sum, climate action will present new costs to the United States—and to Texas—but these costs are a small fraction of overall GDP and will be less than the cost of climate impacts if we do not act.

Preparing for the "new energy economy"

Texas lags behind many states in addressing climate change. An Environmental Protection Agency scorecard shows that Texas has acted on only three out of 15 climate change initiatives that are currently under way in various states: The state completed a greenhouse gas inventory in 2002; since 2002 retail electric providers must inform customers on sources of generation and emissions levels as part of the Electricity Facts Label; and legislation passed in 2005 provides for the transfer of carbon dioxide from a future clean coal power plant to the Texas Railroad Commission.

Although 12 bills were introduced during the 80th Texas Legislature (2007) to curb greenhouse emissions or to otherwise support precautionary measures to adapt to global warming, only one passed – Senate Bill 1762, which directed the Texas Water Development Board to study the impact of climate change on the Rio Grande in Far West Texas.

At the federal level, Congress seriously debated legislation in 2008 that would limit greenhouse gas emissions. While this most recent legislative effort failed, it

appears increasingly inevitable that Congress will soon place limits on carbon dioxide and other greenhouse gas emissions. President-elect Obama has declared that global warming legislation is an early priority for his administration.

The 81st Texas Legislature should take steps to begin preparing the state for a "new energy economy" characterized by carbon constraints. This is likely to be the final opportunity for Texas to determine its fate in this emerging economy. Ignoring this issue until federal legislation is in place will put Texas at a competitive disadvantage compared to more proactive states.

"No-regrets" mitigation measures

As with many policy initiatives, early action is a better investment strategy than delay. To curb global warming, it is logical to pursue a course of action that initially targets the lowest hanging fruit. Texas should give priority to measures that reduce carbon dioxide emissions at a net savings to the state. These "no regrets" measures should be pursued on economic grounds even in the absence of a global warming problem. Two leading examples are discussed below (and will be discussed in more detail in a separate report to be released by EDF in January 2009).

Energy efficiency. One set of measures that scores high on any list of priorities is energy efficiency investments in homes and businesses. Aggressive energy efficiency (EE) policy can save Texans billions of dollars quickly and equitably, and generate over 38,000 jobs by 2023.[56] EDF modeled the environmental and economic benefits of commercial and residential building improvements in lighting, heating and ventilation. The study estimates that Texans can avoid over $10 billion in utility costs through 2030 by aggressively expanding investments in energy efficiency. These actions will avoid carbon dioxide emissions from power plants, while reducing household and commercial utility bills.

Low emissions vehicles and low carbon fuels. "No regrets" policies are also available in the transportation sector. Specifically, Texas could adopt the greenhouse gas emissions standards for automobiles that have been adopted by California and a dozen other states, as well as California's Low Carbon Fuel Standard (LCFS).[57] An EDF analysis finds that if Texas enacted these policies, in 2020 alone crude oil consumption would be reduced by 100 million barrels, 5 million metric tons of global warming pollution would be avoided, and consumers would enjoy fuel savings of approximately $1 billion.

Climate policy: an economic development opportunity

In the last several years, energy efficiency and renewable energy have moved from strictly environmental solutions to economic ones. As global investments in cleaner

energy grows and nations and some states prepare for greenhouse gas restrictions, clean energy is emerging as a potential cure for economic woes. A new Texas group called The Catalyst Project recently released a report urging legislative support of the new energy economy, and its argument was entirely economic.[58] The central thrust of the "new energy economy" advocates in Texas is that we should act now to attract the businesses that can profit while helping our state better capitalize on our abundant wind, solar, and other renewable energy resources, along with opportunities to develop and deploy energy efficient technologies, demand response and energy storage.

Another market opportunity for Texas is carbon sequestration. Texas could recover an additional 2.8 billion barrels of oil, or more, if producers were to begin using carbon dioxide for enhanced oil recovery in areas of the state outside the Permian Basin. Assuming an oil price of $50 per barrel, this could mean an additional $140 billion in new revenues for the state's economy – not counting the additional jobs and economic activity involved in producing this amount of petroleum. Moreover, Texas is blessed with an abundance of geologic sites that, when coupled with a fully developed program for geologic carbon sequestration, would undoubtedly attract investments from industries in other states seeking low-cost emissions-reduction options. Manufacturers and operators of pipelines to transport carbon dioxide would also benefit in a carbon-constrained world.

CHAPTER 5

Recommendations for the 81st Texas legislature

Scientific consensus predicts Texas will be hard hit by climate change. While Governor Perry opposes the regulation of greenhouse gases through the Clean Air Act,[59] it does not appear that Texas state leaders are at the table helping to shape an alternative. As the nation's largest emitter of global warming pollution, Texas should be integrally involved in crafting effective solutions. The state's first order of business: Recognize that climate change is a serious issue and constructively engage at the state and federal levels. Here are some specific recommendations for the Legislature:

Pass a resolution acknowledging the widely expected prospect of federal legislation and/or regulations. Among other issues, the resolution should also address the need to deal with potential burdens on energy intensive industry and urge Texas leaders to constructively engage in the federal policy debate.

Prepare for carbon regulation by getting information on emissions. Create a state registry for carbon emissions or join the National Climate Registry and require industries and other point sources to quantify and report annual greenhouse gas emissions. Among other things, this would enhance the chance for Texas businesses to get regulatory credit for early action.

Adopt specific cost-effective measures that reduce greenhouse gas emissions. Although reducing greenhouse gas emissions may not have been the explicit goal, Texas has taken important steps that do just that, including a renewable portfolio standard (RPS) and transmission system upgrades, energy efficiency requirements, and incentives for "clean coal" technology. Texas should build on these steps, as follows:

- Expand RPS by requiring at least 3,000 MW of non-wind renewables by 2020 and ensure access of solar energy into planned transmission grid improvements.

Texas capitol

Expanding the state RPS would also help ensure compliance with a possible federal RPS, and sales of excess RECs to other states may be a source of new revenue.

- Identify and pursue "no regrets" measures that save more money than they cost, including but not limited to increased energy efficiency requirements, better vehicles and fuels, and enhanced water conservation (which reduces the risk due to more variable precipitation patterns in the future and reduces energy needed to treat and deliver water).

- Authorize adoption of regulations governing sequestration of carbon dioxide in geologic formations, both for purposes of complying with the federal Safe Drinking Water Act and for purposes of calculating emissions reductions and accounting for leakage.

Adopt a Texas-based greenhouse gas emission reduction plan. Other states are developing such plans to, among other things, influence federal legislation and regulations. Legislation is needed to begin identifying Texas-friendly solutions to include in a federal greenhouse gas regulatory regime. In lieu of a Texas-specific plan, the state could join the Western Climate Initiative, which is striving to craft a western solution to global warming, or another regional climate program.

Attract "clean tech" industries to Texas. Commit a specific and significant portion of the Emerging Technology Fund and the Texas Enterprise Fund to companies that will help Texas become a leader in the new energy economy.

Prepare the state for unavoidable impacts from climate change. In addition to reducing greenhouse gas emissions, Texas must act now to prepare for the effects of climate change that are already "in the bank" due to historical and certain future emissions of greenhouse gases. Key adaptation measures include:

- Expand water conservation efforts to make our water supply systems more resilient to more variable precipitation patterns.

- Update the Texas Coastal Zone Management plan to include appropriate adaptation measures to prepare coastal communities for rising sea levels.

- Provide additional incentives to landowners for protection of native habitat, especially for threatened or endangered species in recognition of the fact that over 95 percent of land in Texas is in private ownership. Such support may need to be targeted to help establish corridors and migration routes that help species adapt to a changing climate.

Notes

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APPENDICES

COLLEGE OF GEOSCIENCES
DEPARTMENT OF ATMOSPHERIC SCIENCES

TEXAS A&M UNIVERSITY

Climate Change Statement

We, the tenured and tenure-track faculty of the Department of Atmospheric Sciences of Texas A&M, agree with the recent reports of the Intergovernmental Panel on Climate Change that:

1. It is virtually certain that the climate is warming, and that it has warmed by about 0.7^{o}C over the last 100 years.
2. It is very likely that humans are responsible for most of the recent warming.
3. If we do nothing to reduce or emissions of greenhouse gases, future warming will likely be at least two degrees Celsius over the next century.
4. Such a climate change brings with it a risk of serious adverse impacts on our environment and society.

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Sarah D. Brooks
Ping Chang
Don Collins
Andrew Dessler
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Craig Epifanio
Rob Korty
Mark Lemmon
Shaima L. Nasiri
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Joint science academies' statement: Global response to climate change

Climate change is real

There will always be uncertainty in understanding a system as complex as the world's climate. However there is now strong evidence that significant global warming is occurring[1]. The evidence comes from direct measurements of rising surface air temperatures and subsurface ocean temperatures and from phenomena such as increases in average global sea levels, retreating glaciers, and changes to many physical and biological systems. It is likely that most of the warming in recent decades can be attributed to human activities (IPCC 2001)[2]. This warming has already led to changes in the Earth's climate.

The existence of greenhouse gases in the atmosphere is vital to life on Earth – in their absence average temperatures would be about 30 centigrade degrees lower than they are today. But human activities are now causing atmospheric concentrations of greenhouse gases – including carbon dioxide, methane, tropospheric ozone, and nitrous oxide – to rise well above pre-industrial levels. Carbon dioxide levels have increased from 280 ppm in 1750 to over 375 ppm today – higher than any previous levels that can be reliably measured (i.e. in the last 420,000 years). Increasing greenhouse gases are causing temperatures to rise; the Earth's surface warmed by approximately 0.6 centigrade degrees over the twentieth century. The Intergovernmental Panel on Climate Change (IPCC) projected that the average global surface temperatures will continue to increase to between 1.4 centigrade degrees and 5.8 centigrade degrees above 1990 levels, by 2100.

Reduce the causes of climate change

The scientific understanding of climate change is now sufficiently clear to justify nations taking prompt action. It is vital that all nations identify cost-effective steps that they can take now, to contribute to substantial and long-term reduction in net global greenhouse gas emissions.

Action taken now to reduce significantly the build-up of greenhouse gases in the atmosphere will lessen the magnitude and rate of climate change. As the United Nations Framework Convention on Climate Change (UNFCCC) recognises, a lack of full scientific certainty about some aspects of climate change is not a reason for delaying an immediate response that will, at a reasonable cost, prevent dangerous anthropogenic interference with the climate system.

As nations and economies develop over the next 25 years, world primary energy demand is estimated to increase by almost 60%. Fossil fuels, which are responsible for the majority of carbon dioxide emissions produced by human activities, provide valuable resources for many nations and are projected to provide 85% of this demand (IEA 2004)[3]. Minimising the amount of this carbon dioxide reaching the atmosphere presents a huge challenge. There are many potentially cost-effective technological options that could contribute to stabilising greenhouse gas concentrations. These are at various stages of research and development. However barriers to their broad deployment still need to be overcome.

Carbon dioxide can remain in the atmosphere for many decades. Even with possible lowered emission rates we will be experiencing the impacts of climate change throughout the 21st century and beyond. Failure to implement significant reductions in net greenhouse gas emissions now, will make the job much harder in the future.

Prepare for the consequences of climate change

Major parts of the climate system respond slowly to changes in greenhouse gas concentrations. Even if greenhouse gas emissions were stabilised instantly at today's levels, the climate would still continue to change as it adapts to the increased emission of recent decades. Further changes in climate are therefore unavoidable. Nations must prepare for them.

The projected changes in climate will have both beneficial and adverse effects at the regional level, for example on water resources, agriculture, natural ecosystems and human health. The larger and faster the changes in climate, the more likely it is that adverse effects will dominate. Increasing temperatures are likely to increase the frequency and severity of weather events such as heat waves and heavy rainfall. Increasing temperatures could lead to large-scale effects such as melting of large ice sheets (with major impacts on low-lying regions throughout the world). The IPCC estimates that the combined effects of ice melting and sea water expansion from ocean warming are projected to cause the global mean sea-level to rise by between 0.1 and 0.9 metres between 1990 and 2100. In Bangladesh alone, a 0.5 metre sea-level rise would place about 6 million people at risk from flooding.

Developing nations that lack the infrastructure or resources to respond to the impacts of climate change will be particularly affected. It is clear that many of the world's poorest people are likely to suffer the most from climate change. Long-term global efforts to create a more healthy, prosperous and sustainable world may be severely hindered by changes in the climate.

The task of devising and implementing strategies to adapt to the consequences of climate change will require worldwide collaborative inputs from a wide range of experts, including physical and natural scientists, engineers, social scientists, medical scientists, those in the humanities, business leaders and economists.

Conclusion

We urge all nations, in the line with the UNFCCC principles[4], to take prompt action to reduce the causes of climate change, adapt to its impacts and ensure that the issue is included in all relevant national and international strategies. As national science academies, we commit to working with governments to help develop and implement the national and international response to the challenge of climate change.

G8 nations have been responsible for much of the past greenhouse gas emissions. As parties to the UNFCCC, G8 nations are committed to showing leadership in addressing climate change and assisting developing nations to meet the challenges of adaptation and mitigation.

We call on world leaders, including those meeting at the Gleneagles G8 Summit in July 2005, to:

- Acknowledge that the threat of climate change is clear and increasing.
- Launch an international study[5] to explore scientifically-informed targets for atmospheric greenhouse gas concentrations, and their associated emissions scenarios, that will enable nations to avoid impacts deemed unacceptable.
- Identify cost-effective steps that can be taken now to contribute to substantial and long-term reduction in net global greenhouse gas emissions. Recognise that delayed action will increase the risk of adverse environmental effects and will likely incur a greater cost.
- Work with developing nations to build a scientific and technological capacity best suited to their circumstances, enabling them to develop innovative solutions to mitigate and adapt to the adverse effects of climate change, while explicitly recognising their legitimate development rights.
- Show leadership in developing and deploying clean energy technologies and approaches to energy efficiency, and share this knowledge with all other nations.
- Mobilise the science and technology community to enhance research and development efforts, which can better inform climate change decisions.

Notes and references

1 This statement concentrates on climate change associated with global warming. We use the UNFCCC definition of climate change, which is 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods'.

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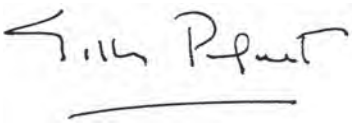
4 With special emphasis on the first principle of the UNFCCC, which states: 'The Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities. Accordingly, the developed country Parties should take the lead in combating climate change and the adverse effects thereof'.

5 Recognising and building on the IPCC's ongoing work on emission scenarios.

Academia Brasiliera de Ciências
Brazil



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Chinese Academy of Sciences,
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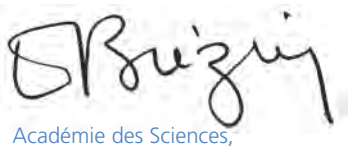

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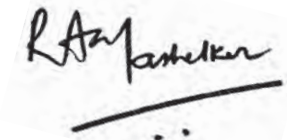
Deutsche Akademie der Naturforscher
Leopoldina, Germany



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Science Council of Japan,
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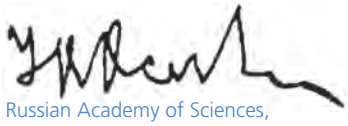

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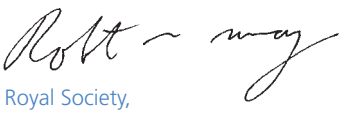

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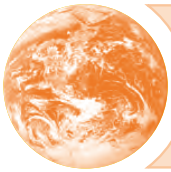


Joint science academies' statement on growth and responsibility: sustainability, energy efficiency and climate protection

Introduction

It is important that the 2007 G8 Summit is addressing the linked issues of energy security and climate change. These are defining issues of our time, and bring together the themes of growth and responsibility in a way that highlights our duties to future generations.

In 2005, the Academies issued a statement emphasising that climate change was occurring and could be attributed mostly to human activities, and calling for efforts to tackle both the causes of climate change and the inevitable consequences of past and unavoidable future emissions. Since then the IPCC has published the Working Group 1 part of the Summary for Policymakers of its fourth assessment report, and further reports are expected later this year from IPCC. Recent research strongly reinforces our previous conclusions. It is unequivocal that the climate is changing, and it is very likely that this is predominantly caused by the increasing human interference with the atmosphere. These changes will transform the environmental conditions on Earth unless counter-measures are taken.

Our present energy course is not sustainable. World population is forecast to reach 9 billion by 2050, with the most rapid growth in the poorest countries. Escalating pressures on land will accelerate deforestation. Major increases in demand for energy are inevitable as economies around the world accelerate and peoples justifiably seek to improve their living standards. Responding to this demand while minimising further climate change will need all the determination and ingenuity we can muster.

The problem is not yet insoluble, but becomes more difficult with each passing day. A goal of confining global warming to an average of 2 centigrade degrees above pre-industrial levels would be very challenging, and even this amount of warming would be likely to have some severe impacts.

Energy, development and climate

Many of the world's poorest people, who lack the resources to respond to the impacts of climate change, are likely to suffer the most. The dilemma, however, is that climate protection goals appear to conflict with prosperity targets within the traditional development paradigm. Access to energy resources and affordability of energy services are key factors for the wealth of nations and the well being of their people.

Last year our academies addressed a further important aspect of the challenges related to energy: the implications for security. We noted then that a key strategic priority will be a diversification of energy sources, as a way to address the wide variety of circumstances and resources, and to decrease vulnerabilities to a wide range of possible disruptions in supply.

Major investments and successful technological and institutional innovation will be needed to achieve better energy efficiency, low- or zero-carbon energy sources and carbon-removing schemes. A clear area for increased investment is energy conservation and efficiency. This has immediate and long-term benefits for local and regional health and environment, security of energy services and climate change, while having potential for local economic development and build-up of local technological capabilities.

Against this background it will be necessary to develop and deploy new sources and systems for energy supply, including clean use of coal, carbon capture and storage, unconventional fossil fuel resources, advanced nuclear systems, advanced renewable energy systems (including solar, wind, biomass and geothermal energy), smart grids and energy storage technologies. Research focused on the energy field must be enlarged significantly. The InterAcademy Council (IAC) is preparing a report on these challenges, which will be available later this year.

Promoting efficiency: a key element

It is urgent to increase efficiency in the global production and use of energy. Energy efficiency has been a major field for the G8 countries since the 2003 Evian Summit. Concentrating on energy efficiency is an effective contribution towards meeting the global energy challenges.

The implementation of measures to increase energy efficiency will depend to a decisive extent on financing options and technology knowledge. A sound financial and technological framework and improved global investment conditions will therefore be vital.

The common strategic priorities should concentrate on the following points:

Sustainable buildings Around 27 % of final energy is consumed by private households, and much could be done with existing technologies to improve the energy performance of buildings. The energy demands of buildings can be covered to a significant extent by using renewable energies.

Efficient transport and alternative fuels There are around 600 million motor vehicles across the globe. This figure may double by 2020. Here in particular lies a large package of possible measures, like innovative engine concepts with energy efficiency standards, alternative fuels and integrated transport systems.

Modern power technology Fossil fuels will continue to dominate electricity production over the next two decades. The best coal-fired power stations now achieve efficiencies substantially better than the average. Modernisation of old power plants could help to save energy and to reduce carbon emissions.

Electrical appliances are proliferating rapidly. New appliances on the market should be brought in line with the state of the art.

Energy consumption is strongly influenced by human behaviour. It is important to create the conditions and opportunities for energy consumers to use energy more efficiently.

Research and innovation

Increasing energy efficiency is a first crucial step towards solving the climate-energy problem. An entire portfolio of approaches will be needed, especially the substitution of fossil fuels by renewable energy sources, clean coal technologies, carbon capture and storage and advanced exploitation of nuclear fission and, in the longer term, fusion. This portfolio can be developed only through aggressive investment in research, development and innovation, with the efforts ranging from basic science over strategic analyses to practical applications.

Key research and innovation issues include: overcoming the intermittency problem for renewables, converting biomass (eg lignocellulose) to transport fuels, and coming to grips with the challenges of safety, waste, and non-proliferation in the nuclear energy domain. A whole-systems approach to energy security needs to be pursued.

Fundamental research is also needed on the climate system, climate impacts, and vulnerability at all scales in order to enhance the adaptive capacities of societies. It is equally vital to promote research on behavioural and other social issues that are central to implementing technological and institutional solutions.

The G8+5 countries should develop national road maps for innovation along with well-defined research agendas. There should be an intense international dialogue about these road maps, agendas and best practices.

Conclusions

We call on all countries of the world to cooperate in identifying common strategic objectives for sustainable, efficient and climate friendly energy systems, and in implementing actions toward them.

G8 countries bear a special responsibility for the current high level of energy consumption and the associated climate change. Newly industrialized countries will share this responsibility in the future.

We call on world leaders, especially those meeting at the G8 Summit in June 2007, to:

- Set standards and promote economic instruments for efficiency, and commit to promoting energy efficiency for buildings, devices, motors, transportation systems and in the energy sector itself.
- Promote understanding of climate and energy issues and encourage necessary behavioural changes within our societies.
- Define and implement measures to reduce global deforestation.
- Strengthen economic and technological exchange with developing countries, in order to leapfrog to cleaner and more efficient modern technologies.
- Invest strongly in science and technology related to energy efficiency, zero-carbon energy resources and carbon-removing technologies.

Academia Brasileira de Ciéncias, Brazil

Royal Society of Canada, Canada

Chinese Academy of Sciences, China

Académie des Sciences, France

Deutsche Akademie der Naturforscher Leopoldina, Germany

Indian National Science Academy, India

Accademia Nazionale dei Lincei, Italy

Science Council of Japan, Japan

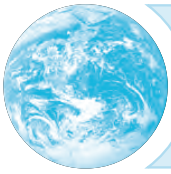
Academia Mexicana de Ciencias, Mexico

Russian Academy of Sciences, Russia

Academy of Science of South Africa, South Africa

Royal Society, United Kingdom

National Academy of Sciences, United States of America



Joint Science Academies' Statement: Climate Change Adaptation and the Transition to a Low Carbon Society

Since 2005, the Academies of Science for the G8+5 countries have called on world leaders to limit the threat of climate change. We have advised prompt action to deal with the causes of climate change and cautioned that some climate impacts are inevitable. However, progress in reducing global greenhouse gas emission has been slow.

In 2007 the Intergovernmental Panel on Climate Change (IPCC) reaffirmed that climate change is happening and that anthropogenic warming is influencing many physical and biological systems. Average global temperatures increased by 0.74ºC between 1906-2005 and a further increase of 0.2ºC to 0.4ºC in the next 20 years is expected. Further consequences are therefore inevitable, for example, from losses of polar ice and sea-level rise.

Key vulnerabilities include water resources, food supply, health, coastal settlements and some ecosystems (particularly arctic, tundra, alpine, and coral reef). The most sensitive regions are likely to include the Arctic, Africa, small islands and the densely populated Asian mega-deltas.

As the concentration of greenhouse gases increases, these impacts become more severe and spread both geographically and sectorally. To stabilize the climate, emissions should eventually be limited to the net absorption capacity of the earth, which is less than half of current emissions. Immediate large-scale mitigation action is required. At the 2007 Heiligendamm Summit, G8 leaders agreed to seriously consider halving global emissions by 2050. We urge G8+5 leaders to make maximum efforts to carry this forward and commit to these emission reductions.

Mitigation policies are essential, but not sufficient. Adaptation is necessary if the worst impacts of climate change, now and in the future, are to be alleviated. Mitigation and adaptation can complement each other and if pursued together can significantly reduce the risks of climate change impacts.

Adaptation

Climate change is a pressing issue for today. Action on adaptation is needed now and failure to respond poses a significant risk. According to the IPCC:

- A global mean temperature change of only 2.0ºC above 1990 levels will exacerbate existing impacts and trigger others, such as reduced water and food security.
- Increases of 2.0-4.0ºC will result in widespread biodiversity loss, decreasing global agricultural productivity and long-term commitment to several metres of sea-level rise due to ice sheet loss.
- Increases above 4.0ºC will lead to major increases in vulnerability, exceeding the capacity of many physical and human systems to adapt.

In April 2007, the UN Security Council addressed the threat that the aggregate impacts of climate change might cause, in particular the serious environmental, social and economic consequences and the implications for peace and security. All regions will be affected in the long term, but developing countries are likely to be affected most and their vulnerability will be exacerbated by pre-existing stresses.

Humans have been adapting to their environment throughout history. But the rate and scale of climate change means there is no time for complacency. A step-change in our response is needed, with action at global, national and local level. Local actors must be engaged in impact assessment and in identifying solutions. But global and national leadership is also required to manage the macro-scale effects that will accompany widespread efforts to adapt to climate change.

A strategic approach to adaptation must be based on the principle of sustainable development. As an immediate first step, governments can take measures to improve resilience to existing environmental stresses. Such measures will, in turn, reduce exposure to the threat posed by climate change. This involves governments recognizing the role that ecosystems and the natural resource base play in meeting basic needs (water, food and shelter). This strategic approach can be strengthened with more targeted measures once detailed assessments of the impacts and key vulnerabilities have been carried out.

Basic research, technology development and transfer will play a major role in improving the ability of nations to adapt. Understanding the underlying economic, social and environmental causes of vulnerability will enable the development of appropriate policy solutions, and strengthen the ability of the market to respond to the impacts. Governments and businesses can then develop adaptation solutions and avoid investment in technologies or infrastructure which fail to take climate change into account. This will also contribute to the achievement of other international priorities, including the Millennium Development Goals (MDGs).

Low Carbon Society

The development of a low carbon society means not merely the replacement of energy sources with less carbon intensive ones, but energy conservation as well. Sustainable consumption requires fundamental changes in all sectors and levels of society, including energy-saving housing, low-carbon transportation and more efficient industrial processes.

A movement to a low carbon society will provide the opportunity to mitigate and adapt. Mitigation cannot provide all the answers, but many impacts can be reduced, delayed or avoided by cutting emissions.

There is also an opportunity to promote research on approaches which may contribute towards maintaining a stable climate (including so-called geo-engineering technologies and reforestation), which would complement our greenhouse gas reduction strategies. The G8+5 academies intend to organise a conference to discuss these technologies.

The transition to a low carbon society requires: setting standards; designing economic instruments and promoting energy efficiency across all sectors; encouraging changes in individual behaviour; strengthening technology transfer to enable leapfrogging to cleaner and more efficient technologies; and investing strongly in carbon-removing technologies and low-carbon energy resources: nuclear power, solar energy, hydroelectricity and other renewable energy sources. These points are also stressed in the InterAcademy Council report[1].

Technologies should be developed and deployed for carbon capture, storage and sequestration (CCS), particularly for emissions from coal which will continue to be a primary energy source for the next 50 years for power and other industrial processes. G8+5 economies can take the lead globally to further develop CCS technologies. This will involve governments and industry working collaboratively to develop the financial and regulatory conditions needed to move CCS forward and international coordination in the development of demonstration plants.

Given the time-lags inherent in the global energy system, actions need to be taken now to reach the desired target by 2050. Whilst the developed world should take the lead and encourage technology transfer and collaboration with developing world partners, it is also an issue where the developing and emerging economies can and must make a significant contribution.

Transition to a low carbon society will also require reducing emissions caused by deforestation and degradation of ecosystems, requiring improved agricultural efficiency and sustainable forestry.

Conclusions

Responding to climate change requires both mitigation and adaptation to achieve a transition to a low carbon society and our global sustainability objectives. We urge all nations, but particularly those participating in the 2008 G8 Summit in Hokkaido, Japan, to take the following actions:

- Call on G8+5 governments to agree, by 2009, a timetable, funding, and a coordinated plan for the construction of a significant number of CCS demonstration plants.
- Prepare for the challenges and risks posed by climate change by improving predictive and adaptive capacities at global, national and local level and supporting the developing world in carrying out vulnerability analyses and addressing their findings.
- Take appropriate economic and policy measures to accelerate transition to a low carbon society and to encourage and effect changes in individual and national behaviour.
- Promote science and technology co-operation, innovation and leapfrogging, e.g., by transfer of some basic critical low-carbon and adaptation technologies.
- Urge governments to support research on greenhouse gas reduction technologies and climate change impacts.

As national science academies, we commit to working with our governments to help implement these actions.

[1] "Lighting the Way – Toward a sustainable energy future", InterAcademy Council, October 2007 www.interacademycouncil.net

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