STOCKHOLM ENVIRONMENT INSTITUTE U.S. Center

SEI-US is an independent research affiliate of Tufts University

Climate Change: The Costs of Inaction

Testimony presented to:

United States Congress
House Committee on Energy and Commerce
Subcommittee on Energy and Environment

Hearing on

"The Climate Crisis:
National Security, Public Health, and Economic Threats"

February 12, 2009

Dr. Frank Ackerman
Senior Economist
SEI-US, Tufts University

11 Curtis Avenue, Somerville, MA 02144-1224
Tel +1 (617) 627-3786• Fax +1 (617) 449-9603
www.sei-us.org

Mr. Chairman and members of the committee,

Thank you for the invitation to testify on my research on the costs of climate change. This hearing comes at a crucial juncture – and not only because the new administration is beginning to make changes in US climate policies. New initiatives are on the table, in part, because there has been a fundamental shift in the terms of the debate, with the focus of controversy moving from science to economics. In the realm of science, the influence of the isolated handful of climate skeptics is rapidly waning; the world's scientists have never been so unanimous, and so ominous, in their warnings of future hazards.

While the climate *science* debate is approaching closure, the climate *economics* debate is still wide open. Climate change is happening, it is threatening our future well-being – but how much can we afford to do about it? The most powerful argument for inaction today is no longer skepticism about the science, but rather the claim that the costs of reducing emissions would be intolerable. The damage to the economy, it is alleged, would be worse than the climate problem we are attempting to solve.

The economic argument for inaction is wrong on two counts: it exaggerates the costs of reducing emissions, and it understates the harm that will occur if we continue to do little or nothing about climate change. My testimony primarily addresses the second point, on the costs of inaction.

On the first point, the costs of reducing emissions, Nicholas Stern's detailed review of the economics of climate change, for the British government, estimated that we need to spend one percent of global income for several decades to bring carbon dioxide emissions down to a relatively safe level. More recent studies of the costs of carbon reduction technologies by McKinsey & Company, an international consulting firm, have led to very similar estimates. The occasional claims of much higher costs are not nearly as well researched and documented as the Stern and McKinsey estimates. Thus one percent of global income is the best available estimate of the cost of solving the climate problem.

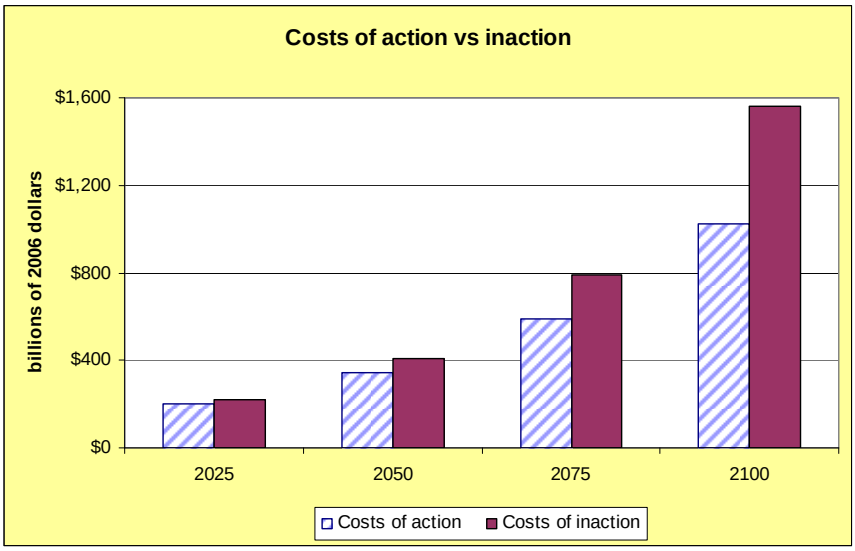
In contrast, my research shows that for the United States as a whole, even a partial accounting of the costs of *inaction* exceeds one percent of GDP, and rises steadily over time. For some parts of the country, such as Florida, a similar, partial accounting of the costs of inaction reaches 5 percent of state income within this century. For particularly vulnerable parts of the world, such as the islands of the Caribbean, the costs will be disastrously greater – with one likely consequence being a much-increased flow of refugees out of that region.

Damages that will result from inaction include (but are not limited to):

- the impacts of increasingly severe hurricanes
- more coastal property at risk from rising sea levels and storm surges
- increased energy costs for air conditioning as temperatures rise
- growing scarcity and rising costs for water
- losses in agriculture due to hotter and drier conditions
- losses of tourism revenue as weather conditions worsen

A graphic comparison of the annual costs of action (one percent of GDP) versus my partial accounting of the annual costs of inaction is shown in Figure 1. There are real costs to reducing emissions; there are much worse, bigger costs to doing nothing. And my analysis includes only a part of the benefits of taking action to reduce emissions.

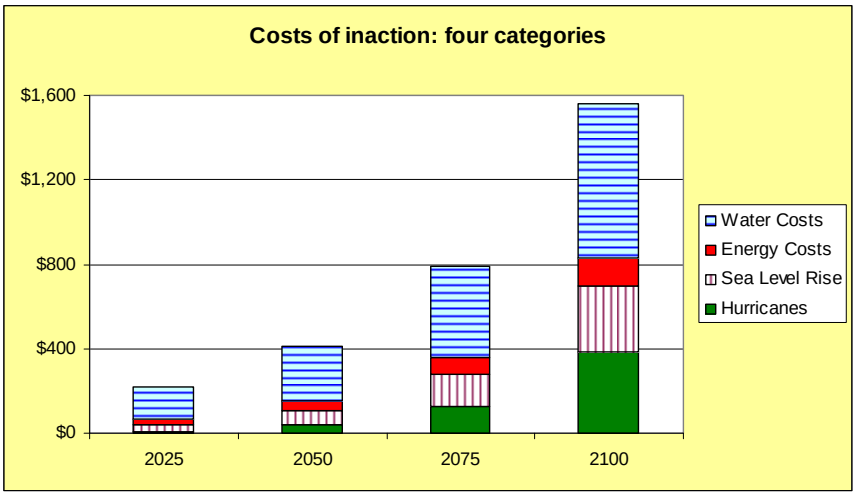
Figure 1



The principal categories of costs of inaction that are estimated in my research are shown in Figure 2 below, and described in my detailed testimony.

The farther we look into the future, the worse that the costs of inaction will become. The longer we do nothing, the greater the risks of an irreversible climate catastrophe, such as a massive rise in sea levels, that could make the world unable to support anything like the current levels of population and economic activity. The costs and risks of inaction are overwhelmingly worse than the moderate and manageable costs of an immediate effort to reduce carbon emissions.

Figure 2



My detailed testimony draws on studies done at the Stockholm Environment Institute-US Center, a research center at Tufts University, in which I have collaborated with another economist, Dr. Elizabeth A. Stanton, as well as Ramón Bueno and Cornelia Herzfeld. For more information on our research on climate economics, please see http://www.sei-us.org/climate-and-energy/climate-economics.html . This website includes links to the studies of the costs of inaction for the US as a whole[1], for Florida[2], and for the Caribbean region[3], which together form the basis for my testimony today. My overall perspective on the economics of climate change is described in my recent book, *Can We Afford the Future? Economics for a Warming World* (London and New York: Zed Books, 2009).

I will be happy to provide any additional information related to this testimony, and to answer any questions that you may have about it.

Sincerely,

Dr. Frank Ackerman

---

[1] Frank Ackerman and Elizabeth A. Stanton, *The Cost of Climate Change: What We'll Pay if Global Warming Continues Unchecked*, May 2008, http://www.nrdc.org/globalwarming/cost/contents.asp. See also the more technical supporting document, Ackerman and Stanton, *Climate Change and the U.S. Economy: The Costs of Inaction*, May 2008, http://www.sei-us.org/climate-and-energy/US_Costs_of_Inaction.doc.
[2] Elizabeth A. Stanton and Frank Ackerman, *Florida and Climate Change: The Costs of Inaction*, November 2007, http://www.sei-us.org/climate-and-energy/Florida_Inaction_Cost.html.
[3] Ramón Bueno, Cornelia Herzfeld, Elizabeth A. Stanton, and Frank Ackerman, *The Caribbean and Climate Change: The Costs of Inaction*, May 2008, http://www.sei-us.org/climate-and-energy/Caribbean_Inaction_Cost.htm.

Introduction: The Costs of Inaction

A scientific consensus has been reached: The earth's climate is changing for the worse, as a result of anthropogenic (human-caused) changes to the composition of the atmosphere. If everyone works together, all around the world, to reduce the concentration of greenhouse gases in our atmosphere, we can slow and even stop climate change. If we fail to do so, the consequences will be increasingly painful – and expensive.

My research group's analyses compare the economic consequences of two possible climate futures: The *business-as-usual* case, the worst likely result of emissions that continue to increase over time, unchecked by public policy, and the *rapid stabilization* case, the best likely result of a program of rapid, ambitious worldwide abatement initiatives.[4] It is too late to avoid all climate damages; even the rapid stabilization case involves significant losses due to climate change. However, the difference between the two scenarios – between the comparatively small losses under rapid stabilization and the huge losses under business-as-usual – is avoidable if we act soon.[5] Failure to act means that we will incur a much bigger and more painful climate loss rather than a smaller and more bearable one. The difference between the two is the cost of inaction.

My testimony begins with our analysis of the costs of inaction for the U.S., and then turns to our findings for Florida and for the Caribbean. A brief conclusion summarizes the message and the meaning of this testimony for climate policy decisions.

---

[4] On many climate projections, the IPCC issues a range of possible forecasts, with estimates of probabilities attached. Here we differ from the simple approach of reporting the median of the IPCC range. Since the future will only happen once, and we want to know how bad the risks of future damages could be, the median is misleading: there is a 50-50 chance that the future will be worse than that, perhaps much worse. Instead, we use the upper (worst) limit of what IPCC calls the "likely" range of outcomes – which they define to mean the 17th to the 83rd percentiles. That is, we report the 83rd percentile of IPCC forecasts, generally using their rapidly growing A2 scenario to represent business as usual. Using similar logic, our best case or rapid stabilization scenario represents the 17th percentile outcome of the more slowly growing B1 scenario – or as good as it is likely to get, according to IPCC projections. Note that IPCC projects a one-in-six chance that the worst case is worse, and the same odds that the best case is better, than our estimates.

[5] Throughout our analyses we assume that the size of the economy and population will be the same in both scenarios. This (perhaps unrealistic) assumption is useful in clarifying the meaning of our two cases, and the contrast between them: all the economic differences between the business-as-usual and rapid stabilization cases reflect different climate impacts applied to the same economy, not changes in the underlying projections of output or population.

U.S. Costs of Inaction: Business-As-Usual Scenario

In the business-as-usual case, the average annual temperature in most of the mainland 48 states will increase 12 to 13°F by 2100 – a little more in the nation's interior, a little less on the coasts. For a few areas of the country, the average annual temperature increase will be near or below the global mean: for the Gulf Coast and Florida, 10°F; and for Hawaii and U.S. territories in the Pacific and the Caribbean, 7°F by 2100. Alaska, like all of the Arctic, will experience an even greater increase in average temperature than the U.S. mainland. On average, Alaska's annual temperature will increase by a remarkable 18°F by 2100, but temperature increases may be even higher in the northernmost reaches of Alaska. Table 1 shows the progression of these temperature changes over time.

Table 1: Business-As-Usual Case: U.S. Annual Average Temperatures by Region

[redacted]

These temperature increases represent a fundamental change to the climate of the United States. In the business-as-usual case, the predicted annual average temperature for Anchorage, Alaska in 2100 – 53°F – is the historical annual average temperature for New York City. Under this scenario, the northern tier of mainland states from Washington to Maine will come to have the current climate of the mid-latitude states, those stretching from Northern California to New Jersey. Those middle tier states will take on the climate of the southern states, while the southern states will become more like Mexico and Central America. Annual average temperatures in Honolulu and Phoenix will match some of the hottest cities in the world today – Acapulco, Mexico and Bangkok, Thailand. The United States' hottest big cities, Miami and San Juan, Puerto Rico, will reach annual averages of 85 and 87°F, respectively – hotter than any major city in the world today.

Changes in precipitation patterns are likely to differ for each region of the United States. Alaska's precipitation will increase by 10 to 20 percent, mostly from increased snowfall. The Great Lakes and Northeast states will receive 5 percent more precipitation each year,

mostly in winter. The U.S. Southwest, including California and Texas, will experience a decrease in precipitation, down 5 to 15 percent, mostly from less winter rain. The U.S. Gulf Coast and Florida will also receive 5 to 10 percent less rain each year. There will also be a higher risk of winter flooding, earlier peak river flows for snow and glacier-fed streams; lower summer soil moisture and river flows; and a shrinkage of sea ice, glaciers and permafrost. Climate change also affects storm intensity; specifically, Atlantic hurricanes and Pacific typhoons will become more destructive.

Our estimates for sea-level rise under the business-as-usual case diverge somewhat from the scenarios presented in the latest IPCC report. This area of climate science has been developing rapidly, but the most recent advances were released too late for inclusion in the IPCC process. Based on our reading of this recent work, we use an estimate of 45 inches by 2100.[6]

We consider four case studies of the economic consequences of climate change under the business-as-usual climate scenario for the United States:

1) increasing intensity of Atlantic and Gulf Coast hurricanes
2) inundation of coastal residential real estate with sea-level rise
3) changing patterns of energy supply and consumption
4) changing patterns of water supply and use, including effects on agriculture

These are far from the only consequences of climate change; the costs in these four areas are only a partial accounting of the economic damage that will result from business as usual. Nonetheless, costs in these four areas will, if present trends continue, amount to $1.8 trillion (in today's dollars), or 1.8 percent of U.S. output per year by 2100 in the business-as-usual case. Once the much smaller, unavoidable costs under the rapid stabilization case (discussed below) are subtracted, the "cost of inaction" or the difference between the business-as-usual and rapid stabilization cases could be more than $1.5 trillion or 1.5 percent of U.S. output *per year* by 2100.

Hurricane damages. In the business-as-usual scenario, hurricane intensity will increase, with more of the most intense types of hurricanes occurring as sea-surface temperatures rise. Greater damages from more intense storms would come on top of the more severe storm surges that will result from higher sea levels. We consider three factors that are expected to increase damages and deaths resulting from future hurricanes; each of these three factors is independent of the other two. The first is coastal development and population growth – the more property and people that are in the path of a hurricane, the higher the damages and deaths. Second, as sea levels rise, even with the intensity of storms remaining stable, the same hurricane results in greater damages and deaths from

[6] For details, see Frank Ackerman and Elizabeth A. Stanton, *Climate Change and the U.S. Economy: The Costs of Inaction*, pp.7-8, http://www.sei-us.org/climate-and-energy/US_Costs_of_Inaction.doc.

storm surges, flooding, and erosion. Third, hurricane intensity may increase as sea-surface temperatures rise. Combining these effects together, the predicted increase to U.S. hurricane damages for the year 2100 is $397 billion, or 0.39 percent of U.S. output in the business-as-usual case.[7]

Rising sea levels. The effects of climate change will have severe consequences for low-lying U.S. coastal real estate. If nothing were done to hold back rising waters, sea-level rise would simply inundate many properties in low-lying, coastal areas. Even those properties that remained above water would be more likely to sustain storm damage, as encroachment of the sea allows storm surges to reach inland areas that were not previously affected. In the business-as-usual case, the annual residential real estate losses in the 48 mainland states rise to $360 billion or 0.35 percent of U.S. output by 2100. No one expects coastal property owners to wait passively for these damages to occur; those who can afford to do so will undoubtedly seek to protect their properties. But all the available methods for protection against sea-level rise are problematical and expensive. It is difficult to imagine any of them being used on a large enough scale to shelter all low-lying U.S. coastal lands from the rising seas of the 21st century.

Energy demand. Climate change will affect both the demand for and the supply of energy: hotter temperatures will mean more air conditioning and less heating for consumers – and more difficult and expensive operating conditions for electric power plants. In the business-as-usual case, increasing average temperatures drive up the costs of electricity above population and per-capita increases. Not surprisingly, electricity demand rises most rapidly in the Southeast and Southwest, as those regions experience more uncomfortably hot days. By the same token, our model projects that while the Northeast and Midwest also have rising air conditioning costs, those costs are largely offset by reduced demand for natural gas and heating oil expenditures. That is, speaking very roughly, the colder half of the country nearly breaks even on energy costs, experiencing reduced heating and increased air conditioning costs of the same magnitude. The warmer half of the country, where heating costs are already small, suffers a substantial net increase in energy costs due to rising air conditioning use.

Overall costs in the energy sector in the business-as-usual case, combining increased costs for electricity and for new air conditioners, net of decreases in heating fuel costs, add up to $141 billion per year by 2100, or 0.14 percent of projected U.S. output.

Water supply. In the business-as-usual future, problems of water supply will become more serious, as much hotter and in many areas drier conditions will increase demand. The average temperature increase of 12-13°F across most of the country, and the decrease

[7] These numbers represent a 6 percent reduction from our previously reported hurricane damage estimates, to correct a technical error in the original numbers that led to a 6 percent overestimate, pointed out by Roger Pielke Jr. (personal correspondence).

in precipitation across the South and Southwest, as described above, will lead to water scarcity and increased costs in much of the country. Responses are likely to include intensified water conservation measures, improved treatment and recycling of wastewater, construction and upgrading of cooling towers to reduce power plant water needs, and a reduction in the extent of irrigated agriculture. Extrapolating from the best available past research, we find that the costs of business-as-usual for water supply could reach $950 billion per year by 2100, while the anticipated gains in crop yields may be small, and would in any case vanish by mid-century.

The annual costs of these four effects alone adds up to $1.8 trillion in 2100 or 1.8 percent of U.S. output in the business-as-usual scenario, as summarized in Table 3 below. The total cost of these four types of damages, however, only represents a lower limit on the total cost of the business-as-usual scenario; many other kinds of damages, while also likely to have important effects on the U.S. economy, are more difficult to estimate. Damage to commercial real estate from inundation, damage to or obsolesce of public and private infrastructure from rapidly changing temperatures, and losses to regional tourism industries as the best summer and winter vacation climates migrate north – just to name a few – are all likely effects of climate change that may be costly in the United States. Effects on human health, natural environments, and endangered species add other important climate damages, which are difficult or impossible to price.

U.S. Costs of Inaction: Rapid Stabilization Scenario

With immediate, large-scale reductions in greenhouse gas emissions, it is still possible for changes in the world's climate to remain relatively small. The rapid stabilization case is an optimistic estimate of the impacts of the most rigorous policy prescription under discussion today: "80 by 2050", or an 80 percent reduction in U.S. emissions by 2050, accompanied by a 50 percent reduction in total world emissions and continuing reductions thereafter. By 2100 in the rapid stabilization case, U.S. temperatures rise by 2 to 4ºF (see Table 2) and sea levels rise 7 inches, but precipitation levels and other climatic trends remain at their historical levels.

Table 2: Rapid Stabilization Case: U.S. Annual Average Temperatures by Region

[redacted]

A small change in annual average temperatures can mean a big difference to a local climate. For example, the historical average annual temperature is 50ºF in Boston, 53ºF in New York City, and 56ºF in Washington D.C. The rapid stabilization scenario still represents a significant change to local climates throughout the United States in the next century. Three degrees Fahrenheit is a big change, but if it happens at a slow enough pace, each locality should be able to adapt to its new climate. Of course, this adaptation will not be costless.

The area of the United States that will suffer the most extreme impacts, even in the rapid stabilization case, is Alaska, where glaciers, sea ice, and permafrost are already retreating today, and an even greater upheaval to ecosystems, infrastructure, and industry can be expected in the decades to come. U.S. Gulf States, Florida, Hawaii, and U.S. territories in the Pacific and the Caribbean, in contrast, will experience smaller temperature changes – much closer to the global mean – than the majority of U.S. states. On the other hand, island and coastal regions are more exposed than the interior of the country to other aspects of climate change, such as increased storm damages and sea-level rise.

Hurricane damages. In the rapid stabilization case, hurricane damages will be only slightly worse than current conditions. U.S. hurricane damages for the rapid stabilization case are projected to be $12 billion per year by 2100, over and above current average damages.

Rising sea levels. In the rapid stabilization case, we assume that the value of U.S. coastal real estate has grown in proportion to GDP, and that annual damages will be proportional to sea level and to GDP. Using the projected 7 inches of sea-level rise by 2100, residential real estate losses from inundation rise to $46 billion annually by 2100.

Energy demand. The milder changes in climate under the rapid stabilization scenario lead

to modest net increases in energy costs, amounting to $8 billion by 2100.

Water use. As temperatures rise, more water will be needed for irrigation, power plant cooling, household needs, and other uses. Moreover, a higher air temperature leads to faster evaporation; this could outweigh the gains from moderate increases in rainfall in some areas, leaving a smaller amount of water available in rivers and reservoirs. The water sector costs for the rapid stabilization case reach $220 billion in 2100; this is an important cost, but still far below the economic burden for water supply under business as usual.

In the rapid stabilization scenario the annual costs of these four effects alone adds up to $287 billion in 2100, or 0.28 percent of U.S. output, as summarized in Table 3 below.

U.S. Costs of Inaction: Summary

How much can we reduce these climate-induced losses by limiting our emissions of greenhouse gases? It is, unfortunately, no longer possible to avoid all adverse climate impacts. Some change from the pre-industrial climate has already taken place, and more is bound to occur as a result of greenhouse gases in the atmosphere, as well as the additional emissions that will be released in the very near future (too soon for policy changes to take effect).

The cost of inaction is the difference between the estimates for the business-as-usual and rapid stabilization cases, summarized in Table 3. The annual cost of inaction – the difference between the two cases – reaches $1.56 trillion, or 1.53 percent of U.S. output by 2100. And there are many other categories of costs that will be imposed by climate change, beyond the four areas we have examined; the total cost of inaction is inevitably much greater.

The costs we have estimated are not evenly distributed throughout the country. Hurricane damages are experienced almost entirely in the southeastern coastal states, on the Gulf Coast and the Atlantic (Pacific storms that affect Hawaii and the West Coast are not included in this calculation). Sea-level rise, of course, affects coastal areas. Energy costs are heavily concentrated in southern states; many northern states would enjoy reductions in winter heating costs that are roughly comparable to increased summer electricity expenses. Water supply costs are concentrated in areas that become drier than at present, particularly the Southeast and Southwest. Costs experienced in Alaska and Hawaii, and in Puerto Rico and other territories, are almost entirely omitted from these calculations. Moreover, the problem of climate change will not end at 2100. Under business as usual, the costs of inaction will continue to mount, more and more rapidly, as time goes on. With rising temperatures there will also be an ever-increasing probability of catastrophic

change, far worse than our estimates of non-catastrophic damages. Collapse of the Greenland ice sheet would lead to sea-level rise of more than 20 feet, destroying coastal communities, industries, and infrastructure everywhere; collapse of the West Antarctic ice sheet would be of a similar magnitude. No one knows exactly at what point this would happen – but everyone knows that ice melts faster as it gets warmer.

In short, the estimates in Table 3 are a very partial accounting for the costs of inaction on climate change. The total costs are uncertain in detail, but are sure to be larger than our estimates.

Table 3: Costs of Inaction for Four Categories of Damages for the U.S.

	in billions of 2006 dollars				*as a percentage of GDP*			
	2025	**2050**	**2075**	**2100**	**2025**	**2050**	**2075**	**2100**
Hurricane Damages								
Business-as-Usual	$9	$40	$133	$397	0.05%	0.12%	0.22%	0.39%
Rapid Stabilization	$1	$2	$5	$12	0.00%	0.01%	0.01%	0.01%
Cost of Inaction	**$9**	**$38**	**$128**	**$385**	**0.04%**	**0.11%**	**0.22%**	**0.38%**
Real Estate Losses								
Business-as-Usual	$34	$80	$173	$360	0.17%	0.23%	0.29%	0.35%
Rapid Stabilization	$4	$10	$22	$46	0.02%	0.03%	0.04%	0.05%
Cost of Inaction	**$30**	**$69**	**$151**	**$314**	**0.15%**	**0.20%**	**0.25%**	**0.31%**
Energy Sector Costs								
Business-as-Usual	$28	$47	$82	$141	0.14%	0.14%	0.14%	0.14%
Rapid Stabilization	$2	$3	$5	$8	0.01%	0.01%	0.01%	0.01%
Cost of Inaction	**$26**	**$45**	**$77**	**$133**	**0.13%**	**0.13%**	**0.13%**	**0.13%**
Water Costs								
Business-as-Usual	$200	$336	$565	$950	1.00%	0.98%	0.95%	0.93%
Rapid Stabilization	$46	$78	$131	$220	0.23%	0.23%	0.22%	0.22%
Cost of Inaction	**$154**	**$258**	**$434**	**$729**	**0.77%**	**0.75%**	**0.73%**	**0.71%**
Total Costs for Four Categories								
Business-as-Usual	$271	$503	$953	$1,847	1.36%	1.46%	1.61%	1.81%
Rapid Stabilization	$53	$93	$163	$287	0.27%	0.27%	0.28%	0.28%
Cost of Inaction	**$218**	**$410**	**$790**	**$1,561**	**1.09%**	**1.19%**	**1.33%**	**1.53%**

Florida: Higher Risks, Higher Costs

The costs of climate change, measured as a share of GDP, are lower for the U.S. than the world as a whole. This is because the U.S. is colder than many parts of the world, is better supplied with fresh water, and has an unusually large percentage of population and economic activity in the interior of the country, far from the coastal damages caused by hurricanes and sea-level rise. Yet the U.S., of course, is large and varied; in hotter, water-stressed, and coastal states, nature and geography offer less protection against climate change.

A case in point is Florida, where a currently comfortable climate has led to a booming economy and fast-growing population – and where the risks and the costs of climate change will be much worse than the national average. In an analysis parallel to our national study, we found that a partial accounting of the costs of inaction on climate change could amount to as much as 5 percent of Florida's state income (gross state product, or GSP) by the end of this century. As with the national estimates, this figure excludes many important costs of climate change for which we could not develop meaningful monetary estimates; and all the costs will become larger and larger as temperatures continue to rise beyond 2100.

Our Florida analysis used the same climate projections and the same two scenarios as the national study. Although the temperature changes projected for Florida are slightly smaller than for most other states, they are still important: business as usual will make Florida, on average, 5ºF warmer than today in 2050 and 10ºF warmer in 2100. The winter, when temperatures are lowest, is currently the most popular time to visit Florida; how much of the state's appeal to visitors and residents will survive an increase in year-round temperatures?

Three of our four categories of national cost estimates could be calculated for Florida; each of them was, unsurprisingly, more serious in the Sunshine State than elsewhere in the nation. The impacts of sea-level rise will be felt all along Florida's lengthy coastline. The calculation of residential real estate losses due to sea-level rise, performed exactly as in the national study, yields a larger percentage of the state economy.

And it is not only residential property that is at risk. Data available for Florida made it possible for us to perform a GIS analysis of the effects of 27 inches of sea level rise – a level that will be reached around 2060 under business as usual. If nothing is done to protect the coastline, 27 inches of sea level rise would put 9 percent of the state's land area, including the homes of 1.5 million people, under water. Of the two counties at the southern tip of the state, Monroe County – including the Keys and most of the Everglades – would lose 99.6 percent of its land area, while Miami-Dade County would lose 70 percent of its area.

Statewide, the facilities at risk from 27 inches of sea level rise include

- 2 nuclear reactors;
- 3 prisons;
- 37 nursing homes;
- 68 hospitals;
- 74 airports;
- 82 low-income housing complexes;
- 115 solid waste disposal sites;
- 140 water treatment facilities;
- 171 assisted livings facilities;
- 247 gas stations
- 277 shopping centers;
- 334 public schools;
- 341 hazardous materials sites, including 5 superfund sites;
- 1,025 churches, synagogues, and mosques;
- 1,362 hotels, motels, and inns;
- and 19,684 historic structures.

Florida's long coastline is also exposed to hurricanes; serious hurricane damages are all too familiar throughout the state. Insurance costs have skyrocketed following major hurricanes in the recent past, forcing the state government to provide expensive subsidies to homeowner insurance. The same method we used to estimate national hurricane damages yields much bigger numbers, as a percentage of the economy, for Florida.

Likewise, the demand for electricity in Florida is strongly correlated with temperature on an hourly basis, reflecting the extensive reliance on air conditioning. On the other hand, there are virtually no heating expenditures to reduce as temperatures rise. As a result, the state's energy costs are projected to rise rapidly, along with the average temperature.

Florida is one of the wettest states in the nation, averaging 54 inches of rainfall annually, and is well supplied with rivers, lakes, and underground aquifers. Nonetheless, heavy agricultural water use for irrigation (both for growing fruits and vegetables during the dry winter months, and for the well-entrenched sugar cane industry), along with rapid residential and commercial development, has led to water shortages in many parts of the state. Florida is already investing in expensive desalination plants to increase water supply – and climate change will make the costs of water supply even higher. However, we were unable to develop a numerical estimate, comparable to our national figure, for climate-related water supply costs in Florida.

We did, however, look at a fourth impact of climate change on the Florida economy: the expected effects on tourism.[8] It is no secret that people from other states and countries like to visit Florida; 10 percent of the state's economy currently depends on tourism, with a seasonal peak in the winter months when the temperatures are lowest. Climate change will mean that winter temperatures will become more like current summer temperatures, while intensified hurricanes and sea-level rise will erode sandy beaches and make the outdoor tourist experience generally less pleasant.

Yet despite the winter peak, Florida has sizeable tourism revenues even in the off seasons, drawn in part by indoor and non-beach-oriented tourist attractions. We projected that by 2100, climate change under the business-as-usual scenario would reduce tourism's role in the Florida economy, throughout the year, to the level of the least attractive season today. That is, by the end of the century, year-round tourism spending in Florida (measured as a percentage of the state economy) would drop to the current level of tourism in the autumn months, or 76 percent as high as the current annual average. Thus we are conservatively projecting only a 24 percent decline in the relative importance of tourism, over a century which includes 45 inches of sea level rise, 10°F hotter temperatures, and more intense hurricanes. It is easy to imagine those business-as-usual climate conditions causing much greater tourism losses.

With our assumptions, the decline in tourism is the largest component of our estimated cost of inaction for Florida. Tourism losses account for about half of the state's cost of inaction; the four areas together reach 5 percent of GSP by 2100, as shown in Table 4.

Table 4: Costs of Inaction for Florida

in billions of 2006 dollars, except percentages

	2025	2050	2075	2100
Tourism	$9	$40	$88	$167
Hurricanes	$6	$25	$54	$104
Electricity	$1	$5	$10	$18
Real Estate	$11	$23	$33	$56
Summary: Costs of Inaction				
in billions of 2006 dollars	**$27**	**$92**	**$184**	**$345**
as percent of Florida GSP	**1.6%**	**2.8%**	**3.9%**	**5.0%**

[8] We did not create a comparable estimate of tourism losses for the U.S. as a whole because the effect of temperature and other climate changes is less clear over such a large and diverse area: for instance, would Florida's tourism losses result in net national losses, or in offsetting gains to other areas as tourism shifted to other states?

Maximum Vulnerability: Climate Costs in the Caribbean

Some parts of the U.S., such as Florida, will face larger climate costs than others. But the worst climate impacts will be experienced in other countries that are uniquely vulnerable to the anticipated changes. Low-lying coastal regions and, above all, small island nations, are most immediately at risk.

In another study of the costs of inaction, we analyzed the expected costs of climate change for 24 island nations and territories in the Caribbean. Data limitations did not allow us to produce an estimate that is strictly consistent with our U.S. and Florida projections.[9] We did, however, estimate three categories of climate damages: increased hurricane damages, infrastructure damages due to sea-level rise, and losses of tourism revenues. The cost of inaction on climate change – the difference between the business-as-usual and rapid stabilization scenarios – amounted to 10 percent of the region's GDP by 2050, and 22 percent by 2100.

While the average impact is large, the costs vary widely from one island to another. The largest, most diversified and least tourism-dependent economies, such as Puerto Rico and Trinidad and Tobago, face lower than average projected damages, as do a few of the smaller islands that lie outside the usual path of hurricanes, or rise well above sea level. On the other hand, greater than average damages are projected for low-lying islands, and those that are frequently struck by hurricanes. Rising sea levels and increased intensity of hurricanes will make some islands unattractive to tourists, if not entirely uninhabitable to the local population. For some islands that are heavily dependent on tourism, the expected losses of visitors and revenues due to climate change will all but destroy the local economy.

Haiti, the poorest nation of the region, is also projected to suffer overwhelming damage to its infrastructure, which it will be unable to afford to replace – a projection that is sadly consistent with that country's experience of recent storm damages. The destruction of some Caribbean economies by climate change will lead to increased migration out of the region, and the United States will be one of the most likely destinations for the new climate refugees. Thus even in the narrowest terms of self-interest (let alone a broader and more reasonable humanitarian perspective), we cannot view the destruction of Caribbean nations by climate change as merely someone else's problem.

---

[9] The U.S. and Florida projections discussed above include projections of expected growth in population and incomes, based on standard government sources. For the 24 disparate political jurisdictions in the Caribbean study, no such economic and demographic projections were available. Therefore, following the example of an earlier World Bank study of some of the Caribbean islands, we assumed no change in population or per capita income for the region. In cases where projected damages grow at the same rate as GDP, our estimates for damages as a percentage of GDP will remain valid under a range of growth rates.

Conclusion: We Can't Afford the Costs of Inaction

There are real costs involved in taking immediate and forceful action to reduce carbon emissions and control the risks of climate change. The best-researched estimates, such as those from Nicholas Stern, or from McKinsey & Company, suggest that roughly one percent of world output needs to be spent on climate mitigation, for some years to come. This is not an amount that should be spent lightly, without careful analysis and planning.

Yet the costs of emission reduction will be a bargain, compared to the high and steadily rising costs of *inaction*. The message of my research, as summarized in this testimony, is that for the United States as a whole, even a partial accounting of the costs of inaction is above one percent of GDP by 2025, and grows steadily worse as time passes and temperatures rise. The most vulnerable parts of the country, such as Florida, face proportionally much greater risks, with a partial accounting of the costs of inaction exceeding five percent of that state's income by the end of this century. Just next door, in the Caribbean, some of the world's most vulnerable nations face more extreme damages, in some cases amounting to near-total destruction of islands and their economies, from the projected business-as-usual climate impacts within this century. This should be viewed by Americans, not just as a loss of exotic vacation opportunities, but as a humanitarian crisis in our backyard, and a likely source of increasing numbers of desperate refugees arriving on our shores.

The bottom line is clear: the cost of taking action to reduce emissions is an offer we can't afford to refuse.