

May 2008

The Cost of Climate Change

What We'll Pay if Global Warming Continues Unchecked

Read the full report online at www.nrdc.org/policy.

Authors

Frank Ackerman and
Elizabeth A. Stanton
Tufts University

Contributing Authors

Chris Hope and
Stephan Alberth
Cambridge University

Jeremy Fisher and
Bruce Biewald
Synapse Energy Economics

Project Managers

Elizabeth Martin Perera
and Dan Lashof
NRDC

For more information,
please contact
Elizabeth Martin Perera
or Dan Lashof at
(202) 289-6868.



Global warming comes with a big price tag for every country in the world, including the United States. The 80 percent reduction in U.S. emissions that will be needed to lead international action to stop climate change may not come cheaply, but the cost of failing to act will be much greater. New research shows that if present trends continue, the total cost of global warming will be as high as 3.6 percent of gross domestic product (GDP). Four global warming impacts alone—hurricane damage, real estate losses, energy costs, and water costs—will come with a price tag of 1.8 percent of U.S. GDP, or almost \$1.9 trillion annually (in today's dollars) by 2100.

We know how to avert most of these damages through strong national and international action to reduce the emissions that cause global warming. But we must act now. The longer we wait, the more painful—and expensive—the consequences will be.



The Cost of Climate Change

This report focuses on a “business-as-usual” future in which the world continues to emit heat-trapping gases at an increasing rate. We base our economic projections on the most pessimistic of the business-as-usual climate forecasts considered “likely” by the scientific community.¹ In this projected climate future, which is still far from the worst-case scenario, global warming causes drastic changes to the planet’s climate, with average temperature increases of 13 degrees Fahrenheit in most of the United States and 18 degrees Fahrenheit in Alaska over the next 100 years. The effects of climate change will be felt in the form of more severe heat waves, hurricanes, droughts, and other erratic weather events—and in their impact on our economy’s bottom line.

We estimate U.S. economic impacts from global warming in two ways: a detailed focus on four specific impacts, and a comprehensive look at the costs to the country as a whole. Our detailed accounting of costs begins with historical data for four especially important climate impacts: hurricane damages, real estate losses, energy costs, and water costs. We then build upward to estimate the impact of future climatic conditions in these four impact areas. The second part of our analysis is a comprehensive view of climate change impacts: We take a general rule about how the climate affects the country as a whole and then apply that rule to business-as-usual climate forecasts. Although the detailed impact studies can provide only a partial accounting of the full economic costs estimated by our comprehensive model, the impact studies allow us to examine the costs of climate change with greater specificity for the particular case of the United States.



Global warming could cost the United States more than \$1.9 trillion each year in hurricane damages, real estate losses, energy costs, and water costs by 2100.

Change in Temperature in U.S. Cities as a Result of Global Warming (in degrees Fahrenheit)

In 2100, this U.S. city	will feel like ...does today	Temperature Change between 2008 and 2100 averages, in degrees
Anchorage, AK	New York, NY	+18
Minneapolis, MN	San Francisco, CA	+13
Milwaukee, WI	Charlotte, NC	+13
Albany, NY	Charlotte, NC	+13
Boston, MA	Memphis, TN	+12
Detroit, MI	Memphis, TN	+13
Denver, CO	Memphis, TN	+13
Chicago, IL	Los Angeles, CA	+14
Omaha, NE	Los Angeles, CA	+13
Columbus, OH	Las Vegas, NV	+13
Seattle, WA	Las Vegas, NV	+13
Indianapolis, IN	Las Vegas, NV	+13
New York, NY	Las Vegas, NV	+12
Portland, OR	Las Vegas, NV	+12
Philadelphia, PA	Las Vegas, NV	+12
Kansas City, MO	Houston, TX	+13
Washington, DC	Houston, TX	+12
Albuquerque, NM	Houston, TX	+12
San Francisco, CA	New Orleans, LA	+12
Baltimore, MD	New Orleans, LA	+12
Charlotte, NC	Honolulu, HI	+13
Oklahoma City, OK	Honolulu, HI	+13
Atlanta, GA	Honolulu, HI	+13
Memphis, TN	Miami, FL	+13
Los Angeles, CA	Miami, FL	+12
El Paso, TX	Miami, FL	+13
Las Vegas, NV	San Juan, PR	+12
Houston, TX	San Juan, PR	+11
Jacksonville, FL	San Juan, PR	+10
New Orleans, LA	San Juan, PR	+11
Honolulu, HI	Acapulco, Mexico	+7
Phoenix, AZ	Bangkok, Thailand	+12
Miami, FL	No comparable city	+10
San Juan, PR	No comparable city	+7

Source: IPCC, 2007; <http://www.worldclimate.com>; authors’ calculations.

Putting a Price Tag on Global Warming

Droughts, floods, wildfires, and hurricanes have already caused multibillion-dollar losses, and these extreme weather events will likely become more frequent and more devastating as the climate continues to change. Tourism, agriculture, and other weather-dependent industries will be hit especially hard, but no one will be exempt. Household budgets as well as business balance sheets will feel the impact of higher energy and water costs. This report estimates what the United States will pay as a result of four of the most serious impacts of global warming in a business-as-usual scenario—that is, if we do not take steps to push back against climate change:²

**Hurricane damages:
\$422 billion**

in economic losses caused by the increasing intensity of Atlantic and Gulf Coast storms.

In the business-as-usual climate future, higher sea-surface temperatures result in stronger and more damaging hurricanes along the Atlantic and Gulf coasts. Even with storms of the same intensity, future hurricanes will cause more damage as higher sea levels exacerbate storm surges, flooding, and erosion. In recent years, hurricane damages have averaged \$12 billion and more than 120 deaths per year. With business-as-usual emissions, average annual hurricane damages in 2100 will have grown by \$422 billion and an astounding 760 deaths just from climate change impacts.

**Real estate losses:
\$360 billion**

in damaged or destroyed residential real estate as a result of rising sea levels.

Our business-as-usual scenario forecasts 23 inches of sea-level rise by 2050 and 45 inches by 2100. If nothing is done to hold back the waves, rising sea levels will inundate low-lying coastal properties. Even those properties that remain above water will be more likely to sustain storm damage, as encroachment of the sea allows storm surges to reach inland areas that were not previously affected. By 2100, U.S. residential real estate losses because of climate change will be \$360 billion per year.

**Energy costs:
\$141 billion**

in increasing energy costs as a result of the rising demand for energy.

As temperatures rise, higher demand for air conditioning and refrigeration across the country will increase energy costs, and many households and businesses, especially in the North, that currently don't have air conditioners will purchase them. Only a fraction of these increased costs will be offset by reduced demand for heat in Northern states. The highest net energy costs—after taking into consideration savings from lower heating bills—will fall on Southeast and Southwest states. Total costs will add up to more than \$200 billion for extra electricity and new air conditioners, compared with almost \$60 billion in reduced heating costs. The net result is that energy sector costs will be \$141 billion higher in 2100 due to global warming.





**Water costs:
\$950 billion**

to provide water to the driest and most water-stressed parts of the United States as climate change exacerbates drought conditions and disrupts existing patterns of water supply.

The business-as-usual case forecasts less rainfall in much of the United States—or, in some states, less rain at the times of year when it is needed most. By 2100, providing the water we need throughout the country will cost an estimated \$950 billion more per year as a result of climate change. Drought conditions, already a problem in Western states and in the Southeast, will become more frequent and more severe.

Our analysis finds that, if present trends continue, these four global warming impacts alone will come with a price tag of almost \$1.9 trillion annually (in today's dollars), or 1.8 percent of U.S. GDP per year by 2100. And this bottom line represents only the cost of the four categories we examined in detail; the total cost of continuing on a business-as-usual path will be even greater—as high as 3.6 percent of GDP when economic and noneconomic costs such as health impacts and wildlife damages are factored in.

The Global Warming Price Tag in Four Impact Areas, 2025 through 2100

	Cost in billions of 2006 dollars				Cost as a percentage of GDP				U.S. Regions Most at Risk
	2025	2050	2075	2100	2025	2050	2075	2100	
 Hurricane Damages	\$10	\$43	\$142	\$422	0.05%	0.12%	0.24%	0.41%	Atlantic and Gulf Coast states
 Real Estate Losses	\$34	\$80	\$173	\$360	0.17%	0.23%	0.29%	0.35%	Atlantic and Gulf Coast states
 Energy-Sector Costs	\$28	\$47	\$82	\$141	0.14%	0.14%	0.14%	0.14%	Southeast and Southwest
 Water Costs	\$200	\$336	\$565	\$950	1.00%	0.98%	0.95%	0.93%	Western states
SUBTOTAL OF THESE FOUR IMPACTS*	\$271	\$506	\$961	\$1,873	1.36%	1.47%	1.62%	1.84%	

*Note: Totals may not add up exactly due to rounding.

The Cost of Climate Change

New Model Provides More Accurate Picture of the Cost of Climate Change

Many economic models have attempted to capture the costs of climate change for the United States. For the most part, however, these analyses grossly underestimate costs by making predictions that are out of step with the scientific consensus on the daunting scope of climatic changes and the urgent need to reduce global warming emissions. *The Economics of Climate Change*—a report commissioned by the British government and released in 2006, also known as the Stern Review after its lead author, Nicholas Stern—employed a different model that represented a major step forward in economic analysis of climate impacts. We used a revised version of the Stern Review's model to provide a more accurate, comprehensive picture of the cost of global warming to the U.S. economy. This new model estimates that the true cost of all aspects of global warming—including economic losses, noneconomic damages, and increased risks of catastrophe—will reach 3.6 percent of U.S. GDP by 2100 if business-as-usual emissions are allowed to continue.

Global Warming and the International Economy

Damage on the order of a few percentage points of GDP each year would be a serious impact for any country, even a relatively rich one like the United States. And we will not experience the worst of the global problem: The sad irony is that while richer countries like the United States are responsible for much greater per person greenhouse gas emissions, many of the poorest countries around the world will experience damages that are much larger as a percentage of their national output.

For countries that have fewer resources with which to fend off the consequences of climate change, the impacts will be devastating. The question is not just how we value damages to future generations living in the United States, but also how we value costs to people around the world—today and in the future—whose economic circumstances make them much more vulnerable than we are. Decisions about when and how to respond to climate change must depend not only on our concern for our own comfort and economic well-being, but on the well-being of those who share the same small world with us. Our disproportionate contribution to the problem of climate change should be accompanied by elevated responsibility to participate, and even to lead the way, in its solution.

Conclusion: We Must Act Now to Avoid the Worst Economic Impacts of Global Warming

It is difficult to put a price tag on many of the costs of climate change: loss of human lives and health, species extinction, loss of

NRDC's Policy Recommendations for Reducing U.S. Emissions

Continuing on the business-as-usual path will make global warming not just an environmental crisis, but an economic one as well. That's why we must act immediately to reduce global warming emissions 80 percent by 2050 and take ourselves off the business-as-usual path. NRDC recommends the following federal actions to curb emissions and avoid the worst economic impacts expected from global warming:

1. Enact comprehensive, mandatory limits on global warming pollution to stimulate investment in all sectors and guarantee that we meet emission targets.

A mandatory cap will guarantee that we meet emissions targets in covered sectors and will drive investment toward the least costly reduction strategies. If properly designed to support efficiency and innovation, such a program can actually reduce energy bills for many consumers and businesses. A successful program will include 1) a long-term declining cap, 2) Comprehensive coverage of emitting sources, 3) pollution allowances used in the public interest, 4) allowance trading, and 5) limited use of offsets.

2. Overcome barriers to investment in energy efficiency to lower abatement cost starting now.

Multiple market failures cause individuals and businesses to underinvest in cost-effective energy efficiency and emerging low-carbon technologies. Price signals alone will not adequately drive these investments, which are already profitable at current energy prices. Therefore, while a mandatory cap on emissions is essential (and the associated allowance value can substantially fund efficiency), many of the opportunities require additional federal, state, and/or local policy to overcome barriers to investments. Specifically, there are substantial gains to be realized in building, industry, and appliance efficiency and in smart transportation such as advanced vehicles and smart growth.

3. Accelerate the development and deployment of emerging clean energy technologies to lower long-term abatement costs.

To accelerate the "learning by doing" needed to develop an affordable low-carbon energy supply, we must support rapid development and deployment of renewable electricity, low-carbon fuels, and carbon capture and disposal that sequesters carbon dioxide in geological formations deep beneath the earth's surface.

unique ecosystems, increased social conflict, and other impacts extend far beyond any monetary measure. But by measuring the economic damage of global warming in the United States, we can begin to understand the magnitude of the challenges we will face if we continue to do nothing to push back against climate change. Curbing global warming pollution will require a substantial investment, but the cost of doing nothing will be far greater. Immediate action can save lives, avoid trillions of dollars of economic damage, and put us on a path to solving one of the greatest challenges of the 21st century.



¹ Intergovernmental Panel on Climate Change, *Climate Change 2007: The Physical Science Basis*, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (Cambridge, UK., Cambridge University Press, 2007).

² A thorough review of existing climate change impact studies for the United States has recently been produced by the University of Maryland's Center for Integrative Environmental Research (CIER), *The U.S. Economic Impacts of Climate Change and the Costs of Inaction* (University of Maryland, 2007). This report complements the CIER research, attempting to develop a single "bottom line" economic impact for several of the largest categories of damages—and to critique the misleading economic models that offer a more complacent picture of climate costs for the United States.