CLIMATE CHANGE 101
Understanding and Responding to Global Climate Change

Overview

Science and Impacts

Technological Solutions

Business Solutions

International Action

State Action

Local Action

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CLIMATE CHANGE 101
Overview

The science is clear: climate change is happening, and it is linked directly to human activities that emit greenhouse gases. This overview summarizes the multi-part series *Climate Change 101: Understanding and Responding to Global Climate Change*. *Science and Impacts* discusses the most current scientific evidence for climate change and explains its causes and projected impacts. As explored here and in greater depth in *Technological Solutions,* a number of technological options exist to avert dangerous climatic change by dramatically reducing greenhouse gas emissions both now and into the future. *Business Solutions, International Action, State Action,* and *Local Action* describe how business and government leaders at all levels have recognized both the challenge and the vast opportunity climate change presents. These leaders are responding with a broad spectrum of innovative solutions. To successfully address the enormous challenge of climate change, new approaches are needed at the international level, and the United States must re-engage in the global effort and adopt strong and effective national policies.

A REAL PROBLEM WITH REAL SOLUTIONS

An overwhelming body of scientific evidence paints a clear picture: climate change is happening, it is caused in large part by human activity, and it will have many serious and potentially damaging effects in the decades ahead. Scientists have confirmed that the earth is warming, and that greenhouse gas emissions from cars, power plants and other manmade sources—rather than natural variations in climate—are the primary cause. Due largely to the combustion of fossil fuels, atmospheric concentrations of carbon dioxide, the principal greenhouse gas, are at a level unequaled for more than 400,000 years. As a result, an enhanced greenhouse effect is trapping more of the sun's heat near the earth's surface and gradually pushing the planet's climate system into uncharted territory (See Figure 1).

Carbon dioxide (CO_2) and other greenhouse gases always have been present in the atmosphere, keeping the earth hospitable to life by trapping heat. Yet, since the industrial revolution, emissions of these gases from human activity have accumulated steadily, trapping more heat and exacerbating the natural greenhouse effect. As a result, global average temperatures have risen both on land and in the oceans, with observable impacts already occurring that foretell increasingly severe changes in the future. Polar ice is melting. Glaciers around the globe are in retreat. Storms are increasing in intensity. Ecosystems around the world already are reacting, as plant and animal species struggle to adapt to a shifting climate, and new climate-related threats emerge.

Scientists predict that if the increase in greenhouse gas emissions continues unabated, temperatures will rise by as much as 10 degrees Fahrenheit by the end of this century, causing dramatic —and irreversible—changes to the climate. The consequences, both anticipated and unforeseen, will have profound ramifications for humanity and the world as a whole. Water supplies in some critical areas will dwindle as snow and ice disappear. Sea levels will rise, threatening coastal populations. Droughts and floods will become more common. And hurricanes and other powerful storms will increase in intensity. Adding to the threat will be the impacts of climate change on agricultural production and the spread of disease. Human health will be jeopardized by all of these changes.

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This brief is part of a series called *Climate Change 101: Understanding and Responding to Global Climate Change*, published by the Pew Center on Global Climate Change and the Pew Center on the States.

Figure 1

The Greenhouse Effect

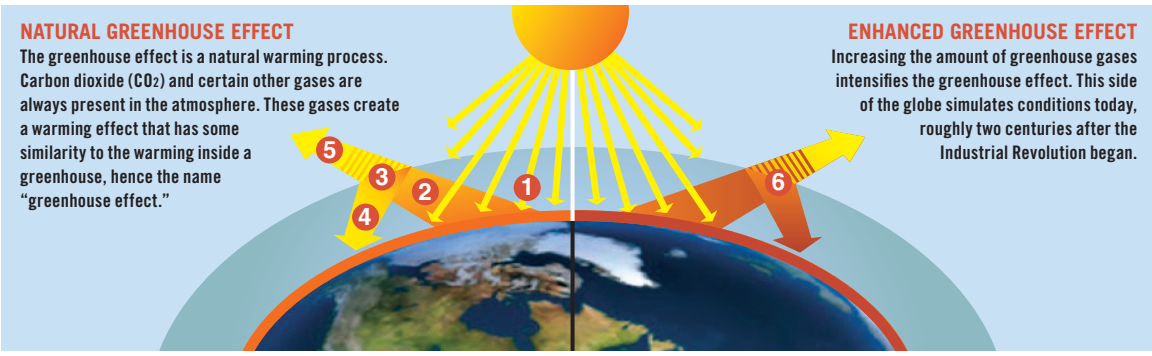

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Illustration of the greenhouse effect (courtesy of the Marian Koshland Science Museum of the National Academy of Sciences). Visible sunlight passes through the atmosphere without being absorbed. Some of the sunlight striking the earth ❶ is absorbed and converted to heat, which warms the surface. The surface ❷ emits heat to the atmosphere, where some of it ❸ is absorbed by greenhouse gases and ❹ re-emitted toward the surface; some of the heat is not trapped by greenhouse gases and ❺ escapes into space. Human activities that emit additional greenhouse gases to the atmosphere ❻ increase the amount of heat that gets absorbed before escaping to space, thus enhancing the greenhouse effect and amplifying the warming of the earth.

Climate change is a real problem, but it also has real solutions. Some of its effects are already inevitable and will require some degree of adaptation. But humanity has the power—working collectively and individually and at all levels of society—to take serious action to reduce the threat posed by climate change. To avoid the worst effects, scientists say we will need to stabilize greenhouse gas concentrations in the atmosphere; that means reducing emissions of these gases by about 50 to 80 percent. It is a major challenge that will require unprecedented cooperation and participation across the globe. Yet, the tools exist to begin addressing this challenge now. Around the country and throughout the world, many political, business, and community leaders already are working to prevent the consequences of global warming. They are acting because they understand that the science points to an inescapable conclusion: addressing climate change is no longer a choice, but an imperative.

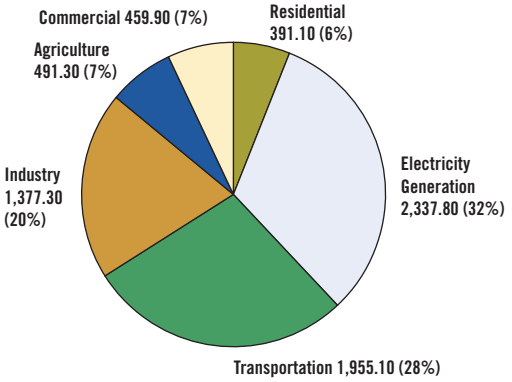
REDUCING EMISSIONS: WHAT IT WILL TAKE

Climate change is not just a daunting challenge; it is also an enormous opportunity for innovation. While there is no "silver bullet" technological solution, many tools already exist for addressing climate change, and new options on the horizon could potentially yield dramatic reductions in worldwide emissions of greenhouse gases.

Although greenhouse gas emissions are primarily associated with the burning of fossil fuels (chiefly, coal, oil and natural gas), they come from many sources. As a result, any effort to reduce the human impact on the climate will need to engage all sectors of society. As Figure 2 shows, the largest contributors to total U.S. emissions are the electricity generation and transportation sectors; significant emissions also come from other commercial and agricultural activity and from buildings in all sectors. In each of these areas, technologies and

Figure 2

2004 U.S. Greenhouse Gas Emissions by Sector (Million Metric Tons CO_2 Equivalent)



Source: U.S. EPA

Getting it Done—in "Wedges"

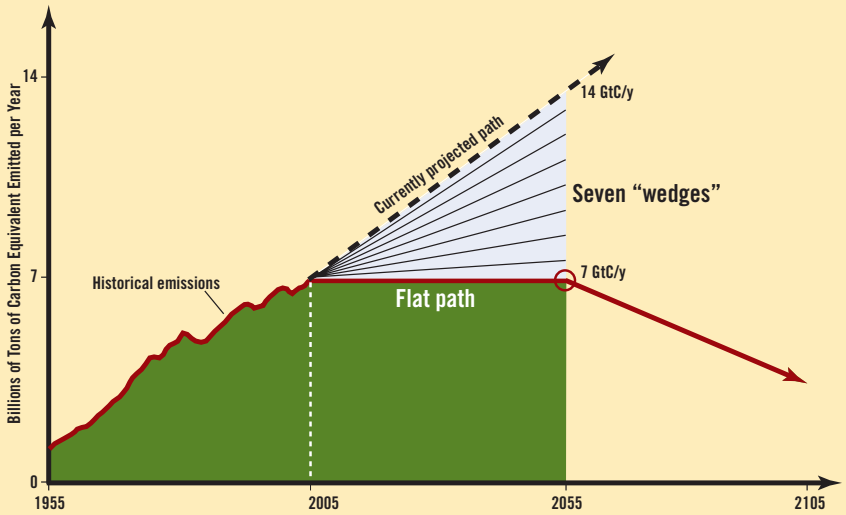
One oft-cited forecast suggests that under a "business-as-usual" scenario, annual global greenhouse gas emissions will reach 14 billion tons (gigatons) per year by 2055. Assuming we need to cut those emissions at least in half (or by a minimum of 7 gigatons), researchers Robert Socolow and Stephen Pacala have suggested that one way to think about the problem is to break the necessary reduction into 7 wedges. Each wedge represents a strategy that can reduce carbon emissions by 1 gigaton per year within 50 years. Figure 3 shows the result of the so-called "wedges" analysis of Socolow and Pacala.*

Achieving the necessary total reductions will require a combination of strategies. The following examples of wedges give an indication of the magnitude of the effort required:

- Producing 2 billion cars that travel 60 miles per gallon of gasoline instead of 30 miles per gallon
- Build 1 million 2 MW wind turbines to displace coal power
- Build 700 GW of nuclear power to displace coal power (twice current global nuclear capacity)
- Decrease car travel for 2 billion 30 mpg cars from 10,000 to 5,000 miles per year
- Capture and store GHG emissions at 1600 large coal plants
- Improve energy efficiency by one-fourth in buildings and appliances
- Produce 100 times current U.S. ethanol output

Figure 3

Stabilizing and Reducing Global Emissions



*Source: Pacala, S. and R. Socolow. 2004. "Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies." *Science*, 305(5686): 968-972.

practices already exist that can reduce emissions. Other tools that are still being developed hold tremendous promise. Significant reductions will require a transformation in global energy use through a combination of short-term and long-term commitments. Real reductions are possible today, but we also need more advanced technology—and we need to begin developing it now.

Given the many sources of emissions, a comprehensive response to climate change requires a portfolio of solutions. In the electricity sector, these solutions include improving the efficiency of power plants; generating an increasing share of electricity from climate-friendly renewable sources such as solar, wind and tidal power; developing new technologies to store carbon-dioxide emissions underground; and investing in new nuclear facilities. Increased energy efficiency in buildings and appliances also can provide significant and cost-effective reductions. At the same time, transportation-sector emissions can be reduced through investments in new and existing technologies to improve the

fuel efficiency of cars and trucks. Other transportation solutions include using low-carbon energy sources (such as biofuels, fuel cells or electricity) and adopting "smart growth" policies that improve accessibility and reduce driving.

There will certainly be costs associated with adopting these technologies and transforming the way we consume energy. Yet, addressing climate change also offers enormous economic opportunities, starting with the opportunity to avoid the considerable costs that climate change will pose to societies and businesses. In addition, the global technology revolution that is needed to protect the climate will create new economic opportunities for businesses and workers, as well as the localities, states and nations that successfully position themselves as centers of innovation and technology development for a low-carbon world. However, innovation will not happen quickly enough or at the necessary scale without government action to push and pull new technologies into mainstream use. A comprehensive strategy of economy-wide and sector-specific policies is needed. Key policy solutions include investments in science and technology research; efficiency standards for buildings, vehicles, and appliances; and perhaps most importantly, an overall limit on GHG emissions and a market for reductions. One such system, known as cap-and-trade, would set a cap on GHG emissions and allow companies to trade emission allowances so they can achieve their reductions as cost-effectively as possible.

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EMBRACING CLIMATE SOLUTIONS

In the absence of a strong U.S. federal policy, leaders in business and government at all levels have begun taking significant steps to address climate change. Current efforts cannot deliver the level of reduction needed to protect the climate, but they provide a foundation for future action, as well as proof that progress is possible without endangering economic success.

Business Solutions. Leading businesses around the globe are taking action to reduce their impact on the climate and to advocate for sensible policy solutions. A survey of over 30 companies asking why they are taking action on climate change revealed a number of key motivations for action, including increasing profits, influencing government regulation, enhancing corporate reputations, and managing risk (See Figure 4).

Recent years have seen a shift in corporate approaches to climate change from focusing exclusively on risk management and protecting the bottom line to the pursuit of new business opportunities. Improvements in energy efficiency, for example, can lead to reduced costs; sales of climate-friendly products and services are growing rapidly; and new markets for carbon reductions are taking off.

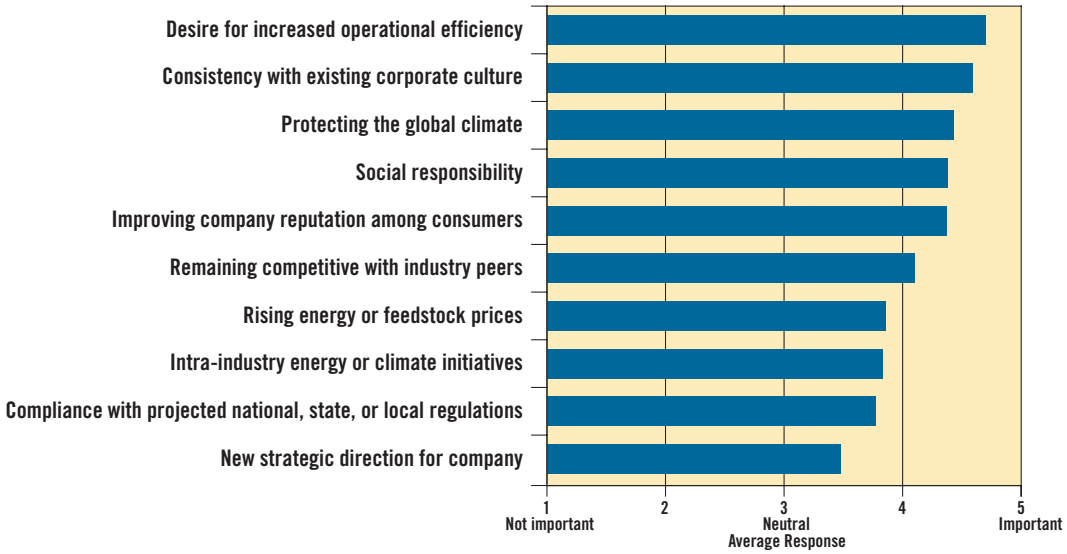
Many corporate leaders increasingly believe that the growing certainty about climate science means that government action is imminent. Companies want a head start over their competitors in learning how to reduce their emissions. Others in the private sector are responding to growing pressure from investor and consumer groups for disclosure of climate-related risks and integration of climate concerns into companies' core business strategies. There may also be considerable risk to a company's brand and reputation if customers, partners, investors and/or employees don't view the firm as responsible with regard to climate change. The potential physical impact of climate change on business operations is another concern among corporate leaders.

Recognizing both that government action is inevitable and that policy decisions made on this issue will have substantial implications for future profits, business leaders increasingly are engaging with policymakers to help influence those decisions. Many of these business leaders favor approaches that level the playing field among companies, create more certainty for businesses, and spread responsibility for GHG emission reductions across all sectors of the economy. The Pew Center on Global Climate Change's Business Environmental Leadership Council includes more than 40 companies at the forefront of corporate action on climate change. Council members'

Figure 4

Drivers of Climate-Related Strategies

How important were the following external drivers in leading your company to pursue its climate-related strategy?



Source: *Getting Ahead of the Curve: Corporate Strategies That Address Climate Change*, Pew Center on Global Climate Change, 2006.

diverse, innovative efforts show the power of business to have a significant impact on reducing GHG emissions while helping the bottom line. These companies employ over 3 million people and have a combined stock market value of over $2.4 trillion. Thirty-two of these companies have set targets that reduce their greenhouse gas emissions.

International Action. Climate change is a global problem requiring a global response. CO_2 emissions have risen 130-fold since 1850 and are projected to increase another 60 percent by 2030. Most emissions come from a relatively small number of countries. An effective strategy to avert dangerous climate change requires commitments and action by all the world's major economies.

The United States, with 5 percent of the world's population, is responsible for 25 percent of global GHG emissions, more than any other country. On an intensity basis (emissions per gross domestic product or GDP), U.S. emissions are roughly 50 percent higher than the European Union's or Japan's. On a per capita basis, U.S. emissions are roughly twice as high as those of the EU and Japan (and five times the world average). U.S. emissions are projected to rise 8 percent above 2004 levels by 2010 (and 28 percent by 2025). By comparison, emissions are projected to hold steady in the EU, and decline 5 percent in Japan, by 2010.

Emissions are rising fastest in developing countries. China's emissions are projected to nearly double, and India's to increase an estimated 80 percent, by 2025. Annual emissions from all developing countries are projected to surpass those of developed countries between 2013 and 2018. Their per capita emissions, however, will remain much lower than those of developed countries. In 2025, per capita emissions in China are expected to be one-fourth—and in India, one-fourteenth—those of the United States.

In 1992, countries signed the United Nations Framework Convention on Climate Change with the objective of avoiding dangerous human interference in the climate system (189 countries, including the United States, have ratified the agreement). In the Convention, developed countries agreed to "take the lead" in addressing climate change and to the voluntary "aim" of reducing their emissions to 1990 levels

by 2000. Soon recognizing that stronger action was needed, governments launched new negotiations on binding emission targets for developed countries. The resulting agreement, the Kyoto Protocol, requires industrialized countries to reduce emissions on average 5.2 percent below 1990 levels by 2008–2012. All major industrialized countries but the United States and Australia have ratified the protocol.

At the national and regional levels, a range of policies contribute to reducing GHG emissions. The most far-reaching is the European Union's Emissions Trading Scheme, which caps emissions from 12,000 facilities across 25 countries. In major developing countries like China and India, policies driven by economic, energy, or development objectives in many cases contribute to GHG reduction. China, for instance, reduced its energy intensity 68 percent from 1980 to 2000 and has ambitious targets to further improve energy efficiency and expand renewable energy.

In 2005, governments launched new processes under the Framework Convention and the Kyoto Protocol to consider next steps in the international effort. The report of the Climate Dialogue at Pocantico, a group of senior policymakers and stakeholders from 15 countries convened by the Pew Center on Global Climate Change, calls for a flexible international framework allowing different countries to take on different types of commitments (including economy-wide emission targets, sectoral agreements, and policy-based approaches). The future of the international effort hinges in large measure on the United States—other major emitters are unlikely to commit to stronger action without the participation of the world's largest economy and emitter. As it strengthens its domestic response to climate change, the United States must also provide the leadership needed for an effective long-term global effort.

The future of the international effort hinges in large measure on the United States—other major emitters are unlikely to commit to stronger action without the participation of the world's largest economy and emitter.

United States: Federal Action. In February 2002, President Bush announced a voluntary target to achieve an 18-percent reduction in U.S. greenhouse gas intensity (the ratio of emissions to gross domestic product) by 2012. Under this target, emissions actually will continue to rise as the economy grows. In 2004, U.S. emissions were 18 percent higher than they were in 1990, and 2.6 percent higher than at the start of 2002. A number of senators and representatives—both Democrats and Republicans—have offered proposals to limit emissions, but a mandatory climate bill has yet to pass in either branch of Congress. Nonetheless, momentum for action is growing, as indicated by the increasing number of bills, votes and hearings held on climate-related issues in Congress in recent years.

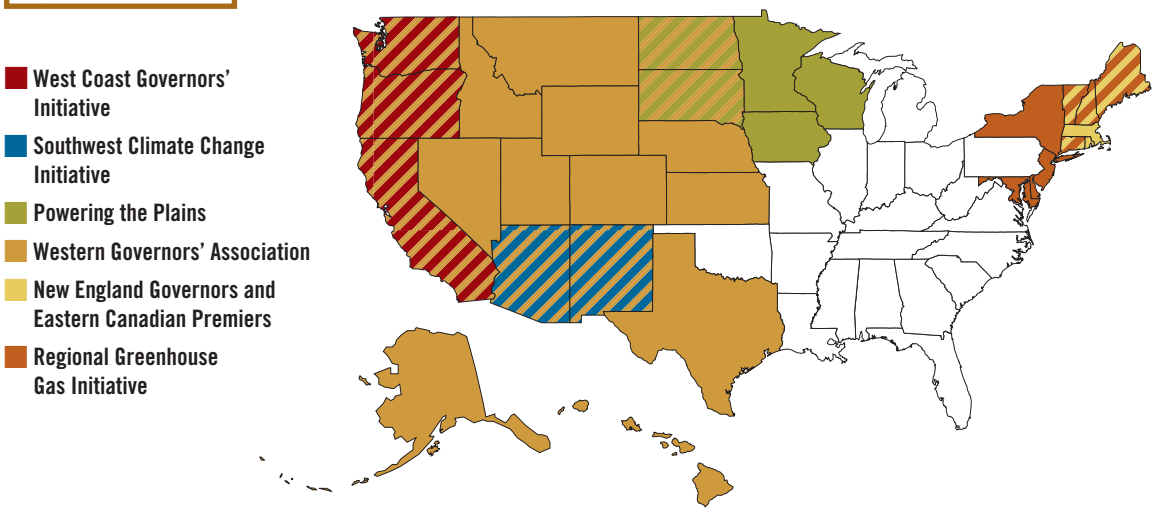
United States: State Action. The lack of action in Washington on the climate issue has prompted many states to seek their own solutions both individually and cooperatively. At this point, nearly every state is engaged in working in some way on climate solutions. By taking action to address climate change, U.S. states are fulfilling their role in American democracy as "policy laboratories," developing initiatives that serve as models for federal action.

To date, states have implemented a broad spectrum of climate policies. Twenty-eight states have adopted climate action plans detailing steps they will pursue in addressing climate change, and 12 states actually have set targets, ranging from modest to aggressive, to reduce their GHG emissions in the decades ahead. Beyond these broad-based plans and targets, many states have adopted sector-specific policies that reduce emissions from electricity generation—for example, by promoting the development of clean and renewable energy resources and by requiring that utilities generate a specified share of power from renewable sources. States also are directing public funds to energy efficiency and renewable energy projects and adopting new standards for power plant emissions and energy efficiency. In the transportation sector, states are adopting policies and standards to promote efficient, low-emission vehicles and climate-friendly fuels. They are also working on smart growth, zoning reform, and transit-oriented development. Agricultural policies also are being redesigned to promote biomass as another solution to climate change.

Among the main motivating factors for state action has been concern about the potential impact of climate change on state economies from consequences such as sea level rise

Figure 5

Regional Initiatives



*States with diagonal shading indicate two categories

or extreme weather. However, many state leaders also see enormous and largely untapped economic opportunities that will come with developing new markets for climate-friendly technologies. In contrast to the global warming debate at the federal level, climate-related policies typically enjoy bipartisan support among the states.

This activity on the part of states is significant because some U.S. states are major emitters of greenhouse gases, producing levels comparable to those of many developed countries. In addition, state actions are showing it is possible to reduce emissions and spur technological innovation without endangering economic competitiveness. And, through interstate partnerships (see Figure 5), states are demonstrating the power of collective action to reduce costs and to achieve increased efficiency, while cutting emissions across a larger geographic area.

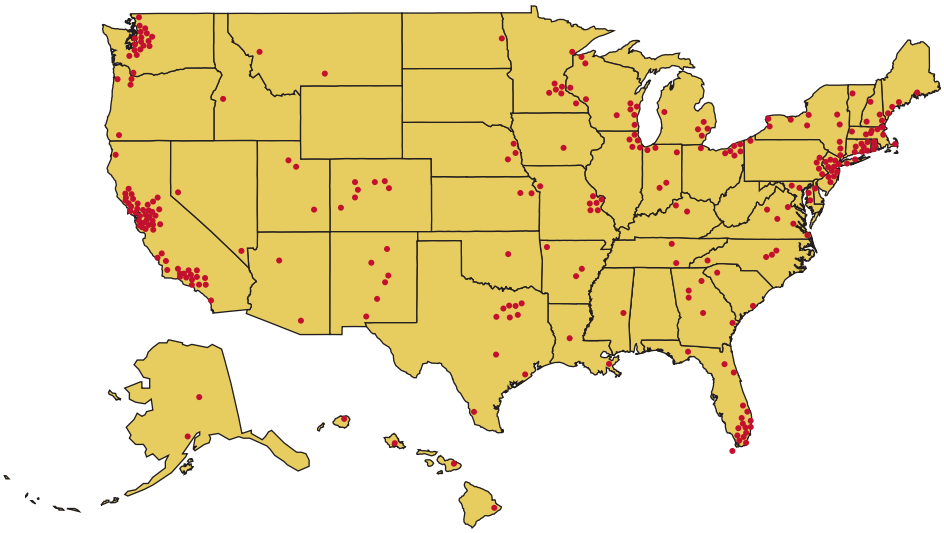
In addition to spotlighting what works, however, states also are demonstrating that their efforts alone are not enough. States have limited resources and strict budget requirements that make far-reaching climate policies difficult to implement, and they also lack certain powers that would be crucial to a comprehensive climate change policy. Moreover, the patchwork quilt that can result when states take individual approaches to the climate issue can be inefficient and pose challenges for business. State action is important, but strong and coherent federal policies are needed to ensure consistency and to mobilize climate solutions throughout the economy and the nation.

Local Action. State leaders are hardly alone in their movement to address climate change. Across the country and all over the world, city and county governments are implementing their own policies aimed at reducing greenhouse gas emissions. Cities have a strong history of climate action, and continue to mount responses to climate change that are resulting in emissions cuts. Cities are working together to achieve their goals through a number of programs and mechanisms, including the International Council for Local Environmental Initiatives and the U.S. Mayors Climate Protection Agreement, both of which have experienced dramatic growth in participation.

Policies adopted by cities and towns within the United States span everything from energy supply to transportation to tree planting. Local leaders are taking action because they recognize that their communities have a lot to lose should emissions remain unchecked and climate change accelerate. Many of the potential effects of climate change—such as extreme weather, higher sea levels and reduced water supplies—will be felt most sharply by urban populations. In addition to reducing risks, cities and towns also can realize

Figure 6

Cities Committed to the U.S. Mayors Climate Protection Agreement



Mayors of 320 cities have signed the U.S. Mayors Climate Protection Agreement as of October 2006.
Source: http://www.seattle.gov/mayor/climate/

indirect benefits by tackling climate change, such as energy savings and improved air quality. Localities, like the states, are offering lessons in what works to protect the climate. However, as is the case with action by the states, a patchwork of local policies is no substitute for economy-wide action at the federal and international level.

THE PATH FORWARD

The science is clear. Climate change is happening, and the time to act is now. While the early actions of local and state governments, nations, and business leaders are significant, climate change remains a global problem requiring a global solution. Ultimately, a fair and effective international approach must engage all of the world's major economies and allow enough flexibility for all countries to contribute. Substantive U.S. engagement at the international level is going to be crucial to the success of the global effort. On the domestic front, the federal government needs to adopt policies that recognize that climate change is real, and that it poses both risks and opportunities for the United States and the rest of the world. With comprehensive federal policy and constructive international engagement, the United States can harness the power of markets to drive innovation and protect the climate.

Pew Center on Global Climate Change

More information on climate change solutions is available at www.pewclimate.org.

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The Pew Center on Global Climate Change is a non-profit, nonpartisan, independent organization dedicated to providing credible information, straight answers, and innovative solutions in the effort to address global climate change.

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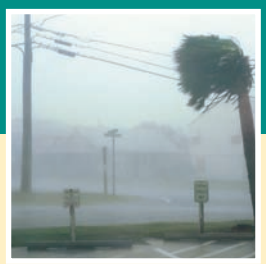
CLIMATE CHANGE 101
The Science and Impacts



Scientists now know for certain that the earth has been warming for the past century. They know that human activities, mainly the burning of coal and oil, have dramatically increased concentrations of heat-trapping gases in the atmosphere. And they understand the science of how these gases are causing the observed warming. As a result, they predict that the world will continue to warm in the centuries ahead, with significant impacts on sea levels and weather patterns, and consequences for human health, ecosystems, and the economy. Avoiding the most severe impacts, scientists say, will require substantial reductions in emissions of the greenhouse gases that are contributing to climate change.

GLOBAL TEMPERATURES: THE EARTH IS WARMING

The world is getting warmer. Average global temperatures have risen by more than 1 degree Fahrenheit over the last century, with average warming of as much as 4 degrees Fahrenheit in some regions (see Figure 1).[1]

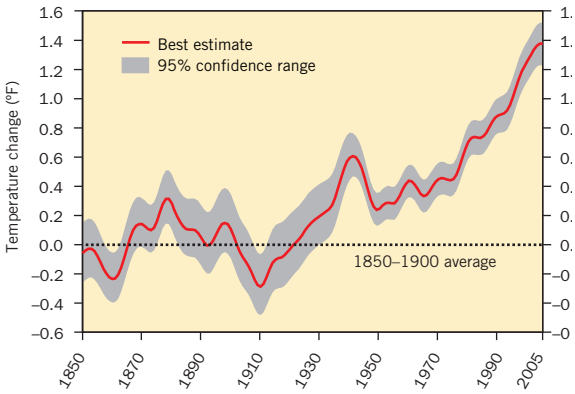
According to scientists, this warming trend has accelerated in recent years. The ten warmest years since thermometer records became available in 1860 all occurred between 1995 and 2005.[2] The World Meteorological Organization has reported that 2005 was the second hottest year on record, surpassed only by 1998, when El Niño conditions in the Pacific Ocean contributed to above-average temperatures worldwide. For the United States, the first six months of 2006 were the warmest such period on record.[3] No U.S. state was cooler than average for the six-month period; five states—Texas, Oklahoma, Kansas, Nebraska and Missouri—experienced record warmth.

Accompanying the increased temperatures at the earth's surface has been a significant rise in ocean temperatures to a depth of 700 meters. Scientists from the U.S. National Oceanic and Atmospheric Administration have demonstrated that the ocean as a whole has been warming for the past five decades.[4] The highest level of warming was recorded at the upper levels of the oceans, evidence that the oceans are absorbing most of the increased heat from the earth's surface (see Figure 2).[5]

Even if greenhouse gas concentrations were stabilized today, the heat that is already in the ocean will warm the atmosphere over time, bringing an additional 1 degree Fahrenheit of warming by the end of the twenty-first century.[6]

Figure 1

Global Surface **Temperature Trend** 1850-2005



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The increases in global temperatures will continue in the decades ahead, scientists say. According to the Intergovernmental Panel on Climate Change (IPCC), which includes more than 2,000 scientists from the United States and other countries, over the next century, average global temperature will rise by two-and-a-half to ten degrees Fahrenheit.[7] Regional increases may be greater or less than the global average, according to the IPCC. For example, the level of warming in the United States is projected to be higher than the global average.[8] The Arctic is likely to experience the greatest warming.

The problem is not just changing temperatures; it is a changing climate—or a change in the weather patterns that people and ecosystems have become accustomed to over time.[9] In fact, "climate change" and "global warming" often are used interchangeably to describe the same phenomenon.

GREENHOUSE GASES: MAKING THE CONNECTION

Global temperatures have experienced natural shifts throughout human history. For example, the climate of the Northern Hemisphere varied from a relatively warm period between the eleventh and fifteenth centuries to a period of cooler temperatures between the seventeenth century and the middle of the nineteenth century.

However, scientists studying the rapid rise in global temperatures during the late twentieth century say that natural variability cannot account for what is happening now.[10] The main culprit, they say, is emissions of carbon dioxide and other greenhouse gases from human activities, primarily the

Figure 2

Ocean Heat Content

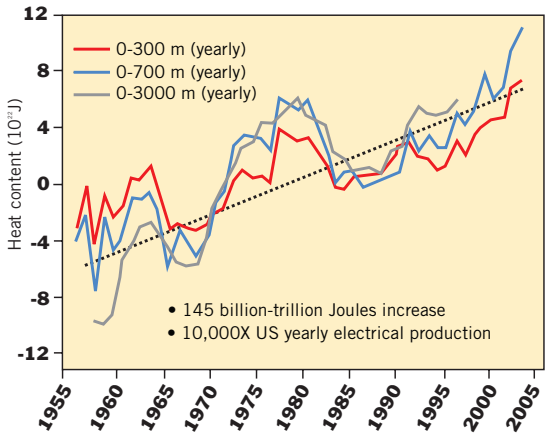

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Figure 3

The Greenhouse Effect

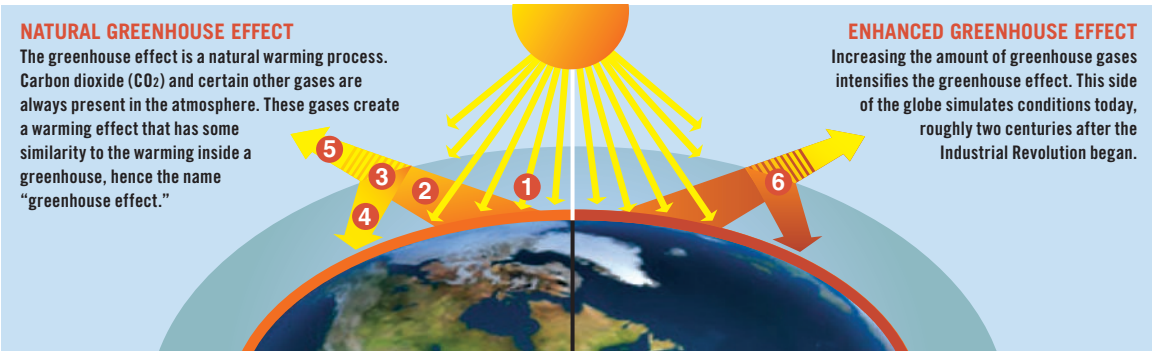

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Illustration of the greenhouse effect (courtesy of the Marian Koshland Science Museum of the National Academy of Sciences). Visible sunlight passes through the atmosphere without being absorbed. Some of the sunlight striking the earth ❶ is absorbed and converted to heat, which warms the surface. The surface ❷ emits heat to the atmosphere, where some of it ❸ is absorbed by greenhouse gases and ❹ re-emitted toward the surface; some of the heat is not trapped by greenhouse gases and ❺ escapes into space. Human activities that emit additional greenhouse gases to the atmosphere ❻ increase the amount of heat that gets absorbed before escaping to space, thus enhancing the greenhouse effect and amplifying the warming of the earth.

burning of fossil fuels such as coal and oil. Other human sources of these gases include deforestation, agriculture and industrial processes.

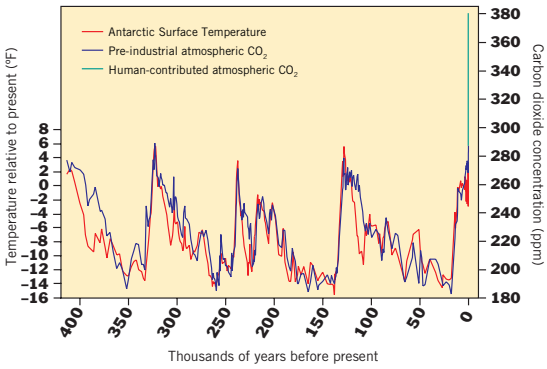
Scientists refer to what has been happening in the earth's atmosphere over the past century as the "enhanced greenhouse effect." By pumping man-made greenhouse gases into the atmosphere, humans are altering the process by which naturally occurring greenhouse gases trap the sun's heat before it can be released back into space.

The greenhouse effect keeps the earth warm and habitable; without it, the earth's surface would be about 60 degrees Fahrenheit colder on average. Since the average temperature of the earth is about 45 degrees Fahrenheit, the natural greenhouse effect is clearly a good thing. But the enhanced greenhouse effect means even more of the sun's heat is trapped, causing global temperatures to rise (see Figure 3).

Among the many scientific studies providing clear evidence that an enhanced greenhouse effect is under way was a 2005 report from NASA's Goddard Institute for Space Studies. Using satellites, data from buoys, and computer models to study the earth's oceans, scientists concluded that more energy is being absorbed from the sun than is emitted back to space, throwing the earth's energy out of balance and warming the globe.[12]

Figure 4

Global Temperature: The Last 400,000 Years



IPCC TAR, 2001

Through the cycle of ice ages, atmospheric CO_2 closely tracks the surface temperature. As temperatures rise, biological activity produces more CO_2, which increases the warming and stimulates more CO_2 production. During the past 400,000 years, CO_2 concentrations never exceeded 300 ppm (parts per million) until industrialization occurred. Current concentrations now exceed that historical maximum by about 80 ppm due to human contributions.

At Issue: Measuring Satellite vs. Surface Temperatures

For many years, skeptics of climate change have pointed to differences between temperature increases recorded at the earth's surface and those recorded by satellites as a way to challenge scientific claims about climate change. However, a May 2006 report from the U.S. Climate Change Science Program corrected errors in the satellite data and other temperature observations, concluding that "(t)he previously reported discrepancy between surface and atmospheric temperature trends is no longer apparent on a global scale."[11]

How much of a jump have we seen in greenhouse gases? In its first *Greenhouse Gas Bulletin*, issued in March 2006, the World Meteorological Organization said average global concentrations of the three main greenhouse gases—carbon dioxide, methane, and nitrous oxide—continued their year-after-year climb in 2004. Compared to pre-industrial times, concentrations of the most abundant greenhouse gas, carbon dioxide, were up by 35 percent, while methane levels had increased by 155 percent and nitrous oxide by 18 percent.[13]

Looking back even further, scientists say the world is entering largely uncharted territory as atmospheric levels of greenhouse gases continue to rise. Today's carbon dioxide levels are substantially higher than anything that has occurred for more than 400,000 years. And, even over all those millennia, there has been a clear correlation between carbon dioxide levels and global temperatures (see Figure 4).

There is no doubt among scientists that the recent spike in carbon dioxide and other greenhouse gases in the atmosphere is the result of human activities. The World Meteorological Organization and many other scientific organizations have confirmed this relationship. While there are natural processes that produce these gases, they are balanced out by other

natural processes that consume them. Therefore, the current rise in atmospheric greenhouse gases can only be explained by human activities that pump additional gases into the atmosphere at a rate of billions of tons each year. A recent review of more than 900 journal articles on climate change revealed that not one of the authors disagreed with the evidence showing that human greenhouse gas emissions impact the climate.[14]

Many of the predictions that scientists have made in the past about the impacts of global warming are already upon us.

In 2005, the United States National Academy of Sciences joined a group of 10 other science academies from around the world in a statement calling for "prompt action" on global warming by world leaders. The statement could not have been more explicit about the connection between human activity and climate change. It stated: "Action taken now to reduce significantly the build-up of greenhouse gases in the atmosphere will lessen the magnitude and rate of climate change."

THE CHANGING CLIMATE: FROM THEORY TO REALITY

It is not just rising average global temperatures that concern scientists but also their effects on weather extremes, declining global ice cover and sea level rise. In fact, many of the predictions that scientists have made in the past about the impacts of global warming are already upon us, including disappearing glaciers, loss of sea ice, more extreme heat waves, accelerated sea level rise, and stronger hurricanes. Scientists say these effects are likely to worsen in the decades ahead.

RISING SEA LEVEL

Among the most serious and potentially catastrophic effects of global warming is sea level rise, caused by a combination of melting glaciers all over the world and the "thermal expansion" of the seas as oceans warm. By the end of the century, if nothing is done to rein in emissions of greenhouse gases, global sea level may be three feet higher than today and rising.[15]

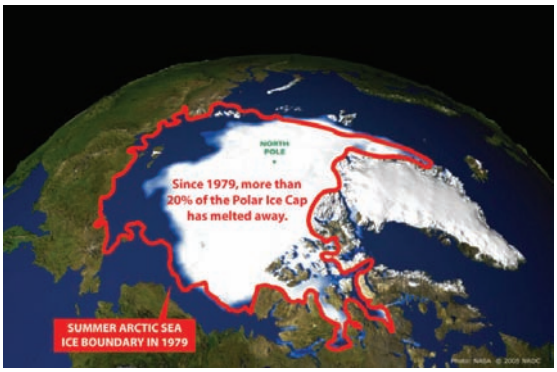
Rising sea level will have severe impacts in low-lying coastal communities throughout the world. In Bangladesh, for example, even a one-meter rise would inundate 17 percent of the country. In the United States, where 54 percent of the population lives in close proximity to the ocean, the most vulnerable areas are the Southeast and Mid-Atlantic coasts. Also at risk are low-lying areas and bays such as North Carolina's Outer Banks, the Florida Coast, and much of southern California.

Melting Polar Ice. In November 2004 an international team of 300 scientists from 15 countries, including the United States, issued a report on the impacts of climate change in the Arctic. In addition to painting a stark picture of how climate change already is affecting the region, the report of the Arctic Climate Impact Assessment predicted that at least half the summer sea ice in the Arctic will melt by the end of this century, along with a significant portion of the Greenland Ice Sheet (see Figure 5).[16]

The decline of the Greenland Ice Sheet was the focus of a February 2006 article in the journal *Science*.[17] Using new satellite-based measurements, researchers showed that the second largest land-based ice sheet in the world is losing ice twice as fast as scientists had estimated. A complete melting of this ice sheet could raise global sea level by almost 20 feet

Figure 5

Summer Arctic Sea Ice Extent



NASA* and *Natural Resources Defense Council

within a few hundred years, a level that would permanently flood virtually all of America's major coastal cities.

Ice cover loss is not limited to the northern hemisphere. Another *Science* article in March 2006 revealed that Antarctica also is losing massive amounts of ice to the melting and slipping of glacier ice into the ocean, a natural process that has been accelerated by global warming.[18] The result is a net loss of polar ice that is adding billions of tons of water each year to the world's oceans.

In addition to causing sea level rise, the disappearance of polar ice actually will intensify global warming. Because water absorbs more solar radiation than ice, as the poles lose ice cover, more heat from the sun will be absorbed at the earth's surface instead of being reflected back into space by the snow and ice.

Loss of Mountain Glaciers and Snow Pack. In addition to the loss of polar ice, climate change is causing a worldwide loss of mountain glaciers at all latitudes. Scientists have observed that glaciers are in retreat in all regions of the world, from the Himalayas to tropical South America to the western United States. By mid-century, scientists say, most mountain glaciers may be gone. If the current rate of global warming continues, there will be no glaciers left in Glacier National Park by 2030.[19]

In addition to contributing to sea level rise, the melting of mountain glaciers also poses a threat to global water supplies. Billions of people around the world depend solely on glaciers for irrigation and drinking water.

Expansion of the Oceans. Another cause of sea level rise is what scientists refer to as the "thermal expansion" of the oceans—put simply, as the oceans continue to warm, they will expand. Even if no more greenhouse gases are added to the atmosphere, global sea level will rise by four inches over the next century because of thermal expansion alone, according to researchers at the National Center for Atmospheric Research.[20]

Even if no more greenhouse gases are added to the atmosphere, global sea level will rise by four inches over the next century because of thermal expansion alone.

CHANGING WEATHER PATTERNS

Scientists predict that climate change will have a significant effect on global weather patterns, causing both more floods and more droughts. Extended heat waves, more powerful storms, and other extreme weather events have become more common in recent years and will continue on this trend. These changes in weather patterns will have serious—and potentially severe—impacts on human societies and the natural world.

Stronger Hurricanes. The 2005 hurricane season in the Atlantic Ocean, with four Category 5 storms for the first time in recorded history, raised questions in many Americans' minds about the potential connections between hurricanes and climate change. Now, scientists have confirmed that hurricanes are becoming more intense—not just in the Atlantic but in all oceans where they occur.[21]

Why would climate change make hurricanes stronger? The answer, scientists say, is because hurricanes draw their strength from the heat in ocean surface waters. Therefore, as ocean waters grow warmer, hurricanes will become more powerful on average, a trend that is already evident over the past 35 years.

At Issue: Twentieth-Century Temperature Trends

Scientists have noted a distinct pattern of warming during the twentieth century, with a large warming between 1910 and 1940, moderate cooling from 1940 to 1975, and a large warming again starting in 1975. The most likely reason for the cooling during the middle of the century: a surge in sun-blocking aerosols, or very fine particles, resulting from volcanic eruptions, human pollution, and other sources.[22] Scientists expect that these causes are on the decline, while greenhouse gas emissions are on the rise, and that both trends will continue.

While there is no way to link one hurricane directly to climate change, Hurricane Katrina, which wreaked havoc along the U.S. Gulf Coast in August 2005, showed the potential of warm ocean waters to contribute to stronger storms. At the same time that Katrina was exploding from a tropical storm to a Category 5 hurricane while still at sea, the surface waters in the Gulf of Mexico were unusually warm—about 2 degrees Fahrenheit warmer than normal for that time of year. With global warming causing ocean temperature to rise, we should expect hurricanes like Katrina to become more and more common.

More Droughts and Flooding. Other weather impacts from climate change include a higher incidence of drought and flooding and changes in precipitation patterns. According to the Intergovernmental Panel on Climate Change, future changes in weather patterns will affect different regions in different ways. In the short term, for instance, farms and forests may be more productive in some regions and less productive at others. Among the reasons: precipitation will increase in high-latitude regions of the world in summer and winter, while southern Africa, Australia and Central America may experience consistent declines in winter rainfall.[23] As a result of these changes, agriculture in developing countries will be especially at risk. Wheat, for example, may virtually disappear as a crop in Africa, while experiencing substantial declines in Asia and South America.[24]

Two reports released by the Pew Center on Global Climate Change in 2004 looked at the likely impact of climate change on the United States. The U.S. areas most at risk, according to the reports, will be the Southeast and southern Great Plains because of the low-lying coasts in the Southeast and the long-term impacts of warmer temperatures on agriculture in both regions. The reports also warned of the potential impacts of climate change on long-lived infrastructure in the United States, especially the nation's water resources.[25]

Climate change holds the potential of inflicting severe damage on the ecosystems that support all life, from hazards to coral reefs due to warmer and more acidic ocean waters to threats to polar bears because of declines in sea ice

Effects on Human Health. A recent United Nations report blamed climate change, along with worsening air and water quality and poor disposal of solid waste, for an increase in malaria, cholera and lower respiratory tract infections in African societies. Africans also are suffering from the effects of reduced crop yields and decreased availability of water.[26] The U.N. report on Africa provides an early glimpse of some of the ways in which scientists say climate change will affect people's health in the decades to come, no matter where they live. Climate change can affect human health directly (for example, because of extreme temperatures and heat waves) and indirectly (for example, by contributing to the spread of infectious disease or threatening the availability and quality of food and water). The elderly, the infirm and the poor will be especially at risk.[27]

Effects on Ecosystems. Climate change holds the potential of inflicting severe damage on the ecosystems that support all life, from hazards to coral reefs due to warmer and more acidic ocean waters to threats to polar bears because of declines in sea ice. Ecosystems around the world already are reacting to a warming world.

For example, one study found that 130 species, including both plants and animals, have responded to earlier spring warming over the last 30 years. These organisms have changed their timing of flowering, migration and other spring activities. The changes occurred regardless of regional difference and were linked directly to enhanced greenhouse warming.[28]

Researchers also have established that climate change is driving some species to extinction. For instance, in the past 20 years dozens of species of mountain frogs in Central America have disappeared because of a disease that formerly did not occur where they live. In 2006, a paper in the journal *Nature* revealed that the disease-causing organism, a fungus, has spread to higher elevations as a result of human-induced climate change.[29]

In other scientific findings, biologists have observed changes in Arctic ecosystems as a result of sea ice loss, including changes in fish populations in southern reaches of the Arctic seas.[30] And researchers predict that if ocean warming continues (along with ocean acidification from rising atmospheric concentrations of carbon dioxide), the world's coral reefs will be at risk from an increase in "coral bleaching," which can ultimately kill the corals and endanger the fish and other creatures that depend on the reefs.[31]

WHAT CAN BE DONE?

The greenhouse gases that are already in the atmosphere because of human activity will continue to warm the planet for several centuries. In other words, some level of continued climate change is inevitable, meaning that humanity is going to have to take action to adapt to a warming world.

However, scientists say it is still possible—and necessary—to reduce the magnitude of climate change by "stabilizing" atmospheric concentrations of greenhouse gases. This means stopping these concentrations from rising further, chiefly by achieving substantial reductions in emissions of carbon dioxide and other greenhouse gases from human sources.

The consensus among climate scientists is that worldwide emissions of greenhouse gases need to start a long-term decline within the next decade or two. According to the Intergovernmental Panel on Climate Change, the world needs to reduce total emissions by about 50 to 80 percent (compared to a business-as-usual scenario) in order to stabilize atmospheric greenhouse gas concentrations and avoid dangerous climatic change.[32]

The science makes it abundantly clear: the time to act is now. The world is already facing severe consequences; we must respond to the overwhelming scientific evidence and take strong action to reduce the greenhouse gas emissions that cause climate change.

Pew Center on Global Climate Change

For more information on the science and impacts of climate change visit www.pewclimate.org.

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CLIMATE CHANGE 101
Technological Solutions

Achieving the 50- to 80-percent reduction in greenhouse gas emissions that scientists say is needed to avoid the worst effects of climate change will not be easy. It will require action across all sectors of the economy, from electricity and transportation to agriculture. Cost-effective opportunities exist today for starting the world on a path toward lower emissions—and there are a number of emerging technologies that hold enormous promise for delivering substantial emission reductions in the future. The successful development of these technologies will require substantial new investments in research, incentives for producers and consumers, and emission reduction requirements that drive innovation. Governments at all levels need to encourage short-term action to reduce emissions while laying the groundwork for a longer-term technology revolution.

THE DAWNING OF A REVOLUTION

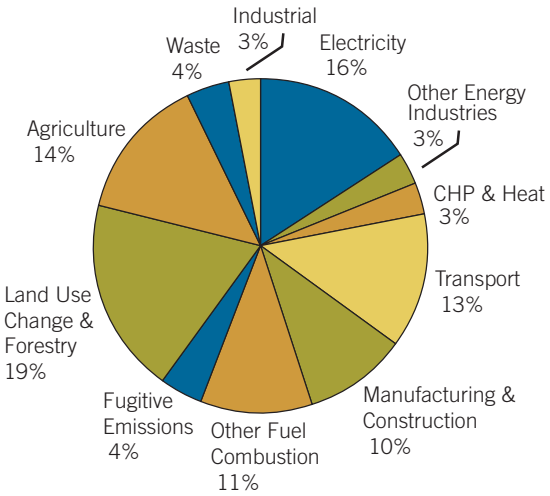
The greenhouse gas (GHG) emissions that are causing global warming come from a wide range of sources, including cars and trucks, power plants, farms, and more (see Figure 1). Because there are so many sources of these gases, there are also many options for reducing emissions, including such readily available steps as improving energy efficiency and changing industrial processes and agricultural practices.

However, seriously addressing global climate change will require a decades-long commitment to develop and deploy new, low-GHG technologies around the world. Most importantly, the world needs to fundamentally change the way it produces and consumes energy. The global population is rising fast; in developing and developed countries alike, population and income growth means more people are using more energy, driving more cars and trucks, and building more homes.

Without a revolution in energy technology, human societies will be pumping ever-increasing amounts of greenhouse gases into the atmosphere, with potentially dramatic effects on

Figure 1

Global GHG Emissions by Sector, 2000



Source: Pew Center on Global Climate Change, *Climate Data: A Sectoral Perspective*

PEW CENTER ON Global CLIMATE CHANGE

PEW CENTER THE on STATES

This brief is part of a series called *Climate Change 101: Understanding and Responding to Global Climate Change*, published by the Pew Center on Global Climate Change and the Pew Center on the States.

the global climate. The time to begin making the necessary investments in new technologies is right now.

Achieving substantial reductions in greenhouse gas emissions is possible—now and in the decades to come. Some emissions-reducing technologies (such as hybrid gas-electric cars and wind power) are commercially competitive today. Others (such as plug-in hybrid cars and solar power) are on their way. And still more (such as hydrogen fuel cells and storing carbon dioxide emissions underground) show great promise, but additional work is needed to demonstrate their effectiveness and cost-effectiveness.

Almost all of these technologies are going to need help moving from the laboratory to the marketplace. Right now, the true "costs" of greenhouse gas emissions are not reflected in the marketplace, meaning there is little incentive for producers or consumers to reduce their contribution to the climate problem. In addition to policies that send a clear "price signal" by placing real limits on emissions, governments will need to invest in research to develop some of the most critical, long-term, climate-friendly technologies and to ensure that they can gain a solid foothold in the marketplace. Consumers and businesses also need government incentives to purchase these technologies so they can enter the mainstream and contribute to substantial reductions in emissions.

Opponents of strong action to address climate change often focus on the economic costs of reducing emissions. Yes, massive investments are needed. But the cost of inaction is even greater. In addition, a global technology revolution will create enormous economic opportunities for businesses and workers, as well as the localities and states that successfully position themselves as centers of innovation and technology development for a low-carbon world.

LOOKING AT THE KEY TECHNOLOGIES

There is no single, silver-bullet technology that will deliver the reductions in emissions that are needed to protect the climate. Success will require a portfolio of solutions, many of which are available today. Looking across key sectors of the economy, it is possible to identify those technologies that may help the most. For policymakers, the priority must be to create incentives that will unleash the power of the marketplace to develop solutions, rather than to pick technologies based on predictions of future performance.

As shown in Figures 2 and 3, most greenhouse gas emissions in the United States can be traced to the electricity, building and transportation sectors. The following pages look at technology options for reducing emissions from each of these critical sectors.

GHG Emissions in the United States

Figure 2
Sources of U.S. CO_2 Emissions in 2002

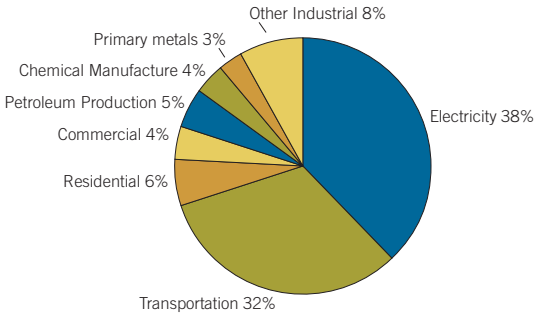
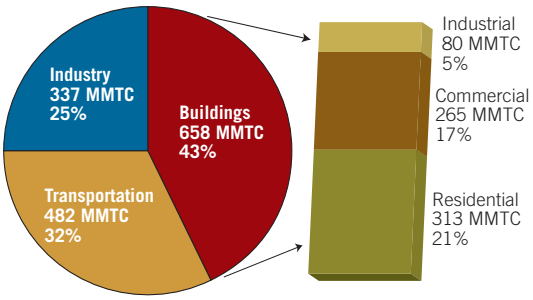


Figure 3
CO_2 Emissions from Fossil Fuel Combustion by End-Use Sector, 2002



Sources: Pew Center on Global Climate Change, *The U.S. Electric Power Sector and Climate Change Mitigation* and *Towards a Climate Friendly Built Environment*

ELECTRICITY AND BUILDINGS

The electricity sector produces 38 percent of U.S. carbon dioxide emissions. Most of the electricity generated by the sector is used in the nation's homes, offices and industrial structures to power everything from heating and cooling systems to lights, computers, refrigerators and cell phones.

This massive use of electricity is not the only way in which buildings contribute to climate change. Non-electrical energy sources such as natural gas furnaces also produce greenhouse gases on their own.

Because they make such a significant contribution to the problem, the electricity and building sectors also can play a crucial role in solutions to climate change.

Because they make such a significant contribution to the problem, the electricity and building sectors also can play a crucial role in solutions to climate change. Reducing emissions from these closely related sectors requires looking at both electric power and building technology options. In other words, it's important to think about the roles of both the producers and the consumers of power.

Electric Power Options. Greenhouse gas emissions from the electric power sector come primarily from power plants burning coal or natural gas. Options for reducing these emissions include:

- ***Improved Efficiency.*** Technologies are available today to produce electric power and heat more efficiently using both fossil fuels and renewable energy. Power plants using the Integrated Gasification and Combined Cycle (IGCC) process, for example, deliver efficiency gains along with reductions in air pollution by converting coal into a cleaner-burning gas. Additional efficiency gains can come from advanced technologies for other fuel sources in power plants, including natural gas and biomass.

- ***Renewable Energy.*** Renewable energy harnesses the power of the wind, the sun, water, tides and other forces to produce electric power. Agricultural "biomass" products also can be used to generate electricity and heat when combusted with coal. Renewables offer the potential to generate electricity without producing greenhouse gases—or producing very little when compared to traditional energy sources. Most renewable resources can be harnessed on a large-scale basis (for example, via wind farms or large geothermal fields) or in more "distributed" forms (for example, by placing solar panels on rooftops). Although larger-scale renewable energy can be cost-competitive with other forms of conventional electricity in some cases, renewables still count for only a tiny share of overall electricity generation in the United States.[1] Options for expanding the use of renewables include Renewable Portfolio Standards, which require generators to produce a specified share of power from renewable sources; consumer rebates and other government incentives;[2] and further support for research and development to advance the technologies and lower their costs.

- ***Carbon Capture and Sequestration.*** As noted above, IGCC power plants can convert coal into a gas that produces substantially fewer pollutants when burned; the IGCC process also allows for the relatively easy "capture" of carbon for long-term storage in underground geological formations. The United States has built demonstration plants using these technologies, and at least one commercial IGCC plant is being planned. But the overwhelming majority of coal-burning power plants in the United States are conventional plants, and more work is needed to provide power producers with the incentives to build cleaner-burning power plants as soon as possible, and to bring down the costs of capturing carbon from conventional coal plants. Work also is needed to prove that underground storage (or sequestration) of carbon on a large scale is a good long-term option for keeping it out of the atmosphere.

- ***Nuclear Power.*** Nuclear power currently provides roughly 20 percent of U.S. electricity with virtually no associated greenhouse gas emissions. Yet, for nuclear power to play a more prominent role in U.S. efforts to address climate change, the industry needs to overcome several important hurdles. These include concerns among citizens and elected officials about the cost of nuclear-generated

electricity; technical, political and environmental concerns about nuclear waste disposal; and threats associated with increased risk of nuclear arms proliferation. No new nuclear plant has been ordered in the United States since 1979, although groups of companies are currently pursuing applications for new plants.[3]

Options for Buildings. Greenhouse gas emissions from the building sector result primarily from the use of power-hungry items such as lighting fixtures, appliances, and heating and cooling systems.[4] Cost-effective technologies for reducing emissions from buildings are readily available, but they often can't compete in the marketplace. Among the reasons are a lack of consumer information, and "market barriers" such as the high fees that electric utilities often charge for back-up power to customers using their own sources of energy.

Because of inefficiencies in how power is generated and reaches consumers, reductions in demand by energy users result in even larger energy savings by the generator. Options for reducing emissions from buildings include encouraging greater energy efficiency and promoting on-site power generation.

- ***Efficiency.*** There are many ways to increase the overall energy efficiency of buildings. From more efficient lighting and instantaneous hot water heaters to EnergyStar®-certified[5] products and better insulation, consumers and businesses have an array of cost-effective options for limiting their energy use and boosting efficiency. However, consumers often do not take advantage of these options on their own. Policymakers can help promote greater energy efficiency through enhanced building codes; building standards, awards or certifications to buildings that are energy-efficient; suspended sales taxes on efficient appliances; publicly funded utility efficiency programs; regulatory reforms that reduce barriers to energy efficiency; appliance standards and labeling; and other steps.

- ***On-site Power Generation.*** Greenhouse gas emissions from the electricity and building sectors also can be reduced through on-site power generation using renewables and other climate-friendly energy resources. Examples include rooftop solar panels, solar water heating, small-scale wind generation, stationary fuel cells powered by natural gas or renewable hydrogen,[6] and geothermal heat-pumps. While the costs for all of these options are falling, some of the technologies remain fairly expensive and thus are not widely used in the marketplace. Expanding their use—which will ultimately reduce costs—may require new incentive programs such as consumer rebates and tax credits. Building standards (such as LEED™–certification)[7] also can help. In addition, combined heat-and-power (or cogeneration) plants, rather than wasting the excess heat generated in the course of producing electricity, capture it for use in heating homes and industrial sites. Many of these technologies already are cost-effective, but they can't compete in the market because of regulatory hurdles and other barriers.

A Key Role for Agriculture

Emissions from agriculture account for approximately 8 percent of U.S. greenhouse gas emissions. Reducing these emissions can make an important contribution to the United States' overall efforts to address climate change. But agriculture can be a part of the solution in other ways as well. For example, less productive agricultural lands can be reforested with carbon-dioxide-consuming trees; and farming practices can be altered to absorb and retain carbon in agricultural soils. At moderate cost, these steps could offset up to 25 percent of current U.S. carbon-dioxide emissions.[8] In addition, biomass from agricultural sources (including corn and grasses) could be used to produce biofuels that can take the place of high-carbon fossil fuels used in transportation and power generation. Many of the farming practices and land use changes involved in achieving these reductions have multiple benefits, including improving soil, water and air quality; increasing wildlife habitat; and providing additional recreational opportunities.

TRANSPORTATION

After the electricity or buildings sector, transportation is the second largest source of greenhouse gas emissions in the United States, primarily carbon dioxide produced by cars and trucks. The ways in which we move from place to place are responsible for almost one-third of U.S. carbon

dioxide emissions, and nearly a quarter of emissions around the world.

Reducing greenhouse gas emissions from transportation can be accomplished in a number of ways. Among the options:

- Adopting new emissions-reducing technologies for cars and trucks;
- Reducing the carbon content of vehicle fuels; and
- Reducing demand for vehicle travel by encouraging "smart growth" and the use of mass transit.

Historically, it has proven very hard to get people to drive less. The way most Americans live today, our cars and trucks are an essential part of our daily lives. There are ways to make Americans less automobile-dependent and new options such as car-sharing and smart growth are emerging.

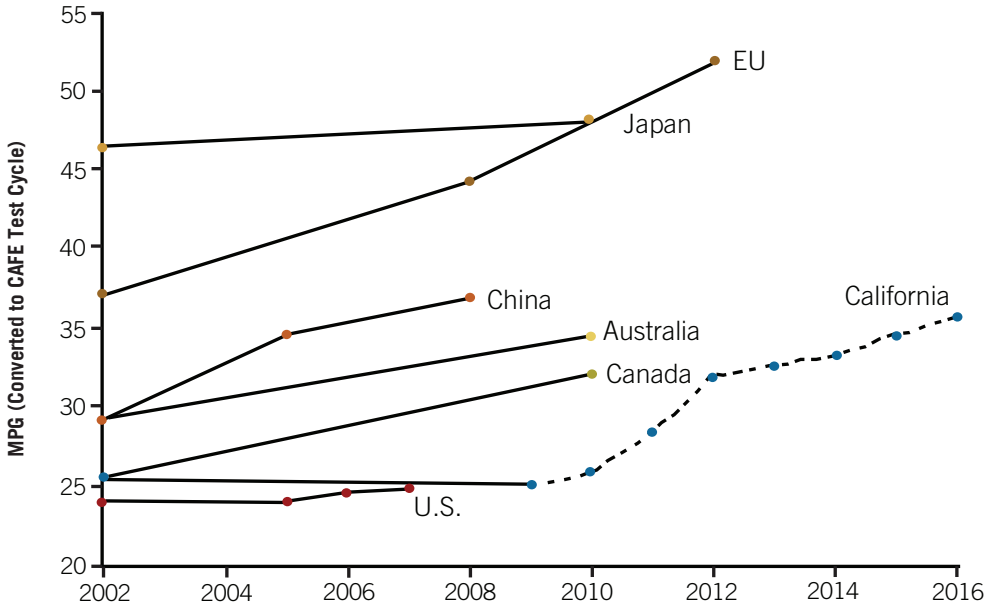
The challenge for lawmakers at all levels is to promote and encourage short-term solutions (for example, more hybrid cars and trucks) while facilitating a long-term transition to alternatively-fueled vehicles.

Short-Term Options: Energy Efficiency, Fuel Blending, Advanced Diesels and Hybrids. Significant reductions in greenhouse gas emissions from conventional cars and trucks are possible through the use of "off-the-shelf" technologies that are commercially available today. One recent study found that commercial (and cost-effective) technologies exist right now to increase fuel economy and/or reduce tailpipe greenhouse gas emissions by as much as 25 percent.[9]

In the United States, however, the average fuel economy of all cars and light trucks sold today is no better than it was in the early 1980s. As Figure 4 shows, governments around the world have adopted more stringent policies than the United States to reduce tailpipe greenhouse gas emissions and/or increase fuel economy. These policies can play a crucial role in hastening the rollout of commercially available technology to reduce vehicle emissions.

Figure 4

Fuel economy and GHG emission standards around the world[10]



Notes: (1) dotted lines denote proposed standards (2) MPG = miles per gallon (3) CAFE is Corporate Average Fuel Economy

Another option for reducing greenhouse gas emissions from cars and trucks in the short term is the blending of ethanol and other biologically-derived fuels with gasoline. Ethanol derived from corn is currently the dominant biofuel in the United States. Depending on how it is produced and processed, corn-based ethanol can yield reductions of as much as 30 percent in emissions for each gallon of regular gasoline that it replaces. Other biofuels that can be developed over the longer term promise to deliver significantly larger reductions (see below).

With ethanol from sugar cane providing almost half of its domestic passenger fuel, Brazil has shown that an aggressive policy push can help biofuels become a mainstream fuel choice.

Beyond these "off-the-shelf" options for reducing car and truck emissions, even greater reductions are available through the use of advanced diesel and hybrid vehicle technologies.

Diesels and hybrids use different engines than the standard internal combustion engine; diesels also use different fuels. The key advantage of these technologies is that they both offer significant improvements in fuel economy. Because hybrid and diesel vehicles use less gas on a per-mile basis, they produce fewer greenhouse gas emissions when compared to other cars and trucks. When both technologies are combined in a diesel hybrid vehicle, it can yield a 65-percent reduction in greenhouse gas emissions per mile.[11]

Longer-term Options: Electricity, Biofuels and Hydrogen. Ultimately, reducing greenhouse gas emissions from cars and trucks to a level where they pose a minimal risk to the climate will require a shift away from petroleum-based fuels. Among the most promising alternatives: running cars and trucks on electricity, next-generation biofuels or hydrogen.

- ***Biofuels.*** As noted above, agricultural sources can be used to produce transportation fuel. While ethanol currently produced in the United States comes from corn, the technology exists to make biofuels from "cellulosic" sources (or the woody and leafy parts of plants). While corn-based ethanol can reduce emissions by as much as 30 percent for every gallon of traditional fuel replaced, cellulosic ethanol and sugar-cane-based ethanol may enable reductions of up to 100 percent. (This is because any emissions produced through the use of these fuels could be offset as farmers grow more carbon-dioxide-consuming biofuel crops.) Biofuels have the potential to offset 10 to 24 percent of current U.S. greenhouse gas emissions, depending on what fossil fuels are replaced and on how the agricultural product is converted into fuels. Another biofuel option is biodiesel, which can be produced from a wide range of oilseed crops (such as soybeans or palm and cotton seeds) and can be used to replace diesel fuel. With ethanol from sugar cane providing almost half of its domestic passenger fuel, Brazil has shown that an aggressive policy push can help biofuels become a mainstream fuel choice.[12]

- ***Electric Cars.*** Historically, electric cars have been viewed as a "niche" product, but advances in battery storage are needed. Another option is the "plug-in" hybrid, a gas-electric vehicle that can be charged at home overnight. Even using the current U.S. mix of electricity sources to charge the vehicles, plug-in hybrids can achieve significant reductions in greenhouse gas emissions compared to traditional vehicles, and even traditional hybrids.[13]

- ***Hydrogen.*** Hydrogen fuel cells, long a staple of the U.S. space program, produce power by combining oxygen with hydrogen to create water. Technological advances and reductions in the costs associated with the use of fuel cells could lay the groundwork for a hydrogen-based transportation system in the decades to come.[14] However, a number of issues still need to be resolved before fuel cells can deliver on the promise of offering a "zero-emission" transportation solution. Among the most important questions: how to produce hydrogen in ways that yield minimal emissions.[15]

GETTING IT DONE

To achieve significant reductions in U.S. greenhouse gas emissions, our nation needs to embrace short-term and long-term solutions. We need to target both supply and demand—engaging consumers and producers of energy in a wide-ranging effort to protect the climate. And we need

broad policies aimed at curbing emissions, together with more targeted policies designed to spur the development of new technologies.

Encouraging greater energy efficiency is a crucial part of the solution. Throughout all sectors of the U.S. economy, gains in energy efficiency can make an important contribution to reducing greenhouse gas emissions—and, in turn, reducing the amount of power needed from new and emerging low-carbon energy sources. One group of experts found that if the United States can boost energy efficiency by 2 percent per year through 2050, we will reduce the amount of power needed from low-carbon sources by two-thirds.[16] Clearly, efficiency across all sectors is essential, both as a path to short-term reductions in emissions and as part of a long-term strategy as well.

Also essential will be a wide-ranging effort to drive innovation. Government at all levels needs to spur investments in new technologies—by making direct investments in research and development, creating and enhancing incentives for private investment, and adopting mandatory targets and other policies that can help create the conditions for technological change.

Among the key climate solutions advocated by many experts is a "cap-and-trade" system that requires emissions reductions while allowing companies to trade emission credits so they can achieve their reductions as cost-effectively as possible. The most important benefit of such an approach is that it establishes a value for emissions reductions, as well as an economic advantage for technologies that can achieve them.

Coupled with government efforts to promote the development and deployment of new technologies, cap-and-trade programs hold the promise of encouraging climate solutions without threatening the competitiveness of U.S. industry.

In order to successfully reduce the threat of climate change, the United States and other nations will have to rely on a wide range of technologies over the next century. The exact portfolio of technologies that will be required to achieve the necessary emission reductions is not clear. What is clear, however, is that policies are going to be needed to aid in the development of new technological solutions and to move many of these technologies into the marketplace.

Given the national and global implications of climate change and efforts to address it, leadership from the federal government on these issues is going to be crucial. At the same time, state and local leaders have jurisdiction over many parts of the economy that are part of the problem—and that can be part of the solution as well. These leaders will play a key role in the search for solutions, and in making sure that communities across the country can benefit from the technology revolution that is needed to deliver a low-carbon future.

FOR MORE INFORMATION

For more information on the issues discussed in this white paper, refer to these Pew Center publications:

Workshop Proceedings on The 10-50 Solution: Technologies and Policies for a Low-Carbon Future (2004)

Towards a Climate-Friendly Built Environment (2005)

The U.S. Electric Power Sector and Climate Change Mitigation (2005)

Agriculture's Role in Greenhouse Gas Mitigation (2006)

Induced Technological Change and Climate Policy (2004)

U.S. Technology and Innovation Policies: Lessons for Climate Change (2003)

Comparison of Passenger Vehicle Fuel Economy and GHG Emission Standards Around the World (2004)

Reducing Greenhouse Gas Emissions from the U.S. Transportation Sector (2003)

Pew Center on Global Climate Change

These reports are available at www.pewclimate.org.

ENDNOTES

1. The U.S. Energy Information Administration (EIA) projects that electricity generated from all renewable resources will grow from 9.0 percent of total generation in 2004 to 9.4 percent in 2030, with non-hydroelectric renewables growing from 2.2 percent in 2004 to 4.3 percent in the same period.
2. See e.g., California Energy Commission, "Emerging Renewables Program," available at: http://www.energy.ca.gov/renewables/emerging_renewables/index.html.
3. See http://www.nei.org
4. Additional emissions are connected to production and transportation of building materials, but the discussion here covers only reductions connected to energy use in building operations.
5. EnergyStar is a joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy aimed at protecting the environment through energy-efficient products and practices. For more information: www.energystar.gov.
6. Stationary fuel cells can also be used in large-scale (e.g., power plant) applications.
7. The LEED (Leadership in Energy and Environmental Design) Green Building Rating System® is a voluntary, consensus-based national standard for developing high-performance, sustainable buildings. For more information: http://www.usgbc.org.
8. See Paustian et al., *Agriculture's Role in Greenhouse Gas Mitigation,* Pew Center on Global Climate Change, September 2006.
9. See e.g., testimony of K.G. Duleep, Science Committee, U.S. House of Representatives, "Hearing on Improving the Nation's Energy Security: Can Cars and Trucks be Made More Fuel-Efficient?" February 8, 2005, Available at: http://www.house.gov/science/hearings/full05/feb9/KGDuleep.pdf, at pg. 2.
10. From An and Sauer, *Comparison of Passenger Vehicle Fuel Economy and GHG Emission Standards Around the World*, Pew Center on Global Climate Change, December 2004.
11. See Greene and Schafer, *Reducing Greenhouse Gas Emissions From U.S. Transportation*, Pew Center on Global Climate Change, May 2003.
12. See e.g., http://edition.cnn.com/2006/WORLD/americas/03/10/brazil.ethanol.example.ap/index.html
13. For a brief discussion of plug-in hybrids and related policy recommendations, see e.g., "Set America Free: A Blueprint for U.S. Energy Security," *available at*: http://www.setamericafree.org/blueprint.pdf; E2I/EPRI, "The Plug-In Hybrid Electric Vehicle: Today's Car for Tomorrow's Technology—An E2I Initiative," August 2002, *available at*, http://www.epri.com/attachments/285860_1007115Print_081902.pdf; Wired.com, "Support Grows for Plug-In Hybrids," Aug. 17, 2005, http://www.wired.com/news/technology/0,1282,68535,00.html
14. Fuel cells combine oxygen with hydrogen to create water, and in the process enable the harnessing of electrical energy associated with this process. For more information, see "Fuel Cells 2000: The Online Fuel Cell Information Resource," available at: http://www.fuelcells.org.
15. Hydrogen can be produced in a variety of ways, including from coal or natural gas, and from electrolysis (using electricity to split water into hydrogen and oxygen).
16. Holdren, John P. 2004. "Integrating Common Themes: Some Observations for the Workshop on 17 Technologies and Policies for a Low-Carbon Future." 2004. Presentation to the Pew/NCEP 10-50 Workshop, citing a 1997 report by the U.S. President's Council of Advisers on Science and Technology (PCAST).

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The Pew Center on Global Climate Change is a non-profit, non-partisan, independent organization dedicated to providing credible information, straight answers, and innovative solutions in the effort to address global climate change.

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CLIMATE CHANGE 101
Business Solutions

The response of business leaders to the problem of climate change is undergoing a major transformation. Even ten years ago, the corporate sector was almost uniformly opposed to serious government action on the issue. But increasing certainty about the science of climate change—and an ever greater understanding of the risks and opportunities it presents for businesses and society—have contributed to a new willingness among corporate leaders to help shape solutions. In addition to acting on their own to reduce greenhouse gas emissions, a growing number of businesses are calling for government action to protect the climate.

ASSESSING THE RISKS

For corporate leaders responsible for paying attention to the full range of risks confronting their businesses, climate change has become a risk that can no longer be ignored. As the CEO of Marsh, the world's largest risk management services company, put it in a February 2006 conference call to which he invited the firm's 30,000 corporate clients worldwide: "Climate change is probably one of the best examples of where long-term risk planning is essential to mitigate some potentially irreversible long-term effects."[1]

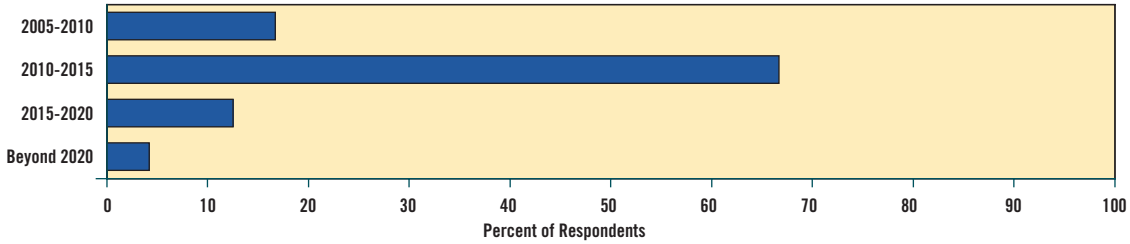
Insurance companies have played an important part in drawing attention to the risk of economic losses from climate change. According to the global insurance giant, Allianz, climate change is increasing the potential for property damage at a rate of between 2 and 4 percent every year. The U.S. insurance company AIG has warned, "Climate change is increasingly recognized as an ongoing, significant global environmental problem with potential risks to the global economy and ecology, and to human health and well-being."[2]

Regulation Viewed as Inevitable. One of the largest and most immediate risks businesses face from climate change is what experts refer to as "regulatory risk"—or the risk to companies posed by government limits on greenhouse gas (GHG) emissions. Nearly all business leaders surveyed for the Pew Center's recent report, *Getting Ahead of the Curve: Corporate Strategies That Address Climate Change*,[3] view national greenhouse gas regulations as inevitable in the United States. Of these, 84 percent believe new standards will take effect before 2015; 17 percent say they believe regulation will take effect before 2010 (see Figure 1).

Figure 1

Anticipated Date of Federal Standards on Climate Change

[If you believe that federal standards on climate change are imminent] when do you believe these standards will take effect?



Source: *Getting Ahead of the Curve: Corporate Strategies That Address Climate Change*, Pew Center on Global Climate Change.

PEW CENTER ON Global CLIMATE CHANGE

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This brief is part of a series called *Climate Change 101: Understanding and Responding to Global Climate Change*, published by the Pew Center on Global Climate Change and the Pew Center on the States.

The effect of these limits on business operating costs and the value of company assets will be significant, especially for firms producing high levels of (GHG) emissions. As a result, many companies are starting to reduce their emissions voluntarily now. Their motivations include gaining a head start over competitors in learning what climate strategies work, preparing to respond rapidly once regulations do take effect, and better managing the costs of reducing their emissions over time. In addition, many companies recognize that acting early to reduce emissions is an important way to gain credibility and influence among lawmakers as they consider what policies will work best.

Threats to Competitiveness. Government climate policies and growing customer awareness about the climate problem are combining with other forces to produce significant changes in the markets for products ranging from cars and trucks to electricity. For companies to remain competitive, they will need to position themselves to succeed in the face of two trends: a decline in the value of inefficient and greenhouse gas intensive technologies; and a corresponding increase in demand for climate-friendly technologies and services.

For example, electric utilities that invest in high-emission power plants today may be at a competitive disadvantage in later years when governments impose limits on GHG emissions. Car companies that produce mainly gas guzzlers already are losing market share to competitors that produce higher numbers of efficient hybrid and diesel models.

Yet, the lack of a coherent climate change policy (and related energy policies) means that U.S. companies don't have a clear sense of the competitive stakes or the true costs of continuing with business-as-usual.

Physical Risks to Business. Businesses also face risks from the projected impacts of climate change, including stronger hurricanes, increased drought, sea level rise, flooding and other natural catastrophes. The industries most likely to be affected directly by the physical risks of climate change include agriculture, forestry and paper products, tourism, real estate, offshore energy development, and insurance.[4] For other industries, as well as companies located far away from regions facing severe climate impacts, the indirect effects can be substantial. As the United States saw following Hurricane Katrina, the loss of oil and gas platforms in the Gulf of Mexico not only pushed up gasoline prices but also hurt profits in other industries, including chemical companies and fertilizer manufacturers that use fossil fuels as ingredients in their own products. Damages to highways and port facilities in Louisiana and Mississippi slowed the shipment of goods to companies in a host of other industries hundreds of miles away.

Other Risks. Businesses face other risks from climate change. For example, some investors and analysts believe that the federal Sarbanes-Oxley law, by requiring disclosure of financially "material" risks, should force some industries to disclose whether (and how) climate change and climate policy

Businesses Face Growing Pressures to Disclose Climate Risks and Strategies

An increasing number of investors are realizing that climate change could affect the value of their investments. As a result, they are pressing companies to disclose climate-related risks and corporate climate strategies. For example:

- During the 2006 proxy season, investors filed more than two dozen climate-related shareholder resolutions, many of them seeking greater analysis and disclosure of business impacts of climate change and future regulation of greenhouse gas emissions.[5] Over the past two years, climate change has emerged as the leading focus of non-financial shareholder resolutions.[6]
- The Carbon Disclosure Project (CDP) was launched in 2003 to enable institutional investors to collectively sign a single global request to companies for disclosure of their greenhouse gas emissions and climate strategies. The latest CDP disclosure request issued in 2006 went out under the signatures of 225 institutional investors with combined assets of $31.5 trillion; 3.3 billion tons of emissions were reported. This is a significant increase over 2003, when 1.8 billion tons of greenhouse gas emissions were reported by 35 participating investors with $4.5 trillion under management.

will affect future earnings. If courts agree, company directors and officers could be held criminally liable for failures to disclose climate risks. There may also be considerable risk to a company's brand and reputation if customers, partners, investors and/or employees don't view the firm as responsible with regard to climate change.

CAPTURING THE OPPORTUNITIES

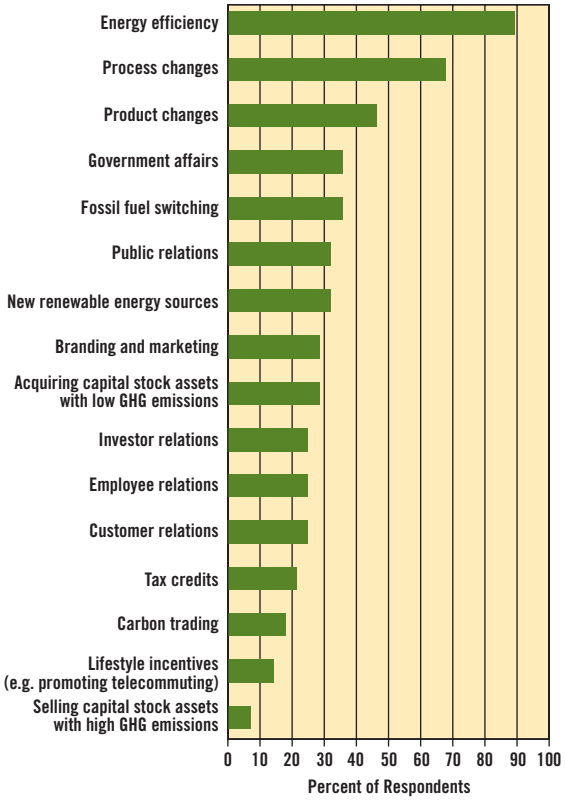
Although there will be significant costs associated with achieving the deep, long-term emission reductions essential to protect the climate, the experience of companies that have led in reducing emissions ahead of regulatory requirements proves there are numerous options for reducing GHGs that decrease costs and increase profits. Figure 2 shows a ranking of programs that benefit the bottom line by major corporations the Pew Center on Global Climate Change polled in Fall 2005. Also, policies that give businesses the flexibility to respond innovatively will minimize costs.

Among the leading companies on climate issues, there is a major shift underway from corporate climate strategies that focus on risk management and emissions reductions toward strategies for developing and marketing new climate-friendly products and services. In a carbon-constrained future, the market will demand a wide range of low-GHG technologies, especially in the electricity, buildings and transportation sectors. Table 2 spotlights key areas of opportunity, including clean energy generation, energy-efficient equipment and materials, and low-emission vehicles. (These technologies and their contribution to global emissions reductions are discussed in *Climate Change 101: Technological Solutions*).

Each technology area represents enormous potential annual revenue for the companies and countries that succeed as major producers. According to an August 2006 *Business Week* article, even given modest assumptions about increasing demand for clean technologies, there is tremendous potential for new revenue growth.[7] For example, if the United States increases the percentage of the nation's power delivered by renewables from 2.5% to 3.4% by 2010, clean power producers will see up to $10 billion in new revenues. In the longer run, new technologies and new market drivers could increase cleantech revenues by orders of magnitude.[8] Key suppliers of components for these new technologies—for example, manufacturers such as Eaton and Parker-Hannifin whose hydraulics and electrical systems can enable hybrid vehicles and wind turbines—stand to tap major new sales opportunities as well.

Figure 2

Ranking of Climate-Related Programs That Increase Companies' Profits



Source: Based on findings of survey in *Getting Ahead of the Curve: Corporate Strategies That Address Climate Change*, Pew Center on Global Climate Change, 2006

As investors focus on the risks of climate change, they also are taking note of opportunities to earn high returns from investments in climate-friendly businesses:

- Venture capital investing in so-called "cleantech" industries—which include firms developing environmentally friendly technologies in the energy, agriculture, information technology, transportation and other sectors—has surged in recent years. Within cleantech, climate-related

energy investments are by far the largest segment (see Figure 3). During 2005, cleantech investing totaled $1.6 billion, a 43-percent jump from the previous year, and investment in the third quarter of 2006 topped $900 million—an increase of almost 300 percent over the third quarter of 2004.

- In 2005, Goldman Sachs bought one of the largest wind power developers in the United States and led financing for a $60 million fund for development of rooftop solar systems. Later that year, the firm committed up to $1 billion more for renewable energy and energy efficiency projects.
- Public pension funds, required by law to safeguard the long-term value of government employees' retirement savings, are investing significant amounts in alternative energy businesses. For example, the California Public Employees Retirement System (CalPERS), the largest public pension fund in the United States, and the California State Teachers Retirement System (CalSTRS) together are dedicating more than $500 million to seed alternative energy businesses through their Green Wave Initiative.
- A recent study by Ceres[9] found that dozens of new insurance products are emerging to tackle climate change and resulting weather losses. For example, Firemen's Fund Insurance is launching a first-of-its-kind "green" coverage, including rate credits and other incentives, for commercial building owners who rebuild damaged properties using green and LEED-certified (Leadership in Energy and Environmental Design) building practices.

Businesses in energy, technology and other sectors also are making substantial new investments of capital and effort to expand their climate-friendly business. GE, for example, has committed to doubling its investment in environmental technologies to $1.5 billion by 2010.[10] Over the next 10 years, BP will invest $8 billion in solar, wind, hydrogen and efficiency-enhancing "combined cycle" power generation.[11] ("Business Actions on Climate" on page 5 outlines other examples of leading companies transforming their businesses to succeed in a carbon-constrained world.) It is important to note that the absence of clear climate policy in the United States has meant that the scale of overall U.S. investment in climate-friendly technologies is not keeping up with the magnitude of the challenge or with investment in Europe. While private funding from investors and corporations can help the United States compete in some of these technology markets, the U.S. cannot compete in other areas without greater government support for research, development, and deployment. The solar power market provides a clear historical example. In 1996, U.S. manufacturers had 44 percent of market share worldwide, but that has slipped to 9 percent in 2005—lost

Table 1. Example Business Growth Opportunities for Climate Friendly Technologies

Technology Type	Illustrations of Size and Type of Market Opportunities
Efficient vehicles	Billions of new drive train components, millions of tons of lightweight body materials, advanced electronics, etc.
Efficient buildings	Billions of efficient appliances, millions of high efficiency heating and ventilation systems, advanced systems controls, etc.
Low-carbon coal power	Hundreds of new plants worldwide—each requiring thousands of specialty components, advanced materials, etc.
Geologic storage of CO_2	Hundreds of underground reservoirs—drilling services, injection well equipment, monitoring equipment, etc.
Wind power	Millions of windmills—revenue for landowners, hundreds of tons of advanced materials, billions of bearing components, etc.
Solar power	Tens of millions of solar panels, tons of advanced materials, control systems, new revenue source for buildings, etc.
Biofuels	Billions of tons of crop yields, major markets for advanced seed stocks and crop inputs, revenue from millions of acres of now-marginal land, thousands of biofuel plants, millions of "flex-fuel" vehicles, etc.

Business Actions on Climate

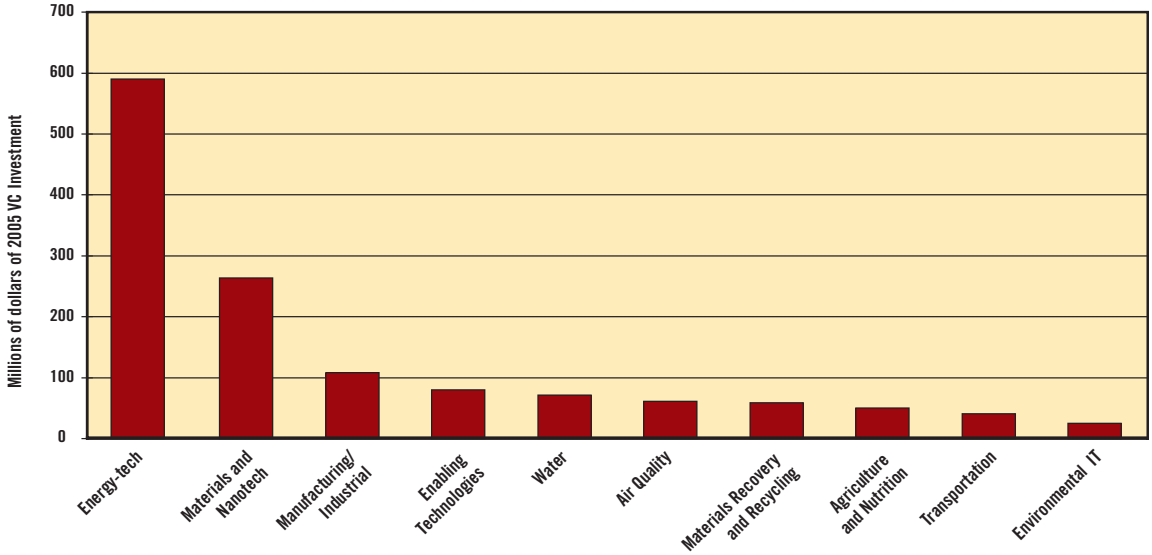
As of December 2006, 42 companies have joined the Pew Center's Business Environmental Leadership Council (BELC). These are mostly Fortune 500 companies with a combined stock market value of over $2.4 trillion and more than 3 million employees. They represent most industrial sectors and many of the largest emitters of greenhouse gases, including coal-burning utilities, mining companies, aluminum producers, automobile manufacturers, pulp and paper manufacturers, chemical companies, oil and gas businesses, and the cement industry.

Thirty-two of these companies have set targets to reduce their GHG emissions, many of them more stringent than those in the Kyoto Protocol under the U.N. Framework Convention on Climate Change. The following are some of the many actions that Council members have taken to reduce emissions, while also reducing costs below those of their competitors and building new climate-related sales growth opportunities:

- In June 2006, **Dupont** and **BP** announced a partnership to develop, market, and produce butanol, a new type of biofuel potentially superior to ethanol in terms of energy content, reduction in greenhouse gases, and ease of integration into existing fuel distribution infrastructure. Dupont projects that 60 percent of its business will stem from the use of biology to reduce fossil fuel use in the next few decades.[12]
- **BP** also is partnering with **GE** to build up to 15 hydrogen power plants that will generate electricity while using advanced technology to capture and store up to 90 percent of the carbon dioxide that would otherwise be emitted.
- **DTE Energy** operates 29 landfill gas recovery projects at sites across the United States. These projects recover methane, a greenhouse gas, and convert it into pipeline-quality gas for producing steam or electricity. DTE Energy landfill projects have captured an amount of methane with the same global warming potential as the annual GHG emissions of four large coal-fired power plants.
- **Baxter's** corporate energy management group performs energy reviews of the company's manufacturing facilities, maintains energy use standards, and researches and communicates best practices in energy conservation. In 2002 alone, these efforts resulted in approximately $4.3 million in reduced energy costs.
- From 1990 to 2002, **IBM**'s energy conservation measures resulted in a savings of 12.8 billion kWh of electricity—avoiding approximately 7.8 million tons of carbon dioxide emissions and saving the company $729 million in reduced energy costs.
- **Alcoa** has saved hundreds of millions of dollars by reducing the electricity required to produce a ton of aluminum by 7.5 percent over the last 20 years. The company also supplies strong lightweight materials to reduce energy use in the aviation and automobile sectors, and sales of these materials will grow significantly as pressure grows to reduce GHG emissions from transportation.
- **Toyota** has become a leader in developing and producing clean energy vehicles, including hybrid, electric, compressed natural gas and fuel-cell electric vehicles. The Toyota Prius, a gas-electric hybrid, became available in the United States in June 2000; as of April 2006, global sales of the Prius topped 500,000; U.S. sales reached 250,000 in May 2006.
- **United Technologies** is developing zero-emission, energy-efficient fuel cells for transportation applications. The company has deployed zero-emission fuel cell buses in Washington, DC, California, Madrid and Turin.
- Since 1990, customer energy efficiency programs at **PG&E Corporation** have cumulatively saved more than 138 million MWh of electricity, avoiding up to 80 million tons of carbon dioxide emissions. In addition, as part of the company's groundbreaking new Climate Protection Program, customers can choose to pay a small premium on their monthly bill to fund projects to reduce or offset carbon dioxide emissions.

Figure 3

U.S. Cleantech Venture Capital Investment by Segment, 2005



Source: Cleantech Venture Network

mostly to producers in Germany and other countries that have strong policies in place to accelerate solar deployment.[13]

BUSINESS SUPPORT FOR STRONGER POLICY

Scientists say that the world needs to reduce total greenhouse gas emissions by 50 to 80 percent (compared to a business-as-usual scenario) in order to stabilize atmospheric greenhouse gas concentrations and avoid "dangerous climatic change."[14] Despite the recent upsurge in private-sector involvement in the climate issue, voluntary action by selected companies and their investors is not achieving sufficient reductions to solve the problem. Goldman Sachs acknowledges this fact in its Environmental Policy Framework: "Voluntary action alone cannot solve the climate change problem."[15]

Recognizing both that government action is inevitable and that policy decisions made on this issue will have substantial implications for future profits, business leaders increasingly are engaging with policymakers to help influence those decisions. Many of these business leaders favor approaches that level the playing field among companies and spread responsibility for reductions to all sectors of the economy. They favor market-based measures such as "cap-and-trade" policies that give businesses flexibility either to reduce their own greenhouse gas emissions or to buy emissions credits from others who can reduce emissions at lower cost (thereby minimizing the overall cost of meeting national and international reduction goals).

An important reason why many corporations support a move to federal regulation is the proliferation of state policies and the prospect of complying with a patchwork of state regulations and programs. In the familiar pattern of how environmental regulation often develops in America, the states are taking the lead on the climate issue ahead of the federal government.[16]

Business leaders also are seeking greater certainty from the government to help guide their long-term planning. In the electricity sector, for example, companies are facing decisions about replacing existing plants and building new capacity to meet demand. Without an understanding of future regulatory requirements, it is impossible to know the bottom-line implications of building lower-cost, higher-emission plants vs. lower-emission alternatives. What is higher-cost today may be cost-effective tomorrow, once carbon emissions are constrained by national policy. The same need for certainty applies to other industries as well.

"Give us a date, tell us how much we need to cut, give us the flexibility to meet the goals, and we'll get it done," said Wayne H. Brunetti, CEO and Chairman of Xcel Energy, in *Business Week*.[17] Jim Rogers, head of Duke Energy and chairman of the electric utilities' main industry association, is a strong advocate of action to reduce carbon dioxide emissions. He said the inevitability of climate regulations makes early action by companies all the more important. "I live with the vision we will live in a carbon-constrained world some day," he said.[18]

Calls for changes in national policies are coming from a diverse array of companies—automobiles, chemicals, heavy and high-tech manufacturing, medical products, retail, information technology, and even major oil and gas companies. Recent examples of their public policy leadership on the issue include:

- In June 2005, 20 companies, including Ford, HP, Cisco, and Cinergy (now Duke Energy) called on the U.S. President and heads of the other G-8 countries to adopt market-based policies for limiting greenhouse gases.[19]
- The same month, five leading companies (Cinergy, DuPont, Baxter International Inc., United Technologies and Whirlpool) appeared before a U.S. House of Representatives Science Committee hearing on climate change and testified that they have been able to increase their profitability while reducing greenhouse gas emissions.
- Duke Energy, Exelon GE and Wal-Mart testified at the Senate Energy Committee's climate conference in April 2006 in support of mandatory greenhouse gas regulations. Eight other companies, including BP, provided written testimony in support of mandatory controls.
- In July 2006, representatives of Baxter, BP, DuPont, Entergy, and GE briefed 60 staff members from both houses of Congress on the design of a cap-and-trade regulatory system.
- Major companies have even supported significant state actions on climate change, although they prefer uniform federal policies. This year, PG&E Corporation, Waste Management, HP, Interface and others backed the passage of California's landmark law to reduce greenhouse gas emissions to 1990 levels by 2020. In addition, BP, Entergy, Staples, Bank of America, and others supported the Regional Greenhouse Gas Initiative, an effort by seven northeastern and mid-Atlantic states to cap and trade carbon dioxide emissions from power plants.

Many of the businesses making the case for government action also see a pressing need for U.S. leadership in the international arena. Multinational firms in particular want to know that policies around the world will be as predictable, integrated and consistent as possible. They are operating in many countries that have signed the Kyoto Protocol and that will be requiring real reductions in emissions. For these companies, it makes sense to implement company-wide strategies for managing their emissions, rather than working under one set of rules in the United States or Australia, and another set of rules everywhere else. Companies also want to be sure that their competitors in developing countries, especially China and India, are soon subject to carbon constraints. Those with the most experience on the climate issue realize that the most important first step for getting China and India to move toward climate commitments is for the United States to adopt its own mandatory limits on emissions and to re-engage in the international effort to address climate change.

CONCLUSION

Businesses that are taking action to address climate change, both within their companies and in the policy arena, recognize two things: 1) regulation of greenhouse gas emissions is inevitable; and 2) mandatory climate policies, if properly designed, are consistent with sound business planning and good corporate governance. As more companies and more investors come to this realization, pressure will mount for other businesses to take a more responsible and proactive stance.

Long-term efforts to address climate change will not be cost-free—but early, voluntary action by companies such as those in the Pew Center's Business Environmental Leadership Council proves that firms can achieve major reductions in ways that actually boost profits. The sooner that flexible, market-based regulations are put in place, the greater the likelihood of motivating climate action that achieves significant emissions reductions with minimal impact on the U.S. economy. With the right policies, the United States can become a global leader in producing the climate-friendly technologies that will dominate markets in the 21st century and beyond.

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More information on climate change solutions is available at www.pewclimate.org.

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The Pew Center on Global Climate Change is a non-profit, nonpartisan, independent organization dedicated to providing credible information, straight answers, and innovative solutions in the effort to address global climate change.

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CLIMATE CHANGE 101
International Action

Climate change is a global challenge and requires a global solution. Greenhouse gas emissions have the same impact on the atmosphere whether they originate in Washington, London or Beijing. To avoid dangerous climate change, emissions ultimately must be reduced worldwide. An effective global strategy requires leadership by the United States, and commitments and action by all the world's major economies.

GLOBAL EMISSIONS

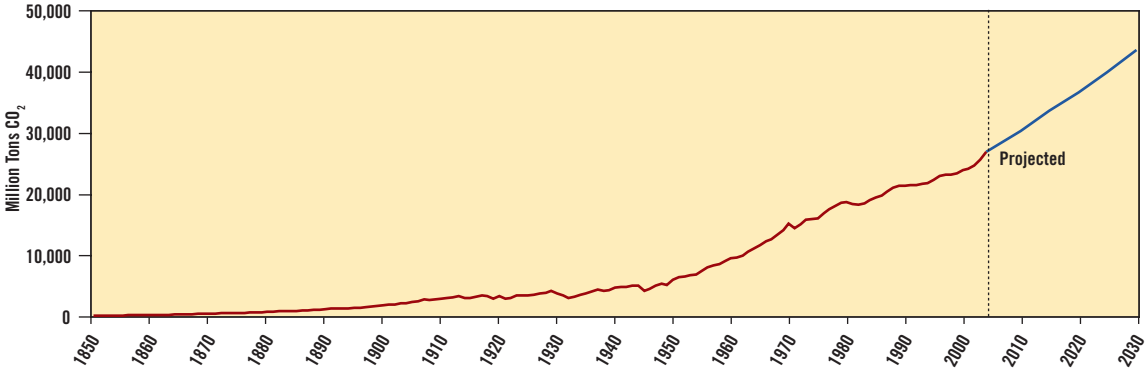
Greenhouse gas (GHG) emissions, largely carbon dioxide (CO_2) from the combustion of fossil fuels, have risen dramatically since the start of the industrial revolution. Globally, energy-related CO_2 emissions have risen 130-fold since 1850—from 200 million tons to 27 billion tons a year—and are projected to rise another 60 percent by 2030 (see Figure 1).[1]

Most of the world's emissions come from a relatively small number of countries. The seven largest emitters—the United States, the European Union (EU),[2] China, Russia, Japan, India and Canada—accounted for more than 70 percent of energy-related CO_2 emissions in 2004. The United States, with 5 percent of the world's population, is responsible for 20 percent of energy-related global emissions[3] and 30 percent of cumulative emissions since 1850. (Cumulative emissions are an important measure because of the long-lasting nature of greenhouse gases in the atmosphere.)

Among members of the Organization for Economic Cooperation and Development (OECD), the United States, the EU, and Japan are the three largest emitters (see Figure 2). In absolute terms, the United States is by far the largest. On an intensity basis (emissions per gross domestic product or GDP), U.S. emissions are significantly higher than the EU's and Japan's (see Figure 3). On a per capita basis, U.S. emis-

Figure 1

Global Carbon Dioxide Emissions: 1850–2030



PEW CENTER ON Global CLIMATE CHANGE

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This brief is part of a series called *Climate Change 101: Understanding and Responding to Global Climate Change*, published by the Pew Center on Global Climate Change and the Pew Center on the States.

Figure 2

CO_2 Emissions of Major Economies

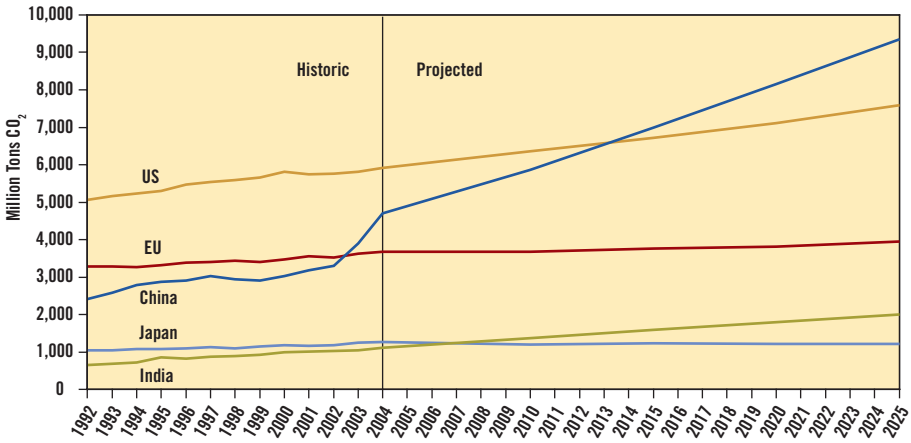


Figure 3

Carbon Intensity: 2002

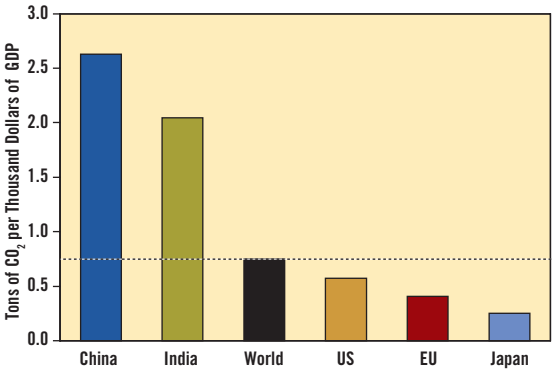
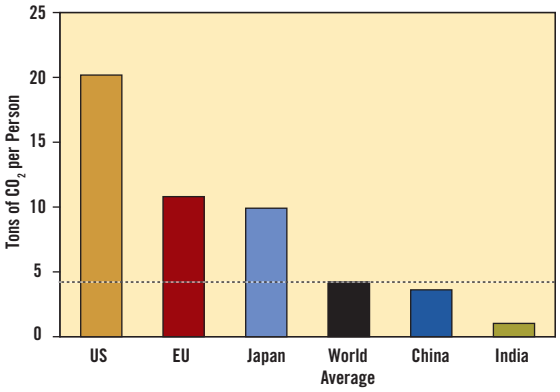


Figure 4

Per Capita CO_2 Emissions: 2004



sions are roughly twice as high as those of the EU and Japan and five times the world average (see Figure 4).

Looking ahead, U.S. emissions are projected to rise 8 percent above 2004 levels by 2010 (and 28 percent by 2025). By comparison, emissions are projected to hold steady in the EU, and decline 5 percent in Japan, by 2010.[4]

Emissions are rising fastest in developing countries. China's emissions are projected to nearly double, and India's increase an estimated 80 percent, by 2025. Annual emissions from all developing countries are projected to surpass those of developed countries between 2013 and 2018. However, the cumulative emissions of developing countries will not reach those of developed countries until several decades later.

At the same time that overall emissions from developing countries are rising, their per capita emissions will remain much lower than those of developed countries. While China's per capita emissions are expected to more than double by 2025, to slightly above the world average, they will still be just one-quarter those of the United States. Over the same period, India's per capita emissions are expected to rise slightly, to about half the world average, and one-fourteenth those of the United States.

THE INTERNATIONAL CLIMATE EFFORT

Governments launched the international climate change effort at the "Earth Summit" in 1992 with the signing of the United Nations Framework Convention on Climate Change. Signed by President George H.W. Bush and ratified by the U.S. Senate, the Convention now has 189 parties.

The Convention set as its ultimate objective stabilizing atmospheric GHG concentrations "at a level that would prevent dangerous anthropogenic [human] interference with the climate system." Recognizing the wide range in countries' historic contributions to climate change, and in their capacities to address it, governments agreed they had "common but differentiated responsibilities." In keeping with that principle, developed countries agreed to "take the lead" and to assist developing countries in combating climate change. Developed countries also agreed to a non-binding "aim" of reducing their emissions to 1990 levels by 2000.

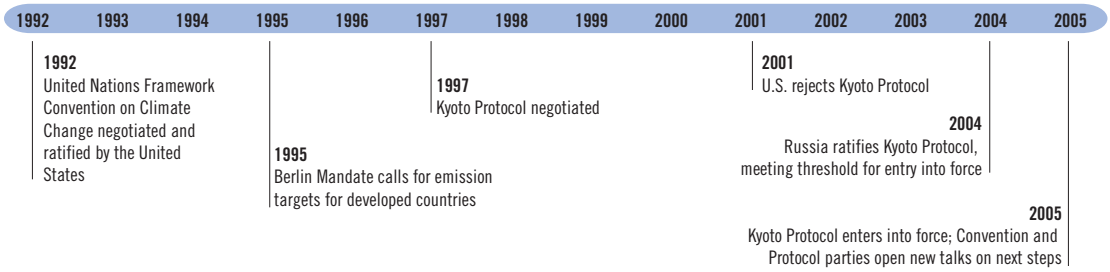
Recognizing the wide range in countries' historic contributions to climate change, and in their capacities to address it, governments agreed they had "common but differentiated responsibilities."

In 1995, recognizing that this voluntary target was insufficient and in most cases would not be met, governments adopted the Berlin Mandate, calling for the negotiation of binding targets for developed countries. These negotiations led in 1997 to the Kyoto Protocol. Under the Protocol, developed countries agreed to an average emission reduction of 5.2 percent below 1990 levels by 2008–2012 (the first commitment period). Individual targets range from –8 percent for EU countries to +10 percent for Iceland; the target the United States negotiated for itself was –7 percent.

Key provisions of the Protocol, urged largely by U.S. negotiators, provide countries with flexibility to meet their targets cost-effectively. These include three market-based mechanisms: international emissions trading (trading of emission allowances[5] among countries with targets); and Joint Implementation and the Clean Development Mechanism (JI and CDM, which credit emission reductions from projects in developed and developing countries, respectively). Other flexibility provisions include: setting emission targets as five-year averages, rather than single-year limits; counting a "basket" of six greenhouse gases, not just carbon dioxide; and providing credit for carbon sequestration (i.e., storage) in forests and farmland.

Following the United States' renunciation of Kyoto in early 2001, other governments completed negotiations on the Protocol's detailed implementation rules and proceeded to ratify it. Russia's ratification in 2004 provided the necessary quorum (at least 55 countries representing 55 percent of 1990 developed country emissions), triggering the Protocol's entry into force in February 2005. Kyoto has now been ratified by 166 countries. The 36 industrialized countries with binding targets (Australia is the only other major industrialized country not to ratify) account for 66 percent of developed country emissions and roughly a third of global emissions.

Timeline: International Action on Climate Change



Climate Action Around the World

Many countries have policies and programs that help reduce or avoid GHG emissions. Some are undertaken specifically to address climate change; others are driven principally by economic, energy, or development objectives, but at the same time contribute to climate efforts.

In the United States, state and local governments are taking the lead. California has enacted GHG standards for cars and light trucks and a mandatory target to reduce statewide emissions from all sources to 1990 levels by 2020 (a 25-percent reduction compared to "business as usual" projections). Eight northeastern states have established the Regional Greenhouse Gas Initiative, a cap-and-trade program to reduce emissions from power plants. Twenty-two states and the District of Columbia require that a significant percentage of their electric power come from renewable sources. At the federal level, the United States has a number of voluntary programs and bills have been proposed in Congress to establish mandatory economy-wide GHG limits. (For more information on U.S. action, see three other reports in the Climate Change 101 series: *Local Action, State Action,* and *Business Solutions.*)

Here is a sampling of policies and programs in other major GHG-emitting countries:

European Union

- *Kyoto Target*—Reduce EU emissions 8 percent below 1990 level by 2008–2012.
- *Emissions Trading Scheme*—Mandatory CO_2 emission limits for 12,000 installations in six major industrial sectors, with emissions trading. Links to the Kyoto Protocol's emission crediting mechanisms.
- *Community Tax Framework*—Minimum tax rates for energy and electricity depending on fuel type, with exemptions for electricity from renewables, biomass, and combined heat and power.
- *Renewable Electricity Directive*—Goal of increasing the share of renewables in the electricity supply to 21 percent in 2010 (from 14 percent in 1997).
- *Agreement with Automakers*—Goal of reducing the CO_2 emissions of new cars by 25 percent from 1995 levels by 2008–2009.

United Kingdom

- *Emission Targets*—National target of reducing CO_2 emissions 20 percent below 1990 level by 2010 (more than required under Kyoto or the EU's internal target-setting), with a long-term goal of 60-percent reduction by 2050.
- *Climate Change Levy*—Tax on fossil fuel-based electricity for industry and other large users, with most revenues used for energy efficiency research.
- *Renewables Obligation Order*—Target of 10 percent of electricity from renewable sources by 2010.

Japan

- *Kyoto Target*—Reduce emissions 6 percent below 1990 level by 2008-2012.
- *Industry Agreements*—Agreements with Nippon Keidanren, Japan's leading industry association, to reduce industrial GHG emissions to 1990 levels by 2010; and with the Federation of Electric Power Companies, to reduce emissions intensity of the electricity sector about 20 percent below 1990 levels by 2010.
- *Energy Taxes*—Schedule of taxes based in part on carbon content of fuel (e.g., $0.45/liter for gasoline; $2/ton for coal, rising to $7/ton by 2007), with a portion of the revenues used for climate purposes.
- *Auto Fuel Economy*—Standards to increase fuel economy of new light-duty passenger and commercial vehicles by about 20 percent by 2010.

China

- *Fuel Economy Standards*—Require all new cars and light trucks to achieve 19 to 38 miles per gallon (mpg) by 2005 (depending on class) and 21 to 43 mpg by 2008. Projected to save 960 million barrels of oil and avoid 130 million tons of carbon emissions through 2030.
- *Energy Intensity Goals*—National goals of reducing energy intensity by 20 percent from 2006 to 2010, and a total of 50 percent from 2000 to 2020; follows a 68-percent reduction in energy intensity from 1980 to 2000.

Climate Action Around the World *(continued)*

- *Renewable Energy Initiatives*—National targets for renewables to provide 15 percent of primary energy (up from 7 percent today) and 20 percent of electricity by 2020, including specific targets for wind power, biomass and hydropower capacity.

India

- *Energy Reforms*—Privatization, decentralization and reduced subsidies in the electric power sector to promote competition among suppliers and improve energy efficiency.
- *Renewable Energy*—Goal of using renewable energy for 10 percent of new power generation by 2010.
- *Rural Electrification*—Goal of electrifying 18,000 rural villages by 2012 from non-conventional sources such as biomass, solar, wind, and small hydropower.
- *Vehicle Conversion*—Rules requiring conversion of taxis, buses and three-wheelers from gasoline and diesel to compressed natural gas in key cities.

EU Emissions Trading Scheme

The world's most far-reaching GHG reduction policy is the EU's Emissions Trading Scheme (ETS), which limits CO_2 emissions from 12,000 facilities across Europe. Launched in 2005, the ETS covers electricity and major industrial sectors (including oil, iron and steel, cement, and pulp and paper) that together produce nearly half of the EU's CO_2 emissions.

Most ETS rules are set for the EU region, but allocation of emission allowances is left to member states. An initial phase runs through 2007; a second will coincide with the Kyoto Protocol compliance period (2008–2012). Excess emissions incur a penalty (100 Euros/ton in phase II) and must be made up in the next phase.

Emission allowance prices have ranged from about 7 Euros to about 30 Euros. Market analysts attribute the price volatility to weather (affecting energy demand), shifts in relative energy prices, and updated information on emission levels; most regard it as characteristic of a new emissions market. EU policymakers have said the ETS will continue beyond 2012 with or without new international climate agreements.

How Does the U.S. Climate Effort Compare?

There are many ways to compare how different countries are responding to climate change. If government spending is the measure, the United States stands well above other countries. In its latest national climate change report to the United Nations, the United States reported spending $1.7 billion a year on climate change research alone, more than the EU and Japan combined, and roughly half of total expenditures globally.

Another measure of effort—and results—is national emission trends. For example, the economies of the EU (the 15 member states prior to 2004) and the United States are roughly comparable in size, and the EU's population is about one-third larger. However, the EU's emissions are one-third lower than those of the United States, and the gap is projected to grow larger.

The Bush Administration's goal—an 18-percent reduction in U.S. emissions *intensity* from 2002 to 2012—allows *actual* emissions to grow 12 percent. (Emissions intensity is the emissions level relative to GDP). Over that same period, EU emissions are projected to remain flat or decline. The European Environment Agency, a watchdog agency of the European Commission, projects that current and planned policies will reduce emissions within the EU's 15 pre-2004 member states to 4.6 percent below 1990 levels. The use of carbon sinks (storing carbon in soil and forests), and anticipated purchases of additional emission reductions outside the EU through the Kyoto Protocol's "flexibility mechanisms" (see page 3), are projected to produce a total reduction of 8 percent, as required under the EU's Kyoto target.[6]

Meeting in Montreal in late 2005, governments launched two processes to begin considering next steps under both the Framework Convention and the Kyoto Protocol. Kyoto parties opened a negotiation on post-2012 commitments for developed countries, to conclude in time to "ensure…no gap" between commitment periods. Convention parties opened a nonbinding "dialogue on long-term cooperative action" focused on sustainable development, climate adaptation, technologies, and market-based opportunities for reducing emissions. The dialogue will conclude in late 2007.

TECHNOLOGY INITIATIVES

The United States and other governments have launched a range of other initiatives to promote development and deployment of climate-friendly technologies, particularly in developing countries.

These include U.S.-initiated efforts such as the Methane-to-Markets Partnership, the Carbon Sequestration Leadership Forum, and the Asia-Pacific Partnership on Clean Development and Climate; and EU partnerships with China and India. Most governments view the efforts as complementary—not alternatives—to the UN Framework Convention and the Kyoto Protocol.

To be fair and effective, the international effort must engage all the world's major economies, which requires a flexible international framework allowing countries to take on different types of commitments.

These initiatives contribute to international climate efforts by identifying technology options and obstacles and developing pilot projects. However, as now designed, they are unlikely to produce the major policy shifts and investments needed for large-scale deployment of climate-friendly technologies. A recent World Bank analysis estimated the cost of reducing GHG emissions in developing countries at $10 billion to $200 billion a year. The largest potential source of funding, the Bank concluded, is a stronger international emissions market, which "will require a long-term, stable and predictable [policy] framework and accompanying regulatory system."[7]

COMPETITIVENESS

In considering the U.S. policy response to climate change, both at home and abroad, one concern is the potential impact on U.S. competitiveness.

Emission limits like those proposed in recent Senate legislation are projected to affect economic growth rates only marginally,[8] and thus pose little risk to the competitiveness of the U.S. economy as a whole. Any potential competitiveness risks would be felt most directly by energy-intensive industries whose goods are traded internationally, a relatively small segment of the U.S. economy.[9] Potential concerns include relocation of energy-intensive U.S. industry to countries with no or looser controls, loss of market share to competitors in those countries, or a shift in U.S. investment to those countries.

However, past experience with the adoption of new environmental standards shows little evidence of such impacts. One major review—synthesizing dozens of studies assessing the impacts of a range of U.S. regulations across a range of sectors—concluded that while environmental standards may impose significant costs on regulated industries, they do not appreciably affect patterns of trade.[10] Other studies indicate that when U.S. producers do relocate to developing countries, factors such as wages and access to raw materials and markets are far more decisive than environmental costs.[11]

Policy options are available to minimize or mitigate potential competitiveness impacts. For example, assuming the United States establishes a cap-and-trade system to regulate emissions economy-wide, "grandfathering" emission allowances to potentially vulnerable firms would help them by conferring assets whose sale can offset any losses.[12] Other policy options include: tax and other incentives for accelerated deployment of cleaner technologies; support for research and development of long-term technologies; and transition assistance for affected workers.

Some economists believe that stronger environmental standards in many cases confer a competitive *advantage* by driving firms to innovate and become more efficient.[13] By spawning markets for new technologies, new standards are as likely to create jobs as reduce them, according to some studies.[14] A recent analysis of proposed climate change policies in California found that by reducing energy use and energy spending, they would likely in-

crease employment and economic growth, and give the state a competitive advantage in climate-friendly technologies.[15]

THE INTERNATIONAL CLIMATE EFFORT POST-2012

As the United States develops its domestic response to climate change, parallel efforts are needed to broaden and strengthen the international climate effort beyond 2012, when the Kyoto targets expire.

To weigh post-2012 options, the Pew Center on Global Climate Change brought together senior policymakers and stakeholders from 15 countries in the Climate Dialogue at Pocantico.[16] A key message from the group is that to be fair and effective, the international effort must engage all the world's major economies, which requires a flexible international framework allowing countries to take on different types of commitments.

The Pocantico report envisions a range of actions and agreements under the umbrella of the UN Framework Convention on Climate Change. Possible "elements" include:

Targets and Trading. Emission targets—varying in time, form, and stringency—coupled with international emissions trading. In addition to binding absolute targets, possibilities include intensity, "no-lose,"[17] or conditional targets.

Sectoral Approaches. Commitments structured around key sectors such as power, transportation, or land use. These commitments could take a variety of forms, including: emission targets, performance- or technology-based standards, or "best practice" agreements.

Policy-based Approaches. Commitments to undertake national policies, such as energy policies, that reduce or avoid emissions while advancing economic or development objectives. These could be complemented by a mechanism granting developing countries tradable credits for the resulting emission reductions.

Technology Cooperation. Stronger coordination and support for research and development of long-term technologies, and for the deployment of clean technologies in developing countries.

Pursuing multiple approaches on an ad hoc basis, with different groups of countries engaging along different tracks, is unlikely to produce a strong overall effort. The Pocantico report favors a more integrated approach: linking efforts, and negotiating them as a package, would not only accommodate different strategies, but allow for the reciprocity needed to achieve stronger commitments and action.

NEXT STEPS

The future of the international climate effort hinges in large measure on the United States, which as the world's largest economy and GHG emitter, has both the capacity and the responsibility to lead. Other major emitters are unlikely to commit to stronger action without the United States.

In a bipartisan call for U.S. leadership, the U.S. Senate Foreign Relations Committee passed a resolution introduced by its chairman and ranking minority member, Senators Richard Lugar (R-Indiana) and Joseph Biden (D-Delaware). The May 2006 resolution calls, in part, for the United States to negotiate under the Framework Convention to "establish mitigation commitments" by all major GHG-emitting countries.

As the United States considers a domestic response to climate change, it must also assess its international role, and provide the leadership needed for an effective long-term global effort.

Pew Center on Global Climate Change

More information on climate change solutions is available at www.pewclimate.org.

ENDNOTES

1. All emissions data cited are for energy-related CO_2 only. Other gases, such as methane, nitrous oxide, and CO_2 from land use change, represent up to 40 percent of total GHG emissions. (On average, these other gases represent an estimated 20 percent of GHG emissions in developed countries, and 60 percent in developing countries, although there is considerable uncertainty about emission levels from land use change.) 1850–1990 data: International Energy Agency and Carbon Dioxide Information Analysis Center. 1990–2004 data: Energy Information Administration (EIA), *International Energy Annual*. Projections: EIA, *Annual Energy Outlook 2006* (2005 projections for European Union). GDP data: World Bank 2005. *World Development Indicators*.

2. Figures for the European Union represent emissions of the 15 EU members pre-2004 (Austria, Belgium, Denmark, France, Finland, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom) plus Iceland, Norway, and Switzerland. The EU is treated here as a "country" because, as a regional economic integration organization, the European Community has "Party" status under the U.N. Framework Convention on Climate Change.

3. Percentages are for energy-related CO_2 emissions only. When all GHGs are taken into account—including methane, nitrous oxide, and CO_2 from land use change—the U. S. is responsible for approximately 25% of global emissions.

4. Projections assume only policies in place as of 2005.

5. Allowances are legally established units entitling those holding them to emit a given level of GHGs.

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7. World Bank, *Clean Energy and Development: Towards an Investment Framework*, http://siteresources.worldbank.org/DEVCOMMINT/Documentation/20890696/DC2006-0002(E)-CleanEnergy.pdf

8. The Energy Information Administration projects that achieving the emission targets of the McCain-Lieberman Climate Stewardship Act would diminish U.S. GDP by 0.4 percent in 2028; total GDP would be 89.6 percent, rather than 90 percent, higher than GDP in 2006. (EIA, *Analysis of Senate Amendment 2028, the Climate Stewardship Act of 2003*. May 2004. Available: http://www.eia.doe.gov/oiaf/analysispaper/sacsa/pdf/s139amend_analysis.pdf).

9. Repetto et al. found in a 1997 analysis that, among all U.S. industries producing tradeable goods and services, roughly 90 percent of output and employment was in industries with energy costs representing 3 percent or less of output value. (Repetto, R., C. Maurer and G.C. Bird. "U.S. Competitiveness is Not at Risk in the Climate Negotiations." *WRI Issue Brief*, October 1997.)

10. The authors found "relatively little evidence to support the hypothesis that environmental regulations have had a large adverse effect on competitiveness...." Jaffe, A.B., S.R. Peterson, P.R. Portney, and R.N. Stavins. "Environmental Regulation and the Competitiveness of U.S. Manufacturing: What Does the Evidence Tell Us?" *Journal of Economic Literature*. Vol. XXXIII, March 1995.

11. Goodstein, Eban. 1994. *Jobs and the Environment: The Myth of a National Trade-Off*. Island Press. Jeppesen, Tim, John List and Henk Folmer, 2002. *Environmental Regulations and New Plant Locations Decisions: Evidence from a Meta-Analysis*, 42 J. Regional Science. 19, 36.

12. Under a "grandfathering" approach, emission allowances are granted free to emitters based on their historic emissions. There are a number of alternative approaches including allocation of allowances by environmental performance benchmarks or by auction.

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15. Hanemann, Michael et al. 2006. "Managing Greenhouse Emissions in California." The California Climate Change Center at UC Berkeley. January. http://calclimate.berkeley.edu/managing_GHGs_in_CA.html. Downloaded January 25, 2006.

16. The report of, and background on, the Climate Dialogue at Pocantico are at http://www.pewclimate.org/pocantico.cfm.

17. Under a "no-lose" target, a country receives credit for any emission reductions beyond its target, and can sell such credits on the international emissions market, but faces no penalty if it fails to meet its target.

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CLIMATE CHANGE 101
State Action

In the absence of federal leadership to address climate change, many states and regions have begun taking action on their own. States are setting targets for reducing their greenhouse gas emissions, adopting policies to promote renewable energy and energy efficiency, and developing statewide climate action plans. At the regional level, states are coming together to launch emissions trading programs and support clean energy development. While confronting the challenge of climate change requires a national and international response, the states and regions have a valuable role to play in showing what works and in laying the groundwork for broader action.

TAKING THE INITIATIVE

By taking action to address climate change, U.S. states are fulfilling their role in American democracy as "policy laboratories," developing initiatives that serve as models for federal action. But state efforts to reduce greenhouse gas emissions are notable for other reasons as well. Many individual states are major sources of these emissions. Texas, for example, emits more greenhouse gases than France, while California's emissions are comparable to those of Australia. State actions also are important because state governments have decision-making authority over many issues and economic sectors—such as power generation, agriculture and land use—that are critical to addressing climate change.

Why are states taking action on this issue? A top concern for many state decision-makers is the long-term economic well-being of their states. State leaders and their constituents are concerned about the projected toll of climate change on their states. In coastal states, the main worry is the impact of rising sea levels. In agricultural states, it is lost farm productivity. And in the dry Western states, it is the prospect of worsening droughts.

In addition, many states view policies that address climate change not as a burden on commerce but as an economic opportunity. These states are trying to position themselves as leaders in new markets related to climate action: producing and selling alternative fuels, ramping up renewable energy exports, attracting high-tech business, and selling greenhouse gas emission reduction credits.

Economic issues are just one motivator for state policies that address climate change. States also are seeking to improve air quality, lessen traffic congestion, and develop reliable energy supplies. And, in the process of working to address these other concerns, they are adopting policies that protect the climate. States also are discovering that climate policies often bring about benefits in these other areas as well.

Because reducing greenhouse gas emissions can deliver multiple benefits, it has been possible for many states to build broad coalitions around climate-friendly policies. In fact, climate change often has been viewed as a bipartisan issue in the states, with Democratic, Republican, and Independent governors signing climate change legislation, and with lawmakers of all political persuasions supporting state action. Even when governorships have changed hands, state policies on climate change and clean energy have remained in place. In addition to offering models for specific policy solutions, the states offer a model for finding

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common ground on an issue that too often has divided lawmakers at the national level.

WORKING ACROSS STATE BORDERS

In working to address climate change, many states have reached beyond their borders to enlist neighboring states in collaborative efforts. These regional initiatives can be more efficient than actions taken by individual states. Regional efforts cover a broader geographic area (and, in turn, more sources of greenhouse gas emissions), they eliminate duplication of work among the states, and they help businesses by bringing greater uniformity and predictability to state rules and regulations. Across the United States, climate-related regional initiatives have been designed to reduce greenhouse gas emissions, develop clean energy sources and achieve other goals (see Figure 1).

In working to address climate change, many states have reached beyond their borders to enlist neighboring states in collaborative efforts. These regional initiatives can be more efficient than actions taken by individual states.

The Northeast Regional Greenhouse Gas Initiative (RGGI). In December 2005, the governors of seven Northeastern and Mid-Atlantic states agreed to a "cap-and-trade" system aimed at reducing carbon dioxide emissions from power plants in the region. Such a system requires emissions reductions while allowing companies to trade emission allowances so they can achieve their reductions as cost-effectively as possible. RGGI offers added flexibility for companies by providing credits for emissions reductions achieved outside the electricity sector. RGGI sets the stage for other states to join the effort or to form their own regional cap-and-trade systems. In addition, the program could be expanded to cover other greenhouse gases and other sectors.

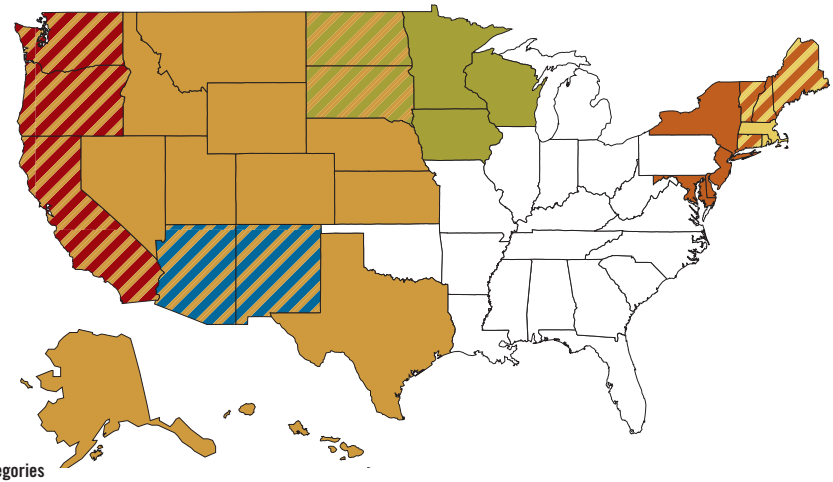
The seven RGGI states—along with Pennsylvania, Massachusetts and Rhode Island—also are developing a greenhouse gas registry, the Eastern Climate Registry, to allow companies and states to register and record their emissions and the reductions they achieve. Reliable registries are important to implementing effective climate change policies. The Lake Michigan Air Directors Consortium (LADCO) is developing a registry for a group of Midwestern states.

Western Governors' Association. The Clean and Diversified Energy Initiative launched by the Western Governors' Association (WGA) has developed and recommended a set of strategies to increase energy efficiency, expand the use of renewable energy sources in the region, and incentivize

Figure 1

Regional Initiatives

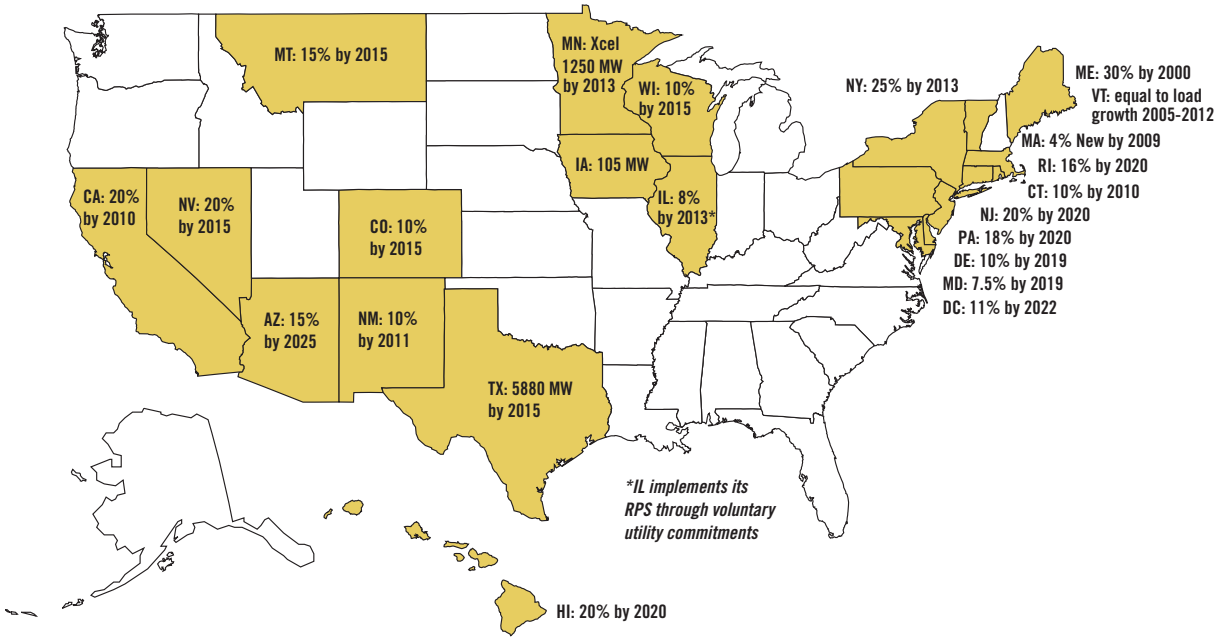
- West Coast Governors' Initiative
- Southwest Climate Change Initiative
- Powering the Plains
- Western Governors' Association
- New England Governors and Eastern Canadian Premiers
- Regional Greenhouse Gas Initiative



*States with diagonal shading indicate two categories

Figure 2

Renewable Portfolio Standards



carbon capture and sequestration. Additionally, the WGA and the California Energy Commission are creating the Western Renewable Energy Generation Information System (WREGIS). This voluntary system is designed to provide data about renewable energy generation across 11 western states in order to support trading in renewable energy credits, as well as other state and regional policies aimed at expanding the use of renewable power.

Southwest Climate Change Initiative. The governors of Arizona and New Mexico signed an agreement in February 2006 to create the Southwest Climate Change Initiative. Under the agreement, the two states will collaborate to reduce greenhouse gas emissions and address the impacts of climate change in the Southwest.

West Coast Governors' Global Warming Initiative. The West Coast states—Washington, Oregon and California—are cooperating on their own strategy to reduce emissions. Among the governors' plans: adopting comprehensive state and regional goals for reducing emissions; and expanding markets for renewable energy, energy efficiency, and alternative fuels.

New England Governors and Eastern Canadian Premiers. In 2001, six New England states agreed to the New England Governors and Eastern Canadian Premiers (NEG-ECP) climate action plan, which includes short- and long-term goals for reducing greenhouse gas emissions in the region.

Powering the Plains. Launched in 2002, Powering the Plains is a regional effort involving participants from the Dakotas, Minnesota, Iowa, Wisconsin and the Canadian Province of Manitoba. This initiative aims to develop strategies, policies and demonstration projects for alternative energy sources including coal gasification, hydrogen, and biomass.

PROMOTING LOW-CARBON ELECTRICITY

States have considerable authority over how electricity is generated in the United States. With the generation of electricity accounting for 30 percent of all U.S. greenhouse gas emissions (and 38 percent of carbon dioxide emissions), states can therefore play a crucial role in reducing the power sector's climate impacts and promoting low-carbon energy solutions. State actions to promote low-carbon electricity include incentives and mandates for renewable

energy and energy efficiency, as well as limits on power plant greenhouse gas emissions.

Renewable Portfolio Standards. Twenty-two states and the District of Columbia have mandated that electric utilities in their borders generate a specified amount of their electricity from renewable sources (see Figure 2). Most of these requirements take the form of "renewable portfolio standards," which require a certain percentage or amount of a utility's power plant capacity or generation to come from renewable sources by a given date. The standards range from modest to ambitious, and what qualifies as "renewable energy" can vary from state to state. While the use of renewable energy does deliver significant reductions in greenhouse gas emissions, climate change is not the primary motivation behind many of these actions. Other motivations include job creation in the renewables industry, energy security and improved air quality.[1]

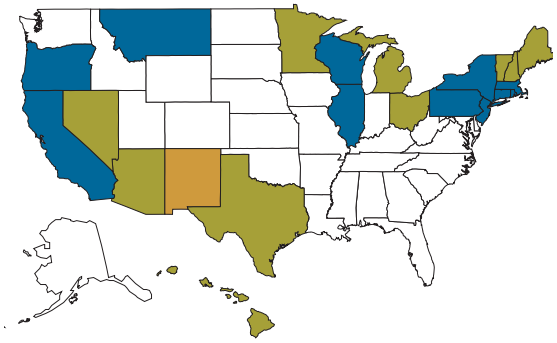
Public Benefit Funds. Almost half of U.S. states have funds, often called "public benefit funds," that are dedicated to supporting energy efficiency and renewable energy projects (see Figure 3). The resources for these funds are collected either through a small charge on the bill of every electric customer or through specified contributions from utilities. Having a steady stream of funding ensures that money is available to fund these projects. To date, 14 states with publicly managed clean energy funds have formed the Clean Energy States Alliance to coordinate public benefit fund investments in renewable energy.

Net Metering and Green Pricing. Forty-one U.S. states have at least one utility that permits customers to sell electricity back to the grid; this is referred to as "net metering." Eighteen of these states offer net metering on a statewide basis (see Figure 4). In addition, 36 states have utilities that offer green pricing, allowing customers the option of paying a premium on their electric bills to have a portion of their power provided from designated renewable sources. Five of these states—Washington, New Mexico, Montana, Minnesota and Iowa—have made green pricing options mandatory for electricity generators.

Limits on Power Plant Emissions. Both Washington and Oregon require that new power plants offset a certain portion of their anticipated carbon-dioxide emissions—for example, by reducing emissions on their own, or by paying a specified fee to a designated organization that will then select and fund offset projects. Massachusetts and New Hampshire have gone even further by requiring carbon-dioxide emissions reductions from existing power plants. The California Public Utilities Commission is developing a cap on greenhouse gas

Figure 3

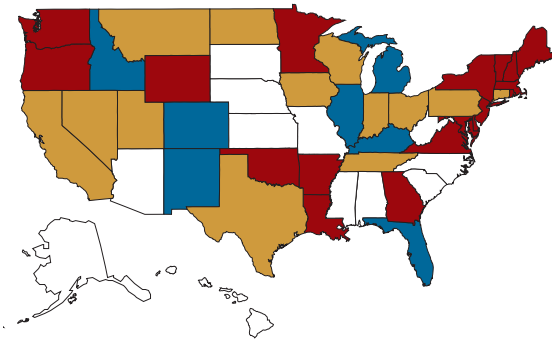
Public Benefit Funds



- Funds that Support Energy Efficiency and Renewable Energy
- Funds that Support Energy Efficiency
- Funds in Development

Figure 4

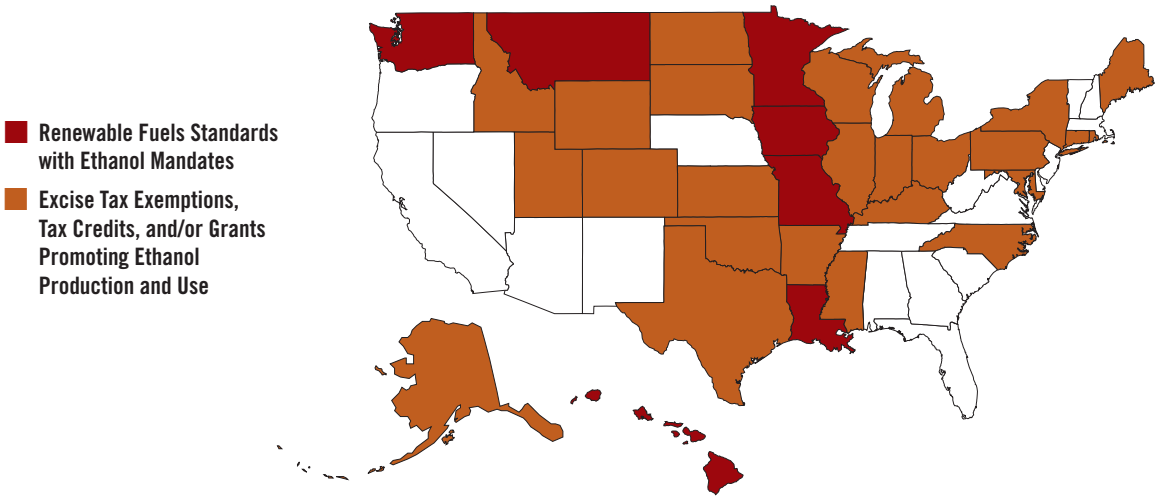
Net Metering



- Statewide Net Metering
- Net Metering Offered by One or More Individual Utilities
- Statewide Net Metering Rules Only for Certain Utility Types (e.g. IOUs only)

Figure 5

Mandates and Incentives Promoting Ethanol



emissions from electricity retailers, which would cover both in-state and out-of-state generation.

Efficiency Standards. The federal government has established minimum efficiency standards for approximately 20 kinds of residential and commercial products, including washers and dryers, refrigerators and freezers, dishwashers, and air conditioners. Numerous states—including Arizona, New York, Rhode Island, Washington, Maryland, Connecticut, California and New Jersey—have set standards on products not covered by federal standards.

STATE TRANSPORTATION POLICIES

Transportation accounts for 28 percent of all greenhouse gas emissions in the United States, and 33 percent of carbon dioxide emissions. State options for reducing these emissions range from adopting more stringent emission standards for cars and trucks to offering incentives for alternative fuels and fuel-efficient vehicles.

New Vehicle Standards. California has adopted a requirement to reduce greenhouse gas emissions from new light-duty vehicles; this requirement is pending a legal challenge from the automobile industry. If it is upheld by the courts, the California standard will reduce new vehicle fleet emissions 30 percent by 2016. The potential for reductions is even higher if other states adopt California's standards. California has unique authority among the states to set vehicle emissions standards, because of a special provision in the federal Clean Air Act. Other states have the option of either following federal standards or adopting California's. To date, 11 states have announced that they will follow California's greenhouse gas emission standards: Arizona, New York, Maine, New Jersey, Vermont, Massachusetts, Oregon, Washington, Rhode Island, Connecticut and Pennsylvania.

More than half of U.S. states provide incentives for alternative fuels, gasoline/ethanol blends, alternative-fuel vehicles, and low-emission vehicles; there are also state incentives for converting traditional vehicles to run on alternative fuels.

Incentives for Climate-Friendly Fuels and Vehicles. More than half of U.S. states provide incentives for alternative fuels, gasoline/ethanol blends, alternative-fuel vehicles, and low-emission vehicles; there are also state incentives for converting traditional vehicles to run on alternative fuels. In addition to these incentives, seven states have established Renewable Fuels Standards (see Figure 5). These are requirements that

gasoline sold in the state must contain a certain percentage of renewable fuel, such as ethanol or biodiesel. Some states also have policies requiring that a certain percentage of state-owned vehicles run on alternative fuels, such as ethanol or natural gas, or that the state fleet meet a specified fuel-efficiency standard. And 23 states provide incentives promoting ethanol production and use. These incentives include excise tax exemptions, tax credits, and grants promoting the production and use of ethanol.

While some U.S. states are delivering real reductions in their greenhouse gas emissions, only in a few cases do their reduction targets reflect what will be needed on a global scale.

AGRICULTURAL POLICIES

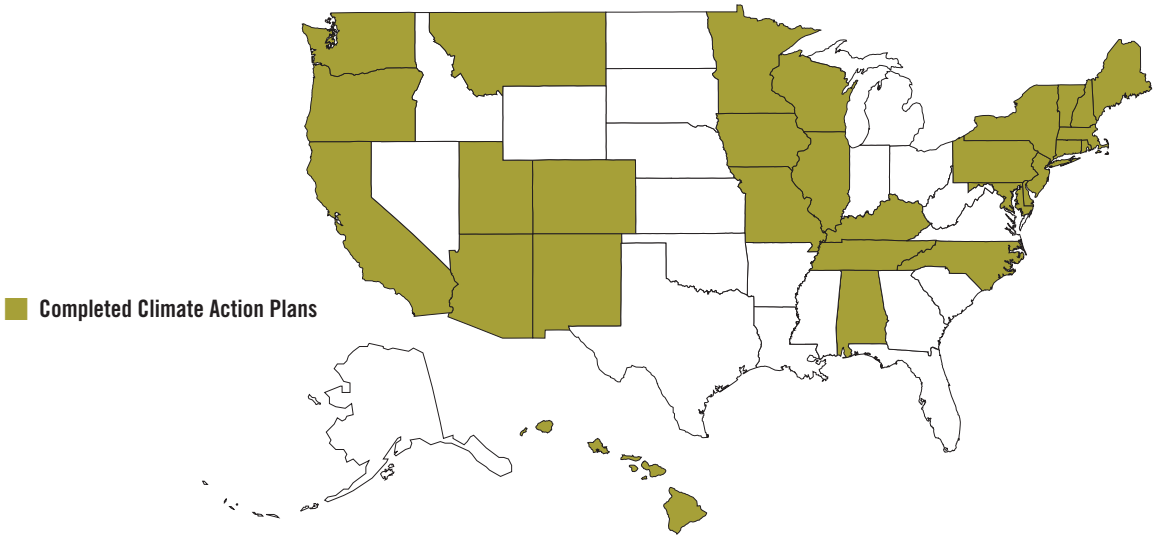
Agriculture contributes approximately 8 percent of total U.S. greenhouse gas emissions, primarily nitrous oxide and methane from livestock, agricultural soils, and the use of fertilizers. In addition to reducing these emissions, farmers can store carbon in plants and soils and substitute biofuels for fossil fuels to "offset" emissions from other sectors of the economy.

Supporting Biomass as a Climate Solution. The use of renewable "biomass" resources—including crops and animal wastes—as a low-carbon energy source offers an opportunity for the agricultural sector to address climate change in a profitable way. Among the states that are taking action to develop and promote biomass solutions is Iowa, which has launched pilot programs to improve the production of switchgrass as a fuel source alongside coal in electric power plants.

Promoting Climate-Friendly Farming Practices. Agriculture also can help protect the climate through soil conservation techniques that increase the amount of carbon stored in the soil, while at the same time improving soil quality. Compared to conventional tilling techniques, soil conservation techniques such as "no-till farming" reduce fuel use while saving time and money. Nebraska, Oklahoma, Wyoming, North Dakota and Illinois have formed advisory committees to investigate the potential for agriculture in their states to play a role in storing, or sequestering, carbon so that it cannot enter the atmosphere and contribute to climate change.

Figure 6

Climate Action Plans



EMISSION TARGETS AND CLIMATE ACTION PLANS

To date, 28 U.S. states have adopted climate action plans detailing the steps their states can take to reduce their contributions to climate change (see Figure 6). In addition, 12 states have statewide emission targets (see Figure 7). Comprehensive climate action plans, combined with enforceable targets aimed at limiting a state's emissions, provide the highest certainty of achieving significant reductions at the state level.

Emission Targets. California and New Mexico are among the states that have adopted proactive and far-reaching targets to reduce their emissions:

- In a 2005 executive order, California Governor Arnold Schwarzenegger committed his state to greenhouse gas reduction targets equivalent to reaching 2000 emissions levels by 2010 and 1990 levels by 2020; by 2050, emissions would be 80 percent below current levels. In 2006, the California legislature made the 2020 target enforceable under state law.
- An executive order signed in 2005 by Governor Bill Richardson of New Mexico commits that state to reduce emissions to 2000 levels by 2012, 10 percent below 2000 levels by 2020, and 75 percent below 2000 levels by 2050. New Mexico is the first major coal, oil and gas-producing state to set targets for cutting its emissions.

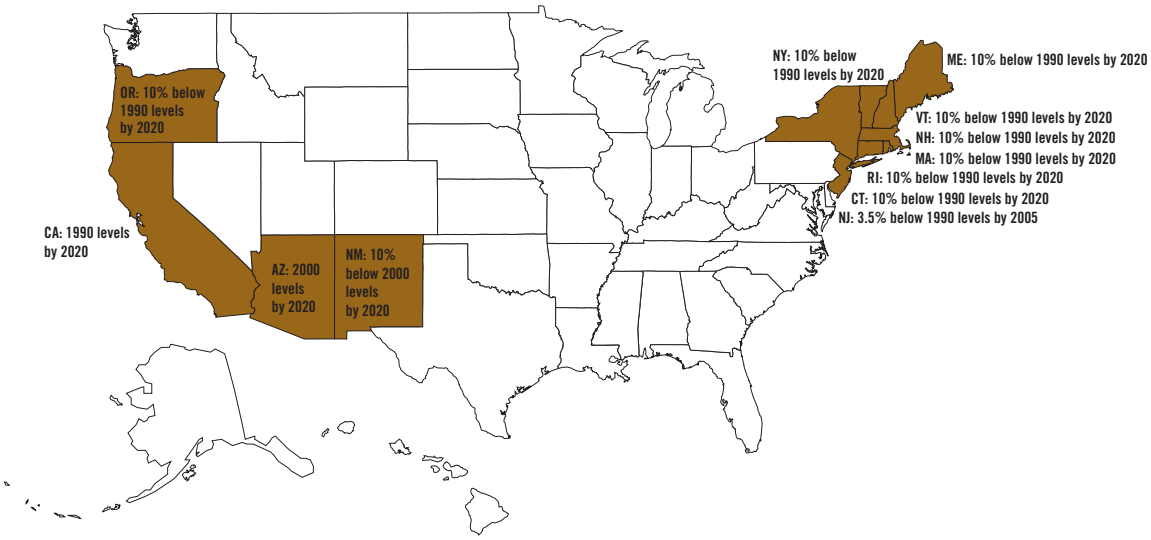
For both states, these targets supplement existing climate-friendly policies, including renewable portfolio standards, renewable energy tax credits, and energy efficiency goals.

Climate Action Plans. The process of developing a climate action plan can help state decision-makers identify cost-effective opportunities to reduce greenhouse gas emissions in ways that are most appropriate for their states. Every state is different, with different economic drivers, different resources and different political structures. As a result, state efforts to address climate change will vary. However, any state adopting a comprehensive climate action plan is going to need to incorporate strong incentives to make it happen.

Among the states that are developing climate action plans is North Carolina. The state's Legislative Commission on Global Climate Change was created to address the threats posed to North Carolina by global warming, determine the costs and benefits of various strategies for addressing the problem, and assess the potential economic opportunities for North Carolina in emerging carbon markets. Many other states are initiating or revising climate plans, including

Figure 7

State GHG Emission Targets



Alaska, Arizona, Florida, Montana, New Mexico, Pennsylvania, and Utah.

LEARNING FROM THE STATES

While most state climate change efforts are relatively new, some lessons already are emerging for future state, regional and federal actions. Although garnering support for mandatory goals is sometimes difficult, these policies are generally more effective at achieving significant reductions than voluntary measures. It is clear from the states' experience to date (together with the emergence of several cross-state climate initiatives) that emissions inventories, cap-and-trade and other efforts should be designed so they can easily be expanded or integrated into other programs—for example, at the regional and national levels. States need to ensure that their early actions are taken into account in the design of regional and federal programs. In fact, those states that are considering their options for dealing effectively with climate change may consider beginning or joining a regional initiative from the start. Among the benefits: more efficient reductions in emissions; and a reduction in the regulatory patchwork so businesses can more easily adapt to new policies.

Among the lessons from the states is that they have limited resources to devote to the climate issue, and their strict budget requirements can put long-term climate policies in jeopardy. Moreover, states lack certain powers that would be crucial to a comprehensive climate change policy, such as the authority to enter into international agreements. The patchwork quilt that can result when states take individual approaches to the climate issue can be inefficient and pose challenges for business. Comprehensive federal legislation would provide consistency and certainty for businesses.

While some U.S. states are delivering real reductions in their greenhouse gas emissions, only in a few cases do their reduction targets reflect what will be needed on a global scale. Ultimately, climate change is a global problem that will demand global action, including national action in the United States. The actions undertaken by states to reduce their emissions are an important first step on the path to solutions. In the end, the most important contribution of the states may turn out to be the lessons they are learning about what works—and what does not—to reduce humanity's impact on the global climate.

Pew Center on Global Climate Change

The Pew Center on Global Climate Change tracks and analyzes state climate action. News, reports, maps, tables, and a database of state action are available at www.pewclimate.org.

ENDNOTE

1. Rabe, B. 2006. *Race to the Top: The Expanding Role of U.S. State Renewable Portfolio Standards*. Pew Center on Global Climate Change, Arlington, VA.

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CLIMATE CHANGE 101
Local Action

Across the United States, cities and counties are enacting policies and programs to reduce greenhouse gas emissions. Many local governments are motivated by concerns about the impacts of climate change in their communities, as well as an understanding that climate solutions can benefit local economies and local residents. These actions reflect a strong history of local leadership in climate protection in the United States. While local governments face a number of limitations in addressing climate change, they can be a key part of the solution. Their most important role may be to provide useful models and calls to action to higher levels of government.

WHY FOCUS ON LOCAL ACTION?

With rates of urbanization increasing around the globe, and per capita energy consumption on the rise, cities and towns around the world are an important part of the climate change problem—and they can be an important part of the solution as well. They recognize that they have real influence—and a crucial role to play—in reducing emissions.

Local officials are already taking action. Local governments nationwide have adopted formal climate protection plans and are achieving cuts in their greenhouse gas emissions. To date, climate protection initiatives reported by cities and counties have reduced greenhouse gas emissions by more than 23 million tons annually (equivalent to the emissions produced by 1.8 million households or 2.1 billion gallons of gasoline).[1] These initiatives also have substantial co-benefits such as reducing local air pollution and saving more than $535 million in energy and fuel costs every year.

Opportunities and Influence. Compared to sprawling suburban areas and rural communities, cities and towns have many more opportunities to influence local energy use—for example, by improving public transit and encouraging bicycle and foot traffic. Many cities are adopting zoning rules that promote higher-density, mixed-use forms of development, often near public transit locations. Such development reduces vehicle emissions and preserves green space, which has its own climate benefits. Under Oregon law, every city or metropolitan area has an urban growth boundary aimed at controlling urban expansion onto farm and forest lands.

Urban Facts and Figures

- As of 2005, the majority of the world's population lived in cities.
- Seventy-five percent of the world's energy is consumed in urban areas.
- Together, greenhouse gas emissions from the 10 largest U.S. cities account for 10 percent of total U.S. emissions.
- Around the world, 2 billion more people are expected to live in cities by 2030.[2]

The Pew Center would like to thank ICLEI: Local Governments for Sustainability for the extensive material they contributed in the preparation of this document.

PEW CENTER ON Global CLIMATE CHANGE

PEW CENTER ON THE STATES

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It's not just about reducing energy demand, however. Cities and towns have some opportunities not available to their suburban and rural counterparts in achieving emissions reductions from the supply side of the energy sector. In a world that is moving to combined heat-and-power supplies and high-efficiency, distributed energy sources, the higher density and the relative compactness of cities and towns enhance their appeal as efficient proving grounds for new and emerging energy technologies. It is the same principle that ensured that high-speed internet and wireless services appeared in cities first—the more potential customers there are in a given area, the greater the efficiency as new technologies are brought to scale.

Many cities see opportunities in protecting the climate. Often, policies that reduce greenhouse gas emissions also provide other benefits for communities.

Relevant Authorities. Beyond having an array of opportunities to reduce emissions, cities also have the authority to make reductions happen. In the United States, local governments are responsible for issuing building and development permits and for making land-use decisions about residential and commercial neighborhoods—decisions that profoundly influence local energy use, especially in the transportation sector. Local governments also have the authority to determine the availability of public transit, and to set building codes that influence the energy efficiency of houses and commercial buildings in their communities.

Many local governments also control the local electricity supply through municipal utilities; others wield substantial influence through franchise agreements with utilities. As a result, governments can take steps to reduce the carbon intensity[3] of the electricity consumed in their communities—for example, by requiring higher percentages of clean, renewable energy in the electricity fuel mix. In the City of Austin, Texas, lawmakers established a requirement that 5 percent of local electricity demand come from renewable energy sources. The city's municipal electric utility is meeting the requirement by stepping up purchases of solar and wind power.

WHAT IS DRIVING LOCAL ACTION?

There is Much to Lose . . . One of the major factors motivating local governments to act on climate change is the recognition that it poses a direct threat to cities and towns. Among the likely consequences of climate change, scientists say, is an increase in extreme weather. Stronger hurricanes and storms, temperature spikes, droughts and flooding all will have serious effects in cities. Hurricane Katrina, which ravaged New Orleans as well as other Gulf Coast cities in 2005, offered a preview of the kinds of storms that could be more likely in the future. The storm and the ensuing damage forced local governments throughout the nation to pay fresh attention to the potential hazards of climate change.

Local officials also are concerned about the higher temperatures projected by scientists. In addition to fears of future heat waves like the one that killed 141 people in California in the summer of 2006,[4] mayors have voiced concern about the effect of higher temperatures on local air pollution. As summer temperatures rise, ground-level ozone or smog increases and can exacerbate respiratory illnesses such as asthma and bronchitis. The health-related impacts of air pollution in California's San Joaquin Valley alone drain the region's economy of $3 billion every year—and communities across the nation face similar costs.[5] These costs result from additional hospital admissions, missed work and school days, and a higher incidence of respiratory and heat-related illnesses, as well as premature deaths.

Climate change will have other effects on cities as well. Decreased snow pack, earlier runoff, and melting glaciers, for example, will affect city water supplies, especially in the West. Sea level rise will pose new and serious challenges for coastal cities. Midwestern cities are concerned about the possibility of more floods, while cities in the Southwest fear a higher incidence of drought. All regions of the country—and all communities in those regions—increasingly will feel the effects of climate change, prompting more and more local officials to act.

… And Much to Gain. But it is not only the potential problems related to climate change that are spurring local action; many cities see opportunities in protecting the climate. Often, policies that reduce greenhouse gas emissions also achieve other benefits for communities. For example:

- Energy efficiency and fuel-saving efforts create financial savings for local government, as well as local businesses and residents—savings that can accrue to the local economy.
- Measures that reduce vehicle travel also contribute to improving local air quality—a strong motivating factor for metropolitan areas that are out of compliance with federal clean air requirements.
- Programs and policies that encourage walking and biking contribute to healthier residents and a stronger sense of community.

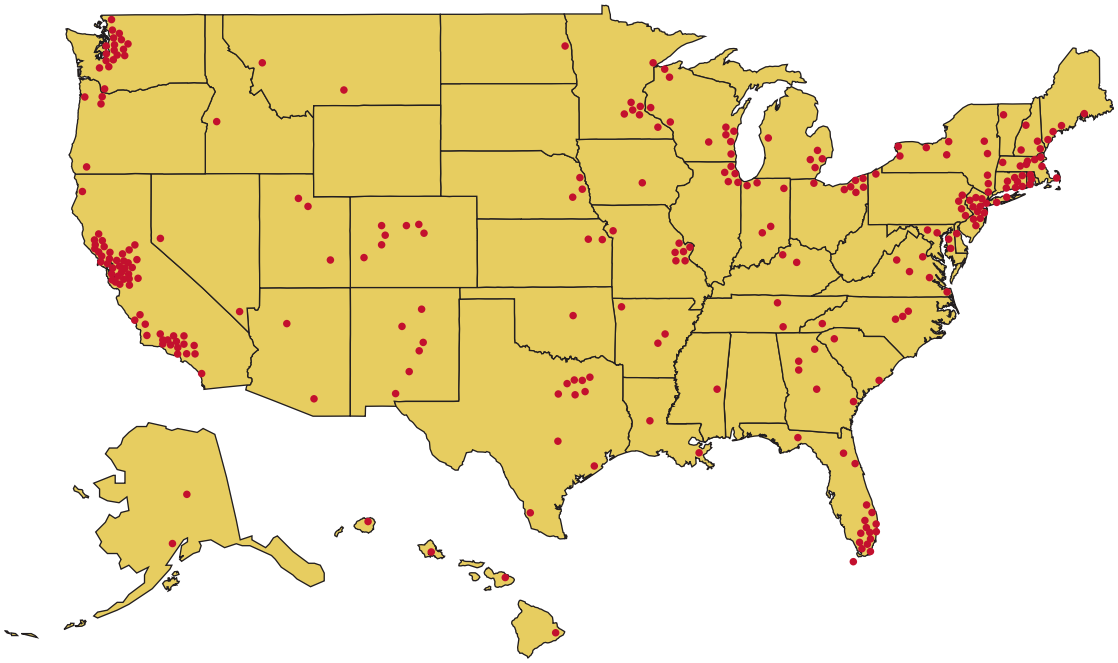
In addition, cities can reap significant rewards as the world embraces GHG allowance trading and other market-based mechanisms for reducing emissions. Cities and towns can achieve reductions more efficiently than lower-density suburbs and rural communities, and sell these credits in carbon markets.

A HISTORY OF LOCAL LEADERSHIP

Local commitment to climate solutions is not new; in fact, cities were leaders in worldwide efforts to reduce emissions from the start. The first greenhouse gas reduction target adopted by any level of government was put forward by Toronto, Canada in 1989. That city's actions helped inspire the first formal municipal program for climate protection, the Urban CO_2 Reduction Project, which was launched in 1991 by the International Council for Local Environmental Initiatives (ICLEI).[6] With only 14 local governments from North America and Europe signed on at the start, this program ultimately developed into the international Cities for Climate Protection (CCP) Campaign, which enlists local governments in developing targets, timelines and implementation strategies for reducing their emissions. The CCP Campaign now represents more than 770 local governments on six continents. In the

Figure 1

Cities Committed to the U.S. Mayors Climate Protection Agreement



Mayors of 320 cities have signed the U.S. Mayors Climate Protection Agreement as of October 2006.
Source: http://www.seattle.gov/mayor/climate/

Local Action on Climate Change

Local governments have a wide range of options for reducing their communities' contributions to climate change. The following examples show some of the steps that localities with climate protection programs are taking.

Energy Supply

Green Power Purchase—Montgomery County, MD

In 2004, Montgomery County led a group of local governments and agencies in a wind energy purchase representing 5 percent of the buying group's total electricity needs. The buying group will collectively purchase 38 million kWh of wind energy each year, for an annual reduction of 21,000 tons of carbon dioxide emissions.

Landfill Methane—San Diego, CA

More than 700,000 tons of carbon dioxide equivalent[7] emissions are being kept out of the atmosphere each year as a result of San Diego's capture of landfill methane gas. In addition to producing electricity for other municipal uses, the gas is converted to liquefied natural gas (LNG) to fuel more than 100 refuse collection trucks.

Combined Heat and Power—St. Paul, MN

District Energy St. Paul burns wood waste to produce steam, which powers turbines that produce electricity. Waste energy from this process provides heat to downtown businesses and homes. This process uses wood waste to displace an estimated 110,000 tons of coal per year, reducing carbon dioxide emissions by an estimated 280,000 tons annually.

Energy Efficiency

ENERGY STAR®—Atlanta, GA

As part of Atlanta's Energy Conservation Program, the city's Department of Procurement has instituted an ENERGY STAR energy-efficient purchasing policy. By purchasing office equipment and other products that have the federal ENERGY STAR label, the city will save energy, which translates into financial savings and reductions in greenhouse gas emissions. The city estimates that it could save nearly $400,000 over ten years if it replaced 1,000 exit signs with ENERGY STAR-qualified models alone.

Low-Income Weatherization—Portland, OR

Designed as a means to increase the disposable income of Portland's low-income families, the city's Block-By-Block Weatherization Program weatherized 261 homes from 2001 to 2003. Low-income families pay a disproportionate amount of their disposable income on utility bills. By reducing the heating and cooling requirements of homes, the city increases the purchasing power of its low-income community.

Municipal Utility Programs/Incentives—Fort Collins, CO

The City of Fort Collins' municipal utility department has instituted the ZILCH program (Zero Interest Loans for Conservation Help) to provide interest-free financing for home energy improvements and upgrades. Loans of up to $2,300 must be repaid within five years or less. Financed projects must have payback periods of 10 years or less in order to ensure that homeowners are getting the most out of their improvements.

Transportation

Transportation Choices—Honolulu, HI

The expansion of Honolulu's Bus Rapid Transit (BRT) program has led to steady growth in passengers choosing the bus for their commute. Monthly ridership has increased from about 100,000 riders in 1999 to more than 630,000 in 2005. Assuming that half of BRT ridership represents a shift from trips made in passenger vehicles to trips taken on BRT, this equals an annual carbon dioxide reduction of approximately 7,000 tons.

Smart Growth/Land Use—Miami-Dade County, FL

Miami-Dade County's Comprehensive Development Master Plan (CDMP) promotes three scales of "Urban Centers" (regional, metropolitan and community) linked by effectively and rationally planned roadway and transit systems. The county is working with municipalities to promote sound transit-oriented design principles, such as mixed residential and commercial developments and commercial revitalization near transit stops, to promote transit use in the urban centers.

Local Action on Climate Change *(continued)*

Clean Diesel and Green Fleet Campaigns—Keene, NH

From fire engines to snowplows, all of the vehicles in the City of Keene, New Hampshire's Public Works Department are running on B20 biodiesel fuel. The fleet is fueled onsite at the department's pump. The biodiesel performs well in cold temperatures and has improved the air quality inside the fleet maintenance facility. The city has burned more than 4,400 gallons of biodiesel since 2002.

Trees and Vegetation

Cool Roofs—Chicago, IL

Chicago is the leading city in the nation, perhaps the world, in implementing green roof technologies. Green roofs add insulation and keep buildings cooler during warm summer months. In addition to the world-renowned rooftop garden on City Hall, the city offers a grant program for homeowners and small businesses to implement green roofs on their buildings. Today, there are more than 80 municipal and private green roofs totaling more than 1 million square feet in Chicago.

Cool Technologies—Houston, TX

Cool Houston! is a program designed to reduce urban temperatures through the use of technologies such as reflective and green roofing, paving with light-colored or porous materials, and a greatly expanded forest canopy. The Cool Houston! plan, published in 2004, includes a goal to plant 10 million new trees in 10 years, along with other strategies for reducing the urban heat island effect.

Cross-Cutting

Lead By Example—Seattle, WA

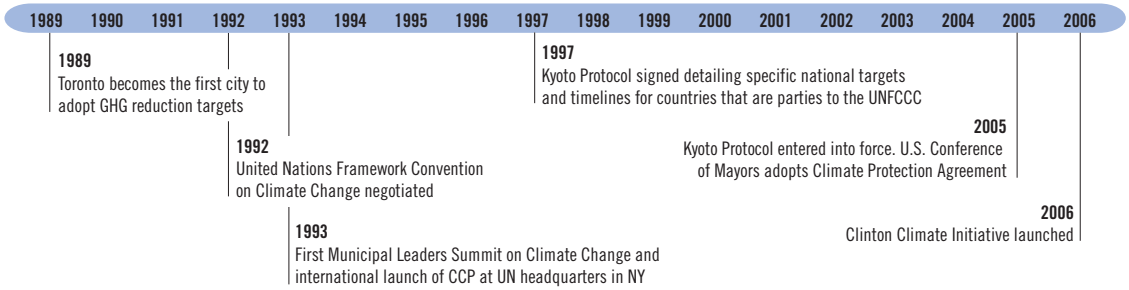
Seattle's city government has reduced its greenhouse gas emissions by more than 60 percent since 1990 by constructing green buildings and operating alternative fuel vehicles. In addition, the city's municipal utility, Seattle City Light, is the only utility in the nation to become "carbon neutral." The utility achieved this goal by offsetting (through funding greenhouse gas-reducing projects) any carbon emissions that it is producing.

Community Outreach—Burlington, VT

The 10-Percent Challenge in Burlington is a voluntary program to raise public awareness about global climate change and to encourage households and businesses to reduce their greenhouse gas emissions by at least 10 percent. Enlisting innovative outreach methods, the program is achieving an estimated annual reduction of 1,500 tons of carbon dioxide in the residential sector alone.

Figure 2

Timeline of Local Government Action Around the World



United States, 200 cities, towns and counties participate in the CCP Campaign, representing 66 million people, or 22 percent of the American population.

Local action on climate change took a major step forward in early 2005, when Seattle Mayor Greg Nickels drafted the U.S. Mayors Climate Protection Agreement. Under this agreement, mayors pledge that their communities will achieve the 7 percent reduction in emissions suggested for the United States in the Kyoto Protocol, the international accord that commits participating developed countries to specific reduction targets relative to 1990 levels. Although the United States has not agreed to ratify Kyoto, more than 320 local elected leaders around the country have signed the mayors' agreement in communities across 46 states plus the District of Columbia, representing over 51 million Americans (see Figure 1). In June 2005, the U.S. Conference of Mayors passed a resolution endorsing the agreement and calling on mayors to begin implementing their climate protection commitments and urging state and federal governments to take comparable action.

Another watershed event in 2005 was The Sundance Summit: A Mayors' Gathering on Climate Protection. Held in July, the summit marked the first-ever national convening of mayors on the sole topic of global warming. The summit created an umbrella effort called Mayors for Climate Protection, which represents more than 300 mayors. Its aim is to help mayors who have committed their cities to reducing greenhouse gases to move from commitments to implementation, share best practices, and harness their collective power to advocate for climate action at the state and federal levels.

In 1995, only 15 local governments in the United States were engaged in climate protection activities. Eleven years later, that number has grown to 200 cities, representing 66 million people.

Most recently, former President Bill Clinton launched the Clinton Climate Initiative in August 2006. Its aim is to mobilize climate action in leading cities. The initiative will begin with the creation of a consortium of large cities to pool their purchasing power in an effort to reduce the costs of energy-saving technologies and products. This effort also will include technical assistance for cities to measure and track their emissions and emission reductions. The Clinton Climate Initiative builds on other efforts, including CO_2: The World Cities Leadership Summit, a 2005 gathering organized by the mayor of London with the assistance of The Climate Group.

Cities and States Are Working Together

Effective coordination between state and local governments can remove state-level barriers to local climate action and support the implementation of local initiatives to meet state goals. In California, ICLEI recently launched a special task force to forge stronger links between local and state actions there. As states develop their own climate protection targets and plans, more and more states are formalizing roles for local governments within those plans.

LIMITATIONS AND CHALLENGES

Despite successes at the local level, many limitations exist on both the scope and effectiveness of local climate initiatives that make them poor substitutes for federal policy. Many of the limitations of local climate action parallel those that constrain state efforts (see *Climate Change 101: State Action*).

Perhaps the biggest weakness of local action is that it simply cannot achieve the economies of scale necessary for widespread and aggressive emissions cuts. Even the best efforts of cities and counties will ultimately be limited in scope.

A related limitation on local climate action is that much regulatory and legislative authority rests in the hands of state and federal governments. For example, urban areas can achieve a lot by promoting smart growth practices and transit, but vehicle and fuel regulation is typically beyond their control. Likewise, municipal utilities have an important role to play, but the power to regulate many larger utilities—with the potential for more significant emissions reductions—lies at the state and federal level.

Local governments also are at a disadvantage because of other pressing needs and tight budgets. For many cities and counties, there are few if any resources available to devote to effective climate action. In addition, different climate policies enacted by various communities across a given area can lead to an inefficient patchwork of regulation, posing challenges to businesses operating in different localities.

LESSONS LEARNED

Local leaders can provide models for climate action for other communities and levels of government to emulate. The experience of local governments suggests that certain elements contribute to the success of local, state or regional climate protection strategies. For example:

Resources for coordination and tracking. Salt Lake City began participating in the Cities for Climate Protection Campaign in 1996. Initially the city's climate efforts were limited because they received only lower-level staff support. This situation changed in 2000 when newly-elected Mayor Rocky Anderson made climate protection a policy priority and designated a staff point person with formal duties and empowerment to work on the city's climate protection plan. Salt Lake City now has one of the premier local climate action plans in the country.

Integration of climate protection into long-term planning. Marin County, California has incorporated climate change impacts and climate protection into its comprehensive general development plan, ensuring that actions to reduce greenhouse gas emissions will be implemented over the long term.

Leadership. Miami-Dade County, Florida has been a leader in climate protection in the United States since 1991. Among the main reasons for the county's success in keeping this issue on the agenda is the advocacy of a strong local elected champion, Clerk of Courts Harvey Ruvin. Ruvin keeps climate protection front and center on the county's priority list and ensures that the necessary resources are allocated to implementing the county's climate action plan.

A network of people and governments who share a commitment to action. In 2002, a cluster of local governments in the metropolitan Boston area began meeting monthly to discuss their climate protection programs and possible areas of collaboration. This network has grown to include more than 20 cities and towns in Massachusetts, which now have a close working relationship with state agencies to advance their local climate work. The same principle applies to climate work at the state, regional, national and international levels: climate action is more effective when government entities collaborate on cross-border actions.

LOOKING AHEAD

In 1995, only 15 local governments in the United States were engaged in climate protection activities. Eleven years later, that number has grown to 200 cities, representing 66 million people. Almost in tandem, state governments increasingly are taking action to adopt greenhouse gas reduction targets, develop climate protection plans, and adopt other policies aimed at protecting the climate. These local and state leaders recognize the importance of action and collaboration at all levels of government to address this global challenge. They can also serve as strong voices in favor of national action. Local and state action needs to be supported by a comprehensive national and international commitment to climate protection.

Pew Center on Global Climate Change

More information on climate change solutions is available at www.pewclimate.org.

ENDNOTES

1. ICLEI U.S. Cities for Climate Protection Progress Report, 2005.
2. United Nations Department of Economic and Social Affairs *World Population Prospects: The 2004 Revision*. 2004
3. Carbon intensity of electricity is the ratio of carbon emissions to the amount of electricity produced, i.e. the amount of carbon emissions produced per kilowatt hour of electricity.
4. "Death Toll Mounts As California's Record-Breaking Heat Wave Ends," *San Jose Mercury News*, July 28, 2006. http://www.mercurynews.com/mld/mercurynews/news/breaking_news/15148596.htm
5. Hall, Jane; Lurmann, Frederick. "The Health and Related Economic Benefits of Attaining Healthful Air in the San Joaquin Valley" *California State University Fullerton: Institute for Economic and Environmental Studies*. March, 2006.
6. In 2003, ICLEI's membership voted to change the name of the organization to ICLEI—Local Governments for Sustainability.
7. Carbon dioxide equivalent is a measure used to compare emissions of various greenhouse gases based on their global warming potential.

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The Pew Center on Global Climate Change is a non-profit, non-partisan, independent organization dedicated to providing credible information, straight answers, and innovative solutions in the effort to address global climate change.

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The Pew Center on the States, a division of the Pew Charitable Trusts, identifies critical issues facing states, examines diverse policy approaches, and shines a spotlight on nonpartisan, pragmatic solutions.

In an effort to inform the climate change dialogue, the Pew Center on Global Climate Change and the Pew Center on the States have developed a series of brief reports entitled *Climate Change 101: Understanding and Responding to Global Climate Change*. These reports are meant to provide a reliable and understandable introduction to climate change. They cover climate science and impacts, technological solutions, business solutions, international action, recent action in the U.S. states, and action taken by local governments. The overview serves as a summary and introduction to the series.

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