CLIMATE CHANGE 101
Understanding and Responding to Global Climate Change

January 2011 Update









PEW CENTER ON Global CLIMATE CHANGE

January 2011

CLIMATE CHANGE 101
Overview

Climate change is happening and it is caused largely by human activity. Its impacts are beginning to be felt and will worsen in the decades ahead unless we take action. The solution to climate change will involve a broad array of technologies and policies—many tried and true, and many new and innovative.

This overview summarizes the eight-part series *Climate Change 101: Understanding and Responding to Global Climate Change*. *Science and Impacts* discusses the scientific evidence for climate change and explains its causes and current and projected impacts. *Adaptation* discusses these impacts in greater depth, explaining how planning can limit (though not eliminate) the damage caused by unavoidable climate change, as well as the long-term costs of responding to climate-related impacts. As explored 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*, *Federal Action*, *State Action*, and *Local Action* describe how business and government leaders at all levels have recognized both the challenge and the vast opportunity dealing with climate change presents. These leaders are responding with a broad spectrum of innovative solutions. To address the enormous challenge of climate change successfully, new approaches are needed at the federal and international levels, and the United States must stay engaged in the global effort while adopting strong and effective national policies.

A REAL PROBLEM WITH REAL SOLUTIONS

The overwhelming body of scientific evidence demonstrates unequivocally that the earth is warming. Climate change is happening, it is caused in large part by human activity, its impacts are beginning to be experienced and these damaging effects will only increase in the decades ahead. Greenhouse gas emissions from cars, power plants, and other human activities—rather than natural variations in climate—are the primary cause of contemporary global warming. Due largely to the combustion of fossil fuels, atmospheric concentrations of carbon dioxide (CO_2), the principal human-produced greenhouse gas, are at a level unequaled for at least 800,000 years. The greenhouse gases (GHGs) from human activities are trapping more of the sun's heat in the earth's atmosphere, resulting in warming. Over the last century, the global average temperatures rose by almost 1.5°F (see Figure 1), and the Arctic warmed about twice as much. The oceans have also warmed, especially within 1,000 feet of the surface (see Figure 1).

Carbon dioxide and other GHGs always have been present in the atmosphere, keeping the earth hospitable to life by trapping heat and warming our atmosphere. Yet, since the industrial revolution, emissions of these gases from human activity have increased steadily, trapping more heat and amplifying the greenhouse effect (see Figure 2). Since pre-industrial times, atmospheric CO_2 concentrations have

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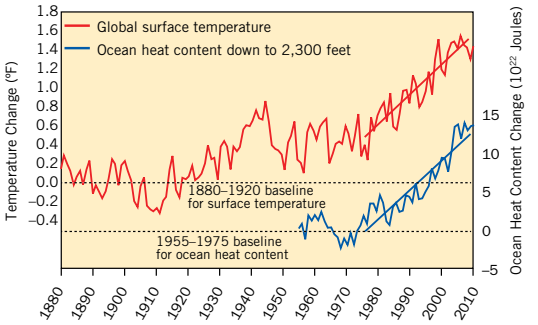
This brief is part of a series called *Climate Change 101: Understanding and Responding to Global Climate Change*, published by the Pew Center on Global Climate Change.

increased by 40 percent, and concentrations of other GHGs have grown significantly as well. As a result, global average temperatures have risen both on land and in the oceans, with observable impacts already occurring that presage increasingly severe changes in the future. Polar ice is melting at record rates. Glaciers around the globe are in retreat. Storms, including hurricanes, are increasing in intensity. Ecosystems around the world already are reacting as plant and animal species struggle to adapt to a shifting climate.

Scientists project that if the increase in man-made GHG emissions continues unabated, additional warming of 2 to 11.5°F over the next century is likely, depending on how much more GHGs are emitted and how strongly the climate system responds to them. Although the range of uncertainty for future temperatures is large, even the lower end of the range is likely to have many undesirable effects on natural and human systems. 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 cause more and more damage. Agricultural production could increase with slight warming in northern countries but is already declining in many low-latitude countries and will decrease everywhere with higher levels of warming due to changes in precipitation, weather extremes, and the spread of crop pests and diseases. Changing weather patterns will also change the distribution and incidence of insect-borne and waterborne diseases, such as malaria and cholera. Human health will be jeopardized by all of these changes. Changes in climate also pose substantial national

Figure 1

Global Warming Trend: Average Surface Warming and Ocean Heat Content



Global average surface temperature change (left axis) and ocean heat content change in upper 2,300 feet (right axis).

SOURCES

Surface temperature: Smith, T.M., R.W. Reynolds, T.C. Peterson, and J. Lawrimore, 2008: Improvements to NOAA's historical merged land–ocean surface temperature analysis (1880–2006). *Journal of Climate*, 21:2283-2296.

Ocean heat: Levitus, S., J.I. Antonov, T.P. Boyer, R.A. Locarnini, H.E. Garcia, and A.V. Mishonov, 2009: Global Ocean Heat Content 1955-2008 in light of recently revealed instrumentation problems. *Geophys. Res. Lett.*, 36, L07608, doi:10.1029/2008GL037155.

Figure 2

The Greenhouse Effect

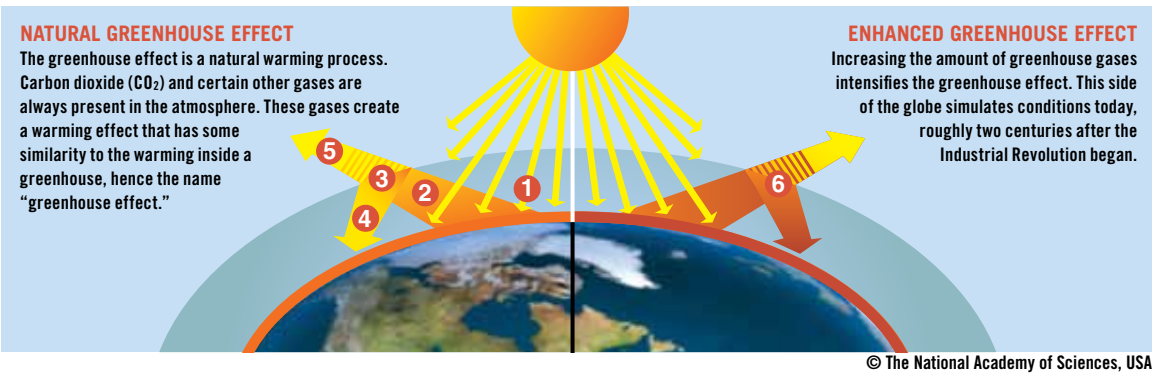


Illustration of the greenhouse effect (adapted with permission from the Marian Koshland Science Museum of the National Academy of Sciences). Visible sunlight passes through the atmosphere without being absorbed. Some of the sunlight striking the earth ❶ is absorbed and converted to heat, which warms 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.

security risks by expanding the number of weather-related humanitarian missions for our military, by opening up new areas for military operations (e.g., the Arctic) and by putting at risk military facilities located in coastal areas.

A growing body of scientific research has documented that climate change is already underway and some dangerous impacts have already occurred. Avoiding more severe impacts in the future requires large reductions in human-induced GHG emissions in the coming decades. Consequently, many governments have committed to reduce their countries' emissions by between 50 and 85 percent below 2000 levels by 2050. If achieved, global emissions reductions on this scale will reduce the costs of damages and of adaptation, and will dramatically reduce the probability of catastrophic outcomes. While committing to and achieving such reductions must be a high priority, adapting to climate change that is now unavoidable is also important. Effective adaptation planning while simultaneously reducing emissions is a major challenge that requires unprecedented cooperation and participation throughout the world.

ADAPTATION

Reducing emissions will decrease both the rate of change and the magnitude of those changes in climate and their related impacts. However, CO_2 and other GHGs can remain in the atmosphere for decades to many centuries after they are emitted, meaning that today's emissions will affect the climate far into the future. As a result, the Earth is committed to additional warming no matter what actions are taken to reduce emissions now. With global emissions on the rise, adaptation efforts are necessary to reduce the cost and severity of climate change impacts for the next several decades.

Recent scientific research demonstrates that many aspects of climate change are happening earlier or more rapidly than climate models and experts initially projected. The rate of change projected for global surface temperatures and related impacts, such as ice melt and sea level rise, is unprecedented in human history. Adapting to climate change will become that much harder and more expensive as changes happen faster, or on a larger scale, than expected.

In general, scientists expect the United States to see overall increases in precipitation (along with decreases in some areas, such as the Southwest), including increases in the intensity of both hurricanes and heavy rainfall events. Projections also indicate declines in snowpack, earlier snow and ice melt in areas including the West and Great Lakes regions, and more land areas affected by drought and wildfires. Sea level rise will affect the U.S. coastline to varying degrees, with the most severe impacts projected along the Gulf of Mexico and Atlantic coastlines, including potentially significant losses of coastal wetlands. More than half the U.S. population lives near the coast, with the most vulnerable areas being the Mid-Atlantic and Gulf Coasts. All of these impacts will affect food and water supplies, natural resources, ecosystems, and human life and property (see Table 1).

Table 1. Sample of Projected U.S. Regional Climate Impacts

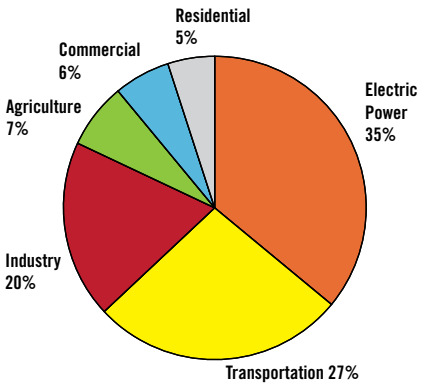
Impacts	Region
Coastal flooding/erosion	South, Southeast, Mid-Atlantic, Northeast, Northwest, Alaska
Hurricanes	Atlantic and Gulf of Mexico coastal areas
Decreased snow cover and ice, more intense winter storms	Alaska, West, Great Lakes, Northeast
Flooding/intense precipitation	All regions, increasing with higher northern latitude
Sea-level rise	Atlantic and Gulf of Mexico coastal areas, San Francisco Bay/ Sacramento Delta region, Puget Sound, Alaska, Guam, Puerto Rico
Decreased precipitation and stream-flow	Southwest
Drought	Portions of the Southeast, Southwest
Wildfires	West, Alaska
Intense heat waves	All regions

Recognizing these risks, governments and other entities around the world are acting now to build in greater resilience to climate change rather than waiting to take more costly, reactive measures in the future. Although national and international action is essential, many important decisions about how best to manage systems affected by climate change are made at local, state, and regional levels. Comprehensive, proactive adaptation planning is still in the early stages in the United States—yet many states and localities have begun to take action. Every level of government, as well as resource managers, industry, and community leaders, has a role to play in assessing the climate vulnerability of both natural and man-made systems. Together, these stakeholders must take action to help these systems adapt and adequately prepare for unavoidable climate impacts.

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, individually, and at all levels of society—to take serious action to reduce global emissions and thus the threat posed by climate change. The tools exist to begin addressing this challenge now. Throughout the United States and the world, many political, business, and community leaders already are working to prevent the consequences of global warming by lowering GHG emissions. 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.

Figure 3

U.S. GHG Emissions by Source, 2008



SOURCE: U.S. EPA, 2010. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008.* EPA 430-R-08-005. Washington, D.C. http://www.epa.gov/climatechange/emissions/downloads10/US-GHG-Inventory-2010_Report.pdf

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 GHGs.

Although GHG 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 the economy. As Figure 3 shows, the largest contributors to total U.S. emissions are the electric power and transportation sectors. Significant emissions also come from the industrial and agricultural sectors. In each of these areas, technologies and practices already exist that can reduce emissions. Other tools that are still being developed hold tremendous promise. However, significant time and money are needed to develop, demonstrate, and commercially deploy these new low-emission technologies that can protect the climate and create new clean energy industries.

Right now, the true costs of GHG emissions are not reflected in the marketplace. Policies that send a clear price signal to the market by putting a financial cost on GHG emissions would make many low-carbon technologies commercially competitive with traditional GHG-emitting technologies. Moreover, putting a price on carbon would spur companies to invest in developing new low-carbon technologies. Governments, however, will also need to invest in research and development to advance technologies for the future.

Significant emission 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 to achieve the reductions required to avoid the most serious consequences of climate change—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 increased share of electricity from climate-friendly, renewable sources, such as solar, wind, and tidal power; deploying technologies to store CO_2 emissions underground; and investing in new nuclear power plants. Since most electricity is used in buildings, 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, which can include biofuels, fuel cells, or electricity, and adopting "smart growth" policies that 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 the development of new technologies and to pull them 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.

Addressing climate change offers enormous economic opportunities, starting with the opportunity to avoid considerable costs that climate change will pose to society.

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 advocate for sensible policy solutions. 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 and sustainable practices. 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. Figure 4 shows a ranking of private sector activities that benefit the bottom line based on a Pew Center on Global Climate Change poll of 33 major corporations.

Many corporate leaders increasingly believe that with the growing certainty about the risks of climate change, future regulation is inevitable. 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 do not 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 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 46 companies at the forefront of corporate action on climate change. Council members' diverse, innovative efforts show the power of business to have a significant impact on reducing GHG emissions

while helping the bottom line. The emergence of the U.S. Climate Action Partnership (USCAP), a coalition of major corporations and non-governmental organizations, which called for the prompt establishment of a binding domestic cap on emissions, was perhaps the most dramatic example of positive business engagement on the climate issue in recent years. The coalition publicly unveiled its "Call for Action" in January of 2007 and followed up with its more detailed "Blueprint for Legislative Action" in January 2009, which urged the adoption of a market-driven, economy-wide approach to reducing GHG emissions 80 percent below 2005 levels by 2050.

Despite concerns that the current global economic turmoil may dampen business and government support for addressing climate change, there are encouraging signs that the climate issue will stay near the top of corporate and government agendas. Governments at all levels remain committed to efforts aimed at reducing GHG emissions, and companies continue to announce new, ambitious programs and voluntary GHG reduction targets. Many analysts also note the potential for investment in clean energy to serve as a powerful economic stimulus tool for the United States and other countries.

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 cumulative emitter.

International Action. Climate change requires a global response. Energy-related CO_2 emissions have risen 145-fold since 1850 and are projected to increase another 36 percent by 2030. Most emissions come from a relatively small number of countries. An effective global 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 17 percent of global GHG emissions. On an intensity basis (emissions per gross domestic product or GDP), U.S. emissions are significantly higher than the EU's and Japan's. On a per capita basis, U.S. emissions are more than twice as high as those of the EU and Japan (and three and a half times the world average). U.S. emissions are projected to remain largely flat through 2020. By comparison, emissions are projected to decline from current levels (2008) by about 4 percent in the EU and 57 percent in Japan by 2020.

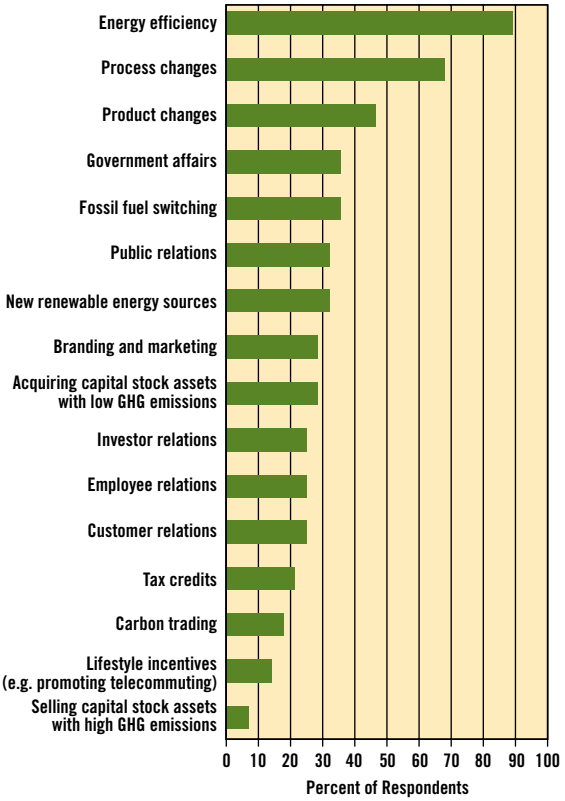
Emissions are rising fastest in developing countries. China's and India's emissions are projected to grow compared to current levels by about 45 percent and 47 percent, respectively, by 2020. Annual emissions from all developing countries surpassed those of developed countries in 2004. Their per capita emissions, however, will remain much lower than those of developed countries. Despite being surpassed by China as the largest annual emitter of GHGs in 2006, the United States accounts for 30 percent of cumulative energy-related CO_2 emissions since 1850 while China accounts for 9 percent. Cumulative emissions are an important measure because of the long-lasting nature of GHGs in the atmosphere. Although developing country emissions are rising, their cumulative emissions are not projected to reach those of developed countries for several more decades.

In 1992, countries signed the United Nations Framework Convention on Climate Change (UNFCCC) with the objective of avoiding dangerous human interference in the climate system (194 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. Kyoto has now been ratified by 182 countries, including all developed countries except the United States.

Meeting in Montreal in 2005, parties to the Kyoto Protocol opened negotiations on post-2012 commitments for developed countries that are party to the protocol. In Bali in

Figure 4

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

2007, governments launched a parallel negotiating process under the Framework Convention, that includes the United States, with the aim of an "agreed outcome" in Copenhagen in 2009. While many parties hoped for a binding agreement in Copenhagen, the summit instead produced the Copenhagen Accord, a political agreement negotiated by a group of world leaders, including President Obama. Although the Accord was not formally adopted by UNFCCC parties in Copenhagen, 140 countries have now associated themselves with the agreement and more than 80—including all the major economies—have pledged specific mitigation targets or actions for 2020.

For the past 15 years, the primary thrust of negotiations within the UNFCCC has been the establishment, and then the extension, of a legally binding regime to reduce GHG emissions. This should remain the long-term objective. The Copenhagen summit, however, demonstrated the difficulty of achieving a new round of binding climate commitments. Under these circumstances, the best course forward may be an evolutionary one. Parties could take incremental steps to strengthen the multilateral architecture in ways that promote stronger action in the near term, while providing a stronger foundation for future binding commitments. Of central importance are a financial architecture to deliver strong, sustained support to developing countries and an improved system of reporting and verifying countries' actions to ensure transparency and a measure of accountability. Over time, such incremental efforts can strengthen countries' confidence in one another's actions and in the emerging climate change regime. The success of the international effort will hinge heavily on domestic action by the United States. Stronger U.S. action will be critical both because it will promote stronger action by other countries and because it will better position the United States to take on the types of binding commitments needed to ensure a sustained and effective global effort.

United States: Federal Action. To date, the federal government has not yet enacted a comprehensive set of policies to reduce GHG emissions. While several senators and representatives—both Democrats and Republicans—have introduced bills or proposed policies in the past few years, in 2009 the House of Representatives became the first body of Congress to ever pass a comprehensive climate and clean energy bill. Despite this success, the Senate did not pass such a bill, and it still remains for Congress to enact comprehensive legislation. Federal policies and programs are already in place, however, that are making a difference at least in slowing the growth of GHG emissions and in promoting low-carbon technologies.

The year 2010 marks the first time for which large GHG emitters must report their emissions to the government. In addition, following a Supreme Court case establishing that the government could regulate GHGs under the existing air pollution law, the federal government has started regulating GHG emissions from vehicles and new large sources, such as new power plants. Efforts to reduce GHG emissions were further aided in 2009 when the economic stimulus bill included roughly $80 billion in funding, tax credits, and other financial

incentives for energy efficiency and clean energy—ranging from home weatherization programs to research on "breakthrough" energy technologies.

These recent federal policy developments build upon existing federal policies to promote energy efficiency, develop and deploy new technologies, and reduce emissions. Some of these policies date back many years and were motivated by concerns other than climate change, such as U.S. dependence on foreign oil. Existing federal policies include fuel economy standards for vehicles, minimum energy efficiency standards for appliances, tax incentives for renewable electricity generation, and national requirements for biofuels for transportation.

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 country.

Existing federal policies have played important roles in improving energy efficiency, helping wind and solar power mature, demonstrating carbon capture and storage technology, and launching the first mass-market electric vehicles. Nonetheless, without new policies from the federal government, the United States cannot achieve the significant emission reductions necessary to address the threat of climate change. Federal policymakers can choose from a variety of policies—including market-based regulations and traditional performance standards—that apply economy wide or that are tailored to certain sectors of the economy or emitters (e.g., power plants). From among these choices, federal policymakers can craft a comprehensive approach to cost-effectively reduce emissions. Moreover, increased federal funding for research, development, and demonstration can accelerate the pace of clean technology innovation.

United States: State Action. The lack of comprehensive action on the climate issue at the federal level has prompted many states to seek their own solutions both individually and cooperatively. Nearly every state is currently 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.

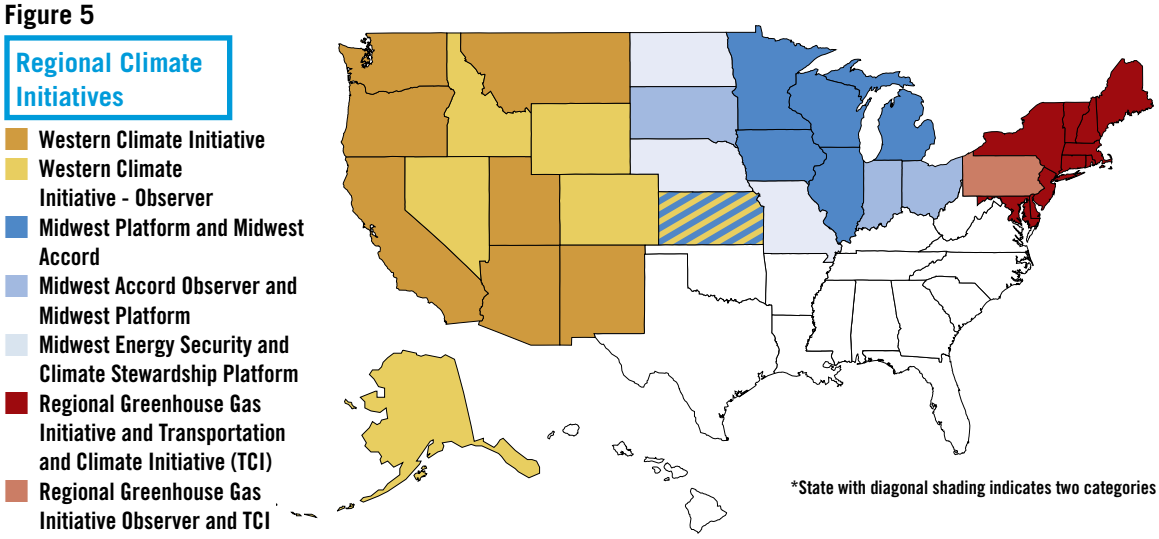
To date, states have implemented a broad spectrum of climate policies. Thirty-six states have completed comprehensive climate action plans, or are in the process of revising or developing one, and 23 states actually have set quantitative targets or goals, ranging from modest to aggressive, to reduce their GHG emissions. Regional climate initiatives, including three cap-and-trade programs are underway among U.S. states and Canadian provinces (see Figure 5).

Beyond these broad-based plans and targets, 31 states have adopted policies that reduce emissions from electricity generation 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 (including electric 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 energy 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 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. Climate-related policies have received bipartisan support among the states. This activity on the part of states is significant because some U.S. states are major emitters of GHGs, 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.

Through interstate partnerships, states are demonstrating the power of collective action to reduce costs and to achieve

Figure 5



increased efficiency while cutting emissions across a larger geographic area.

State and regional climate policy analyses and decisions are providing helpful lessons for federal policy makers. In addition to spotlighting what works, however, states also are demonstrating that their efforts alone are not enough. Because of their authorities and responsibilities (for example, in overseeing electric utilities), states have an important role to play in addressing climate change. States could play an important role in implementing federal climate policies, as they do under the federal Clean Air Act, However, they 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 businesses. 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 country.

Local Action. State leaders are hardly alone in their movement to address climate change. Across the country and the world, local governments are implementing their own policies aimed at reducing GHG emissions. Localities 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, the Clinton Climate Initiative, and the U.S. Mayors Climate Protection Agreement, which has experienced dramatic growth in participation (see Figure 6).

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 indirect benefits by tackling climate change, such as energy savings and improved air quality. Like their partners at other levels of government, local leaders also see an economic opportunity in addressing climate change. Localities, like the states, have climate-relevant authorities and responsibilities, and are offering lessons in what works to protect the climate. However, as is the case with action by the states, local policies are no substitute for broader action at the federal and international level.

Figure 6

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

Mayors of 1,044 cities have signed the U.S. Mayors Climate Protection Agreement as of October 2010. Source: http://www.usmayors.org/climateprotection

THE PATH FORWARD

The science is clear. Climate change is happening, and the time to act is now. While the 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 crucial to the success of the global effort. On the domestic front, the federal government needs to adopt policies that reduce GHG emissions. With comprehensive federal policy and constructive international engagement, the United States can harness the power of markets to drive innovation and protect the climate.

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

CLIMATE CHANGE 101
Science and Impacts

The scientific evidence is unequivocal. Natural climate variability alone cannot explain this trend. Human activities, especially the burning of coal and oil, have warmed the earth by dramatically increasing the concentrations of heat-trapping gases in the atmosphere. The more of these gases humans put into the atmosphere, the more the earth will warm in the decades and centuries ahead. The impacts of warming can already be observed throughout the United States, from rising sea levels to melting snow and ice to more drought and extreme rainfall. Climate change is already affecting ecosystems, freshwater supplies, and human health around the world. Although some amount of climate change is now unavoidable, much worse impacts can be avoided by substantially reducing the amount of heat-trapping gases released into the atmosphere.

CLIMATE CHANGE SCIENCE: THE BASICS

A study released by the U.S. National Academy of Sciences in 2010 said, "Climate change is occurring, is caused largely by human activities, and poses significant risks for —and in many cases is already affecting—a broad range of human and natural systems."[1] The climate will continue to change for decades as a result of past human activities, but scientists say that the worst impacts can still be avoided if action is taken soon.

GLOBAL TEMPERATURES: THE EARTH IS WARMING

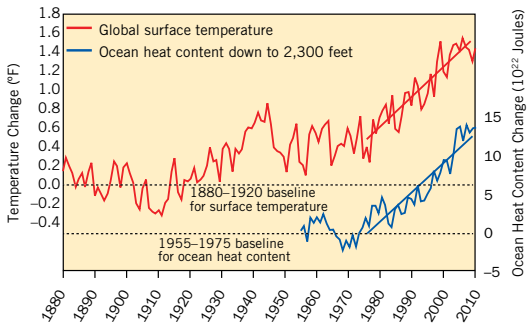
Global average temperature data based on reliable thermometer measurements are available back to 1880. Over the last century, the global average temperatures rose by almost 1.5°F (see Figure 1), and the Arctic warmed about twice as much.[2]

Based on data from the U.S. National Climatic Data Center, the 27 warmest years since 1880 all occurred in the 30 years from 1980 to 2009; the warmest year was 2005 followed closely by 1998.[3]

Over the past 50 years, the data on extreme temperatures have shown similar trends of rising temperatures: cold days, cold

Figure 1

Global Warming Trend: Average Surface Warming and Ocean Heat Content



Global average surface temperature change (left axis) and ocean heat content change in upper 2300 feet (right axis).

SOURCES

Surface temperature: Smith, T.M., R.W. Reynolds, T.C. Peterson, and J. Lawrimore, 2008: Improvements to NOAA's historical merged land–ocean surface temperature analysis (1880–2006). *Journal of Climate,* 21:2283-2296.

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PEW CENTER ON Global CLIMATE CHANGE

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.

nights, and frosts occurred less frequently over time, while hot days, hot nights, and heat waves occurred more frequently.[4]

Warming has not been limited to the earth's surface; the oceans have absorbed most of the heat that has been added to the climate system, resulting in a persistent rise in ocean temperatures (see Figure 1).[5] Over time, the heat already absorbed by the ocean will be released back to the atmosphere, causing an additional 1°F of surface warming; in other words, some additional atmospheric warming is already "in the pipeline."[6]

GREENHOUSE GASES: MAKING THE CONNECTION

Although global temperatures have varied naturally over thousands of years, scientists studying the climate system say that natural variability alone cannot account for the rapid rise in global temperatures during recent decades.[7] Human activities cause climate change by adding carbon dioxide (CO_2) and certain other heat-trapping gases to the atmosphere. When sunlight reaches the earth's surface, it can be reflected (especially by bright surfaces like snow) or absorbed (especially by dark surfaces like open water or tree tops). Absorbed sunlight warms the surface and is released back into the atmosphere as heat. Certain gases trap this heat in the atmosphere, warming the Earth's surface. This warming is known as the greenhouse effect and the heat-trapping gases are known as greenhouse gases (GHGs) (see Figure 2).

CO_2, methane (CH_4), and nitrous oxide (N_2O) are GHGs that both occur naturally and also are released by human activities. Before human activities began to emit these gases in recent centuries, their natural occurrence resulted in a natural greenhouse effect. Without the natural greenhouse effect, the earth's surface would be nearly 60°F colder on average, well below freezing. However, humans are currently adding to the naturally occurring GHGs in the atmosphere, causing more warming than occurs naturally. Scientists often call this human-magnified greenhouse effect the "enhanced greenhouse effect."

Evidence from many scientific studies confirms that the enhanced greenhouse effect is occurring.[8] For example, scientists working at NASA's Goddard Institute for Space Studies found more energy from the sun is being absorbed than is being emitted back to space. This energy imbalance is direct evidence for the enhanced greenhouse effect.[9]

Greenhouse Gas Levels Rising. In 2009, the U.S. Global Change Research Program (USGCRP) released the most up-to-date and comprehensive report currently available about the impacts of climate change in the United States.[10] The report says that average global concentrations of the three

Figure 2

The Greenhouse Effect

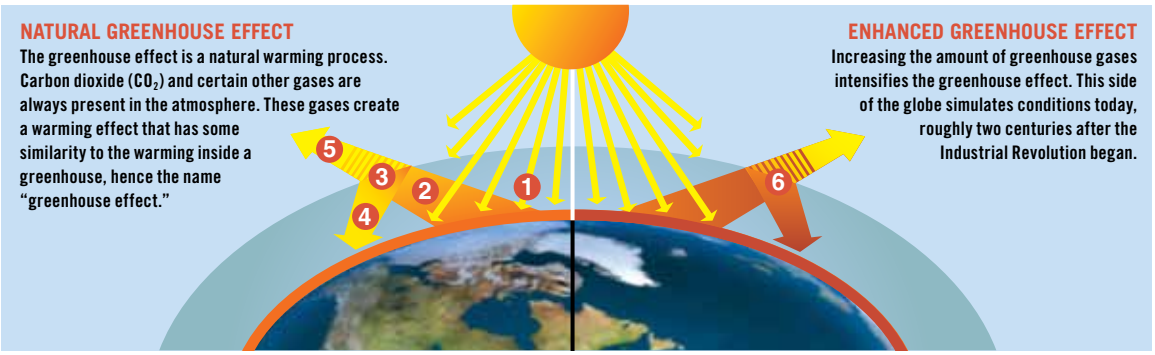


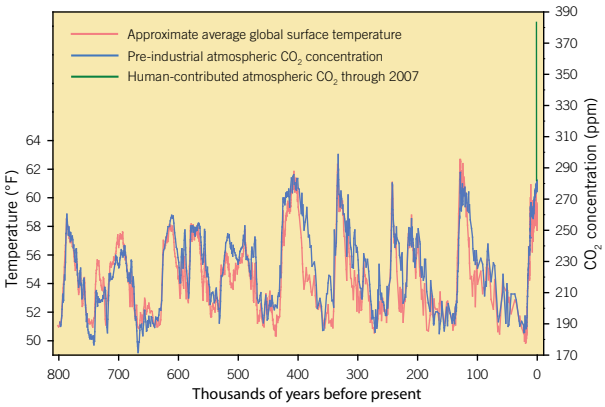
Illustration of the greenhouse effect (adapted with permission from the Marian Koshland Science Museum of The National Academy of Sciences). Visible sunlight passes through the atmosphere without being absorbed. Some of the sunlight striking the earth ❶ is absorbed and converted to heat, which warms 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.

main greenhouse gases—CO_2, CH_4, and N_2O—are rising because of human activities. Since pre-industrial times, CO_2 has increased by 40 percent, CH_4 by 148 percent, and N_2O by 18 percent.

CO_2 is the principal gas contributing to the enhanced greenhouse effect. Many human activities produce CO_2; the burning of coal, oil, and natural gas account for about 80 percent of human-caused CO_2 emissions. Most of the remaining 20 percent comes from changes in the land surface, primarily deforestation. Trees, like all living organisms, are made mostly of carbon; when forests are burned to clear land, the carbon in the trees is released as CO_2.

Figure 3

Global Temperatures: The Last 800,000 Years



Global average surface temperature (left axis) and atmospheric CO_2 concentration (right axis) over the past 800,000 years as determined from Antarctic ice cores and direct atmospheric CO_2 measurements.

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The USGCRP report says that the current trajectory of rising GHG concentrations is pushing the climate into uncharted territory. CO_2 levels are much higher today than at any other time in at least 800,000 years. Through all those millennia, there has been a clear correlation between CO_2 concentrations and global temperatures (see Figure 3), adding geological support for the strong connection between changes in the strength of the greenhouse effect and the earth's surface temperature.

Scientists are certain that the burning of fossil fuels is the main source of the recent spike in CO_2 in the atmosphere. Multiple, independent lines of evidence clearly link human actions to increased GHG concentrations.[11] Moreover, there is strong evidence that this human-induced rise in atmospheric GHGs is the main reason that the Earth has been warming in recent decades. The USGCRP report says, "The global warming of the past 50 years is due primarily to human-induced increases in heat-trapping gases. Human fingerprints also have been identified in many other aspects of the climate system, including changes in ocean heat content, precipitation, atmospheric moisture, and Arctic sea ice." The U.S. National Academy of Sciences draws the same conclusion: "Many lines of evidence support the conclusion that most of the observed warming since the start of the 20th century, and especially the last several decades, can be attributed to human activities."[12]

Looking Ahead. The more GHGs humans release into the atmosphere, the stronger the enhanced greenhouse effect will become.

At Issue: Measuring Atmosphere vs. Surface Temperatures

For many years, skeptics of climate change pointed to differences between temperature increases recorded at the earth's surface and those recorded in the lower atmosphere as a way to challenge scientific claims about climate change. However, a 2006 report from the U.S. Climate Change Science Program reconciled data from surface measurements, satellites, and weather balloons, concluding that "(t)he previously reported discrepancy between surface and the atmospheric temperature trends is no longer apparent on a global scale."[13]

Scenarios in which GHGs continue to be added to the atmosphere by human activities could cause additional warming of 2 to 11.5°F over the next century, depending on how much more GHGs are emitted and how strongly the climate system responds to them. Although the range of uncertainty for future temperatures is large, even the lower end of the range is likely to have many undesirable effects on natural and human systems.[14]

Land areas warm more rapidly than oceans, and higher latitudes warm more quickly than lower latitudes. Therefore, regional temperature increases may be greater or less than global averages, depending on location. For example, the United States is projected to experience more warming than average, and the Arctic is expected to experience the most warming.[15]

The future climate depends largely on the actions taken in the next few decades to reduce and eventually eliminate human-induced CO_2 emissions. In 2005, the U.S. National Academy of Sciences joined with 10 other science academies from around the world in a statement calling on world leaders to take "prompt action" on climate change. The statement was explicit about our ability to limit climate change: "Action taken now to reduce significantly the build-up of greenhouse gases in the atmosphere will lessen the magnitude and rate of climate change."[17]

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 from 1975 to the present. The most likely reason for the cooling during the middle of the century is a surge in sun-blocking aerosols, or very fine particles, resulting from the large-scale ramp-up of polluting industries after World War II. In more recent decades, GHG concentrations have grown to levels that now outweigh the effects of the aerosols, leading to rapid warming. In the future, industrial emissions of aerosols are expected to decrease as environmental regulations improve in developing countries, as they did in previous decades in the United States. The resulting cleaner industrial emissions could lead to more rapid warming as the cooling effect of aerosols diminishes.[16]

CHANGING CLIMATE: THEORY TO REALITY

Although "climate change" and "global warming" are often used interchangeably, rising temperatures are just one aspect of climate change. To understand why, it is important to distinguish between "weather" and "climate." The climate is the average weather over a long period of time. A simple way to think of this is: *weather* is what determines if you will use an umbrella today; *climate* determines whether you own an umbrella. Thus, when looking at climate change and its impacts, it is important to consider more than just global temperature trends. Changes in the climate other than average temperatures have more direct impacts on nature and society.

The USGCRP report says, "Climate changes are underway in the United States and are projected to grow," and "Widespread climate-related impacts are occurring now and are expected to increase." Sea level rise, the loss of sea ice, changes in weather patterns, more drought and heavy rainfall, and changes in river flows are among the documented changes in the United States. Climate change also threatens ecosystems and public health.

Dr. Jane Lubchencko, the Administrator of the National Atmospheric and Oceanographic Administration, has said, "Climate change is happening now and it's happening in our own backyards and it affects the kinds of things people care about."

MORE EXTREME WEATHER

Extreme weather events have become more common in recent years, and this trend will continue in the future. Climate change has a significant effect on local weather patterns and, in turn, these changes can have serious impacts on human societies and the natural world.

Stronger Hurricanes. Scientists have confirmed that hurricanes are becoming more intense.[18] Since hurricanes draw their strength from the heat in ocean surface waters, hurricanes have the potential to become more powerful as the water warms. A recent peer-reviewed assessment of the link between hurricanes and climate change concluded that "higher resolution modeling studies typically project substantial increases in the frequency of the most intense

cyclones, and increases of the order of 20% in the precipitation rate within 100 km of the storm centre."[19]

This trend toward stronger hurricanes is noteworthy because of the vulnerability of coastal communities to these extreme events. The USGCRP report says, "Sea-level rise and storm surge place many U.S. coastal areas at increasing risk of erosion and flooding… Energy and transportation infrastructure and other property in coastal areas are very likely to be adversely affected." In recent years the massive destruction caused by Hurricane Katrina in the United States and by Cyclone Nargis, which devastated Burma in 2008, provide painful reminders of this vulnerability.

Hotter, Wetter Extremes. Average temperatures are rising, but extreme temperatures are rising even more: in recent decades, hot days and nights have grown more frequent and cold days and nights less frequent. There have been more frequent heat waves and hotter high temperature extremes.

In the United States, the USGCRP report says, "Many types of extreme weather events, such as heat waves and regional droughts, have become more frequent and intense during the past 40 to 50 years." More rain is falling in extreme events now compared to 50 years ago, resulting in more frequent flash flooding. In 1994 and 2008, the U.S. Midwest experienced flooding so severe that each event was considered a 500-year flood—a level of flooding so rare that it would not be expected to occur more than once in five centuries! In May 2010, the city of Nashville, Tennessee, experienced the worst flooding in its history, enduring what the U.S. Army Corps of Engineers declared a 1,000-year flood.[20] Nearly the entire central city was underwater for the first time. *The Tennessean*—Nashville's principal daily newspaper—reported that the flood cost the city a year's worth of economic productivity.[21] Individually, these events might be random occurrences, but they are part of a clear, long-term trend of increasing very heavy rainfall in the United States over the past 50 years (see Figure 4).

In 2003, Europe experienced a heatwave so hot and so long that scientists estimated that such an extreme event had not occurred there in at least 500 years. That heat wave caused more than 30,000 excess deaths throughout southern and central Europe.[22] A similarly historic heat wave struck Russia and other parts of Eastern Europe in the summer of 2010, killing thousands of people and destroying a large fraction of Russia's wheat crop. Since Russia is a large grain exporter, its crop losses drove up food prices globally.

Although there is no way to determine whether an individual weather event was caused by human-induced climate change, the types of events discussed here are the types of events that scientists have predicted will become more common in a warmer climate. Therefore, the events that actually occur are useful indicators of our vulnerabilities to project impacts and can teach us about the likely effects of climate change on our lives.

TOO MUCH OR TOO LITTLE: EFFECTS ON WATER

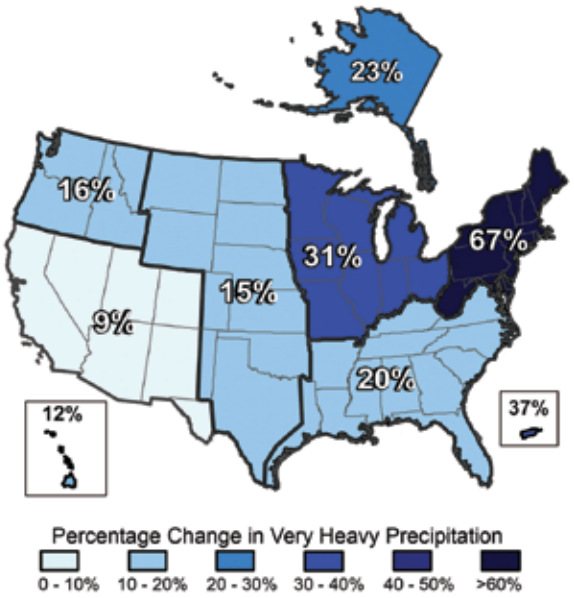
Climate change will alter the quantity and quality of available fresh water and increase the frequency and duration of floods, droughts, and heavy precipitation events. Although climate change will affect different regions in different ways, it is generally expected that dry regions of the world will get drier and wet regions will get wetter.

More Floods and Droughts. A number of factors are expected to contribute to more frequent floods. More frequent heavy rain events will result in more flooding. Coastal regions will also be at risk from sea level rise and increased storm intensity. While some regions will suffer from having too much water, others will suffer from having too little. Diminished water resources are expected in semi-arid regions, like the western United States, where water shortages often already pose challenges. Areas affected by drought are also expected to increase. As the atmosphere becomes warmer, it can hold more water, increasing the length of time between rain events and the amount of rainfall in an individual event. As a result, areas where the average annual rainfall increases may also experience more frequent and longer droughts.

Altered Availability and Quality. Warmer temperatures threaten the water supplies of hundreds of millions of people who depend on water from the seasonal melting of mountain ice and snow in several ways: by increasing the amount of seasonal melt from glaciers and snowpack, by increasing the amount of precipitation that falls as rain instead of snow, and by altering the timing of snowmelt. In the near term, the melting of mountain ice and snow may cause flooding; in the long term, the loss of these frozen water reserves will significantly reduce the water available for humans, agriculture, and energy production. Earlier snowmelt brings other impacts. Western states have experienced a six-fold increase in the amount of land burned by wildfires over

Figure 4

Heavy Precipitation in the United States



Percentage change in heavy precipitation in the United States.

SOURCE: U.S. Global Change Research Program (USGCRP)

the past three decades because snowmelt has occurred earlier and summers are longer and drier.[23]

Climate change will affect the quality of drinking water and impact public health. As sea level rises, saltwater will infiltrate coastal freshwater resources. Flooding and heavy rainfall may overwhelm local water infrastructure and increase the level of sediment and contaminants in the water supply.[24] Increased rainfall could also wash more agricultural fertilizer and municipal sewage into coastal waters, creating more low-oxygen "dead zones" in the Chesapeake Bay and the Gulf of Mexico.[25]

EFFECTS ON HUMAN HEALTH

Climate change is expected to affect human health directly—from heat waves, floods, and storms—and indirectly—by increasing smog and ozone in cities, contributing to the spread of infectious diseases, and reducing the availability and quality of food and water. The USGCRP report says that children, the elderly, and the poor are at the greatest risk of negative health impacts in the United States.

The U.S. Centers for Disease Control and Prevention have identified a number of health effects associated with climate change, including an increase in heat-related illnesses and deaths from more frequent heat waves, a rise in asthma and other respiratory illnesses due to increased air pollution, higher rates of food- and water-related diseases, and an increase in the direct and indirect impacts of extreme weather events, like hurricanes.[26]

THREATS TO ECOSYSTEMS

Climate change is threatening ecosystems around the world, affecting plants and animals on land, in oceans, and in freshwater lakes and rivers. Some ecosystems are especially at risk, including the Arctic and sub-Arctic because they are sensitive to temperature and likely to experience the greatest amount of warming; coral reefs because they are sensitive to high water temperatures and ocean acidity, both of which are rising with atmospheric CO_2 levels; and tropical rainforests because they are sensitive to small changes in temperature and precipitation.

Clear evidence exists that the recent warming trend is already affecting ecosystems. Entire ecosystems are shifting toward the poles and to higher altitudes. This poses unique challenges to species that already live at the poles, like polar bears, as well as mountain-dwelling species already living at high altitudes. Spring events, like the budding of leaves and migration of birds, are occurring earlier in the year. Different species are responding at different rates and in different ways, which has caused some species to get out of sync with their food sources. The risks to species increase with increasing temperatures; scientists say that an additional 2°F of warming will increase the risk of extinction for up to 30 percent of species.[27]

SHRINKING ARCTIC SEA ICE

Arctic sea ice has seen dramatic declines in recent years. In 2007, Arctic sea ice shrank to its smallest summertime extent ever observed, opening the Northwest Passage for the first time in human memory.[28] This new sea ice minimum came only a few months after a study reported that since the 1950s, summer sea ice extents have declined three times faster than projected by climate models.[29] In the summer of 2010, Arctic sea ice set a new kind of record: It decreased to the lowest volume ever observed.[30] While the extent (the area of the Arctic Ocean covered by ice) in 2010 was slightly higher than in 2007, the ice was considerably

thinner in 2010, making the volume lower than in 2007. Scientists are concerned that this historically low volume of ice could be more susceptible to melting in the future, causing sea ice loss to accelerate.[31]

The importance of sea ice decline comes from the role it plays in both the climate system and large Arctic ecosystems. Snow and ice reflect sunlight very effectively, while open water tends to absorb it. As sea ice melts, the earth's surface will reflect less light and absorb more. Consequently, the disappearance of Arctic ice will actually intensify climate change.[32]

Moreover, as the edge of the sea ice retreats farther from land during the summer, many marine animals that depend on the sea ice, including seals, polar bears, and fish, will lose access to their feeding grounds for longer periods. Eventually, this shift will deprive these organisms of their food sources and their populations will not be sustained.

If warming continues, scientists are sure that the Arctic Ocean will become largely free of ice during the summer. Depending in part on the rate of future greenhouse gas emissions, the latest model projections indicate that the opening of the Arctic is likely to occur sometime between the 2030s and 2080s.[33] The opening of the Arctic has enormous implications, ranging from global climate disruption to national security issues to dramatic ecological shifts. The Arctic may seem far removed from our daily lives, but changes there are likely to have serious global implications.

RISING SEA LEVEL

Among the most serious and potentially catastrophic effects of climate change is sea level rise, which is caused by a combination of the "thermal expansion" of ocean water as it warms and the melting of land-based ice. To date, most climate-related sea level rise can be attributed to thermal expansion. Going forward, however, the largest potential source of sea level rise comes from melting land-based ice, which adds water to the oceans. By the end of the century, if nothing is done to rein in GHG emissions, global sea level could be three to six feet higher than it is today, depending on how much land-based ice melts.[34] Moreover, if one of the polar ice sheets on Greenland or West Antarctica becomes unstable because of too much warming, sea level is likely to continue to rise for more than a thousand years and could rise by 20 feet or more, which would permanently flood virtually all of America's major coastal cities.[35]

Even small amounts of sea level rise will have severe impacts in many low-lying coastal communities throughout the world, especially when storm surges are added on top of sea level rise. High population densities and low elevations make some regions especially vulnerable, including Bangladesh and the Nile River Delta in Egypt.[36] In the United States, about half of the population lives near the coast. The most vulnerable areas are the Mid-Atlantic and Gulf Coasts, especially the Mississippi Delta. Also at risk are low-lying areas and bays, such as North Carolina's Outer Banks, much of the Florida Coast, and California's San Francisco Bay and Sacramento/San Joaquin Delta.

Loss of Glaciers, Ice Sheets, and Snow Pack. Land-based snow and ice cover are declining because of climate change and contributing to sea level rise. Mountain glaciers at all latitudes are in retreat, from the Himalayas in Central Asia to the Andes in tropical South America to the Rockies and Sierras in the western United States. As a consequence of warming, many mountain glaciers will be gone by mid-century; Glacier National Park, for example, will likely lose its glaciers by 2030 (see Figure 5).[37]

The polar ice sheets on Greenland and Antarctica have both experienced net losses of ice in recent years.[38] Melting polar ice sheets add billions of tons of water to the oceans each year. Recent peer-reviewed research found that the Greenland Ice Sheet is losing ice twice as fast as scientists had previously estimated and ice loss has accelerated on both Greenland and Antarctica over the past decades.[39]

Antarctica is losing ice to the melting and slipping of glacier ice into the ocean at a rate enhanced by climate change.[40] Scientists who study the ice sheet fear that the loss of ice could be accelerated by rising sea levels and the warming of ocean water around the fringe of the ice sheet, which rests on the seabed around the coast of West Antarctica. Beyond some threshold amount of warming, the ice sheet could become unstable and ongoing rapid sea level rise could then be unstoppable. Not knowing exactly what level of warming would destabilize this ice sheet calls for caution in how much more warming we allow.

WHAT CAN BE DONE

The GHGs that are already in the atmosphere because of human activity will continue to warm the planet for decades

Figure 5

Glacial Retreat in Glacier National Park

1938 T.J. Hileman photo Courtesy of GNP Archives
1981 Carl Key photo USGS
1998 Dan Fagre photo USGS
2009 Lindsey Bengtson photo USGS

Oblique view of Grinnell Glacier taken from the summit of Mount Gould, Glacier National Park.

to come. In other words, some level of continued climate change is inevitable, which means humanity is going to have to take action to adapt to a warming world.

However, it is still possible—and necessary—to reduce the magnitude of climate change. A growing body of scientific research has clarified that climate change is already underway and some dangerous impacts have occurred. Avoiding much more severe impacts in the future requires large reductions in human-induced CO_2 emissions in the coming decades. Consequently, many governments have committed to reduce their countries' emissions by between 50 and 85 percent below 2000 levels by 2050. Global emissions reductions on this scale will reduce the costs of damages and of adaptation, and will dramatically reduce the probability of catastrophic outcomes.

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CLIMATE CHANGE 101
Adaptation

The Earth's climate is rapidly changing. In the United States and other nations, people are seeing how the impacts of rising global temperatures, shifting patterns of precipitation, rising sea levels, and other changes are affecting their communities, their livelihoods, and the natural environment. Substantially reducing greenhouse gas emissions is essential to avoid the worst impacts of climate change. But mitigation alone is not enough. Even with emission reductions, some changes in climate are unavoidable. Adaptation planning at the local, state, and national levels can limit the damage caused by climate change, as well as reduce the long-term costs of responding to the climate-related impacts that are expected to grow in number and intensity in the decades to come.

CLIMATE CHANGE IMPACTS IN THE UNITED STATES

For more than 50 years, the Earth's climate has been changing because of increasing greenhouse gas (GHG) emissions from the burning of fossil fuels, such as coal and oil, as well as deforestation and other human activities.[1] The warming of the Earth's atmosphere and waters, loss of land and sea ice, and rising global sea levels are not new phenomena. However, these global changes have been occurring at increasing rates in the past 30 years, particularly in the last decade. A recent U.S. Global Change Research Program (USGCRP) report states, "Climate changes are underway in the United States, and are projected to grow," with significant impacts on everything from our coastlines and our health to water supplies, ecosystems, and other natural resources.[2]

Warming and impacts vary by location. If GHG emissions continue unabated, this could cause additional warming of 2 to 11.5°F over the next century depending on how much more GHGs are emitted and how the climate system responds. Although the range of uncertainty for future temperatures is large, even the lower end of the range could impose undesirable effects on natural and human systems. The continental United States is expected to experience more warming than average, and the Arctic is expected to experience the most warming.[3, 4] Already, the Arctic region is experiencing an array of impacts, including: severe winter storm surges and flooding; infrastructure damage and loss; land erosion; species loss; and the displacement of people and communities (see Figure 1).[5]

Figure 1. Shishmaref, AK. Erosion from winter storm surges required the village to be relocated. Source: Shishmaref Erosion & Relocation Coalition

In general, scientists expect the United States to see overall increases in precipitation (along with decreases in some areas, such as the Southwest), including increases in the intensity of hurricanes and more intense heavy rainfalls.[6] Projections also indicate declines in snowpack, earlier snow and ice melt in areas including the West and Great Lakes regions,

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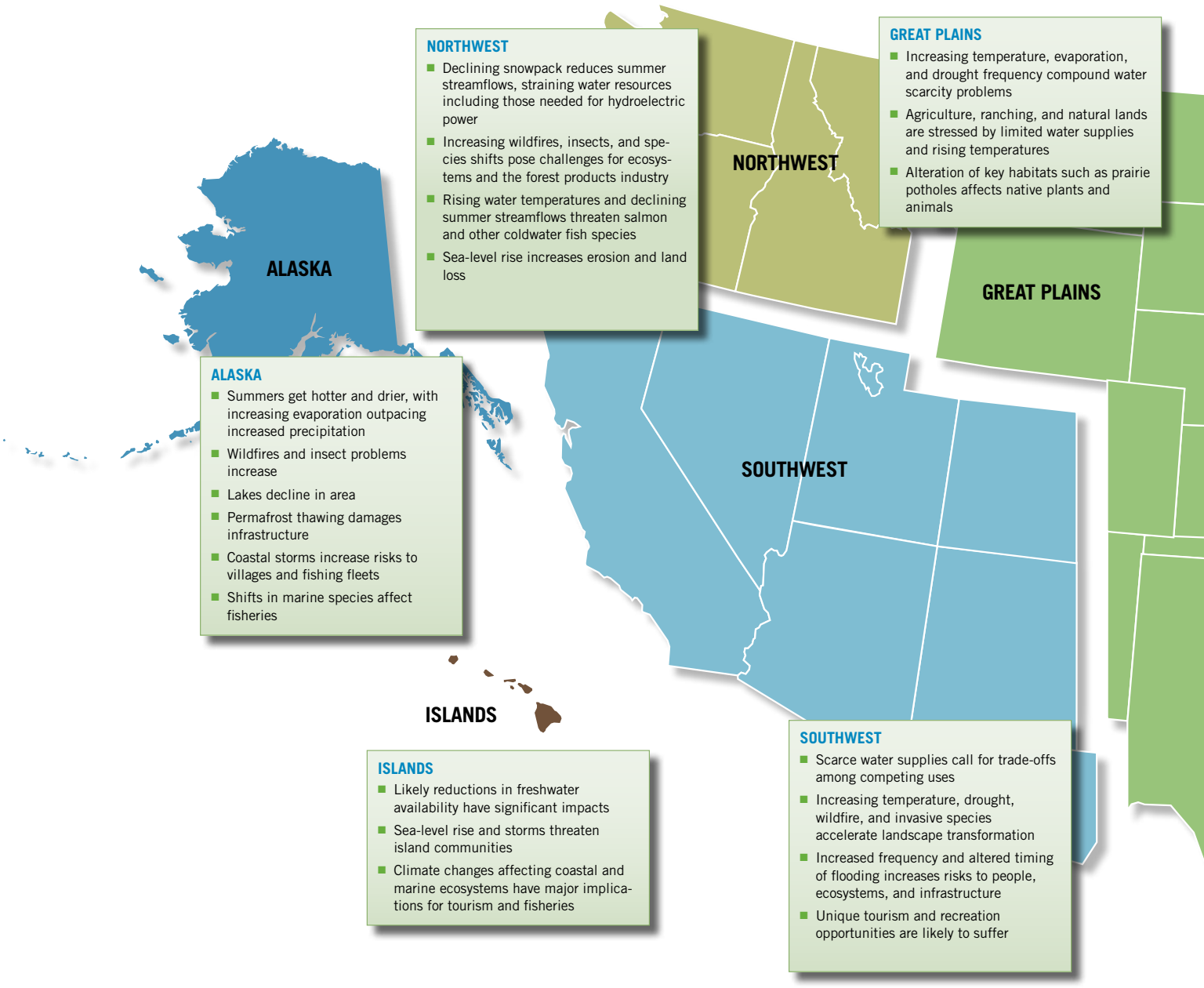
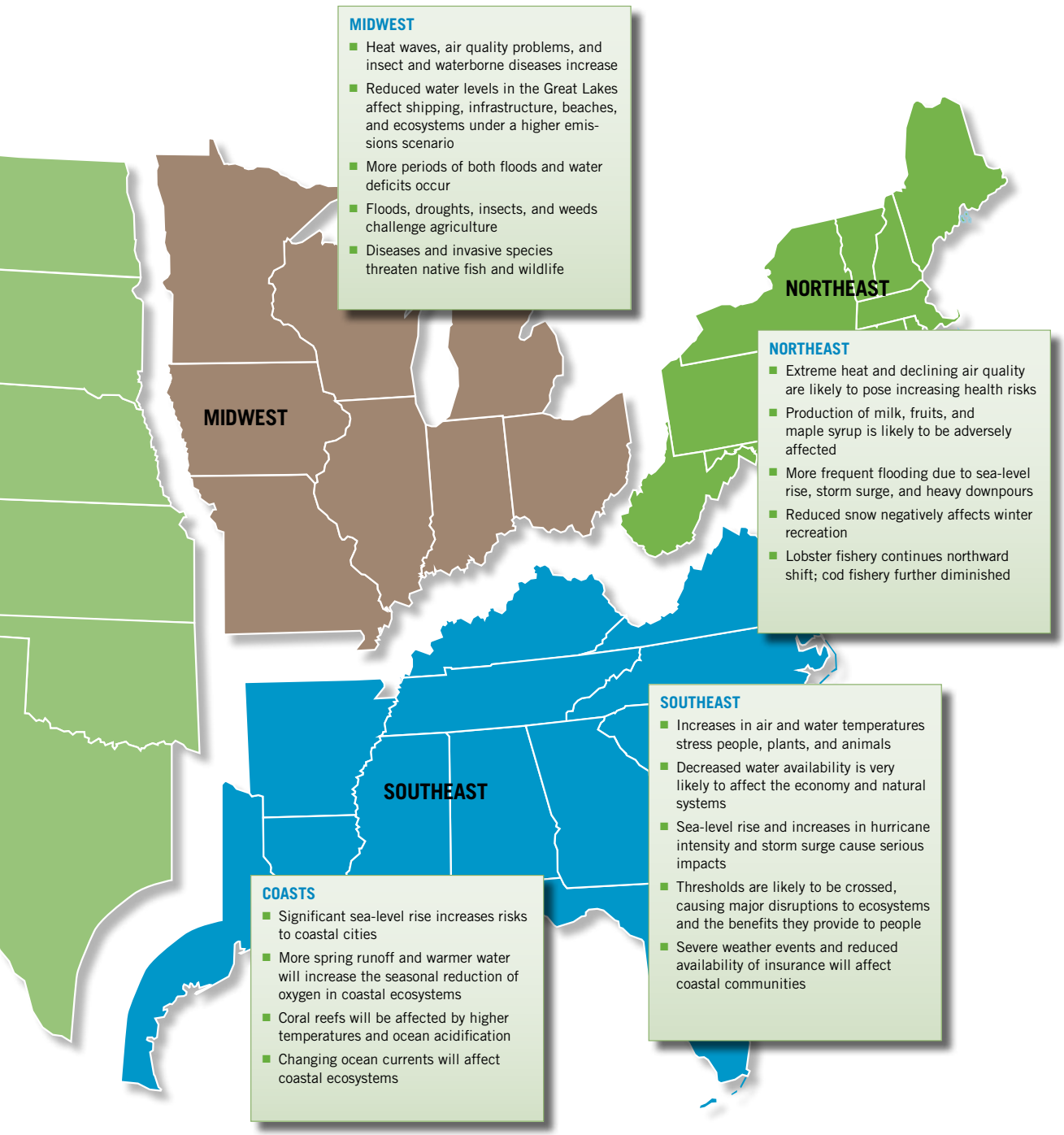
Figure 2. Sample of Projected U.S. Regional Climate Impacts



Source: U.S. Global Change Research Program


MIDWEST
Heat waves, air quality problems, and insect and waterborne diseases increase
Reduced water levels in the Great Lakes affect shipping, infrastructure, beaches, and ecosystems under a higher emissions scenario
More periods of both floods and water deficits occur
Floods, droughts, insects, and weeds challenge agriculture
Diseases and invasive species threaten native fish and wildlife
MIDWEST
NORTHEAST
NORTHEAST
Extreme heat and declining air quality are likely to pose increasing health risks
Production of milk, fruits, and maple syrup is likely to be adversely affected
More frequent flooding due to sea-level rise, storm surge, and heavy downpours
Reduced snow negatively affects winter recreation
Lobster fishery continues northward shift; cod fishery further diminished
SOUTHEAST
SOUTHEAST
Increases in air and water temperatures stress people, plants, and animals
Decreased water availability is very likely to affect the economy and natural systems
Sea-level rise and increases in hurricane intensity and storm surge cause serious impacts
Thresholds are likely to be crossed, causing major disruptions to ecosystems and the benefits they provide to people
Severe weather events and reduced availability of insurance will affect coastal communities
COASTS
Significant sea-level rise increases risks to coastal cities
More spring runoff and warmer water will increase the seasonal reduction of oxygen in coastal ecosystems
Coral reefs will be affected by higher temperatures and ocean acidification
Changing ocean currents will affect coastal ecosystems

and more land areas affected by drought and wildfires (see Figure 2).[7] Sea-level rise will affect the U.S. coastline to varying degrees, with the most severe impacts projected along the Gulf of Mexico and Atlantic coastlines, including potentially significant losses of coastal wetlands.[8] All of these impacts will affect food and water supplies, natural resources, ecosystems, human life, and property (see Table 1). Especially hard hit will be plants and animals, as they will have more difficulty adapting to large-scale, rapid changes in climate, compared to human societies. Where the climate changes at a rate or to a level beyond their ability to adapt, many species will not survive.[9] While models can project levels of drought, precipitation, and severe weather events within very large regions, these models typically do not yet provide reliable projections at smaller scales, such as for individual towns or local ecosystems. As a result, the exact location and timing of these events cannot be forecasted with certainty.

THE CASE FOR ADAPTATION PLANNING

Limits on emissions will not be enough, or happen soon enough, to avoid all impacts of climate change. Reducing emissions will decrease the magnitude of the changes in climate and their related impacts. But carbon dioxide (CO_2) and other GHGs can remain in the atmosphere for decades or centuries after they are produced. This means that today's emissions will affect the climate for years to come, just as the warming we are experiencing now is the result of emissions produced in the past. Because of this time lag, the Earth is committed to additional warming no matter what happens now to reduce emissions. As a result, there are unavoidable impacts already built into the climate system. With worldwide emissions continuing to rise, adaptation efforts are necessary to reduce both the cost and severity of climate change impacts for decades to come.

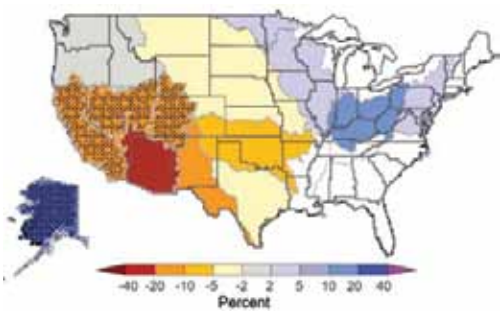
Model projections have underestimated actual rates of climatic changes and impacts. Recent scientific research demonstrates that many aspects of climate change are happening earlier or more rapidly than climate models and experts projected.[14] The rate of change projected for global surface temperatures and related impacts, such as ice melt and sea-level rise, is unprecedented in modern human history. We now have nearly two decades of observations that overlap with model projections. Comparing the model projections to the observations shows the models underestimated the amount of change that has actually occurred. For instance, sea-level rise has occurred 50 percent faster than the projected rate, and the area of summer Arctic sea ice has decreased at three times the projected rate, while several other aspects of climate change have also been underestimated.[15, 16] Adapting to climate change will become that much harder, and that much more expensive, to the extent that the changes happen faster, or on a larger scale, than we expect going forward.[17]

Table 1. Sample of U.S. Sectors and Projected Impacts

Sector	Impacts
Freshwater resource management[7, 11, 12, 13]	Salination of freshwater; water table/aquifer depletion; increased runoff and pollution of freshwater sources; earlier runoff in snowpack-dominated areas. (See Figure 2)
Agriculture[7, 11, 12, 13]	Changes in yields due to precipitation and temperature extremes; increases in pests and disease; salination of irrigation water; changes in timing of biological events.
Coastal resources[7, 11, 12, 13]	Inundation of low-lying areas from storm surges, sea level rise, stronger hurricanes and tropical storms; infrastructure damage; wetland loss; saltwater intrusion; loss of habitat; human displacement.
Forestry[7, 11, 12, 13]	Forest loss to drought, wildfires, infestation, diseases, species migration and loss.
Tourism and recreation[12]	Shorter winter recreation season due to reduced snowcover; longer summer season; loss of beaches to tropical storms, storm surges; loss of forest to wildfires.
Public health/health services[7, 11, 12]	Increased levels of heat stress, respiratory illness, chronic disease, human displacement (short-term and long-term), infectious disease, and premature death.
Transportation infrastructure[12]	Damage from sea-level rise, erosion, flooding and temperature extremes.

Figure 3

Projected Changes in Annual Runoff



Source: USGCRP

Acting now to limit the potential damage from climate change is often smarter—and costs less in the long run—than acting later. There is a human tendency to address current or near-term climate impacts in a just-in-time fashion (for example, water conservation measures to prevent droughts in some southeastern U.S. cities were started only after a severe shortage was evident). This approach may work when: the impacts are predictable or slow in developing; solutions are available and can be implemented in time to save lives, property, or natural resources; and there is low risk of irreparable harm. Even under these conditions, however, people often overlook or delay solutions that reduce the ultimate risk of harm. "Proactive adaptation" requires assessing the vulnerability of natural and man-made systems, as well as the costs and benefits of action versus inaction, and planning alternatives accordingly. This approach recognizes the need to factor climate change into decisions that affect the long-term susceptibility of systems to the impacts of climate change. From the methods for designing or repairing bridges, dams, and other infrastructure, to the rules and regulations governing coastal development and wetland protection, the decision whether to consider climate change now will have implications down the line.

Some systems and societies are more vulnerable to the impacts of climate change than others. Climate change will affect a wide array of systems including coastal settlements, agriculture, wetlands, crops, forests, water supply and treatment systems, and roads and bridges. The vulnerability of different systems varies widely. For example, the ability of natural systems to adapt to increasing rates of climate change is generally more limited than built systems.[18] Similarly, some countries or regions, such as the United States, may be better able to adapt to climate change, or have a greater "adaptive capacity," than others. By contrast, the adaptive capacity of many developing countries is often limited by a number of vital factors, such as economic or technological resources (See Table 2). Even within developed countries such as the United States, some areas have lower adaptive capacity than others. Smart planning ensures that governments and communities are paying attention to those systems that are most vulnerable, while laying the groundwork for actions to reduce the risk to human life, ecosystems, infrastructure, and the economy.

Glossary of Terms

Adaptation: Actions by individuals or systems to avoid, withstand, or take advantage of current and projected climate changes and impacts. Adaptation decreases a system's vulnerability or increases its resilience to impacts.

Adaptive Capacity: A system's inherent ability to adapt to climate change impacts.

Impact: An effect of climate change on the structure or function of a system.

Mitigation: Actions to reduce greenhouse gas (GHG) emissions.

Resilience: The ability of a system to withstand negative impacts without losing its basic functions.

System: A population or ecosystem; or a grouping of natural resources, species, infrastructure, or other assets.

Vulnerability: The potential for a system to be harmed by climate change, considering the impacts of climate change on the system as well as its capacity to adapt.

SUCCESSFUL APPROACHES TO ADAPTATION

Adaptation services and resources are emerging as governments, businesses, and communities worldwide are recognizing the need to address current and potential climate change impacts (see Box 3: *Adaptation Planning Resources for U.S. State and Local Action*). Discussed below are several common elements in the methodology for adapting to climate change impacts.

Table 2. Key Factors for Adaptive Capacity[19]	
Factors	**Examples**
Economic resources	Wealth of individuals and localities.
Technology	Localized climate and impact modeling to predict climate change and variability; efficient irrigation systems to reduce water demand.
Information/awareness	Species, sector, and geographic-based climate research; population education and awareness programs.
Skills/human resources	Training and skill development in sectors and populations; knowledge-sharing tools and support.
Natural resources	Abundant levels of varied and resilient natural resources that can recover from climate change impacts; healthy and inter-connected ecosystems that support migration patterns, species development and sustainability.
Infrastructure	Systems that provide sufficient protection and enable efficient response (e.g., wireless communication, health systems, air-conditioned shelter).
Institutional support/governance	Governmental and non-governmental policies and resources to support climate change adaptation measures locally and nationally.

Recognize that many adaptation efforts must happen at local and regional levels. Climate changes and their associated impacts vary greatly from location to location. Although national and international action is essential, many important decisions about how best to manage systems affected by climate change are made at local and regional levels. For example, states and localities have authority over land use planning decisions, including zoning and building codes, as well as transportation infrastructure. In some cases, state authority is extending to provide insurance coverage where the private market is retreating, exposing these states to larger financial risks. In exercising these authorities, managers, planners, and policy makers need to account for the potential outcomes of climate change. Yet systems, such as water resources and species, span city, county, and state lines. As a result, adaptation also requires planners from government, the private sector, and others to coordinate their activities across jurisdictions. Those engaged in planning need to share information, plan together, and collaboratively modify existing policies and procedures to ensure efficient and effective solutions. The exchange of information, resources, best practices, and lessons learned across jurisdictional lines and among different groups of stakeholders is a key element of successful adaptation planning.

Identify key vulnerabilities. Adaptation planning requires an understanding of those systems that are most at risk—and why. That means finding answers to questions in three key areas:

- **Exposure:** What types of climate changes and impacts can we expect, and which systems will be exposed? What is the plausible range of severity of exposure, including the duration, frequency, and magnitude of changes in average climate and extremes?
- **Sensitivity:** To what extent is the system (or systems) likely to be affected as a result of projected climate changes? For instance, will the impacts be irreversible (such as death, species extinction or ecosystem loss)? What other substantial impacts can be expected (such as extensive property damage or food or water shortages)?
- **Adaptive Capacity:** To what extent can the system adapt to plausible scenarios of climate change and/or cope with projected impacts?[20] What is feasible in terms of repair, relocation, or restoration of the system? Can the system be made less vulnerable or more resilient?

Involve all key stakeholders. Successful adaptation planning relies on input from, and the alignment of, all key stakeholders. This means broadening the participants involved in identifying problems and solutions. Because the impacts of climate change span entire regions, adaptation planning should involve representatives from federal, state, and local government; science and academia; the private sector (see Box 1: *Industry Adaptation Planning*); and local communities. Successful planning will require creativity, compromise, and collaboration across agencies, sectors, and traditional geographic

Box 1. Industry Adaptation Planning

To date, business action on climate change has primarily focused on managing the risks and opportunities associated with emerging regulations and changing market demands. But as recognition grows that some climate impacts are already occurring and many more are likely inevitable, companies are beginning to develop adaptation plans to complement existing climate strategies.

Many of the projected impacts of climate change, such as sea-level rise, increased incidence and severity of extreme weather events, and prolonged heat waves and droughts, could have serious consequences for businesses. Disruptions may include: damage to core operations, such as factories and office buildings; diminished quality and quantity of key inputs, such as water resources and forestry products; restricted access to the broader supply and demand infrastructure, such as electric utilities and transport networks; and sudden (or gradual) changes in demand for products and services.

Specific impacts will likely vary by sector. For example, higher demand for air conditioning during prolonged heat waves could stress and possibly overwhelm the electric grid. Longer and more intense rains could restrict access to construction sites and slow productivity in the buildings sector. Meanwhile, the agriculture industry is at risk of extreme drought that could render large swaths of previously arable land unusable.

Companies are beginning to recognize and act on these risks. Entergy, the New Orleans-based utility, which suffered $2 billion in losses from Hurricanes Katrina and Rita, has begun relocating important business operations to areas less vulnerable to severe weather events. Entergy has also worked with consulting firm McKinsey & Company and global reinsurer Swiss Re to develop the first comprehensive analysis of climate risks and adaptation economics along the U.S. Gulf Coast. Mining giant Rio Tinto is using high-resolution climate modeling to conduct detailed site assessments and gauge risks to high-priority assets. Additionally, Travelers, a major insurance company, is exploring new pricing strategies to encourage adaptive actions from its commercial and personal customers.

For more information on business approaches to adaptation, see Frances Sussman and J. Randall Freed. 2008. *Adapting to Climate Change: A Business Approach.* Pew Center on Global Climate Change: Arlington, VA. To read the Entergy sponsored report on climate risks in the U.S. Gulf Coast, see *Building a Resilient Energy Gulf Coast* at http://entergy.com/content/our_community/environment/GulfCoastAdaptation/Building_a_Resilient_Gulf_Coast.pdf

and jurisdictional boundaries. It also requires the involvement of experts who can help participants understand historical and current climate and other trends affecting various sectors, and who can provide completed impact assessments for other locations with similar sectors and/or projected impacts.[21]

Set priorities for action based on projected and observed impacts. For vulnerable systems, prioritizing adaptive measures based on the nature of the projected or observed impacts is vital. The Intergovernmental Panel on Climate Change published a list of criteria to aid in identifying key vulnerabilities. Some of these criteria include:

- **Magnitude:** Impacts are of large scale (high number of people or species affected) and/or high-intensity (catastrophic degree of damage caused such as loss of life, loss of biodiversity).
- **Timing:** Impacts are expected in the short term and/or are unavoidable in the long term if not addressed. Consider also those impacts with variable and unpredictable timing.
- **Persistence/Reversibility:** Impacts result in persistent damage (e.g., near-permanent water shortage) or irreversible damage (e.g., disintegration of major ice sheets, species extinction).
- **Likelihood/Certainty:** Projected impacts or outcomes are likely, with a high degree of confidence (e.g., damage or harm that is clearly caused by rising temperatures or sea-level). The higher the likelihood, the more urgent the need for adaptation.
- **Importance:** Systems at risk are of great importance or value to society, such as a city or a major cultural or natural resource.
- **Equity:** The poor and vulnerable will likely be hurt the most by climate change, and are the least likely to be able to adapt. Pay special attention to those systems that lack the capacity and resources to adapt.

Choose adaptation options based on a careful assessment of efficacy, risks, and costs. Due to uncertainties in projected climate changes and in how systems will respond to those changes, adaptation options carry varying degrees of uncertainty, or risk, as well. Timing, priority setting, economic and political costs, availability of resources and skills, and the efficacy of various solutions all should be a part of the discussion. The range of options includes but is not limited to:

- **No-regret:** Actions that make sense or are worthwhile regardless of additional or exacerbated impacts from climate change. Example: protecting/restoring systems that are already vulnerable or of urgent concern for other reasons.[22]
- **Profit/opportunity:** Actions that capitalize on observed or projected climatic changes. Example: a farmer is able to shift to different crops that are better suited to changing climatic conditions.
- **"Win-win":** Actions that provide adaptation benefits while meeting other social, environmental, or economic objectives, including climate change mitigation. Example: improving the cooling capacity of buildings through improved shading or other low-energy cooling solutions.[23]
- **Low-regret:** Measures with relatively low costs for which benefits under climate change scenarios are high.[24, 25] Example: incorporating climate change into forestry, water, and other public land management practices and policies, or long-term capital investment planning.
- **Avoiding unsustainable investments:** Policies or other measures that prevent new investment in areas already at high risk from current climatic events, where climate change is projected to exacerbate the impacts.[26] Example: prohibiting new development in flood-prone areas where sea-level rise is increasing and protective measures are not cost effective.
- **Averting catastrophic risk:** Policies or measures intended to avert potential or eventual catastrophic events—i.e., events so severe or intolerable that they require action in advance based on available risk assessment information. Example: relocating Alaskan villages in areas at or near sea-level with projected sea-level rise and increasing severe weather events.

U.S. REGIONS, STATES AND CITIES ARE BEGINNING ADAPTATION EFFORTS

Comprehensive, proactive adaptation planning is still in the early stages in the United States. However, a number of states and localities are beginning to plan and act to address the unavoidable impacts that will occur in the decades to come.

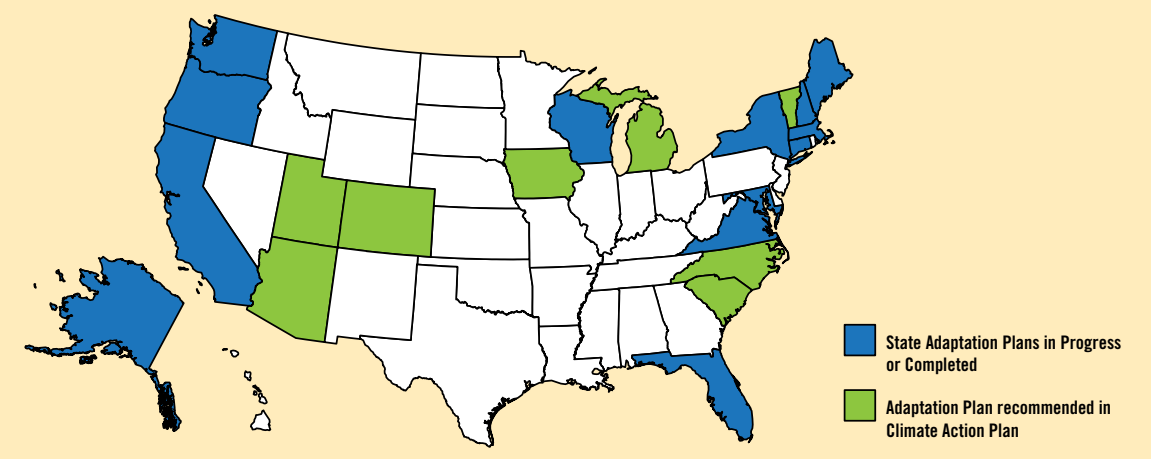
Regional Actions. In 2009, the Western Governors' Association (WGA) adopted a policy resolution on the integration of climate change adaptation science in the West. The resolution directed the WGA staff to create a Climate Adaptation Work Group, composed of western state experts in air, forests, waters, and wildlife to recommend next steps in identifying and filling existing gaps in climate adaptation efforts. In June 2010, the Work Group released an initial Scoping Report with recommendations for building a resilient West in the face of climate change.[27]

State Actions. State governments are recognizing the need for broad-scale adaptation planning, and have started taking steps toward this goal. Eight states—Arizona, Colorado, Iowa, Michigan, North Carolina, South Carolina, Utah, and Vermont—acknowledge adaptation within their climate action plans addressing GHG mitigation and recommending that comprehensive state adaptation plans be created. Thirteen other states have already started their adaptation planning efforts, in parallel with their mitigation activities; these states include Alaska, California, Connecticut, Florida, Maine, Maryland, Massachusetts, New Hampshire, New York, Oregon, Virginia, Washington, and Wisconsin (see Figure 4).

In Alaska, where warming is predicted to occur at a faster pace than any other state, Governor Sarah Palin signed an Administrative Order officially forming the Alaska Climate Change Sub-Cabinet in September 2007. This order stated that "as a result of this warming, coastal erosion, thawing permafrost, retreating sea ice, record forest fires, and other changes are affecting, and will continue to affect, the lifestyles and livelihoods of Alaskans." The Sub-Cabinet was charged with developing and implementing Alaska's overall Climate Change Strategy, including a response plan with policy recommendations. To facilitate this process, an Alaska Climate Change Adaptation Advisory Group (AAG) was formed with technical working groups in the following areas: Pub-

Figure 4

State Level Adaptation Planning



lic Infrastructure, Health & Culture, Natural Systems, and Economic Activities. The AAG released its final report to the Sub-Cabinet in January 2010.[28]

In California, political leaders recognize that climate change is having a wide range of impacts on the state's natural resources, ecosystems, infrastructure, health systems, and economy. As climate change continues and accelerates, it will stress these and other sectors further—bringing hotter, drier summers; increased risk of drought and wild-fires; and expanded water resource needs. In June 2005, California Governor Arnold Schwarzenegger signed an executive order calling for biannual updates from the California Environmental Protection Agency on global warming impacts, mitigation strategies, and adaptation plans for the state. In November 2008, he signed another executive order calling on the state Climate Action Team to coordinate with other state agencies to create a Sea Level Rise Assessment Report and develop a Climate Adaptation Strategy. The state's Climate Change Adaptation Strategy was released in December 2009 and identifies adaptation methods for biodiversity and habitat, infrastructure, oceans and coastal resources, public health, water, and working landscapes, including forestry and agriculture.[29]

As climate adaptation gains greater attention and resources, states will have much to learn from each other, as well as from other countries and localities where adaptation is already occurring.

Local Actions. Hundreds of cities have created climate action plans, with more cities completing their plans every week. Although most plans are principally focused on achieving reductions in GHG emissions, communities across the United States are already taking action to address specific climate impacts. These city actions include: desalinating freshwater sources; protecting infrastructure and communities from flooding, erosion and more severe weather events; and preparing for more severe water shortages and droughts. These initiatives and others may be privately funded or managed, or they may be the responsibility of municipal, emergency response or other agencies. Currently, there is no formal process for sharing information across jurisdictions about their adaptation activities.

In addition to addressing specific impacts now, more localities are recognizing the need for comprehensive adaptation planning. For example, in April 2007, New York Mayor Michael Bloomberg released his PLANYC: A Greener, Greater New York. In this plan, the mayor addresses adaptation, recognizing that the results of climate modeling indicate that New York faces significant economic and human health risks from storm surges, hurricanes and flooding, in addition to heat waves, wind storms and water contamination. While adaptation actions are already being taken to protect the city's water

supply and sewage and wastewater treatment systems, in PLANYC, the Mayor called for the city to conduct adaptation planning to protect critical infrastructure and specific communities at high risk from climate change. In August 2008 the Mayor created the New York City Panel on Climate Change (NPCC) to conduct an overall adaptation planning process. This process resulted in a report released in May 2010 that outlines the measures the city will take to respond proactively to climate change in a way that will provide both long-term environmental and short-term economic benefits to the city.[30]

An adaptation planning leader in the United States is King County, Washington, home to the city of Seattle. In 2006, this county formed its own inter-departmental climate change adaptation team, building scientific expertise within county departments to ensure that climate change factors were considered in policy, planning, and capital investment decisions. The county has considered climate in the development of emergency response plans, water supply planning processes, and all county plans (e.g., river and floodplain management plans). King County and the University of Washington's Climate Impact Group co-authored a guidebook, *Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments,* in association with the International Council for Local Environmental Initiatives: Local Governments for Sustainability.[31] Additional resources to assist states and localities are available at the end of this brief (see Box 3: *Adaptation Planning Resources for U.S. State and Local Action*).

THE FEDERAL ROLE

Just as the federal government must act to reduce U.S. emissions and take other steps to mitigate climate change, it must also take a leadership role in action on adaptation. Although not an exhaustive list, ways in which the federal government can enable efficient and effective adaptation strategies across the United States include:

Intellectual leadership, research and development

- Provide ongoing climate science research with a focus on impacts, sensitivity, and adaptive capacity.
- Provide improved modeling to project climatic changes at smaller scales and better forecast state and local impacts.

Policy and regulation

- Require states to include climate change impact projections in infrastructure projects requesting federal funding.
- Require climate change adaptation screening in Environmental Impact Assessments.
- Update Federal Emergency Preparedness Plans to include potential climate change impacts and set guidelines for state preparedness plans.
- Review and update federal agency regulations and procedures where climate change impacts and adaptation are relevant, such as in the Departments of Interior and Agriculture, EPA and FEMA.

Coordination

- Support coordination and collaboration among state and local agencies, governments, and private-sector entities, particularly for cross-state or cross-jurisdictional impacts and adaptation plans (e.g., integrated or consistent response plans, interstate stakeholder agreements, species or resource management).
- Develop policies to mitigate interstate impact and adaptation issues.
- Help ensure efficiency in adaptation resource planning and implementation.

Sharing of best practices

- Acquire knowledge from nations that are ahead in adaptation planning and action.
- Leverage knowledge, skills, resources, and technologies that are available in other countries to help state and local governments efficiently implement solutions as cost effectively as possible (See Box 2: *Adaptation—A Global Perspective*).
- Support cataloguing of state and global solutions and other forms of knowledge sharing, and oversee nationwide communication and information systems for efficient dissemination of knowledge across locales and jurisdictions.

Models and planning tools

- Provide affordable modeling and adaptation planning tools to states, municipalities, private sector entities, and communities without sufficient funding, to help identify sectors at risk and assess vulnerable systems.

Box 2. Adaptation: A Global Perspective

Adaptation to climate change is a challenge for all countries. Some other industrialized countries, such as the United Kingdom, Netherlands, Germany, Australia, and Canada, are ahead of the United States in planning for climate change impacts, and their experiences provide valuable lessons for U.S. policymakers (see Box 3: *Adaptation Planning Resources for State and Local Action* at the end of this brief).

From a global perspective, the adaptation challenge is probably greatest for developing countries. They are generally more vulnerable to climate change by virtue of being at lower latitudes where some impacts, such as increased disease and extreme heat and drought, will be more pronounced and because their economies are more dependent on climate-sensitive sectors, such as agriculture, fishing, and tourism. What's more, with lower per capita incomes, weaker institutions, and limited access to technology, developing countries have less adaptive capacity.

In the 1992 UN Framework Convention on Climate Change, the United States and other developed countries committed generally to help "particularly vulnerable" countries adapt to climate change. In coming decades, adaptation in developing countries is estimated to require tens of billions of dollars annually.[32] Additional funds are now being generated through a levy on emissions credits generated through the Kyoto Protocol's Clean Development Mechanism (CDM). In the 2010 Cancún Agreements, UNFCCC parties agreed to establish a new Green Climate Fund to support adaptation and mitigation in developing countries, and developed countries committed to mobilize $100 billion a year in public and private finance by 2020. The Agreements also established the Cancún Adaptation Framework to enhance adaptation efforts by all countries; a process to help least developed countries develop and implement national adaptation plans; and an Adaptation Committee to provide technical support to parties and facilitate sharing of information and best practices.

Education and awareness

- Help citizens, communities, and industries understand the risks of climate change impacts and their role in local and regional adaptation efforts, incorporate climate change adaptation into their way of operating, and increase participation and support for necessary actions.
- Fund education, training, and awareness programs to ensure citizens are fully informed and participating in viable adaptation solutions.

Funding

- Provide additional resources to states and localities lacking sufficient funding for proactive adaptation planning in order to avert more costly reactive responses in the future.
- Provide support for updated impact assessments at state and regional levels.
- Provide bilateral and multilateral assistance for adaptation planning and measures in developing countries.

Federal Lands

- Consider the impacts of climate change on federal landholdings (e.g., National Parks, Forest Service, Bureau of Land Management lands) and infrastructure (e.g., naval facilities).

FEDERAL AGENCIES ARE MOVING FORWARD WITH ADAPTATION EFFORTS

In the past several years, the federal government has taken a number of steps towards enabling effective adaptation strategies in the United States. On October 5, 2009, President Obama signed an Executive Order requiring each federal agency to develop performance plans that include an evaluation of the agency's climate-change risks and vulnerabilities and to manage the effects of climate change on the agency's operations and mission. The Executive Order also required agencies to actively participate in the Interagency Climate Change Adaptation Task Force, charged with developing recommendations toward a national adaptation strategy. The Task Force formed multiple workgroups and conducted

Box 3. Adaptation Planning Resources for U.S. State and Local Action

U.S. Global Change Research Program (USGCRP)—The USGCRP integrates federal research on climate and global change from agencies such as the Departments of Agriculture, Energy, Interior, and Transportation. Available GCRP adaptation reports include:

- *Global Climate Change Impacts in the United States*—summarizes the science and current and expected future impacts of climate change on the United States. It also includes examples of the broad range of adaptation options that are currently being pursued in various regions and sectors to deal with climate change. http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts
- *Synthesis Assessment Product 4.4: Adaptation for Climate Sensitive Ecosystems and Resources* focuses on federally owned and managed lands and water, including national parks, forests, wildlife refuges, rivers, estuaries, and marine protected areas. This report provides resource managers with adaptation options and processes for identifying vulnerabilities, and offers recommendations for federal roles and policies. http://www.globalchange.gov/publications/reports/scientific-assessments/saps/sap4-4

U.S. Forest Service Climate Change Resource Center—This clearinghouse was developed to provide Forest Service resource managers and decision makers with information and tools to address climate change mitigation and adaptation in planning and project implementations. The site provides climate change science information, an overview of adaptation management options, modeling and mapping tools, case studies, and a library of more than 1,800 publications on climate change and its effects. http://www.fs.fed.us/ccrc/

NOAA Coastal Climate Adaptation—NOAA's Coastal Services Center maintains this clearinghouse of adaptation resources for coastal states, including sample vulnerability assessments and adaptation plans, guidebooks, case studies, and resources for communication and outreach. http://collaborate.csc.noaa.gov/climateadaptation/default.aspx

DOT Transportation and Climate Change Clearinghouse—This clearinghouse includes information on both mitigation and adaptation, including potential impacts of climate change on transportation infrastructure, approaches for integrating climate change considerations into transportation decision making, and links to both impact and adaptation planning resources. http://www.climate.dot.gov/index.html

Climate Adaptation Knowledge Exchange (CAKE)—Intended as a shared knowledge base for managing natural systems in the face of rapid climate change, CAKE provides case studies, resources, tools, and a social networking function to help build an adaptation community of practice using a directory of practitioners to share knowledge and strategies. CAKE is a joint project of EcoAdapt and Island Press. http://www.cakex.org/

ICLEI Local Governments for Sustainability—ICLEI is a global services organization specializing in both mitigation and adaptation support to local governments in the United States and globally. Through their Climate Resilient Communities Program, ICLEI works with local governments to build resiliency to climate impacts. http://www.iclei.org

UK Climate Impact Program (UKCIP)—UKCIP provides tools and data to support climate change risk assessments and develop adaptation strategies. The program offers climate change and socio-economic scenarios, a framework for making decisions in the face of climate risk and uncertainty, and a methodology for costing the impacts of climate change. Although specific to the United Kingdom, UKCIP's tools and databases of climate change adaptation case studies and adaptation options are relevant and useful for the United States. http://www.ukcip.org.uk/

numerous listening sessions and public outreach events with a wide range of stakeholders before releasing its recommendations in October 2010. The Task Force's recommendations include: making sure that adaptation is a standard part of Agency planning, ensuring information about the impacts of climate change is accessible, and aligning federal efforts that cut across agency jurisdictions and missions.[33]

A number of agencies have already begun to incorporate climate change adaptation into their existing strategies and programs.[34, 35] For example:

- The U.S. Forest Service released a *Roadmap for Responding to Climate Change* in July 2010 to serve as a guide in making the nation's forests and private working lands more resilient to climate change;
- The Department of Homeland Security (DHS) established a Climate Change Adaptation Task Force to examine the implications of climate change for homeland security missions and department operations and make recommendations for adaptation planning and actions; and
- The Centers for Disease Control and Intervention (CDC), is leading efforts to anticipate the health effects of climate change (such as heat waves and changes in disease patterns) to ensure that systems are in place to detect and respond to them.

PREPARING FOR THE FUTURE

While governments at all levels must act to reduce GHG emissions, some degree of climate change is already inevitable. Climatic changes are happening now and are projected to increase in both frequency and severity before the benefits of emission reductions will be realized. Although mitigation is critical in addressing climate change, the need for both adaptation planning and action is also critical. The federal, state, and local governments, as well as resource managers, industry, and community leaders, all have a role to play in assessing the climate vulnerability of both natural and man-made systems, and taking action to help these systems adapt. Citizens and public and private entities can all contribute toward a common goal of averting dangerous climate risk and adequately preparing for those changes that are already unavoidable.

Additional Adaptation reports available from the Pew Center on Global Climate Change (www.pewclimate.org) include:

Climate Change Adaptation: What Federal Agencies are Doing (2010)—This report provides a summary of some of the strategies, institutional mechanisms, programs and policies that federal agencies have developed to facilitate climate change adaptation.

Adapting to Climate Change: A Call for Federal Leadership (2010)—This report provides recommendations on the role of the federal government in leading the effort to reduce vulnerability to unavoidable climate change in the United States.

Adaptation—What U.S. States and Localities are Doing (2009)—This report provides an account of states and localities that have begun adaptation planning, as well as a state level inventory of adaptation planning in state climate action plans.

Adaptation to Climate Change: International Policy Options (2006)—This report examines options for future international efforts to help vulnerable countries adapt to the impacts of climate change both within and outside the climate framework.

Coping with Climate Change—The Role of Adaptation in the United States (2004)—This report provides an in-depth analysis of the need for adaptation action and strategies in the United States, with implications and recommendations for both natural and man-made systems.

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CLIMATE CHANGE 101
Technological Solutions

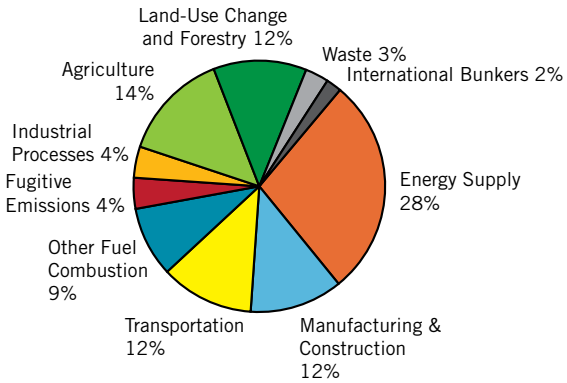
Achieving the very large reduction in greenhouse gas emissions that scientists say is needed to avoid the worst effects of climate change will not be easy. It will require action across all sectors of the economy, from electricity and transportation to agriculture. A portfolio of technologies exists today for achieving cost-effective emission reductions, and emerging technologies hold promise for delivering even more emission reductions in the future. The successful development of these technologies will require research, incentives for producers and consumers, and emission reduction requirements that drive innovation and guide investments. 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 man-made greenhouse gas (GHG) emissions that are causing climate change come from a wide range of sources, including cars and trucks, power plants, factories, and farms (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 decades-long commitment to develop and deploy low-carbon 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, building more homes, and producing more goods and services.

Without a revolution in energy technology, societies will pump ever-increasing amounts of GHGs into the atmosphere, leading to damaging effects from global climate change. To avert these dangerous levels of global warming, the time to begin

Figure 1
Global Emissions by Sector in 2005



Source: Climate Analysis Indicators Tool (CAIT) Version 7.0, World Resources Institute, 2010.

PEW CENTER ON Global CLIMATE CHANGE

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.

making the necessary investments in new technologies is right now. Achieving substantial reductions in GHG emissions is possible—now and in the decades to come. Some emission-reducing technologies (such as hybrid gasoline-electric cars, wind power, and more efficient appliances) are commercially competitive today. Others (such as electric vehicles and carbon capture and storage) are advancing rapidly. Moreover, a wide range of cutting-edge technologies in early stages of development or technologies that have yet to be invented may provide significant emission reductions in the future.

Right now, the true costs of GHG emissions are not reflected in the marketplace, meaning there is little incentive for producers or consumers to reduce their contribution to the climate problem. Policies that send a clear price signal to the market by putting a financial cost on GHG emissions would make many low-carbon technologies commercially competitive with traditional GHG-emitting technologies.[1] Moreover, putting a price on carbon would spur companies to invest in developing new low-carbon technologies. Government incentives for consumers and businesses to purchase these technologies can help them enter the mainstream and contribute to substantial reductions in emissions. Governments, however, will also need to invest in research and development (R&D) to advance technologies for the future.

Opponents of strong action to address climate change often focus on the economic costs of reducing emissions, but the cost of inaction is even greater.[2] In addition, a global technology revolution will create economic opportunities for businesses and workers, as well as the localities, states, and nations that successfully position themselves as centers of innovation, technology development, and manufacturing for a low-carbon world.[3] Even in the absence of national climate change legislation in the United States, private sector investments in clean energy technologies have grown substantially over the past decade. For example, from 2001 to 2009, investments in U.S.-based clean energy technology companies grew from less than 1 percent to 12 percent of total venture capital investments with the size of annual clean technology venture investments growing more than six-fold.[4]

LOOKING AT THE KEY TECHNOLOGIES

There is no single, silver-bullet technology that will deliver the reductions in emissions that are needed to protect society from dangerous climate change. Success will require a portfolio of technologies, 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 while currently unknown innovations may also contribute to emission reductions in the future. As shown in Figures 2 and 3, most GHG emissions in the United States can be traced to the electricity, buildings, and transportation sectors. Carbon dioxide (CO_2) from fossil fuel combustion constitutes the bulk of U.S. GHG emissions.

Figure 2

U.S. GHG Emissions by Source, 2008

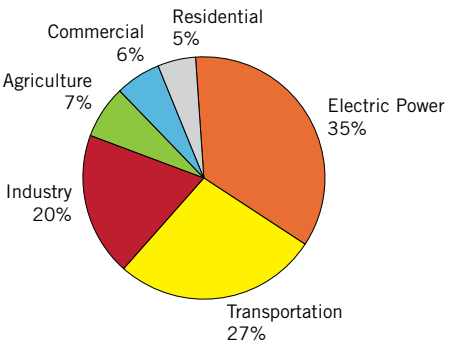
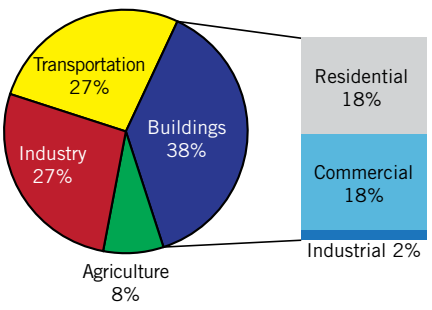


Figure 3

U.S. GHG Emissions by End-Use Sector, 2008



Sources: U.S. EPA, 2010. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008*; U.S. Department of Energy, "Manufacturing Energy and Carbon Footprints."[5]

The following pages look at technology options for reducing emissions from each of these critical sectors (for more information on the technologies described below and others see the *Climate TechBook* on the Pew Center's website).

ELECTRICITY AND BUILDINGS

In 2008, the electricity sector produced 35 percent of U.S. GHG emissions, primarily CO_2 from fossil fuel combustion. Most of the electricity generated by the sector is used in the nation's homes, offices, and industrial facilities to power everything from heating and cooling systems to lights, computers, refrigerators, and cell phones. Electricity use is not the only way in which buildings contribute to climate change. Non-electrical energy sources, such as natural gas furnaces, also produce GHGs. Because they make 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 generation and end-use energy efficiency options. In other words, it is important to think about the roles of both the producers and the consumers of power.

Success will require a portfolio of technologies, many of which are available today.

Electric Power Options. GHG emissions from the electric power sector come almost exclusively from power plants burning coal and natural gas. Options for reducing these emissions include:

- ***Improved Efficiency.*** Increasing the efficiency of fossil-fueled power plants reduces fuel consumption and GHG emissions per unit of electricity generated.

- ***Fuel Switching.*** Replacing electricity generation from coal power plants with generation from efficient natural gas power plants can reduce emissions since natural gas is a less carbon-intensive fuel than coal. In this way, natural gas might be a "bridge" fuel while non-emitting energy sources (such as nuclear power and renewables) ramp up.

- ***Renewable Energy.*** Renewable energy harnesses the power of the wind, the sun, water, tides, heat from deep inside the earth, and other sources to produce electric power. Biomass, such as agricultural residues and energy crops, can be used to generate electricity and heat when combusted alone or co-fired with coal. Renewables generate electricity without producing GHGs—or producing very few when compared to fossil fuels. Most renewable resources can be harnessed on a large-scale basis (for example, via wind farms or large solar arrays) or in more "distributed" forms (for example, by placing solar panels on rooftops). Although wind power can be cost-competitive with fossil-fueled electricity in some cases, other renewables largely remain more costly than electricity from coal and natural gas, and renewables account for only a small share of overall electricity generation in the United States (in 2009 less than 4 percent of total electricity generation came from non-hydro renewables but such generation grew at an average annual rate of 12 percent over the most recent five-year period).[6] Options for expanding the use of renewables include: Renewable Portfolio Standards, which require utilities to acquire a specified share of power from renewable sources; tax credits for renewable energy investments or generation; consumer rebates and other government incentives; GHG emissions standards for power generators; policies that put a price on GHG emissions, such as cap and trade; and government support for R&D to advance renewable energy technologies and lower their costs.

- ***Carbon Capture and Storage (CCS).*** A suite of technologies exists that allows for CO_2 from the combustion or gasification of coal and other fossil fuels to be captured rather than released to the atmosphere. Once captured, CO_2 from fossil fuel use can be injected into and permanently sequestered in underground geologic formations. Because CCS requires expensive equipment and infrastructure to capture, transport, and store CO_2, it is most cost-effectively applied to large stationary sources of CO_2, such as coal-fueled power plants.

Recent years have seen several small-scale CCS demonstration projects completed, and several large-scale projects are proceeding with substantial government financial assistance.[7] Additional government incentives are required to spur investments in large-scale CCS projects beyond those currently planned in order to fully demonstrate the technologies and reduce their cost. Many experts expect CCS to be a major source of GHG emission reductions in the United States and globally.

• ***Nuclear Power.*** In 2009, nuclear power provided one fifth of U.S. electricity and two-thirds of non-emitting electricity generation. The construction of the current fleet of nuclear reactors saw massive budget overruns, delays, and safety concerns, especially after the accident at Three Mile Island in 1979. These factors contributed to a three-decade hiatus from building new nuclear reactors that is only now ending. Government incentives have spurred plans for some new nuclear plants, but for nuclear power to play a more prominent role in U.S. efforts to address climate change, the industry needs to demonstrate that it can build new reactors on time and on budget, and the government needs to develop a plan for long-term nuclear waste management.[8,9]

Options for Buildings. GHG emissions attributed to the buildings sector include both the emissions generated by power plants to supply the electricity used in buildings and emissions from the on-site combustion of fossil fuels for buildings' energy needs, such as natural gas use for space and water heating. People consume electricity in buildings for a variety of end uses, including lighting, space heating and cooling, running appliances, and powering electronics. Households and businesses already have many cost-effective options for reducing building energy use and thus GHG emissions, but consumers often fail to invest in even those options that would save them money. The reasons people do not take advantage of many cost- and energy-saving measures include lack of information and misaligned incentives (e.g., between building owners and tenants).[10] Because of inefficiencies in the generation and distribution of electricity to consumers, reductions in demand by energy users result in even larger primary energy savings by the generators. For the same reasons, on-site power generation can also lead to emission reductions by avoiding losses of electricity in the transmission and distribution system.

• ***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 products and better insulation, households and businesses have an array of cost-effective options for limiting their energy use and boosting efficiency. However, households and businesses often do not take advantage of these options on their own, even when energy efficiency investments would save them money. Policymakers can help promote greater energy efficiency through: enhanced building codes; building standards, awards, or certifications for buildings that are energy-efficient; financial incentives for efficient appliances; publicly funded utility efficiency programs; regulatory reforms that reduce barriers to investment in energy efficiency, such as decoupling utilities' profits from their sales of electricity and natural gas; appliance standards and labeling; and other steps.

• ***On-site Power Generation.*** GHG emissions from the electricity and building sectors also can be reduced through on-site power generation using distributed renewable technologies (such as rooftop solar panels and small-scale wind power) or highly efficient combined heat and power (CHP) systems. Some of these technologies (e.g., rooftop solar panels) remain fairly expensive and thus are not widely used in the marketplace absent subsidies. Expanding their use—which will ultimately reduce costs—requires incentive programs, such as consumer rebates and tax credits. Building standards (such as LEED™ certification) also can help.[11] CHP (or cogeneration) systems make use of the waste heat from on-site electricity generation (e.g., for water heating or industrial processes) and can substantially reduce GHG

A Key Role for Agriculture

Emissions from agriculture account for approximately 7 percent of U.S. GHG emissions. Reducing these emissions can make an important contribution to the overall U.S. effort to address climate change. Agriculture can be a part of the solution in other ways as well. For example, less productive agricultural lands can be reforested with CO_2-absorbing 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. CO_2 emissions and could be a new profitable opportunity for farmers.[12] In addition, biomass from agricultural sources (including corn and grasses) is being used to produce low-carbon biofuels for transportation and as fuel for electricity 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.

emissions compared to separate heat and power systems even when cogeneration systems use fossil fuel. Policymakers can promote cogeneration by addressing regulatory barriers.

TRANSPORTATION

The transportation sector is the second largest source of GHG emissions in the United States, primarily from CO_2 from petroleum fuels used by cars and trucks. The ways in which people and goods move from place to place are responsible for more than a quarter of total U.S. GHG emissions and about 14 percent of emissions around the world. Reducing GHG emissions from transportation can be accomplished in four main ways:

- Making cars and trucks more fuel efficient;
- Switching to lower-carbon vehicle fuels;
- Reducing the number of miles traveled; and
- Increasing the efficiency of the transportation system.

Historically, it has proven very hard to get people to drive less. The way most Americans live today, cars and trucks are an essential part of their daily lives. There are ways to make Americans less automobile-dependent, such as mass transit, 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 a low-carbon transportation sector.

To achieve significant reductions in U.S. greenhouse gas emissions, the United States needs to deploy technologies available in the short term and invest in R&D for long-term solutions.

Short-Term Options: Energy Efficiency, Fuel Blending, Advanced Diesels, and Hybrids. Significant reductions in GHG emissions from conventional cars and trucks are possible using technologies that are commercially available today. Vehicle fuel economy can be improved by increasing the efficiency of the drivetrain (engine and transmission) and by decreasing the amount of energy needed to move the vehicle (through reducing weight, aerodynamic drag, and rolling resistance). In the United States, Corporate Average Fuel Economy (CAFE) standards have governed light-duty vehicle fuel economy for more than 30 years, but the fuel economy standards remained roughly flat for about the last two decades. The Energy Independence and Security Act of 2007, however, required the Department of Transportation (DOT) to issue more stringent CAFE standards, and a 2007 Supreme Court case opened the door for the Environmental Protection Agency (EPA) to regulate GHG emissions from vehicles under the Clean Air Act. In 2010, DOT and EPA jointly issued new rules for light-duty vehicles that would increase average fuel economy for new vehicles to 35.5 miles per gallon by 2016. Regulation is underway for model years after 2016 and for medium- and heavy-duty vehicles.

Another option for reducing GHG emissions from cars and trucks in the short term is the blending of biofuels, such as ethanol and other biologically-derived fuels, with gasoline. Ethanol derived from corn is currently the dominant biofuel in the United States. Corn-based ethanol reduces emissions for each gallon of regular gasoline that it replaces by about 20 percent. Other biofuels that can be developed over the longer term promise to deliver significantly larger reductions (see below).

The use of advanced diesel and hybrid-electric vehicle technologies also can yield emission reductions. Diesels and hybrids use different engines than the standard internal combustion gasoline engine. The key advantage of these technologies is they both offer significant improvements in fuel economy.

By 2035, a gasoline hybrid-electric vehicle could reduce fuel consumption by 65 percent compared to a 2005 Toyota Camry. Also in 2035, an advanced diesel vehicle could reduce fuel consumption by 47 percent.[13]

Longer-Term Options: Electricity, Biofuels, and Hydrogen. Ultimately, reducing GHG 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, and hydrogen.

• ***Electric Cars.*** In 2010 automakers launched the first mass-market fully electric vehicles, and major automakers will roll out additional models in the next couple of years. Improvements in battery technology are needed, however, before fully electric vehicles can become cost-competitive with traditional and hybrid vehicles without substantial subsidies. Another option is the "plug-in" hybrid, a hybrid gasoline-electric vehicle whose battery can be plugged into the electric grid to be charged. Even using the current U.S. mix of electricity sources to charge the vehicles, a plug-in hybrid with a 20-mile electric range would result in a CO_2 emission reduction of about 45 percent relative to a regular hybrid.[14] Widespread deployment of plug-in hybrids and fully electric vehicles will necessitate some electric grid and charging infrastructure investments, and the emission benefits from such vehicles will increase as the carbon intensity of electricity generation decreases.

• ***Biofuels.*** As noted above, agriculture can be used to produce transportation fuel. While ethanol currently produced in the United States comes primarily from corn, the technology exists to make other biofuels from cellulosic sources (or the woody and leafy parts of plants). While corn-based ethanol reduces emissions by about 20 percent for every gallon of traditional fuel replaced, cellulosic ethanol and sugar-cane-based ethanol produce about 60 percent lower emissions compared to gasoline.[15,16] (This is because the CO_2 released by combusting biofuels is CO_2 that the feedstock plants had absorbed from the atmosphere as they grew.) 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. Biofuels have the technical potential to supply almost one-fifth of U.S. energy use, which could reduce current U.S. GHG emissions by 10 to 24 percent, depending on how the biofuels are produced.[17] With ethanol providing more than 50 percent of light-duty vehicle fuel demand, Brazil has shown that an aggressive policy push can help biofuels become a mainstream fuel choice.[18]

• ***Hydrogen.*** Hydrogen fuel cells, long a staple of the U.S. space program, combine oxygen with hydrogen to create water and electricity via an electro-chemical reaction. 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.[19] 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 pieces needed for a hydrogen-based transportation sector are: lower-cost hydrogen-powered vehicles, infrastructure for distributing hydrogen and fueling stations, and cost-effective hydrogen production that does not emit GHGs.[20, 21]

GETTING IT DONE

To achieve significant reductions in U.S. GHG emissions, the United States needs to deploy technologies available in the short term and invest in R&D for long-term solutions. Three broad policy efforts would foster low-carbon technologies. First, government funding for R&D would support the development and improvement of a wide array of possible long-term technologies for GHG abatement. Second, a market-based climate policy would put a price on GHG emissions. Doing so would spur companies to invest in innovation and deployment of low-carbon technologies. The competitive pressures of the market would drive companies to adopt and improve upon technologies fostered by government-funded and private-sector R&D efforts. Finally, complementary policies are needed to address barriers to the use of climate-friendly technologies, such as barriers to adoption of cost-effective energy efficiency measures.

Government needs to spur investments in new technologies—by making direct investments in R&D, and creating and enhancing incentives for private investment.

Government needs to spur investments in new technologies—by making direct investments in R&D, and creating and enhancing incentives for private investment. The most important benefit of a market-based climate policy is that it establishes a financial value for emission reductions, as well as a cost advantage for technologies that can achieve them. Coupled with government efforts to promote the development

and deployment of new technologies, a market-based climate policy holds the promise of achieving the needed reductions at the lowest cost.

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 best achieve the necessary emission reductions is not clear. A number of existing technologies, though, can provide very large emission reductions, and nascent technologies offer the promise of even more reduction potential. Policies are 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 crucial. At the same time, state and local leaders have jurisdiction over many relevant areas, such as transportation planning and electric utility regulation. 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 above, refer to these publications from the Pew Center on Global Climate Change:

Climate TechBook (http://www.pewclimate.org/climate-techbook)

In Brief: Update on the 10–50 Solution: Progress Toward a Low-Carbon Future (2010)

In Brief: Clean Energy Markets: Jobs and Opportunities (2010)

Technology Policies to Address Climate Change (2008)

Towards a Climate-Friendly Built Environment (2005)

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

Addressing Emissions from Coal Use in Power Generation (2008)

Reducing Greenhouse Gas Emissions from U.S. Transportation (2011)

Biofuels for Transportation: A Climate Perspective (2008)

Agriculture's Role in Greenhouse Gas Mitigation (2006)

ENDNOTES

1 Cap and trade is one such policy. For more information on cap and trade, see *Climate Change 101: Cap and Trade* at http://www.pewclimate.org/cap-trade.

2 See *Climate Change 101: Science and Impacts* at http://www.pewclimate.org/global-warming-basics/climate_change_101.

3 See, e.g., Pew Center on Global Climate Change, 2010, *In Brief: Clean Energy Markets: Jobs and Opportunities* at http://www.pewclimate.org/publications/brief/clean-energy-markets-jobs-and-opportunities.

4 CleanEdge. 2010. *Clean Energy Trends 2010*.

5 U.S. Department of Energy, "Manufacturing Energy Footprint," see http://www1.eere.energy.gov/industry/energy_systems/footprints.html.

6 The U.S. Energy Information Administration (EIA) reports that in 2009 renewable energy other than conventional hydropower accounted for 3.6 percent of U.S. net electricity generation. See *Electric Power Monthly* (September 2010 Edition).

7 See CO_2 capture and storage project fact sheets at http://sequestration.mit.edu/tools/projects/index.html.

8 See http://www.nei.org and http://www.eia.doe.gov/cneaf/nuclear/page/nuc_reactors/com_reactors.pdf.

9 Wald, Matthew. 2008. "Nuclear Power May Be in Early Stages of a Revival." *The New York Times*. 23 October.

10 For an overview of barriers to energy efficiency, see the *National Action Plan for Energy Efficiency*, 2006, Chapter 1 p. 9, available at http://www.epa.gov/cleanrgy/energy-programs/napee/resources/action-plan.html.

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13 Bandivadekar, A. et al. 2008. *On the Road in 2035: Reducing Transportation's Petroleum Consumption and GHG Emissions.* Massachusetts Institute of Technology, Laboratory for Energy and the Environment Report No. LFEE 2008-05 RP.

14 Electric Power Research Institute (EPRI) and National Resource Defense Council (NRDC). 2007. *Environmental Assessment of Plug-In Hybrid Electric Vehicles.*

15 U.S. Environmental Protection Agency (EPA). 2010.*Regulation of Fuels and Fuel Additives: Changes to Renewable Fuel Standard Program: Final Rule.*

16 Some researchers have raised concerns over the emissions impact from indirect land-use changes that result from the use of food crops for biofuels. See e.g. Searchinger, Timothy et al. 2007. "Use of U.S. Croplands for Biofuels Increases Greenhouse Gases Through Emissions from Land-Use Change." *Science* 319 (5887): 1238-1240.

17 Paustian, Keith, et al. 2006.

18 See http://www.eia.doe.gov/cabs/Brazil/Oil.html.

19 Hydrogen 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 National Research Council, 2008, *Transitions to Alternative Transportation Technologies: A Focus on Hydrogen.*

20 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).

21 Mouawad, Jad. 2008. "Pumping Hydrogen." *The New York Times.* 23 September.

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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. Just over a decade 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 willingness among corporate leaders to help shape solutions. In addition to acting on their own to reduce greenhouse gas emissions and explore new, low-carbon market opportunities, a growing number of businesses are calling on the government to provide investment certainty through clear climate policy.

ASSESSING THE RISKS

For corporate leaders responsible for paying attention to the full range of risks confronting their businesses, climate change has become an issue that can no longer be ignored. As Marsh, one of the world's leading risk and insurance services firm has stated, "Climate change is a clear example of a risk where long-term 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 reinsurance company Swiss Re, economic losses from climate-related disasters are already substantial and rising: insured losses have jumped from an annual $5 billion to $27 billion over the last 40 years and without further investments in adaptation, climate risks could cost some countries up to 19 percent of annual GDP by 2030.[2] Swiss Re has also said that "it's not possible to predict precisely what the climate will be like in the future. And yet, there is growing consensus that the consequences of unabated climate change are likely to be very serious… . After all, this much is certain: inaction would be far more expensive than taking action."[3]

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 mandatory limits on greenhouse gas (GHG) emissions. Nearly all business leaders surveyed for the Pew Center's report, *Getting Ahead of the Curve: Corporate Strategies That Address Climate Change*,[4] viewed national GHG regulations as inevitable in the United States. More recently, a survey released in 2008 by McKinsey & Company of more than 2,000 global executives found that more than 80 percent of those polled expected some form of climate change regulation in their companies' home country in the next five years.[5]

A major reason why businesses view national climate regulations as inevitable is because a number of U.S. states and regions have already put in place mandatory policies to reduce GHG emissions.[6] Power generators in 10 northeastern states already have to comply with the Regional Greenhouse Gas Initiative (RGGI), a limited cap-and-trade program for the power sector; California has been designing climate regulations (including emissions trading) in response to the landmark AB 32 bill passed in 2006; and a broader emissions trading system could also soon get underway between California, several Canadian provinces, and possibly other western states. Additionally, for the past several years, some U.S. businesses with operations in Europe have had to comply with the European Union's (EU) GHG emission trading system.[7] Finally, the Environmental Protection Agency (EPA) is also moving forward with GHG regulations in several sectors.

PEW CENTER ON Global CLIMATE CHANGE

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.

The effect of regulations on businesses could be significant, especially for firms with large carbon footprints—though climate policy would provide both risk and opportunity. As a result, many companies have begun taking action to reduce their emissions even without regulation. For example, EPA's voluntary Climate Leaders program, which enlisted companies to measure GHG emissions and set long-term reduction targets, grew from its initial 11 partners in 2002 to more than 200 in 2010.[8]

Companies set voluntary goals for a number of different reasons, including getting a head start over competitors in learning what climate strategies work, preparing to respond rapidly once regulations take effect, better managing the costs of reducing their emissions over time, reducing costs in the short term by improving energy efficiency, and responding to consumer and shareholder demands for climate action. In addition, many companies recognize that acting early to reduce emissions is an important way to gain both credibility and influence with policymakers.

Threats to Competitiveness. Government climate policies and growing customer awareness about climate change 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 related trends: a decline in the value of inefficient and GHG-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. Under this scenario, investors may also be exposed to significant risk. This is one of the reasons several major banks, including Citi, JPMorgan Chase, and Morgan Stanley, came together in 2007 to unveil the "Carbon Principles," which lay out a process lenders can use to scrutinize more closely the potential regulatory risks associated with coal-based power plant investments.[9] In the transportation sector, car companies that produce mainly gas guzzlers already are losing market share to competitors that produce higher numbers of efficient hybrid and diesel models. Market dynamics appear to be shifting as record high gasoline prices in 2008 and new domestic fuel economy regulations in 2009 are driving major U.S. automakers to shift some production to smaller, more fuel-efficient vehicles.[10]

Businesses Face Growing Pressures to Disclose Climate Risks and Strategies

An increasing number of investors realize 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 2010 proxy season, investors filed a record 101 climate and energy-related shareholder resolutions with 88 companies—nearly 50 percent higher than the number filed two years ago—many of them seeking greater analysis and disclosure of business impacts of climate change and future regulation of GHG emissions.[11]
- 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 GHG emissions and climate strategies. The 2010 CDP disclosure request was sent to 4,700 companies under the signatures of 534 institutional investors with combined assets of $64 trillion—up over fourteen fold from $4.5 trillion in 2003. In 2009, 2,456 companies responded to the questionnaire. This was a significant increase over 2003, when only 235 companies responded.[12]
- In February 2010, the Securities and Exchange Commission (SEC) issued guidance for public companies on the disclosure of both actual and potential consequences of climate change-related regulations, business trends, and physical effects of climate change. While only guidance, the document clearly demonstrates that the SEC also recognizes that many firms are coming under increased scrutiny for the risks and opportunities that climate change presents.[13]

Physical Risks to Business. Businesses also face risks from the projected impacts of climate change, including stronger hurricanes, increased drought, sea level rise, and flooding. The industries most likely to be affected directly by these physical risks include agriculture, forestry and paper products, tourism, real estate, offshore energy development, and insurance.[14]

For other industries, as well as companies located far away from regions facing direct climate impacts, the indirect effects can be substantial. As the United States experienced following Hurricane Katrina in 2005, the loss of oil and gas platforms in the Gulf of Mexico not only increased 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.

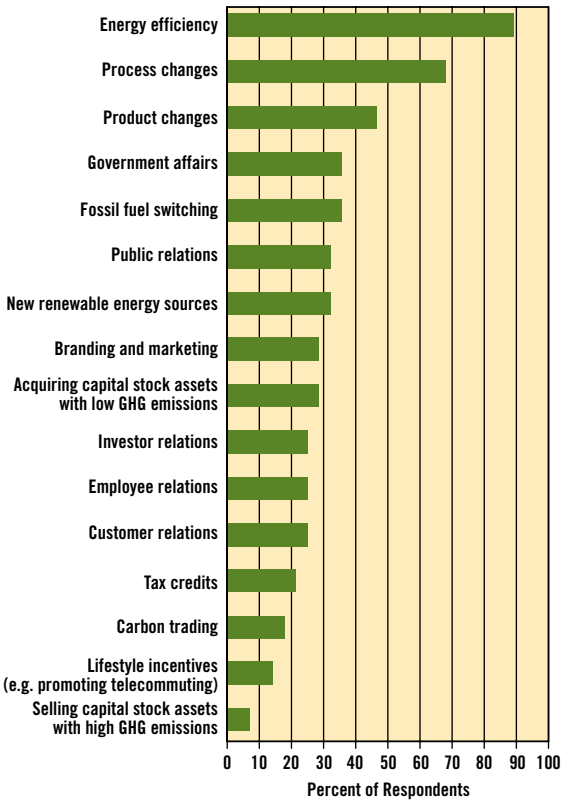
Some companies have begun taking steps to address the physical risks of climate change. Entergy, the New Orleans-based electric utility, began relocating important business operations to areas less vulnerable to severe weather events after suffering $2 billion in losses from Hurricanes Katrina and Rita. Mining giant Rio Tinto has also taken steps to buffer its business against physical risks, including using high-resolution climate modeling to conduct detailed site assessments and gauge risks to high-priority assets.[15] More examples along these lines can be found in the Pew Center brief: *Adapting to Climate Change: A Business Approach*.

Reputational & Litigation Risks. In addition to regulatory and physical risks, businesses face additional climate risks, both in terms of their reputation and from litigation. For example, companies complying with EPA's mandatory reporting rule face the prospect that their GHG emissions will be publicly reported in the spring of 2011, which could have a "naming and shaming" impact on some companies, though many of these companies already report emissions through other venues.

With regard to litigation, the number of climate-related nuisance lawsuits continues to increase. One of the most famous of these is from Alaska, where the City and Native Village of Kivalina has sued 23 energy companies. Plaintiffs claim that defendants' GHG emissions result in increased temperatures that allegedly have melted sea ice near the village, exposing it to storms and eroding the land on which it sits. The plaintiffs seek monetary damages for the cost of relocation, which they estimate to be between $95 million and $400 million. In Comer vs. Murphy Oil, Mississippi residents claim defendants' GHG emissions contributed to global climate change, intensified Hurricane Katrina, and resulted in hurricane-related damages to plaintiffs. While this case was thrown out in 2007, as of November 2010, that decision is under appeal. A third such case is Connecticut vs. American Electric Power, in which eight states and three land trusts filed lawsuits against five utilities alleging that the utilities' carbon dioxide (CO_2) emissions contribute to the "nuisance" of global climate change. This case is still active and similar ones seem likely in the coming years.

Figure 1

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

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 already begun to reduce their GHG emissions demonstrates there are numerous options that can both decrease costs and increase profits. Figure 1 shows a ranking of programs that

benefit the bottom line based on a 2006 Pew Center poll of 33 major corporations. Also, climate policy can be designed so that businesses can respond with innovative solutions that will minimize costs.

As described in the Pew Center brief *Clean Energy Markets: Jobs and Opportunities*, among the companies that have leading climate strategies, there is a major shift underway from a focus on risk management and emission reductions toward 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. (These technologies and their contribution to global emissions reductions are discussed in *Climate Change 101: Technological Solutions*).

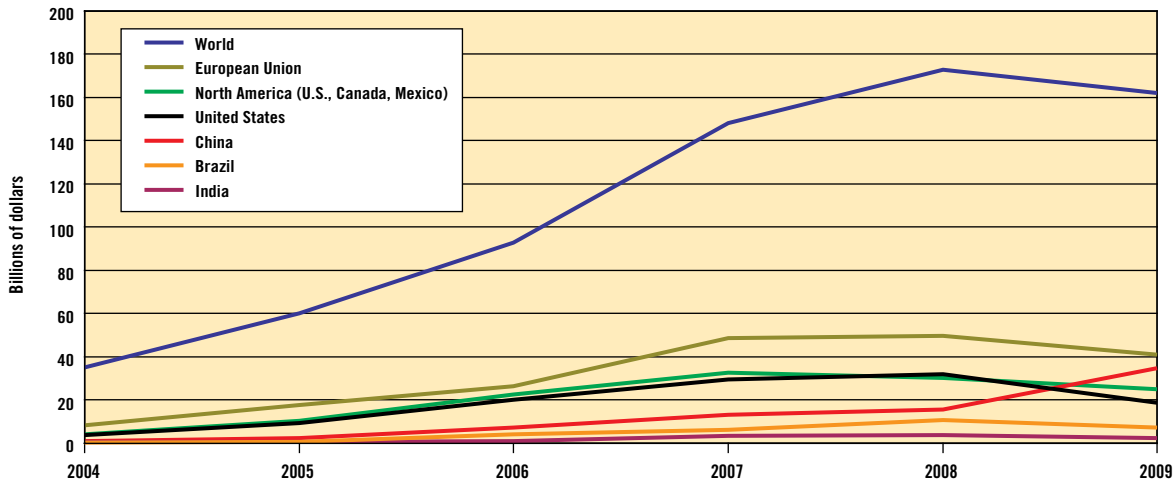
Each technology area represents enormous potential annual revenue for the companies and countries that emerge as major producers. In fact, low-carbon technologies are already experiencing explosive growth in the market place. CleanEdge, a clean technology market research firm, reported that revenue from solar photovoltaics, wind, and biofuels grew from $55 billion in 2006 to $144.5 billion in 2009, a nearly threefold increase. CleanEdge estimates that global revenues from these clean energy technologies could surpass $343 billion within a decade.[16] Key suppliers of components for these new technologies—for example, manufacturers such as Eaton, Parker-Hannifin, and Johnson Controls, whose hydraulics and electrical systems can enable hybrid vehicles and wind turbines—also may have considerable new sales opportunities.

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:

- Between 2004 and 2009, global investments in clean energy technology (including renewables, efficiency technologies, biofuels, carbon capture and sequesteration (CCS), nuclear power, and other low-carbon technologies) grew at an average compound annual growth rate of 39 percent, reaching a peak of $173 billion in 2008. Despite the recession, investment only fell 6.6 percent to $162 billion in 2009.[17]
- Venture capital (VC) 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. While overall cleantech VC investment was down in 2009 due to the recession, as a percent of total VC investments, cleantech grew from 11.4 percent in 2008 to 12.5 percent in 2009, which represented the largest share in the history of the clean energy asset class.[18]

Figure 2

Global New Investment in Clean Energy Technologies, 2004–2009



Source: Pew Center on Global Climate Change, 2010. http://www.pewclimate.org/docUploads/Clean_Energy_Update__Final.pdf

Business Action on Climate

As of December 2010, 46 companies are members of the Pew Center's Business Environmental Leadership Council (BELC). These companies have combined revenues of over $2.5 trillion, and together they employ nearly 4.5 million people.[19] They represent most industrial sectors and many of the largest GHG emitters, including utilities, mining companies, aluminum producers, automobile manufacturers, pulp and paper manufacturers, chemical companies, oil and gas businesses, and the cement industry.

Of the 46 companies, 35 have set targets to reduce their GHG emissions; in fact, many have already met initial targets and subsequently set new, more ambitious targets. The following are some of the many actions that BELC members have taken to reduce emissions while also reducing costs below those of their competitors and building new climate-related sales growth opportunities:

- In November 2010, **Air Products** set a new goal to reduce its global GHG emissions by 7 percent per production index by 2015. The company's production-intensity based emission reduction goal aligns with its 2015 intensity-based energy efficiency goals for large air separation units and hydrogen, carbon monoxide, and synthesis gas facilities. These plants represent approximately 80 percent of the company's total global energy requirements. Air Products intends to meet its GHG emissions reduction goal, investing in efficiency improvements at existing plants and new, high efficiency production facilities. The company expects to achieve a minimum energy reduction of 875 million kilowatt hours/year and 12 million MMBtu of natural gas at 2007 operating rates.[20]

- **Johnson Controls** is retrofitting the 80-year-old Empire State Building with the aim of reducing its energy use by 38 percent per year, placing it in the top 10 percent of all U.S. office buildings in terms of energy efficiency.[21]

- **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 past 20 years.[22] Indirectly, the company also helps other sectors and companies reduce their energy use by supplying strong lightweight material that can substitute for heavier material—for example, in packaging where aluminum has significant transport benefits over heavier materials like glass. The search for light-weight materials will no doubt continue to grow as pressure for GHG reductions from transportation increases.

- As of September 2010, **Toyota** has sold nearly 2.8 million hybrids worldwide since the first Prius was introduced 13 years ago. In calendar year 2009, Toyota sold a combined 195,545 Toyota and Lexus gas-electric hybrids in the U.S. alone. In December 2009, Toyota launched the 2010 Prius Plug-in Hybrid Vehicle (PHV) demonstration program, which in North America will involve more than 150 PHVs placed in regional clusters with select partners for market/consumer analysis and technical demonstration.[23]

- Shipping giant **Maersk** announced in November 2010 that it is the first shipping company to receive independent verification of its CO_2 emissions data, vessel by vessel. The shipping line says it will now add the CO_2 data, verified by Lloyd's Register, as one of eight performance measures in score cards provided to its customers. This is expected to give Maersk's customers more transparency into the carbon footprint of their supply chains.[24]

- By the end of 2009, **Abbott Industries** had reduced CO_2 equivalent emissions from manufacturing by 36 percent compared with 2006 levels, normalized by sales, thereby exceeding its target of a 30 percent reduction by 2011. The company is achieving these reductions primarily by improving energy efficiency and switching to low carbon fuels and renewable energy. It generates electricity through co-generation at five of its manufacturing sites. In 2009, it also achieved a 32 percent reduction in electricity purchased, exceeding its 2011 target of a 12 percent reduction (on a 2006 baseline, indexed to sales).[25]

- In 2007, Citi and Bank of America announced separate environmental initiatives that include commitments to invest billions of dollars in alternative energy and clean technologies over the next decade.[26] Spurred by its 2005 commitment to environmental finance, by the end of 2009 Wells Fargo had made more than $6 billion in loans and investments to environmentally beneficial initiatives which included wind farms and solar installations.[27] From 2003 to 2009, JP Morgan has provided financing of $2.7 billion in renewable energy projects (primarily through tax equity financing) and raised another $3.8 billion from other institutions for investment.[28]

Businesses in energy, technology, and other sectors also are making substantial new investments of capital and effort to expand their climate-friendly products. General Electric (GE), for example, has doubled its annual investment in clean tech research and development to $1.5 billion, resulting in a total investment of $5 billion as of 2010.[29] (*Business Actions on Climate* on page 5 outlines other examples of leading companies transforming their businesses to succeed in a carbon-constrained world.)

While the figures above are significant, the absence of clear mandatory 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 and, increasingly, China.

- Europe invested more than $41 billion in clean energy technologies in 2009, followed by China with $34.6 billion and the United States as a distant third with $18.6 billion.[30]

- U.S. firms face serious competition in the wind and solar power sectors. In 2008, while GE had an 18 percent share of the global installed wind turbine market and 43 percent of the domestic market, it was the only U.S. company among the top five global wind turbine manufacturers.[31] The story is similar in other industries; only one of the top 10 solar panel manufacturers is American, as are only two of the top 10 advanced battery manufacturers.[32]

- China is now home to the world's largest solar panel manufacturing industry—which exports about 95 percent of its production to countries including the United States.[33] China also manufacturers more wind turbines than any other country.[34]

- Investments in German-made renewable electricity-generating systems could be in the range of $18 billion to over $27 billion a year by 2020, with about $15 billion coming from exports, and German companies could capture 15–20 percent of several global markets, particularly in component manufacturing for solar energy systems, wind turbines, and hydropower and biomass plants.[35]

While private funding from investors and corporations can help the United States compete in some of these technology markets, the United States cannot compete in other areas without greater government support for research, development, and deployment.

BUSINESS SUPPORT FOR STRONGER POLICY

The growing body of scientific evidence has clarified that climate change is already underway and that avoiding severe impacts in the future requires large reductions in human-induced CO_2 emissions in the coming decades.[36] Despite the 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.

Recognizing both that government action is inevitable and policy decisions made on this issue could have substantial implications for future profits, business leaders have increasingly engaged with policymakers to help influence those decisions. Many businesses 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 emissions trading, that give businesses flexibility either to reduce their own GHG 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).

The emergence of the U.S. Climate Action Partnership (USCAP), a coalition of major corporations and non-governmental organizations—including the Pew Center on Global Climate Change—which called for the prompt establishment of a binding domestic cap on emissions, was perhaps the most dramatic example of positive business engagement on the climate issue in recent years. The coalition publicly unveiled its "Call for Action" in January of 2007 and followed up with its more detailed "Blueprint for Legislative Action" in January 2009, which urged the adoption of a market-driven,

economy-wide approach to reducing GHG emissions 80 percent below 2005 levels by 2050.[37]

An important reason why many corporations support a move to federal regulation is the specter of complying with a growing patchwork of state and regional climate 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.[38]

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

Calls for changes in national policies are coming from a diverse array of businesses—automobiles, chemicals, heavy and high-tech manufacturing, medical products, retail, information technology, and major oil and gas companies. In addition to USCAP, recent examples of businesses advocating for mandatory climate policy include:

- In June of 2009, more than 40 large companies, including Alcoa, American Electric Power, Dow, Duke Energy, GE, John Deere, HP, NRG, National Grid, PSEG, PG&E, Rio Tinto aligned with environmental, labor, and religious organizations to publicly support the passage of the Waxman-Markey American Climate and Energy Security Act, a bill that would have established a mandatory domestic GHG reduction program.
- In early 2010, more than 70 companies with over $2.5 trillion in revenue, including all of USCAP and others such as Google and Nike, as well as 25 labor unions and NGOs joined together in an ad campaign supporting bi-partisan, comprehensive energy and climate legislation. The ad (www.climatead.org) ran under the banner "A Question of American Leadership" and in *The Washington Post*, *The Wall Street Journal, POLITICO,* and a number of state newspapers.
- American Businesses for Clean Energy (ABCE) gathered together the names of 5,200 small- and medium-sized businesses that support Congressional enactment of clean energy and climate legislation that will significantly reduce GHG emissions.
- Business for Innovative Climate & Energy Policy (BICEP) is a group of 18 mostly consumer products and retail companies, including Best Buy, Nike, Starbucks and Target, that has called for climate and energy legislation that reduces GHG emissions 25 percent by 2020 and 80 percent by 2050.

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 are seeking coordinated global policies that will be as predictable, integrated, and consistent as possible. Many corporations operate in countries that have committed to emissions reductions under the Kyoto Protocol, and for these companies, it makes sense to implement company-wide climate change strategies, rather than operate with varying requirements across the globe. Firms 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 to encourage China and India to move toward climate commitments is for the United States to adopt its own mandatory emissions limits and 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 GHG 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.

While business action on climate has grown over the last several years, some concerns have been raised that the recent economic turmoil may dampen business and government support for addressing climate change. Pessimists fear that

tighter credit markets could slow financing for renewable energy projects, cash-strapped consumers may pull back from paying premiums on "greener" goods, and deteriorating macroeconomic conditions could distract policymakers from putting in place new regulations designed to limit emissions of GHGs, for example.

Despite these concerns, there are encouraging signs the climate issue will stay near the top of corporate and government agendas through this period of global economic anxiety. Governments are continuing efforts at the state, federal and international levels aimed at reducing GHG emissions, and companies continue to announce new, ambitious voluntary GHG reduction targets.[39] Increasingly, leading companies recognize that environmental protection and economic prosperity are not competing ideals but are in fact dependent on one another. And many analysts have noted the potential for government and private sector investment in clean energy to serve as a powerful economic stimulus tool for the U.S. and other countries around the world.

The 95 companies and other organizations that came together in the first half of 2010 on the "American Leadership Ad" understood this message, as they said: "We believe it's time for Democrats and Republicans to unite behind bi-partisan, national energy and climate legislation that increases our security and limits emissions, as it preserves and creates jobs. It's a question of American leadership."

Still, long-term efforts to address climate change will not be cost free—but voluntary action by companies, such as those in the Pew Center's BELC, proves 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 that significant emissions reductions with minimal impact on the U.S. economy can be achieved. 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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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
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

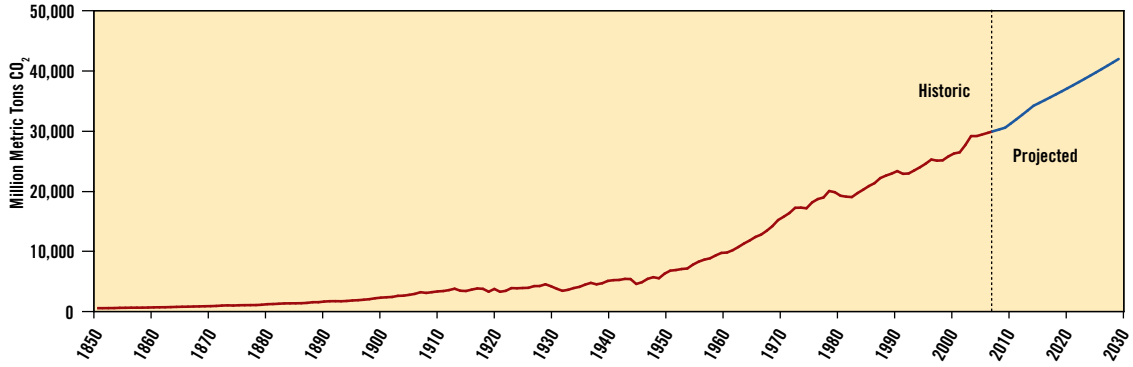
Greenhouse gas (GHG) emissions, largely carbon dioxide (CO_2) from the combustion of fossil fuels, have risen dramatically since the start of the Industrial Revolution. Globally, energy-related CO_2 emissions have risen 145-fold since 1850—from 200 million tons to 29 billion tons a year—and are projected to rise another 36 percent by 2030 (see Figure 1).[1]

Most of the world's emissions come from a relatively small number of countries. The 20 largest emitters, with 70 percent of the world's population and 95 percent of the global gross domestic product (GDP), account for approximately 85 percent of global GHG emissions. The top six emitters—China, the United States, the European Union (EU),[2] India, Russia, and Japan—accounted for more than 60 percent of global emissions in 2008. (If emissions from land use change and forestry are also taken into account, Indonesia and Brazil, with high rates of deforestation, rank among the top 5 emitters.[3])

In absolute terms, China surpassed the United States in 2006 as the largest annual emitter and is currently responsible for 21 percent of global GHG emissions. The United States, with 5 percent of the world's population, is responsible for 17 percent of GHG emissions (see Figure 2).

Figure 1

Global Carbon Dioxide Emissions 1850–2030



PEW CENTER ON Global CLIMATE CHANGE

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.

Figure 2

GHG Emissions for Major Economies

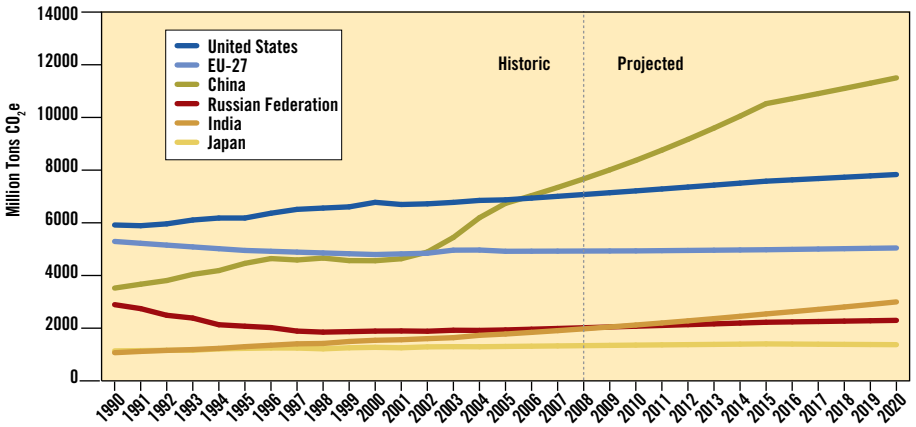


Figure 3

Per Capita GHG Emissions 2008

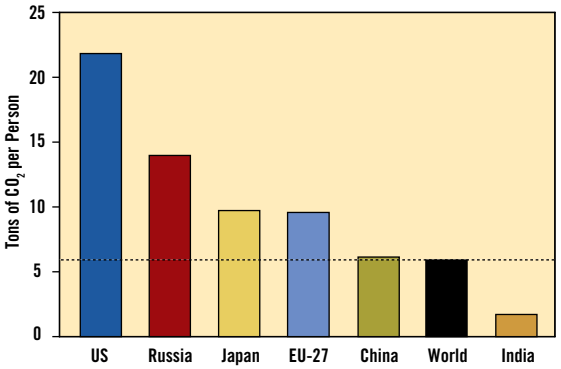
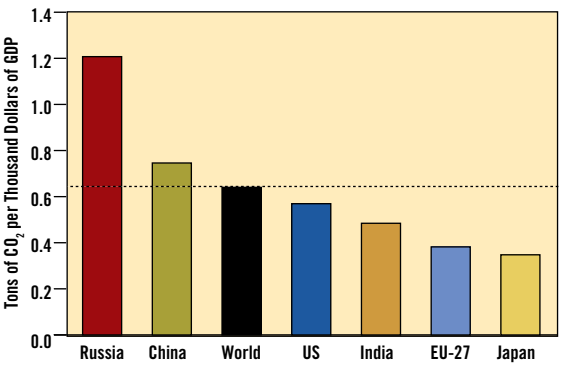


Figure 4

GHG Intensity 2008



On an intensity basis (emissions per GDP), U.S. emissions are significantly higher than the EU's and Japan's (see Figure 3). On a per capita basis, U.S. emissions are roughly more than twice as high as those of the EU and Japan and three and a half times the world average (see Figure 4). Looking ahead, U.S. GHG emissions are projected to remain largely flat through 2020. By comparison, emissions are projected to decline from current levels (2008) by about 4 percent in the EU and 7 percent in Japan by 2020.

Emissions are rising fastest in developing countries. China's and India's emissions are projected to grow compared to current levels by about 45 percent and 47 percent, respectively, by 2020. Annual emissions from all developing countries surpassed those of developed countries in 2004.

As overall emissions from developing countries rise, their per capita emissions will remain much lower than those of developed countries. China's per capita emissions are expected to be a third more than the world average in 2020, but will still be about 40 percent of those of the United States. India's per capita emissions will be about one-tenth those of the United States.

Looking at emissions on a cumulative basis, the United States accounts for 30 percent of energy-related CO_2 emissions since 1850, while China accounts for 9 percent.[4] Cumulative emissions are an important measure because of the long-lasting nature of greenhouse gases in the atmosphere.

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 (UNFCCC). Signed by President George H.W. Bush and ratified by the U.S. Senate, the UNFCCC now has 194 parties.

The UNFCCC 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' historical 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.

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.

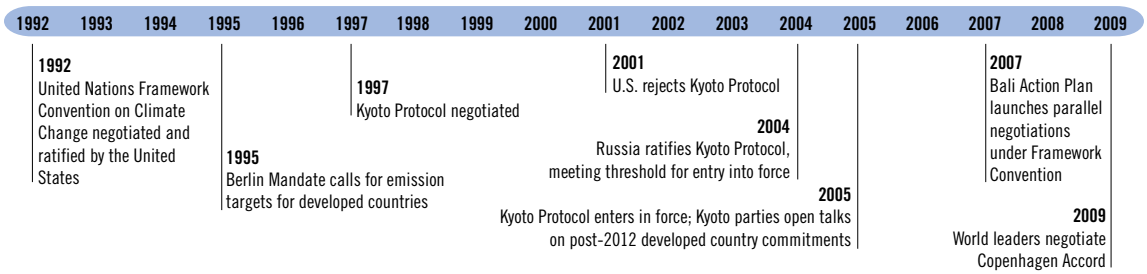
Key provisions of the Protocol, urged largely by U.S. negotiators, provide countries with flexibility to meet their targets cost-effectively. These include three market-based mechanisms: international emissions trading (trading of emission allowances[5] among countries with targets); and Joint Implementation 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 193 countries. The 37 industrialized countries with binding targets account for 60 percent of developed country emissions and about a quarter of global emissions.

Meeting in Montreal in 2005, parties to the Kyoto Protocol opened negotiations on post-2012 commitments for developed countries. In Bali in 2007, governments launched a parallel negotiating process under the Framework Convention, which includes the United States, with the aim of an "agreed outcome" in Copenhagen in 2009. The Bali Action Plan envisions "measurable, reportable, and verifiable" mitigation "actions or commitments" by developed countries; mitigation "actions" by developing countries; and technology, financing, and capacity-building support for developing countries.

While many parties hoped for a binding agreement in Copenhagen, the summit instead produced the Copenhagen Accord, a political agreement negotiated by a group of world leaders, including President Obama. Among its provisions, the Accord: set a long-term goal of limiting global warming to

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 a mandatory target to reduce statewide emissions from all sources to 1990 levels by 2020 (a 28-percent reduction compared to "business as usual" projections). Ten northeastern states have established the Regional Greenhouse Gas Initiative, a cap-and-trade program to reduce emissions from power plants. Thirty-one states and the District of Columbia require that a significant percentage of their electric power come from renewable or alternative energy sources. At the federal level, the United States has taken a number of actions, including new GHG vehicle standards and a Renewable Fuel Standard. Bills have been proposed in Congress to establish mandatory economy-wide GHG limits, but have not been enacted. (For more information on U.S. action, see three other reports in the *Climate Change 101* series: *Local Action, State Action, Federal Action*, and *Business Solutions*.) Here is a sampling of policies and programs in other major GHG-emitting countries:

European Union

- *Kyoto Target*—Reduce EU-15 emissions 8 percent below 1990 level by 2008–2012. Individual targets for 12 new member states range from -8 to +6 percent.
- *Copenhagen Accord Pledge*—Unilateral commitment to reduce EU emissions 20 percent below 1990 levels by 2020; 30 percent below 1990 levels if other developed countries agree to comparable reductions and advanced developing countries contribute according to their capabilities and responsibilities. As part of its Climate and Energy package, the EU has established a law to enforce its unilateral 20 percent target.[6]
- *Emissions Trading System*—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.
- *Renewable Energy Target*—Mandatory target of 20 percent of EU energy mix from renewable sources by 2020, including a minimum of 10 percent biofuels in overall fuel consumption.
- *Energy Efficiency Goal*—A non binding goal of energy efficiency improvement of 20 percent from projected 2020 levels.
- *Auto Fuel economy*—Mandatory standards to reduce average CO_2 emissions of new passenger cars from 160g/km (258g/mile) to 120g/km (193g/mile) by 2015.

China

- *Copenhagen Accord Pledge*—Domestically binding commitment to reduce emissions intensity by 40-45 percent by 2020 compared to 2005 levels, increase share of non-fossil fuels in primary energy consumption to 15 percent by 2020, and increase forest coverage by 40 million hectares and forest stock volume by 1.3 billion cubic meters by 2020 compared to 2005 levels.
- *National Climate Change Program*—Comprehensive program adopted in 2007 outlining existing and planned policies and programs addressing climate change mitigation and adaptation. The government is also currently developing new energy and climate goals for its 12th Five Year Plan, to begin in 2011, which may include initial steps toward establishing a carbon market.
- *Energy Intensity Goals*—National goals of reducing energy intensity by 20 percent by 2010. Achieved through a combination of energy-saving initiatives including: Top 1000 Energy-Consuming Enterprises program; building more efficient coal-fired power plants and shutting down inefficient facilities; appliance standards and consumer subsidies; taxes on petroleum; and mandating provincial and local government action on energy-efficient buildings and public transportation. This will result in 1.5 billion tons of emission savings.[7]

Climate Action Around the World *(continued)*

- *Renewable Energy Initiatives*—National targets for renewables to provide 15 percent of primary energy by 2020, including specific targets for wind, solar, biomass, and hydropower capacity.
- *Fuel Economy Standards*—Proposed standards for 2015 will require all urban cars and light trucks to achieve an average of 36.9 miles per gallon (mpg) (27 percent improvement over 2002 levels).[8]

India

- *Copenhagen Accord Pledge*—Reduce emissions intensity (excluding agricultural emissions) 20 to 25 percent by 2020 below 2005 levels.
- *National Action Plan on Climate Change*—Comprehensive plan adopted in 2008 outlining existing and future policies and programs addressing climate change mitigation and adaptation, and directing ministries to develop detailed implementation plans.[9]
- *Renewable Energy*—Target of achieving installed solar capacity of 20 GW by 2022 as part of the National Action Plan on Climate Change. 19 states have renewable purchase obligations ranging from 1 to 15 percent of total electricity generation and India is launching a renewable energy certificate mechanism.
- *Energy Efficiency*—National program including energy efficiency labels for appliances, mandatory energy audits of large energy-consuming industries, demand-side management programs, and benchmarks for industrial energy use. Mandatory energy efficiency decreases in consumption in large, energy-consuming industries to be met through energy-efficiency certificate mechanism.
- *Coal Levy*—Introduced a levy in July 2010 on domestic and imported coal of about 50 rupees (about $1) per ton. The funds raised will go towards a National Clean Energy Fund.

EU Emissions Trading System

The world's most far-reaching GHG reduction policy is the EU's Emissions Trading System (ETS), which limits CO_2 emissions from 12,000 facilities across Europe. The ETS was launched in 2005 and in 2009 traded 6.3 billion tons of CO_2 at a market value of $118 billion USD.[10]

In its current second phase, which coincides with the Kyoto Protocol compliance period (2008–2012), 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 rules are set at the EU level, but allocation of emission allowances is handled by individual member states. Excess emissions incur a penalty (100 euros/ton) and must be made up in the next phase. In mid 2010, emission allowance prices ranged from about 15 euros to 20 euros.

Changes proposed for the third phase (2013-2020) include: increasing coverage to the petrochemical, chemical, and aviation sectors; setting an EU-wide cap of 21 percent below 2005 levels by 2020 (rather than targets set individually by member states); harmonizing allocation of allowances in key sectors; 100 percent auctioning of allowances for the power sector; and phasing in full auctioning of allowances for some sectors by 2020.

Table 1

Copenhagen Pledges

More than 80 countries have submitted mitigation pledges under the Copenhagen Accord. Below are the pledges submitted by major developed and developing countries.

Developed Countries

Party	2020 economy-wide emissions target	Notes
Australia	5-15-25% below 2000 levels	Australia will reduce its GHG emissions by 25% on 2000 levels by 2020 if the world agrees to an ambitious global deal capable of stabilizing levels of GHGs in the atmosphere at 450ppm CO_2-eq or lower. Australia will unconditionally reduce its emissions by 5% below 2000 levels by 2020, and by up to 15% by 2020 if there is a global agreement which falls short of securing atmospheric stabilization at 450ppm CO_2-eq and under which major developing economies commit to substantially restrain emissions and advanced economies take on commitments comparable to Australia's.
Canada	17% below 2005 levels	To be aligned with the final economy-wide emissions target of the United States in enacted legislation.
European Union*	20-30% below 1990 levels	As part of a global and comprehensive agreement for the period beyond 2012, the EU reiterates its conditional offer to move to a 30% reduction by 2020 compared to 1990 levels, provided that other developed countries commit themselves to comparable emission reductions and that developing countries contribute adequately according to their responsibilities and respective capabilities.
Japan	25% below 1990 levels	Premised on the establishment of a fair and effective international framework in which all major economies participate and on agreement by those economies on ambitious targets.
Russia	15-25% below 1990 levels	The range of the GHG emission reductions will depend on the following conditions: • Appropriate accounting of the potential of Russia's forestry in frame of contribution in meeting the obligations of the anthropogenic emissions reduction; • Undertaking by all major emitters the legally binding obligations to reduce GHG emissions.
United States	In the range of 17% below 2005 levels	In the range of 17%, in conformity with anticipated U.S. energy and climate legislation, recognizing that the final target will be reported to the Secretariat in light of enacted legislation. The pathway set forth in pending legislation would entail a 30% reduction in 2025 and a 42% reduction in 2030, in line with the goal to reduce emissions 83% by 2050.

* Member States (Austria, Belgium, Bulgaria, Czech Republic, Denmark, Germany, Estonia, Ireland, Greece, Spain, France, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Hungary, Malta, Netherlands, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden, United Kingdom). Currently, not all EU Member States are Annex I Parties.

Developing Countries

Party	Nationally Appropriate Mitigation Actions	Notes
Brazil	36.1-38.9% below business as usual (BAU) by 2020	Domestic actions voluntary in nature
China	40-45% emission intensity reduction below 2005 levels by 2020 Increase the share of non-fossil fuels in primary energy consumption to around 15% by 2020 and; Increase forest coverage by 40 million hectares and forest stock volume by 1.3 billion cubic meters by 2020 from the 2005 levels.	Autonomous domestic actions voluntary in nature
India	20-25% emission intensity reduction below 2005 levels by 2020 (excludes agricultural emissions)	Domestic actions voluntary in nature, and will not have a legally binding character.
Indonesia	26% below reference levels by 2020	
Korea	30% below BAU by 2020	
Mexico	Up to 30% reduction below BAU by 2020 (including 51 million tons CO_2-e by 2012)	Conditional on support
South Africa	34% below BAU by 2020, 42% below BAU by 2025	Conditional on support and the finalization of an ambitious, fair, effective and binding multilateral agreement under the UNFCCC and Kyoto Protocol at COP-16 and CMP-6 in Mexico.

2 degrees Celsius; called for a new multilateral climate fund and set goals of mobilizing $30 billion in public finance in 2010-2012 and $100 billion in public and private finance in 2020; further defined how countries' actions are to be reported and verified; and called on countries to list mitigation pledges (economy-wide emission targets for developed countries, and mitigation actions for developing countries). Although the Accord was not formally adopted by UNFCCC parties in Copenhagen, 140 countries have now associated themselves with the agreement and more than 80—including all the major economies—have pledged specific mitigation targets or actions for 2020 (See Table 1).

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. 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.[11] 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.

Past experience with the adoption of new environmental standards shows little evidence of significant competitiveness impacts. One major review—synthesizing dozens of studies assessing the impacts of a range of U.S. regulations across a variety of sectors—concluded that while environmental standards may impose significant costs on regulated industries, they do not appreciably affect patterns of trade.[12] 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.[13]

In gauging the potential impacts of GHG regulation, it is important to distinguish the "competitiveness" effect from the broader economic impact on a given industry or firm. A mandatory climate policy would present costs for U.S. firms regardless of what action is taken by other countries. In the case of energy-intensive industries, one likely impact will be a decline in demand as consumers substitute less

GHG-intensive products. The "competitiveness" impact is only that portion of the total impact on a firm resulting from an imbalance between GHG constraints within and outside the United States.

A Pew Center report, *The Competitiveness Impacts of Climate Change Mitigation Policies*, analyzes the historical relationship between energy prices and production, trade, and employment in order to project the potential competitiveness impacts of mandatory domestic GHG limits, at a price of $15/ton CO_2. Looking at paper, iron and steel, aluminum, cement, and bulk glass, the analysis concludes that most of the anticipated decline in production within those sectors (–1.6 percent to –3.4 percent) reflects a decline in consumption. The gap made up by imports, or the "competitiveness" effect, ranges from –0.7 percent to –0.9 percent.[14]

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.

While most research has focused on the potential negative competitiveness impacts of climate policy, less attention has been paid to the opportunity presented by climate and clean energy policy to enhance the competitiveness of U.S. firms by driving innovation in the high-growth industries of the future. Some economists believe that stronger environmental standards in many cases confer a competitive advantage by driving firms to innovate and become more efficient. By fostering markets for new technologies, new standards are at least as likely to create jobs in some sectors as to reduce them in others—though the circumstances under which this is true remain a subject of ongoing debate.[15, 16]

The fact is that clean energy technology markets are already substantial in scope and likely to grow significantly in the coming decades as worldwide demand for lower-carbon technologies increases. Between 2004 and 2009, clean energy investments (including renewables, efficiency technologies, biofuels, CCS, nuclear power, and other low-carbon technologies) grew at an average compound annual growth rate of 39 percent.[17] Thanks in part to government stimulus packages, global clean energy investments will total about $200 billion in 2010,[18] and even under a business-as-usual case that assumes no changes to existing climate change policy by any major emitters, the International Energy Agency estimates that cumulative global investments in clean power generation technologies between 2010 and 2020 will total about $1.58 trillion, and will be even larger in the following decade.[19]

Recognizing the size and potential of these markets, other nations—most notably China—are aggressively expanding their own domestic clean energy markets by taking steps to reduce GHG emissions, become more energy independent, support lead markets for clean energy technologies, and build up their manufacturing capacity to meet expanded domestic and international demand for new technologies such as wind and solar power, advanced batteries, carbon capture and storage, and nuclear energy. In 2009 Europe led the world in clean energy investments with $41 billion and China invested $34.6 billion, while the United States only invested $18.6 billion.[20, 21]

The United States stands to benefit from the development of these markets, but only if it moves quickly to support domestic demand for and production of clean energy technologies.

NEXT STEPS

Mobilizing an effective global response to climate change requires stronger efforts both within and outside the UNFCCC.

For the past 15 years, the primary thrust of negotiations within the UNFCCC has been the establishment, and then the extension, of a legally binding regime to reduce GHG emissions. This should remain the long-term objective. Binding commitments are the ultimate expression of a countries' will to address an issue of international concern. They provide countries a higher degree of confidence that others will fulfill their obligations. This confidence, in turn, enables each to deliver a stronger level of effort.

The Copenhagen summit, however, demonstrated the difficulty of achieving a new round of binding climate commitments. Most countries with binding targets under the Kyoto Protocol are unwilling to commit to new targets without commensurate commitments from the United States and the major emerging economies. These countries, however, are not yet prepared to assume binding commitments.

Under these circumstances, the best course forward within the UNFCCC may be an evolutionary one. In other international arenas, such as trade, human rights and the law of the sea, multilateral regimes have evolved gradually over time. As initial steps help build parties' confidence in the regime, and in one another's performance, they become willing to assume stronger obligations.

On climate, parties could take incremental steps to strengthen the multilateral architecture in ways that promote stronger action in the near term, while providing a stronger foundation for future binding commitments. Drawing political guidance from both the Bali Action Plan and the Copenhagen Accord, parties could strengthen existing UNFCCC mechanisms and, where necessary, establish new ones. Of central importance are a financial architecture to deliver strong, sustained support to developing countries, and an improved system of reporting and verifying countries' actions to ensure transparency and a measure of accountability.

In parallel, countries could pursue other opportunities outside the UNFCCC to address key aspects of the climate challenge on a multilateral, plurilateral or bilateral basis. For instance, the International Maritime Organization and the International Civil Aviation Organization are examining measures to control GHG emissions from international shipping and aviation, respectively. Other possibilities include further steps under the Montreal Protocol to phase out substances contributing to global warming or an agreement within the World Trade Organization to phase out fossil fuel subsidies.

Over time, efforts within and outside the UNFCCC can strengthen countries' confidence in one another's actions and in the emerging climate change regime. The success of the international effort will hinge heavily on domestic action by the United States. Stronger U.S. action will be critical both because it will promote stronger action by other countries, and because it will better position the United States to take on the types of binding commitments needed to ensure a sustained and effective global effort.

ENDNOTES

1 Global CO_2 emissions from 1850-2030 (Figure 1) includes energy-related CO_2 only. All other data and figures are for all six greenhouse gases, excluding emissions associated with land use, unless otherwise stated. Energy-related CO_2 data: CDIAC 2010. "Global CO_2 Emissions from Fossil-fuel burning, cement manufacture, and gas flaring: 1751-2007" and; IEA, 2010. "CO_2 Emissions from Fuel Combustion 2010 Highlights". Other GHG emissions data: USEPA, 2006. "Global Anthropogenic Non-CO_2 Greenhouse Gas Emissions: 1990-2020." Projections: WEO, 2010. "World Energy Outlook 2010."

2 Figures for the European Union represent emissions of the 27 EU members—the original EU-15 (Austria, Belgium, Denmark, France, Finland, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom) and EU +12 (Czech Republic, Estonia, Latvia, Lithuania, Slovak Republic, Slovenia, Hungary, Poland, Bulgaria, Romania, Malta and Cyprus). 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 National total GHG emissions data (2005): World Resources Institute, Climate Analysis Indicators Tool. Accessed October 2010.

4 Cumulative emissions data: World Resources Institute, Climate Analysis Indicators Tool. Accessed October 2010.

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

6 For more details, see "Climate Change Mitigation Measures in the European Union" by Pew Center on Global Climate Change, Available at http://www.pewclimate.org/brief/international/mitigation-measures-european-union

7 ChinaFAQs: Energy and Climate Policy Action in China http://www.chinafaqs.org/library/chinafaqs-energy-and-climate-policy-action-china

8 International Council on Clean Transportation: Global passenger vehicle fuel economy and GHG emissions standards: April 2010 update http://www.theicct.org/2010/04/ghg-fe-standards-update/

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14 Aldy. Joseph E. and William A. Pizer, 2009. "The Competitiveness Impacts of Climate Change Mitigation Policies." Pew Center on Global Climate Change. May 2009.

15 See, for example, Greaker, Mads. "Spillovers in the development of new pollution abatement technology: A new look at the Porter-hypothesis," Journal of Environmental Economics and Management, Vol. 52, 2006; Porter, Michael. "America's Green Strategy," *Scientific American*, 264, 4: 96, 1991; Porter, M. and C. van der Linde, "Toward a New Conception of the Environment-Competitiveness Relationship," *Journal of Economic Perspectives* 9, 4:97–118, 1995. As discussed in endnote three, this concept remains controversial and has its critics; see Ziesemer, Thomas. "The Porter Hypothesis Revisited: An Overview on Empirical and Theoretical Evidence," Papers in Global Business Management, Universität Augsburg, December 2007, and Palmer, Oates, and Portney, "Tightening Environmental Standards: The Benefit-Cost or the No-Cost Paradigm?" J. of Economic Perspectives, 9(4), 1995.

16 The Pew Center has compiled a review summarizing several studies on the links between environmental policy and job creation, available here.

17 Overall clean energy investment growth estimates are derived using data from United Nations Environment Program (UNEP) and New Energy Finance, "Global Trends in Sustainable Energy Investment 2009: Analysis of Trends and Issues in the Financing of Renewable Energy and Energy Efficiency," 2009 and Pew Charitable Trusts 2010. This figure includes total financial investment (including venture capital, private equity expansion capital, public markets, and asset finance) as well as government research and development (R&D), corporate R&D, and small projects. "Clean Energy Trends 2009," Clean Edge Inc., March 2009.

18 Bloomberg New Energy Finance, March 2010 and Pew Charitable Trusts. "Who's Winning the Clean Energy Race?" Pew Charitable Trusts, 2010.

19 IEA 2009. Unless otherwise noted, all IEA investment figures are in 2008 dollars. Clean power generation technologies includes renewables, CCS, and nuclear power. Cumulative totals for each of these categories in the decade 2010-2020 are $1.25 trillion, $2 billion, and $297 billion, respectively. As noted, investments in the following decade (2021-2030) are significantly higher; for example, cumulative investment in CCS could be $43 billion in those years.

20 Bloomberg New Energy Finance. "Clean energy investment down just 6.5% in 2009; Asia outstrips the Americas," Press release, January 7th, 2010 and Pew Charitable Trust 2010.

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CLIMATE CHANGE 101
Federal Action

In the United States, the federal government plays a critical role in the development of national climate and energy policy. At this point, however, with the failure of Congress to pass comprehensive climate and clean energy legislation, the United States has not yet adopted comprehensive federal policies to achieve the low-carbon technology development and greenhouse gas (GHG) emission reductions required to address the threat of dangerous climate change. Specific federal actions over the past several years, though, have achieved some progress in slowing the growth of GHG emissions and in developing low-carbon technologies. To build upon present and past efforts, federal policymakers have a wide array of policy options, each of which can help the country make progress toward achieving emission reduction goals and together can put the country on the path toward a lower-carbon future.

THE ROLE OF THE FEDERAL GOVERNMENT IN CLIMATE POLICY

The overwhelming body of scientific evidence demonstrates that GHG emissions from the United States and the rest of the world are causing global climate change. To limit damages from climate change, the United States and the rest of the world need to reduce their GHG emissions from across all sectors of the U.S. and global economies. Doing so will require both making use of existing technologies for reducing emissions and developing more advanced low-carbon technologies to enable deep, long-term emission reductions. In the absence of a comprehensive federal policy, many states have (singly and in collaboration) adopted policies to limit emissions (see box on "State and Federal Roles in Climate Policy"). Only the federal government, though, can adopt policies sufficient to achieve necessary reductions in total U.S. emissions and to develop and deploy a portfolio of low-carbon technologies. This document describes existing federal policies, recent policy developments, and potential future policies for reducing U.S. GHG emissions and promoting low-carbon technologies.

The federal government has functions, responsibilities, and policy options related to climate change beyond the domestic emission reduction options discussed in this document that are addressed in the accompanying *Climate Change 101* briefs—including: funding and conducting basic scientific research on climate change (see *Climate Change 101: Science and Impacts*); adapting to the impacts of climate change (see *Climate Change 101: Adaptation*); and negotiating an international climate change agreement (see *Climate Change 101: International Action*).

REDUCING GHG EMISSIONS AND PROMOTING CLEAN TECHNOLOGY

Carbon dioxide (CO_2) from fossil fuel combustion accounts for about 80 percent of total U.S. GHG emissions, and fossil fuels account for more than 80 percent of total U.S. primary energy consumption (see Figure 1 for an overview of U.S. GHG emissions).[1] Households and businesses rely on fossil fuels for such critical energy services as powering cars and trucks, generating electricity, running factories, and heating homes. The main approach to reducing GHG emissions is to reduce traditional fossil fuel use throughout

PEW CENTER ON Global CLIMATE CHANGE

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the economy. This can be accomplished via four main options: (1) reducing demand for fossil fuels through energy efficiency and conservation (e.g., through building codes, more efficient industrial processes, vehicle fuel economy standards, reducing traffic congestion, and carpooling); (2) switching from oil and coal to natural gas, which emits fewer GHGs; (3) replacing fossil fuels with non-emitting energy sources (e.g., wind or nuclear power for electricity generation and biofuels or low-carbon electricity for transportation); and (4) capturing and permanently sequestering the emissions from fossil fuel use through carbon capture and storage.[2] Emission reductions can also be achieved by changing industrial and agricultural processes and practices that release GHGs, such as cement manufacturing and livestock manure management. Lastly, certain agricultural and forestry practices can remove CO_2 from the atmosphere and store it in soils and plants.

Federal polices can target all of the options above for reducing GHG emissions. The federal government can also invest in research, development, and demonstration (RD&D) of new technologies or more advanced versions of existing technologies for reducing emissions, such as more energy-efficient equipment and more advanced clean energy technologies (for more see *Climate Change 101: Technology*).

EXISTING FEDERAL CLIMATE POLICIES

Table 1 at the end of this document summarizes the different types of federal policies for lowering GHG emissions and developing low-carbon technologies. The federal government already has in place many of these types of policies—ranging from GHG emission standards for passenger cars to research grants for "breakthrough" clean technologies.[3] These federal policies owe their existence to several pieces of legislation (see box on "Relevant Federal Legislation"). While the past few years have seen important new legislation with provisions specifically intended to reduce GHG emissions, some relevant legislation dates back as far as the 1970s. Certain policies that are important for funding clean technologies or reducing GHG emissions via energy efficiency predate the emergence of climate change as a major policy issue and started as policies to address such concerns as dependence on foreign oil.

State and Federal Roles in Climate Policy

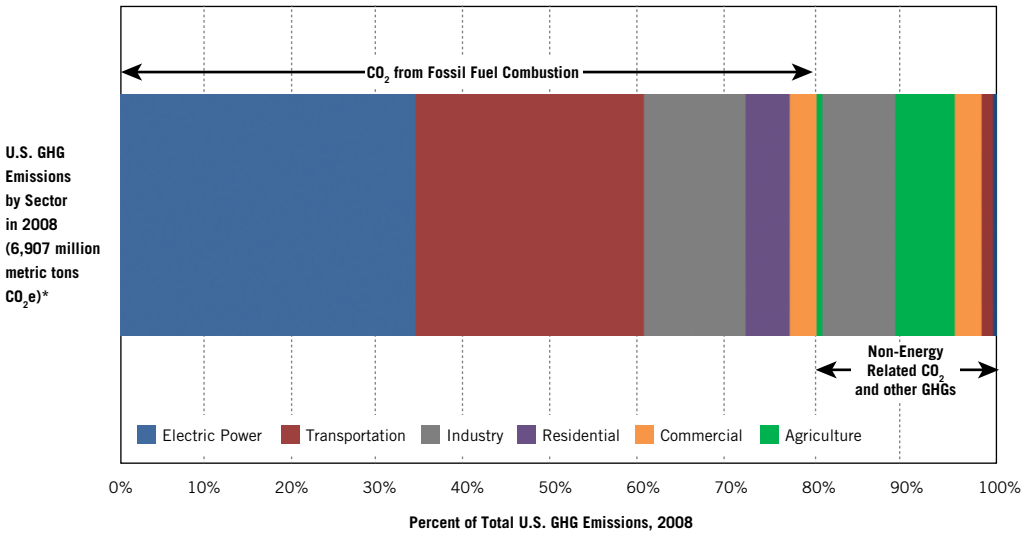
Without federal policies, the United States cannot achieve necessary GHG emission reductions, widespread low-carbon technology development, or international agreement on reducing GHG emissions. Nonetheless, there is still an important role for states (and local governments) in setting and implementing climate policy. Historically, states have been first-movers on important environmental issues and have served as policy innovators—in effect, testing policies that have later been adopted at the federal level. States also benefit from an understanding of their own unique circumstances and a familiarity with their particular stakeholders, which can be valuable both in crafting policy and implementing federal programs. As explained in the Pew Center's *Climate Change 101: State Action* and *Climate Change 101: Local Action,* state and local governments are currently taking important steps to reduce GHG emissions, incentivize the deployment of low-carbon technologies, promote energy efficiency, and build sustainable communities.

RECENT DEVELOPMENTS IN FEDERAL POLICY

The federal government has in place a large number of policies related to GHG emission reduction and low-carbon technology advancement, but it has not yet developed a comprehensive approach. Many of these policies come from a variety of legislative provisions specifically intended to reduce emissions and foster low-carbon technologies. Some relevant policies were enacted by Congress for other purposes (such as reducing dependency on foreign oil) but also help reduce GHG emissions, and other current policies stem from federal agencies exercising their existing statutory authorities. To provide a snapshot of the current "state of play" on federal climate policy, this section focuses on federal climate policy developments during the last two years (2009 and 2010).

Recent developments in federal climate policy have come primarily from executive branch actions under existing statutory authority and climate- and energy-related provisions in the 2009 economic stimulus bill, the American Recovery and Reinvestment Act of 2009 (ARRA, or the Recovery Act).

Figure 1
U.S. GHG Emissions by Sector, 2008



Source: U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2008.*
*Notes: Excludes 49.9 million metric tons CO_2e of GHG emissions reported for U.S. territories, and emissions from electricity generation are reported separately and not apportioned to the economic sectors that consume the electricity.

The Recovery Act included more than $80 billion in climate- and energy-related expenditures and tax incentives—including support for carbon capture and storage (CCS) demonstration projects, "smart grid" deployment, state energy efficiency and weatherization programs, low-carbon technology manufacturers, and renewable electricity projects. The Recovery Act made large investments in reducing GHG emissions via energy efficiency and deployment of low-carbon technologies and developing, demonstrating, and manufacturing new low-carbon technologies.

To understand the basis for recent regulatory actions by the executive branch, one must look back a few years. In the 2007 Supreme Court case *Massachusetts v. Environmental Protection Agency*, the court ruled that the U.S. Environmental Protection Agency (EPA) had the authority to regulate GHGs as "air pollutants" under the Clean Air Act and set the stage for new federal regulation of GHG emitters (see box on "The Role of the Federal Courts").[4] In 2009 in response to the court case and based on an extensive review of the scientific evidence, EPA issued its Endangerment Finding, a formal determination that GHGs contribute to climate change and are thus a threat to the public health and welfare of current and future generations; this marked the first step by the agency toward regulating sources of GHG emissions.[5]

In 2010, EPA started regulating GHGs by addressing emissions from light-duty vehicles (passenger cars and light trucks, which include pickups, SUVs, and vans). Working jointly with the Department of Transportation (DOT), EPA finalized GHG emission standards for light-duty vehicles that require the equivalent of an improvement in the combined average fuel economy of new vehicles from 29.2 miles per gallon (mpg) in model year 2010 to 35.5 mpg for model year 2016. EPA estimated that the new regulations would reduce GHG emissions, lessen U.S. reliance on imported oil, and save consumers money by reducing fuel costs.[6] The light-duty vehicle standards provide compliance flexibility to vehicle manufacturers by allowing for the averaging, banking, and trading of compliance credits both across vehicle categories

Relevant Federal Legislation

The federal government has a long history of laws and policies that promote energy efficiency, clean technologies, and alternative fuels. A recent Pew Center brief, *Update on the 10–50 Solution: Progress Toward a Low-Carbon Future*, summarized important federal climate and energy legislation from the past five years, which included:

- *The Energy Policy Act of 2005 (EPAct05)*—EPAct05 was the first omnibus energy bill enacted in more than a decade and included provisions related to energy efficiency, low-carbon transportation, carbon capture and storage, nuclear power, and renewables.
- *The America COMPETES Act of 2007*—the America COMPETES Act increased science and engineering research and education. In particular, it created the Advanced Research Projects Agency-Energy (ARPA-E) in the Department of Energy (DOE) with the goal of sponsoring transformational energy technology research projects.
- *Energy Independence and Security Act of 2007 (EISA07)*—EISA07 was also a comprehensive energy bill with key provisions concerning energy efficiency, biofuels, carbon capture and storage, and vehicle fuel economy.
- *FY2008 Consolidated Appropriations Act*—spending bill required the EPA to develop a rule for mandatory GHG emission reporting.
- *Emergency Economic Stabilization Act of 2008 (EESA)*—EESA provided for the government to intervene in the mortgage and banking financial crisis. In addition, it included energy tax provisions related to energy efficiency, renewables, and carbon capture and storage.
- *American Recovery and Reinvestment Act of 2009 (ARRA)*—ARRA was an economic stimulus bill enacted in February 2009. It included substantial incentives (roughly $80 billion in funding, tax expenditures, and loan guarantees), for climate- and clean energy-related purposes.

Of course, relevant federal legislation that promotes clean technologies and GHG emission reductions goes back to well before the 2005 energy bill. Some earlier examples of important federal legislation relevant to reducing GHG emissions and deploying low-carbon technologies include:

- *The Energy Policy and Conservation Act of 1975 (EPCA)*—this bill established corporate average fuel economy (CAFE) standards for new passenger cars and gave DOT the authority to set standards for other vehicles, including light trucks. The goal of EPCA was to reduce dependence on foreign oil after the Arab oil embargo of the 1970s.
- *National Appliance Energy Conservation Act of 1987*—this bill created the first federal minimum energy efficiency standards for residential appliances and equipment.
- *Energy Policy Act of 1992 (EPAct)*—a comprehensive energy bill, EPAct included energy efficiency standards for appliances and equipment, promotion of more energy-efficient building codes, tax incentives for renewable electricity (including the production tax credit, or PTC), and a streamlined licensing process for new nuclear power plants.

for a given manufacturer and among manufacturers. Also in 2010, EPA and DOT proposed GHG emission standards for medium- and heavy-duty vehicles (such as tractor trailers) and began developing light-duty vehicle standards for model years 2017 to 2025.

Under the provisions of the Clean Air Act, EPA regulation of GHGs from vehicles (referred to as mobile sources under the law) also triggered EPA regulation of GHG emissions from major new or modified stationary sources (e.g., fossil fuel boilers at power plants and industrial facilities). In 2010, EPA finalized its "Tailoring Rule," which established that new and modified stationary sources would be subject to regulation for GHG emissions starting in January 2011 and limited the regulation to the largest sources (such as

The Role of the Federal Courts

While this document focuses primarily on the actions of and policy options for the executive branch and Congress, the third branch of the federal government—the judicial branch—is also relevant for federal climate and energy policy. While the legislative and executive branches of the federal government make and carry out federal policy, the federal judiciary has two main roles relevant to climate change. First, the federal courts judge cases regarding the regulations issued by federal agencies (or the lack of such regulations). Second, federal courts hear common law nuisance suits against large GHG emitters. These nuisance suits involve claims by a variety of parties (e.g., states and individual citizens) who argue that actions contributing to climate change represent a nuisance that harms them under common law tort doctrine. Several of these are now making their way through the courts.[11]

The aforementioned Supreme Court case, *Massachusetts v. EPA*, was a highly influential case since it determined that GHGs are pollutants under the Clean Air Act and thus would be subject to regulation by EPA if the agency determined that they contributed to harm to public health and welfare.

Ongoing court cases include some states' and environmentalists' efforts to force EPA to use specific Clean Air Act provisions to regulate GHGs and legal challenges from industry groups and others to overturn EPA's GHG Endangerment Finding and the agency's subsequent GHG regulations.[12]

States and public interest groups have also sued federal agencies—successfully in the 2007 case *Center for Biological Diversity v. National Highway Traffic Safety Administration*—over failures to consider GHG emissions and climate change when agencies formally assess the environmental impacts of federal actions as required under the National Environmental Policy Act (NEPA). In 2010, the White House Council on Environmental Quality (CEQ), which oversees NEPA, proposed guidance for when and how federal agencies should consider GHG emissions and climate change when conducting NEPA evaluations of federal actions, such as federal permitting decisions.

power plants). Under the relevant provisions of the Clean Air Act, this regulation of stationary sources involves case-by-case determination (generally by state regulators) of "best available control technology" (BACT) for GHGs for large new and modified sources.[7] EPA's guidance to states suggests that BACT regulation should focus primarily on energy efficiency to limit GHG emissions.[8] There are additional Clean Air Act provisions under which EPA might regulate GHG emissions from new and existing stationary sources, but the agency has (as of November 2010) not yet proposed such regulations.

2010 is the first year for which emitters must report their GHG emissions to EPA under the agency's Mandatory GHG Reporting Rule. In the FY2008 appropriations bill for EPA, Congress required the agency to develop a rule for mandatory GHG emission reporting. EPA finalized its reporting rule in October 2009, and large emitters have to collect data and report their GHG emissions for calendar year 2010 and thereafter. EPA estimates that the reporting rule will initially apply to approximately 10,000 facilities responsible for 85 percent of U.S. GHG emissions.[9] This comprehensive reporting program will improve policymakers' understanding of GHG sources and can inform development of policies and programs to reduce emissions.

In June 2009, the U.S. House of Representatives passed comprehensive energy and climate legislation, the American Clean Energy and Security Act of 2009 (H.R. 2454 or "Waxman-Markey"), which included an economy-wide GHG cap-and-trade program (for details on cap and trade, see *Climate Change 101: Cap and Trade* on the Pew Center's website).[10] This marked the first time either body of Congress passed such a bill. However, even though the Senate saw several comprehensive climate and energy proposals, it did not take up a similar bill, and no such legislation was enacted.

OPTIONS FOR NEW FEDERAL CLIMATE POLICIES

This section describes several options for new federal policies to reduce GHG emissions and advance clean technologies. Most of the policy options discussed require new legislation—the primary exception being the issuance of additional GHG regulations by EPA under its existing Clean Air Act authority. The discussion focuses on policy

Market-Based Policies

Market-based policies seek to influence behavior via market signals rather than through explicit requirements. In general, under market-based policies, an individual or business will face a cost for polluting and be able to reduce costs or make money by reducing pollution.

Traditionally, governments have reduced pollution via "command-and-control" regulations which, in contrast to market-based policies, specifically require or prohibit certain activities, technologies, or performance levels. "Command-and-control" regulations include such approaches as minimum energy efficiency standards for equipment, maximum pollution emission rates for different types of facilities or vehicles, and requirements that certain facilities or vehicles use specific types of pollution control technology. "Command-and-control" approaches have worked effectively on a variety of pollution problems, but successful use of market-based policies has demonstrated the advantages that such policies offer in many cases.

The United States has decades of experience using market-based policies to successfully address pollution problems. At the national level, market-based policies have been used to address such issues as lead in gasoline, ozone depletion, acid rain, smog, vehicle emissions, and water quality. States have used market-based policies to promote renewable electricity generation and to reduce GHG emissions from power plants and transportation fuels.

Several of the existing federal policies and options for new policies for reducing GHG emissions and promoting low-carbon technologies reviewed in this document are market-based. These include emissions pricing, electricity portfolio standards, a low carbon fuel standard for transportation, and incentive payments to farmers for GHG emission reductions. Some existing federal policies have market-based components that provide compliance flexibility, such as limited credit trading under vehicle fuel economy and GHG emission standards.

In general, market-based policies offer two advantages. First, they harness market forces to guide individuals and businesses to make decisions that cost-effectively reduce pollution. If there are many individuals and businesses and many activities responsible for a particular pollution problem, there will be many options for reducing pollution available at widely varying costs. The more pollution reduction options there are and the more costs vary, the harder it is for policymakers to use "command-and-control" regulations to achieve the lowest cost pollution reductions. If harnessed by market-based policies, however, market forces can direct individuals and businesses to take the myriad actions that together achieve pollution reductions at the lowest total cost. Nearly every household and business in the United States plays some role in GHG emissions. Moreover, GHG emissions come from a large number of activities, and there are many different options and technologies for reducing them. These factors make market-based policies especially suitable for reducing GHG emissions.

The second benefit of market-based policies is that they provide a continuous incentive for innovation and improvement. For example, under traditional "command-and-control" regulation, a power plant might be required to achieve a certain emission rate but face no incentive for reducing emissions below that level; however, an emissions pricing policy would provide an incentive for the power plant to reduce emissions by as large an amount as it cost-effectively could, including by adopting innovative technologies.

For more information on market-based regulations, see *Climate Change 101: Market Mechanisms*, available on the Pew Center's website.

options that could have significant impacts and that have attracted recent attention from policymakers and various interest groups. Table 1 at the end of this document presents a more expansive overview of the relevant policy categories with examples of existing federal policies, options for new federal policies, and examples of similar state policies. While some of the policy options described below can promote GHG emission reductions across the entire economy or whole sectors of the economy, other policy options are tailored to reduce emissions from specific

emitters (e.g., coal power plants) or to promote certain technologies that face unique challenges (e.g., financing the large upfront capital costs of new nuclear reactors).

EMISSIONS PRICING

Even though GHG emissions are responsible for climate change and its related costs, GHG emitters currently face no financial costs for their emissions. Emissions pricing policies associate a financial cost with emitting GHGs and thus provide an incentive for reducing emissions. Emissions pricing policies are examples of market-based policies, as are several of the other policy options described below (see box on "Market-Based Policies"). The two main emissions pricing policy options are tradable emission allowances (including cap and trade) and a carbon tax (for a more in-depth discussion of emissions pricing and other market-based policies, see *Climate Change 101: Market Mechanisms*). The federal government has successfully used emissions pricing and similar policies to address other environmental issues, and some states have started using emissions pricing policies to address GHG emissions (see box on "U.S. Experience with Emissions Pricing Policies").

Among emissions pricing policies, cap and trade has received the most recent attention from policymakers. The past several Congresses have seen proposals for GHG cap-and-trade programs, and the House passed a bill (the "Waxman-Markey" bill) that included cap and trade in 2009. Cap and trade works by requiring covered entities (e.g., power plants) to hold tradable allowances for each unit of their GHG emissions, such as one allowance for each metric ton of GHGs emitted (for a detailed explanation of cap and trade, see *Climate Change 101: Cap and Trade* on the Pew Center's website). The government issues a limited number of such allowances, and the total number of such allowances is the "cap" on overall emissions. The scarcity of allowances and the ability of covered entities to trade them make allowances valuable and lead to a carbon price.

Policymakers could also create an emissions pricing policy by implementing flexible performance standards for emitters (e.g., a maximum rate of GHG emissions per unit of electricity produced by power plants) that allowed emitters to earn tradable credits for over-complying with the standard. Under such a policy, regulated emitters could meet the performance standard either by making emission reductions themselves or by buying tradable credits from emitters who outperformed the standard. This was the policy used to phase out lead in gasoline in the 1980s. As discussed below, such an approach might be possible under EPA's existing Clean Air Act authority.

Under an emissions pricing policy, the carbon price signal (i.e., either the market price of a tradable emission allowance or the carbon tax rate) harnesses market forces to achieve the most cost-effective pathway to an overall emission reduction goal. A carbon price provides the incentive for households and businesses to make the millions of individual decisions—ranging from a family buying a more fuel-efficient car to a utility building a new nuclear power plant—that constitute the lowest cost pathway to an overall emission reduction goal. Moreover, a carbon price provides a continuous incentive for technological innovation—from new electric vehicles to advanced "green building" technologies. An emissions pricing policy can be economy-wide, apply to only certain sectors of the economy, or cover just a subset of emitters. For example, the 2009 House-passed climate and energy bill (the "Waxman-Markey" bill) would have created a cap-and-trade program covering about 85 percent of total U.S. GHG emissions, but lawmakers also considered GHG cap-and-trade programs that applied only to electric power generators.[13] Policymakers might consider a power-sector cap-and-trade program since the power sector is generally thought to be the source of most of the lowest cost emission reduction options in the near term, and the sector has more than fifteen years of experience operating under air pollution cap-and-trade programs (the oldest being the acid rain cap-and-trade program).

EPA REGULATION UNDER THE CLEAN AIR ACT

As explained above, under its existing Clean Air Act authority, EPA has already begun to regulate GHG emissions from new vehicles, and new and modified large stationary sources. There are several avenues under the Clean Air Act through which EPA might pursue additional regulation of large stationary sources.[15] As it has done for other non-GHG air pollutants, EPA might set emission performance standards for large stationary sources. For example, power plants might need to emit no more than a certain number of pounds of CO_2 per kilowatt-hour of electricity generated. Power plants could comply via such measures as improving

U.S. Experience with Emissions Pricing Policies

The United States has successfully employed national emissions pricing and similar market-based policies in the past to address environmental challenges, and some states are already moving ahead with emissions pricing policies to reduce GHG emissions.

During the Reagan administration, EPA used a credit trading program among refiners to phase lead out of gasoline. During the first Bush administration, cap and trade was used both to limit the production and use of chemicals responsible for stratospheric ozone depletion (including the ozone hole over Antarctica) and to reduce the pollution from coal-fired power plants that causes acid rain. These trading programs provided regulated entities with compliance flexibility and lowered the cost of achieving environmental goals. The second Bush administration proposed using cap and trade to reduce non-GHG air pollution from power plants.

Several states have already pioneered the use of emissions pricing for reducing GHGs. Starting in 2009, under the Regional Greenhouse Gas Initiative (RGGI), 10 northeastern states have covered their electricity generators under a CO_2 cap-and-trade program. Similarly, California is implementing a multi-sector state GHG cap-and-trade program that may be linked to a regional cap-and-trade program as part of the Western Climate Initiative.[14]

plant efficiency, using biomass, or deploying carbon capture and storage (once the latter technology has been deemed commercially available and costs are considered). In the past, EPA has used its administrative discretion under the Clean Air Act to create market-based trading programs for reducing emissions. Such an approach might be applicable to the agency's regulation of GHGs from large sources. For example, EPA regulations might allow sources to earn tradable credits by over-complying with emission performance standards that they could then sell to other sources who could not as easily meet the emission standards. Such a market-based mechanism would likely prove more cost effective than traditional non-market-based EPA regulations.

FEDERAL ELECTRICITY PORTFOLIO STANDARD

As of 2010, 31 states plus the District of Columbia have renewable portfolio standards or alternative energy standards covering electricity sales.[16] These standards require that electric utilities obtain certain percentages of their electricity from qualified renewable generation (e.g., wind and solar power) or alternative energy (e.g., renewables and non-renewable low-carbon energy sources, such as coal-fueled power plants that capture and sequester their GHG emissions). Utilities generally comply with these portfolio standards by earning tradable credits for their own qualified renewable or alternative electricity generation or their purchases of such electricity, and a utility must annually submit credits equal to a certain percentage of its electricity sales. If one utility generates or obtains more than the required percentage of qualified renewable or alternative energy, it can sell its excess credits to another utility that might otherwise find it more expensive to meet the requirement by buying renewable or alternative electricity directly. In this sense, these portfolio standards are market-based policies that minimize the cost of achieving a given level of overall electricity generation from renewable or alternative energy sources.

Congress could enact a federal electricity portfolio standard very similar to those already adopted by the majority of states. The House and Senate have separately passed bills in different Congresses that would have created a national renewable electricity standard, and recently members of Congress have proposed various forms of a national electricity portfolio standard. Congressional options for a national electricity portfolio standard include a federal renewable electricity standard, which would require an increasing fraction of total U.S. electricity to come from renewable sources over time. Similarly, a federal clean electricity standard would set requirements for the fraction of total U.S. electricity generated from renewable and other low- or non-emitting sources (e.g., nuclear power, fossil fuels coupled with carbon capture and storage, highly efficient and lower-emitting natural gas generation). Both a renewable and a clean electricity standard could allow for demonstrated electricity savings from energy efficiency programs to count toward compliance as well.[17]

EXTENDING OR EXPANDING FINANCIAL INCENTIVES FOR LOW-CARBON ELECTRICITY GENERATION

Federal tax incentives played a major role in spurring the rapid growth of wind power in the United States over roughly the last decade. Federal tax incentives have also proven critical for the deployment of other renewable electricity generation (e.g., solar power), and federal loan guarantees sparked interest in new nuclear power plants, including the first new nuclear plant to start construction in the United States in over thirty years.[18] Congress has also created tax credits for each ton of CO_2 that is captured and stored by qualifying facilities.

Congress could extend the tax credits for renewable electricity (for example, the production tax credit for wind currently expires in 2012) to provide a longer-term incentive for project developers, and Congress could also offer alternative financial incentives for project developers who cannot fully take advantage of tax credits (because of limited profits, for example).[19] Likewise, Congress could increase the amount of nuclear loan guarantees that the Department of Energy (DOE) is authorized to issue, which could encourage power companies to build more new reactors more quickly. Finally, increasing the value of tax credits and the number of credits available for captured and sequestered CO_2 could incentivize more carbon capture and storage projects.

REDUCING ENERGY USE AND EMISSIONS FROM BUILDINGS, APPLIANCES, AND EQUIPMENT

Many analyses find that improving energy efficiency is the least costly way to achieve near-term GHG emission reductions; in many cases, the savings from reduced energy costs can more than pay for the cost of improving efficiency.[20] In past legislation (such as the Energy Policy Act of 1992 and the Energy Independence and Security Act of 2007) Congress has set minimum efficiency standards for a variety of residential, commercial, and industrial appliances and equipment (including lighting) and established schedules for DOE to review and update these standards. During 2009 and 2010, DOE finalized new efficiency standards for more than 20 household and commercial products.[21] The Recovery Act devoted substantial funding to energy efficiency including state energy efficiency programs, the weatherization assistance program, and energy-efficient appliance rebates. Congress could continue and expand efforts to reduce energy use (and associated GHG emissions) by buildings and equipment. Options for Congress include: offering rebates and tax credits to consumers and businesses for energy efficiency investments or purchases (e.g., building insulation, more efficient heating and cooling equipment); setting new or more aggressive minimum efficiency standards for equipment; and promoting more energy-efficient building codes for new homes and offices.[22]

LOW-CARBON FUEL STANDARD FOR TRANSPORTATION

In the Energy Policy Act of 2005, Congress amended the Clean Air Act to create a renewable fuel standard (RFS). The RFS requires the transportation sector to consume increasing volumes of biofuels and requires that such biofuels increasingly be low-carbon on a life-cycle basis. The life-cycle emissions from a fuel include all the emissions associated with producing it, moving it, and using it in a vehicle. Congress could build on the RFS program with a broader federal low-carbon fuel standard (LCFS). An LCFS would require transportation fuel providers to reduce the average life-cycle GHG intensity of their fuels. However, unlike an RFS, an LCFS allows for compliance via more means than just biofuels. An LCFS could spur increased use of biofuels, natural gas vehicles, electricity for transportation, and lower-carbon production of petroleum-based fuels (e.g., through efficiency improvements at refineries). An LCFS can be a market-based policy that allows for trading and banking of emission credits among covered fuel providers in order to enhance flexibility, support innovation, and minimize costs.

As in the case of electricity portfolio standards, several states are already moving ahead with LCFS policies. As of 2010, California has enacted an LCFS, 11 northeastern states are working on a regional LCFS, and 11 other states are considering state or regional LCFS policies.[23]

INCENTIVES FOR LOW-CARBON VEHICLES

Recent congressional proposals have sought to offer financial incentives to spur the deployment of lower-carbon vehicle technology. Three such policies are "feebates," tax credits for alternative vehicles, and fuel infrastructure support.

A "feebate" policy can establish a system of rebates for fuel-efficient vehicles funded by fees on less fuel-efficient vehicles. Such a system can be revenue-neutral for the federal government and shift consumer demand toward

more fuel-efficient vehicles, thus lowering both the demand for oil and GHG emissions from transportation.

Natural gas holds particular promise as an alternative to petroleum for centrally fueled fleet vehicles (e.g., delivery vehicles) and medium- and heavy-duty trucks (e.g., long-haul tractor-trailers). Natural gas in both compressed and liquefied form is a lower-carbon fuel than gasoline and diesel, and the use of domestic natural gas for transportation can displace imports of foreign oil. The Energy Policy Act of 2005 included tax credits for natural gas vehicles and investments in natural gas fueling facilities. To promote the use of natural gas vehicles, Congress could extend and expand these tax credits.

2010 saw the introduction of the first commercially available electric vehicles from major automakers, and more "plug-in" models (both fully electric and plug-in hybrid gasoline-electric vehicles) are on the way. The Recovery Act extended tax credits for plug-in vehicles and funded pilot electric vehicle deployment projects. Congress could expand tax credits and other financial incentives for the purchase of plug-in vehicles and investments in recharging infrastructure in order to spur more rapid and widespread electrification of transportation.[24]

REDUCING TRANSPORTATION EMISSIONS THROUGH INFRASTRUCTURE, SYSTEM EFFICIENCY, AND PLANNING

The federal government influences transportation infrastructure and business and household transportation decisions in myriad ways, including: highway funding; money for mass transit and passenger rail; funding for transportation planning activities by states and metropolitan planning organizations; and money for projects ranging from congestion pricing pilot demonstrations to carpool, biking, and pedestrian programs. A reauthorization of federal spending for highways, transit, and highway safety would offer Congress an opportunity to encourage some of the aforementioned means for reducing transportation GHG emissions through improvements to infrastructure, system efficiency, and transportation and land-use planning. The last such reauthorization was in 2005 and originally expired in 2009. Although fiscally constrained, DOT could use its existing authority to make some progress on these fronts as well.

REDUCING EMISSIONS AND PROMOTING CLEAN ENERGY VIA AGRICULTURE AND FORESTRY

Agriculture and forestry can contribute to reducing GHG emissions by: reducing direct emissions (e.g., from livestock manure and tractors); offsetting emissions from other sectors via biosequestration (i.e., managing forests and cropland to absorb CO_2 from the air); and producing biofuels to displace fossil fuel use (e.g., making ethanol from switch grass to displace gasoline).

Existing programs can be expanded and improved and new programs and funding can help promote emission reductions from agriculture and forestry. Examples of existing U.S. Department of Agriculture (USDA) programs include the Rural Energy for American Program (REAP), which promotes renewable energy and energy efficiency for agricultural producers, and the Environmental Quality Incentives Program (EQIP), which provides incentive payments to farmers who adopt environmentally beneficial practices.

Congress and the USDA could tailor current policies to better promote GHG-reducing practices and to help farmers invest in low-carbon technologies. Congress could also increase support for fundamental research and development of advanced biofuels (such as from algae) that offer more emission reduction potential. In addition, collecting and providing more information about GHG emissions, emission reductions, and biosequestration occurring on farms and forestlands would help policymakers and landowners promote and implement the best emission reduction practices. Expanding the USDA's National Resource Inventory, which is a statistical survey of land use and natural resource conditions, is one strategy for improving such monitoring and assessment. Congress could change existing policies and programs through the next Farm Bill.

INCREASING LOW-CARBON TECHNOLOGY RESEARCH, DEVELOPMENT, AND DEMONSTRATION

In addition to currently available technologies for reducing GHG emissions, new technology innovations will be critical for meeting long-term GHG emission reduction goals cost-effectively. The federal government plays an important role in funding low-carbon technology research, development, and demonstration (RD&D). For example, the Recovery Act provided $3.4 billion for carbon capture and storage RD&D,

including funding for several large-scale demonstration projects at industrial facilities and power plants.

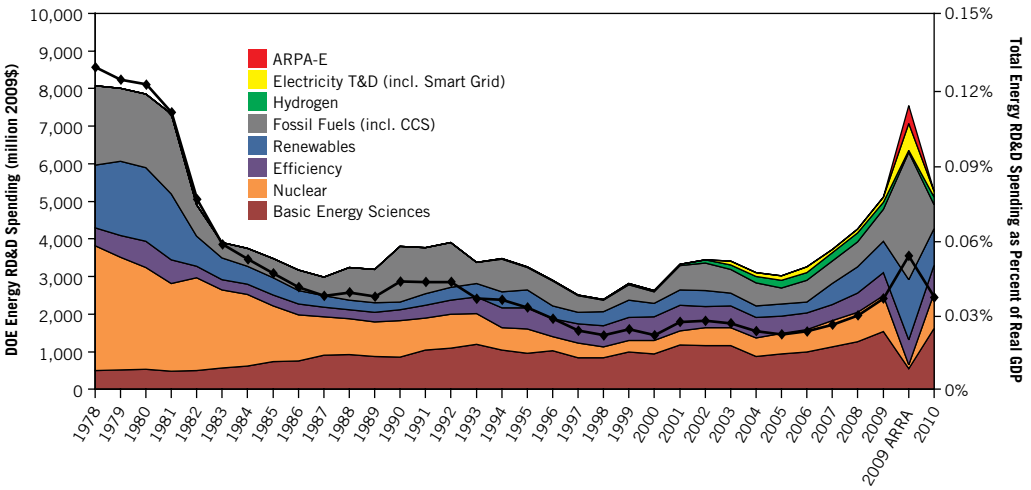
While recent years have seen an upswing in federal funding for energy-related RD&D, including a large amount of such funding in the Recovery Act, federal spending on energy RD&D is still lower in real dollars than three decades ago when the United States responded to the energy crises and much lower as a percentage of gross domestic product (see Figure 2). Congress can increase spending on energy RD&D in order to drive low-carbon technology innovation while also focusing RD&D spending on the most promising technologies and ensuring that such spending delivers performance and cost improvements for these technologies.

CONCLUSION

Federal action through the courts, the executive branch, and Congress has achieved some progress in reducing GHG emissions and promoting technology innovation. The need remains, however, for additional federal action, and there are many opportunities to do more through myriad policies that build on recent state and federal efforts.

Figure 2

U.S. DOE Energy RD&D



Source: Gallagher, Kelly Sims and Laura Diaz Anadon, "DOE Budget Authority for Energy Research, Development, & Demonstration Database," Energy Technology Innovation Policy Research Group, Belfer Center for Science and International Affairs, Harvard Kennedy School, April 2010.

FOR MORE INFORMATION

For more information on the issues discussed above, refer to these publications from the Pew Center on Global Climate Change:

Agriculture's Role in Greenhouse Gas Mitigation

Reducing Greenhouse Gas Emissions from U.S. Transportation

Technology Policies to Address Climate Change

Toward a Constructive Dialogue on Federal and State Roles in U.S. Climate Change Policy

Update on the 10-50 Solution: Progress Toward a Low-Carbon Future

Table 1

Overview of Federal Policy Options for Reducing GHG Emissions and Promoting Low-Carbon Technology

Category	Description	Examples of Existing Federal Policies	Examples of New Federal Policy Options	Examples of Existing State Policies[25]
Research, Development, and Demonstration (RD&D)	Federal agencies and national laboratories undertake RD&D, and the government provides financial incentives and funding for private-sector and academic RD&D related to low-carbon technologies.	Advanced Research Projects Agency-Energy (ARPA-E); FutureGen; Energy Innovation Hubs; National Laboratories	Expand and/or reform current programs	State financial incentives for carbon capture and storage demonstration
Technology Deployment Subsidies	The federal government provides financial incentives that reduce the cost of low-carbon technologies for businesses and households.	The production and investment tax credits for renewable electricity generation; loan guarantees for new nuclear power plants; alternative fuel vehicle tax credits; tax credits for captured and sequestered CO_2	Expand and/or reform current programs	Many states have tax incentives for renewable electricity generation and energy efficiency investments.
Emissions Pricing	Policies that put a price on carbon harness the power of market forces to spur covered sources to make emission reductions and promote technology innovation.	None for GHGs, but emissions pricing has been successfully used to reduce the pollution that causes acid rain and other pollutants.	GHG cap and trade; carbon tax	Northeastern states' Regional Greenhouse Gas Initiative (RGGI) power-sector CO_2 cap-and-trade program; California is implementing a multi-sector GHG cap-and-trade program.
Electricity Portfolio Standard	A portfolio standard requires a certain percentage of total electricity supply to come from qualifying sources that may include renewables, nuclear power, efficiency savings, and fossil fuels with carbon capture and storage. Such a policy can be market-based and allow for compliance via credit trading.	None	Renewable/Clean Electricity Standard	31 states and the District of Columbia have renewable or alternative energy portfolio standards.
Transportation Fuel Standards	A fuel standard sets requirements for the types of fuels used (e.g., biofuels) or the carbon-intensity of fuels. Such a policy can be market-based and allow for compliance via credit trading.	Renewable Fuel Standard (RFS)	Expanded/reformed RFS; Low-Carbon Fuel Standard	California has a Low Carbon Fuel Standard.
Energy Efficiency and Emission Standards	The government sets maximum GHG emission limits or minimum levels of energy efficiency for facilities, buildings, appliances, equipment, or vehicles.	Joint EPA and DOT GHG and fuel economy standards for light-duty vehicles; energy efficiency standards for appliances and equipment; best available control technology (BACT) standards for GHGs from new and modified large stationary sources	New fuel economy and GHG standards for different types of vehicles (standards currently proposed for medium- and heavy-duty vehicles) and later model years; emission performance standards for large stationary sources (e.g., power plants); more energy-efficient model building codes	California, Oregon, Washington, Illinois, and Montana have GHG performance standards that apply to electric power purchase agreements or new coal plants. Many states have building codes that require minimum levels of heating and cooling efficiency.
GHG Reporting	Sources of GHGs must report their emissions to the government.	2010 is the first year for which GHG emitters must report GHG emissions to EPA.	Expand current reporting program to cover more sources	Several states have mandatory GHG reporting programs.

Category	Description	Examples of Existing Federal Policies	Examples of New Federal Policy Options	Examples of Existing State Policies[25]
Information	The government provides information to individuals and businesses to increase awareness of climate change, emission sources, and emission reduction options (especially energy efficiency measures).	Miles-per-gallon labeling for new vehicles; ENERGY STAR labeling program for efficient appliances and equipment; technical support for industry (e.g., DOE's Industrial Assessment Centers); EPA SmartWay program for trucks	Expand current programs	Many states operate education, marketing, and outreach programs related to energy efficiency.
"Leading by Example"	The federal government is the largest single energy consumer in the U.S. economy. The government can achieve substantial emission reductions by changing its own operations and also create markets for low-carbon technologies.	Under a 2009 Executive Order, federal agencies have adopted an aggregate GHG emission reduction goal of 28 percent below 2008 emissions by 2020.	More energy-efficient and lower-carbon procurement by federal agencies and the military	Several states have programs for state buildings to be "green" and for state agencies to purchase low-carbon electricity ("green power").
Infrastructure, Market Oversight, and Other Regulation	Through a variety of policies and authorities the federal government can indirectly encourage GHG emission reductions such as via funding for transportation infrastructure and regulation of electricity markets.	Mass transit funding; "smart grid" interoperability standards; funding for electric vehicle charging stations; electricity market regulations to accommodate renewables and demand response; EPA regulations for CO_2 injection and geologic sequestration	Federal funding for low-carbon transportation infrastructure	State "smart growth" and vehicle-miles-traveled reduction policies; state regulation of geological CO_2 sequestration; state and regional efforts to promote transmission investments needed for renewable electricity
Agriculture, Forestry, and Public Land Management	The government can promote emission reductions through policies related to the management of private and public lands and incentives for production of biofuels.	Renewable energy projects on federal lands and offshore areas; farm bill conservation programs encouraging energy and production efficiency	Financial incentives for biosequestration and renewable energy production activities by farmers and landowners	38 states provide financial incentives promoting ethanol production and use.
Economic Development	The government can promote the growth of low-carbon technology industries via subsidies for manufacturers and training and other education for workers and researchers.	Loan guarantees and grants for low-carbon technology manufacturers (e.g., solar power and electric vehicle battery manufacturers)	Expanding existing programs; worker training for clean energy jobs; funding for science, technology, and engineering education	2008 Massachusetts Green Jobs Act included seed grants for clean energy companies and workforce development grants.

ENDNOTES

1 U.S. Energy Information Administration (EIA), *Annual Energy Review* 2009, Table 1.1.

2 For information on carbon capture and storage, see the Pew Center's *Climate TechBook: Carbon Capture and Storage* at http://www.pewclimate.org/technology/factsheet/ccs.

3 For a detailed description of the actions the federal government is taking to address climate change, see the U.S. Department of State's *U.S. Climate Action Report 2010: Fifth National Communication of the United States of America under the United Nations Framework Convention on Climate Change* at http://www.state.gov/g/oes/rls/rpts/car/index.htm.

4 See the Pew Center's summary of *Mass. V. EPA* at http://www.pewclimate.org/federal/analysis/judicial/massachusetts-et-al-v-epa-et-al.

5 See the Pew Center's overview of the Endangerment Finding at http://www.pewclimate.org/federal/executive/epa-endangerment-finding.

6 EPA, "Regulatory Announcement: EPA and NHTSA Finalize Historic National Program to Reduce Greenhouse Gases and Improve Fuel Economy for Cars and Trucks," April 2010, http://www.epa.gov/oms/climate/regulations/420f10014.pdf.

7 See the Pew Center's "Sequence of Events Leading to Regulation of Greenhouse Gases through EPA" at http://www.pewclimate.org/publications/brief/sequence-events-leading-regulation-greenhouse-gases-through-epa.

8 For more information, see EPA's "Clean Air Act Permitting for Greenhouse Gases" at http://www.epa.gov/nsr/ghgpermitting.html.

9 EPA, "EPA Finalizes the Nation's First Greenhouse Gas Reporting System/Monitoring to begin in 2010," Press Release, 22 September 2009.

10 For details on the 2009 House-passed climate and clean energy bill, see the Pew Center's "The American Clean Energy and Security Act (Waxman-Markey Bill)" at http://www.pewclimate.org/acesa.

11 For details on public nuisance suits see the Pew Center's "Judicial Analyses" at http://www.pewclimate.org/federal/judicial-analysis.

12 For example, the Center for Biological Diversity and 350.org have petitioned EPA to make use of the Clean Air Act's national ambient air quality standards (NAAQS) provisions for regulating GHGs (*Center for Biological Diversity v. U.S. EPA*). For more details on legal challenges to EPA's GHG regulations see Deutsche Bank Climate Change Advisors' "Growth of U.S. Climate Change Litigation: Trends and Consequences" at http://www.dbcca.com/dbcca/EN/_media/US_CC_Litigation.pdf.

13 See: Goode, Darren, "Kerry, Lieberman Circulate Climate Plan Focused on Power Plants," *The Hill E² Wire*, 13 July 2010; Samuelsohn, Darren, "Bingaman Eyes Utility-only Approach to Climate Bill," *Politico*, 13 July 2010.

14 For more on these state efforts, see the Pew Center's "Regional Initiatives" at http://www.pewclimate.org/what_s_being_done/in_the_states/regional_initiatives.cfm.

15 For a helpful discussion of these options, see Richardson, Nathan, Art Fraas, and Dallas Burtraw, 2010, *Greenhouse Gas Regulation under the Clean Air Act: Structure, Effects, and Implications of a Knowable Pathway*, Resources for the Future Discussion Paper 10-23.

16 For details, see the Pew Center's "Renewable & Alternative Energy Portfolio Standards," at http://www.pewclimate.org/what_s_being_done/in_the_states/rps.cfm.

17 For an overview of recent proposed federal renewable and clean electricity standards, see the Pew Center's "Comparison Chart: Diversified/Renewable Energy Standard Provisions in Climate and Energy Legislation in the 111th Congress" at http://www.pewclimate.org/federal/analysis/congress/111/comparison-chart-diversifiedrenewable-energy-standard-provisions-clima.

18 As of November 2010, preliminary construction was underway at Southern Company's Vogtle nuclear power plant in Georgia. The Tennessee Valley Authority had also resumed work on the previously partially completed Watts Bar 2 reactor. For details, see the Energy Information Administration's *Status of Potential New Commercial Nuclear Reactors in the United States* at http://www.eia.doe.gov/cneaf/nuclear/page/nuc_reactors/reactor.com.html.

19 For example, the Recovery Act allowed, for a limited time, renewable energy project developers to choose to receive grants in lieu of tax credits since the economic recession made it difficult for project developers and their financial partners to take advantage of federal tax credits.

20 See, for example, McKinsey & Company, 2007, *Reducing U.S. Greenhouse Gas Emissions: How Much at What Cost?*

21 DOE, "DOE Proposes Higher Efficiency Standards for Refrigerators," Press Release, 28 September 2010.

22 For an overview of recent proposed provisions related to energy efficiency, see the Pew Center's "Comparison Chart: Energy Efficiency provisions in Energy and Climate Legislation for the 111th Congress" at http://www.pewclimate.org/federal/analysis/congress/111/table-energy-efficiency-provisions-energy-and-climate-legislation.

23 For details on the states pursuing LCFS policies, see the Pew Center's "Low Carbon Fuel Standard" at http://www.pewclimate.org/what_s_being_done/in_the_states/low_carbon_fuel_standard.

24 For an overview of recent proposed incentives for electric vehicles, see the Pew Center's "Comparison Chart: Plug-In Electric Vehicles in Climate-Energy Legislation for the 111th Congress" at http://www.pewclimate.org/federal/analysis/congress/111/table-plugin-electric-vehicles-climate-energy-legislation.

25 More information on many of these state policy examples can be found at the Pew Center's "U.S. States & Regions" overview at http://www.pewclimate.org/states-regions.

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CLIMATE CHANGE 101
State Action

For years, U.S. states and regions have been taking action to address climate change in the absence of federal legislation. A wide range of policies have been adopted at the state and regional levels to reduce greenhouse gas emissions, develop clean energy resources, and promote more energy-efficient vehicles, buildings, and appliances, among other things. Although climate change will ultimately require a national and international response, the actions taken by states and regions will continue to play an important role by developing and testing innovative solutions, demonstrating successful programs, and laying the groundwork for broader action.

TAKING THE INITIATIVE

Two trends are apparent with regard to state and regional efforts that address climate change: 1) more states are taking action and 2) they are adopting more types of policies. In this way, states and regions are acting as both leaders and innovators of climate change policy. State and regional efforts are wide ranging, including high-profile policies such as cap-and-trade programs, renewable portfolio standards, and climate action plans. The states and regions are acting as "policy laboratories," developing initiatives that can serve as models for federal action, as well as for other states.

Since many individual states are major sources of greenhouse gas (GHG) emissions, state-level policies have the potential to produce significant reductions. Texas, for example, emits twice the amount of GHGs as Spain while California's emissions exceed those of Italy.[1] As state-level policies proliferate, so too do the climate benefits associated with these actions. Moreover, state actions are important because state governments have decision-making authority over many issues and economic sectors—such as power generation and agriculture—that are critical to addressing climate change.

Why are states taking action on this issue? State leaders and their constituents are concerned about the projected economic and environmental toll of climate change on their states. Coastal states face concerns over rising sea levels. Agricultural states must confront the potential for lost farm productivity. And the dry western states must meet the dual challenges of worsening droughts and increasing wildfire risks.[2]

At the same time, many states view policies that address climate change as an economic opportunity, not as a burden on commerce. 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 GHG emission reduction credits.

Economic issues are just one motivator for state policies that address climate change. Policies to improve air quality, reduce traffic congestion, and develop domestic, clean energy supplies can all have climate benefits. States also are discovering that climate policies often bring about benefits in these other areas as well.

Because reducing GHG emissions can deliver multiple benefits, it has been possible for many states to build broad coalitions around climate-friendly policies. In fact, climate change and clean energy policies have received bipartisan support in many states, with Democratic, Republican, and Independent governors signing climate change and

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clean energy legislation and lawmakers of all political persuasions supporting state action. Governors are pursuing a wide range of policies that reduce GHGs while achieving multiple economic benefits tailored to the specific needs and resources of their states. Thus, in addition to offering models for specific policy solutions, the states also offer models for finding common ground.

WORKING ACROSS STATE BORDERS

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

Regional climate initiatives, including three cap-and-trade programs, are being developed and implemented among U.S. states and Canadian provinces (see Figure 1). Cap-and-trade programs set an overall emissions cap while allowing companies to trade emission allowances so they can achieve their reductions as cost effectively as possible. Similar programs have been successfully implemented in the United States and elsewhere to control other pollutants in an environmentally sound, cost-effective manner.[3]

Regional Greenhouse Gas Initiative. In December 2005, the governors of seven Northeastern and Mid-Atlantic states signed an agreement formalizing the first U.S. GHG cap-and-trade program, the Regional Greenhouse Gas Initiative (RGGI). RGGI now consists of ten Northeastern and Mid-Atlantic states that are implementing a cap-and-trade program to reduce carbon dioxide (CO_2) emissions from power plants in the region. The RGGI cap-and-trade program began in January 2009 and is administered with the technical assistance of a regional organization called RGGI, Inc. The successful implementation of RGGI has been an example for other states and national governments.

Transportation and Climate Initiative (TCI). In 2010, eleven Northeastern and Mid-Atlantic states formed the TCI with the aim to expand safe and reliable transportation options, attract federal investment, lower transportation costs, improve overall air quality and public health, and mitigate the transportation sector's impact on climate change.

Western Climate Initiative. In February 2007, five western governors signed an agreement establishing the Western Climate Initiative (WCI), a joint effort to reduce GHG emissions and address climate change. The WCI has since grown to include seven U.S. states and four Canadian provinces that have jointly set a regional GHG emissions target of 15 percent below 2005 levels by 2020. The WCI is planning to implement a regional cap-and-trade program that will initially cover emissions of six GHGs produced by electricity generators and large industrial sources, and then will expand to include emissions of these gases from the combustion of

Figure 1

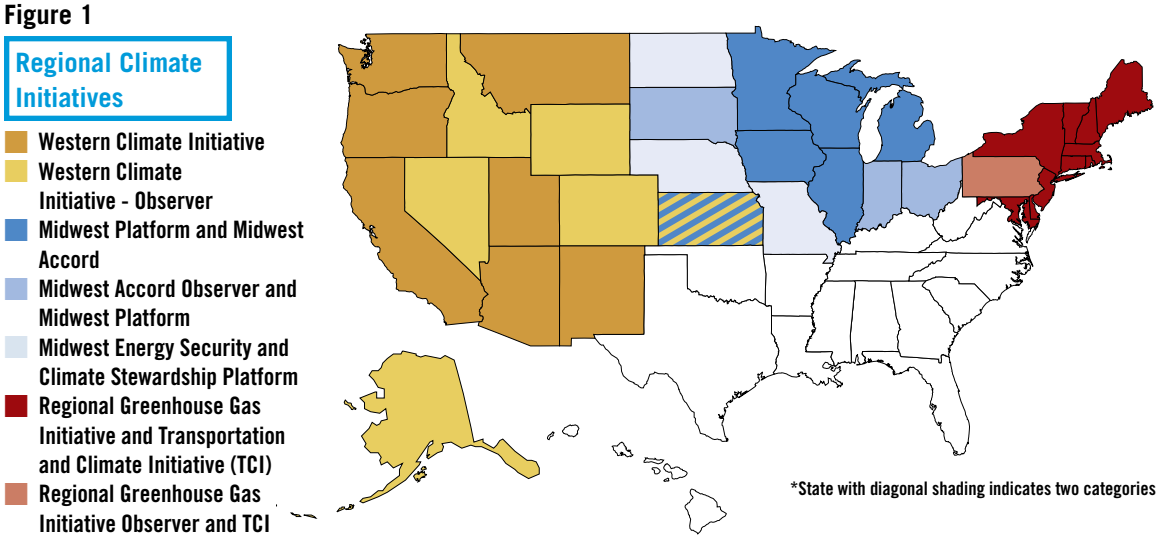
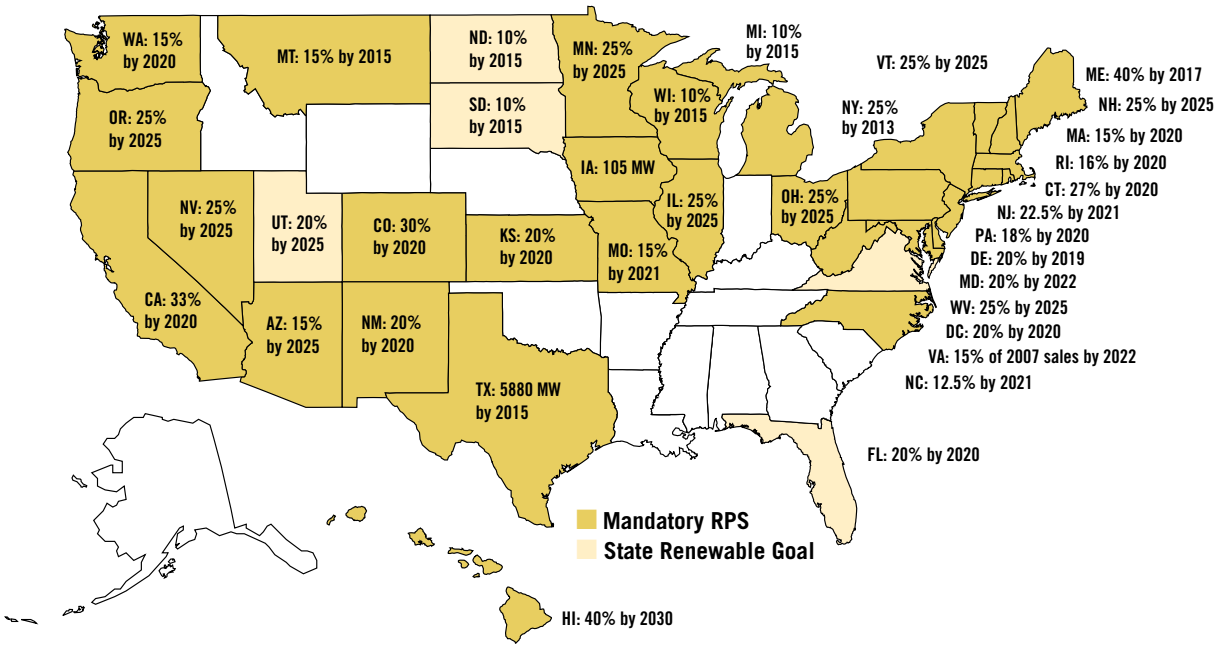


Figure 2

Renewable and Alternative Energy Portfolio Standards



transportation fuels as well as residential, commercial, and small industrial fuels not previously covered. When fully implemented, the WCI cap-and-trade program will have the broadest coverage of any regional GHG cap-and-trade program proposed to date. WCI is also working on a broader set of clean energy and climate policies.

Midwest Energy Security and Climate Stewardship Platform. In November 2007, Governors of twelve Midwestern states and the Premier of Manitoba adopted all or portions of the Platform, which includes goals for energy efficiency improvements, low-carbon transportation fuel availability, renewable electricity production, and carbon capture and storage development. Numerous policy options are described for states as they work toward these goals.

Midwestern Greenhouse Gas Reduction Accord. In parallel with the development of the Midwest Platform, the governors of six states, as well as the premier of Manitoba, established the Midwestern GHG Reduction Accord (MGGRA). Under the Accord, members agreed to establish regional GHG reduction targets, including a long-term target of 60 to 80 percent below current emissions levels, and develop a multi-sector cap-and-trade system to help meet the targets. Final recommendations and a model rule were completed by the Accord's Advisory Group in May 2010.

REDUCING ELECTRICITY EMISSIONS

States have considerable authority over how electricity is generated and used in the United States. With the generation of electricity accounting for 33 percent of all U.S. GHG emissions and 40 percent of U.S. CO_2 emissions,[4] states can play a crucial role in reducing the power sector's climate impacts by promoting low-carbon energy solutions and energy efficiency.

The two major options for reducing GHG emissions from electricity are energy efficiency and low-carbon electricity production. Increasing energy efficiency is often the least expensive way to reduce GHG emissions and meet energy needs. Energy efficiency policies come in many forms, including funding and requirements for energy efficient products, buildings, appliances, and transportation and utility programs that reduce their customers' energy demand. State actions to promote low-carbon electricity include incentives and mandates that reduce emissions by promoting a cleaner energy supply, for example by supporting renewable energy.

Renewable Portfolio Standards. Twenty-seven states and the District of Columbia have established mandatory Renewable Portfolio Standards (RPS), policies that require a certain percentage or amount of electricity generation from eligible renewable sources by a given date (see Figure 2). An additional five states have renewable energy goals. RPS design varies significantly across the states. The standards range from modest to ambitious, and what qualifies as "renewable energy" can vary from state to state. Four states have Alternative Energy Portfolio Standards that include a wider range of low- or no-emission technologies, such as carbon capture and storage. Many states have adjusted their RPS design over time, most often strengthening the previously established requirements. While the use of renewable electricity can deliver significant reductions in GHG emissions, a variety of factors can drive the implementation of an RPS, including job creation in the renewables industry, diversification of energy sources, and improved air quality.[5]

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 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 pay for these projects, which often include low-income household energy assistance, weatherization programs, investment in renewable technologies, and subsidies for efficient appliances. To date, 13 states with publicly managed clean energy funds have formed the Clean Energy States Alliance to coordinate public benefit fund investments in renewable energy.

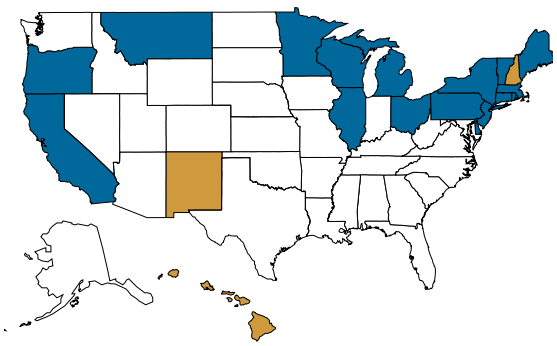
Net Metering and Green Pricing. Forty-five U.S. states have at least one utility that permits customers to sell electricity back to the grid; this is referred to as "net metering." Eighteen of these states offer net metering on a statewide basis for all utilities, 24 others have statewide net metering for certain utility types, and the remaining three have individual utilities that offer net metering. In addition, 42 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. Eleven of these states—Colorado, Delaware, Iowa, Maine, Minnesota, Montana, New Mexico, Oregon, Vermont, Virginia and Washington—have made it mandatory for electricity suppliers to offer green pricing options.

Limits on Power Plant Emissions. Oregon and Washington require that new power plants offset a certain portion of their anticipated CO_2 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. California, Montana, Oregon, and Washington also require new power plants to meet a GHG emissions performance standard.

Carbon Capture and Storage. Acknowledging that coal is a vital economic resource and likely to remain in widespread use

Figure 3

Public Benefit Funds

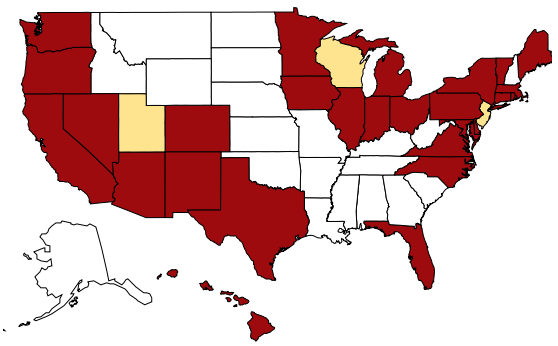


Funds for Renewables and Efficiency

Funds for Energy Efficiency

Figure 4

Energy Efficiency Resource Standards

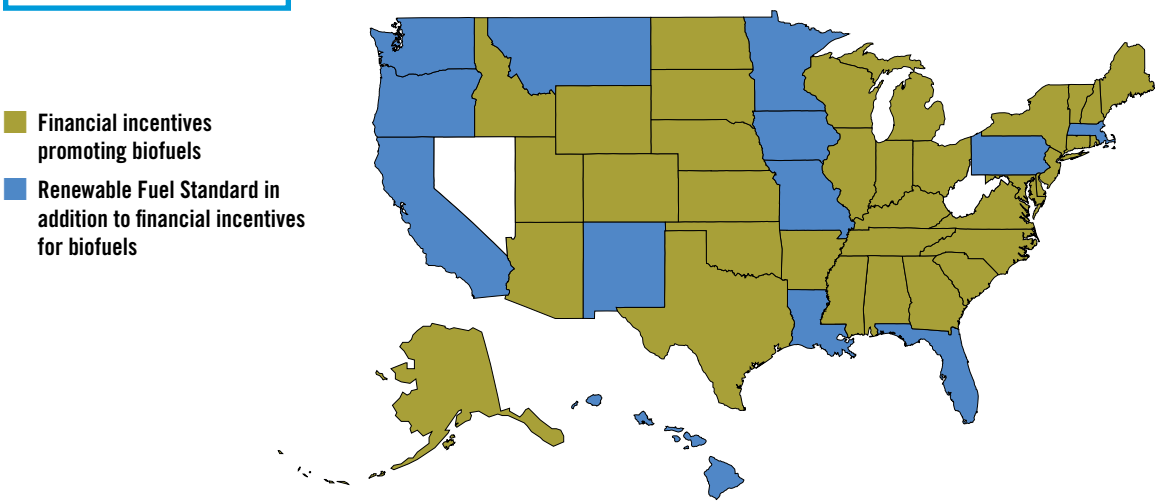


Completed EERS

Pending EERS

Figure 5

Alternative Fuel Policies



for decades, states have recognized the need to channel this resource into cleaner and lower-emission technologies. Carbon capture and storage is an emerging technology for reducing GHG emissions from large sources, primarily coal-fueled power plants. Colorado, Florida, Illinois, Indiana, Kansas, Kentucky, Louisiana, Minnesota, Mississippi, Montana, New Mexico, North Dakota, Rhode Island, Texas, Virginia and Wyoming have direct financial incentives for carbon capture and storage, including state bonds for construction, tax incentives, and utility cost recovery mechanisms. Many states also provide incentives for the development and use of technologies that may make carbon capture easier, such as integrated gasification combined cycle (IGCC) power plants.

Energy Efficiency Resource Standards. Twenty-six states have Energy Efficiency Resource Standards (EERS), which establish a target for utilities to increase energy savings by a specified amount over time from electricity and/or heating fuels (see Figure 4). This encourages utilities to either promote energy-efficient technology for consumers or integrate more efficient technology for generation. In addition, some states allow savings from energy efficiency measures to count toward their RPS requirements rather than having a separate EERS.

Appliance Efficiency Standards. The federal government has established minimum efficiency standards for approximately 30 kinds of residential and commercial products, including washers and dryers, refrigerators and freezers, dishwashers, and air conditioners. Numerous states—including Arizona, California, Connecticut, Maryland, New Jersey, New York, Rhode Island, and Washington—have set standards on products not covered by federal standards. Many states have also implemented a variety of incentive programs, including rebates and tax exemptions, to promote energy efficiency.

TRANSPORTATION POLICIES

Transportation accounts for 27 percent of all U.S. GHG emissions and 32 percent of U.S. CO_2 emissions.[6] 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 adopted a requirement for GHG emissions from new light-duty vehicles that would reduce new vehicle emissions on average 30 percent by 2016. California has unique authority among the states to set vehicle emissions standards because of a provision in the federal Clean Air Act that allows it to set stricter standards if granted a waiver by the EPA. Under the provision, other states have the option of either following federal or California standards. Rather than grant a waiver, the Obama administration opted to move federal standards to match California's fuel economy requirements—35.5 mpg by 2016.

Alternative Fuels. 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. These incentives to promote biofuel production and use include excise tax exemptions, tax credits, and grants. In addition to these incentives, 13 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. While biofuels' emission performance can vary on a life-cycle basis depending on how the fuel is made, they have the potential to diversify the energy supply and promote energy security. States that ensure the production of low-emitting biofuels are well placed to utilize this resource as an alternative to fossil fuels.

Incentives for Low-Carbon Fuels and Vehicles. Building on their policies to promote biofuel use, several states are in the process of implementing performance standards (e.g., a low-carbon fuel standard) to lower the carbon content of the fuels used in transportation. In January 2007, California announced the first low-carbon fuel standard, which set a goal of reducing the life-cycle carbon intensity[7] of transportation fuels by a minimum of 10 percent by 2020. The California LCFS was formally adopted in January 2010 and took effect in January 2011. Market-based mechanisms, such as credit trading, will allow fuel providers to meet the standard in a cost-effective manner. In the Midwest, an advisory group comprised of members of the Midwestern Governors Association's Energy Security and Climate Stewardship Platform, the North Central Bioeconomy Consortium, and various other stakeholders, is considering a regional low-carbon fuel policy as an option to reduce emissions in the transportation sector.

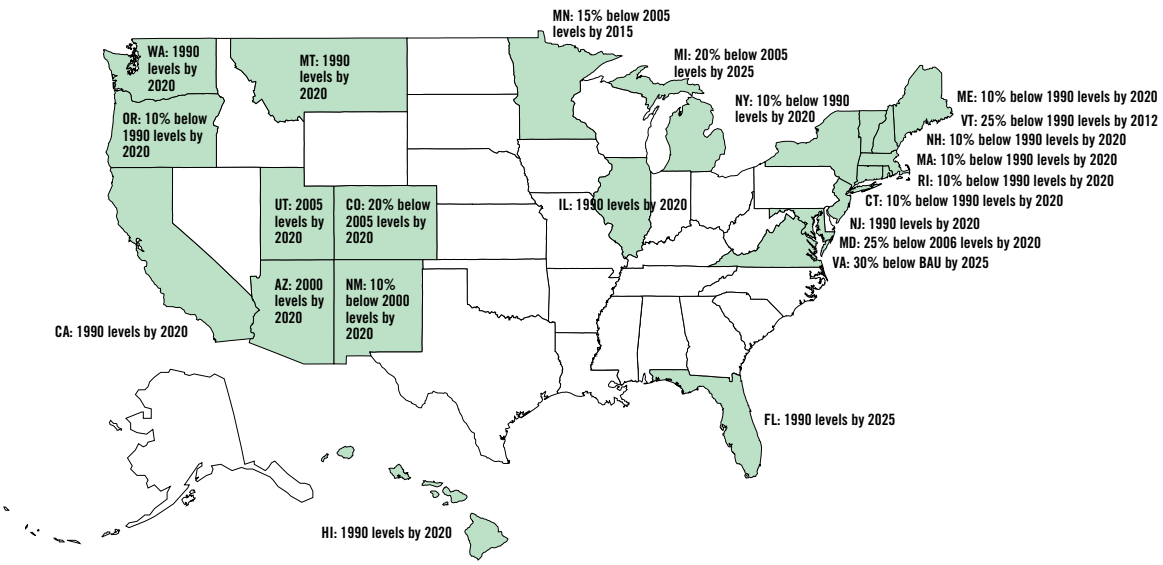
AGRICULTURAL POLICIES

Agriculture contributes approximately 7 percent of total U.S. GHG emissions, primarily nitrous oxide and methane from livestock, agricultural soils, and the use of fertilizers.[8] In addition to reducing these emissions through more strategic land and crop management and more efficient use of agricultural inputs, 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 residual material from agriculture, forestry, or animal wastes—as a low-carbon energy source offers an opportunity for the agricultural sector to address climate change in a profitable way. Biomass can be burned directly for electricity, or it can be converted to other usable fuels, including biofuels.

Figure 6

State Emission Targets



States promote the development and use of biomass resources in a variety of ways. Biomass is an eligible resource under many state Renewable Portfolio Standards, and a variety of grant, tax, and other incentive programs also encourage the use of biomass. Illinois, for example, uses revenue from its Public Benefit Fund to provide grants for on-site electricity generation that uses biogas or biomass gasification.

Promote Soil Conservation. The agricultural sector also can help protect the climate by promoting farming techniques that increase the amount of carbon stored in soil. A variety of practices, including low-till and no-till farming, can increase the amount of carbon naturally stored in soil. In addition to this climate benefit, these practices have other beneficial effects, such as improved soil quality, reduced erosion, and improved water quality. State policies promoting conservation practices come in a variety of forms, including no-interest loans and tax incentives.

EMISSION TARGETS AND CLIMATE ACTION PLANS

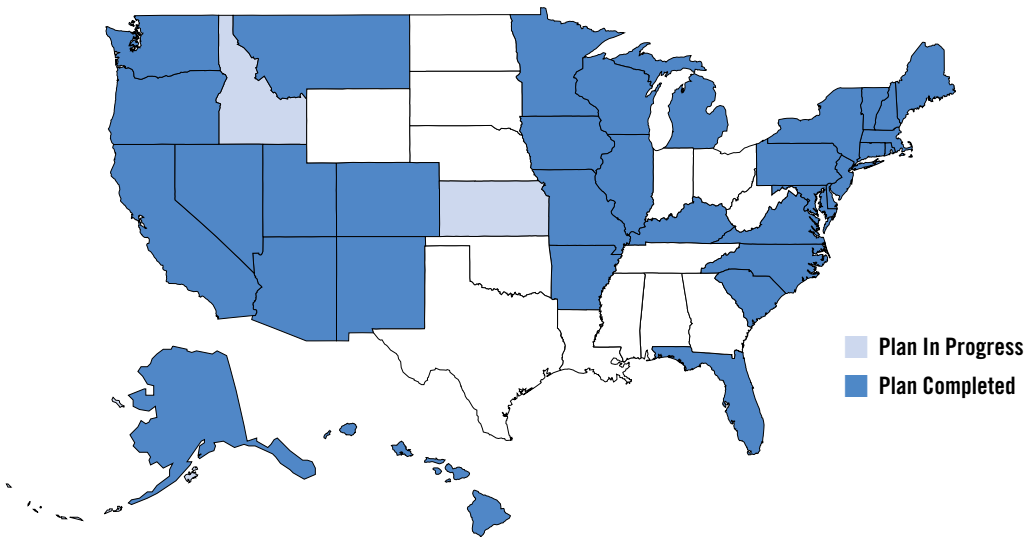
Many states are taking a comprehensive approach to climate policy by establishing statewide GHG emission reduction targets and developing climate action plans that provide a range of policy recommendations to address climate change, including measures to reduce emissions and respond to impacts.

Emission Targets. Twenty-three states have adopted statewide emission targets and goals (see Figure 6). The stringency and timelines associated with these targets varies by state. Each state is using a different suite of actions to achieve its greenhouse gas targets. The first enforceable statewide GHG emissions target was established in 2006 by California with A.B. 32, the Global Warming Solutions Act.

Climate Action Plans. Thirty-six states have completed comprehensive climate action plans or are in the process of revising or developing one (see Figure 7). In addition, more than half of the states have set up advisory boards or commissions to develop and/or implement climate action plans. The process of developing a climate action plan can help state decision-makers identify cost-effective opportunities to reduce GHG emissions in ways that are most appropriate for their states, taking into account the individual characteristics of each state's economy, resource base, and political structure. In addition to addressing measures to reduce GHG emissions, a number of climate action plans have also focused on what the state must do to adapt to some degree of climate change. Note: please see *Climate Change 101: Adaptation* for more information on state adaptation efforts.

Figure 7

State Climate Action Plans



LEARNING FROM THE STATES

In recent years, states have acted as leaders on climate action. Climate-friendly policies have emerged across the country to address key sectors, from electricity to transportation to agriculture, with significant variation in design. By acting as policy laboratories, states have been able to tailor policies to their own circumstances, test innovative approaches, and build experience with program design and implementation. The experiences of early acting states have already helped shape other state policies and will similarly be able to inform future state, regional, and federal action.

For example, state and regional experience to date suggests that some programs, such as emission inventories or cap-and-trade programs, should be designed so they can easily be expanded, linked to, or integrated with other programs at the regional and national levels. Since regional action can be more efficient and effective than individual state programs, designing easily expandable programs or joining a regional program can be an effective way to deal with climate change within the strict budget requirements that states face.

A key issue is the appropriate respective roles of different levels of government. The history of environmental protection in the United States shows that very few areas have been vested in the exclusive control of either the state or federal governments alone; rather, most are areas of overlapping or shared competence. Federal climate policy will be most successful if it is designed with the relative strengths of each level of government in mind.[9] Thus, policy makers need to ensure that state-level efforts are taken into account in the design of federal programs.

ENDNOTES

1 Climate Analysis Indicators Tool (CAIT UNFCCC) version 2.0. (Washington, DC: World Resources Institute, 2008). Available at http://cait.wri.org. Climate Analysis Indicators Tool (CAIT US) version 2.0. (Washington, DC: World Resources Institute, 2008). Available at http://cait.wri.org. http://www.arb.ca.gov/cc/inventory/data/tables/rpt_Inventory_IPCC_Sum_2007-11-19.pdf

2 IPCC 2007. *Climate Change 2007—Impacts, Adaptation and Vulnerability. Contribution to Working Group II to the Fourth Assessment Report of the IPCC.* Cambridge University Press, UK, 976pp.

3 To learn more about how cap and trade works, see "Climate Change 101: Cap and Trade." Pew Center on Global Climate Change, 2008.

4 EPA. 2010. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008.* EPA 430-R-08-005. Washington, D.C. http://www.epa.gov/climatechange/emissions/downloads10/US-GHG-Inventory-2010_Report.pdf

5 For more information see *Race to the Top: The Expanding Role of U.S. State Renewable Portfolio Standards.* Pew Center on Global Climate Change, 2006.

6 EPA. 2010. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008.* EPA 430-R-08-005. Washington, D.C. http://www.epa.gov/climatechange/emissions/downloads10/US-GHG-Inventory-2010_Report.pdf

7 Life-cycle carbon intensity is defined as the amount of GHG emissions per unit of energy consumed over the entire life-cycle of the fuel, from production or extraction, processing and combustion.

8 EPA. 2010. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008.* EPA 430-R-08-005. Washington, D.C. http://www.epa.gov/climatechange/emissions/downloads10/US-GHG-Inventory-2010_Report.pdf

9 For further discussion of the roles of the state and federal governments in climate policy, see Litz, Franz T. *Toward a Constructive Dialogue on Federal and State Roles in U.S. Climate Policy.* Pew Center on Global Climate Change, 2008.

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CLIMATE CHANGE 101
Local Action

Across the United States, cities, towns, 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 energy and climate solutions can benefit local economies and residents. Their 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. Like states and regions, local governments can demonstrate leadership by implementing strategies to confront climate change and laying the groundwork for broader action at the national and international levels.

All levels of government have roles to play in addressing climate change. Some aspects of the climate problem must be addressed at the local level, such as greenhouse gas reductions through smart growth and adapting to climate impacts. Local governments have also been inspired to act when federal and state climate action has not been forthcoming because they face some of the greatest challenges when it comes to climate change. Local governments have already started implementing climate action plans, financial incentives, and other measures that encourage climate-friendly behavior. They have also included greenhouse gas (GHG) considerations in transportation and urban planning. While localities are not large enough by themselves to enact the broad policy changes that are needed to address global climate change, they can take proactive measures to reduce their own GHG emissions, advance the issue of climate change among local residents, and encourage broader action at the state and federal levels.

WHAT DRIVES LOCAL ACTION?

There is Much to Lose… Many of the impacts of a changing climate will be felt on a local level. Cities and local governments will be directly confronted with the challenges of extreme weather, rising sea levels, and climate-related natural disasters.

More Warming in Cities. 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. Cities can experience exaggerated effects of warming due to the urban heat island effect, in which the urban infrastructure retains heat and causes cities to be several degrees hotter than their surroundings.

Weather-related Disasters. Cities, towns, and counties will also be responsible for addressing the local impacts of climate change. The more extreme events scientists expect from a warming climate—including stronger hurricanes, heavier rainstorms, and more frequent floods—directly threaten local infrastructure. Hurricane Katrina, which ravaged New Orleans and other Gulf Coast cities in 2005, drew the attention of local governments throughout the nation by demonstrating their vulnerability to weather-related disasters and indicating the long-term risks that localities face as weather patterns shift and extreme events become more common due to expected climate change.

PEW CENTER ON Global CLIMATE CHANGE

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.

Changes in Freshwater Resources. A number of climate impacts will alter the quality and availability of fresh water. Extreme weather and changes in precipitation will require localities to re-examine critical issues, such as the water supply, storm water management, and the influx of pollutants into water sources. Particularly in the West, decreased snow pack, earlier runoff, and higher drought incidence will affect water supplies. Local governments will be forced to address water rights and management issues.

Rising Sea Levels. In addition to extreme weather events, rising sea levels pose challenges for coastal cities and communities. The implications of higher sea levels include damaged buildings close to shore, increased flood potential, and the contamination of the fresh water supply.

Heat and Health. Local officials also are concerned about the health implications of higher temperatures. Cities all over the United States are expected to face more heat waves each year; the U.S. Centers for Disease Control estimates that by the 2050s, heat-related deaths will increase from their current level of 700 per year to about 3,000–5,000 per year if emissions continue at business-as-usual levels.[1]

In addition to fears of future heat waves, mayors have voiced concern about the effect of higher temperatures on local air pollution. As temperatures rise, ground-level ozone and smog levels increase and can exacerbate respiratory illnesses, such as asthma and bronchitis. Preventing rising temperatures can also mitigate the harmful effects of air pollution and lower associated costs. Cities and localities face economic costs from increased air pollution—from such things as additional hospital admissions, missed work and school days, and a higher incidence of respiratory and heat-related illnesses, as well as premature deaths. Communities that face these costs find that climate action would have positive effects on local health and the local economy.

...and Much to Gain. It is not only the potentially damaging impacts of climate change that are spurring local action. Many cities see opportunities in protecting the climate. Often, policies that reduce greenhouse gases also achieve other benefits for communities. Local governments have many important tools available for climate action and have an important role to play in influencing public behavior and increasing the availability of climate-friendly choices.

Relevant Authorities for Climate Action. Local governments have influence and oversight in areas with potential for greenhouse gas reductions, and exercising their authority in these sectors can result in substantial emission reductions. By adopting zoning laws and land-use plans that promote higher-density and mixed-use forms of development, cities can encourage the growth of livable, accessible communities. "Smart growth" planning—a strategy that highlights high-density, mixed-use, transit-oriented development—also has other goals, such as maintaining open space, farmlands, and other natural areas and directing city resources toward existing communities rather than diverting them to new development in outlying areas. Lancaster County in Pennsylvania, for example, has Urban Growth Boundaries that serve the dual purposes of encouraging higher-density development in urban areas and protecting agricultural land from development. Promoting dense, mixed-use development, creating safe and navigable roads for walkers and bikers, and making public transportation more accessible, extensive, and affordable also reduces the need for personal vehicles. Finally, ensuring that public transit and city vehicles utilize low-carbon technologies can lower GHG emissions directly and accelerate the use of these technologies by consumers as well.

Local governments, also responsible for issuing building and development permits, can set building codes that influence the energy efficiency of houses and commercial buildings in their communities. For example, they can create mandates and incentives for more energy-efficient construction, building operation, and use of renewable electricity. Similarly, governments that control the local electricity supply through municipal utilities or can influence action through agreements with utilities can ensure utilities produce a high percentage of their electricity using clean energy sources. Austin Energy, a municipal utility in Texas, has set a goal of generating 35 percent of its electricity from renewable sources. It has implemented a popular green pricing program

to generate interest and facilitate the transition to renewable sources. Many local governments also have authority over waste management and can implement landfill gas recovery programs. Landfill gas is made up primarily of methane, which is both a highly valued fuel (it is the primary component of natural gas) and a relatively powerful greenhouse gas. These programs prevent unwanted emissions of methane and harness this energy source for other purposes.

Co-benefits Are Experienced Locally. As mentioned previously, initiatives to reduce GHGs can reduce regional air pollution and help cities comply with federal air quality standards established under the Clean Air Act. Energy efficiency and fuel-saving efforts can also reduce the operating costs of government buildings and fleets, local businesses, and residences, creating financial savings for the local government and taxpayers.

Energy efficiency and fuel-saving efforts can also reduce the operating costs of government buildings and fleets, local businesses, and residences.

The creation of jobs from emission reductions and climate mitigation strategies also is likely to have significant benefits for local economies. A study released by the U.S. Conference of Mayors Climate Protection Center in 2008 indicated that adhering to federal, state, and local goals promoting renewable energy, energy efficiency, and alternative fuel can transform the economy by increasing the number of green jobs five-fold. The report suggests that cities are especially well-placed to reap the benefits, as more than 85 percent of green jobs are located in metropolitan areas.[2]

Other co-benefits may be less tangible but nevertheless provide important incentives for climate action. As mentioned in the previous section, mixed-use development that minimizes vehicle use reduces pollution as well as traffic and congestion. Programs that promote walking and biking contribute to healthier residents and a stronger sense of community.

A HISTORY OF LOCAL LEADERSHIP AND COLLABORATION

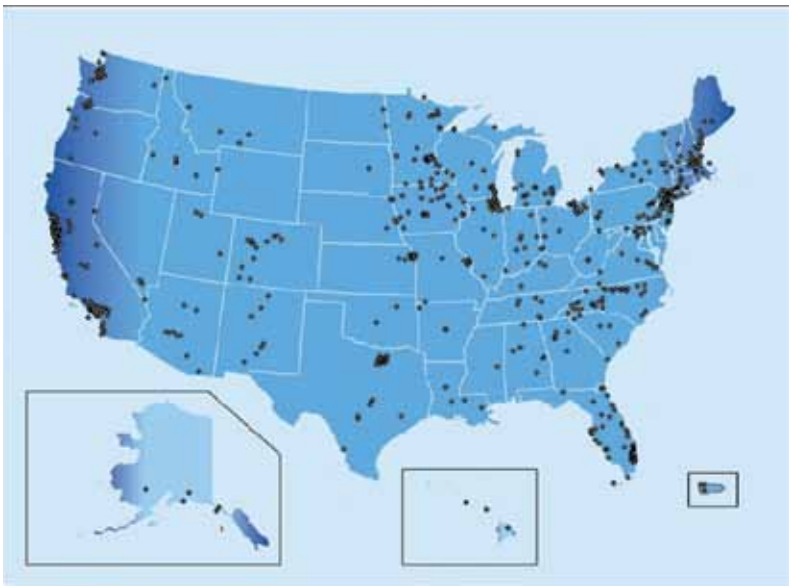
Local commitment to climate solutions is not new; in fact, cities were leaders in worldwide efforts to reduce emissions from the start. In 1989, the City of Toronto adopted the world's first greenhouse gas reduction target of 20 percent below 1988 levels by 2005.[3] The City's actions helped inspire the first formal municipal program for climate protection, the Urban CO_2 Reduction Project,[4] and ultimately developed into the ICLEI-Local Governments for Sustainability: Cities for Climate Protection (CCP) Campaign. The CCP program enlists local governments in developing targets, timelines, and implementation strategies for reducing their emissions and now represents more than 1,000 local governments worldwide, including the 600+ ICLEI members in the United States.

U.S. Mayors Climate Protection Agreement. Local action on climate change in the United States took a major step forward in early 2005 when Seattle's former Mayor Greg Nickels drafted the U.S. Mayors Climate Protection Agreement, which was endorsed by the U.S. Conference of Mayors. Under this agreement, mayors pledge that their communities will achieve a 7 percent reduction from 1990 emissions levels by 2012, and also recommend that state and federal governments take comparable action. More than 1,044 local elected leaders have signed the mayors' agreement from communities across all 50 states plus the District of Columbia and Puerto Rico, representing more than 87 million Americans (see Figure 1). A report released in 2007 indicated that the vast majority of signatories had incorporated renewable energy into their city's electricity mix and taken steps to make city vehicle fleets and buildings more energy efficient.[5] In 2007, the U.S. Conference of Mayors Climate Protection Center was created to assist mayors in meeting goals established by the agreement.

C40 Cities-Clinton Climate Initiative. Former President Bill Clinton launched the Clinton Climate Initiative (CCI) in August 2006. Partnering with members of the C40 Large Cities Climate Leadership Group, CCI is helping cities develop and implement a range of actions that will reduce

Figure 1

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



Mayors of 1,044 cities have signed the U.S. Mayors Climate Protection Agreement as of October 2010.
Source: http://www.usmayors.org/climateprotection.

GHG emissions. The initiative provides technical assistance to measure and track emissions and emission reductions in individual cities as well as financial assistance for clean transportation and building efficiency retrofits. CCI has also created a consortium for cities to pool their purchasing power to negotiate discounts and reduce the costs of energy-saving technologies and products. This effort has increased the affordability and feasibility of efficiency programs.

World Mayors and Local Governments Climate Protection Agreement. At the 2007 UN Climate Change Conference in Bali, local government leaders worldwide reached an agreement to support the reduction of global GHG emissions to 60 percent below 1990 levels by 2050, with an 80 percent reduction for industrialized countries. The agreement, which currently has more than 112 signatories and was created in association with C40-CCI, ICLEI, United Cities and Local Governments, and the World Mayors Council on Climate Change, also calls for the implementation of complementary national and international policies that will facilitate continued local action and enable localities to create adaptive responses and mitigation measures for climate protection.

Cool Counties Climate Stabilization Initiative. In 2007, 12 U.S. counties launched the Cool Counties Climate Stabilization Initiative, which now includes 42 signatories. Under the Initiative, counties pledged to stabilize their greenhouse gas emissions by 2010 and reduce emissions 10 percent every five years until 2050. The Initiative includes several strategies for taking action on climate issues, including creating county greenhouse gas inventories and action plans for implementing emission-reducing programs, and promoting state and federal climate initiatives to create a market-based greenhouse gas reduction system and enact higher mileage standards for vehicles.

ADDRESSING CLIMATE AT THE LOCAL LEVEL

Action at the local level has taken many forms, often depending on leadership and public interest, regulatory gaps in state and federal policy, and local climate concerns. Some local governments have adopted initiatives that parallel state action, others have focused on influencing private behavior, and several have created detailed, multi-pronged approaches to addressing climate change.

Climate Action Plans. Many cities have created climate action plans to address climate issues. These plans include recommendations, guidelines, and location-specific ideas for emission reductions from key sectors, including transportation, waste management, and electricity. New York City launched PlaNYC, launched in April 2007, which includes a set of 127 initiatives addressing 10 goals relating to the city's economic, environmental, and climate-related challenges. Goals include improving public transportation, providing cleaner and more reliable energy, achieving the cleanest air of all the major U.S. cities, and reducing GHG emissions by more than 30 percent.[6] Albuquerque has also created AlbuquerqueGreen, a sustainability plan that reduced GHG emissions by 67 percent from 2000 to 2007 in city operations.[7]

Climate Task Forces and Coordinators. Recognizing that climate is an essential and long-term concern at the local level, cities, towns, and counties have established offices and task forces to understand climate issues better, create strategies to address climate change through both mitigation and adaptive measures, and coordinate between the various regional, state, and federal agencies that also work in this area. The Denver Mayor's Greenprint Council, for example, is comprised of individuals from various government offices and non-profit organizations, as well as other community members. This group guides the implementation of strategies identified in the city's Climate Action Plan.

Regional Climate Networks. Climate action is most effective when government entities collaborate on cross-border and multi-sector actions—a principle that applies to climate work at the regional, state, national, and international levels. Several localities have joined forces to implement common emissions targets and climate strategies. For example, the Sacramento Area Council of Governments is an association that encompasses 22 cities across six counties in the Sacramento, CA, region. Among the group's many goals is a commitment to air quality, public transit, bicycle and pedestrian planning, and land-use planning initiatives.

Emissions Fees and Taxes. Some localities have established taxes and fees to create incentives for reduced energy consumption and reduced emissions. In 2006, Boulder, Colorado, established the Climate Action Plan Tax, which taxes consumers' electricity usage and uses these funds for community action to reduce greenhouse gas emissions. It was projected to raise $1.6 million in 2010. In 2008, the California Bay Area Air Quality Management District also enacted a tax on stationary greenhouse gas emitters, such as power plants, oil refineries, and cement plants. Revenues from both the Bay Area and Boulder initiatives fund their respective climate plans and programs.

Leading by Example. Local governments have the ability to lead by example, serving as models for both state and federal governments as well as private citizens. Many cities have green building laws that require all public facilities meet certain energy efficiency and construction standards. Cities can incorporate low-emission vehicles into their public transportation and government vehicle fleets and they can also opt to meet electricity needs for public facilities with energy obtained from low-carbon sources.

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*.)

Limited Scale. Perhaps the biggest weakness of action by any one locality is that it simply cannot achieve the economies of scale necessary for widespread and aggressive emission cuts. Even the best individual efforts of cities, towns, and counties will be geographically limited and emission reductions will be correspondingly small. However, when localities join together, as is happening under many of the initiatives described earlier, the effects can be substantial.

Limited Scope. Though local governments have authority over several sectors that are important for climate action, regulatory and legislative authority to mandate economy-wide emissions reductions ultimately rests with the state and federal governments. For example, although localities can achieve GHG reductions by promoting smart growth practices and improving public transit, vehicle and fuel regulations are typically beyond their control. While localities may be able to inspire climate-friendly behavior changes, they often do not have the authority to guarantee emissions reductions through legislation or regulations. Likewise, municipal utilities and municipal power purchases 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 levels.

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

LESSONS LEARNED

Local leaders can provide models of climate action for other communities and levels of government to emulate. They

Examples of 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—Santa Monica, CA; Dallas, TX; Albuquerque, NM; Bellingham, WA; Austin, TX

In 1999, the City of Santa Monica became the first city in the nation to purchase green power for 100 percent of its public facilities' energy needs. Cities around the United States have followed this example, and many now purchase green power. Dallas, for example, meets 40 percent of its energy needs from wind power. Albuquerque obtains 20 percent of its electricity from wind and is making efforts to implement solar and landfill gas programs as well. Bellingham, WA not only purchases 100 percent renewable energy for public facilities but has also implemented a program to encourage citizens to do the same. To date, 11 percent of total electricity use in the community comes from renewable sources. In 2007, the City of Austin, Texas set a goal of achieving 100 percent renewable energy sources for city facilities by 2012, representing 45 percent of all city electricity accounts. As of 2009, the city has 19 percent renewable energy.

Landfill Methane—Murray, UT

Murray City Power created a landfill gas energy project to use methane from the Salt Lake Valley Landfill for power generation. The project has a 3-megawatt capacity and has contributed 8 percent to the utility's portfolio. The program has also been widely publicized as an effective way to bring together a diverse group of stakeholders to reduce emissions, increase air quality, and generate renewable energy.

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. Using wood waste displaces an estimated 110,000 tons of coal per year, reducing carbon dioxide (CO_2) emissions by an estimated 280,000 tons annually.

Lancaster County Landfill Gas and Cogeneration—Conestoga, PA

This Combined Heat and Power (CHP) program harnesses methane from two landfills for electric and thermal energy. The landfill gas is processed through generators owned by an electric utility and the heat is utilized by a local dairy company.

Renewable Energy and Energy Efficiency Financing

Renewable Energy Funding—Berkeley, CA

Through the Financing Initiative for Renewable and Solar Technology (FIRST), residents and businesses can receive a loan from the City of Berkeley to pay the up-front costs of renewable energy installations. Entities that receive funding pay off the loan over 20 years through a special property tax addition. Forty solar photovoltaic projects were funded in 2008–9 pilot year, and the program may expand to include solar thermal and energy efficiency technology in the future.

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.

Energy Efficiency

Low-income Weatherization and Efficiency—Boulder, Larimer and Gilpin Counties, CO; Phoenix, AZ

Weatherization programs reduce energy bills for low-income households by increasing building efficiency. Kansas City's program to weatherize homes provides energy audits and weatherization services, including repair or replacement of furnaces and water heaters, ductwork, and window repair.

To date since the program began in 2009, it has weatherized 700 homes. Phoenix has also implemented numerous efficiency programs, including one-time grants for energy-reducing home improvements in qualified households and the use of energy-efficient construction for new, low-income housing.

Transportation

Smart Growth/Land Use—Arlington, VA

Arlington's General Land Use Plan promotes the concentration of mixed-use, high-density development near transit centers. It primarily targets areas that are within walking distance of five specified Metro stations and provides residential, retail and recreational development guidelines. Area residents use public transportation at much higher rates than the national average: more than 50 percent take public transit to work and 73 percent walk to Metro stations.

Clean Diesel and Green Fleet Campaigns—Keene, NH

From fire engines to snowplows, all of the diesel vehicles in Keene'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 saves an estimated 417 tons of CO_2 each year from the use of biodiesel.

Green Fleet—Denver, CO

In 1993, Denver created the first Green Fleet program in the nation. Currently, the program incorporates a variety of green transportation options. As of 2010, there were 138 hybrid vehicles in the city fleet, 239 that use compressed natural gas (CNG) or have a gasoline-CNG dual-fuel system, 1,041 that use a biofuel blend, and 74 electric vehicles. Alternative vehicles make up 43 percent of the city fleet.

Trees and Vegetation

Green Roofs and Cool Roofs—Chicago, IL

Green roofs keep buildings cooler during the summer months by using vegetation to provide shade and cool the area through evapotranspiration; cool roofs use special materials to reflect sunlight, minimizing heat gain during the summer and reducing energy consumption by 20 to 70 percent. The City of Chicago requires that new construction with low- and medium-slope roofs adhere to certain standards of reflectivity in order to maintain energy efficiency and reduce the urban heat island effect. The city also offers a grant program for homeowners and small businesses to implement green roofs and cool roofs on their buildings. Today, there are more than 700 public and private green roof projects, totaling more than 7 million square feet in Chicago.

Cross-Cutting

Lead By Example—Seattle, WA

The 2009 Climate Protection Progress Report announced that, as of 2008, Seattle had reduced its greenhouse gas emissions 7 percent since 1990, partially through the implementation of green building standards in public facilities and alternative fuel vehicles in public fleets. In addition, the city's municipal utility, Seattle City Light, is the first 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 produced.

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. Participants are encouraged to reduce their energy use by 5 percent every year, with an overall goal of reducing emissions 25 percent by 2012. Enlisting innovative outreach methods, the program is achieving an estimated annual reduction of 1,500 tons of CO_2 in the residential sector alone. The 10 Percent Challenge highlights several initiatives for emissions reductions, including incentives to trade out gas-powered lawn mowers, a campaign to reduce vehicle idling, and a campaign to reduce speeding on highways to save fuel.

also provide the majority of government services to households and individuals; thus strong local leadership and proactive policies make it easier for individuals to contribute to changes that reduce GHG emissions. The experience of local governments suggests that certain key elements contribute to the success of local, state, or regional climate protection strategies, including the following:

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. Many localities have found that it is in their best economic, health, and ecological interest to invest in long-term climate strategies.

Leadership. Mayors and other local leaders have been instrumental in initiating climate action. Former Seattle Mayor Greg Nickels, for example, initiated the U.S. Mayors Climate Protection Agreement when the Kyoto Protocol was enacted in 2005, recognizing that localities would have to take action even if the federal government did not join the international climate agreement. The Mayors' agreement has inspired participation from almost 1,000 other mayors and has brought climate issues to the forefront of cities' agendas.

LOOKING AHEAD

In 1995, only 15 local governments in the United States were engaged in climate protection activities. Fifteen years later, more than 1,000 cities, towns, and counties across the nation have committed to climate action. Almost in tandem, state governments 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 and should be supported by a comprehensive national and international commitment to climate protection.

ENDNOTES

1 Department of Health and Human Services. Centers for Disease Control and Prevention. "Heat Waves." http://www.cdc.gov/climatechange/effects/heat.htm

2 United States Conference of Mayors. 2008. "U.S. Metro Economies: Current and Potential Green Jobs in the U.S. Economy." Prepared by Global Insight. October 2008.

3 The targets adopted by the City of Toronto have since been revised. The new targets aim for a 6 percent reduction from 1990 levels by 2012, 30 percent by 2020, and 80 percent by 2050.

4 This program was launched in 1991 by the International Council for Local Environmental Initiatives (ICLEI).

5 United States Conference of Mayors. 2007. Survey on Mayoral Leadership on Climate Protection. Mayors Climate Protection Center. http://www.usmayors.org/climateprotection/climatesurvey07.pdf

6 City of New York. 2007. *PLANYC: a Greener, Greater New York.* http://www.nyc.gov/html/planyc2030/html/home/home.shtml

7 City of Albuquerque. http://www.cabq.gov/albuquerquegreen

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









In an effort to inform the climate change dialogue, the Pew Center on Global Climate Change has 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, adaptation efforts, technological solutions, business solutions, international action, policy options at the U.S. federal level, 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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