CLIMATE CHANGE 101
Understanding and Responding to Global Climate Change

January 2009 Update

PEW CENTER ON Global CLIMATE CHANGE

THE PEW CENTER ON THE STATES

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CLIMATE CHANGE 101
Overview

The science is clear: climate change is happening, and it is linked directly to human activities that emit greenhouse gases. This overview summarizes the eight-part series *Climate Change 101: Understanding and Responding to Global Climate Change*. *Science and Impacts* discusses the most current scientific evidence for climate change and explains its causes and projected impacts. *Adaptation* discusses these impacts in greater depth, explaining how planning can limit 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. *Cap and Trade* explains how a cap-and-trade program sets a clear limit on greenhouse gas emissions and minimizes the costs of achieving this target, offering an environmentally effective and economically efficient response to climate change. *Business Solutions*, *International Action*, *State Action*, and *Local Action* describe how business and government leaders at all levels have recognized both the challenge and the vast opportunity 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 international level, and the United States must re-engage in the global effort and adopt strong and effective national policies.

A REAL PROBLEM WITH REAL SOLUTIONS

Scientists state unequivocally that the earth is warming. Climate change is happening, it is caused in large part by human activity, and it will have many serious and potentially damaging effects in the decades ahead. 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 greenhouse gas, are at a level unequaled for at least 800,000 years. The greenhouse gases from human activities are trapping more of the sun's heat in the earth's atmosphere, resulting in warming. Over the last century, average global temperatures rose by more than 1°F and some regions warmed by as much as 4°F. The oceans have also warmed, especially in the upper layers (see Figure 1).

Carbon dioxide and other greenhouse gases always have been present in the atmosphere, keeping the earth hospitable to life by trapping heat. Yet, since the industrial revolution, emissions of these gases from human activity have accumulated steadily, trapping more heat and resulting in the enhanced greenhouse effect (see Figure 2). In 2005, atmospheric carbon dioxide concentrations had increased by 35 percent compared to pre-industrial levels, and concentrations of other greenhouse gases had grown

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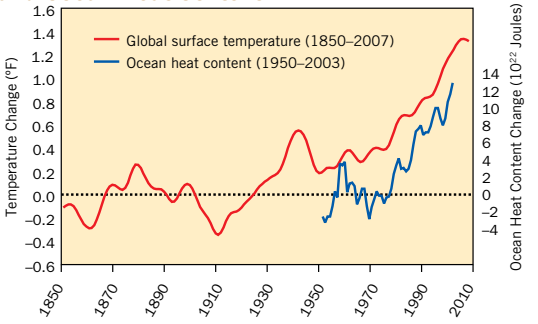
This brief is part of a series called *Climate Change 101: Understanding and Responding to Global Climate Change*, published by the Pew Center on Global Climate Change and the Pew Center on the States.

Figure 1

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: Brohan, P., J.J. Kennedy, S.F.B. Tett, and P.D. Jones. "Uncertainty estimates in regional and global observed temperature changes: A new dataset from 1850." *Journal of Geophysical Research* 111, no. D12106 (2006): doi: 20.2029/2005JD006548.

Ocean heat: Domingues, C.M., J.A. Church, N.J. White, P.J. Gleckler, S.E. Wijffels, P.M. Barker and J.R. Dunn. 2008. Improved estimates of upper-ocean warming and multi-decadal sea-level rise. *Nature* 453:1090-1093.

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 greenhouse gas emissions continues unabated, temperatures could rise by as much as 11°F by the end of this century, likely causing dramatic—and irreversible—changes to the climate, with profound consequences for humanity and the world as a whole. Water supplies in some critical areas will dwindle as snow and ice disappear. Sea levels will rise, threatening coastal populations. Droughts and floods will become more common. And hurricanes and other powerful storms will cause more and more damage. Agricultural production may increase with slight warming, but will decrease thereafter 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.

Figure 2

The Greenhouse Effect

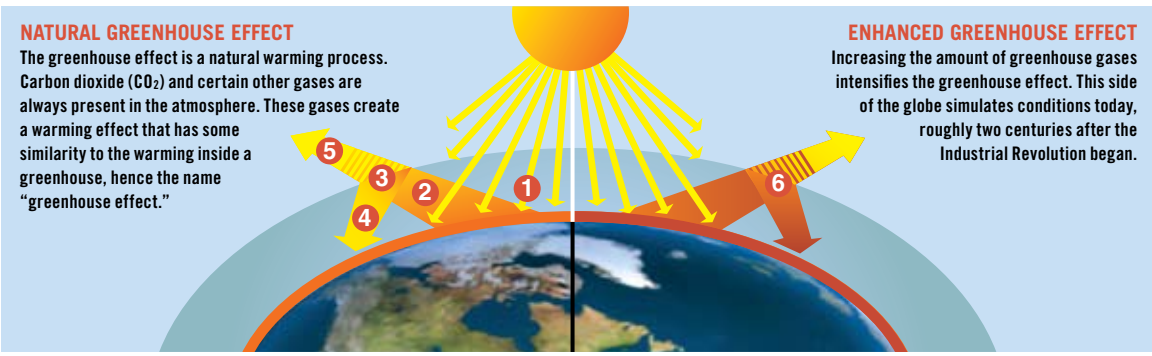


Illustration of the greenhouse effect (adapted with permission from the Marian Koshland Science Museum of the National Academy of Sciences). Visible sunlight passes through the atmosphere without being absorbed. Some of the sunlight striking the earth ❶ is absorbed and converted to heat, which warms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

The consensus among climate scientists is that to avoid the most severe consequences of global warming, global emissions of greenhouse gases need to peak no later than 2015 and decline rapidly thereafter to a level between 50 and 85 percent below 2000 levels by 2050. Later in the century and beyond, emissions must continue to decline to near zero. Adapting to unavoidable climate change while simultaneously reducing emissions to these levels are major challenges that require unprecedented cooperation and participation across the world.

ADAPTATION

Reducing emissions will decrease the ultimate magnitude of global warming and its related impacts. However, carbon dioxide and other greenhouse gases 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. Due to this time lag, the Earth is committed to some 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 the history of civilization. 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).

Recognizing these risks, governments and other entities around the world are acting now to limit potential damage from climate change rather than waiting and having to take more costly, reactive measures in the future. Although

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

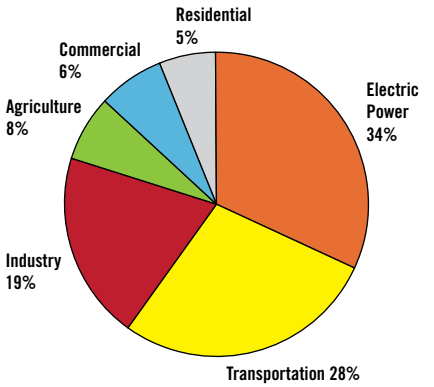
Impacts	Region
Coastal flooding/erosion	South, Southeast, Mid-Atlantic, Northeast, Northwest, Alaska
Hurricanes	Atlantic and Gulf of Mexico coastal areas
Decreased snow cover and ice, more intense winter storms	Alaska, West, Great Lakes, Northeast
Flooding/intense precipitation	All regions, increasing 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

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 and individually and at all levels of society—to take serious action to reduce 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. 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

2006 U.S. Greenhouse Gas Emissions by Sector (Million Metric Tons CO_2 Equivalent)



SOURCE: U.S. EPA, 2008. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006.*

REDUCING EMISSIONS: WHAT IT WILL TAKE

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

Although greenhouse gas emissions are primarily associated with the burning of fossil fuels (chiefly, coal, oil and natural gas), they come from many sources. As a result, any effort to reduce the human impact on the climate will need to engage all sectors of 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 grow the economy and protect the climate.

Right now, the true costs of greenhouse gas emissions are not reflected in the marketplace. Policies, such as "cap and trade," that send a clear price signal to the market by putting a financial cost on greenhouse gas emissions will make many low-carbon technologies commercially competitive with traditional greenhouse gas-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 to develop advanced 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 reduction levels 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 increasing share of electricity from climate-friendly, renewable sources such as solar, wind,

Getting it Done—in "Wedges"

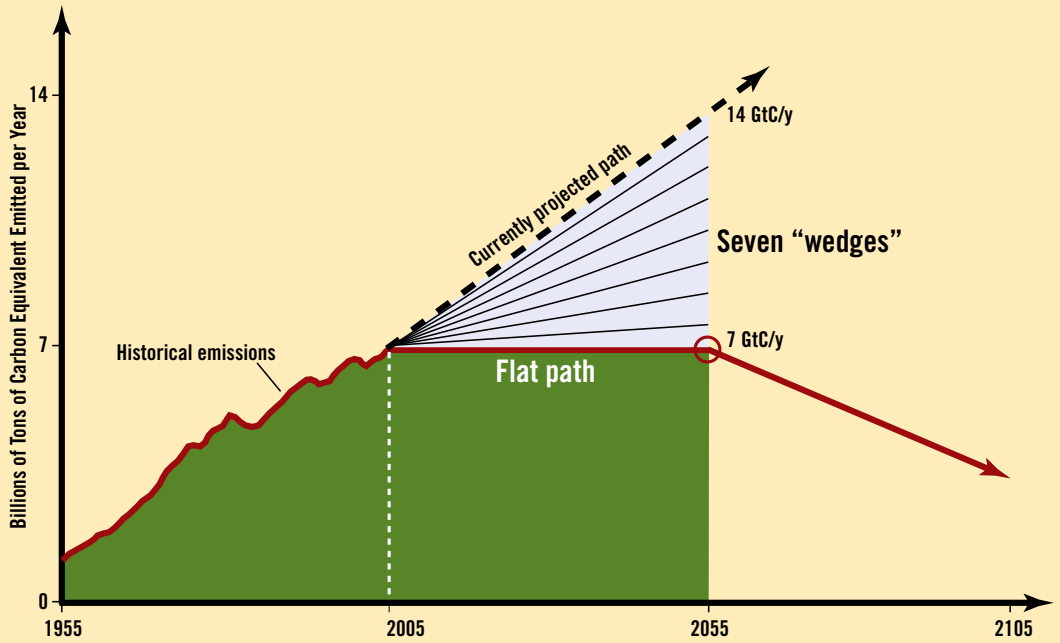
One oft-cited forecast suggests that under a "business-as-usual" scenario, annual global greenhouse gas emissions will reach 14 billion tons (gigatons) per year by 2055. Assuming we need to cut those emissions at least in half (or by a minimum of 7 gigatons), researchers Robert Socolow and Stephen Pacala have suggested that one way to think about the problem is to break the necessary reduction into seven wedges. Each wedge represents a strategy that can reduce carbon emissions by 1 gigaton per year within 50 years. Figure 4 shows the result of the so-called "wedges" analysis of Socolow and Pacala.*

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

- Producing two billion cars that travel 60 miles per gallon of gasoline instead of 30 miles per gallon
- Build two million 1-megawatt wind turbines to displace coal power
- Build 700 gigawatts of nuclear power to displace coal power (twice current global nuclear capacity)
- Decrease car travel for two billion 30 mpg cars from 10,000 to 5,000 miles per year
- Capture and store greenhouse gas emissions at 800 large coal plants
- Improve energy efficiency by one-fourth in buildings and appliances
- Produce 100 times current U.S. ethanol output

Figure 4

Stabilizing and Reducing Global Emissions



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

and tidal power; developing new technologies to store carbon-dioxide emissions underground; and investing in new nuclear facilities if concerns over security and waste disposal are adequately addressed. 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 and pull new technologies into mainstream use. A comprehensive strategy of economy-wide and sector-specific policies is needed. Key policy solutions include investments in science and technology research; efficiency standards for buildings, vehicles, and appliances; and perhaps most importantly, an overall limit on greenhouse gas emissions and a market for reductions.

Despite its strengths, cap and trade alone cannot achieve the GHG emissions cuts necessary to address climate change. However, it can be a key part of the solution when combined with other regulatory measures and incentives.

CAP AND TRADE

Policymakers have many options as they consider how to achieve greenhouse gas emission reductions. One proven market-based approach is cap and trade.

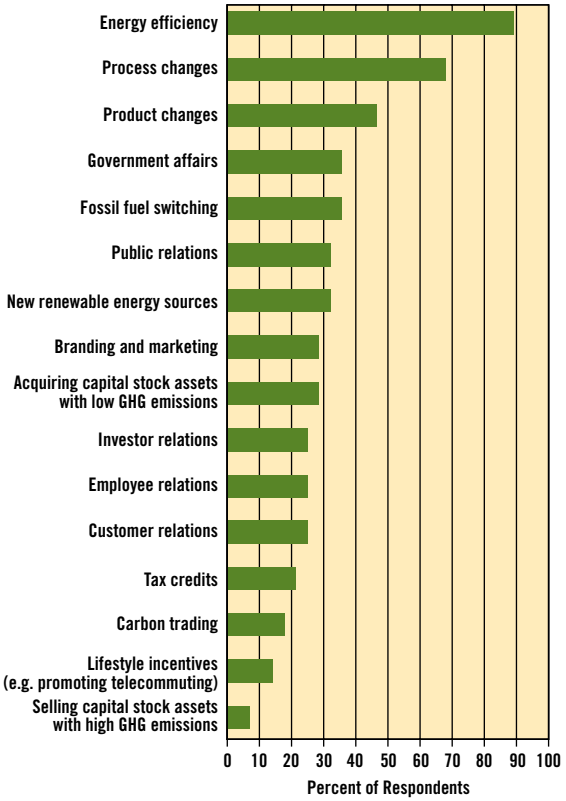
In a cap-and-trade program, the government determines which facilities or emissions are covered by the program and sets an overall emission target, or "cap," for covered entities. This cap is the sum of all allowed emissions from all included entities. Once the cap has been set and covered entities specified, tradable emissions allowances (authorizations to emit) are distributed (either auctioned or freely allocated or a combination of the two). Each allowance authorizes the release of a specified amount of greenhouse gas emissions. The total number of allowances is equivalent to the overall emissions cap (e.g., if a cap of one million tons of emissions is set, one million one-ton allowances will be issued). Covered entities must submit allowances equivalent to the level of emissions for which they are responsible at the end of each of the program's compliance periods.

Allowance trading occurs because firms face different costs for reducing emissions. For some emitters, implementing new, low-emitting technologies may be relatively inexpensive. Those firms will either buy fewer allowances or sell their surplus allowances to firms that face higher emission control costs. Since a ton of carbon dioxide emitted from one source has the same warming effect as a ton emitted from any other, the location of a given emissions reduction does not matter. By giving firms a financial incentive to control emissions and the flexibility to determine how and when emissions will be reduced, the capped level of emissions is achieved in a manner that minimizes overall program costs.

A key advantage of cap and trade (and market mechanisms in general) is that it provides an incentive for continuous innovation in emission reductions. In a cap-and trade-program, a firm that can reduce emissions at a cost lower than the allowance price either reduces its compliance cost (because fewer allowances need to be purchased) or frees up allowances that can be sold to others. This financial incentive drives the private sector to continually innovate and seek new emission-reducing technologies that regulators might not anticipate under more prescriptive command-and-control regulations.

Figure 5

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

Despite its strengths, cap and trade alone cannot achieve the greenhouse gas emissions cuts necessary to address climate change. However, it can be a key part of the solution when combined with other regulatory measures and incentives. Once established, a well-designed cap-and-trade market is relatively easy to implement, can achieve emission reductions goals in a cost-effective manner, and drives low-greenhouse gas innovation.

EMBRACING CLIMATE SOLUTIONS

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

Business Solutions. Leading businesses around the globe are taking action to reduce their impact on the climate and to advocate for sensible policy solutions. Recent years have seen a shift in corporate approaches to climate change from focusing exclusively on risk management and protecting the bottom line to the pursuit of new business opportunities. Improvements in energy efficiency, for example, can lead to reduced costs; sales of climate-friendly products and services are growing rapidly; and new markets for carbon reductions are taking off. Figure 5 shows a ranking of private sector activities that benefit the bottom line based on a 2006 Pew Center on Global Climate Change poll of 33 major corporations.

Many corporate leaders increasingly believe that the growing certainty about climate science, coupled with increasing efforts at the local, state, and international levels, and a new U.S. Administration, means that U.S. federal government action is imminent. Companies want a head start over their competitors in learning how to reduce their emissions. Others in the private sector are responding to growing pressure from investor and consumer groups for disclosure of climate-related risks and integration of climate concerns into companies' core business strategies. There may also be considerable risk to a company's brand and reputation if customers, partners, investors, and/or employees 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 that policy decisions made on this issue will have substantial implications for future profits, business leaders increasingly are engaging with policymakers to help influence those decisions. Many of these business leaders favor approaches that level the playing field among companies, create more certainty for businesses, and spread responsibility for greenhouse gas emission reductions across all sectors of the economy. The Pew Center on Global Climate Change's Business Environmental Leadership Council includes more than 44 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 greenhouse gas 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 calling for the prompt establishment of a binding domestic cap on emissions, is perhaps the most dramatic example of positive business engagement on the climate issue. The coalition urges the adoption of a market-driven, economy-wide approach to reducing greenhouse gas 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 greenhouse gas emissions, and companies continue to announce new, ambitious voluntary greenhouse gas 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 is a global problem requiring a global response. Energy-related carbon dioxide emissions have risen 145-fold since 1850 and are projected to increase another 54 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 18 percent of global greenhouse gas 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 roughly twice as high as those of the EU and Japan (and four times the world average). U.S. emissions are projected to rise 14 percent above 2005 levels by 2020. By comparison, emissions are projected to grow 2.5 percent in the EU and 5 percent in Japan.

Emissions are rising fastest in developing countries. China's and India's emissions are projected to grow 71 percent and 68 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. Looking at emissions on a cumulative basis, the United States accounts for 30 percent of energy-related carbon dioxide emissions since 1850, while China accounts for 7 percent. Cumulative emissions are an important measure because of the long-lasting nature of greenhouse gases 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 with the objective of avoiding dangerous human interference in the climate system (189 countries, including the United States, have ratified the agreement). In the Convention, developed countries agreed to "take the lead" in addressing climate change and to the voluntary "aim" of reducing their emissions to 1990 levels by 2000. Soon recognizing that stronger action was needed, governments launched new negotiations on binding emission targets for developed countries. The resulting agreement, the Kyoto Protocol, requires industrialized countries to reduce emissions on average 5.2 percent below 1990 levels by 2008–2012. 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 2007, governments launched a parallel negotiating process under the Framework Convention, that includes the United States. It is hoped that negotiations under the Kyoto and Convention tracks will converge in a comprehensive post-2012 agreement in Copenhagen in late 2009.

At the national and regional levels, a range of policies contribute to reducing greenhouse gas emissions. The most far-reaching is the EU's Emissions Trading Scheme, which caps emissions from 12,000 facilities across 27 countries. In major developing countries like China and India, policies driven by economic, energy, or development objectives in many cases contribute to greenhouse gas reductions. China, India and other major developing economies have released national climate plans outlining policies and measures that result in climate co-benefits.

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

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.

In considering the U.S. policy response to climate change, both at home and abroad, one concern is the potential impact on U.S. competitiveness. Emission limits like those proposed in cap-and-trade legislation before Congress are projected to affect economic growth rates only marginally, and thus pose little risk to the competitiveness of the U.S. economy as a whole. Any potential competitiveness risks would be felt most directly by energy-intensive industries whose goods are traded internationally, an important but relatively small segment of the U.S. economy.

Under a cap-and-trade system, options for addressing competitiveness include exempting trade-exposed energy-intensive industries from the cap or freely granting them emission allowances on the basis of historical or current emissions, output or environmental performance. Compensation for indirect regulatory costs (higher energy prices) can be provided through additional free allowances or tax rebates. An alternative approach is to impose taxes or allowance requirements on energy-intensive imports from countries with weaker emission controls. Other policy options include: tax and other incentives for accelerated deployment of cleaner technologies; support for research and development of long-term technologies; and transition assistance for affected workers.

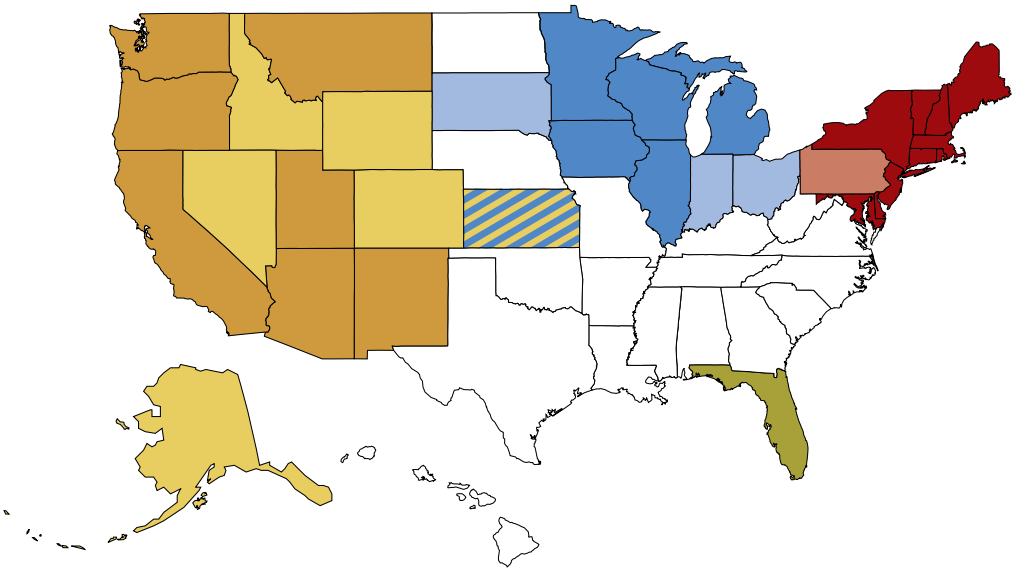
United States: Federal Action. A number of senators and representatives—both Democrats and Republicans—have offered proposals to limit greenhouse gas emissions, but a mandatory climate bill has yet to pass in either branch of Congress. Nonetheless, momentum for action is growing, as indicated by the increasing number of bills, votes, and hearings held on climate-related issues in Congress in recent years. President Barack Obama, who assumed the presidency in January 2009, has repeatedly expressed a firm commitment to comprehensive climate policy that would set mandatory limits on U.S. greenhouse gas emissions, as well as promote investment in clean energy technology and job opportunities.

United States: State Action. The lack of 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 21 states actually have set quantitative targets or goals, ranging from modest to aggressive, to reduce their GHG emissions. A total of 23 states are in the process of establishing regional cap-and-trade

Figure 6

State and Regional Cap-and-Trade Initiatives



- Western Climate Initiative
- Western Climate Initiative Observer
- Midwest Greenhouse Gas Reduction Accord
- Midwest Greenhouse Gas Reduction Accord Observer
- Individual State Cap-and-Trade Program
- Regional Greenhouse Gas Initiative
- Regional Greenhouse Gas Initiative Observer

*State with diagonal shading indicates two categories

programs to reduce greenhouse gases, and Florida is developing its own such program to be linked with one or more of these regional efforts.

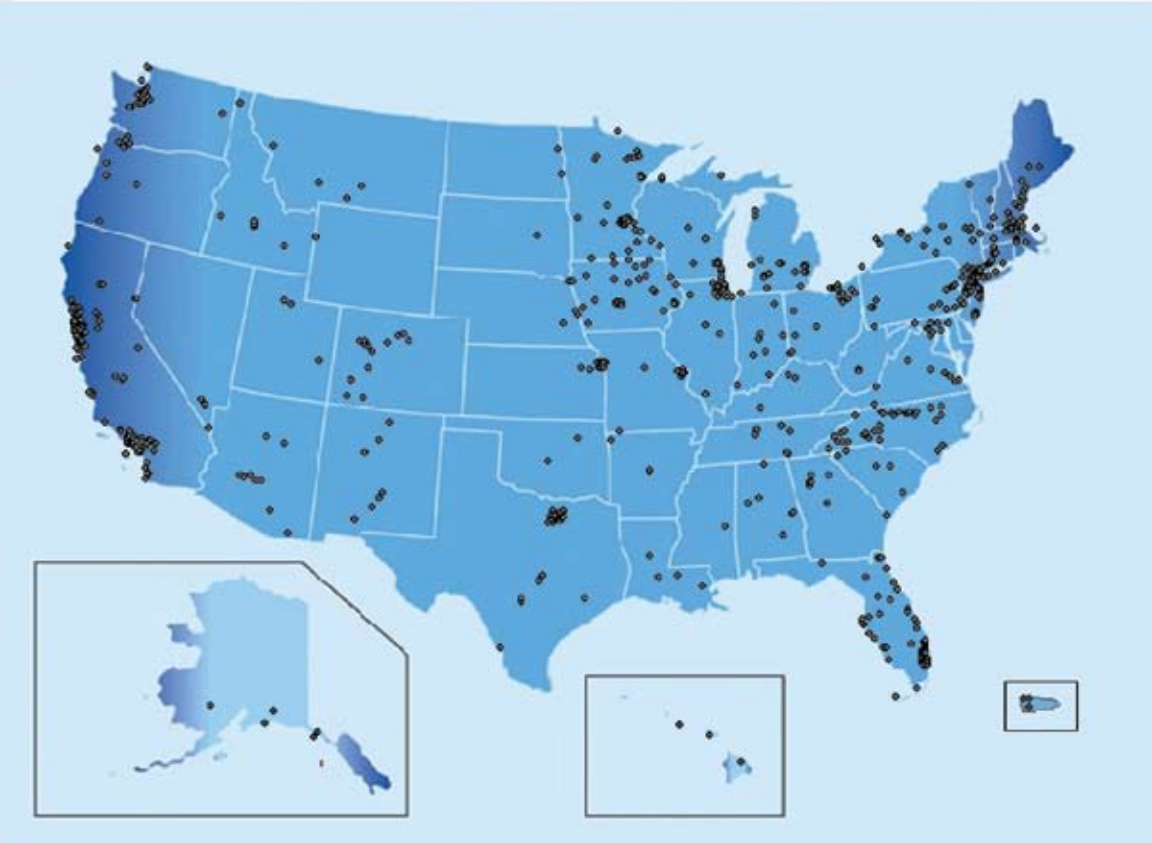
Beyond these broad-based plans and targets, 29 states have adopted policies that reduce emissions from electricity generation by requiring that utilities generate a specified share of power from renewable sources. States also are directing public funds to energy efficiency and renewable energy projects 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 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 greenhouse gases, producing levels comparable to those of many developed countries. In addition, state actions are showing it is possible to reduce emissions and spur technological innovation without endangering economic competitiveness. And, through interstate partnerships (see Figure 6), states are demonstrating the power of collective action to reduce costs and to achieve increased efficiency, while cutting emissions across a larger geographic area.

State and regional cap-and-trade analyses and decisions are providing helpful lessons for federal policy makers designing a federal cap-and-trade program. 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

Figure 7

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



Mayors of 884 cities have signed the U.S. Mayors Climate Protection Agreement as of September 2008. Source: http://www.seattle.gov/Mayor/Climate/

utilities), states have an important role to play in addressing climate change. 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 greenhouse gas 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 7).

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 economy-wide action at the federal and international level.

THE PATH FORWARD

The science is clear. Climate change is happening, and the time to act is now. While the early actions of local and state governments, nations, and business leaders are significant, climate change remains a global problem requiring a global solution. Ultimately, a fair and effective international approach must engage all of the world's major economies and allow enough flexibility for all countries to contribute. Substantive U.S. engagement at the international level is crucial to the success of the global effort. On the domestic front, the federal government needs to adopt policies that establish mandatory limits on 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.

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January 2009

CLIMATE CHANGE 101
Science and Impacts

Scientists state unequivocally that the earth is warming. 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 in many places, from rising sea levels to melting snow and ice to changing weather patterns. Climate change is already affecting ecosystems, freshwater supplies, and human health. Although climate change cannot be avoided entirely, the most severe impacts of climate change can be avoided by substantially reducing the amount of heat-trapping gases released into the atmosphere. However, the time available for beginning serious action to avoid severe global consequences is growing short.

CLIMATE CHANGE SCIENCE: THE BASICS

The climate is changing and humans are both contributing to this change and being affected by it. 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.

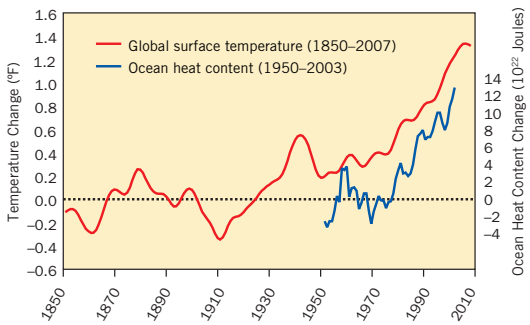
GLOBAL TEMPERATURES: THE EARTH IS WARMING

Global average temperature data based on reliable thermometer measurements are available back to 1850. Over the last century, average global temperatures rose by more than 1°F (see Figure 1), and some regions warmed by as much as 4°F.[1]

According to scientists, this warming trend has accelerated in recent decades. Consequently, data from the University of East Anglia's Climatic Research Unit—the surface temperature data most often used by climate scientists—indicate that the 27 warmest years since 1850 all occurred in the 30 year period between 1978 and 2007.[2] The World Meteorological Organization lists 2005 as the second hottest year on record, surpassed only by 1998.

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).

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PEW CENTER ON Global CLIMATE CHANGE

THE PEW CENTER ON THE STATES

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

Over the past 50 years, the data on extreme temperatures have shown similar trends of rising temperatures: cold days, cold nights, and frosts occurred less frequently over time, while hot days, hot nights, and heat waves occurred more frequently.[3]

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).[4] The upper levels of the oceans have experienced the greatest warming, demonstrating that the oceans are absorbing heat from the atmosphere.[5] Over time, the heat absorbed by the ocean will be released back to the atmosphere as the ocean circulates and deeper waters come into contact with the atmosphere. This equilibration process alone is expected to contribute an additional 1°F of surface warming by the end of the 21st century.[6]

GREENHOUSE GASES: MAKING THE CONNECTION

Although global temperatures have varied naturally in past millennia, scientists studying the climate system say that natural variability cannot account for the rapid rise in global temperatures during the late 20th and early 21st centuries.[7] Human activities cause climate change by adding carbon dioxide 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). Absorbed sunlight warms the surface and is released back into the atmosphere as heat. Certain gases trap this heat in the atmosphere, resulting in warming. This warming is known as the greenhouse effect and the heat-trapping gases are known as greenhouse gases (GHGs) (see Figure 2).

Carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are GHGs that occur naturally and are also released by human activities. Before human activities began to emit these gases, 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 and causing more warming than would occur naturally. Scientists call this human-magnified greenhouse effect the "enhanced greenhouse effect."

Evidence from many scientific studies confirms that the enhanced greenhouse effect is occurring. For example, a 2005 report from NASA's Goddard Institute for Space Studies concluded that more energy from the sun is being absorbed than is emitted back to space. This imbalance is direct evidence for the enhanced greenhouse effect.[8]

Figure 2

The Greenhouse Effect

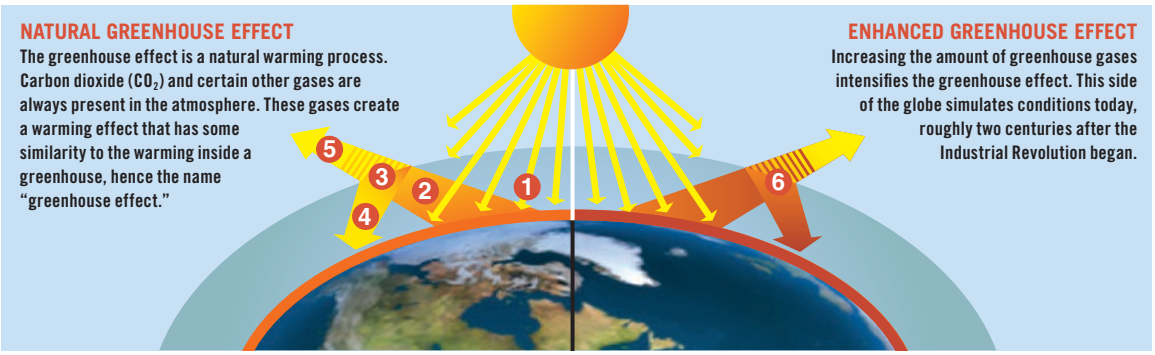


Illustration of the greenhouse effect (adapted with permission from the Marian Koshland Science Museum of The National Academy of Sciences). Visible sunlight passes through the atmosphere without being absorbed. Some of the sunlight striking the earth ❶ is absorbed and converted to heat, which warms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

Greenhouse Gas Levels Rising. In 2007, the Intergovernmental Panel on Climate Change (IPCC), which includes more than 2,000 scientists from the United States and other countries, released its Fourth Assessment Report. It said that average global concentrations of the three main greenhouse gases—CO_2, CH_4, and N_2O—continue to rise. In 2005, CO_2 had increased by 35 percent, CH_4 by 148 percent, and N_2O by 18 percent compared to pre-industrial concentrations.[9]

Carbon dioxide is the principal gas contributing to the enhanced greenhouse effect.[10] 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.

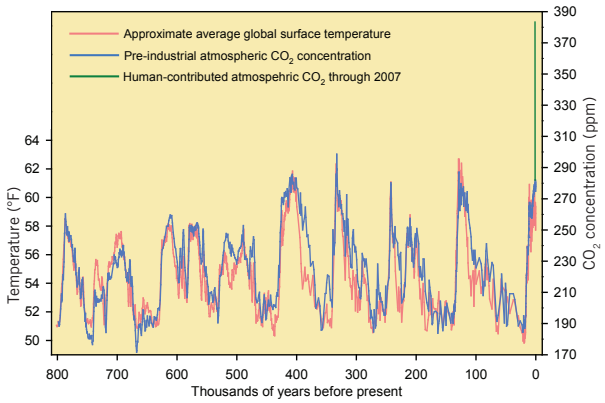
Scientists say that the current trajectory of rising GHG concentrations is pushing the climate into uncharted territory. Carbon dioxide levels are much higher today than at any other time in at least 800,000 years. Through all those millennia, there has been a clear correlation between CO_2 concentrations and global temperatures (see Figure 3), adding geological support for the conclusion by climate physicists that changes in CO_2 concentrations would generate changes in 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 scientific study provide clear evidence linking human actions to increased GHG concentrations. Moreover, the IPCC concluded that there is at least a 90 percent chance that the increase in GHGs in the atmosphere has caused most of the observed global warming in recent decades.[11]

Looking Ahead. The more GHGs we release into the atmosphere, the stronger the enhanced greenhouse effect will become. Global temperatures will continue rising for decades because it takes time for the climate system to

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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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."[12]

respond fully to changing levels of GHGs in the atmosphere. According to the IPCC, human emissions of GHGs to date commit us to a global average temperature increase of at least an additional 1°F. Scenarios in which GHGs continue to be added to the atmosphere by human activities could cause additional warming of 4 to 11°F over the next century if man-made GHG emissions continue to grow as they have in recent years.[13]

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.[14]

The future climate depends largely on the actions taken now to reduce the human activities that contribute to climate change. 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."[15]

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 temperature. Changes in the climate other than average temperatures have more direct impacts on nature and society.

Many of the impacts of climate change anticipated by scientists can already be observed, including the acceleration of sea level rise, the loss of sea ice, changes in weather patterns, and altered water availability and quality in many parts of the world. Climate change also threatens ecosystems and public health. Scientists say these effects are likely to worsen in the decades ahead.

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 2.5 to 6.5 feet higher than it is today, depending on how much land-based ice melts.[17] 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.[18]

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.[19] In the United States, 54 percent of the population lives in proximity to the ocean. 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; the glaciers in Glacier National Park, for example, will likely melt by 2030.[20]

The polar ice sheets have both experienced net losses of ice in recent years.[21] Melting polar ice sheets add billions of tons of water to the oceans each year. A 2006 study showed that the Greenland Ice Sheet is losing ice twice as fast as scientists had previously estimated.[22] Massive amounts of ice are lost annually to the melting and slipping of glacier ice into the ocean, a natural process that has been accelerated by climate change.[23]

The Antarctic ice sheet is also losing ice rapidly. According to a 2007 study, Antarctica is losing ice to the melting and slipping of glacier ice into the ocean at a rate enhanced by climate change.[24] 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. This threshold is unknown, and not knowing exactly what level of warming would destabilize this ice sheet calls for caution in how much more warming we allow.

SHRINKING ARCTIC SEA ICE

Arctic sea ice has seen dramatic declines in recent years. In 2007, Arctic sea ice shrank to its smallest extent observed since satellite measurements began in 1979, opening the Northwest Passage for the first time in human memory (see Figure 4).[25] This new sea ice minimum came only a few months after a study reported that computer models have seriously underestimated the rate of sea ice decline. Since the 1950s, summer sea ice extents have declined three times faster than projected by climate models.[26]

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.

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.

CHANGING WEATHER PATTERNS

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. Scientists explain that hurricanes draw their strength from the heat in ocean surface waters. Therefore, as ocean waters grow warmer, hurricanes become more powerful on average.[27]

This trend toward stronger cyclones is noteworthy because of the vulnerability of coastal communities to these extreme events. Hurricane Katrina, which wreaked havoc along the U.S. Gulf Coast in 2005, and Tropical Storm Nargis, which devastated Burma in 2008, provide painful reminders of this vulnerability. With climate change causing ocean temperatures to rise, the risk of extreme cyclones like Katrina and Nargis can be expected to rise.

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

Figure 4

Summer Arctic Sea Ice Extent

Summertime Arctic sea ice minimum in 2007 (white area) compared to 1979 (red border). **SOURCE:** NASA Goddard Space Flight Center

frequent heat waves and hotter high temperature extremes. 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 between 30,000 and 50,000 excess deaths throughout southern and central Europe.[28]

Extreme rainfall events occur more frequently. 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 100-year flood—a level of flooding so rare that it would not be expected to occur more than once in a century, yet two such floods occurred just 15 years apart.

Extreme weather events will continue to increase and, in turn, affect coastal communities, human health, water quality and availability, and agricultural yields.

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 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 temperature; scientists say that an additional 2°F of warming will increase the risk of extinction for up to 30 percent of species.[29]

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. So, even areas where the average annual rainfall increases may experience more frequent and longer droughts.

Altered Availability and Quality. Warmer temperatures threaten the water supplies of billions of people who depend on water from the seasonal melting of mountain ice and snow in several ways: by causing glaciers and snowpack to melt, 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 the past three decades because snowmelt has occurred earlier and summers are longer and drier.

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.[30] Increased rainfall could also wash more agricultural fertilizer and municiple sewage into coastal waters, creating more low-oxygen "dead zones" in the Chesapeake Bay and the Gulf of Mexico.[31]

EFFECTS ON HUMAN HEALTH

Climate change is expected to affect the health of millions of people 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 populations at greatest risk are those with the least ability to adapt: the elderly, the infirm, and the poor.

Each climate impact also affects public health. As sea level rises, the number of people at risk for flooding from storm surges rises, too. For example, a moderate amount of sea level rise of about 16 inches by 2080 could put an additional 125 million people worldwide at risk from flooding due to storm surges.[32] 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.[33] The negative impacts on public health globally are expected to outweigh the benefits.[34]

WHAT CAN BE DONE

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

However, it is still possible—and necessary—to reduce the magnitude of climate change by stabilizing atmospheric concentrations of GHGs. The consensus among climate scientists is that global emissions of GHGs need to peak by 2015 and decline rapidly thereafter to avoid the most severe consequences of climate change. By 2050, global emissions need to be reduced to between 50 and 85 percent below 2000 levels to stabilize atmospheric GHGs at a level that significantly reduces the risks of climate change.[35]

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

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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 affect 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 warming will still occur. Adaptation planning at the local, state, and national levels can limit the damage caused by climate change, as well as the long-term costs of responding to climate-related impacts that are expected to grow in number and intensity in the decades to come.

CLIMATE CHANGE IMPACTS IN THE U.S.

For more than 50 years, the Earth's climate has been changing because of increasing greenhouse gas 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 last 30 years, particularly in the last decade. Science shows that climate change will continue, and accelerate, in the years ahead, with significant impacts on everything from our coastlines and our health to water supplies, ecosystems, and other natural resources.

Warming and impacts vary by location. If greenhouse gas emissions continue unabated, the continental United States is expected to warm one-third more than global averages,[2] meaning that Americans can expect an increase of 3–7ºC (5.4–12.6ºF), depending on where they live. For Alaska and the Arctic region as a whole, warming projections of 4–11ºC (7.2–19.8ºF) are at least *double* the mean increase for the world.[3] 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).[4]

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. 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 (see Table 1).[5] 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,

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including potentially significant losses of coastal wetlands.[6] All of these impacts will affect food and water supplies, natural resources, ecosystems, and human life and property (see Table 2). 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.[7] 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

Table 1. Sample of Projected U.S. Regional Climate Impacts[3,5]

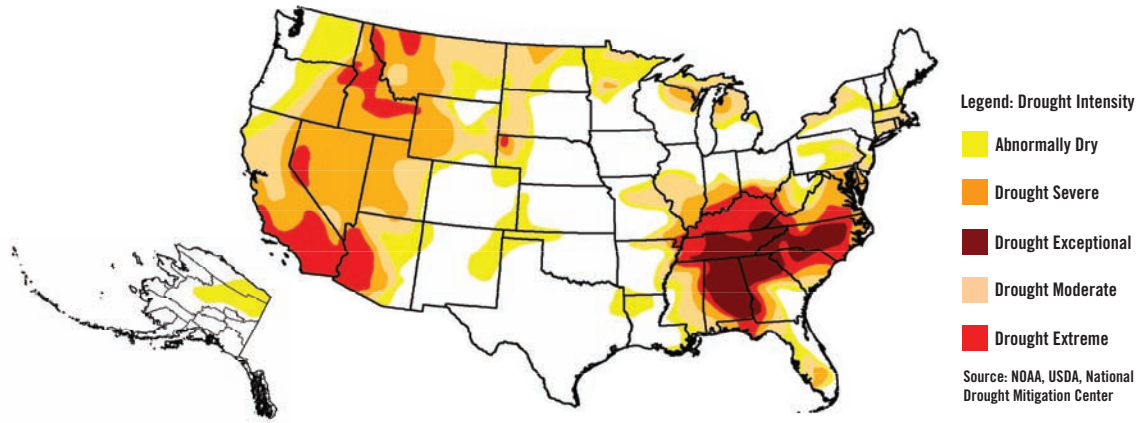
Impacts	Region
Coastal flooding/erosion[8]	South, Southeast, Mid-Atlantic, Northeast, Northwest, Alaska
Hurricanes	Atlantic and Gulf of Mexico coastal areas
Decreased snow cover and ice, more intense winter storms	Alaska, West, Great Lakes, Northeast
Flooding/intense precipitation	All regions, increasing 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 (see Figure 2)
Wildfires[8]	West, Alaska
Intense heat waves[8]	All regions

Table 2. Sample of U.S. Sectors and Projected Impacts

Sector	Impacts
Freshwater resource management[7,9,10,11]	Salination of freshwater; water table/aquifer depletion; increased runoff and pollution of freshwater sources; earlier runoff in snowpack-dominated areas.
Agriculture[7,9,10,11]	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[7,9,10,11]	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[7,9,10,11]	Forest loss to drought, wildfires, infestation, diseases, species migration and loss.
Tourism and recreation[10]	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[7,9,10]	Increased levels of heat stress, respiratory illness, chronic disease, human displacement (short-term and long-term), infectious disease, and premature death.
Transportation infrastructure[10]	Damage from sea-level rise, erosion, flooding and temperature extremes.

Figure 2

U.S. Drought Monitor for the week of October 16, 2007



decrease the magnitude of global warming and its related impacts. But carbon dioxide and other greenhouse gases 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 some 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 both mitigation and 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.[12] 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.[13,14] 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.[15]

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 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.

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 (see Glossary of Terms), 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 building 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.[16] 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 3). 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.

SUCCESSFUL APPROACHES TO ADAPTATION

Adaptation services 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 confronting climate change impacts.

Recognize that adaptation 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

Table 3. Key Factors for Adaptive Capacity[17]	
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.

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?[18] 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 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.[19]

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.[20]
- **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.[21]
- **Low-regret:** Measures with relatively low costs for which benefits under climate change scenarios are high.[22,23] Example: incorporating climate change into forestry, water, and other public land management practices and policies, or long-term capital investment planning.

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. 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. Forthcoming. *Adapting to Climate Change: A Business Approach.* Pew Center on Global Climate Change: Arlington, VA.

- **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.[24] 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. STATES AND CITIES ARE BEGINNING ADAPTATION EFFORTS

Comprehensive, proactive adaptation planning is still in the early stages in the United States. As of November 2008, more than 75 bills had been introduced in Congress that addressed some aspect of adaptation. Many of the bills address mitigating impacts to fish and wildlife, natural resources, oceans or marine life. Others provide research or support to states on vital issues such as water resources or coastal impacts. A number call for both national and regional adaptation cost assessments. One bill focuses on potential conflicts over resources and environmental refugee concerns stemming from climate change. Taken together, these bills recognize the need for a comprehensive approach to identifying or assessing at-risk systems, and the need to address the scope of funding and responsibility that will be required at both national and state levels to prepare for the full breadth of climate change. In the absence of current federal legislation on adaptation, and recognizing the importance of state and local action, states and localities are beginning to plan and act to address the unavoidable impacts that will occur in the decades to come.

State Actions. State governments are recognizing the need for broad-scale adaptation planning, and have started taking steps toward this goal. Seven states—Arizona, Arkansas, Colorado, North Carolina, South Carolina, Utah, and Vermont—acknowledge adaptation within their climate action plans addressing greenhouse gas mitigation, recommending that comprehensive state adaptation plans be created. Eight other states have already started their adaptation planning efforts, in parallel with their mitigation activities; these states include Alaska, California, Florida, Maryland, Massachusetts, New Hampshire, Oregon, and Washington (see Figure 3).

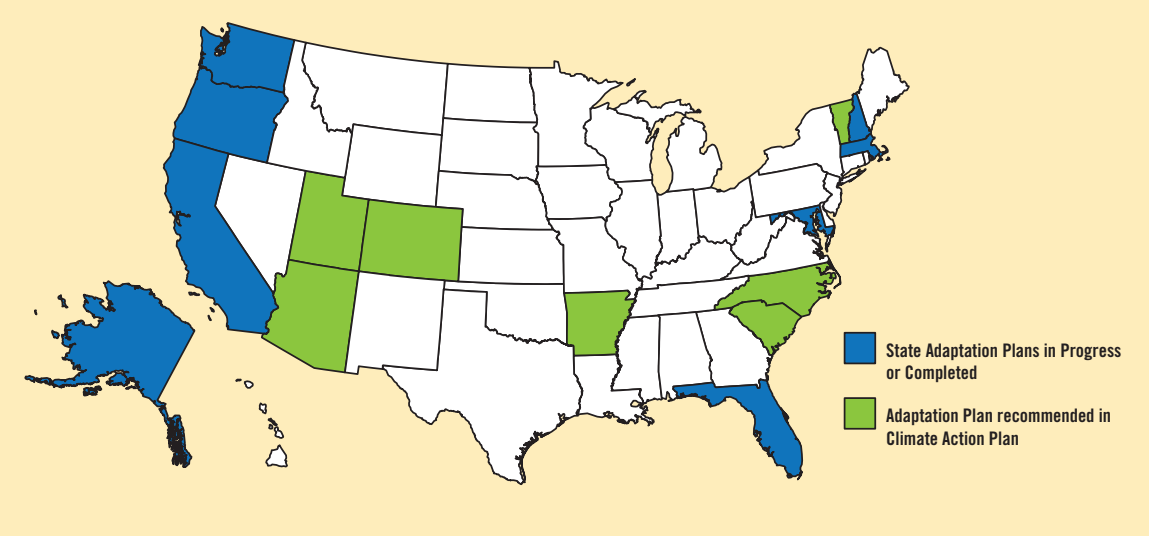
In California, political leaders recognize that climate change is having a wide range of impacts on the state's natural resources, ecosystems, infrastructure, health systems and economy. As climate change continues and accelerates, it will stress these and other sectors further—bringing hotter, drier summers; increased risk of drought and wildfires; 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. Research is under way in the state to identify effective adaptation methods for biodiversity and habitat, infrastructure, oceans and coastal resources, public health, water, and working landscapes including forestry and agriculture.[25]

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. 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*).

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 greenhouse gas 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

Figure 3

State-level Adaptation Planning



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, Seattle's climate action plan calls for an inter-departmental team to prioritize climate change-related issues and to make recommendations on adaptive measures and timing. The plan calls for the evaluation of impacts in several areas, including: sea-level rise, storm water management, urban forestry, building codes, and heat waves. At the same time, Seattle already is engaged in water-supply planning based on projected climate change impacts. 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 calls for the city to conduct adaptation planning to protect critical infrastructure and specific communities at high risk from climate change. The plan also calls for an overall adaptation planning process.

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). Most recently, 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.[26]

THE FEDERAL ROLE

Much investment is needed to help state and local governments, municipalities, private businesses, and individuals manage the impacts of climate change. At the moment, resources are lacking for adaptation planning and related activities, even though

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 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.[27] To date, $279 million in multilateral support has been pledged. Additional funds are now being generated through a levy on emissions credits generated through the Kyoto Protocol's Clean Development Mechanism (CDM). Under the Bali Roadmap, which launched talks on a post-2012 international climate agreement, stronger adaptation support is one of the core issues to be negotiated.

Effective international support will likely require stronger efforts both within and outside the UN climate change regime. Within the regime, options include support for comprehensive national adaptation strategies and for implementation of high-priority projects. Other support can be provided through multilateral and bilateral assistance programs to better integrate climate adaptation into the development process.

For more information on international adaptation, see Burton, I., Diringer, E., Smith, J. *Adaptation to Climate Change: International Policy Options*. The Pew Center on Global Climate Change, Arlington, VA, November 2006.

proactive approaches to reducing risks and limiting impacts can result in significant cost savings in the decades ahead, while protecting critical systems and human life.

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

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).

PREPARING FOR THE FUTURE

While governments at all levels must begin acting to reduce greenhouse gas 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:

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.

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.

Adaptation—What U.S. States and Localities are Doing (2008)—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.

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

U.S. Climate Change Science Program (CCSP): The Climate Change Science Program integrates federal research on climate and global change from agencies such as the Departments of Agriculture, Energy, Interior, and Transportation. Two CCSP adaptation reports currently available for review include:

- *The Impacts of Climate Variability and Change on Transportation Systems and Infrastructure*—This study looks at how climate change could affect roads, airports, rail, transit systems, pipelines, ports, and waterways for a region of the U.S. Central Gulf Coast, and ways to support transportation planning processes. http://www.climatescience.gov/Library/sap/sap4-7/sap4-7-draft3.pdf
- *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.climatescience.gov/Library/sap/sap4-4/public-review-draft/default.htm

The Convention on Biological Diversity: The Convention has created an Adaptation Planning Database and links to scientific studies and other resources, specifically for biodiversity-related climate change adaptation. The database includes data for identifying vulnerable systems, assessing threats and impacts, identifying and evaluating options, and implementing adaptive measures. http://adaptation.cbd.int/

Eldis—Community-Based Adaptation Exchange Program: Eldis is a global services organization specializing in adaptation services in high-risk countries. It offers a database of donors, implementing agencies, academia, and policy organizations involved in adaptation. http://www.cba-exchange.org

ICLEI Local Governments for Sustainability: ICLEI is a global services organization specializing in both mitigation and adaptation support to local governments in the U.S. and globally. Through their Sustainable Cities program, ICLEI works with local governments to build resiliency to climate impacts. http://www.iclei.org

Queensland Climate Change Center of Excellence (QCCCE): Based in Australia, the QCCCE is a new unit within the state's Office of Climate Change, providing policy advice, information, and scientific data on climate change and impacts. *ClimateSmart Adaptation 2007-12* is the government's action plan to increase resilience to climate change impacts in key sectors including: water planning, agriculture, emergency services, human health, tourism, finance, and insurance. http://www.climatechange.qld.gov.au/

University of Washington's Center for Science in the Earth System, Climate Impacts Group (CIG): CIG is an interdisciplinary research group studying the impacts of natural climate variability and global climate change on the U.S. Pacific Northwest. Its research focuses on four key sectors: water resources, aquatic ecosystems, forests, and coasts. CIG performs fundamental research on climate impacts and works with planners and policy makers to apply this information to regional decision-making processes. http://www.cses.washington.edu/cig/

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 U.S. http://www.ukcip.org.uk/

USAID: Through their Global Climate Change Program, USAID helps developing countries and countries in transition address climate-related concerns. In 2007, USAID published a guidance manual for development planning, *Adapting to Climate Variability and Change*. This manual provides guidance on how to assess vulnerability to climate variability and change, as well as how to design or adapt projects so that they are more resilient to a range of climatic conditions. Specific cases on water, flood, and agricultural management impacts and adaptation options are included. http://www.usaid.gov/our_work/environment/climate/docs/reports/cc_vamanual.pdf

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

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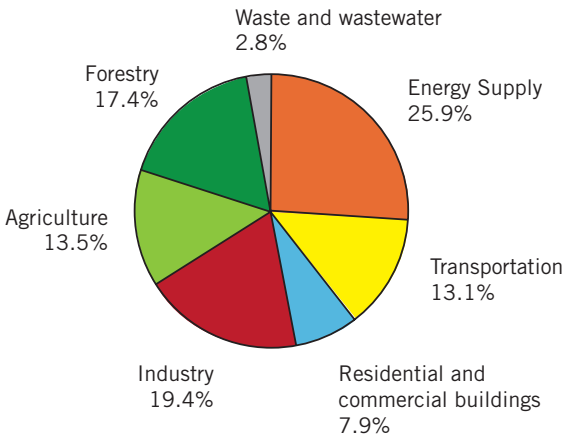
CLIMATE CHANGE 101
Technological Solutions

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. Cost-effective opportunities exist today for starting the world on a path toward lower emissions—and there are a number of emerging technologies that hold enormous promise for delivering substantial emission reductions in the future. The successful development of these technologies will require investments in 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 global warming come from a wide range of sources, including cars and trucks, power plants, factories, farms, and more (see Figure 1). Because there are so many sources of these gases, there are also many options for reducing emissions, including such readily available steps as improving energy efficiency and changing industrial processes and agricultural practices. However, seriously addressing global climate change will require a decades-long commitment to develop and deploy new, low-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, human societies will be pumping ever-increasing amounts of greenhouse gases into the atmosphere. The result will be

Figure 1
Global Emissions by Sector in 2004



Source: *Climate Change 2007: Mitigation.* Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on 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 and the Pew Center on the States.

potentially damaging effects from global climate change. To avert these dangerous levels of global warming, the time to begin making the necessary investments in new technologies is right now. Achieving substantial reductions in greenhouse gas emissions is possible—now and in the decades to come. Some emission-reducing technologies (such as hybrid gas-electric cars and wind power) are commercially competitive today. Others (such as plug-in hybrid cars and carbon capture and storage) are being explored. 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 greenhouse gas emissions are not reflected in the marketplace, meaning there is little incentive for producers or consumers to reduce their contribution to the climate problem. Policies, such as "cap and trade," that send a clear price signal to the market by putting a financial cost on greenhouse gas emissions will make many low-carbon technologies commercially competitive with traditional greenhouse gas-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 to develop advanced 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 and technology development 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 surged in recent years. From 2003 to 2007, venture capital investments in U.S.-based clean energy technology companies grew an average of 56 percent per year.[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 greenhouse gas emissions in the United States can be traced to the electricity, buildings, and transportation sectors. The following pages look at technology options for reducing emissions from each of these critical sectors.

Figure 2

U.S. GHG Emissions by Sector in 2006

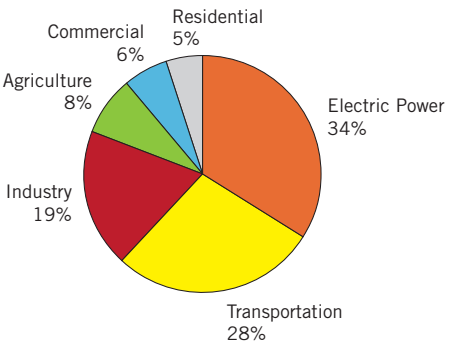
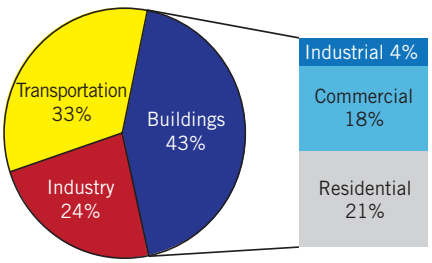


Figure 3

CO_2 Emissions from Fossil Fuel Combustion by End-Use Sector, 2006



Sources: U.S. EPA, 2008. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006;* Pew Center on Global Climate Change, *Towards a Climate-Friendly Built Environment;* U.S. Department of Energy, "Manufacturing Energy Footprint."[5]

ELECTRICITY AND BUILDINGS

In 2006, the electricity sector produced 34 percent of U.S. GHG emissions, primarily carbon dioxide from fossil fuel combustion. Most of the electricity generated by the sector is used in the nation's homes, offices and industrial structures to power everything from heating and cooling systems to lights, computers, refrigerators, and cell phones. 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 greenhouse gases. Because they make such a significant contribution to the problem, the electricity and building sectors also can play a crucial role in solutions to climate change. Reducing emissions from these closely related sectors requires looking at both electric power generation and energy-efficiency options. In other words, it is important to think about the roles of both the producers and the consumers of power.

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

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

- ***Improved Efficiency.*** Technologies are available today to produce electric power and heat more efficiently using both fossil fuels and renewable energy. State-of-the-art natural gas- and coal-fueled power plants produce electricity much more efficiently than do older plants and thus emit fewer greenhouse gases per unit of electricity generated.

- ***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 offer the potential to generate electricity without producing greenhouse gases—or producing very little when compared to traditional energy sources. Most renewable resources can be harnessed on a large-scale basis (for example, via wind farms or large geothermal fields) or in more "distributed" forms (for example, by placing solar panels on rooftops). Although larger-scale renewable energy can be cost-competitive with other forms of conventional electricity in some cases, renewables still account for only a very small share of overall electricity generation in the United States.[6] Options for expanding the use of renewables include: Renewable Portfolio Standards, which require generators to produce a specified share of power from renewable sources; tax credits for renewable energy investments or generation; consumer rebates and other government incentives; greenhouse gas emissions standards for power generators; policies that put a price on greenhouse gas emissions, such as cap and trade; and government support for research and development to advance renewable energy technologies and lower their costs.[7]

- ***Carbon Capture and Storage (CCS).*** While not yet commercially available, a suite of technologies exists that allows for carbon dioxide from the combustion or gasification of coal and other fossil fuels to be captured rather than released to the atmosphere. Once captured, carbon dioxide from fossil fuel use can be injected into and stored long-term (i.e., for thousands of years) in underground geological formations. Because CCS requires expensive equipment and infrastructure to capture, transport, and store carbon dioxide, it is most cost-effectively applied to large stationary sources of carbon dioxide, such as coal-fueled power plants. Around the world, several small-scale CCS demonstration projects are underway and larger projects are planned.[8] However, government incentives are required to spur investments in large-scale CCS projects that can fully demonstrate the technologies and reduce their cost. CCS could prove to be a major source of greenhouse gas emission reductions; modeling done by the International Energy Agency (IEA) forecasts that CCS could provide 20 percent of total global GHG emission reductions in 2050 under a global climate agreement.[9]

- ***Nuclear Power.*** Nuclear power currently provides roughly 20 percent of U.S. electricity with virtually no associated greenhouse gas emissions. Yet, for nuclear power to play a more prominent role in U.S. efforts to address climate change, the industry needs to overcome several important hurdles. These include concerns about the cost of nuclear-generated electricity; technical, political, and environmental concerns about nuclear waste disposal; and risks associated with nuclear arms proliferation. No new nuclear plant has been

ordered and constructed in the United States since 1973, although there is currently a surge in interest in new nuclear plants with groups of companies pursuing applications for new plants.[10,11]

Options for Buildings. Greenhouse gas 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 combustion of fossil fuels in buildings, such as natural gas 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 greenhouse gas emissions, but consumers often fail to invest in even those options that would save them money. The reasons people do not take advantage of more cost- and energy-saving measures include lack of information and misaligned incentives (e.g., between building owners and tenants).[12] Because of inefficiencies in the generation and distribution of electricity to consumers, reductions in demand by energy users result in even larger 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, consumers and businesses have an array of cost-effective options for limiting their energy use and boosting efficiency.[13] However, consumers 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 to 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.*** Greenhouse gas emissions from the electricity and building sectors also can be reduced through on-site power generation using renewables and other climate-friendly energy resources. Examples include rooftop solar panels, solar water heating, small-scale wind generation, stationary fuel cells powered by natural gas or renewable hydrogen, and geothermal heat-pumps. While the costs for all of these options are falling, some of the technologies remain fairly expensive and thus are not widely used in the marketplace. Expanding their use—which will ultimately reduce costs—may require new incentive programs such as consumer rebates and tax credits. Building standards (such as LEED™–certification) also can help.[14] In addition, combined heat-and-power (or cogeneration) plants, rather than wasting the excess heat generated in the course of producing electricity, capture it for use in heating homes and industrial sites. Policymakers should eliminate regulatory barriers that hinder deployment of on-site generation technologies.

A Key Role for Agriculture

Emissions from agriculture account for approximately 8 percent of U.S. greenhouse gas emissions. Reducing these emissions can make an important contribution to the overall U.S. effort to address climate change. But agriculture can be a part of the solution in other ways as well. For example, less productive agricultural lands can be reforested with carbon dioxide-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. carbon-dioxide emissions.[15] In addition, biomass from agricultural sources (including corn and grasses) could be used to produce low-carbon biofuels for transportation or used 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.

TRANSPORTATION

The transportation sector is the second largest source of greenhouse gas emissions in the United States, primarily from carbon dioxide produced by cars and trucks. The ways in which people and goods move from place to place are responsible for almost one-third of U.S. carbon dioxide emissions and about 13 percent of emissions around the world. Reducing greenhouse gas emissions from transportation can be accomplished in three main ways:

- Adopting new emissions-reducing technologies for cars and trucks;
- Reducing the carbon content of vehicle fuels; and
- Reducing the number of miles traveled.

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 greenhouse gas emissions from conventional cars and trucks are possible through the use of 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). One recent study found that available technologies could be deployed to double the average fuel economy of new U.S. cars and light trucks to 45 miles per gallon (mpg) by 2035.[16] In the United States, the Corporate Average Fuel Economy (CAFE) program has regulated light duty vehicle fuel economy for the last 30 years. In 2007, the Energy Independence and Security Act increased CAFE standards, which for passenger cars had been stagnant since 1988. The new standards require that new passenger cars and light trucks, on average, achieve a combined fuel economy of 35 mpg by 2020. California and 16 other states hope to implement even stricter GHG standards that would likely achieve 39 mpg by 2020. These policies can play a crucial role in hastening the rollout of technologies to reduce vehicle emissions.

Another option for reducing greenhouse gas 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. Depending on how it is produced and processed, corn-based ethanol can yield reductions of as much as 30 percent in emissions for each gallon of regular gasoline that it replaces. Other biofuels that can be developed over the longer term promise to deliver significantly larger reductions (see below).

The use of advanced diesel and hybrid vehicle technologies also can yield emission reductions. Diesels and hybrids use different engines than the standard internal combustion engine; diesels also use different fuels. The key advantage of these technologies is that they both offer significant improvements in fuel economy. Because hybrid and diesel vehicles use less fuel on a per-mile basis, they produce fewer greenhouse gas emissions when compared to other cars and trucks. When both technologies are combined in a diesel hybrid vehicle, it can yield a 65 percent reduction in greenhouse gas emissions per mile.[17]

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

- ***Biofuels.*** As noted above, agricultural sources can be used to produce transportation fuel. While ethanol currently produced in the United States comes from corn, the

technology exists to make biofuels from "cellulosic" sources (or the woody and leafy parts of plants). While corn-based ethanol can reduce emissions by as much as 30 percent for every gallon of traditional fuel replaced, cellulosic ethanol and sugar-cane-based ethanol may enable reductions of up to 100 percent.[18,19] (This is because the carbon dioxide released by combusting these biofuels is carbon dioxide that the feedstock plants had absorbed from the atmosphere.) 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.[20] With ethanol from sugar cane providing approximately 40 percent of its domestic passenger fuel in terms of energy, Brazil has shown that an aggressive policy push can help biofuels become a mainstream fuel choice.[21]

- ***Electric Cars.*** Before fully electric cars can become commercially viable, improvements in battery technology are needed. Another option is the "plug-in" hybrid, a 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 40-mile electric range would result in a CO_2 reduction of about 15 percent relative to a regular hybrid.[22]

- ***Hydrogen.*** Hydrogen fuel cells, long a staple of the U.S. space program, produce power by combining oxygen with hydrogen to create water. Technological advances and reductions in the costs associated with the use of fuel cells could lay the groundwork for a hydrogen-based transportation system in the decades to come.[23] 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: affordable hydrogen-powered vehicles, infrastructure for distributing hydrogen and fueling stations, and hydrogen production that does not emit greenhouse gases.[24,25]

GETTING IT DONE

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. 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 greenhouse gas abatement. Second, a market-based climate policy, such as cap and trade, would put a price on greenhouse gas 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.

Government at all levels needs to spur investments in new technologies—by making direct investments in research and development and creating and enhancing incentives for private investment. A cap-and-trade system requires emission reductions while allowing companies to trade emission credits so they can achieve their reductions as cost-effectively as possible. The most important benefit of such an approach is that it establishes a 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 cap-and-trade program holds the promise of encouraging climate solutions without threatening the competitiveness of U.S. industry.

In order to successfully reduce the threat of climate change, the United States and other nations will have to rely on a wide range of technologies over the next century. The exact portfolio of technologies that will be required to achieve the necessary emission reductions is not clear. What is clear, however, is that policies are 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:

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

Induced Technological Change and Climate Policy (2004)

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

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)

A Program to Accelerate the Deployment of CO_2 Capture and Storage: Rationale, Objectives, and Cost (2007)

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

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

Biofuels for Transportation: A Climate Perspective (2008)

Agriculture's Role in Greenhouse Gas Mitigation (2006)

Pew Center on Global Climate Change

These reports are available at www.pewclimate.org.

ENDNOTES

1. 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: The Science and Impacts* at http://www.pewclimate.org/global-warming-basics/climate_change_101.
3. See e.g., *Current and Potential Green Jobs in the U.S. Economy*, 2008, prepared by Global Insight for the U.S. Conference of Mayors.
4. CleanEdge. 2008. *Clean Energy Trends 2008*.
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 2006 renewable energy other than conventional hydropower accounted for 2.4% of U.S. net electricity generation.
7. See e.g., California Energy Commission, "Emerging Renewables Program," available at: http://www.energy.ca.gov/renewables/emerging_renewables/index.html.
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10. See http://www.nei.org and http://www.eia.doe.gov/cneaf/nuclear/page/nuc_reactors/com_reactors.pdf.
11. Wald, Matthew. 2008. "Nuclear Power May Be in Early Stages of a Revival." *The New York Times.* 23 October.
12. 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.
13. EnergyStar is a joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy aimed at protecting the environment through energy-efficient products and practices. For more information, see www.energystar.gov.
14. The LEED (Leadership in Energy and Environmental Design) Green Building Rating System® is a voluntary, consensus-based national standard for developing high-performance, sustainable buildings. For more information, see http://www.usgbc.org.
15. Paustian, Keith, et al. 2006. *Agriculture's Role in Greenhouse Gas Mitigation*. Pew Center on Global Climate Change.
16. Cheah, Lynette et al. 2007. "Factor of Two: Halving the Fuel Consumption of New U.S. Automobiles by 2035." Massachusetts Institute of Technology Laboratory for Energy and the Environment.

17. Greene and Schafer. 2003. *Reducing Greenhouse Gas Emissions from U.S. Transportation*. Pew Center on Global Climate Change.

18. 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.

19. Pena, Naomi. 2008. *Biofuels for Transportation: A Climate Perspective*. Pew Center on Global Climate Change.

20. Paustian, Keith, et al. 2006.

21. Ribando C., Yacobucci B. *Ethanol and Other Biofuels: Potential for U.S.-Brazil Energy Cooperation*. Congressional Research Service, 2007.

22. Kliesch, James, and Therese Langer. 2006. *Plug-In Hybrids: An Environmental and Economic Performance Outlook*, ACEEE, Report Number T061,

23. 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*.

24. 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).

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

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January 2009

CLIMATE CHANGE 101
Cap and Trade

There are a variety of policy tools to reduce the greenhouse gas emissions responsible for climate change. This installment of the Climate Change 101 series explains how a cap-and-trade program sets a clear limit on greenhouse gas emissions and minimizes the costs of achieving this target. By creating a market, and a price, for emission reductions, cap and trade offers an environmentally effective and economically efficient response to climate change.

WHAT IS "CAP AND TRADE"?

Policymakers have many options as they consider how to achieve greenhouse gas (GHG) reductions, but two approaches are most prominent: traditional command-and-control regulation, in which regulatory authorities direct how emissions limits will be achieved, and market-based approaches, which harness the forces of supply and demand to change behavior and achieve environmental goals. One proven market-based approach is cap and trade.

In a cap-and-trade program, the government determines which facilities or emissions are covered by the program and sets an overall emission target, or "cap," for covered entities. This cap is the sum of all allowed emissions from all included facilities. Once the cap has been set and covered entities specified, tradable emissions allowances (rights to emit) are distributed (either auctioned, or freely allocated, or some combination of these). Each allowance authorizes the release of a specified amount of greenhouse gas emissions, generally one ton of carbon dioxide equivalent (CO_2e).[1] The total number of allowances is equivalent to the overall emissions cap (e.g., if a cap of one million tons of emissions is set, one million one-ton allowances will be issued). Covered entities must submit allowances equivalent to the level of emissions for which they are responsible at the end of each of the program's compliance periods.

Allowance trading occurs because firms face different costs for reducing emissions. For some emitters, implementing new, low-emitting technologies may be relatively inexpensive. Those firms will either buy fewer allowances or sell their surplus allowances to firms that face higher emission control costs. Since a ton of carbon dioxide (CO_2) emitted from one source has the same warming effect as a ton emitted from any other, the location of a given emissions reduction does not matter. By giving firms a financial incentive to control emissions and the flexibility to determine how and when emissions will be reduced, the capped level of emissions is achieved in a manner that minimizes overall program costs.

Although a critical and effective component of any comprehensive solution to climate change, cap-and-trade programs alone cannot achieve the GHG emission reductions required to stabilize the climate. Addressing climate change requires a combination of market mechanisms with other policy measures, including incentives and standards. For example, in order to begin rapidly cutting emissions, certain technologies may require additional supportive policies to push them to their full potential. In addition, some emission sources of GHGs cannot easily be covered by a cap-and-trade program and will need to be addressed using other policies.

Figures 1 and 2 illustrate the economic benefits of trading by means of a simplified example.

Emitter A (a power plant) and Emitter B (a manufacturing facility) emit a combined total of 900 tons of CO_2 a year.

PEW CENTER ON Global CLIMATE CHANGE

THE PEW CENTER ON THE STATES

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

The government decides that these total emissions must not exceed 600 tons a year. As can be seen in Figure 1a, the cost of reducing a given amount of emissions for Emitter A is greater than the cost for Emitter B (Emitter A's first 100 tons of reductions cost $2,000, while Emitter B's first 100 tons of reductions cost $1,000, etc.). Under traditional environmental regulation, regulators might direct each facility to cut its respective emissions to 300 tons. Emitter A would spend $5,000, while Emitter B would spend $1,000; the 600 ton goal would be reached at a total of $6,000, or $20 per ton reduced (Figure 1b).

Alternatively, the government could establish a cap-and-trade system, setting an overall emissions cap of 600 tons

Figure 1

Command and Control

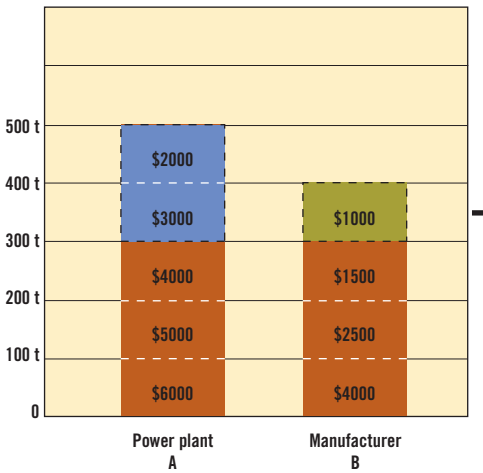


Figure 1a

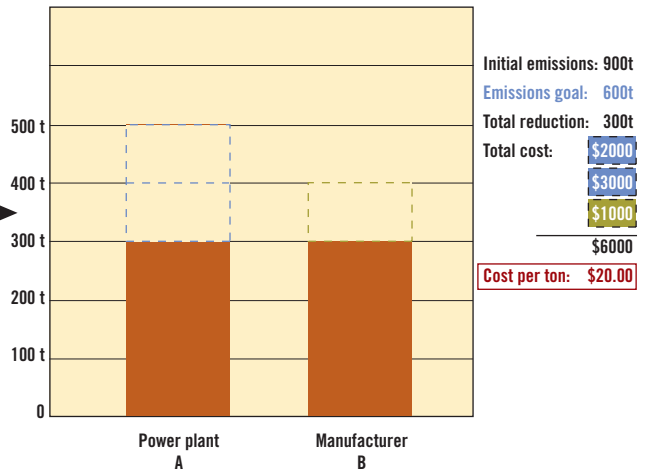


Figure 1b

Figure 2

Cap and Trade

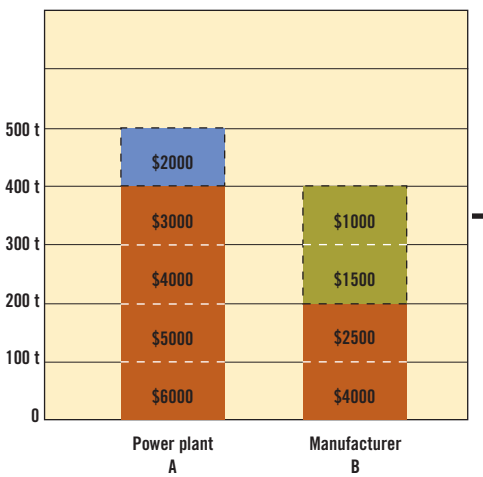


Figure 2a

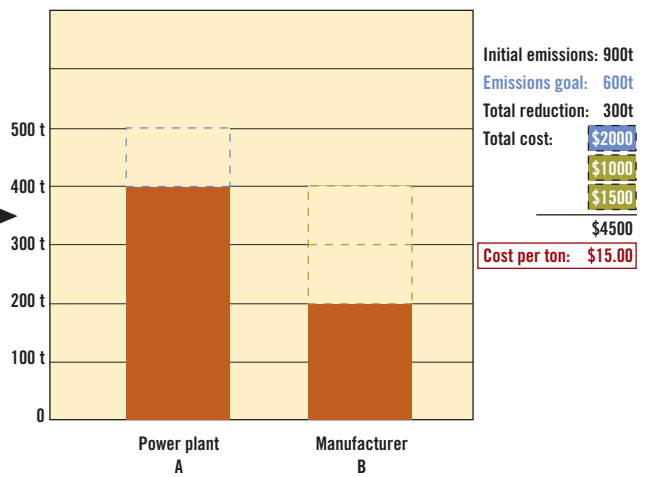


Figure 2b

and then issuing 600 emissions allowances. If allowances were evenly distributed, both emitters would have an incentive to trade because emissions reduction costs are higher for A than for B (Figure 2a). Emitter B might cut emissions by 200 tons and sell its excess allowances to Emitter A for less than it would have cost Emitter A to make the reductions itself (for example, $2,500 for 100 allowances). In this scenario, the desired level of emissions is reached at a lower total cost of $4,500 and a lower cost per ton of $15 (Figure 2b). The total cost is lower, as is the cost for each regulated facility.

DRIVING INNOVATION

A key advantage of cap and trade (and market mechanisms in general) is that it provides an incentive for continuous innovation in emissions reduction.[2] Under traditional command-and-control regulation, there is no incentive to go beyond the regulatory standard. In fact, there may actually be a disincentive to do so because demonstrating the feasibility of additional effort may result in more stringent future regulation. In a cap-and trade-program, a firm that can reduce emissions at a cost lower than the allowance price either reduces its compliance cost (because fewer allowances need to be purchased) or frees up allowances that can be sold to others. This financial incentive drives the private sector to continually innovate and seek new emission-reducing technologies that regulators might not anticipate under more prescriptive command-and-control regulations. In a market system, such emission-reducing innovation can set the stage for deeper emission cuts over time. This is particularly important because meeting the challenge of climate change will require new technology to achieve the very deep emission cuts that are necessary.

CAP AND TRADE MARKET DESIGN

Important decisions have to be made about what a cap-and-trade program will look like, including

- what emissions will be capped by the program (*scope of program*), and what entities will be required to hold allowances equivalent to emissions (*point of regulation*)
- the level of the emissions cap (*stringency)*
- whether provisions will be included to help ensure the costs of the program do not get too high or volatile (*cost containment mechanisms*)
- whether the program should be linked with similar trading programs (*linkage*)
- how allowances are to be distributed (*allowance distribution*)

Emissions Trading: A Homegrown Approach

Emissions trading programs have been used to reduce pollution in the United States since the 1970s, when the Environmental Protection Agency introduced trading as a compliance option for meeting certain requirements under the U.S. Clean Air Act. The 1990 Clean Air Act Amendments established the U.S. Acid Rain program for sulfur dioxide (SO_2), a cap-and-trade system for SO_2 emissions from electric power plants that proved enormously successful, achieving its pollution reduction goals at approximately half the cost of traditional regulation.[3] Moreover, the program has proved administratively efficient, requiring a staff of approximately 50 people to track all emissions data, allowance transfers, and compliance.[4]

Scope and Point of Regulation. The first step in setting up a cap-and-trade program is deciding which greenhouse gases and emissions sources are covered and who is responsible for holding allowances. Some sectors that might be included under the cap are electric power, manufacturing, transportation, or fossil fuel use. In theory, market-based programs are most cost-effective if they cover all GHGs in all major emitting sectors because including more sources and greenhouse gases offers a broader range of opportunities for low-cost reductions. However, including sources that are small or difficult to monitor can make the program too administratively complex; these sources may be addressed more efficiently through other regulatory mechanisms.

After deciding which emissions are covered by the program, policymakers must decide who is responsible for surrendering enough allowances to match their emissions every compliance period. This is known as the "point of

regulation," where compliance is demonstrated by submitting allowances. Which entities are required to submit allowances to cover emissions determines whether a cap-and-trade system is defined as an upstream, downstream, or a product- or load-based program (or some combination of these).

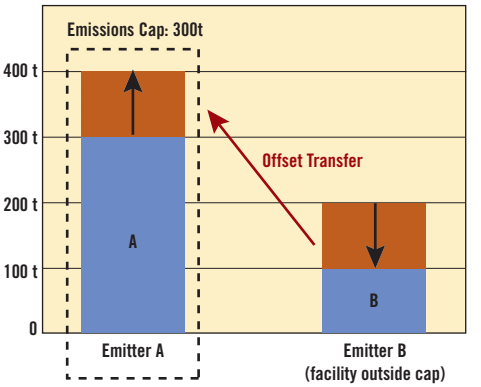
- **Upstream**: A pure upstream, economy-wide system for CO_2 would place a cap on the total amount of carbon contained in fossil fuels and other products used in the economy. It would require importers or suppliers of fossil fuels to submit allowances to cover the carbon in the products they sell. The key argument made in favor of an upstream approach is that one can achieve greater coverage of emissions at a smaller number of sources.
- **Downstream**: Under a downstream, source-based system, the covered entities are direct emitters of greenhouse gases (generally large emitters such as power plants or manufacturing facilities). The key arguments in favor of a downstream approach are that (1) to date, most experience with cap and trade has been based on downstream regulation, and this institutional familiarity makes such an approach less risky; and (2) downstream sources generally have more emission reduction options available, and are thus in a better position to respond to the requirements.[5]
- **Product- or Load-Based:** In a product- or load-based cap-and-trade system, the covered entities are responsible for all the emissions associated with the production of electricity, natural gas, or other product that they provide to customers.[6]

Many argue that, regardless of which entities are covered, an effective cap-and trade-program should follow some basic design criteria:

- Simple, consistent, and transparent rules
- Accurate emissions measurement, monitoring, and reporting, preferably done electronically and including public access to emissions data
- Sound auditing practices to ensure that emissions are being accurately reported
- Consistent enforcement with real penalties for non-compliance and inaccurate reporting
- Unrestricted trading of allowances and minimal transaction costs[7]

Figure 3

Offsets



An offset represents an emissions reduction credit generated by an entity not included under a cap that can be sold to capped entities and used in the same manner as an allowance. In Figure 3 above, Emitter A is included under a cap-and-trade system with an overall cap of 300 tons. If offsets are permitted under the program, an entity outside of the cap (Emitter B) can make an emissions reduction of 100 tons, creating 100 reduction credits that can be purchased by Emitter A to offset a 100 ton increase in its own emissions. Although emissions from the capped entity total 400 tons, Emitter B offsets 100 of those tons, so that, on net, the same emission reductions are achieved.

COST CONTAINMENT MECHANISMS

There are a variety of cost containment mechanisms that can help manage the cost of compliance for covered entities in a cap-and-trade program.

Offsets. Offsets are emission reduction projects undertaken at sources outside a cap-and-trade program. An offset mechanism enables covered entities to offset their own emissions by purchasing emission reduction credits generated through projects at facilities not covered by the cap (Figure 3). Offsets lower the overall cost of the program by bringing in low-cost emission reduction opportunities from outside the cap.

Offset projects may include landfill methane capture, afforestation, or other types of projects. Offsets should be measurable, real, additional,[8] and have clear ownership. Regulators must also be able to verify such projects. Through the Clean Development Mechanism of the Kyoto Protocol, developed countries can use offset projects in developing countries to comply with their targets.[9] The northeast Regional Greenhouse Gas Initiative allows certain types of offsets as well.[10]

Temporal Flexibility: Borrowing, Banking and Compliance Period. Markets can also be designed to include mechanisms for inter-temporal trading, allowing firms greater flexibility in compliance. Such flexibility can reduce allowance price volatility. Regulators can decide to let firms either "bank" or "borrow" their allowances. Banking allows firms to save, or "bank," any excess allowances for future use or to sell later on, encouraging early or over-compliance.[11] Borrowing allows program administrators or covered entities to use in the current year allowances that will be issued in a future year, under the condition that they will "pay back" these allowances (perhaps with interest) by reducing emissions more in the future. Borrowing entails the risk that program administrators or firms will fail to pay back the borrowed allowances and the emission cap could thus be exceeded.

Longer compliance periods also provide some temporal flexibility. A "compliance period" is the length of time for which covered sources must submit allowances equivalent to their level of emissions, or face a penalty for failing to do so. A cap-and-trade program can have several compliance periods, especially if the cap is ratcheted down over time. The length of compliance periods determines how often covered emitters must submit allowances, and has important implications. Longer compliance periods are essentially the same as short-term banking and borrowing.

Safety valves. The term "safety valve" can have many meanings. Generally, it is a mechanism that triggers a change in the cap-and-trade program if compliance costs are higher than expected. The mechanism is often a pre-determined allowance price which triggers additional cost containment measures. The safety valve may allow emitters greater flexibility in how they comply with a cap, for example by increasing the availability of offset credits, changing the timing of program compliance,[12] or expanding the use of "borrowing" allowances (described above).

A safety valve may or may not affect the environmental integrity of the program. One version of a safety valve sets an allowance price cap that triggers the issuance of additional allowances to ensure that the price stays below a certain threshold. Since these additional allowances enable the emissions cap to be exceeded, this type of safety valve does not ensure that environmental goals will be achieved. Another disadvantage of an allowance price cap is that it can inhibit linking or trading with market systems that do not have such a price cap (see below).

Choosing the price at which additional cost containment measures are needed is difficult. If set too high, the price can have little actual effect on costs. If set too low, it can diminish the economic incentive for technological innovation created by a cap-and-trade system.

Linkage. Cap-and-trade programs can be designed to link with other similar trading systems in other regions. Linking to other programs has the advantage of effectively expanding the market, leading to even more opportunities for low-cost emissions reductions and a larger market for new technologies. There are few hard-and-fast barriers to linking, but it is more easily achieved if certain structural elements are comparable in both programs.[13]

ALLOWANCE DISTRIBUTION

Once the cap has been set and the overall design of the cap-and-trade program established, choices have to be made about the best way to distribute emissions allowances.[14] In general, how allowances are initially distributed does not affect the emission reductions achieved by a cap-and-trade program.[15] However, it does affect how the program's costs are distributed and can sometimes affect overall program costs.[16] There are two basic approaches to allowance distribution: some form of free allocation, or some form of auction. A combination of auctioning and free allocation, or a shift from one to the other over time, is also possible. Regardless of which method is favored, either allowance allocation or auction revenues can be used to mitigate economic impacts (e.g., by granting allowances to emitters who are competitively disadvantaged by emission caps) or drive innovation (e.g., by using allowances or auction revenues to fund or incentivize research, development, demonstration and deployment of low-carbon technologies).

Several types of free allocation exist. Allowances can be given away for free based on participating entities' historical emissions (a method also known as "grandfathering"). Output-based methods of allowance allocation are based

on the output of a product in a given sector. For example, allowances might be distributed based on megawatt-hours generated or tons of a product manufactured. Benchmarking, or setting a level of emissions (in the form of allowances) per unit, can be applied based on input or output. Allowance allocations may also be "updated" over time as input, output or emissions change. In the case of free allowance allocation, it is important to bear in mind that the point of regulation described above (where compliance is demonstrated by submitting allowances) does not necessarily need to be the same point at which allowances are initially distributed.

There are tradeoffs between simplicity and equity if allowances are distributed for free. For example, basing allocation on historical emissions is relatively simple. However, it means that some form of credit for early action would be needed to ensure that firms who took voluntary measures to reduce their emissions before the base year are not penalized for doing so. Updating has the advantage of adjusting allocation to changing circumstances. However, while fixed allocations will not affect firms' future behavior, updating encourages firms to behave in ways that will maximize their future allocation. For example, if firms believe that allowances will be distributed based on future emissions, they may try to increase their emissions in order to receive more allowances.

As an alternative to free distribution, allowances can be auctioned. Auctioning generates revenue that the government can use to provide relief for compliance or higher energy costs. The government can also use the auction revenue to reduce other taxes that may be discouraging economic growth, or to fund complementary policies. However, as with the various forms of free allocation, there are tradeoffs involved with auctioning allowances. The impact of costs on a given firm depends on the competitiveness of the industry in which the firm operates as well as that industry's regulatory environment. In some cases, auctioning may unfairly hurt participants lacking the funds to purchase enough allowances from outside the covered region. This is especially true for firms who cannot pass on some or all of the costs of their allowances to consumers. However, firms in other industries might be able to pass on their compliance costs under a cap-and-trade system. In these cases, firms would be over-compensated if most or all allowances were given away for free, which might lead to windfall profits for these firms.

Tax or Trade?

In addition to cap and trade, another type of market mechanism sometimes discussed as a means of reducing GHG emissions is a carbon tax, which would require emitters to pay a tax for every ton of GHGs they emit. The key difference between the two approaches is that cap and trade provides environmental certainty, since the quantity of total allowable emissions is set, while a tax provides price certainty, since the cost of emitting a given amount of GHGs is set. In response to a tax, many emitters will reduce their emissions, but others might simply accept the additional cost and continue to emit. Determining the correct level at which to set a tax in order to drive any given level of emissions reductions is difficult.

Cap and trade and a tax have to address many of the same issues. Both cap and trade and a carbon tax use economic incentives to promote least-cost emission reductions and drive climate-friendly innovation. Both approaches would require careful monitoring and enforcement, and both must address the question of how to distribute costs and benefits. For cap and trade that means figuring out how to distribute and/or auction emission allowances; under a tax that means figuring out who pays the tax and what to do with the tax revenue.

Auctioning some or all allowances could help avoid such windfalls. Auctioning can also help address concerns about crediting early action by firms, as it rewards those who have already reduced emissions by investing in lower-carbon technologies.[17]

Either allowances themselves (in the case of free allocation) or auction revenues (in the case of auctioning) can be used to advance program goals under a cap-and-trade system. For example, if regulators want to promote end-use energy efficiency programs among consumers, they could either use proceeds from auctioning allowances to support efficiency projects, or distribute allowances for free to entities undertaking efficiency projects. Similarly, just as auction revenue can be used to help offset program costs, free allocation can also be used to deal with high compliance costs which might be passed

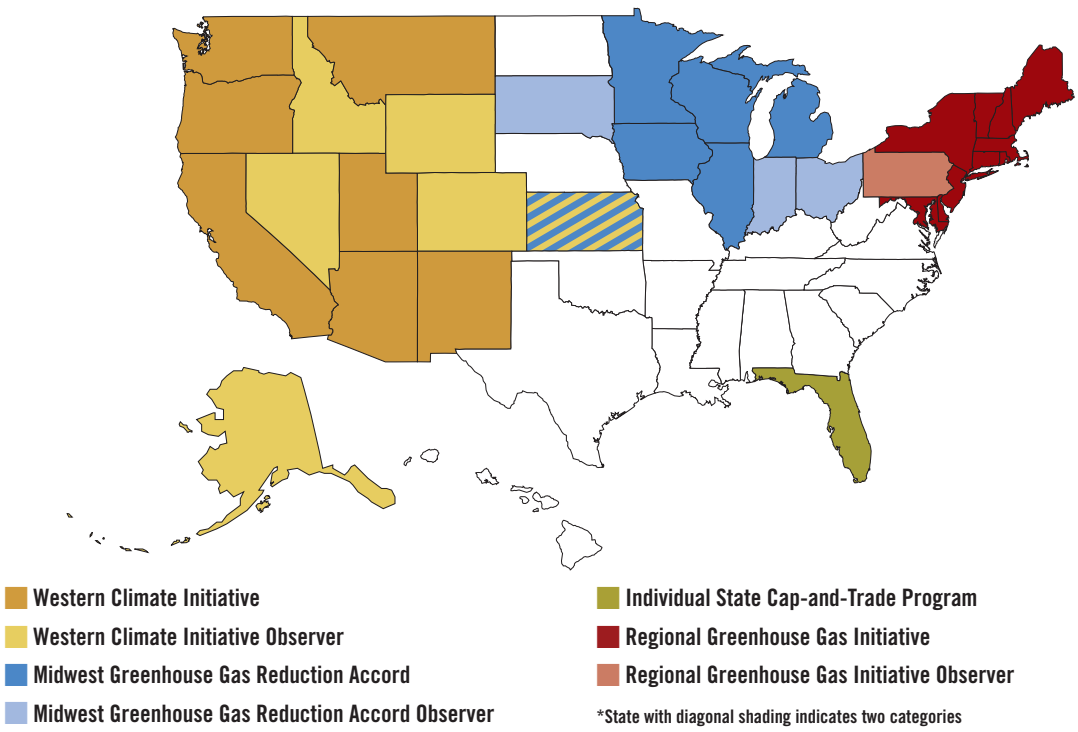
on to consumers. The key difference between auction revenue and allowances is that auction revenue can more easily be used to adjust other taxes, and allowances are more easily limited to purposes more closely tied to the cap and trade program itself.

GREENHOUSE GAS TRADING IN PRACTICE

Emissions trading systems are already proving their value as tools to address climate change by reducing emissions of greenhouse gases throughout the world, and other markets are under development.

EU Emissions Trading System. The world's most ambitious and far-reaching example of greenhouse gas emissions trading is the European Union's Emissions Trading Scheme (ETS), which limits CO_2 emissions from approximately 12,000 facilities in the 27 EU member states. Launched in 2005, the ETS covers power plants and five major industrial sectors (including oil, iron and steel, cement, glass, and pulp and paper) that together produce nearly half the EU's CO_2 emissions. An initial "learning phase" (phase I) ran through 2007; a second coincides with the Kyoto Protocol compliance period (2008-2012). Excess emissions incur a penalty (40 Euros/tonne in phase I, 100 Euros/tonne in phase II) and must be made up in the next phase. During the learning phase, ETS allowance prices fluctuated due to weather (affecting energy demand), shifts in energy prices, and initial over-allocation of allowances as a result of incomplete historical emissions data. Many regard these

Figure 4
States Establishing Regional Cap-and-Trade Programs for Greenhouse Gases



Three regional cap-and-trade programs are currently in development within the United States. A total of 23 states (accounting for 36 percent of total U.S. emissions) are full participants in these programs, and an additional nine states are participating as observers. Florida is developing its own trading program.

fluctuations as characteristic of a new compliance market. The EU ETS plans to adjust its allocations in the next phase and is also considering auctioning a significent portion of the allowances.

The ETS is the first program of its kind and size, and has established a functioning market in a relatively short span of time. Volume of allowance trading reached over 100 million allowances per month in early 2007, and rates of compliance with the program are high. In general, the EU ETS promotes innovation and is seen as flexible and cost-effective. European Union policymakers have said the ETS will continue beyond 2012 with or without a new international climate agreement. In January 2007, the EU commission released its proposal to commit the EU to a GHG reduction target of 20 percent below 1990 levels by 2020 and suggested that if other industrial countries follow suit—namely the United States—the EU will commit to 30 percent.

Regional Greenhouse Gas Initiative. The Regional Greenhouse Gas Initiative (RGGI) is the first mandatory U.S. cap-and-trade program for carbon dioxide. Currently, ten Northeastern and Mid-Atlantic states are participating: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont.

RGGI sets a cap on emissions of carbon dioxide from power plants in the region, and allows sources to trade emission allowances. The program will begin by capping emissions at current levels in 2009, and then reducing emissions 10 percent by 2019. Sources will continuously monitor and report their emissions, and penalties for non-compliance will be enforced according to each state's rules. Member states agree to each set aside at least 25 percent of their emission allowances for public benefit purposes, such as promoting renewable energy and energy efficiency or mitigating possible increases in consumer energy prices. Many of the RGGI states have committed to or are considering setting aside a greater portion of allowances for such purposes. RGGI also allows the use of offset projects for compliance, but these projects will need to meet strict standards and will be limited to ensure that significant reductions occur at electric generators.[18] The RGGI states began trading in January 2009.

California and the West. In September 2006 Governor Schwarzenegger signed AB 32, the Global Warming Solutions Act. The Act caps California's greenhouse gas emissions at 1990 levels by 2020 and represents the first state-wide program in the United States that caps all GHG emissions from major industries and includes penalties for non-compliance. California is currently in the process of designing a comprehensive program to meet its goals under AB 32. The state is considering using market mechanisms, including a cap-and-trade program, as part of AB 32 implementation, and may try to link its program to RGGI and the EU-ETS markets.

California is also part of a larger, regional cap-and-trade program that is likely to emerge in the West. In February 2007 the Governors of Arizona, California, New Mexico, Oregon, and Washington signed an agreement establishing the Western Climate Initiative (WCI), a joint effort to reduce greenhouse gas emissions and address climate change. The states of Utah and Montana as well as the Canadian Provinces of British Columbia and Manitoba joined the Initiative in the following months. Under the agreement, the states and provinces jointly set a regional emissions target in August 2007 of 15 percent below 2005 levels by 2020. In September 2008, the WCI partners released their final recommendations for the design of a regional cap-and-trade program covering multiple economic sectors and nearly 90 percent of regional emissions to aid in meeting this target.

Midwestern Accord. In November 2007, six states and one Canadian Province established the Midwestern Regional Greenhouse Gas Reduction Accord, under which members agree to establish regional greenhouse gas 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. Participants will also establish a greenhouse gas emissions reductions tracking system and implement other policies, such as low-carbon fuel standards, to aid in reducing emissions. Members of the Accord include Illinois, Iowa, Kansas, Michigan, Minnesota, and Wisconsin, as well as the Canadian Province of Manitoba. The Accord partners will release their final design recommendations for a regional cap-and-trade system in early 2009.

THE BENEFITS OF CAP AND TRADE

Cap-and-trade programs offer significant advantages over traditional regulatory policies, particularly in the effort to address climate change. Unlike traditional regulation, cap and trade constrains emissions but lets market forces set a price on greenhouse gas emissions and helps minimize the cost of making substantial reductions in those emissions. Rather than mandating a specific technology, the flexibility afforded by emissions trading markets helps identify where emission reductions can be achieved most cost-effectively. Cap and trade stimulates the development of new technological solutions that can enable much deeper cuts at lower cost in the future—technologies that regulators simply cannot anticipate. Furthermore, emissions trading programs can be designed to cover a wide variety of emissions sources and sectors and serve as the core of an economy-wide GHG reduction program.

Despite its strengths, cap and trade alone cannot achieve the GHG emissions cuts necessary to address climate change, but, combined with other regulatory measures and incentives, can be a key part of the solution. In order to achieve the necessary reductions, certain technologies may need to be targeted by specific supportive policies in order to reach their potential, and some sources of emissions may not be easily covered through cap and trade. A solution to climate change will require a comprehensive approach, combining market mechanisms with more traditional standards and incentives.

Ultimately, cap-and-trade programs offer opportunities for the most cost-effective emissions reductions. Deciding on the most equitable method of initial allowance distribution, what trading rules should be, and other design features is challenging. Once established though, a well-designed cap-and-trade market is relatively easy to implement, can achieve emissions reductions goals in a cost-effective manner, and drives low-greenhouse gas innovation.

ENDNOTES

1. Carbon dioxide equivalent is a metric used to compare the amounts and effects of different greenhouse gases. It is determined by multiplying the emissions of a gas (by mass) by the gas' "global warming potential" (GWP), an index representing the combined effect of the length of time a given greenhouse gas remains in the atmosphere and its relative effectiveness in absorbing outgoing infrared radiation. CO_2 is the standard used to determine the GWPs of other gases. CO_2 has been assigned a 100-year GWP of 1 (i.e., the warming effect over a 100-year time frame relative to other gases). Another greenhouse gas, methane (CH_4), is 21 times more potent than carbon dioxide, and nitrous oxide (N_2O) is roughly 310 times more potent a GHG than CO_2.
2. *An Emerging Market for the Environment: A Guide to Emissions Trading*. United Nations Environment Programme and United Nations Conference on Trade and Development, 2002, p 8.
3. Ellerman et al. *Emissions Trading in the U.S.: Experience, Lessons, and Considerations for Greenhouse Gases*. Pew Center on Global Climate Change, 2003.
4. See *Recommendations for Designing a Greenhouse Gas Cap-and-Trade System for California*. Recommendations of the Market Advisory Committee to the California Air Resources Board, June 2007, p. 99. Available online at http://www.climatechange.ca.gov/documents/2007-06-29_MAC_FINAL_REPORT.PDF
5. For more on the respective advantages of upstream and downstream approaches to regulation, see *Recommendations for Designing a Greenhouse Gas Cap-and-Trade System for California*. Recommendations of the Market Advisory Committee to the California Air Resources Board, June 2007.
6. A load-based system is an example of a product-based cap-and-trade system, in which entities that sell products are responsible for the emissions associated with the products that they provide to customers, and demonstrate compliance with the cap. The term "load-based" is used because gas or electric demand is often referred to as load, and the entities meeting this demand are referred to as load-serving entities. In California and Oregon, where an emissions market is currently being discussed, "load-based" is used to describe a cap on the electricity retailers instead of the power generators, although electricity retailers and generators can be the same entities.
7. Ellerman et al. 2003.
8. "Additional" means that the emissions reductions achieved are in addition to those that would otherwise have occurred in the absence of the project under a business-as-usual scenario.
9. The CDM is designed to promote sustainable development in developing countries. It enables industrialized countries to invest in emission reduction projects in developing countries and to receive credits for reductions achieved. For more information, see the United Nations Framework Convention on Climate Change site at http://unfccc.int/kyoto_protocol/mechanisms/clean_development_mechanism/items/2718.php.
10. For additional information, see the RGGI final model rule, available online at http://rggi.org/docs/model_rule_corrected_1_5_07.pdf.
11. Banking allows firms to better cope with uncertainties and unexpected circumstances that may lead to high allowances prices at a future date, and has proved important to the success of past emissions trading programs, such as the Acid Rain Program in the U.S. See Ellerman et al. 2003.

12. In California's AB 32 legislation, "safety valve" was also used to describe the provision that allows the Governor to delay compliance deadlines by a year under extraordinary circumstances. The Regional Greenhouse Gas Initiative uses price triggers to allow more offsets for compliance purposes.

13. For a detailed discussion on linkage considerations, see *Recommendations for Designing a Greenhouse Gas Cap-and-Trade System for California*. Recommendations of the Market Advisory Committee to the California Air Resources Board, June 2007, p. 69.

14. For a more in-depth discussion of allowance distribution, see *Greenhouse Gas Emissions Allowance Allocations*, prepared by the Pew Center on Global Climate Change, 2008. Available online at http://www.pewclimate.org/brief/allocation

15. Ellerman et al. 2003.

16. United Nations Environment Programme and United Nations Conference on Trade and Development, 2002.

17. For more on the relative merits of auctioning versus free allocation of allowances, see *Greenhouse Gas Emissions Allowance Allocations,* prepared by the Pew Center on Global Climate Change, 2008. Available online at http://www.pewclimate.org/brief/allocation

18. Specifically, RGGI will initially set standards for offset projects in five categories: forest sequestration, sulfur hexafluoride (SF_6) leak prevention, landfill gas capture and destruction, methane capture from animal operations, and oil and gas efficiency improvements. RGGI will also allow international offset projects under certain circumstances. Sources will initially be allowed to cover up to 3.3% of their emissions using offset allowances, an amount on average equal to approximately half of a covered source's emissions reduction obligation. However, if average allowance prices rise above $7 per ton, sources will be allowed to cover up to 5% of their emissions using offsets. If allowance prices rise above $10 per ton, RGGI will allow sources to cover up to 10% of their emissions with offsets, and will allow offset projects outside the U.S. as well as allowances from the EU Emissions Trading Scheme and the Kyoto Protocol's Clean Development Mechanism.

CAP AND TRADE KEY TERMS GLOSSARY

Additionality: Emissions reductions achieved through a given project (or class of projects) over and above those that would otherwise have occurred in the absence of the project(s) under a business-as-usual scenario. Additionality is a criterion for approval of project-based activities (offsets) under the Clean Development Mechanism of the Kyoto Protocol as well as offset projects allowed for credit under other emissions trading programs.

Allowance: A government-issued authorization to emit a certain amount. In greenhouse gas markets, an allowance is commonly denominated as one ton of CO_2e per year. The total number of allowances distributed to all entities in a cap and trade system is determined by the size of the overall cap on emissions.

Allowance distribution: The process by which emissions allowances are initially distributed under an emissions cap-and-trade system. Authorizations to emit can initially be distributed in a number of ways, either through some form of auction, free allocation, or some of both.

Auctioning: A method for distributing emission allowances in a cap-and-trade system whereby allowances are sold to the highest bidder. This method of distribution may be combined with other forms of allowance distribution.

Banking: The carry-over of unused allowances or offset credits from one compliance period to the next.

Baseline: The target, often the historical emissions from a designated past year, against which emission reduction goals are measured.

Benchmarking: An allowance allocation method in which allowances are distributed by setting a level of permitted emissions per unit of input or output.

Borrowing: A mechanism under a cap-and-trade program that allows covered entities to use allowances designated for a future compliance period to meet the requirements of the current compliance period. Borrowing may entail penalties to reflect a programmatic preference for near-term emissions reductions.

Cap and Trade: A cap-and-trade system sets an overall limit on emissions, requires entities subject to the system to hold sufficient allowances to cover their emissions, and provides broad flexibility in the means of compliance. Entities can comply by undertaking emission reduction projects at their covered facilities and/or by purchasing emission allowances (or credits) from the government or from other entities that have generated emission reductions in excess of their compliance obligations.

Carbon Tax: A surcharge on the carbon content of fossil fuels that aims to discourage their use and thereby reduce carbon dioxide emissions.

Circuit Breaker: A threshold or circumstance which, if met, would require suspending further tightening of the program until the circumstances change.

Command and Control: A system of regulation that prescribes emission limits and compliance methods on a facility-by-facility or source-by-source basis and that has been the traditional approach to reducing air pollution.

Cost Containment Mechanisms: Design elements in a cap-and-trade program that reduce the risk of high or volatile compliance costs for affected facilities or industries.

Credits: Credits can be distributed by the government for emission reductions achieved by offset projects or by achieving environmental performance beyond a regulatory standard.

Downstream (source-based) System: Also known as a source-based system, a downstream cap-and-trade system is one in which the point of regulation coincides with the point of emission of covered greenhouse gases. Examples of this approach include the Regional Greenhouse Gas Initiative's cap on power plant CO_2 emissions or the cap on large industrial and utility sources in the European Union's Emissions Trading Scheme.

Emissions Cap: A mandated constraint in a scheduled timeframe that puts a "ceiling" on the total amount of anthropogenic greenhouse gas emissions that can be released into the atmosphere.

Emissions Trading: The process or policy that allows the buying and selling of credits or allowances created under an emissions cap.

Grandfathering: A method by which emission allowances are freely distributed to entities covered under an emissions trading program based on historic emissions.

Greenhouse Gases (GHGs): Greenhouse gases include a wide variety of gases that trap heat near the Earth's surface, slowing its escape into space. Greenhouse gases include carbon dioxide, methane, nitrous oxide and water vapor and other gases. While greenhouse gases occur naturally in the atmosphere, human activities also result in additional greenhouse gas emissions. Humans have also manufactured some GHGs not found in nature (e.g., hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride) that slow the release of radiant energy into space.

Linking: Authorization by the regulator for entities covered under a cap-and-trade program to use allowances or offsets from a different jurisdiction's regulatory regime (such as another cap and trade program) for compliance purposes. Linking may expand opportunities for low-cost emission reductions, resulting in lower compliance costs.

Offset: Projects undertaken outside the coverage of a mandatory emissions reduction system for which the ownership of verifiable GHG emission reductions can be transferred and used by a regulated source to meet its emissions reduction obligation. If offsets are allowed in a cap and trade program, credits would be granted to an uncapped source for the net emissions reductions a project achieves. A capped source could then acquire these credits as a method of compliance under a cap.

Point of Regulation: The point of program enforcement, or where specific emitting entities covered under a cap and trade program are required to surrender enough allowances to match their actual emissions within a compliance period.

Price Trigger: A general term used to describe a price at which some measure will be taken to stabilize or lower allowance prices. For example, RGGI uses price triggers to expand the amount of offsets that can be used for compliance.

Product- or Load-Based System: A system in which the covered emitters are responsible for all the emissions associated with the generation of the electricity, natural gas, or other product that they provide to customers.

Safety Valve: Generally, an optional design element of a cap-and-trade program that seeks to provide cost containment by triggering certain actions if costs turn out to be higher than expected. One form of a safety valve is a price cap, which makes allowances available at some threshold price to ensure that the allowance price does not rise above a certain level.

Scope: The coverage of a cap-and-trade system, i.e., which sectors or emissions sources will be included.

Source: Any process or activity that results in the net release of greenhouse gases, aerosols, or precursors of greenhouse gases into the atmosphere.

Updating: A form of allowance allocation in which allocations are reviewed and changed over time and/or awarded on the basis of changing circumstances rather than historical data. For example, updating can be based on megawatt-hours generated or tons of a product manufactured.

Upstream system: An upstream approach to a cap-and-trade system places the point of regulation with the point of entry of fossil fuels into commerce within the covered region.

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

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CLIMATE CHANGE 101
Business Solutions

The response of business leaders to the problem of climate change is undergoing a major transformation. 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 new 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 establish mandatory measures to protect the climate.

ASSESSING THE RISKS

For corporate leaders responsible for paying attention to the full range of risks confronting their businesses, climate change has become an issue that can no longer be ignored. As Marsh, the world's leading risk and insurance services firm, put it in a 2006 report, "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 the global insurance giant, Allianz, climate change is increasing the potential for property damage at a rate of between 2 and 4 percent every year.[2] The reinsurance company Swiss Re has said, "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 government limits on greenhouse gas (GHG) emissions. Nearly all business leaders surveyed for the Pew Center's 2006 report, *Getting Ahead of the Curve: Corporate Strategies That Address Climate Change*,[4] view national greenhouse gas regulations as inevitable in the United States. More recently, a December 2007 survey conducted by the McKinsey Quarterly of more than 2,000 global executives found that over 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 many U.S. states and regions have already put in place mandatory policies to reduce greenhouse gas emissions.[6] Power generators in 10 northeastern states already have to comply with a recently established cap-and-trade program, and a similar, but broader regulatory system will soon get underway in the western region of the country. Additionally, there continues to be strong international action on climate change, particularly within the European Union (EU).[7] For several years, U.S. businesses with significant operations in Europe have had to comply with the EU's emissions trading system.

The effect of regulations on business operating costs and the value of company assets could be significant, especially for firms with large carbon footprints. As a result, many companies have begun taking early action to reduce their emissions voluntarily now. For example, EPA's Climate Leaders program, which enlists companies to measure GHG emissions

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and set long-term reduction targets, has grown to over 200 members since it began in 2002.[8] Companies set voluntary goals for a number of different reasons, including gaining a head start over competitors in learning what climate strategies work, preparing to respond rapidly once regulations do take effect, better managing the costs of reducing their emissions over time, and reducing costs in the short-term by improving energy efficiency. In addition, many companies recognize that acting early to reduce emissions is an important way to gain credibility and influence among lawmakers as they consider what policies will work best. Increasingly, firms are also taking steps to reduce emissions in response to consumer and shareholder demands for climate action.

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 greenhouse gas-intensive technologies; and a corresponding increase in demand for climate-friendly technologies and services.

For example, electric utilities that invest in high-emission power plants today may be at a competitive disadvantage in later years when governments impose limits on GHG emissions. Under this scenario, investors, too, may 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 more closely scrutinize 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 and new domestic fuel economy regulations are driving major U.S. automakers to shift production to smaller, more fuel-efficient vehicles.[10]

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.[11] 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 gasoline prices, but also hurt profits in other industries, including chemical companies and fertilizer manufacturers that use fossil fuels as ingredients in their own products. Damages to highways and port facilities in Louisiana and Mississippi slowed the shipment of goods to companies in a host of other industries hundreds of miles away. 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

Businesses Face Growing Pressures to Disclose Climate Risks and Strategies

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

- During the 2008 proxy season, investors filed a record 54 climate-related shareholder resolutions—nearly double 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.[12]
- 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 2008 CDP disclosure request was sent to 3,000 companies under the signatures of 385 institutional investors with combined assets of $57 trillion—up over tenfold from $4.5 trillion in 2003. In 2008, 1,550 companies responded to the questionnaire. This was a significant increase over 2003, when only 235 companies responded.[13]

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.[14]

Litigation & Reputational Risks. In addition to regulatory and physical risks, businesses face additional climate risks. For example, some investors and analysts believe that the federal Sarbanes-Oxley law, by requiring disclosure of financially "material" risks, should force some industries to disclose whether (and how) climate change and carbon policy will affect future earnings.

CAPTURING THE OPPORTUNITIES

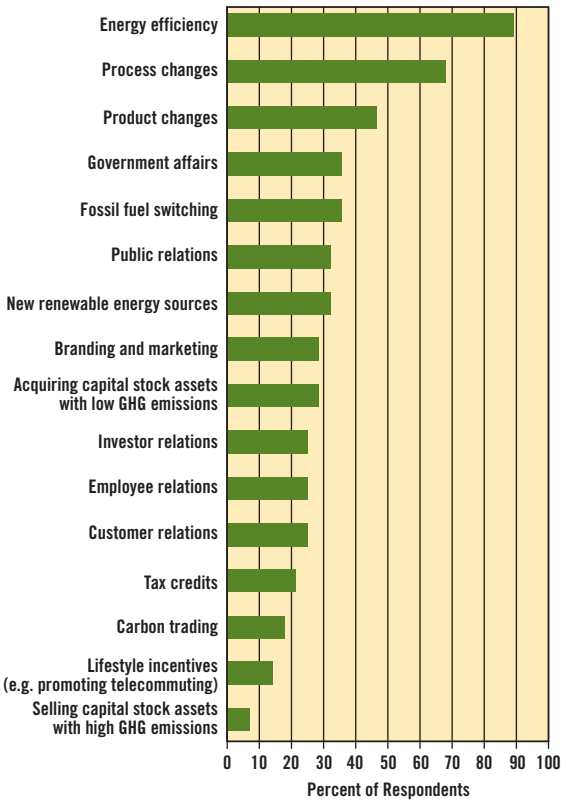
Although there will be significant costs associated with achieving the deep long-term emission reductions essential to protect the climate, the experience of companies that have already begun to reduce their emissions demonstrates there are numerous options for reducing GHGs that can both decrease costs and increase profits. Figure 1 shows a ranking of programs that benefit the bottom line based on a 2006 Pew Center on Global Climate Change poll of 33 major corporations. Also, climate policy can be designed so that businesses can respond with innovative solutions that will minimize costs.

Among the companies that have leading climate strategies, there is a major shift underway from a focus on risk management and emissions 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, biofuels, and fuel cells grew from $55 billion in 2006 to $77.3 billion in 2007, a 40 percent increase. CleanEdge estimates that global revenues from these clean energy technologies could surpass $250 billion by 2017.[15] Key suppliers of components for these new technologies—for example, manufacturers such as Eaton and Parker-Hannifin whose hydraulics and electrical systems can enable hybrid vehicles and wind turbines—also may have considerable new sales opportunities.

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

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:

- The U.N. Environment Programme (UNEP) reported that in 2007 global clean energy investment surpassed $148 billion, a 60 percent increase over 2006 levels. Total investment in clean energy technologies is expected to reach $450 billion a year by 2012 and $600 billion a year by 2020, UNEP projects.[16]

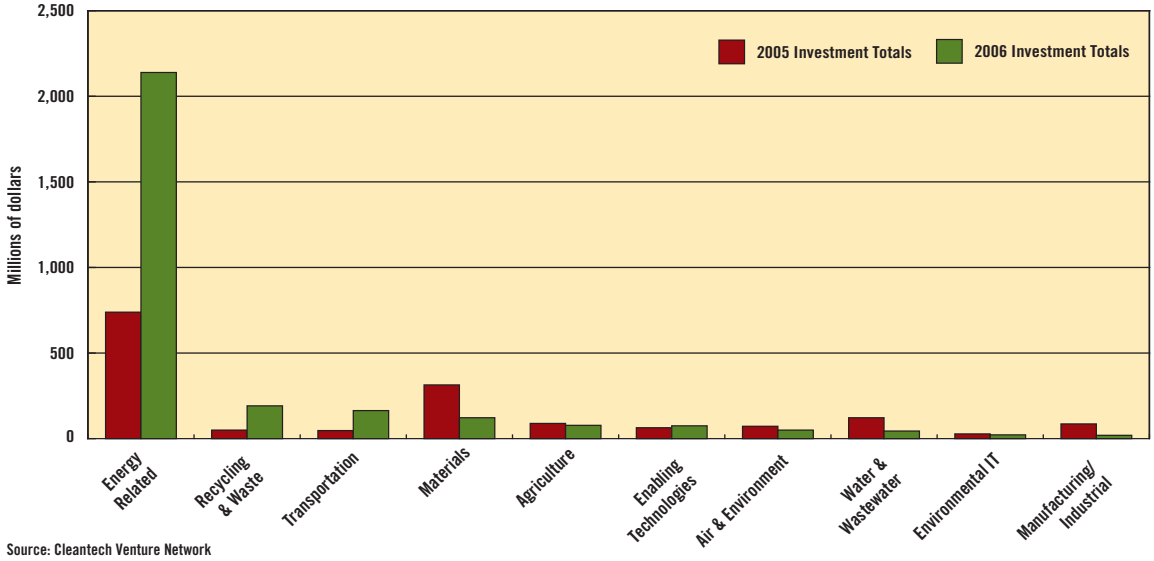
- Venture capital investing in so-called "cleantech" industries—which include firms developing environmentally friendly technologies in the energy, agriculture, information technology, transportation, and other sectors—has surged in recent years. In 2006, cleantech investing in North America totaled $2.9 billion, a 78-percent jump from the previous year's level of $1.6 billion.[17] Within cleantech, climate-related energy investments are by far the largest segment (see Figure 2).
- 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.[18]
- A recent study by Ceres found that hundreds of new insurance products are emerging to tackle climate change and resulting weather-related losses. For example, Lexington Insurance Company is launching a green buildings product for homes, Japanese insurers are offering lower premiums for low-emitting cars, and Swiss Re is developing a program to assist vulnerable regions of the world to adapt to the physical impacts of climate change.[19]

Businesses in energy, technology, and other sectors also are making substantial new investments of capital and effort to expand their climate-friendly business. GE, for example, has committed to doubling its annual investment in environmental technologies to $1.5 billion by 2010,[20] and BP aims by 2015 to invest $8 billion in solar, wind, hydrogen, and efficiency-enhancing "combined cycle" power generation.[21] ("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. 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. The solar power market provides a clear historical example. In 1996, U.S. manufacturers had 44 percent of market share worldwide, but that has slipped to 9 percent in 2005—lost mostly to producers in Germany and other countries that have strong policies in place to accelerate solar deployment.[22]

Figure 2

North American Cleantech Venture Capital Investments by Industry Segment, 2005–2006



Source: Cleantech Venture Network

Business Action on Climate

As of October 2008, 44 companies have joined the Pew Center's Business Environmental Leadership Council (BELC). The majority are Fortune 500 companies; collectively, they have revenues over $2 trillion and nearly 4 million employees.[23] They represent most industrial sectors and many of the largest emitters of greenhouse gases, including coal-burning utilities, mining companies, aluminum producers, automobile manufacturers, pulp and paper manufacturers, chemical companies, oil and gas businesses, and the cement industry.

Of the 44 companies, 40 have set targets to reduce their 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 June 2006, **Dupont** and **BP** announced a partnership to develop, market, and produce biobutanol, a new type of biofuel potentially superior to ethanol in terms of energy content, reduction in greenhouse gases, and ease of integration into existing fuel distribution infrastructure.[24] Dupont projects that 60 percent of its business will stem from the use of biology to reduce fossil fuel use in the next few decades.[25]

- **BP** and **GE** in July of 2006 formed a partnership to build up to 15 hydrogen power plants that will generate electricity while using advanced technology to capture and store up to 90 percent of the carbon dioxide that would otherwise be emitted.[26]

- **Weyerhaeuser**, the world's largest lumber company, announced in April of 2007 that it had entered into a partnership with Chevron to explore the development of cellulosic biofuels from plants, wood fiber, and other organic materials.[27]

- From 1990 to 2002, **IBM**'s energy conservation measures resulted in a savings of 12.8 billion kWh of electricity—avoiding approximately 7.8 million tons of carbon dioxide emissions and saving the company $729 million in reduced energy costs. IBM in 2007 also launched Project Big Green, which includes a number of new products and services designed to use information technology to increase energy efficiency and reduce greenhouse gas emissions in its own operations and those of its clients.[28]

- **Alcoa** has saved hundreds of millions of dollars by reducing the electricity required to produce a ton of aluminum by 7.5 percent over the last 20 years. 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.

- **Toyota** has become a leader in developing and producing clean energy vehicles, including hybrid, electric, compressed natural gas and fuel-cell electric vehicles. In May of 2008, Toyota announced that global sales of its Prius, a highly efficient gas-electric hybrid car, had topped 1 million.[29]

- **United Technologies** (UTC) is developing zero-emission, energy-efficient fuel cells for transportation applications. The company has deployed zero-emission fuel cell buses in Washington, DC, California, Madrid, and Turin. UTC is also co-chairing an initiative of the World Business Council on Sustainable Development with the ambitious goal that by 2050 new buildings will consume zero net energy from external power supplies and produce zero net carbon dioxide emissions.

- Since 1976, customer energy efficiency programs at **PG&E Corporation** have cumulatively saved more than 135 million tons of carbon dioxide emissions.[30] In addition, as part of the company's groundbreaking Climate Protection Program, customers can choose to pay a small premium on their monthly bill to fund projects to reduce or offset carbon dioxide emissions.

BUSINESS SUPPORT FOR STRONGER POLICY

Scientists say that the world needs to reduce total greenhouse gas emissions by 40 to 75 percent below baselines in order to stabilize atmospheric greenhouse gas concentrations and avoid dangerous climatic change.[31] Despite the recent upsurge in private-sector involvement in the climate issue, voluntary action by selected companies and their investors is not achieving sufficient reductions to solve the problem.

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

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—calling for the prompt establishment of a binding domestic cap on emissions, is perhaps the most dramatic example of positive business engagement on the climate issue. The coalition urges the adoption of a market-driven, economy-wide approach to reducing GHG emissions 80 percent below 2005 levels by 2050. USCAP also supports a robust federal research and demonstration program aimed at developing low-carbon technologies, as well as renewed U.S. leadership in the ongoing efforts to craft a viable international climate change agreement. 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.[32]

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.[33]

Business leaders also seek greater 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 national policy. 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 business leadership on climate policy include:

- In June of 2008, Alcoa, Exelon, FPL Group, GE, NRG, National Grid, the Public Service Enterprise Group, and PG&E aligned with several environmental and labor organizations to publicly support the Lieberman-Warner Climate Security Act, a bill that would have established a mandatory domestic GHG reduction program.
- Representatives from Shell, American Electric Power, and Pacific Gas & Electric Co. spoke at a September 2007 briefing, organized by the Pew Center, for Capitol Hill staff on the various approaches to distributing emissions allowances under a national cap-and-trade regulatory system.
- Duke Energy, Exelon, GE, and Wal-Mart testified at the Senate Energy Committee's climate conference in April 2006 in support of mandatory GHG regulations. Eight other companies, including BP, provided written testimony in support of mandatory controls.

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 re-engage in the international effort to address climate change.

CONCLUSION

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

While business action has grown over the last several years, some concerns have been raised that the current global 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 greenhouse gases, for example.

Despite these concerns, there are encouraging signs that the climate issue will stay near the top of corporate and government agendas through this period of global economic anxiety. Governments at the state, federal, and international levels have so far shown no signs of slowing or drawing down efforts aimed at reducing greenhouse gas emissions, and companies continue to announce new, ambitious voluntary GHG reduction targets.[34] Increasingly, leading companies recognize that environmental protection and economic prosperity are not competing ideals, but are in fact dependent on one another. In the midst of the turmoil on Wall Street in October 2008, the 26 companies in USCAP and their NGO partners released a statement saying, "Given current economic challenges, USCAP believes a sustainable environment is inextricably linked to a strong economy where increased energy efficiency, new technologies and wise energy infrastructure investments will create economic opportunities."[35] Many analysts have also 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.

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

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

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The Pew Center on Global Climate Change is a non-profit, 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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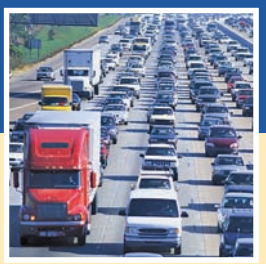
January 2009



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

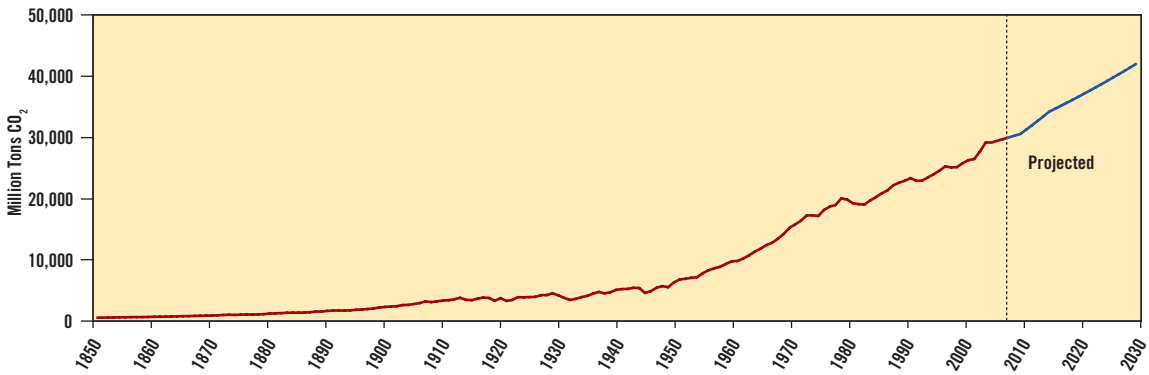
Greenhouse gas (GHG) emissions, largely carbon dioxide (CO_2) from the combustion of fossil fuels, have risen dramatically since the start of the Industrial Revolution. Globally, energy-related CO_2 emissions have risen 145-fold since 1850—from 200 million tons to 29 billion tons a year—and are projected to rise another 54 percent by 2030 (see Figure 1).[1]

Most of the world's emissions come from a relatively small number of countries. The 25 largest emitters, with 75 percent of the world's population and 90 percent of the global gross domestic product (GDP), account for approximately 85 percent of global GHG emissions. The top six emitters—the United States, China, the European Union (EU),[2] Russia, India, and Japan—accounted for more than 60 percent of global emissions in 2005. (If emissions from land use change and forestry are also taken into account, Brazil, Indonesia and other countries with high rates of deforestation rank among the top emitters.[3])

Among members of the Organization for Economic Cooperation and Development (OECD), the United States, the EU, and Japan are the three largest GHG emitters (see Figure 2). In absolute terms, the United States is by far the largest. The United States, with 5 percent of the world's population, is responsible for 18 percent of GHG emissions.[4]

Figure 1

Global Carbon Dioxide Emissions 1850–2030



PEW CENTER ON Global CLIMATE CHANGE

THE PEW CENTER ON THE STATES

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

Figure 2

GHG Emissions for Major Economies

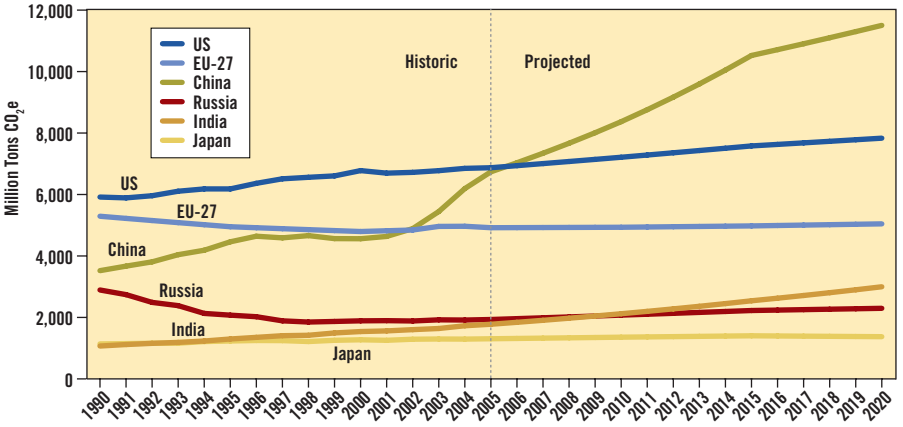


Figure 3

GHG Intensity 2005

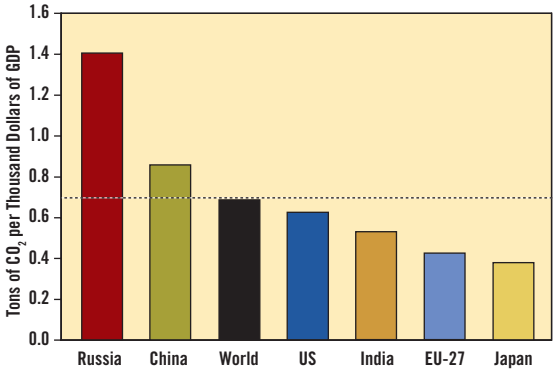
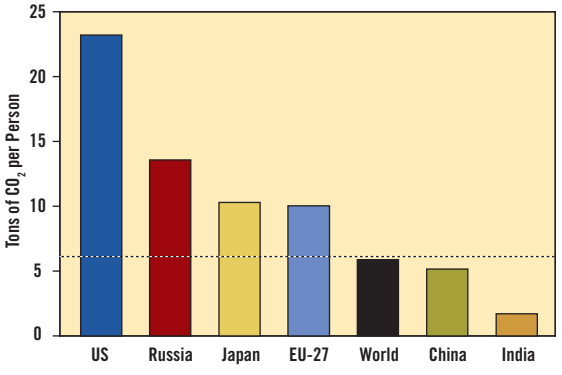


Figure 4

Per Capita GHG Emissions 2005



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 twice as high as those of the EU and Japan and four times the world average (see Figure 4). Looking ahead, U.S. GHG emissions are projected to rise 14 percent above 2005 levels by 2020. By comparison, emissions are projected to grow 2.5 percent in the EU and 5 percent in Japan.

Emissions are rising fastest in developing countries. China's and India's emissions are projected to grow 71 percent and 68 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. While China's per capita emissions are expected to more than double by 2020, to slightly above the world average, they will still be just one-third those of the United States. India's will rise to 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 7 percent.[5] Cumulative emissions are an important measure because of the long-lasting nature of greenhouse gases 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.

THE INTERNATIONAL CLIMATE EFFORT

Governments launched the international climate change effort at the "Earth Summit" in 1992 with the signing of the United Nations Framework Convention on Climate Change. Signed by President George H.W. Bush and ratified by the U.S. Senate, the Convention now has 192 parties.

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

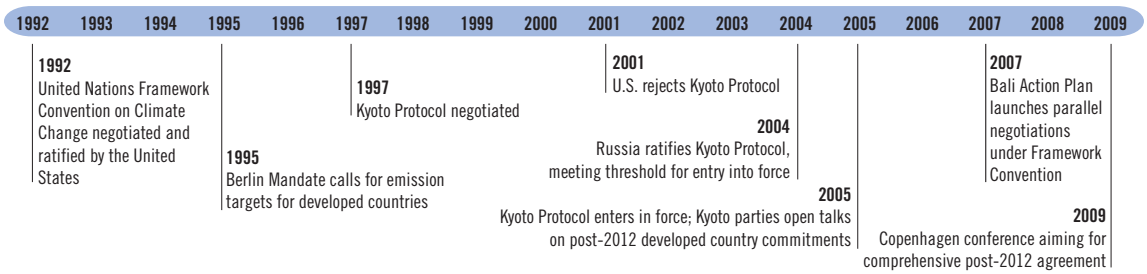
In 1995, recognizing that this voluntary target was insufficient and in most cases would not be met, governments adopted the Berlin Mandate, calling for the negotiation of binding targets for developed countries. These negotiations led in 1997 to the Kyoto Protocol. Under the Protocol, developed countries 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[6] 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 182 countries. The 37 industrialized countries with binding targets account for 64 percent of developed country emissions and about a third 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. 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. It

Timeline International Action on Climate Change



Climate Action Around the World

Many countries have policies and programs that help reduce or avoid GHG emissions. Some are undertaken specifically to address climate change; others are driven principally by economic, energy, or development objectives, but at the same time contribute to climate efforts. In the United States, state and local governments are taking the lead. California has enacted GHG standards for cars and light trucks and a mandatory target to reduce statewide emissions from all sources to 1990 levels by 2020 (a 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. Twenty-nine states and the District of Columbia require that a significant percentage of their electric power come from renewable sources. At the federal level, the United States has a number of voluntary programs and bills have been proposed in Congress to establish mandatory economy-wide GHG limits. (For more information on U.S. action, see three other reports in the Climate Change 101 series: *Local Action, State Action,* and *Business Solutions*.) Here is a sampling of policies and programs in other major GHG-emitting countries:

European Union

- *Kyoto Target*—Reduce EU-15 emissions 8 percent below 1990 level by 2008–2012. Individual targets for 12 new member states range from -8 to +6 percent.
- *EU Target*—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.[7]
- *Emissions Trading Scheme*—Mandatory CO_2 emission limits for 12,000 installations in six major industrial sectors, with emissions trading. Links to the Kyoto Protocol's emission crediting mechanisms.
- *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.
- *Community Tax Framework*—Minimum tax rates for energy and electricity depending on fuel type, with exemptions for electricity from renewables, biomass, and combined heat and power.
- *Auto fuel economy*—Mandatory standards to reduce average CO_2 emissions of new cars from 160g/km (0.57lbs/mile) to 120g/km (0.43lbs/mile) by 2012 (Draft legislation awaiting approval).

United Kingdom

- *Emission Targets*—National target of reducing CO_2 emissions 20 percent below 1990 level by 2010 (more than required under Kyoto or the EU's internal target-setting), with a mandatory long-term target of 80 percent reduction by 2050.
- *Climate Change Levy*—Tax on fossil fuel-based electricity for industry and other large users, with most revenues used for energy efficiency research.

Japan

- *Kyoto Target*—Reduce emissions 6 percent below 1990 levels by 2008-2012.
- *Industry Agreements*—Agreements with Nippon Keidanren, Japan's leading industry association, to reduce industrial GHG emissions to 1990 levels by 2010 and with the Federation of Electric Power Companies to reduce emissions intensity of the electricity sector about 20 percent below 1990 levels by 2010.
- *Energy Taxes*—Schedule of taxes based in part on carbon content of fuel (e.g., $0.45/liter, or about $1.70/gallon for gasoline; $2/ton for coal, rising to $7/ton by 2007), with a portion of the revenues used for climate purposes.
- *Auto Fuel Economy* —Standards to increase fuel economy of new passenger vehicles to 16km/l (37.6 miles per gallon or mpg), and commercial vehicles to 15km/l (35.2 mpg), by 2015 (an improvement of 22 percent and 13 percent from 1990 levels respectively).

Climate Action Around the World *(continued)*

China[8]

- *National Climate Change Program*—Comprehensive program adopted in 2007 outlining existing and planned policies and programs addressing climate change mitigation and adaptation.
- *Fuel Economy Standards*—Require all new cars and light trucks to achieve 19 to 38 mpg by 2005 (depending on class) and 21 to 43 mpg by 2008. Projected to save 960 million barrels of oil and avoid 130 million tons of carbon emissions through 2030.
- *Energy Intensity Goals*—National goals of reducing energy intensity 20 percent from 2005 to 2010, and a total of 50 percent from 2000 to 2020; follows a 68 percent reduction in energy intensity from 1980 to 2000.
- *Renewable Energy Initiatives*—National targets for renewables to provide 16 percent of primary energy (up from 7 percent today) and 20 percent of electricity by 2020, including specific targets for wind power, biomass, and hydropower capacity.
- *Taxes on Energy-Intensive Exports*—Increased export taxes on energy-intensive goods including aluminum and steel (and reduced import tariffs on energy and resource products including coal and petroleum) to conserve domestic energy resources.

India[9]

- *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.[10]
- *Renewable Energy*—Target to increase renewable power to more than 10 percent of total installed electrical generation capacity by 2012.
- *Rural Electrification*—Goal of electrifying 18,000 rural villages by 2012 from non-conventional sources such as biomass, solar, wind, and small hydropower.
- *Vehicle Conversion*—Rules requiring conversion of taxis, buses, and three-wheelers from gasoline and diesel to compressed natural gas in key cities.
- *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.

EU Emissions Trading Scheme

The world's most far-reaching GHG reduction policy is the EU's Emissions Trading Scheme (ETS), which limits CO_2 emissions from 12,000 facilities across Europe. The ETS was launched in 2005 and in 2007 traded 2 billion tons of CO_2 at a market value of $50 billion.[11]

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 2008, emission allowance prices ranged from about 20 euros to 30 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.

is hoped that negotiations under the Kyoto and Convention tracks will converge in a comprehensive post-2012 agreement in Copenhagen in late 2009.

Governments are engaging in other international venues to supplement and contribute to efforts under the U.N. framework. Leaders of the Group of 8 (G8) industrialized countries have addressed climate change in each of their recent annual summits; in 2008, they endorsed a goal of reducing global emissions at least 50 percent by 2050. Discussions among the world's 17 major economies convened by the Bush administration led to a leaders' summit in 2008 calling for major developed economies to implement economy-wide goals and achieve absolute emission reductions, and major developing economies to undertake mitigation actions "with a view to achieving a deviation from business as usual emissions."

COMPETITIVENESS

In considering the U.S. policy response to climate change, both at home and abroad, one concern is the potential impact on U.S. competitiveness. Emission limits like those proposed in cap-and-trade legislation before Congress are projected to affect economic growth rates only marginally,[12] and thus pose little risk to the competitiveness of the U.S. economy as a whole. Any potential competitiveness risks would be felt most directly by energy-intensive industries whose goods are traded internationally, a relatively small segment of the U.S. economy.[13] 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 range of sectors—concluded that while environmental standards may impose significant costs on regulated industries, they do not appreciably affect patterns of trade.[14] 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.[15]

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 will 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 forthcoming Pew Center report 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 chemicals, paper, iron and steel, aluminum, cement, and bulk glass, the analysis concludes that most of the anticipated decline in production within those sectors (-2.6 percent to -5.3 percent) reflects a decline in consumption (-1.5 percent to -4.3 percent). The gap made up by imports, or the "competitiveness" effect, ranges from -1.0 percent to -1.5 percent. Within some sub-sectors (the analysis examines more than 400 individual manufacturing industries), the impact ranges up to 5.9 percent.[16]

Targeted policies minimize or mitigate potential competitiveness impacts. Under a cap-and-trade system, options include exempting trade-exposed energy-intensive industries from the cap or freely granting them emission allowances on the basis of historical or current emissions, output, or environmental performance. Compensation for indirect regulatory costs (higher energy prices) can be provided through additional free allowances or tax rebates. An alternative approach is to impose taxes or allowance requirements on energy-intensive imports from countries with weaker emission controls. Other policy options include: tax and other incentives for accelerated deployment of cleaner technologies; support for research and development of long-term technologies; and transition assistance for affected workers.[17]

Some economists believe that stronger environmental standards in many cases confer a competitive *advantage* by driving firms to innovate and become more efficient.[18] By spawning markets for new technologies, new standards are as likely to create jobs as reduce them, according to some studies.[19] A recent report commissioned by the United States Conference of Mayors estimated that strong investment in

areas such as renewable energy and fuels and building efficiency retrofits could add a total of 4.2 million new green jobs to the U.S. economy within 30 years, representing 10 percent of all new jobs growth over this period.[20]

THE INTERNATIONAL CLIMATE EFFORT POST 2012

The move toward a mandatory national climate policy in the United States and the ongoing negotiations under the Framework Convention and Kyoto Protocol present an opportunity to broaden and strengthen the international climate effort beyond 2012, when the Kyoto targets expire.

To weigh post-2012 options, the Pew Center on Global Climate Change brought together senior policymakers and stakeholders from 15 countries in the Climate Dialogue at Pocantico.[21] A key message from the group is that to be fair and effective, the international effort must engage all the world's major economies, which requires a flexible framework allowing countries to take on different types of commitments.

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.

For developed countries, binding economy-wide *emission targets* like those established under Kyoto are generally regarded as the most appropriate form of mitigation commitment in a post-2012 agreement. Major developing countries are very unlikely to accept binding economy-wide targets; among other reasons, most lack the capacity to accurately measure and project their emissions economy-wide. One option for developing countries is sectoral emission targets (either absolute or intensity). Another is *policy-based commitments*—nationally-defined policies such as energy efficiency standards, renewable energy targets, or forestry goals that produce verifiable greenhouse gas reductions.[22] These could be complemented by a mechanism granting developing countries tradable credits for policy-driven emission reductions.

A post-2012 framework also could include international *sectoral agreements* setting commitments across developed and developing countries in major emissions-generating sectors. Sectoral agreements could take a variety of forms, including emission targets, performance- or technology-based standards, or "best practice" agreements.[23] In the case of energy-intensive industries, sectoral agreements can help address competitiveness issues by establishing mutual terms among major producing countries.

In addition to different types of mitigation commitments, a post-2012 agreement will likely include mechanisms to provide technology, finance, and adaptation support to developing countries. Key issues in negotiating a post-2012 agreement include the stringency and comparability of emission targets and other commitments, the means and level of support provided to developing countries, and the terms for reporting and verification of countries' actions.

NEXT STEPS

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

Governments are aiming for a new international climate agreement in late 2009 in Copenhagen. Unless Congress has completed work on a mandatory national climate policy, the United States is unlikely to commit to a specific international target at that time, making a full agreement improbable. Governments could, however, agree on the basic architecture of a post-2012 framework—for instance, economy-wide targets for developed countries, other commitment types for major developing countries, and types of technology and adaptation support—with the specific terms still to be negotiated. Whatever the outcome in Copenhagen, governments will have to continue working in the years ahead to achieve an effective long-term international climate effort.

Pew Center on Global Climate Change

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

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: IEA, 2007. "CO_2 Emissions from Fossil Fuel Combustion 1971-2005". Other GHG emissions data: USEPA, 2006. "Global Anthropogenic Non-CO_2 Greenhouse Gas Emissions: 1990-2020." Projections: WEO, 2007. "World Energy Outlook 2007: China and India Insights."

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.

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4 When only energy-related CO_2 is taken into account, the U. S. is responsible for approximately 21 percent of global emissions.

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January 2009

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 leadership. 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 early 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 to 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. In this way, 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 policies have received bipartisan support in the states, with Democratic, Republican, and Independent

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governors signing climate change legislation and lawmakers of all political persuasions supporting state action. Even when governorships have changed hands, state policies on climate change and clean energy have remained in place. Thus, in addition to offering models for specific policy solutions, the states also offer models for finding common ground on an issue that too often has divided lawmakers at the national level.

WORKING ACROSS STATE BORDERS

In working to address climate change, many states have reached beyond their borders to enlist 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.

Three regional GHG cap-and-trade programs are being developed and implemented among U.S. states and Canadian provinces (see Figure 1). Florida is also developing a cap-and-trade program and is considering joining one of the regional programs. 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 have developed 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. Emissions are recorded and tracked through The Climate Registry, an independent greenhouse gas registry. The successful implementation of RGGI would not only be an example for states and national governments, but could lay the groundwork for including other GHGs and emitting sectors as well.

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 begin in 2012 and initially cover emissions of six GHGs produced by electricity generators and large industrial sources. In 2015 the program will expand to include emissions of these gases

Figure 1

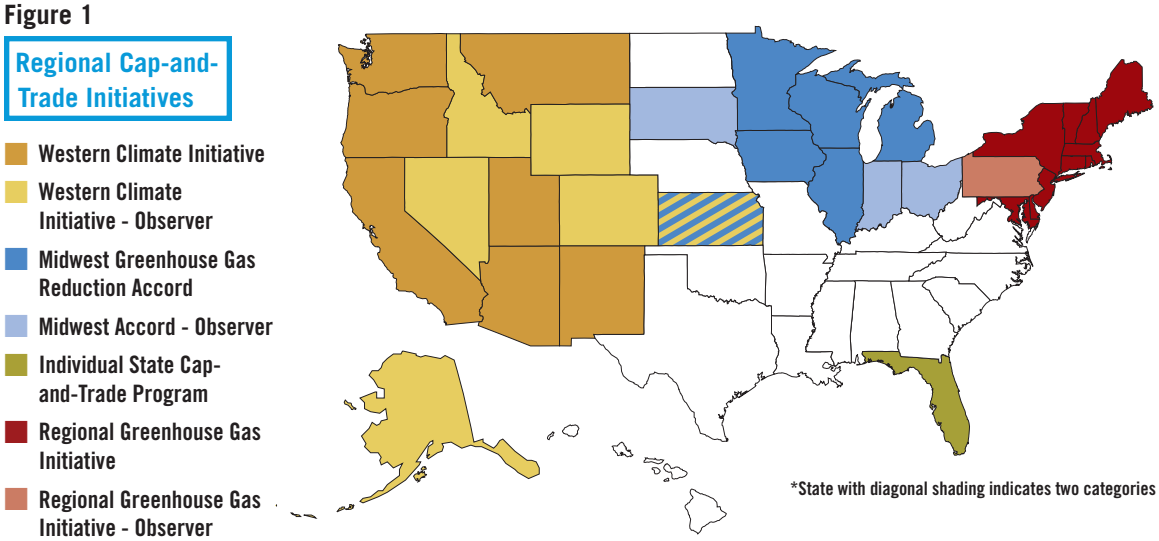
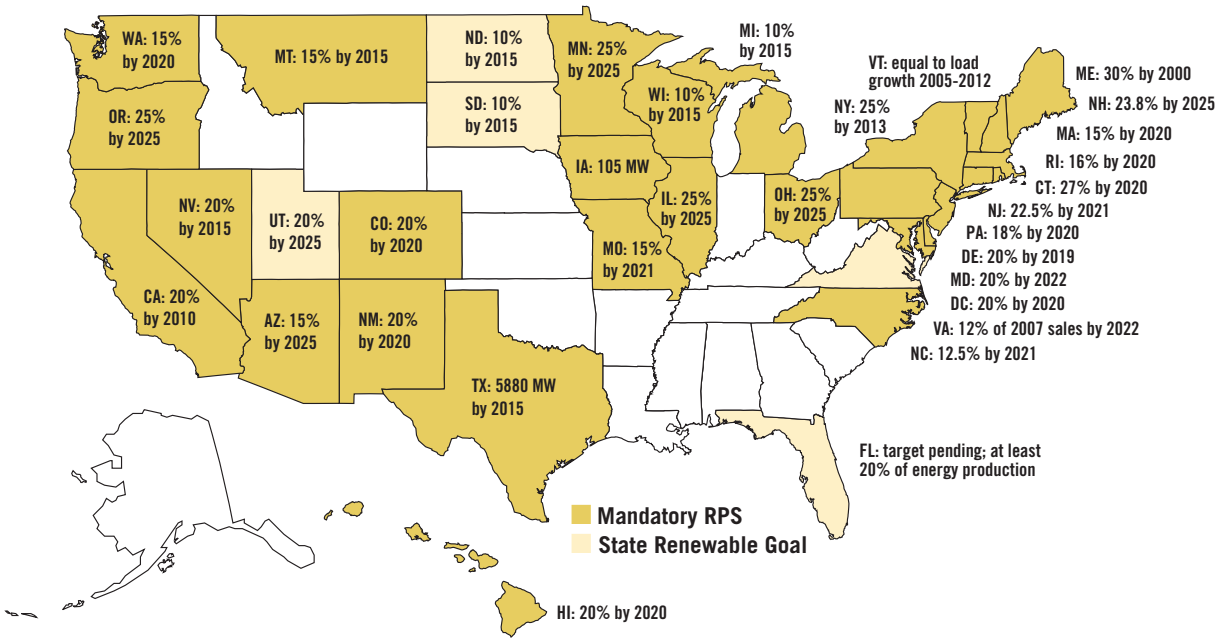


Figure 2

Renewable Portfolio Standards



from the combustion of 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 GHG cap-and-trade program proposed to date.

Midwestern Greenhouse Gas Reduction Accord. In November 2007, the governors of Illinois, Iowa, Kansas, Michigan, Minnesota, and Wisconsin, as well as the premier of Manitoba, established the Midwestern Greenhouse Gas Reduction Accord (MGGRA). Under the Accord, members agree 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. Participants will also establish a GHG emissions reductions tracking system and implement other policies, such as low-carbon fuel standards, to aid in reducing emissions.

Member jurisdictions are expected to finalize a cap-and-trade program design in 2009 and begin program implementation in 2010. The Accord was created in conjunction with the Midwestern Governors Association's Energy Security and Climate Stewardship Platform.

REDUCING ELECTRICITY EMISSIONS

States have considerable authority over how electricity is generated in the United States. With the generation of electricity accounting for 34 percent of all U.S. GHG emissions and 41 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-nine 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 voluntary RPSs. 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. In fact, some 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, energy security, 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 fund these projects, which often include low-income household energy assistance, weatherization programs, investment in renewable technologies, and subsidies for efficient appliances. To date, 18 states with publicly managed clean energy funds have formed the Clean Energy States Alliance to coordinate public benefit fund investments in renewable energy.

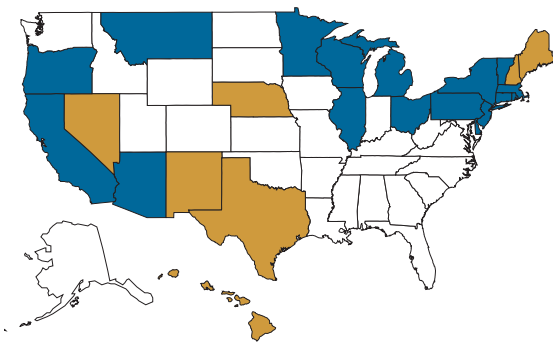
Net Metering and Green Pricing. Forty-four U.S. states have at least one utility that permits customers to sell electricity back to the grid; this is referred to as "net metering." Eighteen of these states offer net metering on a statewide basis for all utilities, 23 others have statewide net metering for certain utility types, and the remaining three have individual utilities that offer net metering. In addition, 44 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. Six of these states—Colorado, Iowa, Minnesota, Montana, New Mexico, and Washington—have made it mandatory for electricity suppliers to offer green pricing options.

Offsets for and 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. Massachusetts and New Hampshire have gone even further by requiring emissions reductions from existing power plants. California, Montana, Oregon, and Washington also require that new power plants 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 for decades, states have recognized the need to channel this resource into cleaner and lower-emission technologies. Carbon

Figure 3

Public Benefit Funds

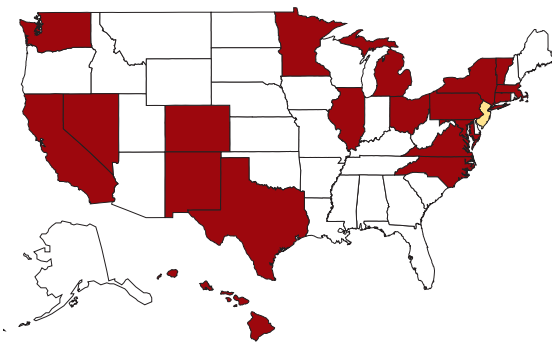


Funds for Renewables and Efficiency

Funds for Energy Efficiency

Figure 4

Energy Efficiency Resource Standards

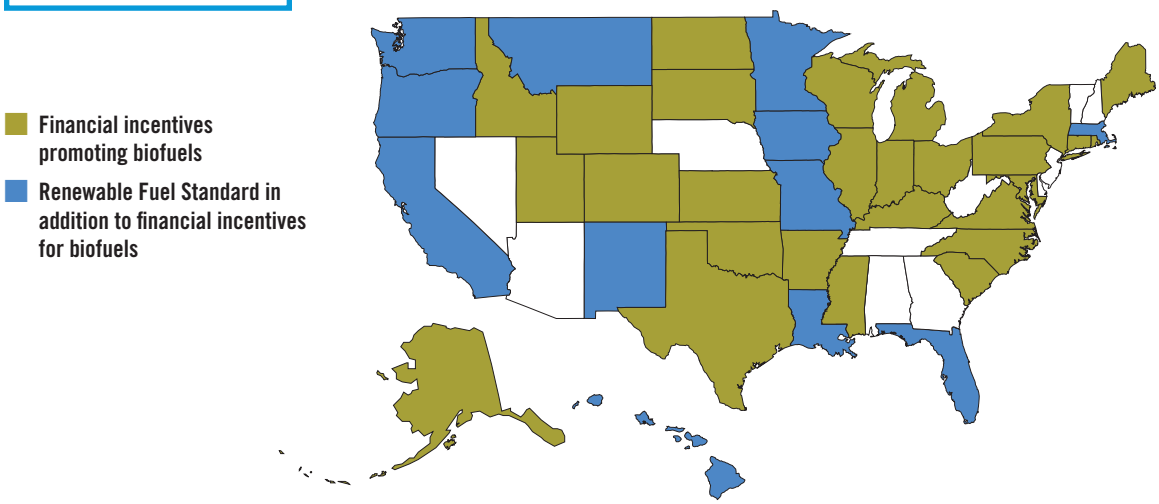


Completed EERS

Pending EERS

Figure 5

Alternative Fuel Policies



capture and storage is an emerging technology for reducing GHG emissions from large sources, primarily coal-fueled power plants. California, Florida, Illinois, Indiana, Kansas, Montana, New Mexico and West Virginia are considering legislation pertaining to carbon capture and storage, and members of the Energy Security and Climate Stewardship Platform for the Midwest are also working to establish a framework for utilizing this technology. 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. Nineteen states have Energy Efficiency Resource Standards (EERS), which establish a target for utilities to increase energy savings over time from electricity and/or heating fuels (see Figure 4). This encourages utilities to either promote energy-efficient technology for consumers or integrate cleaner 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 28 percent of all U.S. GHG emissions and 33 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 30 percent by 2016, on average. 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. Other states have the option of either following federal or California standards, and to date 16 states have announced that they will follow California. In December 2007, the EPA denied the waiver request for higher standards; California and several other states have sued to have the decision overturned.

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, 12 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' emissions 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-emissions 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. 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 standard to reduce emissions in the transportation sector.

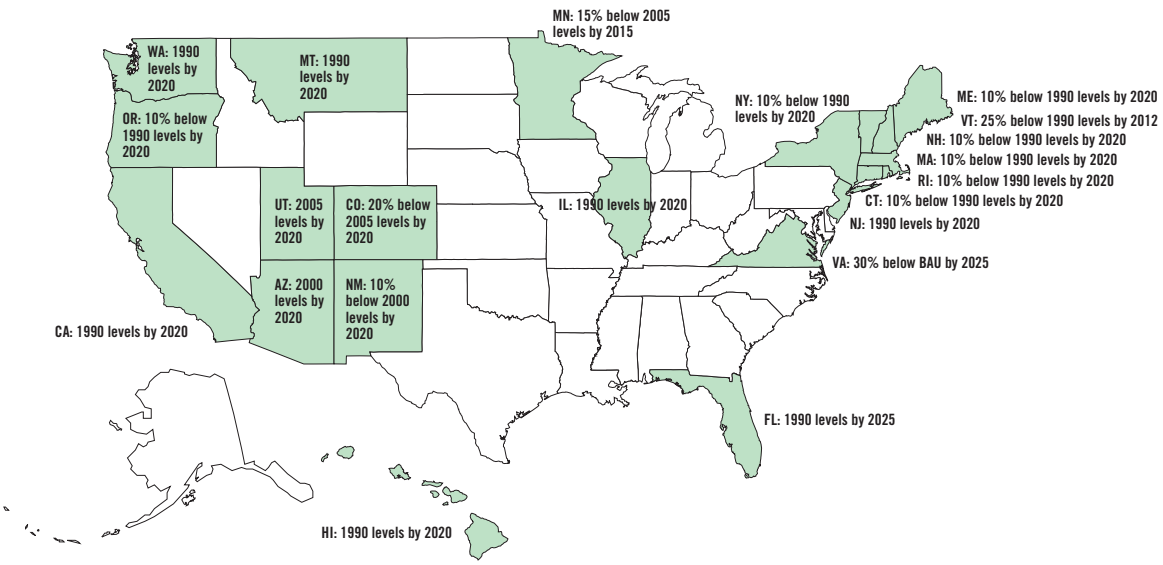
AGRICULTURAL POLICIES

Agriculture contributes approximately 8 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

Figure 6

State Emission Targets



be burned directly for electricity, or it can be converted to other usable fuels, including biofuels.

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

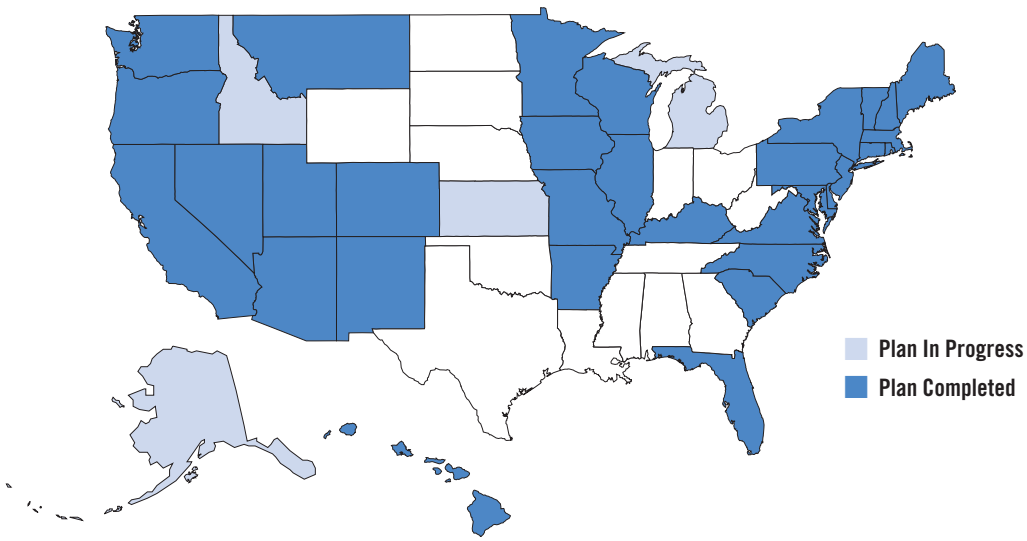
Many states are taking a comprehensive approach to climate policy by passing statewide GHG emission reduction targets and developing climate action plans that provide a range of policy recommendations to address climate change, including measures to reduce emissions and respond to impacts.

Emission Targets. Twenty-one 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.

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 emissions 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.

As federal policy becomes more likely, a key emerging 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.

Pew Center on Global Climate Change

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

ENDNOTES

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January 2009

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 and behavioral 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.

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

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 3000–5000 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 emissions 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 that 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 20 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.

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The creation of jobs from emission reductions and climate mitigation strategies is also 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

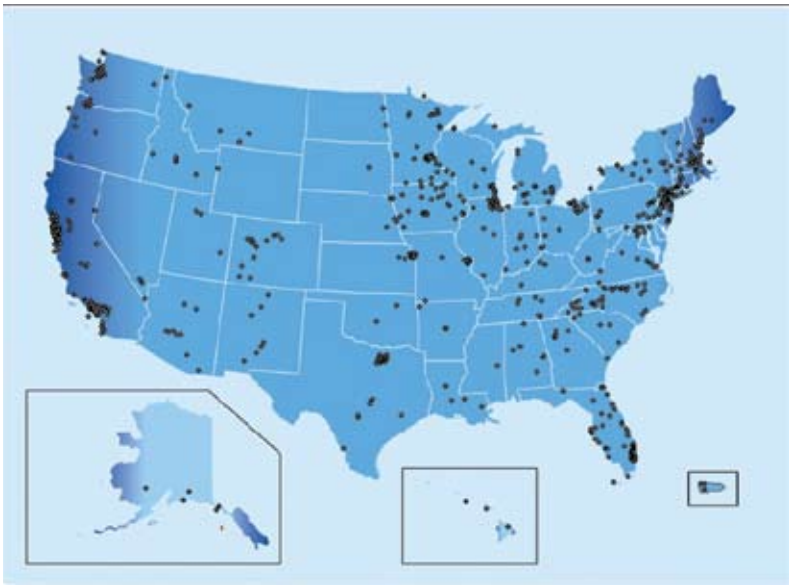
Local commitment to climate solutions is not new; in fact, cities were leaders in worldwide efforts to reduce emissions from the start. In 1989, the City of Toronto adopted the world's first greenhouse gas reduction target of 20 percent below 1988 levels by 2005.[3] The City's actions helped inspire 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 687 local governments in 31 countries, including 157 cities, towns, and counties 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 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, as suggested for the United States in the Kyoto Protocol, and also recommend that state and federal governments take comparable action. More than 884 local elected leaders have signed the mayors' agreement from communities across all 50 states plus the District of Columbia and Puerto Rico, representing over 80 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 to develop and implement a range of actions that will reduce GHG emissions. The initiative provides technical assistance

Figure 1

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



Mayors of 884 cities have signed the U.S. Mayors Climate Protection Agreement as of September 2008. Source: http://www.seattle.gov/Mayor/Climate/

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 over 60 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 36 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 emissions-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 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 has already reduced GHG emissions by 67 percent 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. 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, requiring that 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 cover electricity needs for public facilities with energy obtained from renewable 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 emissions 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, mandatory 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.

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; Montgomery County, MD

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 2004, Montgomery County led a group of local governments and agencies in a wind energy purchase representing 5 percent of the buying group's total electricity needs. The group has since increased its purchase commitment and by 2011 will account for 20 percent of electricity consumption with clean 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 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 will be funded in 2008–9 pilot year, but 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. The Longs Peak Energy Conservation, Weatherization, and Home Rehab Programs in Colorado provide extensive retrofits and weatherization services as well as smaller-scale audits and lighting efficiency assistance for qualified households. In 2007, more than 1,600 households participated in this program. 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: over 50 percent take public transit to work, and 73 percent walk to Metro stations. The program has been so successful that Arlington had to relax density restrictions to allow for more development.

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 carbon dioxide 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 2008, 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 200 public and private green roofs totaling more than 2.5 million square feet in Chicago.

Cross-Cutting

Lead By Example—Seattle, WA

Seattle has reduced its greenhouse gas emissions 8 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 carbon dioxide 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.

LESSONS LEARNED

Local leaders can provide models for climate action for other communities and levels of government to emulate. They 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. Seattle Mayor Greg Nickles, 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 900 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. Fourteen years later, more than 800 cities, towns, and counties across the nation have committed to climate action. Almost in tandem, state governments increasingly are taking action to adopt greenhouse gas reduction targets, develop climate protection plans, and adopt other policies aimed at protecting the climate. These local and state leaders recognize the importance of action and collaboration at all levels of government to address this global challenge. They can also serve as strong voices in favor of national action and should be supported by a comprehensive national and international commitment to climate protection.

Pew Center on Global Climate Change

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

ENDNOTES

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

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