

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

A REAL PROBLEM WITH REAL SOLUTIONS

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

Carbon dioxide (CO₂) and other greenhouse gases always have been present in the atmosphere, keeping the earth hospitable to life by trapping heat. Yet, since the industrial revolution, emissions of these gases from human activity have accumulated steadily, trapping more heat and exacerbating the natural greenhouse effect. As a result, global average temperatures have risen both on

land and in the oceans, with observable impacts already occurring that foretell increasingly severe changes in the future. Polar ice is melting. Glaciers around the globe are in retreat. Storms are increasing in intensity. Ecosystems around the world already are reacting, as plant and animal species struggle to adapt to a shifting climate, and new climate-related threats emerge.

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



Figure 1

The Greenhouse Effect

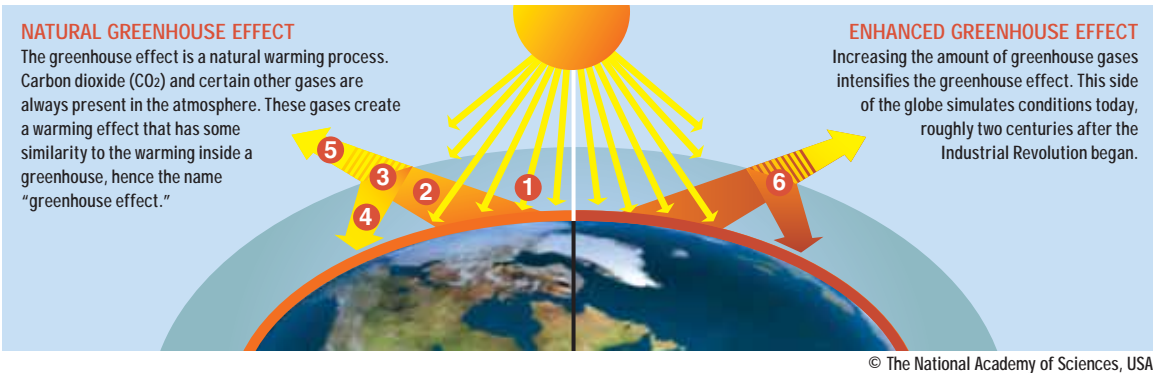


Illustration of the greenhouse effect (courtesy of the Marian Koshland Science Museum of the National Academy of Sciences). Visible sunlight passes through the atmosphere without being absorbed. Some of the sunlight striking the earth ① is absorbed and converted to heat, which warms the surface. The surface ② emits heat to the atmosphere, where some of it ③ is absorbed by greenhouse gases and ④ re-emitted toward the surface; some of the heat is not trapped by greenhouse gases and ⑤ escapes into space. Human activities that emit additional greenhouse gases to the atmosphere ⑥ increase the amount of heat that gets absorbed before escaping to space, thus enhancing the greenhouse effect and amplifying the warming of the earth.

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

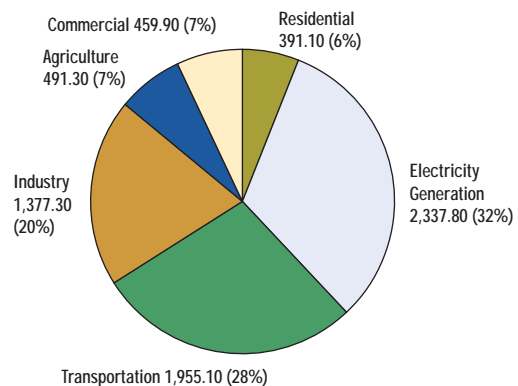
REDUCING EMISSIONS: WHAT IT WILL TAKE

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

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

Figure 2

2004 U.S. Greenhouse Gas Emissions by Sector (Million Metric Tons CO₂ Equivalent)



Source: U.S. EPA

Getting it Done—in “Wedges”

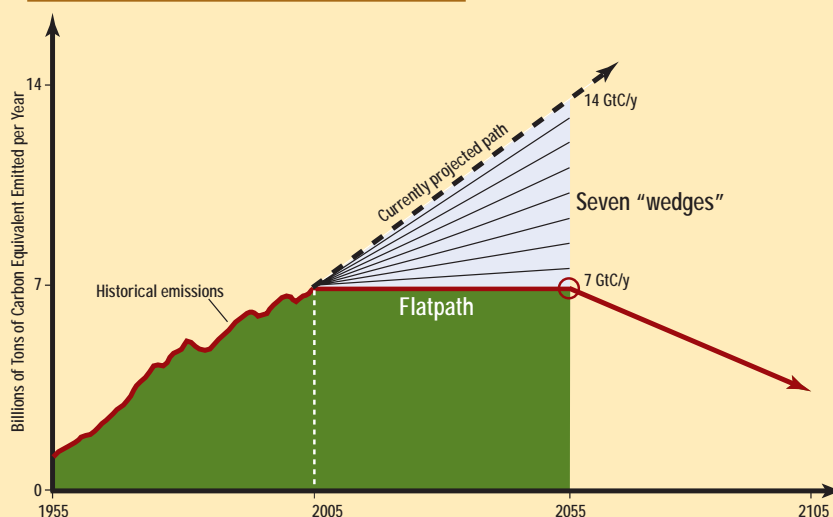
One oft-cited forecast suggests that under a “business-as-usual” scenario, annual global greenhouse gas emissions will reach 14 billion tons (gigatons) per year by 2055. Assuming we need to cut those emissions at least in half (or by a minimum of 7 gigatons), researchers Robert Socolow and Stephen Pacala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

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

- Producing 2 billion cars that travel 60 miles per gallon of gas instead of 30 miles per gallon
- Build 1 million 2 MW wind turbines to displace coal power
- Build 700 GW of nuclear power to displace coal power (twice current global nuclear capacity)
- Decrease car travel for 2 billion 30mpg cars from 10,000 to 5,000 miles per year
- Capture and store carbon emissions at 800 GW of coal plants
- Improve energy efficiency by one-fourth in buildings and appliances
- Produce 100 times current U.S. ethanol output

Figure 3

Stabilizing and Reducing Global Emissions



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

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

Given the many sources of emissions, a comprehensive response to climate change requires a portfolio of solutions. In

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

to improve the fuel efficiency of cars and trucks. Other transportation solutions include using low-carbon fuels (such as 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 GHG emissions and a market for reductions. One such system, known as cap-and-trade, would set a cap on GHG emissions and allow companies to trade emission allowances so they can achieve their reductions as cost-effectively as possible.

EMBRACING CLIMATE SOLUTIONS

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

Business Solutions. Leading businesses around the globe are taking action to reduce their impact on the climate and

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

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

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Many corporate leaders increasingly believe that the growing certainty about climate science means that government action is imminent. Companies want a head start over their competitors in learning how to reduce their emissions. Others in the private sector are responding to growing pressure from investor and consumer groups for disclosure of

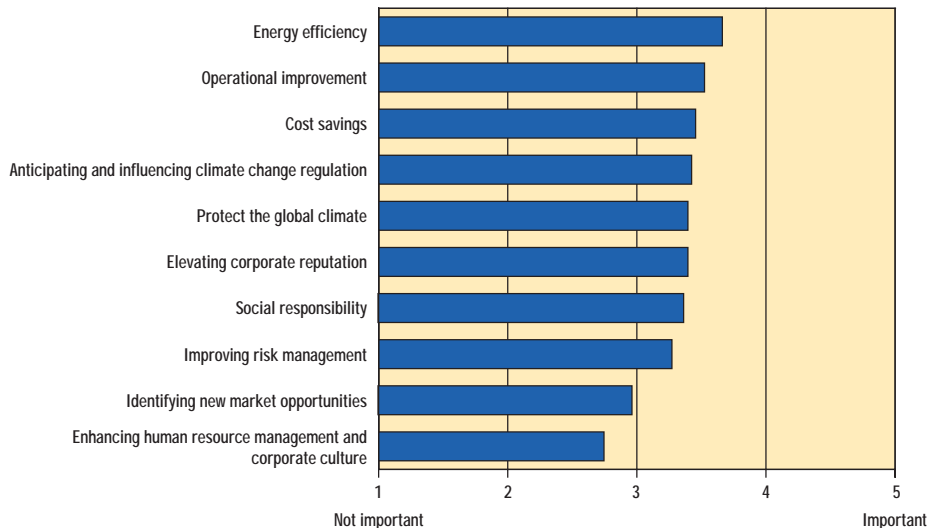
climate-related risks and integration of climate concerns into companies' core business strategies. There may also be considerable risk to a company's brand and reputation if customers, partners, investors and/or employees don't view the firm as responsible with regard to climate change. The potential physical impact of climate change on business operations is another concern among corporate leaders.

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

Figure 4

Why Companies Take Action

Once begun, how important are the following measures of success in undertaking your climate-related strategy?



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

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

International Action. Climate change is a global problem requiring a global response. CO₂ emissions have risen 130-fold since 1850 and are projected to increase another 60 percent by 2030. Most emissions come from a relatively small number of countries. An effective strategy to avert dangerous climate change requires commitments and action by all the world's major economies.

The United States, with 5 percent of the world's population, is responsible for 25 percent of global GHG emissions, more than any other country. On an intensity basis (emissions per gross domestic product or GDP), U.S. emissions are roughly 50 percent higher than the European Union's or Japan's. On a per capita basis, U.S. emissions are roughly twice as high as those of the EU and Japan (and five times the world average).

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

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

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

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

At the national and regional levels, a range of policies contribute to reducing GHG emissions. The most far-reaching is the European Union's Emissions Trading Scheme, which caps emissions from 12,000 facilities across 25 countries. In major developing countries like China and India, policies driven by economic, energy, or development objectives in many cases contribute to GHG reduction.

China, for instance, reduced its energy intensity 68 percent from 1980 to 2000 and has ambitious targets to further improve energy efficiency and expand renewable energy.

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

United States: Federal Action. In February 2002, President Bush announced a voluntary target to achieve an 18-percent reduction in U.S. greenhouse gas intensity (the ratio of emissions to gross domestic product) by 2012. Under this target, emissions actually will continue to rise as the economy grows. In 2004, U.S. emissions were 18 percent higher than

they were in 1990, and 2.6 percent higher than at the start of 2002. A number of senators and representatives—both Democrats and Republicans—have offered proposals to limit emissions, but a mandatory climate bill has yet to pass in either branch of Congress. Nonetheless, momentum for action is growing, as indicated by the increasing number of bills, votes and hearings held on climate-related issues in Congress in recent years.

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

To date, states have implemented a broad spectrum of climate policies. Twenty-eight states have adopted climate action plans detailing steps they will pursue in addressing climate change, and 12 states actually

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

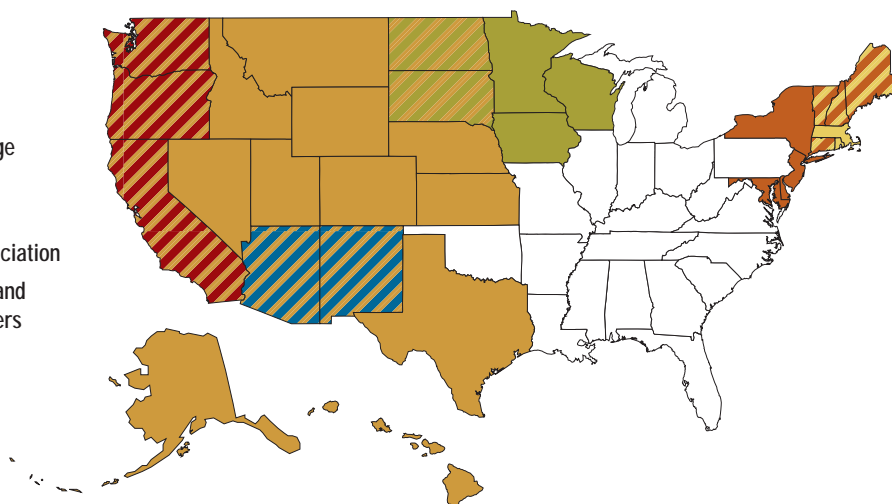
Among the main motivating factors for state action has been concern about the potential impact of climate change on state economies from consequences such as sea level rise

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Figure 5

Regional Initiatives

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



*States with diagonal shading indicate two categories

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

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

In addition to spotlighting what works, however, states also are demonstrating that their efforts alone are not enough. States have limited resources and strict budget requirements that make far-reaching climate policies difficult to implement, and they also lack certain powers that would be crucial to a comprehensive climate change policy. Moreover, the patchwork quilt that can result when states take individual approaches to the climate issue can be inefficient and pose

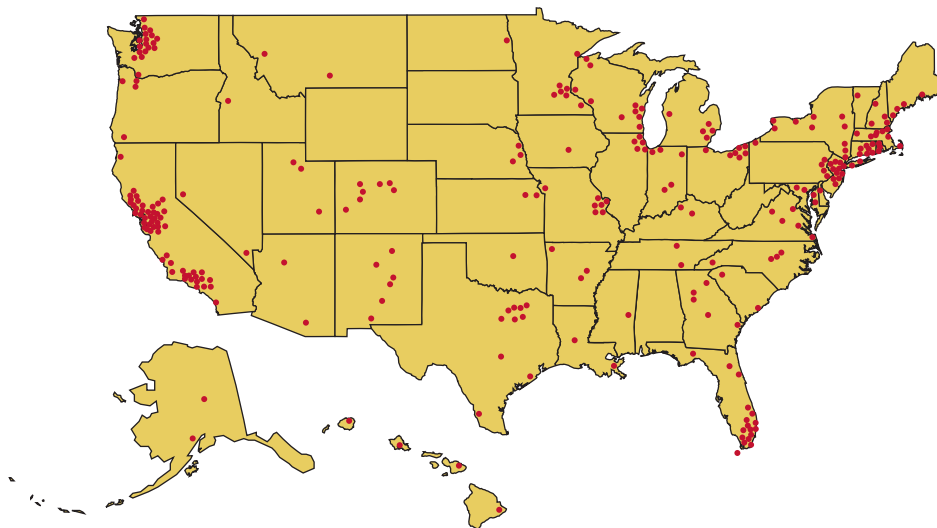
challenges for business. State action is important, but strong and coherent federal policies are needed to ensure consistency and to mobilize climate solutions throughout the economy and the nation.

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

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

Figure 6

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



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

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

THE PATH FORWARD

The science is clear. Climate change is happening, and the time to act is now. While the early actions of local and state governments, nations, and business leaders are significant, climate change remains a global problem requiring a global solution. Ultimately, a fair and effective international approach must engage all of the world's major economies and allow enough flexibility for all countries to contribute.

Substantive U.S. engagement at the international level is going to be crucial to the success of the global effort. On the domestic front, the federal government needs to adopt policies that recognize that climate change is real, and that it poses both risks and opportunities for the United States and the rest of the world. With comprehensive federal policy and constructive international engagement, the United States can harness the power of markets to drive innovation and protect the climate.

Pew Center on Global Climate Change

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

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