

Climate Change

Will governments act to curb rising temperatures?

The effects of climate change are steadily becoming more evident across the globe. Atmospheric concentrations of carbon dioxide — the main heat-trapping greenhouse gas produced by human activities — are the highest in 3 million years, and climbing. Scientists say climate change is increasing the frequency and severity of extreme weather events such as hurricanes, heat waves and droughts. President Obama has called for cutting emissions of greenhouse gases from power plants and other sources and pledged to use regulations if Congress fails to act. Americans increasingly agree that climate change is real and human actions are contributing to it, but many conservative legislators oppose measures designed to address the problem, such as taxing carbon-based fuels. Some experts want to start researching large-scale geoengineering technologies for cooling Earth's climate, but many observers fear that these strategies could do more harm than good.



Superstorm Sandy flooded parts of Manhattan and much of coastal New Jersey last October, including taxicabs parked in Hoboken. Scientists say climate change is magnifying the effects of storms like Sandy, droughts in Texas and the Southwest and other extreme weather events worldwide.

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Climate Change

BY JENNIFER WEEKS

THE ISSUES

News reports last month marked a scientific milestone: Earth's atmosphere now contains more carbon dioxide (CO₂) than at any time in up to 3 million years.¹ And the average annual rate of increase for the past decade was more than twice as steep as during the 1960s.²

With carbon dioxide levels climbing at such a rapid pace, scientists said, it is clear that humans already have set dramatic climate change in motion. "Even if we all decided to stop emitting CO₂ immediately, it would take at least 20 years to start putting new [low-carbon or carbon-free] systems in place, and another 50 years for the climate to adjust," says Kevin Trenberth, a senior scientist at the National Center for Atmospheric Research in Boulder, Colo.

Carbon dioxide is a "greenhouse gas" (GHG) that traps heat in the atmosphere, warming Earth's surface. It is generated by natural sources such as wildfires and volcanic eruptions, and by human activities — primarily burning fossil fuels such as coal, oil and natural gas. Before the Industrial Revolution, Earth's atmosphere contained about 280 parts per million of CO₂. Now, numerous scientific studies warn, GHG concentrations have reached levels that will cause drastic warming with widespread consequences.³

"We cause global warming by increasing the greenhouse effect, and our greenhouse gas emissions just keep accelerating," climate scientist Dana



AFP/Getty Images/Biju Boro

A villager rafts through flood waters in northeastern India on Sept. 25, 2012. Scientists say the negative effects of climate change, including flooding caused by sea-level rise, as well as heat waves and storms, will affect developing countries most severely because they are less prepared for disaster and have limited funds for disaster relief.

Nuccitelli wrote in May. In a review of more than 4,000 peer-reviewed studies, Nuccitelli and others found that 97.1 percent endorsed the idea that human activities were contributing to climate change.⁴

Other researchers say that while human activities may be warming the Earth, climate scientists are drawing conclusions that go beyond the evidence. "[T]here is no *prima facie* reason to think that global warming will make most extreme weather events more frequent or more

severe. . . . Extreme events are by definition rare, and the rarer the event the more difficult it is to identify long-term changes from relatively short data records," said Judith Curry, chair of the School of Earth and Atmospheric Sciences at Georgia Tech, testifying to Congress in April.⁵

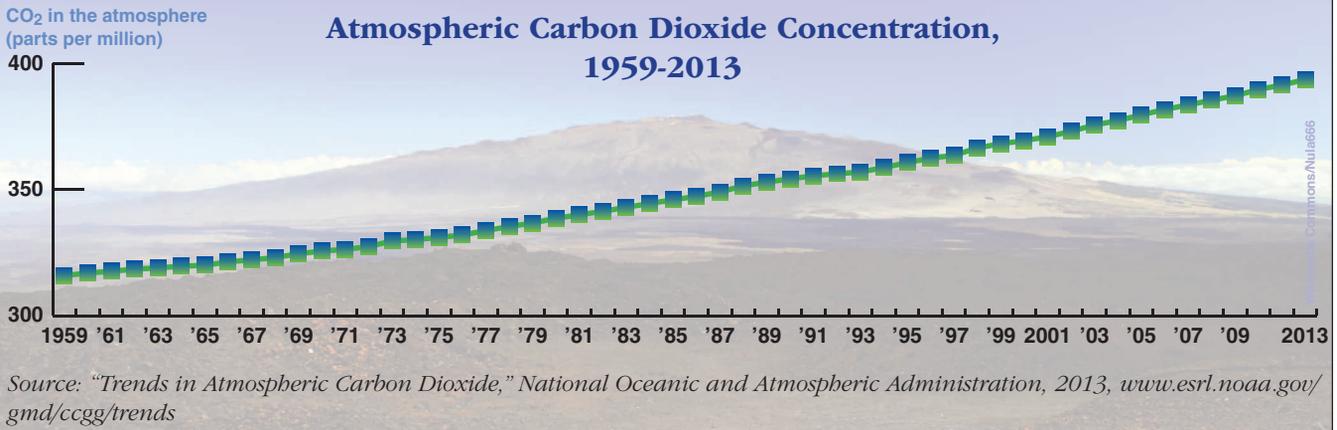
But many experts are deeply concerned. "The clock is ticking," said Jerry Melillo, a scientist at the Marine Biological Laboratory in Woods Hole, Mass., and chairman of a committee that published a national assessment earlier this year of the science and impacts of climate change.⁶ According to the assessment, average U.S. temperatures have risen about 1.5° Fahrenheit since 1895, most of it in the past 20 years.

That change may not seem large, but small shifts can have big impacts. During the so-called Little Ice Age (1300s-1800s), when average temperatures fell by just under 1°C (1.8°F), widespread crop failures in Europe caused millions of deaths.⁷ At the end of the last full-scale ice age about 10,000 years ago, average temperatures were only 5 to 9 degrees Fahrenheit cooler than modern levels, and much of North America and Europe was covered by glaciers.⁸

Recent warming already has caused significant changes. "Certain types of weather events have become more frequent and/or intense, including heat waves, heavy downpours, and, in some regions, floods and droughts," authors of the assessment report wrote. "Sea level is rising, oceans are becoming more acidic and glaciers and arctic sea ice are melting."⁹

Carbon Dioxide Concentrations on the Rise

The amount of carbon dioxide (CO₂) in the atmosphere reached 400 parts per million this spring, about a 25 percent increase since 1959. Scientists say CO₂ measurements, taken at an observatory in Mauna Loa, Hawaii, show that global carbon dioxide concentrations have climbed steadily in recent decades as a result of intensive fossil fuel combustion worldwide.



During his 2008 presidential campaign, President Obama called for action to slow climate change, but prospects faded in 2010 after a Democratic controlled Congress failed to enact legislation and control of the House shifted to the GOP. Most congressional Republicans and some conservative Democrats oppose legislation to limit climate change.¹⁰

Campaigning for reelection in 2012, Obama supported developing all types of energy sources, including fossil fuels. In his second inaugural address in January he issued a strong call for action. Ignoring climate change, he said, "would betray our children and future generations."¹¹ In his State of the Union address in February he asked Congress to pass a "bipartisan, market-based solution to climate change." If not, Obama said, he would direct federal agencies to propose steps that could be taken through regulations.¹²

But the politics of climate change remain highly polarized. Some Republican politicians question the overwhelming scientific consensus that human actions are altering Earth's climate.¹³ "All the things they're [the

Obama administration] saying happened, they're all part of [former Vice President] Al Gore's science fiction movie, and they've all been discredited," said Oklahoma Sen. James Inhofe, former chairman of the Senate Environment and Public Works Committee.¹⁴

Others say the case is not proven, focusing on issues that researchers are still analyzing. "There is a great amount of uncertainty associated with climate science," wrote Rep. Lamar Smith of Texas, chairman of the House Science Committee.¹⁵ And many legislators oppose measures that would raise fossil fuel prices. More than a dozen moderate and conservative Democrats joined Republicans in symbolic votes earlier this year against a carbon tax — which would raise the price of fossil fuels based on their carbon content — and for construction of the Keystone XL pipeline. The pipeline would facilitate development of Canadian "tar sand" oil and is opposed by many environmentalists who say it will enable greater use of fossil fuels.¹⁶

At the same time, polls show a growing share of Americans — in-

cluding Republicans — believe climate change is occurring and support some kind of action. And some observers say Republican legislators' opposition is eroding.¹⁷ (See "Current Situation," p. 535.)

"There is a divide within the party," said Samuel Thernstrom, a scholar at the conservative American Enterprise Institute who served on the White House Council on Environmental Quality under President George W. Bush and has written that humans are changing Earth's climate, with potentially severe effects. "The position that climate change is a hoax is untenable," he says.¹⁸

Other conservatives view climate change as a serious problem but question whether government actions — particularly through regulation — can slow it. "The real obstacle to making meaningful emissions reductions is that it's unbelievably difficult to do," says Jonathan Adler, a professor of law and director of the Center for Business Law and Regulation at Case Western Reserve University. Adler describes himself as a conservative who believes that climate change is a serious problem, but is skeptical that government

can mandate solutions. “We don’t know how to do it at anything remotely approaching a cost that countries are willing to bear,” he says. Instead, Adler favors policies that encourage energy innovation without prescribing specific technical solutions.

As Congress, the Obama administration and advocacy groups debate how to address climate change, here are some issues they are considering:

Are catastrophic climate change impacts inevitable?

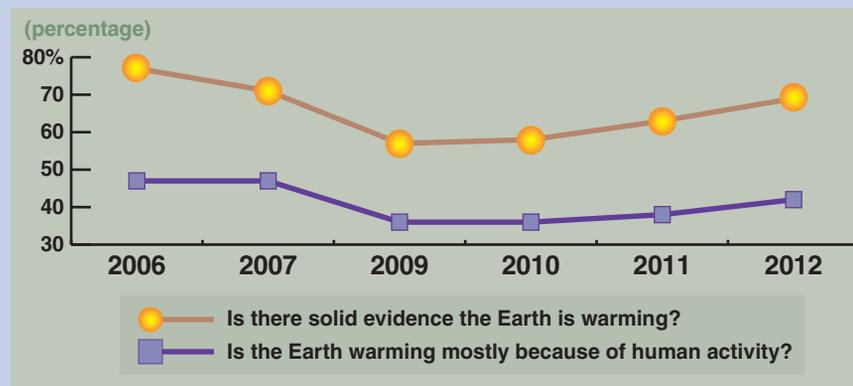
Scientists say human activities have increased the amount of CO₂ in the atmosphere by more than 40 percent from pre-industrial levels. CO₂ remains in the atmosphere for years, so some climate change has already been set in motion. However, scientists and policymakers are debating how much climate change is inevitable.

During negotiations over the past decade, some officials — particularly from Europe — have called for limiting carbon emissions enough so global temperatures do not rise more than 2°C (3.6°F) above pre-industrial levels. That target recognizes that some climate change is unavoidable but strives to prevent more disastrous effects, such as large-scale melting of polar ice caps. The goal was noted at a 2009 climate conference in Copenhagen, although nations did not formally commit to reductions large enough to achieve it.¹⁹

Limiting warming to 2°C would require capping CO₂ concentrations at about 450 parts per million, a level the planet could hit by mid-century if emissions keep rising at current rates, scientists say. Warming could be limited to that level if governments make polluters pay for their carbon emissions, eliminate subsidies for fossil fuels and increase investments in energy efficiency and renewable energy, according to Maria van der Hoeven, executive director of the International Energy Agency, which works to help

Partisan Divide Is Wide on Climate Change

About 70 percent of Americans say there is solid evidence the Earth is warming, and about 40 percent say the planet is warming mainly because of human activity. The percentage of those with either view declined between 2006 and 2009–2010 but has risen since, including among Republicans. Nevertheless, the partisan divide over climate change remains wide: Fewer than 20 percent of Republicans believe human activity causes it. And although 42 percent of Republicans favor stricter environmental limits on power plants, significantly more Democrats and Independents want such restrictions.



Percent Who Think the Earth Is Warming, by Party, 2013

Yes

Republicans.....	44%
Democrats	87%
Independents.....	68%

Yes, and mostly due to human activity

Republicans.....	19%
Democrats	57%
Independents.....	43%

Percent Who Think Scientists Agree Human Activity Is Causing Climate Change, by Party, 2012

Republicans.....	30%
Democrats	58%
Independents.....	45%

Percent Who Favor Setting Stricter Limits on Power Plants to Address Climate Change, by Party, 2013

Republicans.....	42%
Democrats	72%
Independents.....	64%

Source: “Climate Change: Key Data Points From Pew Research,” Pew Research Center, April 2013, www.pewresearch.org/2013/04/02/climate-change-key-data-points-from-pew-research

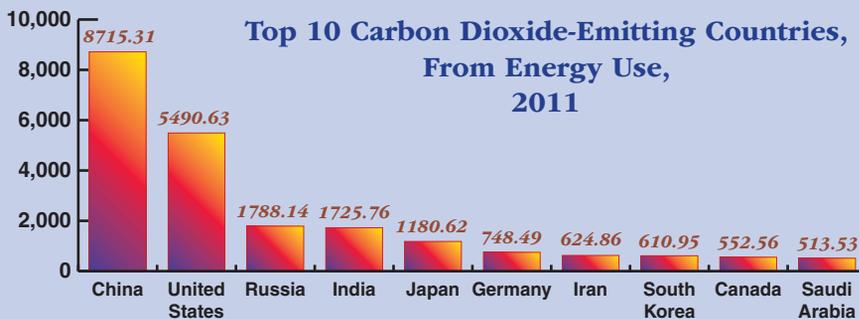
nations secure reliable, affordable and clean energy. “While ambitious, a clean energy transition is still possible,” van der Hoeven said. “But action in all sectors is necessary to reach our climate targets.”²⁰

Other experts are more pessimistic. Sir Robert Watson, a British scientist and former chair of the Intergovernmental Panel on Climate Change (IPCC), an international organization established to advise governments on

China, U.S. Emit the Most Carbon Dioxide

China emitted more carbon dioxide (CO₂) in 2011 than any other country. Its nearly 9 billion metric tons of carbon dioxide emissions were about 60 percent greater than the 5.5 billion metric tons emitted in the United States, which ranked second. Worldwide, CO₂ emissions from energy use totaled nearly 33 billion metric tons in 2011. Most carbon dioxide, a major source of heat-trapping greenhouse gases, comes from energy consumption. Emissions of other types of greenhouse gases — such as methane and nitrous oxide — are not included in these totals.

(millions of metric tons of carbon dioxide)



Source: "International Energy Statistics," Energy Information Administration, 2013, www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=90&pid=44&aid=8

climate change science and impacts, argues that nations have 50-50 odds of limiting warming to 3°C (5.4°F), but should prepare for an increase of up to 5°C (9°F). At that level, scientists say the effects will be severe, especially for developing countries. (See sidebar, p. 532.)

"When I was chairing the IPCC . . . we were hopeful that emissions would not go up at the tremendous rate they are rising now," Watson said in February. While cost-effective and equitable solutions exist, he added, "political will and moral leadership is needed" to address climate change. And the substantial changes in policies, practices and technologies are "not currently under way."²¹

Climate scientist Trenberth of the National Center for Atmospheric Research (NCAR) also doubts that it will be possible to limit warming to 2°C. "But it matters enormously how rapidly we get to that number," he says.

"The rate of change matters as much as the change itself. Getting to 2°C in 50 years is quite different than if it takes 200 years or longer."

Yet he believes it is still possible to limit the rate of warming to a pace that will allow societies to adapt. "We can slow things down enough to make a big difference and push the 2°C mark well into the 22nd century," Trenberth says.

To meet that target, nations would have to sharply cut fossil fuel use. "To stay at 2°C we can't emit more than 565 gigatons of carbon dioxide into the atmosphere by mid-century," he explains. "World CO₂ emissions in 2011 were 31.6 gigatons, which was a 3.2 percent increase from the year before. At current rates, we'll go through our limit in 16 years."^{*}

Scientists say many of the effects of climate change will occur even if

* A gigaton is one billion tons.

the planet warms by 2°C or less. "There's an impression that if we hold warming below two degrees we're safe, which is demonstrably false," says Christopher Field, a professor of global ecology at Stanford University and lead author of IPCC climate change assessment reports. "Climate change in the next 20 to 40 years will be the result of actions that are already baked into the system."

In the United States average temperatures are rising; frost-free seasons are lasting longer; precipitation is up in the Midwest, southern Plains and Northeast and down in parts of the Southeast, Southwest and Rocky Mountain states; and extreme weather events, such as heat waves and flooding, are becoming more frequent and intense.²²

Some experts, such as James Hansen, who retired early this year as director of NASA's Goddard Institute for Space Studies, calls the 2-degree target "a prescription for disaster." Hansen says nations should cut CO₂ emissions back sharply enough to reduce atmospheric concentrations to 350 parts per million — a level last seen in 1987 — to avoid effects such as melting most of the world's glaciers and ice caps.²³

Other scientists share his perspective. "Two degrees is actually too much for ecosystems," Thomas E. Lovejoy, a professor of environmental science and policy at George Mason University, wrote in January. "A 2-degree world will be one without coral reefs (on which millions of human beings depend for their well-being)." At current warming levels, he noted, U.S. and Amazonian forests already have been heavily damaged. "The current mode of nibbling around the edges is pretty much pointless," he concluded.²⁴

Is climate engineering a good idea?

As atmospheric concentrations of greenhouse gases climb and international negotiations fail to make progress, some say it is time to begin research-

ing ways to alter Earth's climate system on a large scale to slow the rise of global temperatures, at least until nations make serious commitments to cut emissions.

Various climate engineering schemes (also called geoengineering) have been proposed, such as injecting particles into the atmosphere to reflect sunlight back into space or removing tons of carbon from the atmosphere and injecting it deep underground. (See sidebar, p. 534.) But these concepts raise

difficult technical, political and ethical questions, and some say they are unworkable or unnecessary.

The National Research Council concluded in 2010 that more research was needed on ways to reduce carbon emissions, such as improving energy efficiency, capturing and storing power plant emissions and developing more low-carbon energy sources. Geoengineering strategies "may also warrant attention, provided that they do not replace other research efforts," the authors wrote.²⁵

Similarly, the Royal Society, Britain's national science academy, said in 2009 that "properly researched geoengineering methods . . . could eventually be useful to augment conventional mitigation [emission-reducing] activities, even in the absence of an imminent emergency."²⁶ Both academies emphasized that little was known about how well various geoengineering methods work or how easy they would be to deploy.

But some advocates are undeterred. Many cite the 1991 eruption of Mt.



Getty Images/Sean Gallup

A coal-fired power plant spews smoke over Mebrum, Germany, on March 4, 2013. Burning fossil fuels — such as coal, natural gas and oil — creates carbon dioxide (CO₂), a greenhouse gas that traps heat in the atmosphere, warming the Earth's surface. CO₂ is also generated by natural sources, such as volcanoes and wildfires.

Pinatubo in the Philippines, which injected millions of tons of sulfur dioxide into the atmosphere. There the gas formed sulfate particles, which reflected some of the sun's radiation back into space, lowering average global temperatures the following year by just under 1°C.

David Keith, a professor of physics and public policy at Harvard University, calls strategies to reduce incoming sunlight an imperfect but fast and cheap way to partly offset climate risk. "You can stop the warming or even do cooling if that's what you wanted to do," Keith said in January. "All the really hard problems [with geoengineering] are public policy problems."²⁷ For example, there are no broad international rules for governing geoengineering research or policies for assigning liability if an experiment harms natural resources or alters weather patterns.

Other scientists say geoengineering cannot be evaluated without better understanding of Earth's complex cli-

mate systems. For example, researchers at California's Scripps Institution of Oceanography have used shipboard generators to produce smoke (the same type used in skywriting) to see how it affects clouds on a small scale. They found that smoke particles brightened the clouds, making them more reflective, but that low clouds and multiple cloud layers made the process less effective.²⁸

Clouds are still poorly understood, according to Scripps atmospheric chemistry professor Lynn Russell, lead author of the cloud brightening study. "Cloud droplets are measured in micrometers,

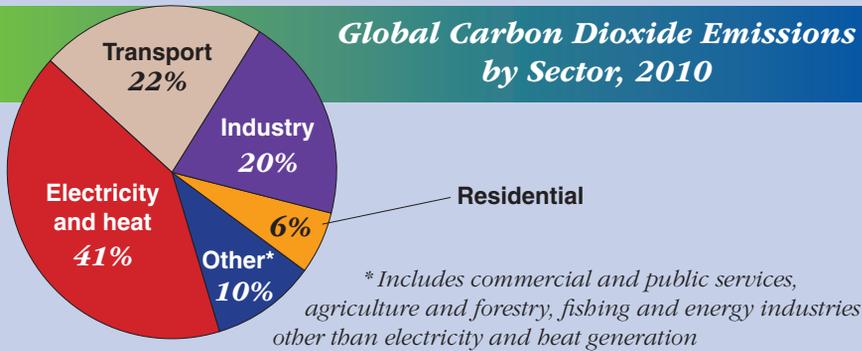
but the heating and cooling that makes clouds appear occurs over areas of many kilometers. And droplets form in microseconds, but clouds form and dissipate in hours or days," she says. Computer models have trouble combining such large- and small-scale measurements, so they usually represent some variables well and approximate others, Russell notes.

Moreover, she says, scientists do not have good ways to measure some conditions that affect cloud formation, such as extremely high humidity or three-dimensional turbulence in the atmosphere. Nonetheless, Russell believes more small-scale experiments would be useful. "Before you think about investing money in long-term geoengineering studies, you need to know what's possible," she says.

Trenberth, of the National Center for Atmospheric Research, worries that adding particles to the atmosphere could harm Earth's weather and climate cycles. For example, an NCAR study of the impacts of the Mt. Pinatubo

Electricity, Heat Generation Biggest CO₂ Sources

More than 40 percent of global carbon dioxide (CO₂) emissions in 2010 came from electricity and heat generation. The transportation and industrial sectors each accounted for about one-fifth of CO₂ emissions, the main component of human-generated greenhouse gases.



** Figures do not total 100 because of rounding.

Source: "CO₂ Emissions From Fuel Combustion," International Energy Agency, 2012, p. 9, www.iea.org/co2highlights/co2highlights.pdf

eruption found that besides temporarily lowering global temperatures, the event caused large declines in rainfall over land and extensive droughts worldwide.²⁹ "It was an extreme event," Trenberth says. "Geoengineering might cool off temperatures, but if it also shuts down parts of the weather and hydrological cycles, the cure could be worse than the disease."

In a recent article in the journal *Science*, Keith and UCLA law professor Edward Parson suggested governments start organizing modest field experiments in geoengineering to see how various techniques affect the atmosphere — on a scale small enough that it won't alter the climate — and start developing cooperative rules and limits.

"If research is blocked, then in some stark future situation where geoengineering is needed, only unrefined, untested and excessively risky approaches will be available," they contended.³⁰

Should the United States adopt a carbon tax?

Although there is little prospect that Congress will adopt broad climate change

legislation in the next several years, many liberal and conservative experts advocate taxing carbon — more specifically, the carbon content of fossil fuels. That would promote low-carbon and carbon-free fuels and technologies without having government agencies pick specific solutions, they argue.

"A carbon tax would encourage producers and consumers to shift toward energy sources that emit less carbon — such as toward gas-fired power plants and away from coal-fired plants — and generate greater demand for electric and flex-fuel cars and lesser demand for conventional gasoline-powered cars," wrote George P. Shultz, a former budget director, Treasury secretary and secretary of State during Republican presidential administrations, and Gary S. Becker, a Nobel laureate in economics and professor at the University of Chicago.³¹

Nearly a dozen nations or regions have adopted some version of carbon taxes, including the Canadian province of British Columbia, Australia, Japan, South Africa, Switzerland, Norway, Sweden, Finland and Denmark.³² In

2009-2010 Congress debated another way of pricing carbon: emissions trading through a so-called cap-and-trade system, which also has been adopted or is being considered by countries and regions in Europe, North America, Latin America and Asia.³³ The Waxman-Markey bill, which passed the House, would have created a U.S. emissions trading system, but it was never brought up in the Senate.*

Waxman-Markey illustrated the complexities of cap-and-trade systems, in which government agencies set a ceiling, or a cap, on total emissions of a pollutant, then issue emissions allowances to businesses that generate that pollutant. Companies must obtain allowances to cover all of their emissions or pay fines. Sources that reduce their emissions can sell their extra allowances, so they have a financial incentive to clean up their operations.

Conservatives lobbied hard against Waxman-Markey, which they labeled "cap-and-tax" because government would keep the revenues from selling allowances. But many liberal activists also disliked the bill. They said it gave businesses permission to pollute. And most Americans had trouble understanding how the complex program would work or how it would benefit them.³⁴ Many observers say carbon taxes can be simpler and more understandable.

In addition, a carbon tax can be revenue-neutral, many supporters argue. Government could collect taxes on high-carbon fuels, either by taxing fuel producers (the simplest approach) or energy purchasers, then rebate the money to consumers when they file their annual income tax returns.

This approach "would make energy more expensive, but would greatly offset the regressive impact of increasing the cost of energy," says Adler

* The measure was named after its sponsors, Democratic Reps. Henry A. Waxman of California and Edward J. Markey of Massachusetts.

of Case Western Reserve University. "It's also transparent. The more clearly we tax one thing and then send money directly back to people, the less ominous a carbon tax appears to be. Waxman-Markey was littered with special-interest giveaways, which magnified the suspicions that people have about this kind of legislation."

But many business interests strongly oppose a carbon tax, which they say would increase production costs, making their companies less competitive, especially if they compete with manufacturers in other countries where carbon isn't taxed. A study released earlier this year by the National Association of Manufacturers (NAM) contended that a carbon tax would reduce total U.S. manufacturing output by up to 15 percent in energy-intensive sectors. Higher production costs would put millions of jobs at risk and impel companies to reduce wages, which in turn would reduce workers' income. Eventually, workers would reduce their spending, which would dampen economic growth, the study said.³⁵

"Manufacturers use one-third of all energy consumed in the U.S. and depend on reliable, low-cost energy sources to compete in a global marketplace," a coalition of manufacturing trade associations wrote to members of Congress in May, citing the NAM study.³⁶

Industry representatives also say a carbon tax would hurt their ability to compete against fast-growing developing countries like China, which

overtook the United States in 2006 as the world's largest GHG emitter. Earlier this year, however, China pledged to adopt its own carbon tax, although it has not yet offered details.³⁷

Carbon tax advocates respond that emitting greenhouse gases imposes costs on society, in the form of climate change and all of its negative environmental effects. In their view, taxing carbon corrects an unfair ad-



A snorkeler views a coral reef near Mansuar Island, in eastern Indonesia's Papua region. The surrounding Raja Ampat archipelago, considered one of the most important biodiversity environments in the world, was nominated as a UNESCO World Heritage Site. A 2°C temperature rise would kill the world's remaining coral reefs, according to scientist Thomas Lovejoy of George Mason University.

vantage that fossil fuel producers reap when they are not required to pay the costs of carbon pollution.

"Oil and coal companies have been sending carbon pollution into the atmosphere since the Industrial Revolution. When these industries started, the risks were poorly understood. Today they know better," argued Sen. Sheldon Whitehouse, D-R.I., who has cosponsored legislation to impose a carbon tax. "On average, [economists'] estimates of the social cost of carbon are about \$48 per ton of carbon dioxide — \$48 per ton that these big businesses dodge and that we all pay for." ■

BACKGROUND

Measuring GHGs

Anthropogenic (human-driven) climate change is a relatively new scientific field, but it has deep roots. Scientists have understood for well over a century that Earth's climate has fluctuated between warm and cold phases throughout history, and have studied factors that contribute to such changes.

For example, in 1864 Scottish physicist James Croll theorized that regular variations in Earth's orbit could trigger ice ages by changing how and where the sun's energy fell on the planet. Eighty years later Milutin Milankovic, a Serbian geophysicist, calculated these shifts more precisely and developed a theory of glacial periods, now known as Milankovic cycles.

Swedish chemist Svante Arrhenius was the first scientist to suggest that human activities could affect planetary climate cycles. In 1896 Arrhenius published the first explanation of how two greenhouse gases — CO₂ and water vapor — trapped heat in the atmosphere. He also recognized that humans were increasing CO₂ concentrations by burning fossil fuels, but assumed that it would take thousands of years for those activities to have a measurable impact.

In 1938 Guy Callendar, an English inventor, estimated that humans had added about 150 billion tons of CO₂ to the atmosphere since the 1880s. He collected temperature records from

AFP/Getty Images/Romeo Gacard

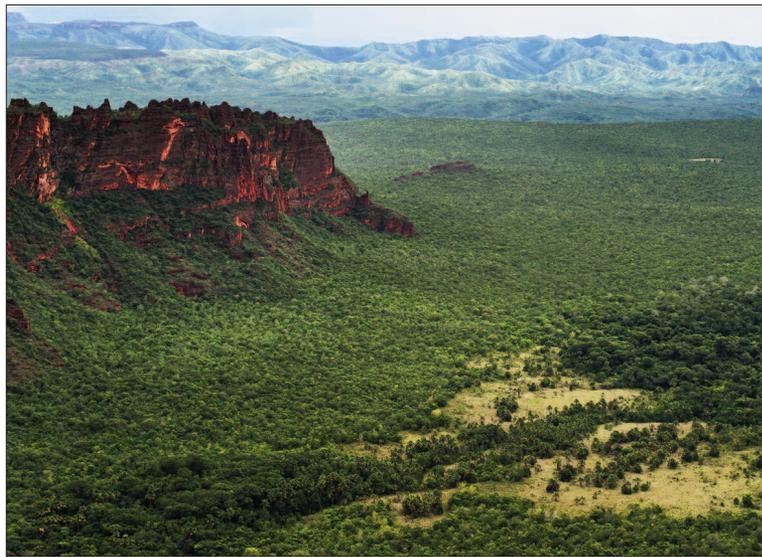
around the world and concluded that rising GHG concentrations were raising the planet's temperature. Like Arrhenius, he thought warming would benefit humans by extending growing seasons. "In any case, the return of the deadly glaciers should be delayed indefinitely," he wrote.³⁸

But after further study, scientists began to worry about where all of the excess CO₂ would go. In 1957 Roger Revelle and Hans Suess of California's Scripps Institution of Oceanography published a study showing that most human-generated CO₂ emissions up to that time had been absorbed by the world's oceans. But the oceans were nearing their capacity for absorbing CO₂, so the gas was accumulating in the atmosphere, they contended, with unknown results.

"[H]uman beings are now carrying out a large-scale geophysical experiment," Revelle and Suess warned. "Within a few centuries we are returning to the atmosphere and oceans the concentrated organic carbon [that was] stored in sedimentary rocks over hundreds of millions of years."³⁹

Climate science expanded rapidly in the 1950s and 1960s. International research groups in the United States, England, Mexico and elsewhere began designing general models to simulate the many complex processes that created Earth's climate, such as ocean currents and wind patterns. Scientists used these models to test theories about how the system might change in response to natural or manmade events.

French, Danish, Swiss, Russian and U.S. scientists drilled into ice sheets in Greenland and Antarctica and analyzed air bubbles from thousands of years earlier to determine how the atmosphere's composition had changed over time. A growing body of research showed that many processes shaped global climate patterns, and that human actions could disrupt the system.



AFP/Getty Images/Yasuyoshi Chiba

The Amazon rain forest — already being devastated by global warming — faces further damage from climate change. Scientists say a 2°C temperature rise would decrease water flow in the Amazon basin by 20-40 percent, causing widespread drought and other environmental problems.

Calls for Action

In the late 1960s public concerns about pollution and over-development in industrialized countries triggered a global environmental movement. Governments began setting standards for air and water quality, waste management and land conservation.

Congress established the Environmental Protection Agency (EPA) in 1970 and a wave of major environmental laws followed, including the Clean Air and Clean Water acts, the Endangered Species Act and the National Environmental Policy Act, which required federal agencies to consider the environ-

mental impacts of major government projects. A 1972 international conference on the environment in Stockholm set lofty goals for international cooperation and led to creation of the United Nations Environment Programme.

Global climate change had not yet become a policy issue, but scientists were drawing more connections between atmospheric GHG concentrations, rising temperatures and alarming potential consequences, such as a melting and breaking apart of Antarctic ice sheets. By the early 1980s, many prominent scientists were warning that heavy fossil fuel use was warming the planet, with possible widespread effects.⁴⁰

By the late 1980s, environmental groups were calling for reductions in fossil fuel use. But critics argued that scientific evidence for climate change was uncertain and that reducing emissions would seriously harm economic growth by forcing businesses and households to use more expensive low-carbon energy sources.

Western Europe, with its strong Green parties, pressed for an international agreement to limit GHGs. In 1992 nations signed the Framework Convention on Climate Change (FCCC) at the Earth Summit in Rio de Janeiro, Brazil. The treaty called for voluntarily reducing GHGs to 1990 levels, but did not set binding national limits or timetables.

Climate Wars

As it became clear that nonbinding pledges would not slow rising GHG concentrations, the focus shifted to numerical limits. In 1997 nations

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Chronology

1890s-1950s

Scientists study weather and the role of heat-trapping greenhouse gases (GHGs).

1896

Swedish chemist Svante Arrhenius develops first theory of human-caused climate change.

1945

U.S. military agencies start funding basic weather and climate research.

1950

The World Meteorological Organization is founded; it becomes a U.N. agency the next year.

1957

American geochemist Charles David Keeling begins measuring atmospheric carbon dioxide (CO₂) levels at Mauna Loa, Hawaii.

1980s *Environmentalists push for pollution limits in developed countries. Scientists warn that human activities are warming the planet.*

1988

Testifying before Congress, NASA scientist James Hansen warns that Earth's climate is warming with potentially disastrous impacts.

1987

Nations adopt the Montreal Protocol, setting international limits on gases that destroy Earth's ozone layer.

1988

U.N. creates Intergovernmental Panel on Climate Change (IPCC) to provide governments with expert views on climate change science.

1990s *Governments pledge to tackle climate change, but worry about costs.*

1990

First IPCC assessment report says global temperatures have risen and are likely to continue warming.

1992

At the Earth Summit in Rio de Janeiro, the United States and more than 150 other nations sign the Framework Convention on Climate Change (FCCC), pledging to cut all GHG emissions to 1990 levels by 2000.

1995

Second IPCC report finds scientific evidence of human-driven warming.

1997

FCCC member nations adopt the Kyoto Protocol, which requires developed countries to cut GHG emissions 5.2 percent, on average, by 2012. The Senate votes 95-0 not to adopt binding U.S. targets until developing nations also have to make cuts.

2000s-Present

Evidence mounts that human activities are warming the planet. Scientists find increasing evidence that climate change is altering weather patterns, ocean chemistry and other Earth systems.

2001

Third IPCC report says major global warming is "very likely."

2005

The Kyoto Protocol enters into force after Russia ratifies it, leaving the United States and Australia as

the only nonparticipating industrialized nations.

2006

Dutch Nobel laureate Paul Crutzen calls for active research into geo-engineering.

2007

Fourth IPCC assessment finds with more than 90 percent certainty that human activities are warming the climate. . . . Australia ratifies Kyoto Protocol. . . . U.S. Supreme Court rules that the Environmental Protection Agency can regulate CO₂ as a pollutant.

2008

Newly elected President Barack Obama pledges quick action on climate change

2009-2010

Legislation creating a system of marketable permits to emit GHGs narrowly passes House (2009), fails to reach Senate floor. . . . Republicans win control of House in midterm elections.

2011

A conservative government announces that Canada will withdraw from the Kyoto Protocol because Canadian companies would have to buy too many carbon emission credits in order to meet the country's emission-control target.

2012

Kyoto Protocol member countries extend the agreement at the last minute and commit to developing a follow-on treaty requiring cuts from more countries by 2015.

2013

President Obama calls for action to slow climate change, pledging to use regulations if Congress will not pass legislation.

Global Warming Will Hit Poor the Hardest

“The heat must be turned down.”

Will the planet warm by 2°C in coming decades, or 4 degrees — or even more? The question may seem trivial, but the difference could mean life or death for millions of people worldwide, especially in poor nations.

A 2012 report commissioned by the World Bank warned that while all countries will be affected by climate change, “the poor will suffer most, and the global community could become more fractured and unequal than today.” That scenario is especially likely if the world warms by 4°C (7.2° F) above pre-industrial levels — the likely outcome if nations don’t start cutting emissions sharply.¹

“The projected 4°C warming simply must not be allowed to occur — the heat must be turned down,” the report asserted.²

Scientists are still quantifying all of the potential impacts from a 4°C jump in temperature, but the report warns that risks from heat waves, altered rainfall patterns and drought will increase — even with a 2°C (3.6°F) temperature rise — and will be much more severe with 4°C of warming. For example:

- With a 2-degree rise in temperature, the average amount of water flowing yearly through the Danube, Mississippi and Amazon river basins would fall 20 to 40 percent, while flow in the Nile and Ganges river basins would rise by about 20 percent. With 4°C of warming, those changes would roughly double, increasing the likelihood and severity of droughts and flooding.

- If temperatures rise 1.5 to 2 degrees Celsius by 2050, the number of forest fires in the Amazon rain forest could double. With 4°C of warming, the number of fires would increase even more.³

Geophysical factors are part of why climate change will affect poor countries more than rich countries. Sea-level rise is likely to be 15 to 20 percent higher in the tropics than the average increase around the globe because of warming-related changes in ocean circulation patterns. And warming is expected to make tropical cyclones (hurricanes) more intense, while dry areas in many tropical and subtropical regions are likely to become drier as the climate warms.⁴

In addition, developing countries typically are less prepared for disasters and may not be able to provide adequate disaster relief to those whose lives will be uprooted by storms, floods or heat waves. According to the Intergovernmental Panel on Climate Change (IPCC), a scientific organization that advises national governments, more than 95 percent of deaths from natural disasters between 1970 and 2008 occurred in developing countries. However, economic losses were higher in wealthy countries, where more buildings and infrastructure were at risk.⁵

The IPCC’s definition of disaster risk is based on three factors:

- Weather and climate events, such as hurricanes or heat waves;

- Exposure — people living in areas where those events occur; and

- Vulnerability — whether victims have well-built homes or shelters, access to medical care, insurance and other resources to help them through the disasters.

“For the poor and vulnerable, a non-huge disaster can have huge consequences,” says Christopher Field, a professor of global ecology at Stanford University and co-chair of the IPCC’s working group on impacts, adaptation and vulnerability. For example, during urban heat waves the poor, elderly and infirm are much more likely to die than their more affluent neighbors.⁶

“Societies can moderate impacts of high heat by setting up cooling centers and increasing access to electricity for air conditioning, but if they’re unprepared there can be very heavy loss of life,” says Field.

Climate change threatens basic needs for the poor, such as access to clean drinking water and adequate food supplies. According to the World Bank report, 2°C to 2.5°C of warming would increase the rate of childhood stunting (failure to grow at normal rates because of undernourishment), especially in sub-Saharan Africa and South Asia, a problem likely to be more severe as warming increases. Higher temperatures also will expand the geographic ranges of many infectious diseases such as malaria, with higher risks for those without access to vaccinations and medical care.⁷

Climate change is a “clear and present danger . . . to our development plans and objectives and the health of economies large and small in all regions,” United Nations Secretary-General Ban Ki-moon said in April. “The poor and vulnerable are the ones most hit and targeted, but no nation will be immune.”⁸

— Jennifer Weeks

¹ “Turn Down the Heat: Why a 4°C Warmer World Must Be Avoided,” Potsdam Institute for Climate Impact Research and Climate Analytics, (prepared for the World Bank), November 2012, p. xviii, http://climatechange.worldbank.org/sites/default/files/Turn_Down_the_heat_Why_a_4_degree_centrigrade_warmer_world_must_be_avoided.pdf.

² *Ibid.*

³ *Ibid.*, p. xvi.

⁴ *Ibid.*, p. xiii.

⁵ “Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation,” Intergovernmental Panel on Climate Change, 2012, p. 7, http://ipcc-wg2.gov/SREX/images/uploads/SREX-SPMbrochure_FINAL.pdf.

⁶ For example, see Micah Maidenburg, “The 1995 Heat Wave Reflected Chicago’s ‘Geography of Vulnerability,’” *ChicagoNow.com*, July 20, 2011, www.chicagonow.com/chicago-muckrakers/2011/07/the-1995-heat-wave-reflected-chicagos-geography-of-vulnerability/.

⁷ “Turn Down the Heat,” *op. cit.*, p. xvii.

⁸ “Climate change is a ‘clear and present danger,’ says UN Chief,” United Nations, April 19, 2013, www.unmultimedia.org/radio/english/2013/04/climate-change-is-a-clear-and-present-danger-to-humankind-says-un-chief/.

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adopted the Kyoto Protocol, which required developed countries to reduce their GHG emissions, on average, by 5.2 percent below 1990 levels by 2012. It also created programs to slow emission growth in developing countries, including international trading of emission allowances and credits for wealthy countries that paid for emission reduction projects in developing countries.⁴¹

The framework recognized that developed countries were responsible for virtually all warming above pre-industrial levels that had already occurred, but fast-growing developing nations such as China, India and Brazil also were becoming major emitters. But the U.S. Senate made clear that it would not ratify the pact unless developing countries also were required to make binding reduction pledges. Accordingly, President Bill Clinton, who had signed the Kyoto Protocol in 1997, never submitted it to the Senate for ratification, although both he and Vice President Al Gore supported action to address climate change.

The prospect of national legislation to cut GHG emissions energized fossil-fuel interests, which were funding work by some conservative think tanks and media outlets to discredit scientific evidence of a human role in climate change. As long as the scientific evidence was uncertain, these advocates argued, it did not make sense to limit GHG emissions. Over time, the Republican Party came to strongly oppose government efforts to ad-



AFP/Getty Images/Nicholas Kamm

President Obama has called for cutting emissions of heat-trapping gases from power plants and other sources and pledged to use regulations if Congress fails to act. Environmental advocates say the president could take other steps as well, including rejecting the proposed Keystone XL crude oil pipeline from Alberta, Canada, and tightening restrictions on hydraulic fracturing, or fracking.

dress climate change.⁴²

Shortly after he was sworn into office, Republican President George W. Bush (2001-2009) renounced Clinton's decision to sign the Kyoto agreement and said cutting GHG emissions would harm the U.S. economy. Bush's presidency was also marked by what many observers came to refer to as "climate wars" — harsh debates over the accuracy of climate science. "There is still a window of opportunity to challenge the science," Republican political consultant Frank Luntz wrote in a 2002 strategy memo. To prevent voters from supporting action to slow climate change, he argued, politicians should "continue to make the lack of certainty a primary issue in the debate."⁴³

Despite these arguments, some national leaders — including Republicans — pressed for the United States to take action. In 2003, 2005 and 2007, Sens. John McCain, R-Ariz., and Joseph Lieberman, D-Conn., introduced bills to create a cap-and-trade system for reducing

U.S. carbon emissions. And some major corporations began endorsing carbon controls. "We know enough to act on climate change," the U.S. Climate Action Partnership (an alliance of major corporations including Alcoa, DuPont and General Electric) said in January 2007.⁴⁴

Also in 2007 the IPCC and former Vice President Gore — who had argued strongly for action on climate change in the Academy Award-winning documentary *An Inconvenient Truth* — were awarded the Nobel Peace Prize, a sign of strong international concern about climate change.⁴⁵

Obama's Record

Many observers expected progress on climate change after Obama was elected in 2008. As a candidate, he had pledged to support clean-energy options and work for passage of a national cap-and-trade system to limit GHG emissions.

Initially, however, Obama's attention was consumed by the worldwide recession that had begun in 2007. Obama's major legislative successes in 2009 were economic rescue measures, including a \$787 billion economic stimulus package and a bailout plan for U.S. automakers. In such economic circumstances, proposing policies that would raise the price of fossil fuels was much more challenging than it would have been in a strong economy.

In June 2009 the House passed the Waxman-Markey cap-and-trade bill by a narrow 219-212 margin.⁴⁶ Many

Geoengineering Proposals Would Alter Earth's Climate

Scientists say the controversial techniques demand more study.

Shooting small particles into Earth's upper atmosphere to reflect incoming sunlight back into space. Dumping large quantities of iron into the oceans to stimulate the growth of pollution-eating plankton. Those are just two of the futuristic methods engineers have considered as ways to keep the planet from overheating.

So-called geoengineering techniques involve large-scale efforts to alter Earth's climate system in order to reduce the impact of climate change. They fall into two broad categories: Managing the amount of energy from the sun that falls on Earth's surface, and scrubbing millions of tons of heat-trapping carbon dioxide (CO₂) from the atmosphere.

Strategies designed to control the amount of heat from the sun striking the Earth include:

- Injecting small reflective particles, such as sulfates, into the upper atmosphere to reflect some sunlight back to space.
- Spraying salt water into the lower atmosphere, which makes clouds brighter and more reflective (water vapor in the atmosphere condenses around salt particles, increasing the number of droplets in clouds).
- Installing reflective objects in space between the Earth and sun; and
- Increasing the percentage of Earth's surface covered with light-colored, reflective surfaces, through such techniques as painting millions of roofs white.

Engineers believe shooting reflective particles into the atmosphere would be the most cost-effective and feasible approach, but some scientists worry that it could change rain and snowfall patterns, damage the Earth's ozone layer or increase air pollution.¹

Strategies for removing carbon dioxide from the atmosphere include planting more forests, which consume and store carbon as trees grow; "fertilizing" the oceans by dumping large

quantities of iron to stimulate the growth of plankton, which absorbs CO₂ as it multiplies; and capturing CO₂ by passing air through "scrubbers" that remove carbon dioxide. The CO₂ would then be injected into deep underground reservoirs.

No international treaty or agency governs geoengineering, and many critics say efforts to manipulate weather and climate on such massive scales could threaten human health, forests or fisheries.

One widely publicized geoengineering experiment was conducted by Russ George, an American businessman who has tried several ocean-fertilization experiments, seeking to demonstrate that by locking CO₂ up in the deep ocean a company can generate marketable "carbon credits." But studies have not yet shown that ocean fertilization actually removes significant amounts of carbon from the atmosphere, so he doesn't have any buyers yet.

Spain and Ecuador barred George from their ports after he sought to carry out ocean fertilization experiments near the Galápagos and Canary islands, which officials contended would pollute the seas and threaten biodiversity.² Controversy over his proposals spurred the United Nations to adopt a moratorium on ocean fertilization experiments. Nonetheless, George dumped 100 metric tons of iron sulphate off Canada's west coast last fall, generating a large plankton bloom. He said international treaties barring ocean dumping and actions that might threaten biodiversity were "mythology" and did not apply to his activities.³

The Canadian government belatedly launched an investigation into George's experiment, which was partly funded by a native Haida community on the coast in hopes that a plankton bloom would help restore traditional salmon runs.⁴ But the president of the Haida Nation, Guujaw, denounced the village's action. "Our people, along with the rest of humanity, depend on the oceans and cannot leave the fate of the oceans to the whim of the few," he said.⁵

environmental advocates hailed it as a first step, but others complained it set what they saw as weak emissions limits and allowed polluters to "offset" some of their emissions by paying for cleanup projects elsewhere.⁴⁷

Without strong support from the public or liberal environmentalists, and with conservatives labeling it an "energy tax," Senate Democratic leaders opted not to bring the bill up for consideration.⁴⁸ Then in the 2010 midterm elections Republicans won control of the House, making it effectively impossible to enact climate change legislation. Conservative legislators, particularly those affiliated

with or seeking support from the conservative anti-tax Tea Party movement, challenged numerous laws and regulations as government intrusions into private decisions — including previously uncontroversial policies such as efficiency standards for light bulbs.⁴⁹

Obama's main climate-related success was negotiating tighter fuel efficiency and greenhouse gas pollution standards for new cars and trucks. These changes, announced in 2011, were projected to cut U.S. oil use by 12 billion barrels and avoid 6 billion metric tons of CO₂ emissions — equivalent to all of U.S. emissions in 2010.⁵⁰

During the 2012 presidential race, Obama and his GOP opponent, former Massachusetts Gov. Mitt Romney, largely avoided the topic of climate change. (Romney had supported state GHG limits as governor, then reversed his position shortly before leaving office.) Instead, they both emphasized producing energy from as many sources as possible, including coal, oil and natural gas. Obama also advocated more government support for solar, wind and other renewable energy sources, while Romney called for leaving energy choices up to the market.⁵¹

Just before the election, New York

In its last major climate change assessment report, the Intergovernmental Panel on Climate Change (IPCC) called geoengineering techniques such as ocean fertilization “speculative” and noted that many of the potential environmental side effects had yet to be studied, no detailed cost estimates existed and there was no legal or political framework for implementing such projects.⁶ The IPCC held an expert workshop on geoengineering in 2011, and its next assessment, scheduled to be published in late 2014, will consider the science, potential impacts and uncertainties of geoengineering in more detail.

Meanwhile, many nations are concerned about how geoengineering strategies could affect climate cycles and natural resources. A 2012 report for the U.N. Convention on Biological Diversity (an international treaty signed by 193 countries that aims to protect Earth’s natural resources) concluded that few proposed geoengineering strategies had been well researched and no good systems had been designed for regulating them. In short, the report concluded, much more study was needed.⁷

Large-scale application of geoengineering techniques “is near-certain to involve unintended side effects and increase sociopolitical



AFP/Getty images/Arlan Naeg

The 1991 eruption of Mt. Pinatubo in the Philippines caused global temperatures to drop temporarily by nearly 1°C by sending millions of tons of sulfur dioxide into the atmosphere. The gas formed sulfate particles, which reflected some of the sun’s radiation back into space.

tensions,” the report observed. “While technological innovation has helped to transform societies and improve the quality of life in many ways, it has not always done so in a sustainable manner.”⁸

— Jennifer Weeks

¹ “IPCC Expert Meeting on Geoengineering,” Intergovernmental Panel on Climate Change, June 20-22, 2011, pp. 19-20, www.ipcc.ch/pdf/supporting-material/EM_GeoE_Meeting_Report_final.pdf.

² Kalee Thompson, “Carbon Discredit,” *Popular Science*, July 1, 2008, www.popsci.com/environment/article/2008-07/carbon-discredit?single-page-view=true.

³ Martin Lukacs, “World’s Biggest Geoengineering Experiment ‘Violates’ UN Rules,” *The Guardian*, Oct. 15, 2012, www.guardian.co.uk/environment/2012/oct/15/pacific-iron-fertilisation-geoengineering.

⁴ “B.C. Village’s Ocean Fertilization Experiment Probed,” CBC News, March 28, 2013, www.cbc.ca/news/canada/british-columbia/story/2013/03/27/bc-iron-restoration-fifth-estate.html.

⁵ “West Coast Ocean Fertilization Project Defended,” CBC News, Oct. 22, 2012, www.cbc.ca/news/canada/british-columbia/story/2012/10/19/bc-ocean-fertilization-haida.html.

⁶ “Climate Change 2007: Mitigation of Climate Change,” Intergovernmental Panel on Climate Change, section 11.2.2, 2007, www.ipcc.ch/publications_and_data/ar4/wg3/en/ch11s11-2-2.html.

⁷ “Impacts of Climate-Related Geoengineering on Biological Diversity,” Convention on Biodiversity, April 5, 2013, pp. 3, 9, www.cbd.int/doc/meetings/sbstta/sbstta-16/information/sbstta-16-inf-28-en.pdf.

⁸ *Ibid.*, p. 8.

City Mayor Michael Bloomberg, an independent who had been courted by both campaigns, endorsed Obama, partly because he believed Obama was more likely to act to slow climate change. Bloomberg made his announcement just after Superstorm Sandy, an immense hurricane, flooded parts of Manhattan and devastated coastal New Jersey.

“Our climate is changing. And while the increase in extreme weather we have experienced in New York City and around the world may or may not be the result of it, the risk that it might be — given this week’s devastation — should

compel all elected leaders to take immediate action,” Bloomberg said.⁵² ■

CURRENT SITUATION

Bypassing Congress

With Congress sharply divided along party lines, observers see little prospect for legislation to address

climate change during Obama’s second term. But environmental advocates say he can make significant progress through executive actions and regulations.

“By far the most important step the president can take is using his authority under the Clean Air Act to finalize carbon pollution limits for new power plants [i.e., plants not yet constructed] and develop limits for existing power plants,” says David Goldston, government affairs director for the Natural Resources Defense Council (NRDC), a national environmental advocacy group. “That could reduce CO₂ output from power plants by 25 percent.”

The EPA proposed a carbon pollution standard for new power plants in 2012 after the Supreme Court ruled in 2007 that the agency had authority to regulate carbon dioxide as a pollutant under the Clean Air Act.⁵³ The proposed standard would limit carbon emissions from fossil-fuel-burning power plants to 1,000 pounds of CO₂ per megawatt-hour of electricity generated.⁵⁴

According to the agency, new natural gas plants should be able to meet the standard without additional controls. But coal-fired plants emit carbon dioxide at about twice that rate, so new coal plants would need extra pollution controls. Because the price of natural gas has dropped sharply in recent years, the EPA and Department of Energy (DOE) expect that new power plants likely will burn gas, so they don't expect the coal plant rule to affect energy prices or reliability.⁵⁵

But in April the EPA put the new rule on hold indefinitely after energy companies said it would effectively kill any new coal-fired power plants. Agency officials said the rule would be rewritten to provide more flexibility.⁵⁶ And during her confirmation hearings this spring to be administrator of EPA, Gina McCarthy said the agency was not developing GHG regulations for existing power plants.⁵⁷

Environmentalists also suggest other steps Obama could take to limit GHG emissions, including:

- Rejecting the proposed Keystone XL pipeline, which would carry crude oil

from tar sand deposits in Alberta, Canada, to refineries on the U.S. Gulf Coast. "Tar sand oil is far more polluting than traditional fossil fuels," says Goldston.

- Further tightening energy efficiency standards for appliances, electronics and other equipment.

panies say the problem can be managed.⁵⁹

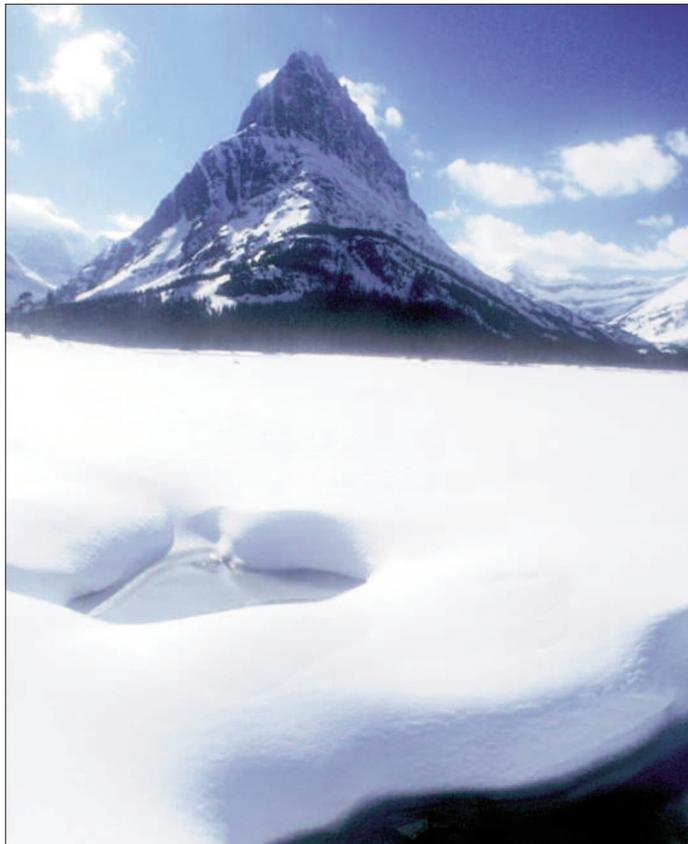
Any new regulations could face legal challenges, especially if industry says they would cost too much to implement. But Goldston believes courts will uphold reasonable climate protection rules. "Everyone knows there will be challenges, but there's no reason that well-written standards shouldn't survive in court," he says.

Republican opposition to greenhouse gas regulations figured prominently in debate over Obama's choice of McCarthy as EPA administrator. McCarthy currently heads the agency's Air and Radiation program (a position for which the Senate confirmed her by voice vote in 2009) and has also worked for Republican governors in Massachusetts and Connecticut. Her nomination was praised by business leaders: Gloria Bergquist, vice president of the Alliance of Automobile Manufacturers, called her a "pragmatic policymaker" who "accepts real-world economics."⁶⁰

But Republicans on the Senate Environment and Public Works Committee asked McCarthy more than 1,100 questions for the record during her confir-

mation process — seven times as many as McCarthy's predecessor, Lisa Jackson, faced. The Republican Policy Committee contended that McCarthy had "played a central role in authoring environmental regulations that could effectively ban the use of coal as an energy source," alluding to the carbon standards for new power plants. The committee also charged that EPA was working to undercut approval of the

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The glaciers at Glacier National Park in Montana (above) are melting, along with many of the world's other glaciers and Arctic ice. Some officials have called for limiting temperature increases to 2°C, but some climate experts say even that could cause most of the world's glaciers and ice caps to melt.

USGS Climate Change in Mountain Ecosystems Program

- Maintaining robust funding for renewable energy research and development; and

- Regulating the environmental impacts of hydraulic fracturing, or "fracking," for natural gas, including limits on methane emissions.⁵⁸ Methane, the main component of natural gas, is a greenhouse gas, and critics contend that methane leaks from fracking operations contribute significantly to climate change, although energy com-

At Issue:

Should the United States adopt a carbon tax?



WILLIAM G. GALE
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POLICY CENTER*

FROM "THE TAX FAVORED BY MOST ECONOMISTS,"
BROOKINGS INSTITUTION, MARCH 12, 2013,
[WWW.BROOKINGS.EDU/RESEARCH/OPINIONS/2013/
03/12-TAXING-CARBON-GALE](http://WWW.BROOKINGS.EDU/RESEARCH/OPINIONS/2013/03/12-TAXING-CARBON-GALE)

Looking for a public policy that would improve the . . . economy, lower our dependence on foreign oil, reduce pollution, slow global warming, allow cuts in government spending and decrease the long-term deficit? Then a carbon tax is what you want. . . .

Energy consumption [involves] substantial societal costs — including air and water pollution, road congestion and climate change. Since many of these costs are not directly borne by those who use fossil fuels, they are ignored when energy production and consumption choices are made, resulting in too much consumption and production of fossil fuels. Economists have long recommended a tax on fossil-fuel energy sources as an efficient way to address this problem. . . .

Most analyses find that a carbon tax could significantly reduce emissions. Tufts University economist Gilbert Metcalf estimated that a \$15 per ton tax on CO₂ emissions that rises over time would reduce greenhouse gas emissions by 14 percent. . . .

A carbon tax . . . has been implemented in several other countries, including the Scandinavian nations, the Netherlands, Germany, the United Kingdom and Australia. . . . Estimates suggest that a well-designed tax in the United States could raise . . . up to 1 percent of GDP, [which] could . . . address the country's . . . medium- and long-term budget deficits.

A carbon tax could [also reduce U.S.] dependence on foreign sources of energy and [create] better market incentives for energy conservation, the use of renewable energy sources and the production of energy-efficient goods. . . .

Two problems are sometimes raised in response to a federal carbon tax proposal. The first is its impact on low-income households, who use most of their income for consumption. However, this . . . could be offset [through] refundable income tax credits or payroll tax credits.

The second concern is whether the U.S. should act unilaterally. Without cooperation from the rest of the world, critics fear that a U.S. carbon tax would reduce economic activity here and make little difference to overall carbon emissions or levels. This view . . . discounts the experience of other countries that unilaterally created carbon taxes; there is no evidence that they paid a significant price, or any price at all, in terms of economic activity levels.

No one is claiming the carbon tax is a perfect outcome. But relative to the alternatives, it has an enormous amount to offer.



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FROM "WHY A CARBON TAX IS STILL A BAD IDEA,"
AMERICAN ENTERPRISE INSTITUTE, AUG. 28, 2012

Taxes on carbon are not simply taxes on consumption, they're a tax on production as well, since energy is a primary input to production. Taxing both production and consumption seems like a poor way to stimulate your economy, reduce your costs of production or make your exports more competitive.

Carbon taxes are regressive. Poorer people spend a higher portion of their household budget on energy than do the better off. [Unless] you were to posit redistributing the tax to the poor, higher energy costs [will] slap the lower-end of the income spectrum hard.

Taxing carbon gets you virtually no climate or health benefit unless it exists within some binding, international carbon control regime, which is unlikely. China and India will dominate global carbon emissions for the next century, while emissions in the developed world are already level or in decline. And, global negotiations over carbon controls have become a farce in which developing countries fish for wealth and intellectual property transfers, while developed countries make promises they have little intention of keeping.

Carbon taxes would put a share (potentially a large share) of the U.S. tax system under the influence of bureaucrat-scientists at the U.N. You can guarantee that there would be steady pressure to tax carbon at ever-higher rates (and transfer some of that booty to developing countries!). Do we really want "the science" of climate change as developed by the U.N. setting our tax rates?

We already have a vast array of regulations aimed at reducing carbon emissions, [so] new carbon taxes would represent double-taxation. You're already paying carbon taxes in the additional costs of new vehicles with higher fuel emission standards, more expensive appliances that aim to conserve energy, renewable energy standards that raise your cost of electricity, etc.

For the record, I'm a "lukewarmer" [on global warming] and I've written (since 1998) that some resilience-building actions would be wise in the face of climate risk, but a carbon tax? In the real world, like other eco-taxes, carbon taxes would quickly morph into just another form of taxation that feeds the ever-hungry maw of big government.

* Green was a policy analyst at the American Enterprise Institute when he wrote this commentary.

Continued from p. 536

Keystone XL pipeline by criticizing the State Department's environmental review of the project.⁶¹

All eight committee Republicans voted against McCarthy's nomination, which was supported by all 10 Democrats. The nomination could face a Republican filibuster on the Senate floor. A *Boston Globe* editorial said the GOP was trying to "bully the EPA into lowering pollution standards." If McCarthy is eventually confirmed, *The Globe* observed, she will face looming challenges — in particular, rising GHG emissions.⁶²

Public Concern

Recent polls show that while climate change remains a divisive issue, the public is much less polarized than Congress, with a majority of respondents believing global warming is occurring. (See box, p. 525.) And while Democrats are more likely than Republicans to believe in global warming, some polls show that Republicans increasingly agree. For instance:

- A March Gallup poll found that 66 percent of Americans believe global warming has already begun or will begin soon or within their lifetimes. And the share of those who believe human activity causes climate change has jumped from 50 percent in 2010 to 57 percent today.⁶³

- An April Pew Research Center poll found that 69 percent of Americans believe there is solid evidence Earth is warming (including 44 percent of Republicans), and 42 percent believe it is caused mostly by human activity. Both beliefs have been increasing since about 2010.⁶⁴

- A University of Michigan study conducted last fall found that the percentage of Republicans who believe in global warming rose from 33 percent in 2010 to 51 percent in 2012.⁶⁵

- Similarly, a George Mason University survey in January found that 52 per-

cent of Republicans and Republican-leaning independents believe climate change is occurring.⁶⁶

However, Stephen Ansolabehere, a professor of government at Harvard University who has conducted numerous surveys of public views about energy and climate change, says "the public is of two minds about climate change. People generally accept that it's happening, but they don't see it as an urgent issue." The Gallup survey, for instance, found that 64 percent of respondents did not see climate change as a threat to them or their lifestyles, while the Pew poll found that only 33 percent of respondents called global warming a "very serious" problem.

Since climate change is not considered an impending crisis, surveys indicate Americans are only willing to make minor sacrifices to deal with it. Ansolabehere has found that respondents, on average, would spend only \$10 per month to shift to low-carbon energy sources. "That's an important first step, but it's only a modest one," he says.

Polls also suggest that many Americans do not support broad national, taxpayer-supported solutions. In a March survey commissioned by Stanford University, respondents were asked who should pay for projects to protect coastal communities from flooding, such as building sea walls and manmade dunes. More than 80 percent said such projects should be funded by raising local property taxes for those who live near shorelines.⁶⁷

More extreme weather events could convince Americans that climate change is an imminent threat. "Big galvanizing examples can change public opinion across generations in a lasting way," says Ansolabehere. "The cleanest examples are the accident at Three Mile Island, which completely reset the nuclear power industry in the United States, and Chernobyl, which did the same in Europe. But Hurricane Sandy plus droughts in Texas and the Midwest are starting to make people realize they

need to be concerned about weather."

Indeed, wrote Trenberth, at the National Center for Atmospheric Research, and Princeton's Michael Oppenheimer, "There is conclusive evidence that climate change worsened the damage caused by Superstorm Sandy. Sea levels in New York City harbors have risen by more than a foot since the beginning of the 20th century. Had the storm surge not been riding on higher seas, there would have been less flooding and less damage. Warmer air also allows storms such as Sandy to hold more moisture and dump more rainfall, exacerbating flooding."⁶⁸ ■

OUTLOOK

Adapting and Leading

As the impacts of climate change become increasingly clear, scientists say the United States must spend more money and resources to help the nation adapt to extreme weather and other climate-related events.

"Water will be one of the biggest pressure points on society," says NCAR's Trenberth. "The intensity and frequency of rain and storms will increase, with longer dry spells. Even if we get the same average amount of precipitation yearly, the way it's distributed over time will become harder to manage, and shortages will be more likely."⁶⁹

Rising sea levels are also highly likely. "Storm surges, high tides and flood events all are amplified by rising seas. A few inches of sea level rise can make a big difference in the amount of damage," says Stanford's Field.

Other effects could be devastating for many regions. "Droughts are becoming longer or more severe in some parts of world, but shortening in others," says Field. Hurricane frequency "probably won't change, but more

storms will grow to the most damaging levels. Tornadoes are a very active area of research, and we may see some new results over the next decade.”

As the science of climate change improves, prospects for leadership from the United States or other major greenhouse gas emitters remain murky. Environmental advocates hope for strong action from the Obama administration, especially on power plant emissions. “President Obama took very important actions in his first term, especially raising mileage standards for passenger cars,” says the NRDC’s Goldston. “That policy will save money, reduce fuel consumption, and cut a large chunk of carbon pollution. Power plant standards are the next logical step.”

Others see promoting innovative low-carbon energy sources and technologies as a better long-term strategy. “We need ways to drive down the cost of decarbonization, and regulatory mandates aren’t likely to do that,” says Adler of Case Western Reserve University. “Encouraging more innovation is the way to get large developing countries onto a low-carbon development path. Going after energy subsidies, especially for high-carbon fuels, would also help. So would reducing regulatory barriers that impede nontraditional energy sources like offshore wind energy, tidal power, solar generation on federal lands and next-generation nuclear reactors.”

Meanwhile, environmentalists and policymakers are closely watching China, the world’s largest GHG source. “If China puts a price on carbon, that could really change the international dynamic,” says Arvind Subramanian, a senior fellow at the Center for Global Development, a research center in Washington, D.C. “And if China becomes a leader in green technologies, that would have an even bigger impact. It could make developed countries fear that they were losing leadership and rouse the United States into stronger action.”

Field would like to see more emphasis on potential profits from build-

ing low-carbon economies. “There are rich and exciting prospects for developing new technologies that will help us solve the climate problem,” Field says. “I’d like to shift away from viewing climate policies as scary economic choices and frame them as exciting business opportunities. One person’s risk is another person’s opportunity to capture markets.” ■

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About the Author



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Additional Articles from Current Periodicals

Aiding Poor Countries

Broder, John M., "At Climate Talks, a Struggle Over Aid for Poorer Nations," *The New York Times*, Dec. 6, 2012, p. A12, www.nytimes.com/2012/12/06/science/earth/money-issues-thwart-united-nations-climate-talks.html.

Efforts to address climate change have been stymied by disagreements between wealthy and poor countries.

Eilperin, Juliet, "Aid Reaches Far, Wide to Buck Global Warming," *The Washington Post*, Dec. 3, 2012, p. A6, articles.washingtonpost.com/2012-12-02/national/35584932_1_climate-aid-climate-change-rich-countries.

The U.S. has contributed \$7.5 billion over the past three years to help developing countries cope with climate change.

Koch, Wendy, "World Bank Warns Global Temps to Rise," *USA Today*, Nov. 20, 2012, p. A4, www.usatoday.com/story/news/nation/2012/11/19/world-bank-warns-climate-change/1715165/.

Global temperatures are likely to rise by 7.2° Fahrenheit by 2100, hurting developing countries the most.

Geoengineering

Basken, Paul, "As Temperatures Keep Rising, Geoengineering Gets a Closer Look," *The Chronicle of Higher Education*, Jan. 28, 2013, chronicle.com/article/As-Temperatures-Keep-Rising/136861/.

Scientists say there hasn't been enough discussion about the pros and cons of climate engineering.

Carroll, James, "The Earth Experiment," *The Boston Globe*, Nov. 26, 2012, p. A11, www.bostonglobe.com/opinion/2012/11/26/hands-off-mother-earth/iZQKJkGcDg8CY3x3wVBfHN/story.html.

Advocates of geoengineering say manipulating atmospheric systems must be done responsibly.

Klein, Naomi, "Geoengineering: Testing the Waters," *The New York Times*, Oct. 28, 2012, p. SR4, www.nytimes.com/2012/10/28/opinion/sunday/geoengineering-testing-the-waters.html?pagewanted=all&r=0.

Geoengineering would negatively alter the chemistry between the atmosphere and oceans, says a columnist.

Politics

Blumner, Robyn, "On Climate, We're All in This Together," *Tampa Bay (Fla.) Times*, Jan. 20, 2013, p. P5, www.tampabay.com/opinion/columns/on-climate-were-all-in-this-together/1271163.

Most lawmakers who opposed the Superstorm Sandy relief bill deny that climate change is caused by humans.

Lochhead, Carolyn, "How GOP Took Road to Denial on Global Warming," *San Francisco Chronicle*, April 28, 2013, p. A1, www.sfchronicle.com/politics/article/How-GOP-became-party-of-denial-on-warming-4469641.php.

The author traces the Republican Party's transformation from acceptance to denial on the climate change issue.

Reynolds, Mark, "GOP Can Be Part of Climate Change Solution," *St. Louis Post-Dispatch*, Feb. 27, 2013, p. A15, www.stltoday.com/news/opinion/columns/gop-can-be-part-of-climate-change-solution/article_405028ad-0355-5c07-bd27-6bf733a1de66.html.

The Climate Protection Act, which would reduce carbon emissions and boost investments in clean energy, has little chance of passing without Republican support, a columnist says.

Treaty

Chipman, Kim, "Obama Laying Groundwork for Climate-Change Treaty," *Detroit Free Press*, Dec. 3, 2012, www.freep.com/article/20121203/NEWS07/312030143/Obama%20laying%20groundwork%20for%20climate-change%20treaty.

President Obama is devising policies that may lead to a treaty requiring the United States and China to reduce emissions.

Rosenthal, Elisabeth, and Andrew W. Lehren, "Relief in Every Window, But Global Worry Too," *The New York Times*, June 21, 2012, p. A1, www.nytimes.com/2012/06/21/world/asia/global-demand-for-air-conditioning-forces-tough-environmental-choices.html?pagewanted=all.

The growing middle classes in tropical countries are buying millions of window air conditioners, which scientists say emit huge amounts of greenhouse gases.

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