ISSN 1941-6466

Baker Institute Policy Report

Published by the James A. Baker III Institute for Public Policy of Rice University

Number 41 June 2009

Sustainable U.S. Policy Options to Address Climate Change: Highlights of the Debate

Introduction

Climate change is one of the greatest challenges facing humankind today. Its global scope and multigenerational scale make it uniquely daunting. The United States is the world's largest consumer of hydrocarbons and one of the largest emitters of greenhouse gases (GHGs) and, thus, must play a key role in any global effort to reduce GHGs. American scientists have been at the forefront of the emerging scientific consensus on the human role in climate change, and U.S. policymakers, politicians, academics, and the media have been struggling in recent years to fashion a concrete response.

The Intergovernmental Panel on Climate Change (IPCC), a group sponsored by the United Nations (UN) that has published evidence-based scientific research vetted by more than 1,500 scientists, has concluded that the "warming of the climate system is unequivocal" and that "many natural systems are being affected by regional climate changes," which the IPCC links with "very high confidence" to anthropogenic (man-made) greenhouse gas emissions stemming from land use changes and the burning of fossil fuels. The likely impacts of these changes on human civilization, global ecosystems, global agriculture, water resources, coastlines, and coastal infrastructure need to be better understood through increased science and economic research based on the best available scientific knowledge about climate.

While advances in climate science continue to improve our understanding of how climate change is likely to impact our world, addressing climate change is a complex public policy issue because the challenges are global and will span several generations. It will require global cooperation on a scale never before achieved in human history. In addition, since climate change will not affect all parts of the world the same way, adaptation measures will need to be tailored to meet the needs of particular regions and countries. The complexity of dealing with the challenges presented by climate change, through both mitigation and adaptation, means that the policy responses must be equally diverse and multidimensional, including the full spectrum from international agreements and programs to local efforts.

An effective U.S. climate policy must consider the threats to human life and basic infrastructure posed by extreme weather events, rising ocean temperatures and sea levels, and shifts in rainfall patterns. It must also address the economic impacts and social implications of the high costs of climatic events, as well as the costs and benefits of various policy responses to reduce greenhouse gas emissions. In addition, sound policy must address how a changing climate will impact relations among countries and their willingness to cooperate with the United States in addressing the various challenges associated with climate change.[1]

Finally, an effective climate policy must consider issues related to national security. The United States has 63 coastal military facilities that are threatened by sea level rise and severe weather events, and the U.S. military will increasingly be challenged by a larger number of humanitarian disasters and refugee crises. Moreover, the melting of the Arctic has rekindled competition for territory and trade routes in this geographic tip of the northern hemisphere.

In the United States, the policy response to climate change has so far been uncoordinated and

[1] See Neal Lane, "Emerging U.S. Climate Policy: Trans-Atlantic Approaches and Market Harmonization" (conference keynote address, James A. Baker III Institute for Public Policy, Houston, TX, December 15, 2008), http://www.bakerinstitute.org/. And Neal Lane and Malcolm Gillis, "Ideas that will actually cut into global warming," *Houston Chronicle*, February 8, 2008.

politically charged. The absence of a federal policy on carbon emissions and climate change has resulted in individual states and municipalities forging their own independent pathways. Now, with a new U.S. administration, there is the renewed opportunity to address this policy conundrum by devising an effective U.S. climate response and working to achieve a greater consensus on approaches both at home and abroad.

In the United States, policy actions that will be necessary to respond to climate change are now under debate. While many U.S. policymakers are eager to address this issue, some continue to question the science or, for political reasons, are hesitant to move forward. Concerns about the economic consequences of proposed policies on various constituents have presented problems politically. As a result, a clear consensus on the components of effective U.S. climate policy legislation has yet to emerge.

While the United States as a nation has been slow to act, there is a growing movement among policymakers worldwide to address climate concerns through concrete policies and actions aimed at reducing greenhouse gas emissions and helping affected populations adapt to ongoing climate impacts. It is clear that other nations expect the United States to play a leading role in international dialogue and strategic planning.

In order for the United States to make progress on the home front, U.S. federal policymakers, under the leadership of the president, will need to sit down with scientists, economists, health experts, state and local officials, and business leaders to understand the costs and benefits for different communities and economic sectors of competing approaches to dealing with climate change and to develop policies that are most likely to be effective. Since the costs of not taking action increase over time, there is considerable urgency in making early progress. Furthermore, the public needs to be actively engaged in the policy debate to ensure that special interests do not capture the political process to the detriment of effective solutions.

To explore these issues, the James A. Baker III Institute for Public Policy at Rice University held two major conferences on climate change research and policies. On February 9, 2008, participants at the conference "Beyond Science: The Economics and Politics of Responding to Climate Change" discussed the scientific consensus, evaluated the economic impact of policy alternatives, and reviewed technology options. A summary of the conference proceedings was published under the title of the event.[2] On December 15, 2008, the conference titled "Emerging U.S. Climate Policy: Trans-Atlantic Approaches and Market Harmonization" explored existing U.S. and European policy responses to climate change and analyzed how future international policies might evolve.

These two events were conferences and not workshops—therefore no effort was made to develop a policy consensus among attendees. In addition, these conferences did not debate the scientific findings of climate experts; rather, the events focused on alternative policy approaches and, in particular, the economic implications of different policies. As the scientific basis for discussion, this policy study relies on the 2007 IPCC report as the authoritative record on the state of climate science.[3] The two conferences provided a forum for speakers and other participants to share their individual views on what a U.S. climate policy should look like. This report is based on the proceedings of these conferences and draws heavily on presentation materials and relevant points raised during the meetings. However, the tone of this report and any recommendations and findings presented here are the views of the authors and not necessarily those of conference participants.

In summary, this policy study highlights the need for the following:

1. A U.S. climate policy addressing both mitigation strategies to limit the buildup of GHG concentrations in the atmosphere and targeted adaptation strategies to prepare communities to deal with climate change impacts;
2. A mechanism to price the national security and climate externalities of the rising use of fossil-based energy;[4]
3. Increased funding for research and development (R&D) focused on new, clean (low or zero GHG emissions), and efficient energy technologies, as well

[2] "Beyond Science: The Economics and Politics of Responding to Climate Change" (conference report, James A. Baker III Institute for Public Policy, December 10, 2008), http://www.bakerinstitute.org/.

[3] "Climate Change 2007: The Physical Science Basis," contribution of Working Group I to the *Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, S. Solomon et al., eds. (Cambridge, U.K., and New York: Cambridge University Press), http://www.ipcc.ch/ipccreports/ar4-wg1.htm.

[4] "Climate externalities" refer to the relative costs associated with mitigating and/or adapting to the effects of climate change. They include, for example, the inherent expense (time and money spent) of relocating industries and government or population centers at risk from sea level rise. http://www.ipcc.ch/ipccreports/ar4-wg1.htm.

as further modeling research on climate change impacts on humans and ecosystems; and

4. The coordination and harmonization of U.S. climate policies with existing and future international policies.

The Science on Climate Change

The Earth is undergoing significant climatic change, largely driven by the buildup of greenhouse gases in the Earth's atmosphere, which are trapping increased amounts of heat energy, thereby impacting the Earth's average temperature, ice cover, sea level, and weather patterns. The basis of most science and policy discussions on climate change is the body of periodic assessment reports written by the IPCC. The IPCC is a group of more than 1,500 scientists who meet regularly and assess the scientific, technical, and socioeconomic research literature relevant to understanding all aspects of climate change. The data and conclusions in these reports are based on peer-reviewed research published prior to the formation of the latest assessment committees (for the 2007 Assessment Report this date was 2005) and require a consensus of the IPCC scientists before arriving at final conclusions.

In its 2007 Assessment Report, the IPCC concluded that "warming of the climate system is unequivocal, as is now evident from observations of increasing global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level." The report claims "very high confidence" (more than 90 percent probability) that anthropogenic carbon dioxide (CO_2) emissions are driving climate change.

In presenting the IPCC report at the February 2008 Baker Institute conference, Timothy Killeen, at that time director of the National Center for Atmospheric Research, noted, "Even if we find a way to stabilize greenhouse gas concentrations at current levels, we will still see continued global warming and, for example, sea level rise for centuries due to the time scales associated with climate processes and feedbacks." But Killeen pointed out that if we do not stabilize GHG concentrations, global warming and its consequences will be much greater.

According to the IPCC report, the global average surface temperature of the Earth has increased by approximately 0.8°Celsius (C) (or 1.4°Fahrenheit [F]) since 1750, and the rate of warming has increased in recent decades. GHG concentrations in the atmosphere have increased since the 1700s due to increasing GHG emissions (GHGe). The report also states that CO_2 is the most important GHG. The concentration of CO_2 in the atmosphere has increased from 280 parts per million (ppm) in pre-industrial times to 379 ppm in 2005. Recent growth rates are due to CO_2 emission increases of 1.9 ppm/year. Over the past 30 years alone, CO_2 emissions have increased by 70 percent.[5]

The IPCC analyzed more than 20,000 data sets, which confirm that plant and animal species reacting to changes in climate are starting to shift to higher latitudes and altitudes. "Observational evidence from all continents and most oceans show that many natural systems are being affected by regional climate changes, particularly temperature increases," the IPCC report stated. Increases in temperature will depend on the extent to which greenhouse gas concentrations in the Earth's atmosphere continue to increase. The IPCC projects warming at the rate of 0.2°C per decade over the next 20 years, under a variety of world economic scenarios. Even if the emissions of CO_2 and other GHGs were halted today, the climate would continue to change and sea levels would continue to rise, since the Earth's surface is slow to respond to changes in atmospheric concentrations of GHGs.[6] But without effective global policy intervention, greater warming and more dramatic levels of climate change can be expected, including additional ice melting, higher sea level rise (in the magnitude of anywhere from 0.18 to 0.59 meters, depending on the levels of future GHG concentrations), and alterations of natural systems such as ocean acidification, changes in wind patterns, and increased heat extremes.[7] The IPCC report notes that its sea level projections do not include contributions from possible accelerated future melting of the Greenland and West Antarctic ice sheets because too little published research was available at the time the report was written.

Precise projections of climate impacts on individual regions and countries need to be further developed. New climate models will enable more precise predictions of long- and short-term impacts and at different geographical scales—from global

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[5] GHG emissions include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and surfurhexafluoride (SF_6).

[6] IPCC further estimates that a 0.1°C increase per decade would still occur even if all GHG and aerosol emissions were held constant at 2000 levels.

[7] "Climate Change," Table SPM.3. Projected global average surface warming and sea level rise at the end of the twenty-first century.

to continental to national, regional, and urban. In order for nations, states, and cities to plan, they will need this kind of improved resolution in the projections.

U.S. politicians, climate scientists, economists, and policy scholars have struggled to fashion a consolidated opinion or a concrete response. But in the absence of a U.S. federal policy on climate change, current climate policies consist of a hodgepodge of state and local initiatives that reflect the growing concerns of the American people but are largely ineffective in addressing the larger national and global challenges. However, these smaller early efforts, along with industry input, can be used to create a truly lasting and sustainable U.S. national policy on climate change and develop and institutionalize mitigation and adaptation strategies to marginalize the negative impacts of climate change.

John Holdren, currently assistant to President Barack Obama for science and technology, spoke last year at the Baker Institute conference as the Teresa and John Heinz Professor of Environmental Policy at Harvard University.[8] He believed that mitigation policies alone would not be enough since it is already too late to avoid substantial climate change. But he added that adaptation-only measures would become much more costly and less effective if we continue to emit GHGs without restraint, given the large rates of future GHGe predicted for the coming decades under a business-as-usual approach to global energy consumption. Holdren noted that there is no silver bullet strategy, but a need for a "silver shotgun approach," which would include both mitigation and adaptation approaches.

"Integrated strategies for mitigation and adaptation together clearly can drive investment and growth in a whole variety of ways," he said. Addressing mitigation strategies, Holdren called for an array of measures—what he called "a portfolio"—to mitigate GHGe to avoid increasing beyond the "tipping point," assessed as an increase in the global average temperature of 2 to 2.5°C from 1750 levels or reaching atmospheric CO_2 levels of over 450-500 ppm. Beyond this tipping point, Holdren explained, many of the consequences of climate change would have major impacts on humans, and some effects could be irreversible.

[8] "Beyond Science: The Economics and Politics of Responding to Climate Change" (conference, James A. Baker Institute III for Public Policy, Houston, TX, February 9, 2008).

The Economics of Climate Change

Based on the IPCC consensus view that climate change is occurring and that it is most likely due to anthropogenic GHGe, especially CO_2, economists have been focusing on developing models to: (a) accurately project GHGe (hence, climate change) scenarios based on various assumptions about the future global economy; and (b) determine the economic impacts of climate change and policies addressing climate change by assessing the costs and benefits of various approaches to mitigate and/or adapt to these changes. A key problem in making such economic assessments is the high level of uncertainty about the future price of various fuels and future deployment costs of both new and existing technologies.

John Weyant, professor of management science and engineering at Stanford University and director of the university's Energy Modeling Forum, which is sponsored by the U.S. Department of Energy, has extensively studied economic modeling approaches to climate change. He told the Baker Institute conference that it would be a mistake to wait for perfect information to take action.[9] "We can find general trends in predictions and from these create general policies that we can adapt over time as we learn more," he explained. "As we learn more, we have to be willing to eliminate ineffective policies." According to Weyant, flexible policy architecture allows for continual redirection, which lets "different regions do what they can do easily, politically, resource-wise and economy-wise, because everybody has a different resource base, a different economic structure, and a different set of policies." However, Weyant believes that flexible policy will not be enough to effect change. He stated that policy must be drafted to encourage technology development and noted that policy uncertainty and unstable price signals over time are significant constraints on innovation. He warned that costs depend on future fuel prices, economic growth, and the manner in which policies are implemented. Costs will also vary depending on international cooperation. Weyant said studies have shown that GHG atmospheric stabilization could cost anywhere between 0.1 percent (with an effective international approach) and 10 percent (without a concise, organized international effort) of gross domestic product (GDP) per year.

[9] Ibid.

The issue of uncertainty about costs has plagued even the most respected studies on the costs of climate mitigation policy. While there are many studies on this topic, two in particular have been cited more than others: the *Stern Review* and a report prepared by McKinsey & Company.

The *Stern Review*, released in December 2006 by a group led by Sir Nicholas Stern, assessed the long-term economic impacts of various climate change scenarios and policy approaches.[10] The *Stern Review* specified that to hold the average global temperature increase to no more than 3°C, the atmospheric concentration of CO_2 must be stabilized in a range of 450–550 ppm. The *Stern Review* estimated that costs could be as little as 1 percent of GDP worldwide if immediate action were taken. However, the study also noted that given probable delays in many countries around the world, the total cost would likely be greater than 1 percent and costs would not be borne equally across countries. Dimitri Zenghelis, member of the *Stern Review* team, noted at the Baker Institute conference that some countries will inevitably pay more than 1 percent of GDP to reduce their GHGe.[11] The total cost per country will depend on the intensity of each country's fossil fuel use and its ability to substitute to different sources of energy. Zenghelis conceded that top-down economic models require "a lot of behavioral assumptions" and "they cannot represent all of the substitution opportunities available in an economy … which actually may tend to overstate the costs." He added that since different countries are likely to progress at different speeds to reduce GHGe, this could create a problem of carbon leakage, where emission-intensive businesses relocate to countries where regulations have not yet been implemented, resulting in a global carbon shift rather than a global reduction.

In most economic analyses that consider values of decisions in the present that have lasting effects, future values are discounted. This is done because (a) the value of a dollar today is not the same as the value of a dollar tomorrow; and (b) there are opportunity costs associated with actions today. The former can be thought of as a simple "time-value of money" adjustment. The latter case is pertinent because dollars spent today cannot be used for alternative actions, and those alternatives, if executed today, might hold some future value. In other words, we cannot go back in time and change our minds *ex post*. The *Stern Review*, however, applies a very low rate of discount in accounting for the future values of money and opportunity costs, arguing that the deleterious effects of climate change could make people poorer. The argument, therefore, hinges on the idea that since we care about future economic well-being, a lower rate of discount ought to be applied in the analysis. This approach has left the *Stern Review* open to broad criticism. Critics argue that the projections in the analysis regarding the cost of implementation are skewed heavily to the low side, precisely because the rate of discount is far too low for real world application. In other words, critics argue that the real cost of action would be far greater than the 1 percent of global GDP cited by the report.

A McKinsey & Company study titled *Reducing U.S. Greenhouse Gas Emissions: How Much at What Cost?* has also received considerable attention, especially on Capitol Hill.[12] Using information from the U.S. Energy Information Administration's Annual Energy Outlook 2007 forecast, the McKinsey study indicates that U.S. annual GHG emissions are "projected to rise from 7.2 gigatons [Gt] CO_2e [carbon dioxide equivalent] in 2005 to 9.7 Gt in 2030—an increase of 35 percent" and will be "accompanied by a gradual decrease in the absorption of carbon by U.S. forests and agricultural lands" (equating to a carbon absorption decline from 1.1 Gt [2005] to 1.0 Gt [2030]).[13] As U.S. emissions rise and carbon absorption declines, the United States would exceed its GHG reduction targets by 3.5–5.2 Gt. As a result, the McKinsey study sought to identify the means through which the United States could reduce its CO_2e by 3–4.5 Gt by 2030 with minimal costs via carbon mitigation options and utilizing "tested approaches and high-potential emerging technologies."

10 The study was commissioned by the Treasury of the United Kingdom. See Nicholas Stern, *The Economics of Climate Change: The Stern Review* (Cambridge University Press, January 15, 2007), http://www.hm-treasury.gov.uk/sternreview_index.htm.

11 "Beyond Science," February 9, 2008.

12 *Reducing U.S. Greenhouse Gas Emissions: How Much at What Cost?* (U.S. Greenhouse Gas Abatement Mapping Initiative, Executive Report, McKinsey & Company, December 2007), http://www.mckinsey.com/clientservice/ccsi/pdf/US_ghg_final_report.pdf.

13 Gt represents a billion tons of CO_2e. And 2.13 Gt of carbon is equivalent to 1 part per million by volume (ppmv) of atmospheric CO_2. If "atmospheric CO_2 concentrations rose from 288 ppmv in 1850 to 369.5 ppmv in 2000, for an increase of 81.5 ppmv," this equates to about 174 Gt of carbon increase over the 150 year period (64 percent of the increase has been attributed to fossil fuel combustion)—or 1.16 Gt of carbon per year. See Carbon Dioxide Information Analysis Center, "Frequently Asked Global Change Questions," http://cdiac.ornl.gov/pns/faq.html.

Scott Nyquist, a director at McKinsey & Company, explained at the Baker Institute conference, "These reductions would involve pursuing a wide array of abatement options with marginal costs less than $50 per ton … with the average net cost to the economy being far lower if the nation can capture sizable gains from energy efficiency."[14] In fact, the McKinsey study identifies 250 options for carbon abatement that would cost less than $50 per ton of CO_2e. Moreover, the study claims these options utilize technologies with predictable costs and development paths (including life cycle and maintenance costs), and would not result in burdensome costs to society. While carbon capture and storage (CCS) is an important element in a strategy to achieve CO_2 emissions reductions, it is not sufficient by itself. Energy efficiency is a very important source of reductions, which can lower the overall costs of reductions since gains from energy savings would offset the capital costs of adoption. If all of the reductions suggested by McKinsey were implemented, the cost to the economy would be quite low, Nyquist explained.

The potential for abatement in the United States varies by region, according to the McKinsey study. The West has the biggest potential for emissions reductions in the power generation sector, the Midwest in agriculture, the South in buildings and appliances, and the Northeast in transportation. The study also concludes that the industrial sector could have significant opportunities to reduce GHGe if the correct incentives are put in place. The United States has little opportunity for carbon sinks, because there are not significant stretches of land that could be reforested. Energy efficiency gains in the United States have the potential to reduce the net cost of carbon intensity reductions to roughly $1 trillion by 2030 as gains from energy savings can offset capital investment costs in abatement ventures. The McKinsey study determined that the United States has more opportunities to reduce GHGe through efficiency gains than the rest of the world.

Critics of the McKinsey study argue that a carbon price of $50 per ton to achieve a stated emissions target is well below the true cost of removing carbon from the U.S. economy. In particular, the McKinsey analysis uses a social rate of discount,[15] rather than a private, risk-adjusted rate, when determining the cost associated with deployment of various low-carbon options. For example, the McKinsey study assumes a 5 to 7 percent return to capital in its analysis. However, private companies are not likely to make large capital investments in unproven technologies or initiatives unless an appropriate risk adjustment is made. This risk-adjusted rate of return to capital is likely to be significantly higher, perhaps around 20 percent. Making this simple change to the analysis moves the McKinsey estimated carbon cost of $50 per ton upward of $200 per ton, according to critics.

A U.S. Climate Policy

In his opening keynote address to the conference "Beyond Science," U.S. Senator John Kerry (D-MA) reiterated how "truly grave and significant" the threat of climate change is and emphasized the importance of the United States playing an active role in addressing it.[16] Referring to James Baker's warning on the impact of climate change in his first speech as secretary of state in 1989 that "time will not make this problem go away," Kerry remarked, "Those words of Jim's ring truer than ever. Time has not made the problem go away; on the contrary, time has obviously accelerated the consequences of this issue."

In response to a question about the U.S. Senate's rejection of the Kyoto accord in 1997, Kerry said it was "a very complicated situation," and noted that the U.S. Senate unanimously passed a resolution stating that the United States would not be party to any agreement that did not include GHGe targets for developing countries or which did serious harm to the U.S. economy. Fearing certain rejection, the Clinton administration never submitted the Kyoto Protocol to the Senate for ratification. The administration hoped, perhaps unrealistically, that subsequent international negotiations would permit changes to the protocol that would make ratification possible.

Kerry explained that "we took the position, with the 95-to-nothing vote on the floor of the Senate,

14 "Beyond Science," February 9, 2008.

15 A "social rate of discount" is the discount rate applied to private investments if there were zero risks involved with the commitment of investment dollars. The social discount rate is typically applied to investments such as public infrastructure or other publicly funded projects where commercial profitability does not apply. The private, risk-adjusted rate for investment is generally larger because the level of risk to a private firm is higher than for public spending (i.e., if a private firm engages in a risky investment and incurs high losses as a result, significant losses can cause the firm to go out of business).

16 "Beyond Science," February 9, 2008.

that we need to get the less developed countries involved, and thereby avoided a rejection of Kyoto altogether, expecting a president responsibly to say, 'now, I am going to go back to the table and negotiate, and we're going to get the less developed countries in, and we'll use the framework of Kyoto and go forward.'" The United States was never able to negotiate such concessions, nor attain an acceptable starting point for judging its own base line; 1990 was seen as a base line year that would greatly disadvantage the United States while allowing Europe to grandfather-in the closure of inefficient Eastern European facilities. These problems paved the way for rejection of the accord by President George W. Bush in 2002.

Fundamental Principles for an Effective U.S. Climate Policy

Kerry and other speakers acknowledged that an appropriate U.S. climate policy must incorporate a variety of strategies and ideas. Zin Smati, president and CEO of SUEZ Energy North America, Inc., speaking at the Baker Institute conference "Emerging U.S. Climate Policy: Trans-Atlantic Approaches and Market Harmonization," noted that U.S. climate legislation must balance concerns of security of supply, the environment, and costs. He noted that the United States needed a federal, economy-wide program that could be implemented "in integration with an international program." Brice Lalonde, ambassador in charge of international negotiations on global warming for France's Ministry for the Environment, also emphasized at the same conference the importance of effective climate policy to U.S. allies in Europe and noted that since approximately 80 percent of all greenhouse gases were emitted by only 16 countries, an international program was needed so that the burden and responsibilities of reducing emissions could be shared.

For U.S. policy, given the size and scale of U.S. emissions, no single "silver bullet" option will suffice. Single-minded agendas and single-technology solutions should not be pursued. Choosing a technology early in the research stage can lead to unintended consequences—negative environmental impacts or detrimental effects on other industries (such as occurred with corn ethanol)—or wasting funds on unproven concepts or technologies. A more comprehensive, portfolio approach is required that incorporates varied and integrated tactics and technologies to: (a) mitigate the effects of current damages and minimize future damage; (b) address the future adaptation of systems and infrastructure to changing climate circumstances; and (c) deal with the harmonization of strategies with other international policies.

A U.S. policy should address the costs and benefits of policy responses to GHG reduction targets and carbon permit allocation schemes and the impact they would have on the sustainable development of the U.S. economy. Sound U.S. climate policies should lead to long-term benefits and positive externalities (such as new technology patents, efficiency gains, and reduced foreign energy dependence)—beyond their GHG reduction targets—so that the United States maintains a competitive edge globally. Moreover, a prudent policy must consider the impact on energy security, national security, and geopolitics. Changing U.S. demand for natural resources through the implementation of climate policy can shift balances of power across the world as well as make the United States more susceptible to hostile state and nonstate actors. A climate policy must also consider the threats that extreme weather, rising ocean temperatures, and shifts in rainfall patterns will pose to human life and basic infrastructure (such as transportation, energy supply routes, buildings, and water reservoirs).

In addition, the policy should be flexible to change with new information and must promote R&D in science and technology to create new solutions to issues such as energy generation, storage, and transmission to minimize damage to the environment. U.S. climate policy should acknowledge that developed countries have a responsibility to fund R&D on climate change impacts and the development of potential strategies and new technologies, and seriously consider transferring these capabilities to developing states. These considerations will permit the United States to promote future prosperity, domestically and abroad, while addressing national energy security priorities, encouraging innovations in alternative and reliable energy supplies, and responding to changing climate conditions.

Mitigation and Adaptation Strategies

The United States must create policy that mitigates climate change and develop cost-effective adaptation strategies to sustain economic development and achieve humanitarian goals worldwide. While addressing local and state issues, U.S. climate policy should also recognize the global nature of the problem and allow the United States to lead international action. A climate policy should consider aspects of existing climate policies in other countries. This will permit legislating and enforcing mitigation and adaptation strategies, covering all major emitting nations regardless of their development status.

In 2007, the UN Foundation and Sigma Xi (an international, multidisciplinary, nonprofit scientific research society) published a report, *Confronting Climate Change: Avoiding the Unmanageable and Managing the Unavoidable*, which suggested technology, policy, and institutional changes that will facilitate both mitigation of and adaptation to climate change.[17] The report made recommendations such as increasing efficiency in the transportation sector, improving design and efficiency of infrastructure, expanding the use of environmentally responsible biofuels and weather-tolerant crops, and designing and deploying coal plants that capture and sequester CO_2.[18] Furthermore, they suggested research to identify and understand vulnerable regions, expand adaptation research, and improve early warning systems for extreme weather events.

Rosina Bierbaum, dean of the School of Natural Resources and Environment at the University of Michigan and a lead author of the UN Foundation and Sigma Xi report, noted in a presentation at the Baker Institute conference[19] that climate change could imperil the UN Millennium Development Goals (MDG), which aim to reduce extreme poverty worldwide and address hunger, education, child mortality, maternal health, and the spread of diseases such as HIV/AIDS, malaria, and tuberculosis. Many of the objectives outlined in the MDG, she argued, will be negatively impacted by changes resulting from global warming. Bierbaum stated that “climate change is degrading the progress” toward the MDG and “is changing the base line against which we are going to test things.” She encouraged the UN to identify 15 vulnerable regions in the world and systematically conduct comprehensive vulnerability assessments of climate change and other stresses.

Mitigation strategies and adaptation strategies can be “win-win.” They can be implemented to improve energy efficiency and security. In addition, more mitigation now has the potential to lessen the need for extensive and expensive adaptation measures in the future. Many of the adaptation ideas proposed—such as increased surveillance for the spread of disease vectors, water conservation and management, infrastructure fortification, and improving early warning systems—should be considered wise environmental management tools, regardless of climate change.

Specific mitigation strategies should focus on improved energy use technologies and practices as well as enhanced carbon sinks (such as forestation and altered agricultural practices). Improved mitigation approaches can be accomplished through legislation, regulation, and R&D funding of new technologies. Mitigation technologies can include alternative energy, carbon sequestration, and energy efficiency technologies that reduce overall anthropogenic CO_2 emissions, as well as agricultural and other technologies that can remove excess CO_2 from the atmosphere.

Proposed U.S. Policy Approaches for Limiting CO_2 Emissions

Several options for reducing CO_2 emissions have been proposed in the United States. The discussions during the 2008 U.S. presidential campaign signaled a clear trend toward a more definitive position on climate change. This focus was influenced by strong, preexisting local, state, and regional initiatives that range from binding CO_2 emissions targets and developing renewable energy programs to engaging in collective action, like carbon-credit trading schemes. Within the U.S. domestic policy community, five mitigation strategies for a carbon-constrained economy are generally discussed: regulation of the transportation sector, a cap-and-trade system (CTS), a carbon tax, an energy tax, or a hybrid approach.

Regulating the Transportation Sector

California is well positioned to lead climate policy with its legislation. Daniel Sperling, founding director of the

[17] R.M. Bierbaum et al., eds., *Scientific Expert Group on Climate Change, 2007: Confronting Climate Change: Avoiding the Unmanageable and Managing the Unavoidable* (Research Triangle Park, NC: Sigma Xi and Washington, D.C.: United Nations Foundation, Washington, D.C.), http://www.unfoundation.org/press-center/publications/confronting-climate-change.html.

[18] Infrastructure efficiency gains have many applications: more energy- and water-conserving buildings, the location of population centers, reinforced transit routes, and water management. Water conservation through projects like drip-irrigation and low-flow plumbing is key to countering the impact of projected precipitation changes, but protecting populations from flood impacts is also critical; the latter can be done through preventive measures by protecting natural watersheds and flood plains from development or with levees.

[19] “Beyond Science,” February 9, 2008.

Institute of Transportation Studies at the University of California, Davis, and a member of the California Air Resources Board (CARB), told the Baker Institute conference that California acts as a "laboratory for others to learn from," since it represents a large, relatively isolated market with innovative consumers and industry, and a political landscape with bipartisan support for climate legislation and virtually no major local coal or automotive industries to insert themselves into the political process.[20]

California has fashioned aggressive climate legislation,[21] as transportation contributes to 38 percent of GHGe in the state.[22] For example, the Pavley Law, or AB1493 (an assembly bill), would in effect reduce GHGe from vehicles by 30 percent by model year 2016.[23] Separately, Governor Arnold Schwarzenegger signed into law the California Global Warming Solutions Act (AB32), which uses market-based incentives to reduce carbon emissions across many sectors with a target for 80 percent reductions below 1990 levels by 2050.[24] Under AB32 provisions, the CARB has approved a long list of early action measures to be implemented by January 1, 2010. The measures include statewide low-carbon fuel standards (LCFS)—which could be applied nationwide—that quantify and limit a fuel producer's net CO_2 emissions per unit of output. The California LCFS will reduce the carbon intensity of transportation fuels sold in California 10 percent by 2020.[25] The LCFS will use life cycle analysis and is a preferable standard of quantifying net emissions, according to Sperling, because it does not force the government to pick winners or losers, but at the same time, provides for consistency and compatibility between states and countries.

By imposing GHGe caps on sellers of fuel within the state, California hopes to stimulate near- and long-term transitions to low-carbon alternative fuels and technological innovation in alternative fuel used in the state's automobile fuel system. But unless it is restructured to allow tradable credits to technology companies or companies that market alternative fuel vehicles, an LCFS is unlikely to promote renewable energy because fuel providers, mainly refiners, are not in the electricity or car manufacturing/distribution business and, therefore, cannot switch to wind or solar power or similar alternatives as a means to meet the LCFS. Credits offered to California utility PG&E will also fail to promote new transportation technologies because PG&E also does not produce innovative cars or primary fuels. Fuel providers will have limited options to reduce CO_2 emissions.[26]

The LCFS may also stimulate carbon-reducing "solutions" that are the most commercial and readily available—such as biofuels—without stimulating the intended innovation, since other promising carbon-reducing technologies, such as plug-in hybrid cars, are ones that refining companies are not equipped to pursue. Thus, the LCFS may initially promote technologies that, while cheaper, may hold less long-term promise in lowering CO_2 emissions. Moreover, those entities best suited to meet an LCFS, such as start-up technology companies, may not operate at the scale needed to meet specified targets.

California policymakers and others are pushing for a federal LCFS to be passed on Capitol Hill. As proposed before Congress in March 2009 (the Waxman-Markey bill), the federal LCFS would reduce GHGe per unit of fuel production by 5 percent from the 2005 fuel emission base line by 2023 and achieve a 10 percent reduction by 2030.[27]

California's low-emission vehicle (LEV) regulations further enforce reductions in passenger vehicle, light-duty truck, and medium-duty vehicle exhaust emissions, and also include provisions for the introduction of zero-emission vehicles to the California fleets.[28] In addition, President Obama has indicated that federal corporate average fuel economy (CAFE) standards will rise to an average

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20 Ibid.

21 Over the past several years, California has actively pursued legislation to improve energy efficiency and reduce GHGe, particularly CO_2. For example, AB1493 was signed into law by California governor Gray Davis on July 22, 2002. And AB32 was introduced on December 06, 2004, passed on August 31, 2006, and effective as of September 27, 2006.

22 California Environmental Protection Agency Air Resources Board, "Low Carbon Fuel Standard Program," April 29, 2009, http://www.arb.ca.gov/fuels/lcfs/lcfs.htm.

23 "California's Global Warming Vehicle Law," Union of Concerned Scientists, April 22, 2005, http://www.ucsusa.org/clean_vehicles/solutions/cleaner_cars_pickups_and_suvs/californias-global-warming.html.

24 State of California: Office of the Governor, "Gov. Schwarzenegger Signs Landmark Legislation to Reduce Greenhouse Gas Emissions," September 27, 2006, http://gov.ca.gov/index.php?/press-release/4111/.

25 The LCFS was promoted by Governor Arnold Schwarzenegger in Executive Order S-01-07, issued January 18, 2007, which called for a 10 percent reduction in the carbon intensity of transportation fuels by 2020. (See Executive Order S-01-07, State of California: Office of the Governor, January 18, 2007, http://gov.ca.gov/index.php?/executive-order/5172/ and California Environmental Protection Agency Air Resources Board, Low Carbon Fuel Standard Program, April 29, 2009, http://www.arb.ca.gov/fuels/lcfs/lcfs.htm.)

26 See California Assembly and Senate Bills, http://www.leginfo.ca.gov/cgi-bin/postquery?bill_number=ab_32&sess=0506&house=B&author=nunez.

27 Jessica Resnick-Ault, "U.S. Low Carbon Fuels Standard Draft Mandates Broad Cuts," *Wall Street Journal Online*, March 31, 2009, http://online.wsj.com/article/BT-CO-20090331-720689.html.

28 See California Environmental Protection Agency Air Resources Board, http://www.arb.ca.gov/homepage.htm.

gasoline mileage requirement of 39 miles per gallon (mpg) for passenger cars and 30 mpg for light trucks by 2016, bringing the overall average fuel economy of cars and light trucks in the United States to 35.5 mpg by 2016. Since the CAFE regulation applies only to new vehicles sold, it will take some time for the full effect of the new standard to be realized. Nevertheless, this regulatory effort is expected to reduce U.S. oil demand by 1.6 million barrels per day (bbl/d) relative to a base line under conditions where CAFE standards are not changed. The fuel savings relative to the base line increases beyond 2016 to as high as 4.8 million bbl/d by 2030 as newer vehicles diffuse into the aggregate vehicle stock.[29]

The first stages of California's "scoping plan"[30] are expected to reduce California's total GHGe by 146.7 million tons of CO_2 equivalent ($MMTCO_2e$). However, California plans to augment its emissions reductions by incorporating a CTS in addition to the scoping plan. CTS is a market-oriented pollution credit trading system whereby government establishes a ceiling for CO_2 emissions and then industries buy permits to meet their carbon limits. The intent is for the cap on CO_2 emissions to become increasingly binding over time as more sectors are brought into the system.

California's AB32 further provides for the establishment of a CTS to reduce overall GHGe to 1990 levels by 2020 (achieving an 80 percent reduction from 1990 levels by 2050 as outlined in AB32). The California CTS will begin in 2012, with initial caps focused on the electricity generation sector (including imports) and large industrial sources, to be followed by caps on commercial and residential natural gas consumption, and on transportation fuels. Caps will have three-year compliance periods and a minimum of 10 percent of permits must be auctioned (with a transition to 100 percent permit auctioning). Credits can only be used to cover up to 49 percent of required GHGe reductions.[31] California anticipates that these plans combined will reduce its GHGe from 596 $MMTCO_2e$ (pre-scoping plan) to 365 $MMTCO_2e$ by 2020.

29 Note these estimates assume historical average rates of new automobile sales and diffusion. Thus, to the extent these variables may change, the associated fuel savings may be higher or lower. The "rebound effect" of higher fuel efficiency is incorporated into the calculation.

30 California's scoping plan includes the Pavley standards and the LCFS, as well as gains in energy efficiency, solar installations, and implementing sustainable forestry and recycling programs, for example.

Cap-and-Trade Systems

A CTS has already been adopted by the European Union (EU) through its emission trading scheme (ETS). It is currently under consideration by the U.S. Congress as a politically palatable program to implement carbon limits. A well-designed CTS can ensure that emission reductions take place first where costs are the lowest, and at a price that is determined by the market.

Representatives Henry A. Waxman (D-CA) and Edward J. Markey (D-MA) proposed a new climate bill in the U.S. House of Representatives. The bill, called "The American Clean Energy and Security Act of 2009," seeks to establish a U.S. federal CTS with mandated carbon emission reductions, incentives for CCS, and a renewable electricity standard. The bill includes mandates and timelines for smart grid technology[32] and for initiating the planning for plug-in hybrid-electric car charging infrastructure, as well as mandated targets for the adoption of low-carbon fuels, renewable electricity, and energy efficiency gains by utilities and in industry, buildings, lighting, and appliances.

Speaking at the Baker Institute conference, Milo Sjardin, head of New Carbon Finance, North America, and a consultant to many participants in the EU ETS, argued that CTS would become "the preferred policy measure to ensure emissions reductions" on a global basis.[33] Saying the EU had learned from early failures, he asserted the EU's ETS "has so far been very successful in stimulating the transition to a carbon-constrained economy." The EU's ETS was adopted by the Environment Council on October 13, 2003, and has been in effect since January 2005.[34] It established

31 The California CTS will be linked with programs in the other Western Climate Initiative (WCI) partner states, which include Arizona, British Columbia, California, Manitoba, Montana, New Mexico, Ontario, Oregon, Quebec, Utah, and Washington. WCI anticipates that regional harmonization will reduce carbon "leakage" to other states or countries after the CTS is in effect. See California Air Resources Board, "AB 32 Cap-and-Trade Rulemaking to Reduce Greenhouse Gases," Public Workshop, January 29, 2009.

32 A "smart grid" uses advanced metering infrastructure (AMI) to signal consumer devices near real-time electricity prices so that the consumer can decide when to charge appliances or use electricity. For example, if you notice that prices are very high at one time, you may decide to run your washing machine later. It also allows electricity providers to determine demand specific to neighborhoods, times, seasons, etc., to reduce congestion and bottlenecking as well as blackouts. This system also allows for the possibility of time-zone pricing of electricity, similar to existing pricing structures now used for cellular telephones, and would allow consumers to sell electricity back to the grid. For example, in a smart grid, a consumer could sell any unused electricity generated by solar roof panels or a fuel cell vehicle back to the grid.

33 "Beyond Science," February 9, 2008.

34 "Emission Trading in the EU," *Climate Action Network Europe*, http://www.climnet.org/euenergy/ET.html.

the cap-and-trade system for EU member states and is currently the largest trading scheme in operation, covering 46 percent of the EU's CO_2 emissions. The value of global CO_2 emissions trading has increased from $11 billion in 2005 to an estimated $64 billion in 2007. All 27 EU member states are involved in the ETS, and ETS targets are legally binding, accompanied by a fine of 100 euros/ton carbon emitted above the allowance.

The ETS had several problems during its "Learning Phase" (2005–2007). To begin with, the EU did not have accurate CO_2 emissions data on which to base the allocation of credits; therefore, over-allocation occurred as governments and industrial companies overestimated emissions, resulting in the market generating too low a carbon credit price to promote sufficient emissions reductions and also stimulating volatility in permit prices. In addition, to ensure no emission reductions were carried over from the Learning Phase to the next "Kyoto Commitment Period" (2008–2012), the EU did not allow banking or borrowing of permits in these phases and this created extreme permit price volatility where permit values dropped to zero in 2007.

Several lessons have been gleaned from the EU's ETS experience. First, the European system was hindered by an over-allocation of permits. Thus, it is important that the number of permits issued reflects sufficient scarcity as to promote adequate carbon pricing in the marketplace and the limitation of CO_2 emissions. Carbon prices projected to emerge from various systems, such as the current localized CTS in the Northeast (Regional Greenhouse Gas Initiative [RGGI]), are too low to encourage investment in less carbon intensive technologies. Second, the ETS experience shows that increased auctioning activity could prevent distortions created by free allocation, reduce windfall profits, and stimulate low-carbon investment.[35] If permits are given free of charge to large emitters, as has been proposed in the United States under some legislation, including the Waxman-Markey bill, this represents a hidden transfer of revenue. Since permits are valuable assets, emphasis should be placed on compensating affected parties (which could include energy consumers), not rewarding politically important regional districts or powerful regulated sectors.

Third, banking and borrowing of permits without limits is essential to support stable prices and long-term predictability. Fourth, reducing imports of GHG-intensive goods should be included in domestic GHG reduction targets.

ETS' failure to meet the caps for limiting carbon in the first phase has caused the amount of verified emissions from EU ETS companies to increase from 2,012,043,453 tons of CO_2 emitted in 2005 to 2,049,927,884 tons emitted in 2007. In fact, 68 CO_2 emitters failed to surrender enough allowances to cover their 2007 emissions.[36] The EU's Clean Development Mechanism (CDM), a carbon credit offset program, has also been beset by its own problems. Numerous fraudulent reduced-emission schemes have been funded through offsets, including nonexistent projects and double-selling of carbon offsets.[37] In 2008, the UN suspended DNV, the world's largest auditor of clean energy projects, because the company incorrectly approved projects for carbon-trading schemes.[38]

Kyoto Commitment Period ETS permit prices have mainly traded within the range of 15–25 euros/ton of carbon since early 2005. Such prices, while more stable than prices in the Learning Phase, may also prove to be too low to stimulate massive investment in carbon-free energy and CCS technologies.

In designing an effective U.S. federal CTS system, congressional lawmakers must consider these drawbacks and failures in the ETS. The ETS experience demonstrates the importance of instituting economy-wide coverage of GHGs (including non-CO_2 emissions) to achieve real reductions, and of issuing an accurate number of permits and favoring the auctioning of the widest number of permits versus distributing large numbers of free permits to targeted industries.

The United States can develop its own carbon policy; however, according to Roger Williams, vice president of portfolio development at Blue Source,[39] there are benefits to linking and harmonizing U.S.

35 Cameron Hepburn, Michael Grubb, Karsten Neuhoff, Felix Matthes, and Maximilien Tse, "Auctioning of EU ETS phase II allowances: how and why?" *Earthscan*, Climate Policy 6 (2006) 137–160, http://www.electricitypolicy.org.uk/pubs/tsec/hepburn.pdf.

36 Europa, "Emissions trading: 2007 verified emissions from EU ETS businesses," news release, May 23, 2008, http://europa.eu/rapid/pressReleasesAction.do?reference=IP/08/787&format=HTML&aged=0&language=EN&guiLanguage=en#fnB1.

37 Nick Davies, "National: Special report: Climate change: The inconvenient truth about the carbon offset industry," *The Guardian (London)*, June 16, 2007. In the concluding part of a major investigation, Davies shows how greenhouse gas credits do little or nothing to combat global warming.

38 Danny Fortson and Jonathon Leake, "UN suspends carbon-trading auditor," *The Sunday Times (London)*, December 21, 2008.

39 "Emerging U.S. Climate Policy: Trans-Atlantic Approaches and Market Harmonization" (conference, James A. Baker III Institute for Public Policy, Houston, TX, December 15, 2008).

policy with other countries' existing or future policies. First, he noted "carbon policies can achieve cost savings if marginal costs of emissions reductions vary across the tradable permit systems (price-convergence)," and second, "larger, more liquid markets can reduce transaction costs, reduce concerns about market power, and reduce total price volatility."

While national policy efforts are important, Williams suggested that creating a global system of harmonized climate policies should be the long-term policy goal. According to Williams, a well harmonized global policy should include a carbon price signal (to internalize the carbon cost externality). He added that this carbon price should be applied across the broadest number of sectors and with the greatest possible long-term predictability in order to best support investment and technological innovation. He said flexibility is also important so that lessons learned from ongoing carbon pricing systems can be tapped to redirect efforts, when necessary, to better accomplish targeted emissions reductions goals.

Carbon Tax

Despite increasing political support for a CTS, many academic studies have shown that a carbon tax, if set sufficiently high, would be more economically efficient than a carbon permit market. Scholarly research from Harvard, Yale, and Tufts Universities, among others, has demonstrated the benefits of a tax versus a permit system. Those in favor of a carbon tax believe that a straightforward tax is easier to enforce and adjust over time than CTS, particularly because a tried-and-true tax bureaucracy already exists (the Internal Revenue Service). Proponents further claim that a carbon tax could be implemented in a year, as opposed to decades for CTS. But implementing an effective carbon tax could require adjustments, if it turns out the initial tax level is not high enough to discourage the necessary amount of CO_2 emissions.

For the United States, however, studies show that such a policy would be regressive. Gilbert E. Metcalf, professor of economics at Tufts University, explained to the Baker Institute conference that one big concern of any kind of carbon or energy tax, including pricing of CO_2, is the distribution effect.[40] Higher prices for energy, which are likely to result from carbon pricing, will disproportionately impact low-income households over wealthier households. Metcalf noted that carbon taxes have been shown to be distinctly regressive, with half of the tax burden passed on through non-energy products that are fuel-intensive in their production or distribution. Lower-income households are estimated to pay 3 percent of income to cover these higher costs versus only 1 percent of income for wealthier households, if no rebate is issued to offset the tax.

Metcalf also noted that similar problems exist in a CTS where permits are given out entirely for free. He stated such a program "simply leads to higher returns to shareholders in the energy sector, and owners of shares tend to be wealthier than typical households in the U.S. economy … so the impact of complete grandfathering is distinctly regressive." According to Metcalf, "The top 20 percent of the income distribution is actually made better off by this policy (free permits under cap-and-trade), which is being paid for in higher prices by the lowest income families in the distribution curve. So I think there is a real distributional cost to grandfathering."

Metcalf pointed out that although any form of carbon pricing is regressive, such effects can be undone through a well-designed rebate plan for carbon revenue. U.S. Representatives Jeff Flake (R-AZ) and Bob Inglis (R-SC), along with co-sponsor Dan Lipinski (D-IL), in May 2009 proposed carbon tax legislation that countered the congressional democrats' CTS proposal (the Waxman-Markey bill). The alternative bill proposes to tax carbon at $15/ton, with a gradual increase to $100/ton over the next 30 years. The carbon tax is combined with an equivalent payroll tax reduction to neutralize consumer pocketbook strain from rising commodity prices.

Another possibility is a hybrid system that combines the attributes of taxes and CTS. These systems can incorporate a CTS with a safety valve (where government will issue more CO_2 emissions credits if their price exceeds a certain level, effectively setting a ceiling price), or a CTS with a carbon fee. To achieve carbon reductions in the most cost-effective manner, the program must incorporate as much of the emissions as possible through comprehensive programs that include all sectors. This means implementation of carbon taxes or pricing at the point of upstream production at the coal mine, refinery gate, or electric utilities as opposed to downstream at the point of fuel use. Bills have been proposed in the U.S. Congress that utilize a CTS with a carbon price set by legislation (and not the market), such as the Bingaman-Specter bill (S.1766), or the "Low Carbon Economy Act of 2007."

[40] "Beyond Science," February 9, 2008.

Energy Tax

The fifth option for regulating carbon while also addressing energy security concerns is a tax on energy. Peter Hartley, Baker Institute Rice scholar and the George and Cynthia Mitchell Chair and professor of economics at Rice University, discussed this issue at the "Beyond Science" conference. Proponents, like Hartley, argue that while an energy tax could result in more emissions in the short term than the other plans, it would encourage transition and R&D in the most efficient, cost-effective energy alternatives in the long run. Energy producers (electricity generation, transportation fuel, etc.) emit the most carbon. By taxing energy consumption, one reduces emissions by promoting energy efficiency and conservation among consumers, thereby reducing consumption. Greater efficiency also results in less vulnerability to energy price shocks, which buttresses energy security. Furthermore, while carbon taxes favor alternative energies with the greatest immediate profitability (such as wind power, which has limited opportunity for scaling up), these investments may not be optimal for long-term goals or for encouraging energy security. An energy tax, however, could foster goals of both climate and energy security. An energy tax could also achieve carbon reductions while generating revenue, which could be directed to subsidize investments in renewable energy. This would ensure the best long-term low-carbon solution is ultimately adopted. In addition, an energy tax would be more likely to promote energy security than the previous models by reducing energy imports (which tend to be fossil fuel intensive, such as oil and natural gas).

However, climate policy and energy security may not always be complementary. Energy security proponents typically prefer cheap, reliable, and domestic energy sources. The United States has 29 percent of the world's proven, recoverable coal reserves and 74 percent of its shale oil; but energy production from these carbon-intensive sources emits higher levels of GHGs, in the absence of a viable sequestration technology.

The Role for Science and Technology Development

Notable scientists and economists agree that the mobilization of new, cost-effective, and clean technologies will be pivotal to the ability of the United States to develop an effective strategic response to climate change. Thus, a successful climate policy will have to include measures that promote rapid technology development, including broad investment in research and development, international collaboration, and cost-effective strategies to promote widespread commercial deployment of promising existing technologies and stimulation of new technologies and innovation. The magnitude of the requirements for cleaner energy production and enhanced efficiency is so large that small-scale innovation will not be adequate to address the challenges. Instead, policies are needed that will promote a rapid turnover in billions of dollars of infrastructure development in technologies that can be readily scaled up and dispersed with unprecedented market penetration.

Sufficient funding for the R&D of new technologies will play a key role in combating climate change. An important point to keep in mind is that we cannot "pick winners" when it comes to new technologies. Attempts to implement new technologies should be as efficient as possible, and we should not promote one idea over the rest of the field. There are many potential avenues and ways to correct existing problems, and all should be considered for maximum efficiency and effectiveness. Although technological advances may be ahead in some areas, certain technologies could potentially make broad leaps of progress in the near future, surpassing existing technologies.

Steve Koonin, chief scientist at BP p.l.c., told the Baker Institute conference in his keynote address, "Corporate Greenhouse Gas Policies," that "partial solutions" were not going to be effective and that the largest multinational corporations such as BP needed to be part of the solution.[41] "This aspect of materiality means that large corporations must be actively involved in GHG reductions, since it is through them that societies get things done, at least in the developed world." Koonin added that the timely adoption of climate policy is urgently needed, because energy infrastructure is not easily replaced or retired from service. "Apart from universality, greenhouse gas policies must also be timely—one of the defining characteristics of the energy infrastructure is its longevity," he explained. "Power plants last 50 years, automobiles last 20 years, and buildings in which half the world's energy is used last about 100 years." He noted that future GHGe are being locked in for decades by the infrastructure built right now. "We have little time to set the policies right," he warned.

41 Ibid.

Research should be focused on finding new and innovative technologies that provide alternative sources for energy that are sustainable and do not require the release of GHGs, as well as novel ways of dealing with existing GHGs in the atmosphere. Additionally, we must consider the necessity of transitional technologies, such as hydrogen fuel cells, electric and hybrid vehicles, and wind-generated electricity to provide a bridge between current systems and those we are moving toward.

Furthermore, climate scientists need to move from independent groups to environmental centers. The United States should push for a large international climate change modeling and research project similar to the human genome project. To plan for climate change consequences, institutional capacity should be harnessed and enhanced, then integrated into social networks. For example, the UN could begin by identifying several vulnerable regions in the world, and then conduct comprehensive assessments of the impacts of climate change, identifying possible adaptation options and proposing new institutional arrangements to manage land and water resources in a world of changing climate. These regional assessments could serve as models or templates for other parts of the world.

In addition, scientists must get involved in the decision making process, developing a dialogue with policymakers. Their input is vital to generating interest and support in tool generation and appropriate planning schemes to support society, markets, and the environment.

Conclusions

This report is based on presentations and discussions at two Baker Institute conferences held in 2008: "Beyond Science: The Economics and Politics of Responding to Climate Change" and "Emerging U.S. Climate Policy: Trans-Atlantic Approaches and Market Harmonization." These events were not workshops. No effort was made to reach a consensus on findings or recommendations, but it is possible to draw some key conclusions based on the presentations and discussions.

The United States needs to address the growing problems associated with climate change by developing a comprehensive and flexible policy. There is a window of opportunity to find ways to mitigate these problems as well as adapt to what is already occurring before the costs of climate change begin to soar. As a major GHG emitter, the United States should take the lead in orchestrating a global policy framework.

In the United States so far, proposed legislation has focused on mitigation strategies related to driving reductions in GHGe via regulation. However, over time, the United States will need to develop a more comprehensive approach to climate change. The United States will have to implement a comprehensive set of policies that encompasses a more proactive international diplomatic effort, a stronger science and technology research and development program, a set of regulations for CO_2 emissions across the country, and adaptation strategies for the protection of vital infrastructure and vulnerable communities, especially human coastal populations.

Domestically, U.S. federal policy should be multifaceted, including transportation regulations—such as improving CAFE standards—and a scheme to price carbon through a hybrid CTS or an energy tax to increase efficiency. While the policy must be specific enough to help industry, it should be flexible to accommodate new information, economic alterations, or geopolitical changes.

According to a 2008 study by the Baker Institute Energy Forum, a 35 mpg fuel efficiency standard (as signed into law by President George W. Bush in December 2007) will reduce U.S. oil demand by 2.3 million bbl/d by 2020.[42] President Obama's May 2009 announcement that CAFE standards for cars and light trucks should increase to an average of 35.5 mpg by 2016 accelerates the original Bush policy timeline by four years, and is a step in the right direction. But if policymakers were to push for a more ambitious target of 50 mpg by the mid 2020s, the United States could see oil savings of 7 million bbl/d by 2030 compared to business-as-usual consumption. This is equivalent to the projected increase in oil demand from China in the same time frame. Moreover, the fuel savings would continue to grow as more and more new vehicles diffuse into the existing vehicle fleet.

Federal policy also needs to stress the importance of science and technology R&D. Policy must take into account the rapid pace of technological development, and reflect concern for scientific discovery, invention, and innovation. While current technologies can be improved, new "breakthrough" technologies will be required for the production, distribution, and efficient use of energy.

In addition, research on vulnerable populations and cities in the United States and abroad is vital

[42] Amy Myers Jaffe and Kenneth B. Medlock III, "U.S. Gasoline Policy" in *Recommendations for the Next Administration*, James A. Baker III Institute for Public Policy, January 8, 2009.

to developing effective adaptation responses. The U.S. military and National Guard will increasingly be challenged by larger numbers of humanitarian disasters and refugee crises, and proper preparation and international coordination is needed to meet these new demands for intervention and evacuation. The United States is also a major producer of food for its own population and the world market. More research is needed on the impact of climate change on the productivity of U.S. agricultural lands and fisheries, as well as on the safety and supply availability of U.S. water resources.

Finally, federal policy should reflect the combined efforts of industries and consumers to reduce their carbon footprint. This can be achieved through promoting energy efficiency and the adoption of new technologies. In addition, ending the practice of natural gas flaring, protecting natural carbon sinks by increasing forest coverage and reducing deforestation rates around the world, and promoting farming methods that enhance carbon adsorption can also have a large positive impact.

A rational U.S. climate policy has the potential to improve the nation's security in the face of diminishing nonrenewable resources and to attain global climate stability. It also represents a market opportunity—in terms of technological innovations and carbon pricing—for the early actors. The global scope and multigenerational scale of climate change impacts demand a concerted, international, and immediate policy response beyond the Kyoto Protocol, incorporating changes in consumer habits and involving cooperation between business, government, academia, and civil society. The United States is fortunate to have the human and financial resources to take on this challenge. Success will require cooperation among nations. But success will not be possible without the leadership of the United States. Time is of the essence and policies need to be developed now.

Acknowledgments

The Baker Institute would like to thank the Energy Forum and Science and Technology Policy Program's sponsors for their generous support.

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The Baker Institute Energy Forum and Science and Technology Policy Program would also like to thank Rice University undergraduate interns Mark Hoffman, Rachel Marcus, Devin McCauley, and Matthew Schumann, as well as high school intern Philip Angelides, for their valuable research assistance.

The Baker Institute's conferences on climate policy in 2008 were made possible through the support of the Baker Institute Science and Technology Policy Program and the Energy Forum, the Energy and Environmental Systems Institute and the Shell Center for Sustainability at Rice University, as well as The Institute of Energy Economics, Japan; the Science and Innovation Section of the British Consulate-General in Houston; ConocoPhillips; SUEZ Energy North America, Inc.; Baker Botts L.L.P.; and the General Consulate of France in Houston.

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