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CONFERENCE PROCEEDINGS

Integrating U.S. Climate, Energy, and Transportation Policies

Proceedings of Three Workshops

Liisa Ecola • Scott Hassell • Michael Toman • Martin Wachs

Sponsored by the McCormick Foundation

RAND INFRASTRUCTURE, SAFETY, AND ENVIRONMENT

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Preface

About This Document

In June 2008, the RAND Corporation convened three workshops on policies for mitigating climate change. These workshops brought together representatives of government, industry, advocacy groups, and the research community, who hold different perspectives on what the goals of climate change mitigation policy should be and which strategies should be implemented to achieve them. The workshop series was made possible by a generous grant from the McCormick Foundation.

Addressing the interconnection of climate change mitigation policy with the key sectors of energy and transportation will be a major challenge for the United States in the coming years. The competing interests of these groups sometimes hamper progress on this front. Bringing them together enabled them to share different perspectives and to identify some common points of view on such issues as technological innovation; federal, state, and local roles; potential legislative and regulatory solutions; international cooperation; and public engagement.

These RAND conference proceedings summarize key issues and discussion topics of the three workshops. This document is not intended to be a transcript of the discussions, and, in deference to our observation of the Chatham House rule,[1] it does not quote any participants by name or affiliation. Rather, it organizes the key themes of the workshops by topic—in particular, pointing out areas of agreement as well as disagreement.

These proceedings should be of interest to stakeholders in the climate, transportation, and energy policymaking processes and especially to those responsible for crafting U.S. climate policy. Readers interested in these topics may also wish to see two upcoming RAND occasional papers:

- *U.S. Programs for International Energy Assistance and National Energy Objectives*, by Michael Toman, Scott Hassell, Liisa Ecola, Tewodaj Mengistu, Endy Min, Aimee Curtright, Noreen Clancy, and Eileen Hlavka
- *Evaluating Options for U.S. Greenhouse Gas Mitigation Using Multiple Criteria*, by Nicholas Burger, Liisa Ecola, Thomas Light, and Michael Toman.

[1] The Chatham House rule holds that,

> When a meeting, or part thereof, is held under the Chatham House Rule, participants are free to use the information received, but neither the identity nor the affiliation of the speaker(s), nor that of any other participant, may be revealed. (Chatham House, undated)

The RAND Environment, Energy, and Economic Development Program and the Transportation, Space, and Technology Program

This research was conducted under the auspices of two programs: the Environment, Energy, and Economic Development Program (EEED) and the Transportation, Space, and Technology (TST) Program, both within RAND Infrastructure, Safety, and Environment (ISE). The mission of RAND Infrastructure, Safety, and Environment is to improve the development, operation, use, and protection of society's essential physical assets and natural resources and to enhance the related social assets of safety and security of individuals in transit and in their workplaces and communities.

The EEED research portfolio addresses environmental quality and regulation, energy resources and systems, water resources and systems, climate, natural hazards and disasters, and economic development—both domestically and internationally. EEED research is conducted for governments, foundations, and the private sector.

The TST research portfolio encompasses policy areas including transportation systems, space exploration, information and telecommunication technologies, nano- and biotechnologies, and other aspects of science and technology policy.

Questions or comments about these conference proceedings should be sent to the project leader, Liisa Ecola (Liisa_Ecola@rand.org).

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Contents

Tables

Summary

Climate change and the greenhouse gases that contribute to it are becoming a focus of growing concern among policymakers and the broader public. The interconnection of climate change mitigation policy with the key sectors of energy and transportation will be major challenges facing the new president and his administration in the coming years. Although there are many stakeholders who hold a wide range of perspectives on potential strategies to address climate change, it is important that major policy players seek some level of general agreement on an approach that encompasses both energy and transportation policy solutions. Otherwise, proposed climate change mitigation policies will engender dissent and risk failure.

In an effort to share different perspectives and identify common points of view that could lead to new climate policy solutions, RAND convened three workshops—one each on climate-change policy, energy, and transportation—that brought together participants representing multiple government agencies, industries, and advocacy and research organizations. The workshops, held at RAND's Arlington, Virginia, offices in June 2008, featured discussion of various issues related to climate change mitigation policy, including technological innovation; federal, state, and local roles; potential legislative and regulatory solutions; international cooperation; and public engagement.

Context for Making Climate Policy

The workshop participants generally agreed that the context for making policy on climate issues can be summarized in four broad themes, described here.

Climate Change Is a Significant Problem Requiring Action on Many Fronts

The core scientific findings that support the occurrence of human-induced climate change are no longer in doubt. The business and environmental communities agree that climate change is a real and growing concern and that significant emissions reductions in greenhouse gases will be needed to prevent harmful environmental change. Broad-based policies are needed soon, and all major sectors of the economy should be involved because climate change cannot be mitigated by responses in only a few sectors or industries.

Climate-Change Mitigation Is Intrinsically Linked to Other Important Public-Policy Issues

Because taking on climate-change mitigation will affect other policy areas, policymakers must understand these interconnections and consequences. For example, it is very likely that some transportation policies could help reduce traffic in addition to mitigating greenhouse-gas emis-

sions. However, in other cases, climate policy goals may conflict with other national goals, such as greater energy security.

Policymakers and the Public Differ in Their Recognition of the Problem

Awareness of climate change and the need for urgency varies among actors. Some states are more aggressive than the federal government, while other states are doing little. The general public understands that climate change is a problem, but additional education may be necessary to generate public support for potential solutions.

Executive Leadership Is Needed to Make Progress on Climate Change

Top executive-branch officials at all levels of government—from the president to governors and mayors—must take the lead on developing, building public support for, and implementing climate-change policies. Such leadership will be necessary to help guide constructive policy debates with legislative bodies at all levels.

Policies to Confront Climate Change

Workshop participants identified and debated the advantages and drawbacks of specific approaches to confronting climate change.

Market-Based Approaches

Market-based approaches are seen as a necessary component for a climate policy to gain acceptance and succeed in reducing emissions**.** Two types of market-based approaches were discussed: (1) a cap-and-trade system, in which the government sets an emissions limit and issues tradable permits for the amount of emissions that can be produced by an emitter, and (2) a carbon tax, which sets a price for emissions but imposes no limit on the amount of emissions an emitter can produce. While many economists and some industry leaders believe that a carbon tax would be more economically efficient, most experts view cap and trade as more politically feasible and still effective.

At the climate workshop, participants debated a range of issues relating to cap-and-trade policy, including how to distribute the permits and what to do with the substantial revenues collected if the government sold some permits. While participants in the energy workshop agreed that market-based approaches would be a key strategy for reducing energy emissions in general, participants in the transportation workshop generally felt that a market-based approach was necessary but not sufficient to reduce emissions from transportation.

Direct Regulations

Regulations require individuals and businesses to reduce certain types of emissions in certain ways, with costs borne by the regulated entities. Current regulations with implications for greenhouse gases include the following:

- Corporate Average Fuel Economy (CAFE) standards, which require manufacturers to produce vehicles that use fuel more efficiently
- energy-efficiency standards for both residential- and commercial-use appliances

- building codes that regulate types and efficiencies of heating and cooling systems, lighting, windows, and so forth
- renewable portfolio standards, which require electricity companies to use a minimum percentage of renewable energy sources to produce electricity.

Not surprisingly, there was a great deal of debate about the most effective types of regulation as well as which level of government—federal or state—should set regulatory standards. For example, industry tends to favor nationwide standards, while some states would like to continue enacting state-specific regulations.

Technology Policies

Although all participants agreed that many technology innovations will be needed to reduce emissions, they expressed a range of views about the impact of new technology as well as policies designed to promote research, development, demonstration, and deployment of innovations designed to reduce emissions. While some believed that new technology would ultimately be the principal way to achieve greenhouse-gas reductions, others thought the promise of technology had been overhyped because significant behavioral and infrastructure changes would also be needed to make new technology widely available and affordable. However, there was wide agreement that work should continue on promising technologies, such as wind and solar power, carbon capture and storage, biofuels, and alternative vehicle technologies, such as plug-in hybrids.

In addition, some discussed an appropriate federal role in identifying and funding promising climate-change innovations and technologies. While participants thought that the government should not be choosing winners and losers, they also agreed that, if the public sector provides financial incentives for private-sector innovation, the incentives need to be available consistently in order to prevent boom-and-bust cycles for certain technologies.

Behavioral Change

Behavioral change can take many forms, including driving less, purchasing more energy-efficient appliances and vehicles, using less electricity, and switching to alternative sources of electricity. Small changes in individual and business behavior can add up to large decreases in collective greenhouse-gas emissions. Although some behavior change may occur voluntarily through increased public awareness of climate change, government policy incentives seek to encourage such change. Market-based approaches are one form of incentive; direct financial benefits, such as tax credits, represent another category. Participants generally agreed that there are significant obstacles to achieving major emissions reductions, especially in the nearer term. Energy-saving investments often require high up-front costs, while the energy savings can be small and spread over many years, and, for many businesses, energy costs are not a major determinant of their overall costs.

Another key obstacle is that existing land-use patterns make it difficult for Americans to reduce their driving. Changing this may require a variety of approaches, including regulatory reform of land-use patterns and congestion pricing, to reduce vehicle miles traveled. Although emissions have been reduced in the past through technological innovations, efforts to address climate change by reducing emissions will also require Americans to drive less.

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Abbreviations

CAFE	Corporate Average Fuel Economy
CCS	carbon capture and storage (also known as carbon capture and sequestration)
CNG	compressed natural gas
GHG	greenhouse gas
HOT	high-occupancy toll
ICE	internal combustion engine
mpg	miles per gallon
PTC	Production Tax Credit
VMT	vehicle miles traveled

CHAPTER ONE

Context and Approaches for Climate Policy

Introduction

In June 2008, the RAND Corporation convened three half-day workshops on policy approaches to climate-change mitigation and how they would affect two key sectors: transportation and energy. The workshops, which were held at RAND's offices in Arlington, Virginia, included speakers, panelists, and other workshop participants representing multiple government agencies, industries, and advocacy and research organizations.

Given the many perspectives of stakeholders in the climate policy debate, RAND organized the three workshops for participants to offer their own perspectives and to help foster broader agreement on policy approaches that would be effective and could gain support from all three groups of stakeholders. Among the main stakeholder groups that participated in the workshops, each offered distinct perspectives: Government officials tended to focus on what can be implemented and show results in a short to medium time frame; businesses were concerned chiefly with costs and economic competitiveness; and advocacy groups often focused on the solutions that will reduce greenhouse gas (GHG) emissions by the greatest amount.[1]

For a set of national responses to emerge from ongoing climate change policy discussions, these interest groups will have to come to agreement on how to mesh sometimes-conflicting goals. Because any effective action on climate change will have to be broad and far-reaching, the major policy players will need to come to a general agreement on an effective framework that can garner support from a wide range of stakeholders. Otherwise, policy prescriptions will provoke significant dissent and risk failure.

While the climate workshop focused on how to construct a framework for climate policy, the other workshops examined two key sectors: energy and transportation. Electricity generation is the largest emitter of GHG, responsible for about 40 percent of all emissions in the United States, and would be directly affected by attempts to limit energy use or switch to alternative sources. The transportation sector emits roughly 30 percent of all GHG in the United States, which stems from both personal travel in cars and an increasing share derived from goods movement (EPA, 2008).

[1] This document uses the term *GHG* to refer to the range of gases, chief among them carbon dioxide, responsible for climate change. Although workshop participants used the terms *GHGs*, *carbon dioxide*, and just *carbon* interchangeably, we use *GHG* in these proceedings. The focus in the workshops was predominantly on carbon dioxide, but people working in this field commonly intend for non–carbon dioxide gases to be included in climate policies, since they can also provide cost-effective opportunities for reductions, given the high global-warming potentials of the other gases. However, we use the common term *carbon tax* rather than *GHG tax* when referring to this policy instrument.

The remainder of this chapter focuses on the common themes from all three workshops, while the next three chapters delve into more specifics from the workshops on climate policy, energy, and transportation. Since the three topics overlap, we have organized the chapters along thematic lines wherever possible, rather than provide a strict recording of what was said at each workshop.

Each workshop featured two or three speakers (representing government, business, and advocacy organizations), as well as an additional four to five panelists who responded to the speakers' presentations. Questions and comments from all workshop participants were welcome, and each workshop was moderated by a RAND researcher. A list of speakers, panelists, moderators, and other workshop participants is provided in the appendix. To encourage participants to speak freely, we operated under the Chatham House rule, under which all participants agreed not to quote any comments by name. Respecting this agreement, no comments in this document are attributed to specific participants.

Context for Making Climate Policy

Participants at each of the three workshops generally agreed that the context for making policy on climate issues is defined by the following four broad themes:

Climate Change Is a Significant Problem Requiring Action on Many Fronts

The core scientific findings that support the occurrence of human-induced climate change are no longer in doubt. The business and environmental communities, long on opposite sides of this question, now agree that climate change is a real and growing concern. Significant emissions reductions in GHGs will be needed to prevent harmful climatic change. Although workshop participants did not discuss specific reduction targets or timetables in detail, the general consensus was that broad-based policies should be put in place soon.

The scope of the problem is large enough that all major sectors of the economy should be involved because climate effects cannot be mitigated by changes in just a few sectors or industries. Any specific sector viewed as not pulling its weight will face potential political problems, regardless of the relative cost-effectiveness of specific mitigation measures. In addition, participants noted that the United States should take an integrated approach because it makes sense economically to mitigate GHGs nationally, rather than only on a regional or state basis.

Similarly, no single strategy will reduce emissions to the levels needed to sufficiently slow the pace of climate change. Technological and behavioral changes are both required. Increased energy efficiency—often referred to as the fifth fuel[2] because it can help meet energy needs as effectively as the development of alternative energy sources—is the most widely agreed-upon strategy, and it will need to be implemented in a wide variety of settings.

Climate-Change Mitigation Is Intrinsically Linked to Other Important Public-Policy Issues

Because taking on climate-change mitigation will have effects in other policy areas, it is important to understand these interconnections and their consequences. In the case of transportation, it is likely that many policies to reduce GHG emissions will also have a positive impact in other areas. For example, climate change can interact with transportation policy challenges,

[2] The other four are coal, natural gas, nuclear, and renewable energy.

such as shortages of financing for infrastructure maintenance and urban congestion. Some policies, such as congestion pricing, would help achieve all these goals simultaneously.

However, in other cases, climate policy goals can conflict with other goals. For example, shifting away from coal, which is carbon-intensive but abundant in the United States, may result in more energy insecurity if the country shifts to alternate sources that have to be imported and may be subject to greater instability, such as natural gas. There was some difference of opinion about the potential scope of consequences of U.S. dependence on imported energy—how vulnerable it makes the United States to the decisions of other countries and whether the high price of foreign oil creates excessive wealth transfer away from the United States. Given those factors, the potential exists for conflict between the goals of lower GHG emissions and reduced dependence on imported energy.

Policymakers and the Public Differ in Their Recognition of the Problem

The level of awareness of climate change and the need for urgency varies among actors. In general, the executive and legislative branches of the federal government are aware of the need to make GHG reductions. Awareness among the states varies greatly; some states are more aggressive than the federal government, and others are doing little. Such variance in awareness or commitment to climate-change policy may make it difficult to achieve national-level policy solutions in which a wide variety of governmental bodies need to act in a coordinated or integrated manner.

In terms of public awareness, the general public understands that climate change is a problem, but additional education may be necessary to bring the public on board to support potential solutions. Furthermore, rigid stances by some interest groups and policymakers—for example, total opposition to nuclear power or support for its unlimited use—can impede the compromises needed to reach workable solutions.

Executive Leadership Is Needed to Make Progress on Climate Change

Developing plans for climate-change policies, building public acceptance of the policies, and implementing them will require leadership from top elected officials in the executive branch at all levels of government—from the president to governors and mayors. Such leadership will be necessary to help structure constructive policy debate by congressional committees, state legislatures, and city councils, all of which will play a role in debating and ultimately approving necessary policy changes.

Policies to Confront Climate Change

At the workshops, participants debated advantages and drawbacks of specific policies to mitigate climate change. We organized mitigation policies into four broad categories: market-based approaches, regulations, technology policies, and behavioral change.[3] Speakers, panelists, and other workshop participants discussed examples of each, along with advantages, drawbacks, and related issues. In some cases, there was broad agreement; in others, there was significant

[3] Although workshop participants did not assign policies to these four categories, we believe that they provide a useful framework for sorting out a wide range of policies that were discussed.

debate. The upcoming sections describe each policy type, provide examples, and present the most salient points from the workshop debates.

Market-Based Approaches

This type of policy attaches a price to a specific quantity of GHG emissions. Currently, emitting GHGs is a *negative externality* in economic terms, meaning that the emitter does not bear a direct financial cost for emissions. Policies based on market incentives use *price signals*—that is, prices associated with emissions tell individuals and businesses the cost of not mitigating emissions. Emitters should react to price signals by implementing various means to curb their emissions when the costs of such efforts are lower than the price of emissions, so that mitigation saves them money.

Two types of market-based approaches have been considered in the United States. The first is known as a cap-and-trade policy, in which the government sets a limit on total GHG emissions and issues permits that allow the permit holder to emit a specific amount. The permits can be bought and sold on an open market. Companies that have excess permits because their emissions are below their allowable limit or because they have low costs of emissions mitigation can sell their permits; companies that find it more cost-effective to exceed their allowable emissions limit will need to buy additional permits. As a result, if one business can reduce its emissions at a lower cost than another business, it makes sense all around for the first business to sell some of its permits to the second. Over time, the value of permits will rise or fall depending on technology advances and changes in targets for total permissible GHG emissions.

The second approach is known as a carbon tax, which charges emitters a fixed amount per unit of GHG emitted. Unlike a cap-and-trade system, which sets a quantity of emissions but leaves the price of a permit up to the market, a carbon-tax approach sets a price for GHG but imposes no direct limit on the amount of emissions that companies can release. Both a carbon tax and a cap-and-trade system can be applied to fuel supplies based on their GHG content, not just to measured emissions from fuel combustion.

Workshop participants debated which of these two broad approaches would be superior. While many economists and some industry leaders believe that a carbon tax would be more economically efficient, others view cap and trade as still effective and more politically feasible. One critique of the cap-and-trade approach, however, is that it does not provide investors with compliance cost certainty, because the price of emitting GHGs can fluctuate with the permit market. A detailed discussion of the advantages and disadvantages of a cap-and-trade policy as opposed to a carbon tax can be found in Chapter Two.

Regardless of which approach (or combination of the two approaches) is ultimately selected, there was broad agreement that market-based approaches are a necessary component for a climate policy to succeed in reducing emissions. A number of other implementation issues would also need to be decided. One key issue is who would set the emissions cap levels or carbon tax and how they would be set. Participants agreed that over time, in order to decelerate and subsequently reduce emissions, either the carbon tax would have to be raised or the overall emissions cap in a cap-and-trade system would have to be lowered. However, they disagreed on whether Congress would be more likely to take action to raise a tax or lower the emissions cap. Tax or cap adjustments also could be set to take place automatically, thus distancing them from the political process by putting them into a more bureaucratic realm.

Participants' perspectives varied on whether permits would be auctioned or allocated if a cap-and-trade system were to be adopted. Auctions would require emitters to purchase the emissions permits from the government initially, after which they could be bought and sold by permit holders. This would engender a very large revenue flow from emissions sources to the government. In contrast, allocations would be available at no cost to businesses, perhaps on the basis of current emissions profiles.

If permits were auctioned, a second key question is what would be done with the revenues. They could be used to invest in lower-GHG technology, offset the impact of higher energy costs on low-income groups, and/or reduce other taxes. This is an important issue because the revenues could be substantial—on a par with corporate income tax revenues. There are already strong political pressures for different uses of these funds.

Participants agreed that getting the price right is necessary for an effective climate policy, but not sufficient. They argued that there are too many market failures in this arena to assume that GHG pricing alone would induce the desired behavior relatively cost-effectively. Therefore, while some type of market-based approach should be enacted, it should be used in conjunction with other types of policies.

Two other observations emerged from the discussion of market-based approaches. First, participants noted that climate-change policies should be effective regardless of the price of energy sources. A suite of policies premised on high oil prices (for example, assuming that the private sector will invest heavily in alternative energy research and development) will lose at least some effectiveness if the price of oil falls. Second, depending on the sector, there may be other ways to send effective price signals beyond cap and trade and carbon taxes. For example, drivers might reduce their amount of driving if congestion pricing is implemented (see details in Chapter Four, which examines transportation policies).

Regulations

Regulations require individuals and businesses to reduce certain types of emissions, without direct concern for the cost of doing so. Many regulations currently in place have implications for GHG mitigation, including the following:

- Corporate Average Fuel Economy (CAFE) standards, which require manufacturers to produce vehicles that use fuel more efficiently
- appliance standards that set energy-efficiency levels for goods such as dishwashers and dehumidifiers for both residential and commercial use
- building codes that regulate types and efficiencies of heating and cooling systems, lighting, windows, and so forth
- renewable portfolio standards, which require electricity companies to use a minimum percentage of renewable-energy sources to produce the electricity they provide to customers.

Even with a cap-and-trade or carbon-tax policy, workshop participants largely agreed that regulations are needed to correct other market failures that occur when markets do not respond adequately to a price signal. For example, even with a carbon tax, some builders might not invest in state-of-the-art energy-efficiency technology if they do not expect to recover the additional costs in building sale or lease prices.

However, participants disagreed in several key areas regarding the form and focus of such regulations. First, there was no consensus on what kinds of regulations are best suited for overcoming the market failures that impede the effects of emissions pricing. For example, some argue that auto manufacturers would not have achieved the current levels of fuel economy without CAFE standards. The auto industry has sharply disputed this, saying that it would have responded to consumer demand for more fuel-efficient cars when the price of gasoline rose.

The second area of contention was over which level of government should set standards. Industry representatives tended to favor federal regulation, since responding to a single set of national regulations would be easier and less costly than responding to different state and local regulations. On the other hand, states that want to go beyond federal standards have argued that they would like to be allowed to innovate and that relying exclusively on federal standards would prevent them from raising the bar.[4] This may be a more contentious point in some sectors than others. For example, there was support for state, regional, or local solutions in allowing different types of transportation investments depending on the existing land use. However, it is clear that tensions among industry and state governments will persist on this set of issues.

Technology Policies

As discussed in the climate workshops, *technology policies* refers to a suite of measures that promote research, development, demonstration, and deployment of innovations that can reduce GHG emissions. The potential technologies themselves vary widely. Among those specifically discussed at the workshops were alternative fuels, such as ethanol and other biofuels; alternative vehicles, such as plug-in hybrid gasoline-electric vehicles and exclusively electric vehicles; and carbon capture and storage (CCS),[5] in which GHG that would otherwise be released into the atmosphere is instead collected and stored. Potential technology-related policies range from tax credits designed to promote investment in specific technologies (for example, the national Production Tax Credit [PTC] for wind power) to direct government investment in promising avenues of research or pilot technology deployment programs.

Participants strongly disagreed about the appropriate role for government in the development and deployment of new climate-related technology. One particular area of disagreement was the question of how important technological solutions will be in reducing emissions. While all felt that many technologies will be needed to reduce emissions, participants expressed a range of views about how large a role technology should play. Some believed that technology would ultimately be the dominant path to achieving progress, while others thought that the promise of technologies had been overhyped because significant behavioral and infrastructure changes would also be needed. For example, even with plug-in hybrids available to consumers, if the infrastructure to recharge them does not become widely available, demand will be constrained. Despite these disagreements, most participants concurred with the idea that no single technology can reduce emissions to the degree needed for long-term climate protection and that efforts to research, develop, demonstrate, and deploy new technologies should be broad in scope.

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[4] In some cases, even lower levels of government adopt regulatory standards, such as local building codes.

[5] Also known as carbon capture and sequestration; for our purposes, the two terms are interchangeable.

A second area of disagreement was the proper federal role in technology policy. Some proposed a federal Manhattan Project–style effort for climate-change technologies, in which major public funding would be made available to the scientific community for a wide variety of initiatives. Others thought that federal money would be wasted on an effort predicated on selecting unproven or uncertain technologies and that the private sector has sufficient financial incentive to innovate in many areas. For example, rising gasoline prices have led to greater consumer demand for fuel-efficient vehicles and thus provided manufacturers sufficient incentives to develop such vehicles. Although this particular issue was not resolved, participants noted that, in cases in which the government is involved in providing financial incentives to spur innovation, those incentives have to be stable to ensure continued investment. For example, the PTC for wind power has expired and been subsequently renewed a number of times, resulting in wildly fluctuating U.S. investment levels in wind-power projects. One outcome of this uncertainty is that businesses have built manufacturing facilities in other countries that provide more stable incentives.

Finally, participants asked how the government could best evaluate various technologies and proposals for new technology financing. Any government investments or incentives involve some selection of technologies deemed most promising, and it is not clear that the federal government has the expertise to make the best decisions. For example, some previous advocates for ethanol research have backed down from this position because of the unanticipated impact that ethanol production has had on food prices. There will inevitably be controversy whenever the government tries to decide which technologies will be supported through public funding.

Behavioral Change

The final group of policies is defined by changes in individual and corporate behavior that complement those changes induced by fluctuations in energy prices. Desired behavioral changes include driving less, purchasing more energy-efficient appliances and vehicles, using less electricity, and switching to alternative sources of electricity. Small changes in individual and business behavior can add up to large decreases in collective GHG emissions.

Although some behavioral change may occur with increased public awareness of climate-change issues, the government can adopt policies to help encourage such change. For example, ENERGY STAR® is a voluntary labeling program in which businesses whose products meet certain U.S. Environmental Protection Agency standards can use the ENERGY STAR label to inform consumers that their products are energy-efficient. Alternatively, governments could provide tax and other incentives to consumers who purchase energy-saving equipment or make other lifestyle changes leading to less energy consumption. Finally, in many cases in which government regulations are enacted to achieve other purposes, the regulations create conditions that lead to more energy use. Such regulations could be repealed or amended. For example, zoning regulations in many cities make it difficult to combine residential and commercial land uses. Amending such zoning rules could lead to the development of more mixed-use neighborhoods in which residents could drive fewer miles.

It was generally agreed that there are significant obstacles to achieving major emissions reductions from voluntary measures. One main concern is that it is difficult, time-consuming, or expensive for consumers to get needed information on energy efficiency, and, in some cases, it is hard to act on such information effectively. For example, it can be difficult to know how much money one can save by improving home insulation. A second problem is that the costs of energy-saving investments are often high and up-front, while the energy savings are some-

times small and spread over many years. Third, for many businesses, the cost of energy is not a major factor in the overall cost of doing business. A business searching for ways to cut costs would focus on other areas first, if, by saving energy, it would save only a small percentage of its overall operating costs. Finally, behavioral change is particularly difficult in transportation, where land-use patterns make it difficult for people to drive less.

Participants mentioned several potential ways to overcome these obstacles. First, it is important to reduce investment cost barriers to consumers. For example, one innovative program allows residential solar panels to be installed and financed over time through a special assessment levied by the city, rather than to be paid up-front by the owner. The homeowner pays off the costs gradually over time, and, if the house is sold, the next owner assumes responsibility for the payments. Second, consumer education is essential. This can be done through better labeling, as with the ENERGY STAR system, or through publicity materials, Web sites, courses, or other means to inform people about not only the environmental consequences of their behavior, but also how to take practical action for change. Finally, in transportation, it will be important to change land-use patterns, but this may require significant reform at the local level and may take decades to achieve.

Summary

Workshop participants agreed that an effective climate policy requires action on many fronts. However, they disagreed considerably on the correct balance between market-based approaches, regulation, technology, and behavioral change. Even reaching agreement on the appropriate mix of approaches will require many compromises between the various stakeholder groups, as will decisions on how best to use the revenues collected from market-based approaches.

CHAPTER TWO

Climate-Change Workshop

Overview

Participants at the climate-change workshop discussed the growing consensus about the science of climate change as well as the likelihood of an emerging U.S. policy response, even as many important details remain to be determined. In particular, workshop participants agreed on several points:

- Although climate-change science is widely understood, solutions for climate change are not.
- Current technologies and policies will not be sufficient to solve the problem.
- Market-based solutions must be pursued, including a cap-and-trade system or a carbon tax.
- States should continue to play leading roles in finding solutions.
- The executive branch needs to take the lead on domestic and international action.

These issues are discussed in detail in the following sections.

Climate-Change Science and Solutions

Climate science is increasingly solid on fundamental issues of human influence and association with emissions and land use. Industry, the U.S. Congress, and most state governments accept this, and the general public is reaching a greater awareness as well. As a result, the public and policymakers increasingly understand that the United States must deal with this problem. However, they do not broadly understand the massive reductions in GHG emissions that will be required, nor the challenges to accomplishing these reductions, including the trade-offs between faster and more gradual reductions. In particular, there is limited understanding that the longer the United States waits to begin reducing emissions, the costlier it may be to make deep reductions because major capital investments typically have long lifetimes. However, sharp reductions in the nearer term would also be costly given the rapidity of the capital stock turnover and the need to rely on as yet pre-commercial low-GHG technology.

To improve public understanding of the potential challenges of solutions to climate change, participants felt that policy options should be discussed in a broader context. For example, the costs of reducing emissions should be considered along with the costs of inaction, and the costs should be put into context by comparing them to the magnitude of the nation's gross domestic product and the long-term threats of climate change. One panelist said

that presenting information in this context creates an understanding that an aggressive GHG program, while imposing costs, will also reduce the long-term costs of unmitigated climate change. Policymakers need to compare this option with a future in which the United States does not reduce emissions and the costs of climate change could be much higher.

Role of Technologies and Policies

During their discussion of how to address climate change, panelists shared insights and analyses that illustrated the magnitude of needed emissions reductions, the role of specific technologies, and the inability of today's technologies and policies to achieve the proposed 2050 emissions goals that are commonly discussed.[1]

One panelist put the challenge of reducing GHG emissions in a global context by noting that global emissions are projected to increase by 200 to 300 percent by 2100, with most growth originating in developing countries. Without a global commitment to reduce emissions using affordable technology that does not compromise the basic needs of developing countries for economic progress, even sharp cuts in emissions by the United States and other advanced, industrialized countries will have limited impact on the problem.

In the context of that global trend, current U.S. legislative proposals call for reducing domestic GHG emissions in 2050 to anywhere from 60 to 80 percent below 1990 levels. For the United States to reach these reduced emissions levels, a recent analysis cited by a participant found that aggressive levels of energy efficiency, renewable energy, nuclear power, advanced coal, CCS, plug-in hybrid electric vehicles, and distributed energy resources will all be needed.

Participants agreed that confronting climate change will require more aggressive policies and more advanced technologies than are currently envisioned. To demonstrate both the potential and limitations of today's technologies and policies, another participant presented an unpublished analysis of the GHG reductions that could be achieved under three increasingly aggressive energy-efficiency and clean energy–technology scenarios. The first scenario estimated that current federal and state laws[2] may be able to stabilize, but not reduce, GHG emissions by 2030. The second scenario improves building energy efficiency and increases windpower generation to 20 percent of electric-power production. The result was a net reduction in GHG emissions. The third scenario assumed maximum deployment of energy efficiency and clean energy technologies, subject to a constraint on feasible growth rates. Even under these optimistic assumptions, efficiency and clean energy technologies alone were unable to reach the GHG reductions proposed in the 2007 Lieberman-Warner Climate Security Act (S. 2191), which called for a reduction of 71 percent below the 2005 level by 2050 (Pew Center, 2008).

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[1] Many world leaders have called for a 50-percent reduction in overall emissions by 2050. See, e.g., Wintour and Elliott (2008).

[2] The scenario assumed that state renewable portfolio standards would be attained and that the Energy Independence and Security Act of 2007 (Pub. L. No. 110-140) would be implemented. Key provisions of this act that were included in the analysis were a renewable-fuel standard, higher CAFE standards, and more stringent appliance and lighting efficiency standards.

Importance of Market-Based Solutions

Given that reductions are needed above and beyond what can be envisioned today, participants strongly preferred market-based mechanisms to conventional command-and-control approaches, in which regulators prescribe specific technologies and approaches. As noted in Chapter One, the two fundamental market-based approaches that can reduce GHG emissions are a cap-and-trade system and a carbon tax.

A cap-and-trade system seeks to reduce emissions to a given level with 100-percent certainty and to do so at the lowest possible cost. Costs are minimized, given the target, because emissions permits provide firms with an incentive to identify innovative and low-cost opportunities to reduce their own emissions and sell the excess emissions permits to others facing higher costs. As firms buy and sell permits, the price of a permit fluctuates in response to supply and demand. As the emissions cap is lowered, firms continue looking for opportunities to reduce their own emissions or buy additional permits from others, as well as undertaking research and development of new approaches for mitigation.

A key advantage of cap and trade is that it offers certainty about the amount of emissions. For this reason, it is often favored by those most concerned about the risks of climate change. However, in cap-and-trade systems, market forces set the price of an emissions permit. Some argue that the uncertainty that this creates about the price of GHG is a burden to the economy as a whole and presents a challenge to those seeking to develop new technologies and finance the deployment of new projects.[3] (Chapter Three provides more detail on the challenge that price uncertainty presents to project financing.)

A carbon tax seeks to reduce GHG emissions by providing firms with a specific price signal. Once the emissions price is set by the tax rate, the government taxes all unabated emissions. The tax motivates emissions reductions so long as emitters' incremental cost per unit of abatement is less than the tax rate. While this approach provides certainty about the price of emissions, the amount of emissions reductions is uncertain. If the tax is set too low, emissions may not fall to the desired level. Likewise, if the tax is set too high, emitters and the economy as a whole will devote more resources to emissions reductions than are needed to achieve the nominal environmental goal.[4]

Cap and Trade Is Considered the Most Pragmatic Solution, but Many Details Remain Unresolved

Participants generally agreed that a cap-and-trade approach, while imperfect, seems more politically feasible than a carbon tax. Although a carbon tax might be a more economically efficient approach to reducing GHG emissions, they agreed this approach has at least three major practical drawbacks. First, taxes remain deeply unpopular and thus unlikely to succeed politically. Second, stakeholders seeking guaranteed GHG reductions will oppose carbon taxes because of their uncertain environmental impacts. And third, those arguing that a carbon tax could

[3] While cap-and-trade policies generally allow the price of a permit to float, there are ways to constrain or bound these prices. For example, policymakers can essentially place a safety valve on the price of emissions by selling new permits at a fixed price. Alternatively, prices can float within specified minimum and maximum prices. These approaches seek to combine the benefits of cap and trade with increased certainty about the price of emissions permits.

[4] This brief comparison of cap-and-trade with carbon tax does not address several other important differences and commonalities in these instruments, which were not discussed in detail at the workshops. For example, participants did not discuss whether to apply these instruments at the point of production or consumption.

be simpler to implement than a cap-and-trade system do not acknowledge that the current tax code is already full of loopholes and that a carbon tax is unlikely to be any different.

In addition to these drawbacks of carbon taxes, it was noted that both major-party 2008 presidential candidates favored cap and trade. As a result, participants were confident that future U.S. climate policy would revolve around a cap-and-trade policy. At the same time, it was noted that the discussion in Congress of cap-and-trade legislation in the spring of 2008 had not progressed very effectively.

This led to discussions about how to design and implement a workable cap-and-trade system within the United States. Some of these issues found broad agreement, while others did not.

Economy-Wide Emissions Cap Would Have Benefits

Under a cap-and-trade system, one of the most fundamental design questions is whether it should apply to the entire economy or only to those sectors with the greatest emissions. Proponents of sector-based approaches believe that they would be administratively simpler and lower cost. Others argue that, as fewer sectors are addressed, larger reductions must be made by those sectors to achieve the desired goals. This will lead to higher compliance costs relative to an economy-wide approach, which would provide additional opportunities to look for reductions. To illustrate this point, an analysis cited by a participant found that electricity prices could increase 45 percent under an economy-wide cap-and-trade system. In contrast, imposing a cap on only the power sector could cause electricity prices to increase up to 260 percent, because much larger reductions would be required from this sector alone. A cap-and-trade system focused on just a few industries or sectors is not likely to be economically sustainable or politically acceptable.

Distributing Allowances and Allocating Potential Government Revenues from Allowance Sales Are Contentious

For a cap-and-trade system, other major design questions focus on how the government should distribute emissions permits and what should be done with any resulting government revenues from government-run allowance sales, which could, at the upper end, be on the order of several hundred billion dollars per year.

The government has three options for distributing emissions permits. First, it could sell the permits, for example, through an auction. Second, it could allocate them (give them away based on some criteria, such as past emissions levels). Third, it could use some combination of the first two approaches.

Workshop participants offered a range of views on the three options. Some favored allocating permits for free to reduce the cost of compliance. Others favored full auctioning to prevent firms from obtaining windfall profits as well as to raise revenues for various purposes related to GHG mitigation. Another suggestion was allocating permits to load-serving entities (e.g., electric and gas utilities) that would then have an incentive to reduce emissions on behalf of their customers.

Under scenarios in which permit sales would lead to government revenues, participants suggested many potential uses, including returning the funds to consumers to soften the impact of higher prices, sponsoring GHG-reducing research and development, compensating specific groups of affected business or other stakeholders, and more aggressively supporting efforts to adapt to climate change. Another suggestion was that funds should be invested in

new transportation and communication infrastructure, which, in turn, could guide the country toward greater overall energy efficiency and lower emissions. One participant cautioned that the country should abstain from awarding revenues to different constituencies and creating new programs that would require new studies and new federal employees and would be subject to litigation.

Yet another participant suggested that policymakers are approaching these issues in the wrong order. Instead of talking about how to spend potential auction revenues, policymakers should determine which types of investments are needed and then provide dedicated funding to reach these goals.

Emissions Targets Must Be Credible to Induce Action

Participants did not argue for or against particular emissions-reduction targets but rather agreed that the eventual targets must be realistic. To illustrate this point, one participant argued that the near-term emissions trajectories proposed in the Kyoto Protocol (UNFCCC, 1997) and the medium-term targets proposed by the European Union are unrealistic. The participant expressed concern that the European Union has stated that it will change its targets if it is unable to meet them. The participant stressed that this kind of uncertainty would not be acceptable to U.S. businesses.

Additional Policies Must Complement a GHG Price

Participants agreed that a price on GHG is needed to induce reductions but that higher prices alone will not bring about the needed reductions. This is because there are other barriers to realizing economically beneficial reductions in GHG emissions (e.g., improvements in energy efficiency). One such barrier is the cost of obtaining information and finding reliable solutions. For example, participants cited the difficulty of hiring a reliable home contractor to make energy-efficiency improvements. This example illustrates that the search cost of gathering information and the transaction cost of implementing a solution both add to the capital cost.

Split incentives are another barrier to beneficial investments. Incentives are split when different parties have different incentives to conserve energy or reduce emissions. Common examples include landlords who typically obtain no benefits from making energy-efficiency improvements at their properties because tenants are usually responsible for utility bills, while tenants' incentives are weak because the benefits of the improvements often outlast their tenancy.

To overcome these sorts of barriers, participants suggested that a number of complementary policies may be needed to lower the cost of gathering information and conducting transactions and to improve the alignment of incentives. These barriers and potential solutions are discussed further in the following chapters.

Role of States in Finding Solutions

Many states have played important roles in driving innovative responses to climate change, particularly by improving energy efficiency and encouraging the use of renewables. For example, California has a history of leading energy-efficiency initiatives and supporting clean energy technology. As a result, California has held its per capita energy consumption flat in the recent past. California's Global Warming Solutions Act (AB 32) suggests that the state still sees

opportunities to reduce GHG emissions through state-level energy efficiency, demand reduction, and many other strategies.

Participants discussed what role states should play once a federal response to climate change has been developed and implemented. One particular question was whether a federal program should preempt all state programs or whether states should be allowed to set standards that exceed those adopted by the federal government.

Most participants felt that states would voluntarily close overlapping programs, but one participant felt that five to ten states would seek to preserve their programs as a source of state revenue.[5] Other participants felt that states have played such an important role in spurring the federal government to act that they should continue to have the right to mandate reductions above and beyond federal requirements. These participants argued that states should have the right to demonstrate what can be done and to position their state industries for success. They suggested that harmonization should be viewed as preserving the authority of states to lead and influence national policy.

Executive-Branch Leadership for Domestic and International Action

Panelists and participants discussed how the federal government can build support for improving climate policy. Given the successes at the state level, one panelist argued that the next president has an opportunity to educate the public, work with Congress to pass new legislation, and push executive-branch agencies to cut through bureaucratic obstacles and implement necessary climate-change policies. In contrast, another panelist felt that this will be an enormous challenge because there are large gaps in understanding about the potential risks and solutions to climate change between national leaders in Washington and ordinary Americans.

Participants also stressed that the United States needs to provide international leadership. Instead of using international negotiations as a means to slow down the process, the United States should look for solutions that benefit the United States and allow partner countries to participate or adopt similar measures. If the United States can take the initiative in international climate-change efforts and attract support from a significant number of counties, workshop participants felt that there would be a good opportunity for the United States to create momentum for additional actions in the rest of the world.

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[5] The right of states to set higher standards for automotive fuel economy or for GHG reductions in private transportation has received considerable attention, although this example was not discussed at the workshop. Critics of allowing states to retain rights to supersede federal standards express particular concern over the implications for interstate commerce and overall compliance costs.

CHAPTER THREE

Energy Workshop

Overview

Many of today's conveniences can be tied back to the production, conversion, distribution, and consumption of energy. From the electricity that powers air conditioning and the electronic age to the gasoline that fuels motor vehicles to the natural gas that heats many people's homes, the production and use of energy is the result of government policies and decisions by individuals and firms throughout the nation. These policies and the decisions by which they are implemented affect a broad range of issues, including energy security, climate change, and economic growth. During the workshops, participants discussed many of these issues. They also focused on the trade-offs and need for compromises in energy policy, the role of technology in meeting national energy goals, and the need to improve the development and deployment of existing and new technologies.

Complexity of Energy Policy

When it comes to energy policy, it is sometimes said that Washington is asleep at the wheel, but, in the past five years, three major pieces of legislation have been passed. These are the Energy Policy Act of 2005 (Pub. L. No. 109-58), the Energy Independence and Security Act of 2007 (Pub. L. No. 110-140), and the Food, Conservation, and Energy Act of 2008 (Pub. L. No. 110-246).[1] Unfortunately, these achievements have not laid to rest continuing concerns about climate change or the national security and economic implications of reliance on oil imports.

Participants stressed that overcoming these challenges will require difficult trade-offs because energy-policy goals often conflict. For example, some energy policies seek to lower the cost of energy to promote economic growth. Many participants stressed that if the United States is serious about addressing climate change, it should not simultaneously have policies and programs that subsidize or distort the price of energy. Another example mentioned by participants was that near-term incentives to reduce GHG emissions could lead to large-scale substitution of natural gas for coal. While this will reduce GHG emissions, it could also lead to higher natural-gas and electricity prices, significant increases in imported liquefied natural

[1] A participant explained that these laws have led to or will lead to thousands of megawatts of new wind capacity, planning for new nuclear-power plants, the development of new natural-gas fields in the Gulf of Mexico, higher CAFE standards, a renewable-fuel standard of 36 billion gallons, and higher energy-efficiency standards for federal buildings.

gas, and increased dependence on foreign energy sources, thereby creating new concerns over the nation's energy security.

A final example of these trade-offs related to water, especially in the southwestern United States. Many forms of primary energy and electricity production require significant volumes of water. As water becomes increasingly scarce due to increased development and the possibility of climate-related changes in precipitation, the competition for water will become increasingly intense, and policies may be needed to allocate water between energy-related uses and other purposes.

To help resolve these trade-offs, compromises will be needed. Unfortunately, energy-policy stakeholders often lobby and argue for their positions without compromise. For example, some constituencies strongly oppose offshore drilling under any circumstances. Others argue for maximizing domestic production from all sources. This type of all-or-nothing debate often leads to policy gridlock.

One way to help achieve energy-policy compromise is for elected officials to engage in a dialogue with their constituents to simultaneously represent those constituents and explain to them that a portfolio of technologies and policies is needed to solve the country's energy problems. For example, elected officials may need to explain to their constituents that the country needs both a permanent wind PTC *and* offshore oil and gas production, even if their constituents oppose one policy or the other.

Attraction of Technological Solutions

Using technology—both existing capacities and future innovations—to meet energy and climate goals is a highly attractive strategy, since it holds the promise of achieving several national goals without the trade-offs that characterize many of today's technologies.[2] However, participants agreed that a broad technology portfolio is needed to overcome energy challenges. Although some participants were hesitant to try to pick winners, many felt that the potential benefits of some technologies made them worthy of significant national investments. Several examples included coal, biomass, and CCS; cellulosic ethanol; and proliferation-resistant nuclear power and safe nuclear-waste disposal. Others suggested that technology investments are needed across the board. Among the broader classes of investment, energy efficiency, renewable energy, and transportation were discussed in greater depth and are described in the balance of this section and in the next chapter on transportation. One participant noted that if the United States sets demanding energy-efficiency and renewable-energy goals, it would prompt expanded entrepreneurship and greater technological innovation.

Energy Efficiency

Energy efficiency is often described as the fifth fuel (behind coal, natural gas, nuclear, and renewables) because it represents yet another way for society to meet its growing energy needs. Opportunities for energy efficiency come in many forms, including more efficient production, conversion, distribution, and consumption of energy. Specific examples mentioned by

[2] Promising technologies can also create unanticipated problems. Participants discussed how the rush to invest in corn ethanol—which was intended to reduce demand for imported oil—led to increased food prices globally. The rise in global food prices led many to question whether food crops should also be used as energy crops.

participants included more energy-efficient forms of housing,[3] building and appliance energy-efficiency standards, cool roofs,[4] urban forestry,[5] water efficiency, and waste treatment.

Despite the potential for these improvements, opportunities for increasing energy efficiency face several well-understood barriers. Residential adoption of energy-efficiency opportunities may be limited by a lack of information, the unknown quality and reliability of contractors, and the possibility that residents will underestimate the cost savings from energy-efficiency improvements. Likewise, commercial investments in energy efficiency may be limited by internal-rate-of-return calculations, split incentives,[6] and the fact that energy is typically a small part of a firm's operations and maintenance budget and thus may receive more cursory consideration within the firm's decisionmaking. As discussed in Chapter Two, although participants felt that investments in energy efficiency will increase if a price is imposed on GHG emissions, higher prices alone will not overcome these challenges.

One participant felt that overcoming these barriers to energy-efficiency improvements will require a broad range of state and city experiments designed to reduce GHG emissions. Fortunately, cities and states are already leading the search for climate solutions because their citizens are requesting it and because of the co-benefits, including improved air quality, and reduced energy consumption and costs. California has been recognized for 30 years for demonstrating the potential of energy efficiency. A workshop participant explained that the state believes that further efficiency improvements are available for $0.03–$0.04 per kilowatt-hour.[7] To achieve this goal, California is pursuing more energy-efficient building codes and working to find creative solutions with local energy providers, cities, and others.

Another participant suggested that corporations have a significant opportunity to improve energy efficiency and thus help overcome these barriers by creatively extending their traditional business models. For example, utilities could change how they think about providing services to their customers. Instead of selling kilowatt-hours, they could focus on providing services. Under this model, the utility might provide its customers with a new refrigerator or a plug-in hybrid electric vehicle. Under such a model, firms might be better positioned to meet customer needs while increasing energy efficiency and reducing GHGs.

Renewable Energy

As the United States looks for strategies to reduce GHG emissions, the development and deployment of today's existing renewable-power technologies can help to reduce emissions in the United States and internationally.[8] In this context, one participant summarized the benefits

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[3] Higher-density housing, such as apartment buildings and townhouses, are more likely to share walls and floors and be able to benefit from more efficient heating, ventilation, and air conditioning that can improve energy efficiency over that of single-family homes.

[4] A cool roof reflects and emits the sun's heat back to the sky instead of transferring it to the building below. This reduces the building's cooling load and the urban heat-island effect (CRRC, undated).

[5] Urban forestry provides additional shade for buildings, streets, and the built environment. This can lower the temperature indoors and outdoors and reduce the demand for air conditioning.

[6] Split incentives were also discussed in Chapter Two.

[7] To put the cost of these potential energy-efficiency improvements in context, the average retail price for residential electricity in the United States was $0.104 per kilowatt-hour in 2006 (EIA, 2007, Table 7.4).

[8] Renewable-energy sources include wind, solar, geothermal, hydropower, and biomass. While participants discussed renewable energy broadly, most specific examples were from wind and solar. Chapter Four briefly discusses biofuels.

of wind power: It produces no GHG emissions, it is commercially available today, it is commonly the most competitive source of renewable power, and, since it has no fuel costs, it provides a valuable hedge against an important source of volatility in electricity-generation costs.

Although wind-power capacity grew 35 percent in 2007 (from a fairly low base), its further growth is constrained by several issues. First, the on-again, off-again nature of the PTC (which is typically renewed in one-year increments) leads to boom-and-bust cycles that frustrate efforts to expand capacity and lower costs throughout the industry and its supply chain. One panelist noted that it would help the investment climate if the wind PTC and solar investment tax credit were treated as permanent like other tax credits. Second, wind still faces challenges because most project developers and utilities (with a few exceptions, such as Xcel Energy® and FPL Energy [now NextEra Energy Resources]) view wind as an intermittent source of power limited by an insufficient transmission infrastructure.

Solar power is another growing source of renewable power. Although solar power is more expensive than other renewable sources, a growing number of state renewable portfolio standards require that a specified percentage of renewable power be generated from solar power. While these policies, known as solar carve-outs, are accelerating the adoption of solar power, the cost of this source still is a barrier to further penetration. Another participant stressed that the United States is falling further behind in the solar market. That participant argued that Germany's aggressive solar subsidies were used to strategically position Germany as the international leader in the solar market and that this has had spin-off benefits. For example, Germany's Technische Universität Darmstadt won the U.S. Department of Energy's 2007 Solar Decathlon by designing and building a highly efficient, solar-powered home on the National Mall in Washington, D.C. The participant stressed that the longer it takes for the United States to take solar energy seriously, the further behind it falls in production and spin-off industries.

Improving the Development and Deployment of Technologies

For the types of technologies described in the previous section to be developed and deployed, the federal government needs better strategies and policies for developing and deploying technology.

More Federal Research and Development Is Needed Despite Concerns That It May Be Wasted

Participants expressed a range of views about federal investments in research and development. While most agreed that additional funding is needed, some participants expressed concern that current federal research and development dollars are being wasted and that increased federal funding would only create new opportunities for waste.

Financial Incentives Are Needed to Demonstrate and Deploy Innovative Technologies

Private capital markets need incentives to demonstrate and deploy innovative technologies. Innovative technologies are often seen as too risky for the private sector at the very initial stage of commercial development. Initial commercial investment is not normally considered a proper use of taxpayer funding. As a result, promising technologies may fail to be commercialized because they are unable to get financing for demonstration or pioneer plants, which

include the first few efforts to scale new technologies up from small pilot projects to medium- and, eventually, full-size plants.

Financial Uncertainty and Private Funding. Participants argued that stimulating greater private investment requires creating a more stable financial and regulatory environment, so investors are able to assess the risks and rewards. For example, in order to finance such projects with lower-cost debt (i.e., through the bond market), financiers need to see relatively clear, low-risk policies.

Historically, financiers provided regulated utilities with low-cost debt because they believed that regulators would ensure that they would be repaid. However, as electricity markets have been partly deregulated and regulatory uncertainty surrounding climate-change mitigation has increased, new technologies may not be able to demonstrate that they can provide the predictable cash flows needed to obtain debt financing. This led one participant to recommend that the United States develop hybrid policies that can provide the predictable cash flows demanded by debt markets. Another participant countered that regulated utilities are already making investments in new technologies when required through such policies as renewable portfolio standards.

Participants also raised a number of concerns about the sources of uncertainty that limit investment in new energy projects. One participant argued that a cap-and-trade policy will not provide the stability needed to attract long-term investment, since the cost of allowances will rise and fall with the market. Another participant stressed that new energy projects of all types increasingly face litigation, which can lead to significant delays or even project cancellation.[9] A third participant stressed that continuing uncertainty on domestic climate policy and commitments generally has created a very strong incentive for industry to do nothing. Finally, a critical constraint on financing alternative-fuel technology is the financial community's understanding that the future price of oil depends on production decisions of the world's large, low-cost oil–producing nations. Since these countries potentially could lower world oil prices if they desired, financiers understand that potential returns on investments in alternatives to oil could be quickly undermined.

Federal Policies to Encourage Investment. The federal government can help manage risk and uncertainty and provide incentives for desired behavior. Previous discussion regarding the annual renewal of the PTC for wind illustrates the concern that participants expressed. Although longer-term policies can have a useful effect, participants also pointed out that policymakers need to examine the long-term implications of federal tax credits and other incentive policies. This is because as eligible investments are made, the cost to the government also grows, resulting in greater lost tax revenues. For example, the Energy Information Administration recently completed a study of federal energy subsidies and found that the United States provided $16.6 billion in energy-related subsidies and tax breaks in fiscal year 2007, which is double the level in fiscal year 1999 (EIA, 2008a).

Constraints Exist on Technology Deployment

Two additional constraints that limit the deployment of technology were also discussed. First, local opposition to new power generation, transmission, and other forms of energy infrastructure is seen as preventing the next generation of investments. Second, deploying energy tech-

[9] This participant suggested that fast-track regulatory approval of nonfossil energy sources would reduce uncertainty and accelerate investment, since these projects would be exempt from litigation.

nology requires a broad range of skilled professionals and corresponding educational capacity. For example, some energy projects require years of design work and construction. These specialized employees must be trained, which requires universities or professional schools to establish training programs in these fields. There is concern over future shortages of such trained experts. Potential students must be convinced that there will be sufficient demand for these skills to motivate them to obtain the education and training.

CHAPTER FOUR

Transportation Workshop

Overview

The transportation sector is a major contributor to climate change, and steep reductions in emissions are needed. As with other sectors, such reductions must come from a variety of sources; a single new technology or one or two policy changes will not be sufficient.

In transportation, participants agreed that changes to reduce GHG emissions necessarily must happen in two broad areas: behavior—namely, encouraging people to drive less—and technology, including greater fuel efficiency and new types of fuels that emit less GHG. To change peoples' behavior, higher costs of driving are seen as necessary to reduce overall emissions. But higher gas prices alone are not enough to produce the desired results, and other strategies for raising the cost of travel, such as the emerging policy of congestion pricing,[1] remain politically contentious. On the other hand, progress toward climate goals can help address other concerns in the area of transportation, such as energy security and congestion relief, and this may help generate greater political momentum for pursuing policies that help reduce emissions.

This chapter addresses the rationale for transportation to reduce GHG emissions and the role of market approaches in achieving these goals. The following sections address behavioral change in terms of land use and driving behavior, as well as technology in terms of fuel efficiency and emerging vehicle technologies. The chapter concludes with some observations on how U.S. policies in transportation compare with those in other countries and ways in which the freight sector can reduce emissions.

Transportation's Contribution to Climate Change

The vast majority of the GHGs produced by the transportation sector come from surface transportation, with passenger transportation accounting for about 60 percent and freight for 25 percent of the total. All other transportation modes contribute about 15 percent, of which about half is domestic aviation.[2] Given the great importance of passenger transportation in the emissions share and the apparent challenges in reducing it, the workshop discussion focused largely on this subsector and ways of reducing its emissions.

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[1] Broadly defined, congestion pricing is a policy under which drivers pay higher tolls to drive during congested times of day than they would during less congested ones.

[2] Only the figure of 25 percent for freight was mentioned at the workshop. Other figures are from EPA (2008).

Several panelists suggested that the transportation sector should set a goal of reducing GHG emissions by 70 percent of 2005 levels by 2050. Although this figure was not backed up by any technical rationale, it drew broad agreement. However, it was noted that reducing transportation GHG emissions by this amount may not be the most practical or cost-effective way of reducing the total U.S. GHG emissions. Transportation is interwoven with virtually every aspect of the economy, and more effective and lower-cost approaches might be available in other sectors. Yet, if total U.S. emissions are to be reduced to a small fraction of 2005 levels by 2050, substantial reductions need to occur in transportation as well. Given the size of the transportation sector's contribution to total GHG emissions, transportation will have to do its share in the interest of political fairness.

Participants noted that the transportation sector faces other serious challenges in addition to climate change, including aging infrastructure, congestion, energy security, and safety. Improvements in those areas may mutually benefit GHG-reduction goals. One speaker noted that reducing congestion would help reduce GHG emissions, since vehicles moving at faster speeds are more fuel-efficient. Another noted that using less fuel for transportation would contribute to increased energy security, since the United States currently imports such a large percentage of its petroleum. A third panelist pointed out that reducing vehicle miles traveled (VMT) would be beneficial to states, since they lack funds to build enough new infrastructure to keep pace with the growth in VMT. Therefore, by working to reduce transportation emissions, policymakers can simultaneously pursue several transportation goals.

Participants agreed that reducing emissions in the passenger-transportation sector will not be easy. Although GHG emissions have declined on a per-mile basis for individual vehicles due to improvements in fuel economy, these reductions have been overwhelmed by enormous increases in VMT. In the 1960s, Americans drove 600 billion miles per year; in recent years, that figure is about 3 trillion. The Federal Highway Administration predicts that VMT will grow by 1.9 to 2 percent annually. Therefore, total emissions will continue to grow even as individual vehicles produce lower emissions.

The general consensus among workshop participants was that achieving GHG reductions requires a variety of approaches: appropriate, market-driven prices along with significant behavioral and technological change.

Market-Based Approaches in Transportation

In other sectors, a market-based approach—using prices to achieve behavioral change—is considered one of the most effective (and, thus, important) policy approaches to achieve GHG-emissions reductions. In transportation, market approaches could be implemented in several non–mutually exclusive ways, including raising gas prices or charging drivers for using roads. Workshop participants agreed that raising gas prices alone is inadequate in transportation, because Americans are fairly dependent on driving, largely due to land-use patterns. Congestion pricing might be more effective at curbing VMT and emissions, but it is largely untried in the United States, its effects on driving and fuel economy are complicated to estimate, and it could be difficult to implement on a large scale.

Motor-Fuel Prices

As one panelist noted, currently 95 percent of trips in the United States are made by car. Because of this great dependence on personal vehicles, drivers are not very sensitive to the price of gasoline, especially in the short term. In the United States, demand for gasoline tends to be relatively inelastic, meaning that increases in fuel prices do not produce proportionate decreases in driving (that is, even a large increase in fuel prices tends to produce a relatively small decrease in VMT). For example, although the price of gasoline increased by more than 20 percent from May 2007 to May 2008 (EIA, 2008b), VMT declined by only about 4 percent over the same period (FHWA, undated).

For this reason, participants agreed that higher gasoline prices would not produce the needed declines in VMT, at least not in the relatively short term. One participant stated that achieving a 20-percent decrease in VMT would require gasoline prices to quadruple. That magnitude of price increase would be politically untenable as well as potentially disruptive economically. However, the cap-and-trade approach being debated (detailed in Chapter Two) would likely add only $0.50 per gallon to gasoline prices. Therefore, while a price increase for GHG emissions can have a major effect in the electricity sector, it would be less effective for reducing VMT.

Participants made two other points about gas prices. First, they argued that getting the price right is necessary, even if not sufficient, to reduce emissions. Participants still wanted to see transportation included in whatever carbon tax or cap-and-trade regime is developed at a national level, since they agreed that motor-fuel prices need to reflect the cost of GHG emissions. It would be difficult to implement other, potentially stronger policies if gas prices remain low.

Second, participants felt strongly that the existing gasoline tax should be retained. The gasoline tax remains a convenient way to link the amount people drive with the amount they pay. Although gasoline and diesel tax revenues fluctuate with both VMT and fuel efficiency, the gasoline tax rate (in cents per gallon) remains the same regardless of the pump prices of the fuels.[3] The gasoline tax also continues to provide an incentive for energy efficiency, since consumers with more fuel-efficient vehicles pay less in gas taxes.

Congestion Pricing

Congestion pricing is a relatively new policy tool in the United States. It refers to a set of policies under which drivers pay higher tolls to use certain roads at more congested times of day. The goals are generally two-fold: to reduce congestion by discouraging unnecessary trips during peak hours and to raise revenues to re-invest in the transportation system. Reducing congestion might be an important contributor to addressing climate change, since vehicle fuel efficiency depends on constant speeds.

Studies have found that congestion pricing could have quite significant effects on reducing VMT and ultimately emissions. One participant noted that in the San Francisco Bay area, transportation planners analyzed several scenarios to determine which policies would achieve

[3] The federal gasoline tax is levied on a per-gallon basis ($0.184 per gallon). Most states with gasoline taxes levy them the same way; only a few charge sales taxes on gasoline, so that the dollar amount per gallon increases when the price of gasoline goes up.

their GHG-reduction goals and found that congestion pricing was more effective than infrastructure investments.[4]

A major obstacle is that, for congestion pricing to be effective, prices have to be high enough to serve as a deterrent to drive alone. In the San Francisco scenario, prices were projected at five times the typical cost of driving (including not just congestion tolls but parking fees and carbon taxes as well). Since, as one panelist put it, politicians see protecting citizens from high gasoline prices as one of their main jobs, it seems unlikely that they will support policies that make driving more expensive than it already is. While some panelists claimed that congestion pricing is inevitable, others noted that it will be extremely difficult to implement congestion pricing without the support of elected officials, the business community, and the general public.

Given the prevailing political climate, panelists suggested that the correct role for the federal government is to encourage regions[5] to adopt congestion pricing by setting broad parameters and making the funding available on a performance basis. They concurred that the U.S. Department of Transportation should not dictate specific forms of congestion pricing but rather should encourage regions to innovate and determine what works best in their particular circumstances. Participants agreed, for example, that a congestion pricing system for New York City would have to be far different from one in Phoenix because of the differences in land use and transit availability. Fortunately, there are forms of congestion pricing, such as HOT lanes, that would work in an auto-dominated context, while cordon tolls or area-based charges might work better in dense, transit-rich downtowns. Participants indicated that the next transportation reauthorization bill could include federal funding that would be available only to regions willing to experiment with implementing congestion pricing.[6] The view was that federal funding provides good political cover in areas where there may be local opposition to congestion pricing.

Land-Use Changes to Reduce Vehicle Miles Traveled

Land use was a key issue in discussions about how to reduce VMT. Land use influences travel behavior because the location of housing, employment, stores, education, and recreation facilities affects the frequency of trips and distances people have to drive. It is harder to predict how changing land-use patterns might affect the magnitude of VMT, and participants did not agree on the magnitude of such changes that has been suggested in some analytical studies (see next page).

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[4] A pricing scenario alone was found to reduce emissions by about 8 percent over a baseline with no changes through 2035. Reductions of almost 50 percent were obtained by combining pricing with land use, high-occupancy toll (HOT) lanes, increased highway speeds, augmented transit service, and increased fuel efficiency. However, the fuel efficiency required to achieve this target was 50 miles per gallon (mpg) with conventional vehicles, or conversion of 30 percent or more of the fleet to alternative-fuel vehicles (MTC, 2007).

[5] While congestion pricing would generally be implemented at the regional level, the planning and implementing agencies might include local and state governments and metropolitan planning organizations.

[6] This is essentially what the federal government tried to do with New York City, the first U.S. city to propose a widespread congestion pricing program. However, when the state legislature blocked implementation in New York City, that funding was disbursed to Chicago and Los Angeles with similar strings attached.

One way to reduce VMT is by changing land-use patterns such that some trips currently taken by car could be made via other modes. In many cities and towns across the United States, trips among housing, offices, and shops are too long to make on foot or too inconvenient to make using public transit. As a result, the average American drives between 21 and 27 miles per day, depending on the region in which he or she lives. In general, areas with long distances separating distinct and low-density land uses tend to have higher VMT than those with mixed uses and higher densities.

Changing land-use patterns can be a leading factor helping people to drive shorter per capita distances. One study quoted at the workshop found that VMT could be reduced by 7 to 10 percent by 2050 with changes in land-use patterns (Ewing et al., 2008).[7] Adding other changes, such as transit, road pricing, and parking policies,[8] the figure could increase to 30 percent. While some participants were skeptical about the magnitude of the impact that was quoted in the report, they generally agreed that land use was an important component in reducing VMT.

Participants, however, also generally agreed that shifting trips to public transit was not a viable strategy outside of major metropolitan areas. On a nationwide basis, public transit accounts for only 3 to 4 percent of all trips, and 40 percent of those are in and around New York City. In many cities, building new public transit would have little impact, since the development pattern is oriented toward driving. In areas where transit ridership is very low, increasing investment in transit might even result in transportation being less energy-efficient than car travel. Transit was seen as critically important, however, in larger, denser metropolitan areas where it could serve as an important complement to land-use strategies. Some areas also might be able to encourage drivers to switch to bicycling.

Given its importance, why is land use so difficult to change? Workshop participants put forward several reasons. First, land-use regulations, such as zoning rules, can inhibit the creation of neighborhoods and regions where residents could reduce their driving. While some researchers have asserted that low-density, single-family development was a product of market forces, a recent book shows that land-use regulations restrained mixed-use development in locations where the market would have wanted it (Levine, 2005). According to one panelist, developers agree that more than one-third of today's market would prefer to live in an area with a compact development pattern.[9] Developers want to respond by building more townhouses and town centers instead of detached single-family houses and strip malls, but regulations often make higher-density development difficult. While consumers should not be forced into any particular housing type, the market should be able to respond to such preferences.

A second reason is that the authority to make decisions about transportation investments is generally at the regional or state level, while authority over land-use decisions is typically local. The term *fiscal zoning* is used to describe the fact that cities and towns often make land-use decisions based on property-tax implications, since local communities are generally quite

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[7] According to Ewing et al. (2008, p. 9), "smart growth could, by itself, reduce total transportation-related carbon dioxide emissions from current trends by 7 to 10 percent in 2050. This reduction is achievable with land use changes alone."

[8] While participants mentioned that more expensive parking could also affect driver behavior, this topic was not discussed at length.

[9] While a percentage figure was not discussed at the workshop, the previously cited report mentions surveys showing that approximately one-third of respondents on housing preference surveys prefer "smart growth housing products and communities" (Ewing et al., 2008, p. 8).

dependent on property-tax revenues. Transportation considerations are important, but they often follow rather than lead local development decisions.

As a result, according to one participant, drivable suburban development is oversupplied, and walkable, compact development is undersupplied. Arlington County, Virginia, which was cited as an example, has built more compact development in recent years than comparable communities. Not only are the resulting neighborhoods popular with current and prospective residents, but they have held down car ownership: In Arlington, 12 percent of households do not own any cars, while, in a neighboring county, the rate of carless households is 4 percent. In a commercial corridor, office space has increased, but VMT has remained level. So land-use changes can have real effects on driver behavior and in such a way that still allows choices in the marketplace.

How can more such land-use changes be made? A panelist made three broad suggestions:

- Invest government capital (e.g., government buildings, roads and transit, water and sewer) in developed communities, not newly developing areas.
- Change regulations that prevent building with older neighborhood patterns (such as small houses on small lots, on narrow streets with alleys).
- Alter the development process to make it easier to build compact communities as opposed to low-density ones.

As it is projected that the country will build half again as much housing by 2050 as that which currently exists, land-use changes could represent a major opportunity to reduce VMT.

Fuel and Vehicle Technologies

When the workshop participants turned their attention to technology, two broad topic areas emerged: fuel efficiency and emerging fuels and vehicles. Participants agreed that progress is needed on both fronts to achieve significant emissions reduction, but they disagreed on how much emphasis to put on technological solutions, the best mechanisms by which to make such progress, and whether better consumer information on fuel economy would make any difference in vehicle purchases or in driver behavior.

Increasing Fuel Efficiency for Vehicles That Have Internal Combustion Engines

Workshop participants raised a number of issues that focused on improving the fuel efficiency of vehicles with internal combustion engines (ICEs).

Market Failure in Fuel Efficiency. Participants generally agreed that a market failure seems to exist with respect to vehicle fuel efficiency. Consumers buy vehicles based on a number of attributes, and, depending on the price of gasoline, different attributes may be important at any moment in time. When fuel prices are high, consumers want more fuel-efficient vehicles. However, when prices are low, as they were through the 1990s, U.S. consumer tastes shift to larger vehicles, such as sport-utility vehicles. As auto manufacturers seem to interpret consumer behavior as a preference that fuel economy is not important even in the long term, the result is what one participant called a boom-and-bust cycle in fuel economy. In practical terms, when auto manufacturers believe that consumer interest in more fuel-efficient cars is only temporary,

they underinvest in research and development in this area, which makes it difficult to achieve consistent progress in fuel economy.

Why do consumers not value fuel efficiency more highly on a consistent basis? One reason is that gasoline prices fluctuate fairly dramatically over time, while vehicle purchases represent longer-term investments. The vehicle fleet—the total number of vehicles owned by individuals and businesses—turns over slowly; the average car lasts 16 years, and the average truck, 18 years. If people had reliable information about how fuel prices might behave over the next decade or more, they might make different decisions, but, of course, such information is not available. Second, Americans do tend to trade off other attributes with fuel economy, such as the speed and power of vehicles. These market preferences do not mean that fuel efficiency is unimportant but that it interacts in complex ways with the desire for other attributes.

Sufficiency of CAFE Standards. In the United States, vehicles are regulated by CAFE standards, which are federal mandates for minimum levels of fuel efficiency. In late 2007, Congress passed legislation to raise the CAFE standard to an average of 35 mpg for cars by 2020. Workshop participants noted that the regulations to implement this increase would force automakers to begin increasing fuel economy before the 2020 deadline.

One participant noted that, although 35 mpg is a substantial increase over the current U.S. standard of 27.5 mpg, in Europe, the average vehicle already gets 42 mpg. The consensus was that fuel economy in the United States could not be pushed this much higher exclusively with technology applied to the current vehicle mix; it would require reducing the size and power of vehicles. As noted earlier, those attributes are still valued by many U.S. car buyers, so the general view was that it would be extremely difficult at this point to go much beyond 35 mpg.

Personal Fuel Economy. Fuel economy could be increased in several ways in addition to those represented by the CAFE standards. For example, participants had a lively discussion of "personal fuel economy." The U.S. Environmental Protection Agency provides consumers with average figures on fuel efficiency, but, given the widely differing driving habits and environments to which vehicles are subjected, actual fuel economy varies. Some participants felt that providing drivers with their personal fuel economy based on their own driving patterns would encourage drivers to waste less fuel. Others said that providing such information in a way that would be useful to drivers would be too difficult and would likely not achieve the desired result.

Adaptive Cruise Control. Another suggestion to increase fuel efficiency was through wider use of *adaptive cruise control*, a version of cruise control in which the vehicle automatically senses the presence of other vehicles and slows if necessary. According to one panelist, even relatively fuel-efficient vehicles work better when they are not stuck in traffic. While this feature would be added to the vehicle in the manufacturing process, greater consumer reliance on it would help traffic flow and increase the operating efficiency of the road network.

Fee-Bates. Finally, consumers could receive "fee-bates." A fee-bate is a tax per unit of energy consumption or per unit of GHG emissions. In the realm of vehicle fuel efficiency, it would involve setting a pivot point (a specific mpg level): All vehicles less fuel efficient than the pivot point would be taxed, and all vehicles more efficient would receive rebates. The panelist who suggested this said that the approach would be more effective than CAFE standards, since it would provide a continuing incentive to invest in research and development to increase fuel efficiency.

Emerging Fuels and Vehicle Technologies

Regardless of the importance of increasing the fuel economy of ICE vehicles, there was broad consensus that research and development should focus on developing vehicles that rely less heavily on gasoline. Two reasons were offered: First, oil prices could very well return to their mid-2008 heights. Second, changes in market fundamentals—most notably, growing demand for automobiles and petroleum-based fuels in China, India, and other emerging markets—are driving long-term demand for oil. Second, panelists felt that dependence on foreign oil has negative consequences for U.S. national security. One panelist noted that two-thirds of the country's oil dependence is because of the transportation sector.[10] Although it was noted that the higher level of dependence on imported petroleum can leave Americans "unacceptably vulnerable" to hostile nations, it was also noted that the United States imports more petroleum from Canada than from other nations that are likely to be more hostile.

In the short term, biofuels are one important choice to bridge the gap between ICE vehicles and those in the longer-term future. Three points were made related to biofuels. First, some previous supporters have moved away from ethanol because of concerns that current ethanol production is driving up demand for corn (a key ingredient), which, in turn, drives up food prices more generally. Second, participants noted, for this reason, it would be beneficial to put more research dollars into cellulosic ethanol, which is produced from the nonedible portion of the plant. Finally, use of biofuels is not limited to surface passenger transportation; aviation and trucking may also eventually be able to use biodiesel, if availability increases and costs come down.

Participants also discussed a variety of long-term technologies that could be developed over the next several decades; however, no clear front-runner emerged. The general agreement was that having a range of short- and long-term technology options was essential to achieve target GHG reductions. As one panelist noted, the main drawback of current liquid-fuel ICE vehicles is that they can run only on gasoline and ethanol.[11] Future generations of vehicles will be able to tap into a wider range of fuel sources, such as electricity and hydrogen, making them more flexible.

While the gasoline-electric hybrids currently on the market will remain important, three other types of vehicles were mentioned. Plug-in hybrids can be connected to an electrical socket to recharge the battery (unlike existing hybrids, in which the battery is recharged by an ICE).[12] Electric-drive vehicles will be powered entirely by batteries; an engine generator can take over when the battery is depleted. The upcoming Chevy Volt is one example. Finally, hydrogen fuel-cell vehicles use power from hydrogen and a battery assist for acceleration.

Panelists and audience members disagreed about the appropriate role for government in developing and diffusing these technologies. Some supported a Manhattan Project–style federal program, perhaps concentrated on battery types and use. Others cautioned that, once

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[10] The workshop did not devote significant time to evaluating specific interpretations of energy security and their implications. One panelist proposed a goal of reducing the economic costs of dependence to less than 1 percent of gross domestic product with 95-percent probability by a particular date. There was broad agreement that high or very unstable oil prices were bad for U.S. interests.

[11] Although they were not mentioned at the workshop, other fuels, such as compressed natural gas (CNG) or butanol, are in use or technically feasible.

[12] While plug-in hybrids can reduce on-road emissions, their total contribution to reducing total GHG emissions depends on how the electricity to re-power the battery is generated.

federal money is available, it is hard to turn off, which can lead to wasteful spending. In such areas as hybrids, it was asserted, the private sector has a powerful market incentive to innovate, as hybrid vehicles have been selling well. Regulations can also foster technological innovation; California's Low-Carbon Fuel Standard, for example, is intended to accelerate the introduction of low-GHG fuels.

Finally, technology can enable another innovation: interconnected networks of vehicles. Over time, vehicles will evolve from the conventional model of stand-alone, mechanical, ICE vehicles to interconnected networks of vehicles that can run on a variety of fuel sources. Given the immense value of interconnectivity for computer networks, interconnected vehicles could provide many significant improvements for the transportation sector. For example, a car could receive information about parking availability, and the driver could proceed directly to the empty spot. Given that one panelist claimed that, in urban areas, drivers waste a large amount of gasoline in cruising about while looking for parking, this could have profound effects on vehicle emissions.

Behavior and Technology in Other Countries

Participants briefly discussed how U.S. policies in these areas compare with those implemented overseas. Various European cities have been taking GHG emissions quite seriously and have implemented programs such as congestion pricing (London), bike promotion (Paris), and emissions pricing (Stockholm and Milan).[13] Singapore integrates land use, transportation, and pricing very effectively, but in such a way that does not leave much consumer choice. It would be difficult to implement a similar model in the United States.

In developing countries, mobility has largely taken the form of increased driving. As mobility increases for those with higher incomes, the government's primary concern is often how to keep the rest of the population from being left behind. Moreover, where developing countries are addressing environmental concerns, the focus is on conventional pollution, since its effects are immediate and local. The issue of reducing GHG is secondary.

Reducing Emissions in the Freight Sector

A final issue was the role of freight-transportation emissions in climate change. Although freight moved by rail consumes much less energy than freight moved in trucks, it would be difficult to shift much additional freight from roads to rail at present, due to existing capacity constraints and the fact that rail travel times tend to be slower (making rail a poor choice for goods that need to be shipped quickly). In Europe, where there has been substantial investment in intercity passenger rail, most freight moves on roads. In terms of reducing overall emissions, it is not clear whether the European model—moving passengers by rail and freight by roads—is superior to the U.S. approach. However, there may be some advantages because, unlike passenger transportation, freight movements are generally less time-sensitive and more flexible because most freight does not care how far it travels or what time it gets delivered.[14]

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[13] Emissions pricing is a form of congestion pricing that ties the amount paid to a vehicle's emissions profile. Both Stockholm and Milan exempt electric and hybrid vehicles from paying congestion tolls.

[14] While not discussed at the workshop, there are obviously exceptions to this generalization, such as perishable goods or packages sent by courier. However, these types of shipments constitute a relatively small percentage of all freight move-

Panelists briefly mentioned some ways to improve the energy efficiency of the freight sector. These included reduced idling, in part by introducing truck cabs that can remain heated or cooled without idling, which would constitute an estimated 10-percent improvement; just-in-time delivery; larger vehicles with better usage and less dead-heading (the industry term for driving empty vehicles); on-board computers to calculate fuel economy; and reduced packaging of shipped goods. Although it is possible to introduce fuel-economy standards for heavy trucks (as Japan has), at the moment, fuel-efficiency technologies for trucks are less well-developed than for cars.

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ments. Ton-miles of air freight, which are generally time-sensitive, are less than 1 percent of all domestic freight shipments (BTS, 2008, Table 1-46b, "U.S. Ton-Miles of Freight").

APPENDIX

Workshop Participants

Table A.1
Participants, Climate-Change Workshop, June 4, 2008

Participant	Affiliation
Moderator	
Michael Toman	RAND
Speakers	
Judi Greenwald	Pew Center on Global Climate Change
Robert M. Margolis	National Renewable Energy Laboratory
Quinlan J. Shea III	Edison Electric Institute
Panelists	
Kelly Bennett	Sterling Planet
Anthony R. Eggert	California Air Resources Board
Peter Molinaro	The Dow Chemical Company
Billy Pizer	Resources for the Future
Gerry Waldron	U.S. House of Representatives Select Committee on Energy Independence and Global Warming
Sponsor	
Andrea Jett	McCormick Foundation
Attendees	
David H. Austin	Congressional Budget Office
Monica Bansal	Metropolitan Washington Council of Governments
James T. Bartis	RAND
Nicole M. Bauer	Transportation Learning Center, Community Transportation Center
Drury Crawley	U.S. Department of Energy
Reid Detchon	Energy Future Coalition
Liisa Ecola	RAND
Scott Hassell	RAND

Table A.1—Continued

Participant	Affiliation
Debra Knopman	RAND
Kara M. Kockelman	The University of Texas at Austin
Kevin Lillis	Energy Information Administration
Bill Newman	Clean Air–Cool Planet, Climate Policy Center
Margaret Peloso	Vinson & Elkins
Ronald Santoro	U.S. Department of Energy
Linda Silverman	U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy
Eric Smith	U.S. Environmental Protection Agency
Eleen Trang	Office of Representative Zoe Lofgren, U.S. House of Representatives
Thomas F. Walton	General Motors
Elizabeth C. Wiener	Decker, Garman & Sullivan Associates

Table A.2
Participants, Energy Workshop, June 19, 2008

Participant	Affiliation
Moderator	
Michael Toman	RAND
Speakers	
Kenneth Kern	National Energy Technology Laboratory
William L. Kovacs	U.S. Chamber of Commerce
Panelists	
Howard K. Gruenspecht	Energy Information Administration
Colin Hayes	U.S. Senate Committee on Energy and Natural Resources
Hillard G. Huntington	Stanford University, Energy Modeling Forum
Elizabeth Salerno	American Wind Energy Association
Tracy Terry	National Commission on Energy Policy
Attendees	
Sherri Alston	U.S. Department of Transportation, Federal Highway Administration
James T. Bartis	RAND
Joel Darmstadler	Resources for the Future
Michael Dougherty	U.S. Department of Transportation, Federal Highway Administration
Liisa Ecola	RAND
Abraham E. Haspel	U.S. Department of the Interior

Table A.2—Continued

Participant	Affiliation
Scott Hassell	RAND
Audrey Ja-Chin Lee	U.S. Department of Energy
Andrew D. Paterson	Econergy International
Eleen Trang	Office of Representative Zoe Lofgren, U.S. House of Representatives
Alan Lamont	Lawrence Livermore National Laboratory
Michael J. Whinihan	General Motors
Elizabeth Wiener	Decker, Garman & Sullivan Associates

Table A.3
Participants, Transportation Workshop, June 5, 2008

Participant	Affiliation
Moderator	
Martin Wachs	RAND
Speakers	
Christopher Borroni-Bird	General Motors
Tyler D. Duvall	U.S. Department of Transportation, Office of the Secretary
Emil Frankel	Bipartisan Policy Center
Panelists	
Geoff Anderson	Smart Growth America
George C. Eads	CRA International
David L. Greene	Oak Ridge National Laboratory
John Horsley	American Association of State Highway and Transportation Officials
Kara M. Kockelman	The University of Texas at Austin
Sponsor	
Andrea Jett	McCormick Foundation
Attendees	
David H. Austin	Congressional Budget Office
Monica Bansal	Metropolitan Washington Council of Governments
James T. Bartis	RAND
Jennifer Bovair	Center for Strategic and International Studies
Liisa Ecola	RAND
Brigid DeCoursey	U.S. Department of Transportation, Office of the Secretary
Shannon Eggleston	American Association of State Highway and Transportation Officials

Table A.3—Continued

Participant	Affiliation
Scott Hassell	RAND
Debra Knopman	RAND
Linda Lawson	U.S. Department of Transportation
Thomas R. Menzies Jr.	Transportation Research Board
Margaret Peloso	Vinson & Elkins
Steven E. Plotkin	Argonne National Laboratory
Ronald Santoro	U.S. Department of Energy
Eric Smith	U.S. Environmental Protection Agency
Eleen Trang	Office of Representative Zoe Lofgren, U.S. House of Representatives
Elizabeth Wiener	Decker, Garman & Sullivan Associates
Christopher Zimmerman	Arlington County (Virginia) Board

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