policy

Designing a climate-friendly energy policy

Options for the Near Term

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PEW CENTER ON Global CLIMATE CHANGE

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Prepared for the Pew Center on Global Climate Change

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Foreword *Eileen Claussen, President, Pew Center on Global Climate Change*

Energy use and climate change are inextricably linked. In the current national energy policy debate, choices made today will directly impact U.S. greenhouse gas (GHG) emissions far into the future. In addition, near-term energy policy decisions will affect the costs of implementing any future climate policy. Decision-makers face the challenge of crafting policies that allow the United States to meet its energy needs while acting responsibly to reduce GHG emissions. This report contributes to the debate by examining a number of "climate-friendly" energy policy options for the near term—that is, policies that would advance U.S. energy policy goals during the next few decades while at the same time contributing to efforts to curb global warming.

For this most recent report in the Pew Center's policy series, a diverse team of authors from Van Ness Feldman, P.C. and The Brattle Group has identified key elements of a climate-friendly energy policy. The authors describe important U.S. energy policy objectives, including: (1) a secure, plentiful, and diverse primary energy supply, (2) a robust, reliable infrastructure for energy conversion and delivery, (3) affordable and stable energy prices, and (4) environmentally sustainable energy production and use.

Often, these objectives are thought of as competing goals – that energy policy and security issues are in conflict with environmental objectives and vice versa. In reality, our authors find a substantial convergence between the goals of energy policy and climate policy, and that many feasible and beneficial policies from supply and security perspectives can also reduce future U.S. GHG emissions. Some key elements of a climate-friendly energy policy identified here include: increasing natural gas production and expanding natural gas transportation infrastructure; developing and deploying renewable energy technologies and efficient electricity production technologies; enhancing efficiency of automobiles and light trucks, industry, and buildings; and research and development on non-fossil fuels and carbon sequestration.

The authors caution, however, that a climate-friendly energy policy is not a substitute for climate policy. More significant GHG emissions reductions would be necessary in order to address climate change than can be justified solely on the basis of traditional energy policy objectives. The policy options outlined in this report represent sensible and important first steps in the United States' efforts to reduce GHG emissions.

In other reports and workshops, the Pew Center is evaluating options to produce more dramatic changes to the U.S. energy system, which could eventually lead us to an economy based on energy sources other than the carbon-based fossil fuels that are the primary contributors to global warming. Indeed, in the long run, we can only curb climate change by weaning ourselves of our reliance on fossil fuels.

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Executive Summary

Energy policy and climate policy are closely linked because the majority of U.S. greenhouse gas (GHG) emissions are in the form of carbon dioxide (CO_2) emissions resulting from the combustion of fossil fuels. Energy policies can reduce CO_2 emissions by, for example, increasing energy efficiency, reducing reliance on fossil fuels, and shifting from high-carbon to lower-carbon fuels. Conversely, energy policies that miss opportunities to make such changes will leave unchecked the trend of increasing CO_2 emissions. Consequently, energy policy decisions made today can help reduce GHG emissions in the near term and can significantly affect how costly it would be to implement any future climate policy.

The federal government is in the throes of one of its periodic comprehensive reviews of U.S. energy policy. It is likely that significant federal energy policy questions will be addressed in the near term, before the development of any climate change regulatory program. Yet, there is also the distinct possibility that the United States will eventually adopt a mandatory GHG reduction program. This report considers energy policies that can be adopted in the context of the energy policy debate, short of adopting a GHG program now, to best position the nation to reduce GHG emissions and to implement future climate change policies. These are the options that make up a "climate-friendly energy policy."

In reviewing policy options, we have identified four key objectives that drive energy policy:

(1) Secure, plentiful and diverse primary energy supply,

(2) Robust, reliable infrastructure for energy conversion and delivery,

(3) Affordable and stable energy prices, and

(4) Environmentally sustainable energy production and use.

In developing a template for a climate-friendly energy policy, we have limited ourselves to a review of energy policy options, i.e., policies that serve one or more of these objectives. We have not considered climate policies that lack a direct energy policy nexus. We have also limited ourselves to relatively near-term energy policy initiatives, i.e., initiatives that could begin to produce energy policy benefits over the next decade or two.

Climate-friendly energy policies fall into one of three general categories—policies that:

(1) Reduce GHG emissions now,

(2) Promote technology advancement or infrastructure development that will reduce the costs of achieving GHG emissions reductions in the future, and

(3) Minimize the amount of new capital investment in assets that would be substantially devalued (or "stranded") if a GHG program were implemented.

Using these guidelines, the following are highlighted as key elements of a climate-friendly energy policy:

Fossil Fuels

Increased natural gas production and expanded natural gas transportation infrastructure will lower the price and increase the availability of natural gas and, in turn, support the continued use of gas in lieu of coal in new power plants.

Electricity

Deployment of efficient electricity production technologies, including combined heat and power, fuel cells, and highly efficient power plant technologies, can significantly increase the amount of useful energy gleaned from fuels, and thus reduce both energy costs and GHG emissions.

Maintaining a role for nuclear and hydroelectric power can enhance diversity of energy supply. It also will reduce growth in fossil fuel consumption for electricity generation and may reduce energy prices.

Deployment of renewable energy technologies can help diversify the nation's energy portfolio. These technologies are environmentally beneficial—most produce little or no GHG emissions.

Building and Industrial Efficiency

Enhancing end-use efficiency in buildings and industry can reduce overall consumer costs in many cases, can reduce the need for new electric power plants, and can reduce GHG emissions related to energy use.

Transportation

Enhancing efficiency of automobiles and light trucks reduces oil consumption, and thereby mitigates reliance on oil imports and reduces GHG emissions.

Research and Development

Research and development on efficient technologies in all sectors can provide options to reduce future energy costs to consumers and future energy consumption, with corresponding GHG benefits.

Research and development on non-fossil fuels and carbon sequestration can provide future alternatives to reliance on oil and could enable continued use of coal consistent with a GHG emissions limitation.

In many areas, there is a substantial convergence between energy policy objectives and climate policy objectives. In particular, climate-friendly energy policies aim to: (1) increase the efficiency of energy use; (2) increase the use of renewable (including biofuels) and other non-emitting technologies; (3) promote the use of natural gas instead of coal or oil; and (4) encourage research and development on new energy technology.

This set of climate-friendly energy policies advances energy policy objectives. Taken together, these measures would build on the policies implemented to date to: enhance energy security by reducing growth in demand for oil, increase the diversity of the country's energy mix, strengthen the energy delivery infrastructure, and contribute to improvements in air quality without significantly increasing consumer energy costs. In addition to the policies listed above, there are other energy policy options that have no significant climate change impacts but may address central energy policy concerns and, thus, should be considered for inclusion in any comprehensive energy policy. These could include policies to increase domestic production of oil, to expand electricity transmission infrastructure, and to promote competitive electricity markets.

The set of climate-friendly energy policies discussed in this report advances climate objectives, but it does not constitute a fully elaborated climate policy. It does not produce the magnitude of reductions needed, for instance, to meet the non-binding goal set forth for the United States in the 1992 Rio Framework Convention on Climate Change, i.e., to return U.S. GHG emissions to 1990 levels. Based on the U.S. Department of Energy's analysis[1] of a similar set of policy elements, it appears that this package could significantly slow the projected growth of GHG emissions, but is not sufficient to reduce energy-related GHG emissions from current levels, much less return them to 1990 levels. Moreover, trying to achieve climate goals indirectly through energy policy tools will necessarily be more expensive than achieving the same climate goals through an effectively designed, market-based GHG regulatory program covering all sectors of the economy. Instead, this is a collection of near-term energy policies that stand on their own as energy policies and would help better position the U.S. economy for possible future GHG emissions limitations.

I. Energy Policy Context

The energy policy choices the United States makes in the near term will have long-term consequences for U.S. emissions of greenhouse gases (GHGs), which contribute to climate change. The purpose of this paper is to review the range of energy policy choices available to address the energy issues currently facing the United States and to describe a path to a more climate-friendly energy policy in the near term.

As a foundation for this discussion, the paper reviews U.S. energy policies as they have developed over the past three decades, provides a snapshot of current levels of U.S. GHG emissions, and highlights some of the relevant insights from economic analyses of energy policies. The paper then embarks on an analysis of potential energy policies and their implications for GHG emissions in the five principal U.S energy sectors: (1) fossil fuel supply, (2) electricity production, (3) buildings,[2] (4) industrial processes, and (5) transportation. On the basis of this analysis, the conclusions section identifies a set of policies that would achieve energy policy objectives while enhancing the position of the U.S. economy to comply with a future GHG regulatory regime.

A. The Link Between Energy and Climate

Eighty-four percent of U.S. GHG emissions are carbon dioxide (CO_2) emissions, resulting almost entirely from the burning of fossil fuels.[3] Energy policies that reduce fossil fuel use will reduce CO_2 emissions. Fossil fuel use can be reduced by: (1) deploying technologies that increase energy efficiency (e.g., more efficient power plants, cars, and appliances) and (2) employing non-fossil fueled energy sources (e.g., solar, wind, geothermal, biomass,[4] hydroelectric, nuclear energy, or renewables-based hydrogen). CO_2 emissions also can be reduced by shifting from high-carbon to lower-carbon fuels (e.g., shifting from coal to natural gas in the electricity production sector). Conversely, energy policies that increase fossil fuel consumption, discourage or miss opportunities for efficiency improvements, and expand reliance on high-carbon fuels will increase CO_2 emissions and thereby exacerbate climate change.

Given this close relationship between energy use and GHG emissions, near-term energy policy choices have significant future implications for climate change. First, energy policies can affect GHG emissions in the near term. Second, energy policy choices can enhance or impede development and deployment of new technology and infrastructure that will reduce the cost of controlling GHG emissions in the future. Third, energy policies can shape decisions about capital-intensive investment in equipment, plant, and resource development, and thus can affect the degree of dislocation potentially associated with implementing future GHG policies. Today's energy policy choices can have important future ramifications, influencing both energy and GHG emissions outcomes for years to come.

B. Energy Policy Retrospective—How We Got to Where We Are Today

A discrete and unified U.S. energy policy does not exist. Rather, policies affecting energy production and use in the United States have a multitude of sources and take a multitude of forms. For example, while this report focuses for the most part on federal energy policies, state and local governments also play a key role in regulating energy-related activities. In addition, while there are federal policies aimed directly at achieving energy objectives, there are also federal policies aimed at achieving other objectives—ranging from environmental protection to easing traffic congestion—that have indirect but nevertheless substantial impacts on energy production and use. Finally, even those policies aimed squarely at achieving energy-related objectives are shaped by other policy concerns, such as labor and foreign policy issues. Energy policy, in short, operates in multiple dimensions.

While U.S. energy policy has many sources, forms, and influences, it is nevertheless possible to identify four traditional objectives on which U.S. energy policy has focused:

1. Secure, plentiful, diverse energy supply. Sources of primary energy need to be secure from interruption, adequate to meet short- and long-term needs, and diverse enough so that a natural or political interruption of one source of supply will not cripple the U.S. economy.

2. Robust, reliable energy infrastructure. The infrastructure for energy delivery and conversion (e.g., pipelines; refineries; and electricity transmission, generation, and distribution facilities) needs to have adequate capacity (including a margin for unforeseen events), be reliable in normal operation, and be secure.

3. Affordable and stable energy prices. Delivered energy prices should be at levels that are affordable to consumers and support the nation's overall economic health. Energy prices should give consumers price signals that encourage efficient use of energy and producers sufficient returns for providing new supply. Excessive price volatility also is a concern because highly unstable prices dampen consumer confidence and create uncertainty for investors.

4. Environmentally sustainable energy production and use. Energy production and use must be consistent with the need to protect public health and safety and the environment in both the short term and the long term.

As a predicate to understanding today's energy policy debate and its focus on these four objectives, it is useful to review quickly the history of the debate. The U.S. energy policy debate began in earnest almost 30 years ago with the Arab oil embargo of 1973–74. The embargo exposed the vulnerability of the U.S. economy to concerted action by foreign producers to withhold crude oil supplies from the United States. The initial U.S. reaction to the embargo was to impose price controls on petroleum, to adopt emergency conservation measures, and to mandate that power plants that had switched from coal to oil (to comply with Clean Air Act requirements) switch back to coal. The Nixon Administration's Project Independence Study concluded (to no one's surprise) that it was infeasible for the United States to become wholly independent of imported oil. The Ford Administration in 1975 submitted legislative proposals to reduce U.S. vulnerability to action by the Organization of Petroleum Exporting Countries (OPEC). The proposals included steps to decontrol oil and natural gas prices, encourage U.S. fossil fuel production, establish a strategic petroleum reserve (SPR), participate in the International Energy Program (IEP), and provide better information to consumers on the energy efficiency of products. The Democratic Congress responded by enacting the Energy Policy and Conservation Act, which maintained price controls on oil and natural gas, mandated efficiency standards for automobiles and appliances, established the SPR, and authorized participation in the IEP. In the same time frame, Congress enacted the Alaska Natural Gas Transportation Act (ANGTA) to facilitate development of Alaska's gas resources. Because of market conditions, however, this project has not yet been constructed.

By the late 1970s, severe interstate natural gas shortages and the continuing vulnerability of the United States to oil supply interruptions gave rise to Carter Administration proposals to increase gasoline taxes; impose new taxes on crude oil, natural gas, and petroleum products; require virtually all new base load electric generation[5] to use coal; promote energy efficiency and renewable energy; and ultimately remove price controls on new natural gas. Congress balked at the energy taxes, but enacted most of the Carter program.

Within months after the Carter program was enacted, and before it could have any effect, the Iranian revolution triggered a second oil shock in which crude oil prices tripled. This, in turn, led to another round of Carter Administration proposals that resulted in energy legislation aimed at increasing domestic supply through incentives for production of domestic fuels and synthetic fuels. In response to a third oil shock—the crude oil price increase associated with the Persian Gulf War—the Bush Administration proposed and Congress enacted a further set of supply enhancement and energy efficiency proposals in the Energy Policy Act of 1992.

In retrospect, the crude oil supply interruptions in 1973, 1979–80, and 1990 and the associated world crude oil price run-ups that occurred in connection with those interruptions have been important drivers for U.S. energy policy. In each case, the crude price increases triggered contractions in gross domestic product (GDP), and, in the case of the 1970s oil shocks, severe inflationary pressures. The policy prescriptions for reducing supply vulnerability have included increasing U.S. production of conventional and alternative fuels, emphasizing market forces, reducing demand through efficiency measures, establishing and maintaining the SPR,[6] and maintaining international arrangements under the IEP to coordinate petroleum stock drawdowns. As a result of both price increases and policy measures, and the diversification of the sources of its petroleum supply, the United States has reduced its vulnerability to a physical interruption of crude oil supplies. However, the OPEC cartel countries continue to be the source of significant oil imports, leaving the transportation sector in particular and the economy in general exposed to supply and price risk.

C. Energy Policy Today

Today's energy policy debate confronts a mixture of old and new issues. World crude prices increased from less than $10 per barrel in late 1998 to a high of $31 in late 2000, which once again contributed to an economic slowdown.[7] The United States remains vulnerable to concerted action by oil-producing nations to curtail production and increase prices. Moreover, conflicts in Central Asia and the Middle East have brought fuel supply concerns again to the fore. In addition, the events of September 11, 2001, have given rise to a new energy policy priority: securing domestic energy facilities from terrorist attack. Finally, sharply increased rates of U.S. economic growth in the late 1990s exposed energy supply shortages, transportation and transmission bottlenecks, and regulatory idiosyncrasies that sharply increased prices of natural gas, electricity, and petroleum products in some regions.

Energy policy today operates in a different regulatory environment than it did 25 years ago: The prices of natural gas, oil, and wholesale electric power have been substantially deregulated (though the rates for transmission and distribution services[8] in all three sectors remain regulated, as do rates for retail sale of electricity and natural gas in many areas), energy efficiency standards are in place for a number of consumer products, environmental regulation has expanded, and the prospect of future climate change policy has emerged as a significant uncertainty in business planning. Perhaps the most striking of these changes is the greater market-orientation of energy policy. Overall, energy policy is much more market-oriented, less focused on cost-based price regulation, and more focused on environmental regulation than it was in the 1970s.

Accordingly, after three decades, U.S. energy policy is primarily focused on four key objectives: (1) a secure, plentiful, and diverse primary energy supply; (2) a robust, reliable infrastructure for energy conversion and delivery; (3) affordable and stable energy prices; and (4) environmentally sustainable energy production and use. This report's assessment of energy policy options will take into account the extent to which each option serves one or more of these four basic energy policy goals, and whether it achieves these objectives in a climate-friendly manner.

II. Current Energy Picture

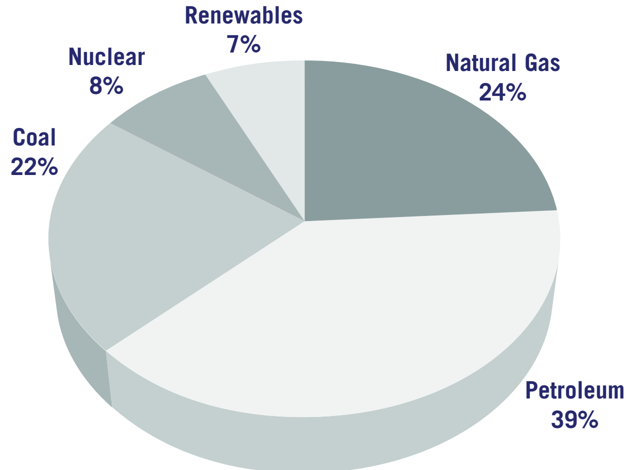
The United States consumed nearly 100 quadrillion British Thermal Units (or "quads") of energy in 2000, at a cost of nearly $700 billion.[9] As background, this section breaks down the current energy picture in the United States, discussing fuel mix, imports, end uses of energy, and energy efficiency.

A. Fuel Mix

Fossil fuels provided 85 percent of U.S. primary energy[10] *in 2000: petroleum products accounted for 39 percent, natural gas 24 percent, and coal 22 percent. (See Figure 1.)*

Figure 1

Sources of **Primary Energy**



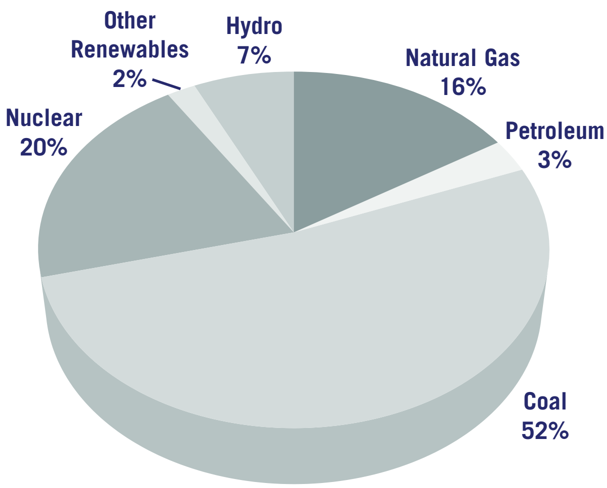
2000 U.S. Total: 98.5 quads

Source: U.S. DOE, EIA. Annual Energy Review 2000, Table 1.3.

Non-fossil sources provide about 15 percent of U.S. primary energy. Nuclear energy represents approximately 8 percent and renewable energy resources account for 7 percent (about half of the renewable energy is hydropower). The amount of energy provided by nuclear sources is peaking for the next several years. It is then expected to decline markedly over the next 15–20 years as existing nuclear power stations reach the end of their operational lifetimes and are not replaced. Hydropower output is expected to be static. Other renewable sources (biomass, wood, municipal solid waste, ethanol, wind, and solar) now supply only 3.6 percent of total U.S. energy and only 2.1 percent of total U.S. electricity generation. Renewable sources have the potential to provide much more energy, but this is highly dependent on the relative price of other energy supplies, technological advancements, regulatory policies, and consumer choice.

Figure 2

Electricity Generation by Fuel



2000 U.S. Electrical Output:
3.8 million gigawatt-hours

Source: U.S. DOE, EIA. Annual Energy Review 2000, Table 8.2.

The mix of fuels consumed in the different sectors varies significantly. Electricity production, which accounts for approximately 37 percent of total energy use, is quite diversified, with significant contributions from coal, nuclear, natural gas, and hydropower. (See Figure 2.) Transportation fuels, in contrast, are nearly all petroleum-based.

B. Domestic Fuel Production

The United States supplies about three-quarters of its energy needs from domestic sources. The nation has ample sources of coal and, indeed, is a coal exporter. The United States supplies much of its own natural gas; imports, mostly from Canada, account for about 15 percent of consumption.

Oil presents a very different picture, however. The United States imported 53 percent of its petroleum in 2000 and imports are projected to increase.[11] The nation's reliance on oil imports from regions outside of North America has been a key issue for U.S. energy policy because of concern about supply disruptions and the consequent economic impacts.

C. End Uses of Energy

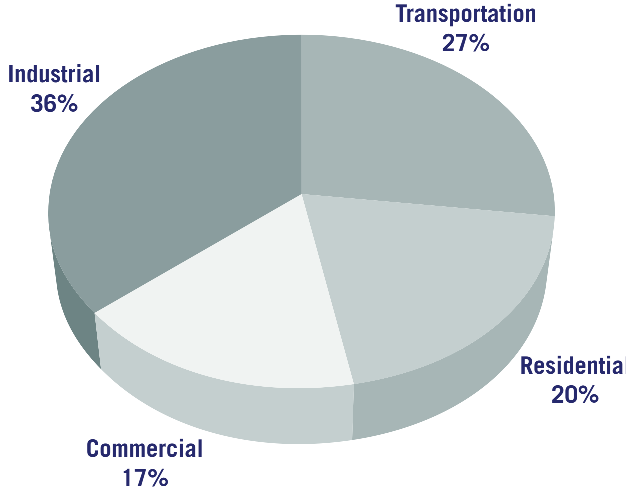
The United States consumed 98.5 quads of energy in 2000.[12] Industrial consumers accounted for 36 percent; residential and commercial uses accounted for 37 percent; and transportation accounted for 27 percent, allocating the primary energy used for electricity generation to each sector in proportion to its electricity consumption. (See Figure 3.)

Petroleum-based fuels predominate in the transportation sector. Given the level of oil imports, the transportation sector has been a focal point for concern about possible energy supply disruptions.

GDP and energy use moved in lockstep from the late 1950s until the early 1970s, i.e., energy intensity (measured by energy used per dollar of GDP created) was relatively constant. The first oil price shocks severed this link. From the early 1970s to the mid-80s, energy intensity declined by an average of 2.3 percent per year. More than half of this rapid decline was due to the use of more energy-efficient equipment in response to increased energy prices as well as the introduction of corporate average fuel economy standards. Major structural shifts in the economy (decline of the manufacturing sector and rise in the service and high-tech sectors) accounted for the balance of the decrease.[13] From 1986 to 1999, the decrease in energy intensity slowed to an average 1.3 percent per year as energy prices moderated.

Figure 3

End Uses of Energy



Source: U.S. DOE, EIA. Annual Energy Review 2000, Table 2.1a, and Annual Energy Outlook 2002, Table A2.

D. Conversion, Transmission, and End-Use Efficiency

Much of the primary energy used is lost (as waste heat) in the conversion of primary fuels to useful energy forms, in energy delivery, and in conversion of energy into desired services at the point of end-use.

A new conventional steam boiler/turbine generator combination converts about 35 percent of fuel energy into electric power, while new natural gas combustion turbines and natural gas combined cycle units are about 35 percent and 52 percent efficient, respectively. A combined heat and power (CHP) facility, which puts otherwise wasted thermal energy to use for process steam or space heating, can achieve efficiency levels of about 80 percent. Investments in higher efficiency conversion technologies, and broader use of CHP technologies, can substantially reduce the amount of fuel needed to produce energy in useful forms.

Transmission efficiency is another concern for energy policy. About 9 percent of the electricity generated in the United States is lost as heat in the system that transmits and distributes electricity to end-users.[14] The extent of such losses is a function of the distance that the electricity must travel along the transmission and distribution lines as well as the voltage. Distributed generation (DG), where smaller generators are located near the electrical load, improves efficiency by minimizing such losses.

End-use equipment (e.g., cars, appliances, industrial motors) that uses fuel or electricity varies substantially in technical efficiency. The internal combustion engine that powers the vast majority of automobiles is less than 20 percent efficient. Processes to provide heat (such as process heat for industry and space heating for buildings) are much more efficient; furnaces typically achieve 90 percent efficiency and boiler systems for steam/hot water are more than 85 percent efficient. Consequently, the opportunities for technology improvements, and subsequent energy savings, vary widely across sectors and technologies.

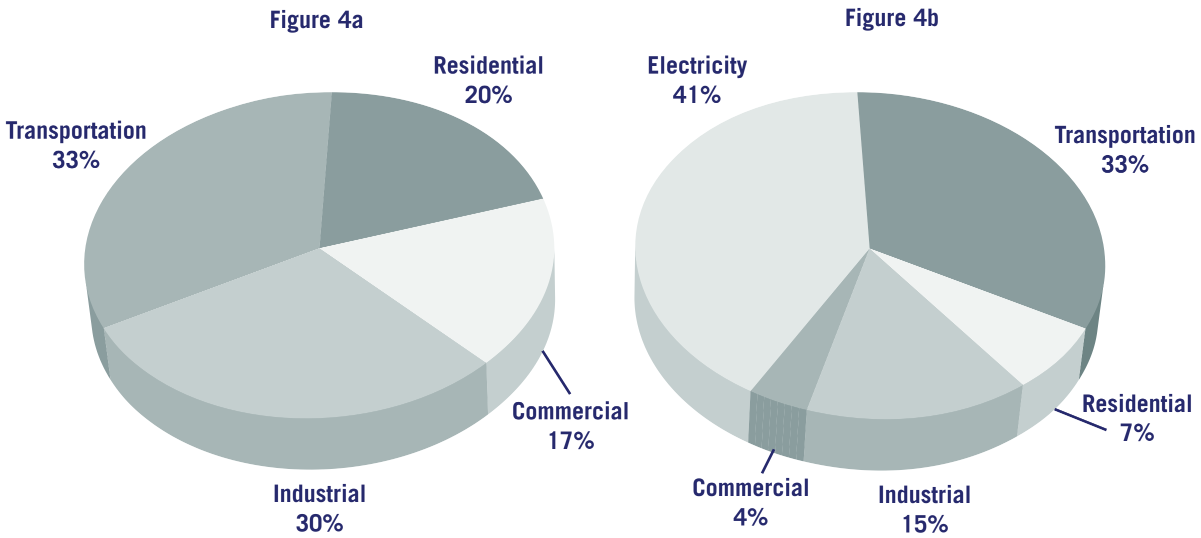
III. Current Greenhouse Gas Emissions Picture

Greenhouse gas emissions from U.S. energy use and production are primarily CO2 emissions from the combustion of fossil fuels in electricity generation, buildings, industrial processes, and transportation activities.[15]

CO_2 from fossil fuel burning accounts for 82 percent of total U.S. GHG emissions.[16] Energy-related CO_2 emissions are distributed evenly through the main end-use sectors of the economy: the buildings (residential/commercial) sector accounts for 37 percent of energy-related CO_2 emissions; transportation accounts for 33 percent; and industry accounts for 30 percent, with electric generation emissions allocated to the end-use sectors by sales. (See Figure 4a.) When electricity is accounted for separately, it represents about 41 percent of CO_2 emissions. (See Figure 4b.)

Figure 4

CO_2 Emissions by **Sector**



With Emissions from Electricity Generation Allocated to End Use

With Emissions from Electricity Generation Stated Seperately

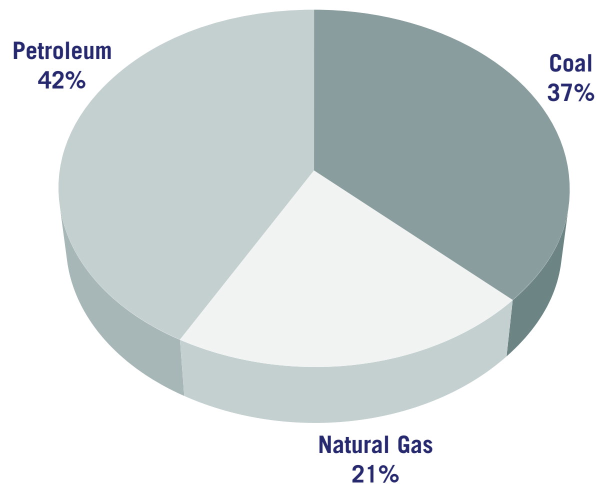
Source: U.S. DOE, EIA. Emissions of Greenhouse Gases in the United States 2000, DOE/EIA-0573 (2001).

When broken down by fuel source, petroleum accounts for 42 percent of U.S. CO_2 emissions, coal accounts for 37 percent and natural gas accounts for 21 percent. (See Figure 5.)

One way to view the broad relationship between economic growth and CO_2 emissions is to examine shifts in two intermediate indices: energy intensity (measured by energy used per dollar of GDP created) and carbon intensity (measured by CO_2 emissions per dollar of GDP created). The first value indicates the economy's overall energy efficiency, while the second is a function of the fuel mix used to meet the nation's energy needs. With regard to fuel mix, it is important to understand that different types of fossil fuels have different levels of carbon content. (See Figure 6.) Both energy intensity and carbon intensity are influenced by energy policy choices.

Figure 5

CO_2 Emissions by Fuel



Total Energy-related Emissions: 5,700 MMT CO_2

Source: U.S. DOE, EIA. Emission of Greenhouse Gases in the United States 2000, DOE/EIA-0573 (2001).

As the U.S. economy has grown, CO_2 emissions have increased, although at a slower rate than conventional measures of economic output. During the 1990s, the divergence between CO_2 and GDP was primarily a result of lower energy intensity. From 1990 to 2000, GDP grew by about 3.2 percent per year, while CO_2 from energy grew by about 1.6 percent per year, i.e., CO_2 grew at half the rate of GDP. Energy use per dollar of GDP fell by 1.6 percent per year, while CO_2 emissions per unit of energy consumed fell by only 0.1 percent per year.[17]

The primary CO_2 growth components during the 1990s were electricity generation and transportation. Emissions from electricity generation grew by 21 percent between 1990 and 1999.[18] CO_2 emissions from transportation increased 15 percent during the 1990s. The demand for electricity has grown with the growth in the U.S. economy and with substantial increases in the market penetration of electricity-consuming electronic equipment, consumer appliances, and manufacturing technologies. In the transportation sector, an increasing proportion of vehicles on the road (e.g., minivans, sport utility vehicles, and light trucks) are not subject to the passenger car Corporate Average Fuel Economy (CAFE) standards, but instead are subject to the significantly less stringent "light-duty truck" CAFE standards. Moreover, the CAFE standards themselves have not changed since the passenger car standard was adjusted in 1985. Finally, all vehicles are being driven more miles as a result of relatively low gasoline prices and land-use patterns characterized by sprawl.

IV. Economic Analysis of Energy Policy

The body of economic work on energy and climate change contains several important themes to be considered in any effort that aims to identify "climate-friendly" energy policies. These key themes are discussed below.

The first key theme is that energy use in the U.S. economy is largely a function of the current equipment (or "capital stock") used to extract, produce, convert, and use energy. Examples include machinery used in longwall coal mining, technology used to explore for and produce oil and natural gas, boilers and turbines used to convert fossil fuel to electric power, automobiles and trucks used to transport people and goods, furnaces and air conditioners that heat or cool homes and offices, and even light bulbs used to illuminate houses. All of this equipment has been purchased under the assumption that it will produce the desired service over a long period of time, but also that it eventually will wear out or break down and need to be replaced. This "natural" rate of capital stock turnover, retirement, and replacement, however, is not easily or cheaply accelerated. On the other hand, when capital stock is retired and replaced, there is often a cost-effective opportunity to enhance energy efficiency or improve environmental performance.[19]

A second key theme, related to the first, is that new energy technologies usually take time to develop, mature, and find broad acceptance in the market. Thus, premature actions (e.g., policies that require specific technologies in the near term) may actually "lock in" capital that could have been superseded by superior technologies. Moreover, technological improvements that do not translate into economic advantages (whatever their beneficial emissions characteristics might be) may never gain a foothold in the market unless encouraged or required by regulation or policy.

A third important finding is that the market penetration of improved equipment reflects economic behavior, not just technological potential. The behavioral aspect of energy efficiency requires policy analysts to model consumer and firm choices in markets that do not necessarily conform to the stylized ideal (e.g., information is poor, decisions are not always made with life-cycle cost considerations). There is considerable dispute in the economic literature regarding the impact of market imperfections, and their importance is likely to vary across different technologies and alternative policies.[20] Therefore, predicting the full effect of policies that are designed to alter or influence market choices is prone to substantial uncertainty, which often complicates the process of selecting among policy alternatives.

A fourth key theme is that energy or fuel prices can play a substantial role in energy use and emissions outcomes, apart from long-run technology choices. For example, gasoline prices can influence how much one may drive an existing car. Likewise, the relative prices of coal and natural gas can impact the utilization rates of different electric generation plants and thus can impact overall emissions. Over the longer term, fuel prices play a role in technology selection (e.g., high gasoline prices may encourage people to buy more fuel-efficient cars; high natural gas prices may lead to construction of new coal-fired generation plants). While there exists a broad range of estimates of the responsiveness of fuel consumption to the prices of fuel and other goods, these responses are crucial to understanding the impact of energy policies that create incentives through changes in prices.

Fifth, to the extent that policy actions alter the market supply or demand of specific fuels or energy types, such policies can change energy prices. As a consequence, future energy use decisions would be based on a new set of prices, which may affect the expected level and cost of eventual emissions reductions. For example, policies that might encourage natural gas as an electricity generation fuel may increase the demand for and price of natural gas, which may limit the role of natural gas for other uses, such as heating and cooking in homes. Policies that improve natural gas production and delivery infrastructure could lower natural gas prices and encourage its use in all sectors.

Sixth, expectations regarding future prices, technologies, and policies can play a large role in shaping current investment decisions. Thus, the form and direction of energy policy enacted in the near term can encourage market participants to alter longer-term decisions even before regulatory compliance deadlines or other milestones occur.

Finally, it is critical to assess the impact of today's energy policy choices in terms of the future cost of pursuing future GHG reduction policies. A mandatory program of GHG emissions reductions, no matter how well constructed to minimize overall economic costs, will have a significant and immediate impact on the value of energy-related capital stock already in place. Energy policy choices made today will influence the types of investments made in the near term, and these investments vary considerably in their likely value under GHG policies. Some investments would appreciate in value, while others would be substantially impaired. One of the hallmarks of a climate-friendly energy policy is to encourage investments in long-lived energy-related capital stock that addresses current energy policy objectives without increasing economic risks when GHG policies are pursued. This report does not attempt to conduct a full-scale cost-benefit analysis of energy policy options, but rather identifies policies most likely to encourage the energy-related investments that would retain substantial value in a GHG policy scenario.

Policies promoting investments in long-term research and development (R&D) on some energy technologies will be a critical element of any comprehensive set of climate-friendly energy policy options. Such policies may have little or no impact on near-term GHG emissions, and could incur costs that may or may not be fully recouped (in the form of economic benefits) under a future policy scenario that does not emphasize GHG reductions. On the other hand, some amount of energy-related R&D almost certainly will contribute to the achievement of energy policy objectives. And the same R&D may have substantial economic and environmental benefits if aggressive future actions to curb GHG emissions are taken.

V. Energy Policy Choices

Outlined below is a review of key energy policy options receiving consideration in the current debates. The options are organized into five categories reflecting the principal U.S. energy sectors: (1) fossil fuel supply, (2) electricity production, (3) buildings, (4) industrial processes, and (5) transportation. The discussion for each category identifies representative energy policy proposals, describes the energy policy objectives served by such proposals, flags key limitations on such policies, and assesses the significance of such policies for GHG emissions and costs of compliance with a future climate change policy.

A. Fossil Fuel Supply

Traditionally, many elements of U.S. energy policy have focused on increasing domestic production of fossil fuels to enhance energy security or increasing fuel supply overall to put downward pressure on consumer prices. These policy choices on fuel supply have an indirect influence on GHG emissions. To the extent that fossil fuel supply policies result in lower energy prices, they can result in greater overall energy use and therefore increased GHG emissions. In addition, if fuel supply policies drive down the price of higher-carbon fuels relative to lower-carbon fuels, they can increase GHG emissions by increasing the carbon intensity of the U.S. economy.[21] On the other hand, fuel supply policies that reduce the price of lower-carbon fuels will have favorable effects on carbon intensity. The relative price and availability of different kinds of fuels is an important determinant of CO_2 emissions, particularly in the electricity production sector.

In overview, policies relating to domestic oil production are potentially important for energy supply security, but have little impact on prevailing world market prices and thus little impact on GHG emissions. Policies to promote increased North American production of natural gas and construction of adequate delivery infrastructure, on the other hand, lay the foundation for enabling increased use of natural gas at reasonable prices and are a key part of climate-friendly energy policy. Little has been proposed with regard to promoting enhanced domestic coal production or deliverability. The principal constraints on coal use now are not production or delivery, but rather regulations limiting emissions of conventional pollutants from power plants. As discussed in the Electricity Production section below, the key opportunity with respect to coal is in the areas of developing and deploying highly efficient combustion technologies at power plants to reduce GHG emissions per kilowatt-hour (kWh), and developing carbon capture and sequestration technologies.

Oil

The nation's reliance on fuel imports has been a key energy policy concern for decades, because of concern about vulnerability to foreign supply disruptions and the consequent economic impacts. In 2000, 53 percent of the petroleum consumed in the United States was imported, and this figure is growing. The focus of energy security policy has been on responding to the high and increasing reliance on imported oil. However, as explained below, while reducing dependence on imported oil contributes to energy security, it has little direct effect on consumer prices and thus little secondary effect on GHG emissions.[22]

A number of energy policy options related to increasing production of domestic petroleum products have been identified, including:

- Increasing access to public lands for exploration and development,
- Providing tax or royalty incentives for production,
- Funding research and development on exploration and production technologies, and
- Streamlining air pollution regulatory programs to facilitate development of new or expanded refinery capacity.

Increasing domestic crude oil production will contribute to enhancing energy security by holding down dependence on oil imports. However, increased domestic production would have little impact on overall consumer prices because crude oil is traded in a worldwide market and increased supply from the United States would have only a small impact on world market prices.[23] Because displacing foreign crude oil imports with domestic production would not lower the price of oil consumption, it would not have a significant effect on U.S. or global GHG emissions resulting from oil consumption.

It is possible that policies aimed at enhancing or expanding domestic refining capacity could lower petroleum product prices, or at least mitigate some regional price spikes when refinery capacity is fully utilized. However, in normal circumstances, refining costs are not a large fraction of product prices, and some regions (e.g., the Northeast) can import refined products when refinery capacity is tight.

Foreign policy on matters such as relations in the Middle East and energy infrastructure development in Asia can affect U.S. access to foreign oil supplies and world oil prices. International energy policies, such as mitigating the risk of oil price shocks in the United States by supporting efficient world oil markets and maintaining or expanding the SPR, are important components of an overall energy policy. However, as with policies aimed at increasing domestic production, such international energy policies will have little or no impact on domestic GHG emissions unless they noticeably affect the world oil price.

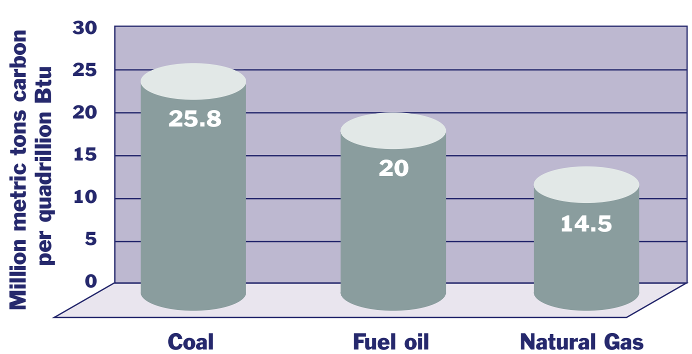
Natural Gas

Actions that increase supply and delivery capability for natural gas can have an important downward effect on its price and thus encourage, at the margin, its use in lieu of coal and oil. Fuel policies that tip the relative attractiveness (price and availability) of competing fuels—natural gas and coal, for example—can have significant climate effects because of the differences in carbon content. For example, until cost-effective carbon capture and sequestration technologies are developed and employed, combustion of one Btu of natural gas will produce 40 percent less CO_2 than combustion of one Btu of coal. (See Figure 6.)

In the electricity sector, natural gas has been the fuel of choice for new generating capacity over the past decade. Recently, however, several energy companies have announced plans to build new coal-fired units after many years of virtually no new coal capacity coming on line.

Figure 6

Carbon Content of Fossil Fuels



Source: U.S. DOE, EIA. Emission of Greenhouse Gases in the United States 2000, DOE/EIA-0573 (2001), (Appendix B) Table B1.

Market decisions concerning fuel choice are driven by a number of considerations. Many factors favor natural gas, such as the relative capital costs of coal versus natural gas capacity (natural gas plants are cheaper and quicker to build), the advantages of natural gas over coal with respect to conventional pollutants, and the higher efficiency of converting natural gas to electricity in modern combined-cycle plants. Other factors favor coal, such as historically lower and less volatile fuel costs.

The U.S. Department of Energy (DOE) projects that the use of natural gas for electricity generation will grow by 110 percent by 2015 and its share of total generation will rise from 12 percent to 26 percent.[24] By contrast, DOE projects that coal use will increase by 23 percent by 2015, and that the share of electricity generation fueled by coal will decline from 55 percent to 49 percent.

Energy policies intended to enhance availability of natural gas include:

- Increasing access to public lands for exploration and development,
- Providing tax or royalty incentives for production,
- Funding research and development on exploration and production technologies,
- Expediting construction of an Alaska natural gas pipeline,
- Providing incentives for enhancement of natural gas pipeline and storage infrastructure in the lower 48 states,
- Promoting development of new liquefied natural gas (LNG) facilities, including streamlining regulatory review of proposals to construct such facilities, and
- Providing tax incentives for production of coalbed methane.

Virtually all of the natural gas used in the United States is from North American sources. Sixteen percent of domestic consumption is supplied by imports, nearly all from Canada.[25] Accordingly, natural gas does not raise, at present, the same energy security concerns about political or economic disruptions of supply that crude oil does.[26] There are, however, issues about the sufficiency of the natural gas delivery infrastructure that must be addressed to ensure that adequate supplies can reach key markets. Significant additional pipeline capacity will be needed to transport gas to growing markets, continuing a healthy trend of natural gas transmission pipeline investment that began in the 1990s.[27] Estimates vary widely regarding the level of investment in new delivery capacity needed to support a rapidly growing natural gas market. While lower estimates are in the $10–$15 billion range over the next 10 to 15 years, some analysts have indicated that between $40 and $80 billion may be required over the next 20 years to provide a robust delivery system for increased gas use.[28] Tax and rate incentives can be effective tools for promoting pipeline infrastructure investment while still balancing the interests of taxpayers and gas consumers. Siting of new pipeline facilities can be contentious, especially in highly developed areas, fueled by citizen concern about safety and environmental issues. Likewise, major expansion of domestic gas production may raise environmental issues to the extent that it involves opening up areas currently not available for drilling.

Tax incentives can have a substantial impact on gas production. For example, during 1989–99, when tax incentives were available for coalbed methane production, production grew from 91 billion cubic feet (Bcf) to 1,252 Bcf.[29]

As with production tax incentives, policies that promote development of gas production technology can increase domestic natural gas supply by significant amounts. According to the U.S. Energy Information Administration, technology advances would increase domestic natural gas production by about 1.5 percent in 2010 and 4 percent in 2020. Impacts on U.S. domestic prices would be even more pronounced, with projected prices 8 percent lower in 2010 and 16 percent lower in 2020.[30]

Another area that offers promise is methane recovery from landfills and coal mines. The process of methane recovery converts potential methane emissions (a GHG) into useful energy. There are currently 335 landfill methane recovery projects in the United States with a total generating capacity of about 1,000 megawatts (MW), which corresponds to approximately 0.1 percent of total U.S. capacity. Some of these projects were built as a result of now expired tax credits, while others are the result of more stringent landfill air pollution emissions standards introduced in 1996, which required many landfills to install gas collection systems. The U.S. Environmental Protection Agency (EPA) estimates that there may be 500 additional landfill sites that are candidates for methane recovery and energy utilization projects.[31]

Because natural gas markets are regional, not worldwide, enhancements to U.S. natural gas supplies can directly decrease prices and perhaps reduce price volatility.[32] Likewise, increased investment in natural gas infrastructure can enhance availability of natural gas to consumers, and may lower delivered prices. To the extent that lower prices and improved availability of natural gas result in displacement of coal or oil use at the margin in the near term, overall U.S. GHG emissions would decrease.

Coal

Coal is an abundant and relatively inexpensive domestic energy resource. Energy policies designed to enhance coal production and delivery include:

- Enhanced access to public lands, and
- Policies to promote competitive rail transport rates and reliable delivery.

Policies that reduce the cost of using coal for generating electricity may keep electricity prices low, but may increase CO_2 emissions because coal is a high-carbon fuel. Current energy policy proposals have not focused on tax or regulatory incentives to increase coal production, since coal production responds reliably to economic signals. Perhaps the most important policy issues affecting delivered coal prices are railroad competition issues and environmental regulation of mining practices such as mountain-top removal.

The key climate-related issues on coal use relate to emissions regulation and technology development for coal-fired power plants. These are discussed in the Electricity Production section below.

B. Electricity Production

Electricity production is a central focus of both energy policy and climate change policy. U.S. electric power production accounts for 41 percent of U.S. CO_2 emissions. (See Table 1.) Four principal factors drive CO_2 emissions from this sector: choice of fuels, generation technology, conversion and transmission efficiency, and end-use demand. If all else were held equal, any move from coal to low-carbon or no-carbon fuel would decrease emissions; any move from emitting to non-emitting generation technologies would decrease emissions; any increase in the conversion or transmission efficiency of the fossil-fuel-fired segment would decrease emissions; and, in general, any decrease in end-use demand would lower emissions.

There is a substantial, but not complete, convergence between energy policy and climate policy objectives for the electric power sector. Improvements in efficiency and decreases in end-use demand both reduce GHG emissions and decrease and stabilize energy prices. Switching to lower-carbon fuels in electricity generation, on the other hand, may not unambiguously advance energy policy goals, depending on the extent to which a switch from coal to natural gas puts upward pressure on natural gas prices, or strains the gas delivery infrastructure. Similarly, policies promoting GHG-free generation technologies can result in significant climate benefits, but also can lead to higher energy prices and, in the case of nuclear and hydropower, are subject to significant environmental constraints.

Table 1

Fuel Use and GHG Emissions

in the Electric Power Sector

Energy Source	Percent of U.S. Electricity Output	CO_2 Emissions	
		Percent of Electricity Sector	Percent of U.S. Total
Coal	52	81	33
Gas	16	15	6
Oil	3	4	2
Nuclear	20	0	0
Hydro	7	0	0
Other Renewables	2	0	0
Total	**100**	**100**	**41**

Source: U.S. DOE, EIA. Annual Energy Review 2000, Table 8.2; and U.S. DOE, EIA. Emissions of Greenhouse Gases in the United States 2001, pp. 23, 28.

The discussion below focuses on: (1) policies affecting the choices among fossil fuels used in electricity production, (2) policies affecting the choice between fossil-fuel-fired and non-fossil-fuel-fired electricity production, and (3) policies affecting the efficiency with which electricity is produced and delivered. Policies concerning end-use efficiency, including efficiency of electricity use, are discussed in the subsequent sections on the buildings and industrial sectors. The implications of end-use efficiency for the electricity sector are discussed at the end of this section.

Choosing Between Coal and Natural Gas as a Generation Fuel

Fuel choices—whether influenced by the market or dictated by government regulation—have important consequences for all the U.S. energy policy objectives. Because of slow capital stock turnover in the generation sector—generating units last for 40 to 60 years in the current environment—most changes in fuel use occur at the margin in the form of new capacity and replacement of retired units. Absent a regulatory mandate, significant changes in the mix of generation fuels would ordinarily occur over the space of several decades.

Two fossil fuels—coal and natural gas—dominate electricity production. Compared to natural gas, coal offers lower cost and higher supply security, but much higher carbon content. Accordingly, federal policies affecting levels of coal utilization could have very substantial impacts on CO_2 emissions.

A policy that has the effect of increasing, or even just maintaining, coal's current share of U.S. electric power output will significantly increase GHG emissions as demand grows unless there are offsetting decreases in net CO_2 emissions rates resulting from dramatic efficiency improvements, new generation technologies, or significant advances in "carbon capture" and sequestration technologies. For example, if electric output were to increase by 30 percent over the next 20 years and coal maintains its current percentage share of the output, CO_2 emissions from coal-fired power plants would increase by 500 million metric tons (MMT) CO_2/yr (a 9 percent increase in overall U.S. CO_2 emissions from 2000 levels). By contrast, if that output increase were supplied by efficient combined cycle natural-gas-fired generation, the increase would be substantially less, because these plants can produce electricity with about 60 percent less CO_2 per kWh than a pulverized coal plant.[33] However, retiring existing coal-fired plants and replacing them with efficient gas plants on a scale that would substantially decrease U.S. CO_2 emissions could impose major capital requirements on the generation sector, stress the existing gas pipeline network, and trigger increases in natural gas prices. For example, switching enough coal-fired generation to natural gas to lower U.S. CO_2 emissions by 10 percent would require the production and delivery of more than 5 trillion cubic feet (Tcf) of additional natural gas (a 25 percent increase from 2000 levels).[34]

Federal policy options that can influence the choice between coal and natural gas as a fuel for electricity generation include:

- Policies affecting availability and relative price of coal and natural gas (see discussion regarding "Fossil Fuel Supply" above),
- Tax or other incentives to promote utilization of particular fuels or advanced technologies,
- Reforming Clean Air Act regulations, including adoption of a "multi-pollutant" regulatory regime, and
- Supporting R&D for carbon capture and sequestration technologies.

To be sure, it would be possible to establish federal policies that mandate or prohibit the utilization of particular fuels. One of the Carter Administration initiatives developed in response to the oil crisis of the late 1970s was the Fuel Use Act, which prohibited the construction of power plants that could use only oil or natural gas as a baseload generation fuel.[35] These substantive requirements of the Fuel Use Act were repealed in the 1980s. Today, most federal policies affect the choice of coal or gas for electricity production only indirectly, but nevertheless significantly. Most importantly, Clean Air Act regulatory policies, including the current multi-pollutant proposals and New Source Review policy, influence both fuel choice and conversion efficiency. Multi-pollutant proposals would replace or supplement existing Clean Air Act regulations addressing power plant emissions of sulfur dioxide (SO_2), nitrogen oxides (NO_x), and mercury with a comprehensive new program that includes a nationwide emissions limit and inter-source emissions trading. An outstanding question in the debate over multi-pollutant legislation is whether requirements to limit or reduce CO_2 also should be included.

Major studies on different options for multi-pollutant legislation[36] indicate that in the absence of a requirement also to control CO_2, the owners of most existing coal-fired generation would comply with a three-pollutant program (SO_2, NO_x, and mercury) primarily by retrofitting their coal units with additional pollution controls rather than retiring the units, "repowering" those units with more efficient combustion control technologies, or converting them to use natural gas. Thus, under a three-pollutant approach, CO_2 emissions likely would not be significantly reduced and in fact might increase because the retrofit devices themselves consume energy; devices such as scrubbers to remove SO_2 can increase CO_2 emissions per megawatt hour by about 1 to 2 percent.

On the other hand, a four-pollutant approach (implementing SO_2, NO_x, mercury, and CO_2 controls contemporaneously) could have a higher near-term cost, but also might be less costly in the long term, assuming GHG regulation ultimately is adopted. This is a possibility because an approach that regulated SO_2, NO_x, and mercury in the near term, left the timing and stringency of future CO_2 controls uncertain, and then ultimately imposed stringent CO_2 controls could end up "stranding" many of the three-pollutant control costs.[37]

Another federal policy area that could affect the choice of fuel for electricity production is research and development policy regarding carbon capture and storage technologies and practices. DOE has given priority to research on technologies that can collect CO_2 emissions at the stack and store the carbon in underground formations or in the ocean. In addition to such "direct" sequestration technologies, it also is possible to sequester CO_2 emissions indirectly through various types of agricultural and forest management activities. The long-term viability of coal could depend on the pace at which such sequestration strategies develop and mature. Significant advances in this area could allow coal, which is in abundant supply and is central to the economy of some states, to continue to play a substantial role in electricity production without compromising the future ability of the United States to address net GHG emissions.

Encouraging Non-Emitting Generation Technologies

Increased use of zero-emissions energy technologies (e.g., nuclear, hydropower, wind, solar, and other renewable fuels) offers significant opportunities for CO_2 displacement, particularly in the electricity sector. However, these technologies can raise other significant challenges, such as the nuclear waste disposal problem for nuclear power, the protection of fisheries (which could give rise to conflicts with hydropower), and the capital costs and intermittent nature of wind and solar power.

Policy options for non-GHG emitting technologies include the following:

Nuclear

- Expediting nuclear license extensions,
- Approving nuclear plant upratings[38] where warranted,
- Reauthorizing the Price-Anderson Act,[39]
- Addressing nuclear waste storage issues, and
- Funding research on new nuclear technologies and development of standard-design facilities and fundamentally redesigning the nuclear fuel cycle.

Renewables

- Reforming the hydropower relicensing process,
- Easing access to land for renewable resource deployment,
- Funding research and development of renewable technologies,
- Providing tax credits for renewable energy development,
- Providing for better consumer information through "green power labeling,"
- Adopting a renewable portfolio standard, and
- Establishing net metering and uniform interconnection standards.

Maintaining or increasing use of nuclear energy to generate electricity has very large CO_2 emissions benefits, but raises other important policy issues, such as adequately addressing the problem of nuclear waste disposal. Also, concerns about safety and security (such as vulnerability to direct terrorist attack or the possibility of having nuclear material used for weapons) present important challenges. While license extensions and upratings for existing nuclear plants are possible, and provide large near-term GHG benefits, it does not appear that investment in significant new nuclear plant capacity is likely in the foreseeable future, given nuclear waste issues and the public's continuing health and safety concerns with this technology. Any development of new nuclear power plants seems to depend largely on the industry's ability to build public confidence in the cost, safety, and waste issues associated with nuclear plants.

Even maintaining current levels of nuclear generation will be a challenge because nearly all existing nuclear plants face a relicensing requirement in the next 25 years. To the extent they are not relicensed, nuclear plants are likely to be replaced by fossil-fueled capacity, and electric sector CO_2 emissions would increase as a result. Importantly, even if nuclear plants are relicensed and their nuclear waste storage and disposal issues resolved, most current plants will come to the end of their useful lives in 20 to 40 years.

Hydropower dominates the current renewable energy picture. In the United States, most of the attractive hydropower sites have already been developed or are protected for natural resource values. There are opportunities for increasing energy production at some existing dams, and thereby displacing the GHG emissions of fossil generation, but such changes are subject to regulatory delays and can also trigger problems with fisheries and other resources. Thus, at present, there appears to be little prospect of addition of any significant new U.S. hydropower electric capacity.[40] Given the absence of opportunities for significant new or expanded hydro capacity, maintaining existing capacity is likely to become a near-term priority for both energy and climate policy purposes. Streamlining the relicensing process for non-federal hydropower projects could make an important contribution in this regard. In addition, discussions are underway about the possibility of breaching certain federal dams to restore salmon populations; because the electricity from breached dams almost certainly would be supplanted by fossil fuel energy, these decisions will have GHG impacts.

Box 1

Implementing Climate-Friendly Energy Policies Presents Coordination Challenges

One challenge in implementing the kinds of climate-friendly energy policies identified by this report is achieving coordination among the myriad federal, state, and local institutions that make policies affecting energy. In the United States, no individual agency has total control over energy policy, as energy policy has been described in this paper. Rather, even in discrete areas of energy policy, authority over key issues can be spread among multiple federal agencies or between federal and state agencies. For example, hydropower licensing involves the Federal Energy Regulatory Commission, the Department of the Interior, the Department of Commerce, the Department of Agriculture, and state resource agencies. While national energy policy is nominally the province of the Federal Energy Regulatory Commission and the DOE, the EPA promulgates many regulations with perhaps more substantial impacts on the energy sector than policies or regulations established by the "energy" agencies.

Current non-hydro renewable generation accounts for only 2 percent of total electric output and is expected to increase to about 3 percent in 2020.[41] The economics of non-hydro renewable resources (including solar, wind, geothermal, and biomass) are improving. A number of policy approaches are available for expanding the market for renewable resources. One example is consumer choice policies for retail electric markets. These policies, which have been adopted by a number of states, give end-use consumers the opportunity to purchase renewable energy products, often at a premium. In some cases, there has been strong public demand for these products. The federal government itself can be an important consumer; federal facilities could set an important example and help increase demand by purchasing more renewable energy.

A more ambitious regulatory alternative is a renewable portfolio standard (RPS). Several states have adopted RPS requirements as part of their retail restructuring initiatives, and a federal RPS was included in the energy bill recently adopted by the U.S. Senate.[42] RPS laws typically provide for "renewable energy certificates" to be issued to renewable electricity generators, and then require retail sellers of electricity to hold certificates equal to a certain percentage of the electricity they sell. This approach allows retail sellers to comply by employing renewable generation resources or by acquiring certificates, and creates a market for certificates. In general, RPS policies impose a greater up-front cost than voluntary approaches because they force more renewable power generation than might occur under prevailing market conditions. On the other hand, RPS policies allow the industry the freedom to meet the requirement through the least-cost mix of renewable output from different generating units; in theory, this market-based approach should minimize compliance costs. In any event, the ultimate cost of an RPS policy will depend on a number of factors, including the level of the percentage requirement. A recent study by DOE's Energy Information Administration concluded that a federal RPS requiring 10 percent of total electricity sales to be generated from renewable power by 2020 would result in an approximately 1 percent increase in electricity prices, and would lower projected electricity sector GHG emissions by 53 million metric tons of carbon equivalent per year (MMTCE/yr), or about 7 percent.[43]

While renewable energy's market share (particularly wind) is increasing rapidly in percentage terms, it starts from a low base. The cost of wind energy in the United States has declined from 40 cents/kWh to 4–6 cents/kWh over the past two decades, and is projected to decline further.[44] U.S. wind energy production increased from 3.0 billion kWh in 1990 to 4.9 billion kWh in 2000.[45] It is expected to provide 24 billion kWh by 2020 (increasing from 0.1 percent to 0.4 percent of total U.S. electricity).[46] It is unlikely that new renewable capacity could be added fast enough to do more than capture a portion of the growth in electricity demand in the near term, much less displace a share of existing output. But renewables and low- or no-carbon fuels will be important from a long-term energy policy perspective as their costs decline and fossil fuels face increasing economic and environmental limitations. The long-term potential for displacement is much greater if federal financial and regulatory incentives are consistently pursued.[47]

Although they are more expensive currently, renewables contribute to fuel diversity and environmental improvement. In the context of a climate-friendly energy policy, renewable energy should be encouraged as its value will substantially appreciate if GHG reductions are mandated in the future.

Conversion and Transmission Efficiency

Energy policies that encourage developers of new and repowered fossil-fuel-fired generation to use highly efficient and clean technologies can do much to retard growth in CO_2 emissions associated with increased electricity demand. Advances in gas and coal generation technology promise to significantly increase the thermal efficiency (lower the heat rate) of power production using these fuels.[48] Gas-fired combined cycle units that achieve a heat rate of 6,350 British thermal units per kilowatt-hour (Btu/kWh) and advanced coal technologies (integrated gasification combined cycle) at 7,000 Btu/kWh are expected by 2010.[49]

Compared with average existing coal-fired generation heat rates, these technologies represent a 65 percent and 30 percent reduction (respectively) in CO_2 emissions per kWh from emissions rates of current coal plants. (These reductions result from increased conversion efficiency and, in the case of gas-fired combined cycle plants, the lower carbon content of natural gas relative to coal.) Combined heat and power can achieve overall efficiencies of approximately 80 percent, depending on the nature and size of the thermal application. Distributed generation can reduce transmission and distribution losses.

Policy options relating to conversion and transmission efficiency include:

- Funding research and development on improving electricity generation and transmission efficiency,
- Tax incentives to encourage high-efficiency technologies such as combined heat and power and fuel cells,
- Adoption of regulatory policies that support faster deployment of combined heat and power and distributed generation (e.g., reforms on interconnection, access to back-up power, and net metering),
- Reform of Clean Air Act regulation to remove obstacles to repowering with efficient technologies and to encourage new investment in efficient technologies,
- Reducing transmission losses through better management of the grid, and
- Research on superconductivity.

Shifting the focus of "clean coal technology" R&D to emphasize efficiency improvements could produce significant GHG benefits if new higher-efficiency technologies are used in new or retrofitted coal plants. In addition, replacing existing coal generation with integrated gas combined cycle (IGCC) could reduce emissions of conventional pollutants to well below current standards for new coal plants and reduce CO_2 emissions per megawatt hour by about 30 percent. Current coal plants have a heat rate that averages about 10,000 Btu/kWh. IGCC heat rates are expected to reach 7,000 Btu/kWh with a concomitant decrease in CO_2 emissions. If one assumes that the alternative to construction of IGCC plants is construction or continued operation of conventional pulverized coal plants, policies promoting IGCC plants will produce substantial benefits in terms of reductions in CO_2 emissions. In addition, to the extent that carbon capture and sequestration systems become increasingly feasible, it will be more economical to utilize such technologies with IGCC than with pulverized coal units. Alternatives to IGCC include supercritical pulverized coal or fluidized bed combustion. While not as efficient as IGCC, these technologies allow for the co-firing of biomass with coal.

Uncertainty as to whether efficiency upgrades trigger expensive Clean Air Act requirements may have discouraged some generators from undertaking efficiency improvements that could have GHG reduction benefits. The Clean Air Act's New Source Review (NSR) program requires any stationary source that undergoes a "major modification" (i.e., a "non-routine" physical or operational change that significantly increases annual emissions of any of the conventional air pollutants), to comply with extensive permitting requirements and to install costly state-of-the-art emissions control technologies. One key NSR issue is whether upgrading a generating unit's thermal efficiency should trigger NSR; such a policy discourages investment in plant efficiency. It may be preferable from a climate change policy perspective to distinguish investments that raise conversion efficiency from those that simply increase the capacity of existing coal-fired plants. The former can be a source of "emissions-free" generation (at the margin). Although estimates vary, studies suggest that existing coal-fired capacity could increase efficiency by 4 to 8 percent under conditions where competition encourages cost-effective investment in improving heat rates. This would translate into carbon emissions reductions of 20 to 40 MMT, compared to a scenario in which such efficiency improvements are discouraged either by regulatory treatment or by lack of market incentives.[50]

Other reforms to the Clean Air Act also could significantly affect the ability of new highly efficient generation technologies to enter the market. For instance, air regulations that express emissions limits on an output basis (e.g., lbs/kWh) as opposed to input basis (e.g., lbs/Btu of fuel) would encourage investment in new efficient plants. Vintaging rules also put new investments in clean technologies at a competitive disadvantage relative to existing plants functioning under less stringent air quality standards.

On-site electric generation, including combined heat and power (CHP)[51] and distributed generation (DG), can improve the reliability of electricity supply to a specific location, reduce congestion on the transmission grid, and avoid losses associated with transmission and distribution. Moreover, use of CHP, for example, can greatly improve conversion efficiency. In the regulated monopoly framework, however, incumbent utilities have economic incentives to raise obstacles to distributed generation and other forms of self-supply. Obstacles to the development of DG, such as discriminatory practices related to interconnection and access to back-up power, can be addressed through legislation or rules promulgated by the Federal Energy Regulatory Commission or state regulatory commissions.

The impact of DG development on system efficiency and GHG emissions depends on the DG technology used, considering the GHG benefits of avoided transmission and distribution losses and the net impact on emissions of substituting on-site generation for system power. Efficient CHP systems and distributed zero-emissions technologies such as photovoltaics can produce significant GHG benefits. Increased use of diesel generators for DG, in contrast, could result in increased emissions of conventional pollutants and GHGs. Microturbines have relatively low efficiency ratings, typically 25–30 percent.[52]

Fuel cells have been around for more than 100 years, but current research is improving their efficiency, reducing their cost, and making them viable for real-world stationary (particularly DG) and transportation applications.[53] Until an inexpensive, renewable-source method of providing hydrogen to power fuel cells is found, most fuel cells will run on hydrogen derived from a fossil fuel, usually natural gas. Today's fuel cells, which use natural gas, emit less than half the CO_2 per unit of electricity emitted from a coal-fired power plant, but still more than an efficient combined cycle gas plant. Accordingly, while fuel cells are not, at this point, a non-emitting technology, they are highly efficient relative to many current technologies and, depending on the alternative, their use can result in substantial reductions in GHGs. In addition, in all cases, fuel cells virtually eliminate emissions of criteria pollutants (NO_x, SO_2, and particulates).

Efficiency of Electricity Use

Increased efficiency in the end use of electricity in the buildings sector and industrial sector offers cost-effective alternatives to construction of new electricity generating capacity. Moreover, such policies also can attain significant climate benefits in the form of reduced CO_2 emissions from power plants.

The Electric Power Research Institute (EPRI, the electric power industry's research organization) estimates that a $4.2 billion annual investment in energy efficiency and other demand response programs would reduce U.S. peak demand by 45,000 MW (about 6.4 percent).[54] Fifty-eight percent of their predicted decrease in demand would result from energy efficiency rather than shifting demand from peak to off-peak. By contrast, building new generation to serve this 45,000 MW of demand would have annual costs of about $8.5 billion per year and CO_2 emissions would be about 100 million tons higher (about 2 percent of U.S. emissions).[55]

C. Buildings

Office, commercial, and residential buildings—and the energy-consuming appliances and products in them—account for two-thirds of the nation's electricity use. They also account for approximately 36 percent of natural gas and 6 percent of oil use. Therefore, decreases in building energy use can contribute significantly to achieving reductions in the emissions that contribute to global climate change. Current forecasts indicate that energy use in residential and commercial buildings will increase by nearly 20 percent by 2010.[56] It is often difficult to develop simple policies that substantially alter patterns of energy use in the buildings sector because of the very large number of building owners and operators, high first costs, and the fact that energy costs are, in some cases, borne by tenants while investments are made by building owners. Not only is the buildings sector market fragmented, the regulatory regime for the sector is fragmented as well. Authority over key matters is divided among federal, state, and local agencies, making the development and implementation of comprehensive energy policies for the buildings sector difficult. Consequently, although many highly efficient technologies and processes for the sector are available and extremely cost-effective, market penetration has been disappointing. Nevertheless, DOE estimates that a 30 percent reduction in building energy use nationally is a goal well within reach.[57] In addition to energy use and CO_2 reductions, such an improvement would reduce building operating costs and reduce demands on the electricity infrastructure.

Available energy-efficient technologies for the buildings sector include efficient lighting, space conditioning, control systems, water heating, and office equipment and appliances installed in the building, all of which have shown efficiency improvements over the past two decades. Utilization of green building design and materials in new building construction and retrofits provides further, although longer-term, ways to achieve significant reductions in building sector energy use.

Policy options in the buildings sector include:

- Adopting stricter appliance energy efficiency standards in combination with market incentives to go beyond the standards,
- Expanding the range of products covered by appliance efficiency standards,
- Encouraging inclusion of efficiency requirements in building codes and construction standards,
- Encouraging utility incentive payments for purchase of energy-efficient equipment,
- Expanding product labeling and certification programs (e.g., Energy Star™ program),
- Providing tax credits for manufacture or purchase of high-efficiency products,
- Encouraging federal investment in building efficiency (e.g., energy savings performance contracts) and green building design,
- Providing funding for efficiency upgrades in low-income housing,
- Promoting energy-efficient mortgages,
- Reforming retail utility regulation to shift away from incentives for utilities to maximize energy sales,
- Adopting "public benefits charges" that support investments in efficiency, and
- Providing funding for research and development on efficient end-use technologies.

Federal appliance efficiency standards have been effective—reducing energy use by more than 1 quad annually.[58] This program could have a greater impact if there were an expansion of the products covered and more frequent updates. However, the actual impacts (including the net costs to consumers and manufacturers) of strengthening standards will depend on the standards promulgated, the technologies developed, and the market reaction to the new equipment.

Consumer information strategies, such as efficiency labeling and the Energy Star™ ratings and rewards program, can be effective tools for encouraging consumers to make cost-effective energy efficiency investments.[59] Another market-based approach is energy performance contracting programs. In such programs, private companies or utilities audit building energy use, propose energy saving opportunities, and contract to install the improvements using their own capital. In return, they receive a share of the savings from the customer's utility bill to pay for the improvements.[60] (Such programs are most effective when customer savings are guaranteed by the contractor.) Expanded use of energy savings performance contracting could be achieved by increasing the use of such programs in federal facilities and by providing tax incentives for use of such programs in the private sector.

Monetary incentives, in the form of tax credits or utility rebates for either the purchase or manufacture of highly efficient products, also can be effective tools for encouraging investment in efficiency improvements. However, to remain cost-effective, such programs must be carefully designed to maximize the marginal efficiency impact while limiting the degree to which the monetary rewards flow to those who would make such investments even in the absence of the incentive. Another financial incentive is a system that factors building energy use into mortgage decisions. For example, the Federal Housing Administration's energy-efficient mortgage program allows new home buyers to qualify for a larger loan amount if the home is highly energy efficient, because more disposable income is available to make mortgage payments.

A number of efficiency policies in the buildings area can be implemented at the state or local level. For instance, state or county governments can promote efficiency improvements through climate-zone-appropriate building codes and the establishment of retrofit standards. Similarly, state regulation of electric utilities can encourage investment in real-time metering (or time-of-day metering as an interim step), which would allow sophisticated building operators to manage their energy demand according to the varying market price of electricity. Such metering provides a more accurate price signal to consumers and thereby encourages cost-effective management of energy use. Perhaps most importantly, state regulation of retail gas and electric utilities can seek to redirect the incentives for utilities. Under the current regulatory framework, utilities profit by maximizing their sales.

Federal policy-makers can provide leadership in such traditionally state and local activities by adopting model building codes, developing regulatory standards to be considered by state agencies,[61] or providing funding to support such initiatives. The federal government also can provide leadership by adopting ambitious efficiency measures and green building design for federal facilities, insisting on performance improvements by federal agencies, and rewarding agencies that achieve significant reductions in energy use.

Policies that result in increased end-use efficiency can have substantial energy policy and GHG benefits. For example, as discussed above, EPRI has concluded that policies to improve the efficiency of electricity use can avoid the need for investment in new generation costing billions of dollars per year, and can reduce CO_2 emissions by about 100 million tons per year.

D. Industrial Processes

The industrial sector accounts for about 36 percent of primary energy use in the United States. Of this energy use, 35 percent is from petroleum, 35 percent from natural gas, 13 percent from electricity, 9 percent from coal, and 8 percent from renewables. Two-thirds of this energy provides process heat and power.

The industrial sector is highly diverse; it ranges from the transformation of raw materials to the production of highly finished goods. This diversity complicates the design of public policies to improve energy efficiency. On the other hand, industry has the clearest incentive to reduce energy use where it leads to cost savings, since successful companies can gain competitive advantage. For this reason, the industrial sector can be expected to be somewhat more aggressive about identifying and taking advantage of efficiency improvements compared with the buildings sector. Nevertheless, there is still a role for policies that can provide information and promote new technologies that enable investments in cost-effective energy efficiency improvements.

The most energy intensive sectors are petroleum refining, chemicals, forest products, steel, aluminum, glass, metal casting, and cement. Historically, energy efficiency improvements (measured in terms of Btu/$ value produced) in the industrial sector have been maintained at a rate of about 1.1 percent per year.

While some improvement in energy efficiency can be realized through changes in behavior (maintenance and operations), more significant gains are achieved through the introduction of new, more efficient processes and technologies. These process and technology changes can be classified into three groups: (1) changes in equipment and operating practice; (2) improvements in existing processes (e.g., advanced sensors and use of recycled inputs); and (3) fundamental process changes. The most dramatic improvements in energy efficiency may require research, development & deployment (RD&D) investments in breakthrough technologies.

As discussed above with regard to electricity production,[62] increased use of on-site CHP technologies represents another opportunity for reducing the amount of energy consumed by industry. Depending on steam utilization, CHP can double fuel efficiency. Four industries make the most extensive use of CHP: chemicals, forest products, petroleum refining, and primary metals.

Companies also can reduce their energy use through better steam recovery, more efficient end-use systems, and better waste heat utilization. Other possibilities exist in improving materials efficiency through more recycling/reuse and dematerialization or material substitution opportunities. All industries can benefit from increased use of best practices and the adoption of more efficient equipment.

Policy options for the industrial sector include:

- Providing tax and regulatory incentives for investment in energy efficiency or combined heat and power,
- Expanding coverage of efficiency standards for standard-design equipment,
- Establishing standards on minimum levels of recycling and reclamation,
- Providing information and energy audit programs, and
- Providing funding or tax incentives for research, development, and deployment on energy-efficient industrial processes (including public-private partnerships).

Although the industrial sector is diverse, opportunities for effective efficiency-oriented regulatory programs do exist. Setting recycling/reclaiming standards could greatly lessen the energy needed for materials input in several sectors, notably aluminum and iron and steel. For example, producing aluminum with recycled aluminum as the input uses only 5 to 8 percent of the energy required when aluminum is produced from raw materials.

While the industrial sector ordinarily is adept at identifying opportunities for improving energy efficiency, in some areas there are unexploited efficiency gains. For example, many firms fail to take into account relative energy efficiency when they go into the market to purchase a range of small and ubiquitous items, even where there are opportunities to save enough money in energy costs to “pay back” the added incremental purchase cost in months rather than years. Accordingly, energy policy could help provide better information to enable better decisions and possibly establish minimum efficiency standards for certain equipment categories such as pumps, fans, compressors, process heat boilers, belts, and refurbished motors. The energy-saving and CO_2 reduction opportunities are greatest for standards applied to equipment that is used broadly in the industrial sector.

Various information programs, including efficiency labeling for standard equipment, energy audit programs, and best-practices education, also are useful tools for informing industrial sector consumers of opportunities for cost-effective efficiency investments. These can complement product marketers’ efforts to demonstrate the economic benefits of energy efficiency.

There is also a role for using tax incentives to spur efficiency investments. For example, the government could provide tax credits and favorable depreciation schedules for qualifying equipment. Increases in industrial energy efficiency typically occur when new equipment replaces older, less efficient capital stock. Tax credits (or more rapid depreciation) targeted for investment in new highly energy-efficient capital will result in immediate energy efficiency improvements and will encourage development of additional efficient technologies over the long term. Although these policies may lead to reduced federal tax revenues, the benefits can justify such expenses from an energy policy standpoint.

Another area for industrial energy policy is research and development. One estimate indicates that expanded R&D alone could double improvement in industrial energy intensity.[63] The Energy Information Administration’s Annual Energy Outlook 2002 estimates a decline in energy intensity of the industrial sector of 25 percent over the next 20 years; one quarter of that improvement is due to improved efficiency in equipment and production.[64] If the rate of efficiency improvement were doubled, by 2010 annual energy use by industry would decline by 2 quads, or about 2 percent of all current energy use. As an example, if support were increased to commercialize black liquor gasification for the forest products industry, that industry could meet all of its energy needs using renewable resources and produce surplus electricity for sale on the grid. This expansion of biomass energy alone could offset 1.5 quads of annual fossil fuel use,[65] and thereby reduce 132 MMT of annual CO_2 emissions.[66]

As discussed above in Section V(B) regarding conversion and transmission efficiency, combined heat and power is also an important option for industry to meet its energy needs in a cost-effective manner. Use of CHP can be supported with tax incentives and with reforms of utility and air regulation to address existing obstacles to CHP development.

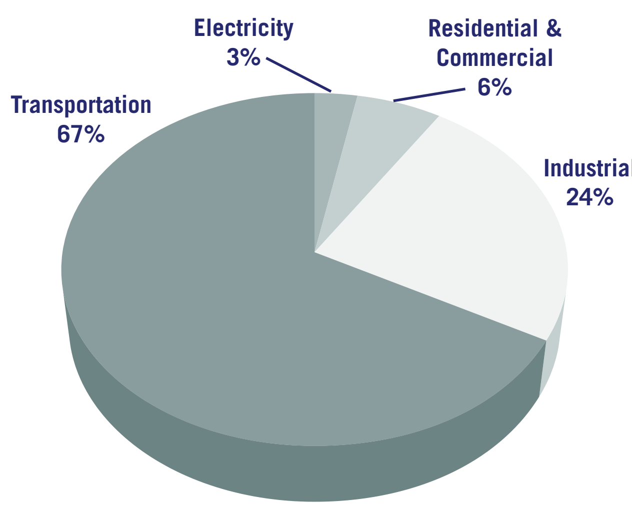
E. Transportation

The transportation sector accounts for approximately two-thirds of U.S. oil consumption (see Figure 7), and about 60 percent of transportation-related oil consumption is for passenger cars and light trucks. Because of our dependence on imported oil, the political volatility of the Middle East, and the continuing cartel behavior of OPEC, there is a strong link between transportation energy policies and U.S. energy security. This vulnerability has been a major driver of energy policy over the past three decades.

The transportation sector accounts for about 27 percent of total energy demand. Energy demand for transportation is projected to grow at an average annual rate of 1.9 percent, to 39.4 quadrillion Btu in 2020. The transportation sector accounts for 33 percent of CO_2 emissions. Notably, GHG emissions from the transportation sector are projected to increase at a higher rate in the next two decades than emissions from any other sector, including the electricity sector.[67]

Figure 7

Petroleum Users



Source: U.S. DOE, EIA. Annual Energy Review 2000, Tables 2.1b,c,d,e,f.

In overview, improving vehicle fuel efficiency presents very important opportunities to reduce GHG emissions and reduce dependence on oil imports at reasonable cost. Thus, enhancing vehicle efficiency is a key element of climate-friendly energy policy. Reducing vehicle miles traveled (or VMT) also leads to direct energy and GHG benefits, but the policy options practically available seem less likely to have a significant impact on VMT. New technologies such as fuel-cell-powered cars offer large potential energy security and climate change benefits in the long term, but face important cost and infrastructure hurdles in the near term. Investing in R&D for such technologies now will help make their widespread use a viable option for the future.

Vehicle Efficiency

The opportunities for making automobiles more efficient, and thereby reducing gasoline use, are significant. Typically, only 12 to 20 percent of the energy value of fuel is converted into useful energy in an automobile. The greatest opportunities include improving engine efficiency, reducing vehicle weight, reducing aerodynamic drag, and reducing rolling friction of tires.

More substantial redesigns are also just entering the market. Hybrid vehicles, for example, capture and use energy otherwise lost in braking and use smaller, more efficient engines to power electric motors without any sacrifice in performance. Fuel-cell-powered vehicles also have substantial promise; for example, using hydrogen derived from natural gas, fuel-cell vehicles emit half as much CO_2 as conventional automobiles.

Policy options in the area of improving vehicle efficiency include:

- Tightening CAFE standards for passenger automobiles and light trucks,
- Establishing efficiency standards for tires,
- Extending the "gas guzzler" tax to light trucks and raising the mileage thresholds,
- Providing tax credits for very high-efficiency automobiles, including hybrid and fuel-cell vehicles, and related fuel infrastructure,
- Funding research and development for advanced transportation technologies, and
- Coordinating emissions and efficiency policies for the transportation sector.

The largest impacts on oil consumption in this sector are likely to come from improving vehicle efficiency, as are the most significant potential climate benefits. One tool for increasing new vehicle fuel economy is to impose stricter CAFE standards. The 2002 National Research Council report on CAFE standards concludes that significant efficiency benefits can be achieved using technologies that will leave the consumer better off economically. Improvements that would pay for themselves in fuel savings in three years would generate mileage gains of 3 to 22 percent; improvements that would pay for themselves in fuel savings over the typical 14-year life of a vehicle would produce mileage gains of 16 to 47 percent, depending on vehicle size.[68] These levels of improvement can be achieved without affecting the vehicle size or weight.

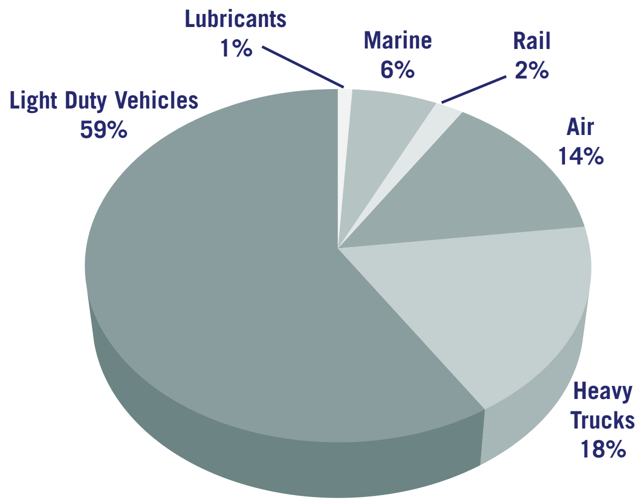
CAFE standards have proven an effective policy tool for reducing oil consumption. CAFE standards in place today, for instance, are estimated to have reduced U.S. oil consumption by about 2.8 million barrels per day (or 13 percent) and avoided emissions of 100 MMTC/yr.[69] Phasing in new car fuel economy improvements of 15 percent by 2013, for example, would produce fuel savings of about 22 billion gallons per year (almost 12 percent) from projected levels by 2030, with approximately the same percentage reduction in projected GHG emissions.[70]

In addition to regulatory approaches, financial incentives can be created to promote fuel economy. These include tax incentives for very high-efficiency vehicles using hybrid or fuel-cell technologies, reforms to the "gas guzzler" tax to increase its effectiveness,[71] and "feebates" which create symmetrical taxes and rebates for buying low- or high-fuel-economy cars. These measures can produce significant reductions in both oil consumption and GHG emissions.

There are some constraints on improving vehicle fuel economy. First, some argue that making vehicles lighter, which is one means of enhancing fuel economy, could create safety problems.[72] As discussed above, however, significant efficiency improvements can be gained without reducing vehicle weight. Moreover, others argue that automobile safety has improved since the introduction of CAFE standards in the 1970s, and that such improvements in safety engineering can be expected to

Figure 8

Energy Use in **Transportation**



Source: U.S. DOE, EIA. Annual Energy Outlook 2002, Table A7.

continue. Also, while increasing use of diesel engines could have significant climate benefits due to their efficiency relative to internal combustion engines, diesel use may be constrained by other environmental factors such as ability to comply with new criteria pollutant emissions limits.

Elements of the transportation sector other than light-duty vehicles (heavy trucks and buses, aircraft, railroads, and maritime shipping) cumulatively account for 41 percent of the sector's energy consumption. (See Figure 8.) As with the industrial sector discussed above, these commercial elements of the transportation sector have strong economic and competitive incentives to reduce fuel costs and invest in fuel efficiency. Perhaps for this reason, current energy policy proposals do not focus on these elements of the transportation sector to any significant degree.

By 2007, heavy-duty trucks and off-road equipment will be subject to new requirements for reductions in criteria air pollutants; compliance with these requirements could lead to efficiency losses and therefore higher GHG emissions. Better coordination between energy and environmental policy-makers could help head off this potential conflict between Clean Air Act and climate change policy concerns.

Alternative Fuels

Another means of reducing consumption of gasoline is to increase the use of alternative transportation fuels. These include compressed natural gas, liquefied natural gas, hydrogen, propane, methanol, ethanol, and electricity. Currently, alternative fuels account for only about 0.2 percent of transportation fuel consumption. In order to make significant increases in the use of alternative fuels, issues of vehicle cost, fuel cost, refueling infrastructure, and vehicle range will need to be overcome. It should be recognized, moreover, that not all alternative fuels offer GHG benefits relative to gasoline.

Replacement fuels, such as methyl tertiary-butyl ether (MTBE, made from natural gas) and ethanol (a biofuel), have had a more significant effect on gasoline displacement. Replacement fuels are added to gasoline for environmental reasons. Replacement fuels now account for 2 to 3 percent of vehicle fuel consumption.

Policy options relating to use of alternative fuels in the transportation sector include:

- Expanding alternative fuel vehicle purchase requirements,
- Requiring use of alternative fuel in alternative-fuel vehicles in government and commercial fleets,
- Expanding use of ethanol and methanol blends in conventional automobiles through regulatory requirements or tax incentives, and
- Expanding incentives for use of alternative fuels in buses.

Unless there is a dramatic increase in the penetration of alternative fuel vehicles along with increased alternative fuel use in dual-fuel vehicles, alternative-fuel policies will have only a small impact on oil consumption. Climate impacts of using alternative fuels vary considerably from fuel to fuel.

Moreover, in addition to considering GHG emissions from the vehicle itself, there are important differences in the GHG emissions associated with the production of each fuel. Electricity and hydrogen, for instance, produce no GHG emissions when used to power a vehicle, but typically involve significant GHG emissions at the generation stage. Ethanol, by contrast, has CO_2 emissions when combusted, but the biomass used to produce the fuel is a carbon sink.[73] The increased use of ethanol (the largest non-petroleum-based transportation fuel) either as an oxygenate or as a larger component of the fuel may reduce GHG emissions, but its life-cycle GHG characteristics vary depending upon the biomass feedstock and the ethanol production process. The current method of producing ethanol from corn requires the use of fossil fuels and nitrogen-based fertilizers in agricultural production and refining. Newer methods of obtaining cellulosic ethanol from organic waste, however, may yield greater GHG reduction benefits. Hydrogen may be an important long-term transportation fuel in conjunction with fuel cells. (See Box 2.)

Reducing Vehicle Miles Traveled (VMT) and Traffic Congestion

There are many opportunities for crafting policies that provide alternatives to automobile use. For instance, transit systems can be expanded and their use encouraged, employees can be encouraged to increase their use of telecommuting in lieu of driving, carpooling can be encouraged, support for inter-city rail services such as AMTRAK can be continued and new high-speed rail developed, and zoning and other development policies can reduce the need for driving.

Box 2

Hydrogen: The Transportation Fuel of the Future?

The use of hydrogen in fuel cells offers a technologically viable alternative to gasoline in internal combustion engines as a primary transportation fuel. Hydrogen can be manufactured in several ways – the most common are reforming natural gas and water electrolysis powered by electricity. Indeed, substantial amounts of hydrogen are manufactured today, mostly for use in petroleum refining and other industrial processes.

The use of hydrogen in a fuel cell to power a car could be attractive from an energy policy perspective, because it offers an alternative to reliance on petroleum-based transportation fuels. Moreover, the use of hydrogen in a fuel cell produces no emissions of conventional pollutants or GHGs. However, the process of producing hydrogen does have climate impacts associated with extracting it from fossil fuels or generating electricity for use in electrolysis. One "well-to-wheel" analysis finds that use in fuel cells of hydrogen produced by electrolysis has about the same overall GHG emissions as a conventional gasoline-powered engine, but that, in the future, use of hydrogen produced by reforming natural gas has the potential to reduce GHG emissions by as much as 70 percent relative to conventional engines.[74]

Cost is a very substantial challenge for use of hydrogen as a transportation fuel in the near term. The changeover to hydrogen-using cars will involve developing new infrastructure to produce, transport, and store hydrogen, as well as the transformation of the automobile fleet to fuel-cell technologies. One estimate is that the infrastructure alone would cost $100 billion in the United States.[75] Moreover, the costs of fuel cells themselves must come down substantially for fuel-cell vehicles to be cost competitive. Thus, the near-term energy policy agenda should focus on research and development to advance fuel-cell and related technologies, so that if regulatory and market conditions make the relative economics of hydrogen-powered fuel cells more attractive, these technological options will be readily available.

Policies for reducing automobile use or increasing the efficiency of their use include:

- Funding public transit expansion,
- Funding inter-city rail service,
- Expanding tax benefits for transit passes,
- Promoting telecommuting,
- Promoting carpools by, for example, establishing high-occupancy vehicle (HOV) lanes,
- Establishing electronic toll collection,
- Utilizing "smart" traffic technologies, and
- Establishing "pay at the pump" auto insurance.

Transportation policies may be undertaken for energy policy reasons. The advent of right-turn-on-red laws, for instance, was an element of Carter Administration energy policy designed to save fuel. Transit and car-pooling policies often are elements of regional programs to control transportation-related air pollutant emissions in areas deemed "nonattainment" with regard to Clean Air Act air quality standards. Doubling the rates of carpooling and transit use would reduce oil consumption by about 0.3 and 0.1 million barrels per day, respectively.[76] Any success with these programs to reduce vehicle-miles traveled or increase the average speed of daily automobile commutes by reducing congestion may produce GHG reduction benefits.[77]

With respect to commercial trucking, one option identified is to provide incentives to retrofit truck stops to allow trucks to be "plugged in" at night. This would reduce truck idling and therefore reduce emissions and fuel use. Policies can also promote intermodal freight transportation, in which trucks deliver freight to trains for more efficient long-distance transport.[78]

Another policy tool for reducing vehicle-miles traveled is to raise the marginal cost of driving. Higher gasoline taxes would discourage consumption by raising consumer costs, but such taxes are politically difficult to implement. A more novel mechanism is "pay at the pump" automobile insurance, which would base insurance premiums on the amount of driving. This would not raise overall consumer costs, and thus may not be as politically charged as tax increases, but they would change the costs borne by different drivers; drivers with above-average vehicle use would face higher costs, while drivers with lower-than-average vehicle use would face lower costs.

Reducing VMT would produce direct energy security and GHG benefits. However, the policy options receiving serious consideration are not likely to significantly affect VMT.

VI. Conclusions

The premise of this paper is that in making energy policy, there are important choices to be made with respect to climate change policy. In reviewing policy options, we have identified four key objectives that drive energy policy:

(1) Secure, plentiful, diverse primary energy supply,

(2) Robust, reliable infrastructure for energy delivery and conversion,

(3) Affordable and stable energy prices, and

(4) Environmentally sustainable energy production and use.

In developing a template for a climate-friendly energy policy, we have limited ourselves to a review of energy policy options, i.e., policies that serve one or more of these objectives. We limit ourselves also to relatively near-term energy policy initiatives, that is, initiatives that could begin to produce tangible energy policy benefits over the next decade or two. We did not focus on longer-term issues, such as whether renewable energy sources and hydrogen will displace coal and gasoline in 2050 or 2100. This focus on relatively near-term measures mirrors the focus of policy-makers in the current energy policy debate.

In identifying energy policy options that are "climate-friendly," we have considered the following:

(1) Does the policy reduce GHG emissions now?

(2) Does the policy promote technology advancement or infrastructure development that will reduce the costs of achieving GHG emissions reductions in the future?

(3) Does the policy minimize the amount of new capital investment in assets that would be substantially devalued (or "stranded") if a GHG program were implemented?

Using this approach, we have identified the following elements of a climate-friendly energy policy:

Fossil Fuels

Expand natural gas transportation infrastructure. Encouraging expansion of the natural gas transportation system in North America through, for example, rate incentives, streamlined pipeline right-of-way permitting, and expediting approvals needed for construction of an Alaska natural gas pipeline, will increase the delivery capability for natural gas and lower the price of the delivered product. This will, in turn, permit the use of gas as a substitute for coal in electricity production and thus reduce GHG emissions.

Increase natural gas production. Encouraging increased production of natural gas in North America through, for example, providing tax incentives, royalty relief, and access to public land for resource development, will lower the price and increase the availability of natural gas. This, in turn, will permit the use of gas as a substitute for coal in electricity production and thus reduce GHG emissions.

Electricity

Encourage deployment of efficient electricity production technologies. Encouraging developers of new generation capacity to employ very efficient generation technologies—with tools such as tax incentives for combined heat and power and high-efficiency distributed generation—can significantly increase the amount of useful energy gleaned from fuels, and thus reduce both energy costs and emissions. Moreover, support for repowering existing plants with technology that improves the efficiency of the electricity generation process, through tax incentives and relief from obstacles arising from New Source Review, can reduce electricity prices and reduce fuel consumption per kWh, with corresponding GHG benefits. Conversely, policies that discourage such investments in improved efficiency, and instead result only in energy-consuming pollution control retrofits, may be counterproductive from a climate perspective.

Maintain role for nuclear and hydroelectric power. Policies that allow the safe continued use of nuclear power plants—such as granting license extensions, approving plant upratings where warranted, and finding new solutions to the nuclear waste problem—preserve diversity of energy supply, may reduce electricity prices, and avoid very substantial coal consumption for electricity generation. Likewise, maintaining or expanding hydroelectric capacity consistent with natural resource protection goals provides low-cost electricity without GHG emissions.

Encourage development of renewable energy resources. Policies that encourage the development of renewable energy resources—such as production tax credits, a renewable portfolio standard, transmission policies that do not discriminate against intermittent renewable resources such as solar and wind, and net metering for small distributed renewable resources—can help diversify our energy portfolio and are environmentally attractive. Wind, solar, geothermal, and hydropower generation produce no GHG emissions, and use of biomass produces no net GHG emissions. Increasing renewable generation may be constrained, however, by the economics associated with their high capital costs and (for some technologies) intermittent power output.

Buildings End-Use Efficiency

Promote use of efficient technologies and green design in buildings. Policies that require increased efficiency of energy end-use (such as building codes or appliance efficiency standards), and policies that encourage use of highly efficient equipment and technologies (such as tax incentives, product efficiency labeling, and Energy Star™ programs) can significantly reduce energy consumption, can reduce consumer operating costs over a product's or building's lifecycle, can reduce the need for investment in new power plants, and can reduce emissions related to energy use.

Industrial End-Use Efficiency

Promote the use of more efficient processes and technologies in industry. Policies that provide incentives for investment in efficient processes and combined heat and power technologies, expand coverage of efficiency standards to standard-design equipment, and provide more information on efficient technologies to industrial consumers in the industrial sector can lead to further emissions reductions in the industrial sector.

Transportation

Enhance end-use efficiency of automobiles and light trucks. Regulatory and tax policies—such as more stringent CAFE standards, reforms to the "gas guzzler" tax, efficiency standards for tires, and tax or other incentives for the purchase of highly efficient hybrid vehicles—can significantly reduce fuel consumption per mile, thus reducing oil consumption and mitigating reliance on oil imports. Very significant energy and climate policy benefits can be gained in this area. According to a recent National Research Council study, if lead times are long enough, automakers can produce substantially more fuel-efficient vehicles without increasing net consumer costs or compromising safety.[79] Moreover, fundamental redesigns such as hybrid vehicles and fuel-cell vehicles offer important further potential benefits.

Research and Development

Promote research and development on efficient electricity production technologies. Federal funding or tax incentives for R&D on improving the efficiency of the electricity generation process, regardless of fuel source, can provide options to reduce future energy prices and reduce future fuel consumption per kWh, with corresponding GHG benefits.

Promote research and development on efficient end-use technologies. Federal funding or tax incentives for R&D on improving transportation, building, and industrial end-use efficiency can provide options to reduce future energy costs to consumers and to reduce future energy consumption, with corresponding GHG benefits. Support for R&D is particularly important in areas where fundamental changes are possible, such as the widespread use of hydrogen in fuel cells to power vehicles.

Promote research and development on non-fossil fuels and carbon sequestration. Federal funding or tax incentives for R&D on alternatives to fossil fuels, such as biofuels and hydrogen, can provide future viable alternatives to oil. Development of economical carbon sequestration technologies could enable continued reliance on coal consistent with a GHG regulatory regime.

Box 3

An International Perspective on Climate-Friendly Energy Policies

What can readers from other countries draw from this paper? The paper's general finding—that a range of energy-sector policies not only can promote traditional energy policy objectives but also contribute to GHG emissions reduction goals—holds true across all countries with highly developed energy sectors. In addition, the elements of the "climate-friendly" energy policy outlined in the paper reflect general approaches that likely could be effective in most other countries, e.g., encouraging the development of renewable energy policies and promoting end-use efficiency.

Non-U.S. readers should be aware, however, that the specific recommended policies might not make sense for all countries. The authors have developed these recommendations on the basis of particular fuel supply, electricity-production, and end-use characteristics of the U.S. energy sector. Moreover, the recommendations reflect the distinct opportunities and constraints inherent in existing U.S. energy policies and politics.

The elements described above include four types of policies: Those that increase the efficiency of energy use, increase the use of non-emitting technologies, enable greater use of natural gas in lieu of coal or oil, and encourage research and development on new energy technologies.

There are important constraints on the use of various types of federal policy tools aimed at achieving national energy objectives. For example, budget dynamics limit the use of federal appropriations and tax incentives, concern for the economic welfare of consumers limits the use of regulatory requirements (e.g., product efficiency rules that reduce product utility or significantly raise life-cycle costs), and concern about maintaining safety may constrain further development of nuclear power and lightweight vehicles.

The ways in which policy options are pursued can have a significant impact on how effectively a government program achieves its goals. This assessment does not attempt to evaluate the options for how, for instance, the CAFE program might be reformed, although such details are quite important in determining how effective it is as an energy policy, what its climate impacts are, and what its costs are.

There are also a number of key energy policies that have no significant climate change impacts, and thus can be included or excluded based on other factors. These include, for instance, policies to increase domestic production of oil, to expand the electricity transmission infrastructure, and to promote competitive electricity markets. While such policies have little or no effect on GHG emissions, they can address central energy policy concerns and thus should be considered in crafting an energy policy.

Does a climate-friendly energy policy advance energy policy objectives?

Yes. The climate-friendly steps described in this report would: enhance energy security by reducing growth in demand for oil, increase the diversity of the country's energy mix, strengthen the energy delivery infrastructure, and contribute to improvements in air quality without significantly increasing consumer energy costs. While calculating the economic costs and benefits of such policy measures is beyond the scope of this paper, the overall directions are consistent with attaining coherent energy policy objectives. As mentioned above, there are also important energy policy options (such as transmission system expansion or electricity restructuring) that may advance energy policy goals but are either ambiguous or neutral on GHG emissions. Such options must also be considered in framing comprehensive energy policy initiatives.

Is a climate-friendly energy policy a substitute for a climate policy?

No. This collection of steps would produce some significant GHG emissions reductions over the coming years, but it would not produce the magnitude of reductions needed, for instance, to meet the goal set in the 1992 Framework Convention on Climate Change to reduce emissions to 1990 levels. Moreover, trying to achieve climate goals indirectly through energy policy tools will necessarily be more expensive than achieving the same climate goals through an effectively designed policy to directly control GHG emissions such as a "cap-and-trade" system. Instead, this collection of steps can be thought of as a list of federal policy steps that will help address the problem of climate change and are independently justified as useful energy policies. Perhaps more importantly, pursuing these options will start gradually moving capital investments in energy-producing or energy-consuming equipment in a direction that is consistent with a climate policy to reduce GHG emissions, so that the economic dislocations and "stranded costs" associated with implementing a climate change regime later will not be made worse by investment over the coming decade.

Can the impact of these policies be quantified?

Only roughly. The policies are discussed only in general terms, and are not sufficiently specific to permit formal estimates of energy use, market price, and emissions impacts. However, the electricity, buildings, industry and transportation sector options discussed are similar to packages analyzed as the "moderate" scenario in a recent DOE interlaboratory study.[80] That study found that a broad menu of moderately aggressive efficiency, renewables, and R&D policies pursued in this decade could reduce overall primary energy use from projected levels by about 4 percent in 2010 and 8 percent by 2020, with nearly uniform percentage reductions obtained in all sectors. Overall energy consumption, however, would be higher than current levels, i.e., these policies could reduce but not eliminate growth. Energy prices are moderately lower than projected levels under those policies, and CO_2 emissions reductions were about 5 percent and 9 percent lower than projected 2010 and 2020 levels, respectively, but still well above current levels and not even close to 1990 levels.

As an additional point of reference, the interlaboratory study also examined a set of additional, much more aggressive policies focused on reducing CO_2 emissions, including a $50/metric ton of carbon fee on primary fossil energy and "pay at the pump insurance" that increased gasoline prices. That "advanced" scenario reduced CO_2 emissions by 17 percent in 2010 and 29 percent in 2020, nearly returning U.S. CO_2 emissions to 1990 levels by 2020. However, those policies also implied substantial increases in energy prices and significant changes in patterns of U.S. energy production and use.

The broad findings of the interlaboratory study reinforce the conclusions of this paper, namely, that near-term energy policies exist that can help reduce the projected growth in U.S. energy-related CO_2 emissions, but that significant reductions in CO_2 require concerted effort and more substantial energy market interventions than can be justified on the basis of the traditional objectives of energy policy. However, a "climate-friendly" energy policy can meet energy policy objectives and place the U.S. economy on a more advantageous footing to address climate change in the future.

Endnotes

1. Interlaboratory Working Group. 2000. *Scenarios for a Clean Energy Future.* Oak Ridge National Laboratory and Lawrence Berkeley National Laboratory, November 2000, ORNL/CON-476 and LBNL-44029.

2. The “buildings” sector includes residential and commercial structures and the appliances and other equipment in those structures.

3. A large percentage of methane emissions (the second largest GHG emissions) are attributable to production of natural gas or coal, or to transportation of natural gas.

4. CO_2 emissions from combustion of biomass are offset by CO_2 removed from the atmosphere by the plants.

5. “Base load” electric capacity refers to plants that are designed to run regardless of whether electricity demand is high or low.

6. Crude oil in the SPR plus private company stocks would cover approximately 150 days without imports.

7. U.S. DOE, Energy Information Administration (EIA). 2002. *Chronology of World Oil Market Events 1970-2000,* available at http://www.eia.doe.gov/emeu/cabs/chron.html.

8. Transmission facilities are the lines and associated equipment for transferring electric energy in bulk between points of supply and points where it is transformed for delivery to the distribution system. Distribution facilities are the lines and associated equipment dedicated to delivering electricity to consumers.

9. U.S. DOE, EIA. 2001. *Annual Energy Outlook 2002,* Tables A-2, A-3.

10. “Primary energy” consists of the sum of “site energy” (the energy directly consumed by end users) and the energy consumed in the production and delivery of energy products to end users, available at http://www.eia.doe.gov/emeu/consumptionbriefs/cbecs/cbecs_trends/primary_site.html.

11. U.S. DOE, EIA. 2001. *Annual Energy Outlook 2002,* Figure 80.

12. U.S. DOE, EIA. 2001. *Annual Energy Review 2000,* Table 1.3.

13. U.S. DOE, EIA. 2000. *Annual Energy Outlook 2001,* p. 49.

14. U.S. DOE, EIA. 2001. *Annual Energy Review 2000,* p. 217.

15. In addition to CO_2 emissions, energy production and use contribute two other GHGs: methane (CH_4) primarily from natural gas systems and coal mining, and nitrous oxide (N_2O) from fuel combustion. There are opportunities to remove CO_2 from the atmosphere and store it as carbon in forests and soils. It is not possible to utilize this mechanism on a scale to prevent climate change, but it can be part of the solution to deal with GHG emissions.

16. Although CO_2 makes up the lion’s share of U.S. GHG emissions, other gases also play a role in enhancing the greenhouse effect. Non-CO_2 GHGs account for roughly 18 percent of the global warming potential of U.S. GHG emissions. Some of them have a very weak effect; options to control GHG emissions have focused on the five with the strongest impact. CH_4 and N_2O are created through decomposition, chemical processes, fossil fuel production and combustion, and many smaller sources. Sulfur hexafluoride (SF_6) is used as an insulating gas in large-scale electrical equipment. The remaining two are hydrofluorocarbons (HFCs) used as refrigerants and perfluorocarbons (PFCs) released during aluminum smelting and used in the manufacture of semiconductors. Their global-warming-potential-weighted emissions are as follows: CH_4, 9 percent; N_2O, 5 percent; HFC/PFC/SF_6, 2 percent (with an additional 2 percent CO_2 from non-combustion sources).

17. U.S. DOE, EIA. 2001. *Emissions of Greenhouse Gases in the United States 2000,* pp. 25-26.

18. These figures combine utility and non-utility generation, and attribute all emissions from industrial cogeneration to electric utilities (i.e., the thermal component is not attributed to industrial emissions). See footnotes 21, 22, and 24 of U.S. DOE, EIA 2000 for additional explanation.

19. A forthcoming Pew Center report will focus on the importance of timing in capital stock turnover decisions. See Lempert, R., et al. *Capital Cycles and the Timing of Climate Change Mitigation Policy* (forthcoming).

20. Jaffe, A.B., R.G. Newell, and R.N. Stavins. 2001. "Energy Efficient Technologies and Climate Change Policies: Issues and Evidence." In *Climate Change Economics and Policy: an RFF Anthology.* M. Toman, ed. Resources for the Future.

21. General Motors Corporation, *et al.* April 2001. Executive Summary Report: *Well-to-Wheel Energy Use and Greenhouse Gas Emissions of Advanced Fuel/Vehicle Systems - North American Analysis,* Vol. 1 (Draft Final).

22. Even when oil prices are influenced by policy, EIA predicts very little impact on U.S. CO_2 emissions. According to Table C19, p. 205 of *Annual Energy Outlook 2002,* world oil prices could vary between about $17 and $30 per barrel and U.S. CO_2 emissions in 2010 and 2020 would differ by about 1 percent.

23. Estimates of the peak production rates of Arctic National Wildlife Refuge (ANWR) production, for instance, are less than one million barrels per day. While potentially significant relative to current U.S. consumption of about 20 million barrels per day, it is a small addition relative to the projected world consumption of 117 million barrels per day in 2020.

24. U.S. DOE, EIA. 2001. *Annual Energy Outlook 2002,* pp. 137, 143, 146.

25. Id., p. 143.

26. While most of the natural gas imported into the United States comes from Canada, 0.7 percent of the natural gas used in the United States takes the form of LNG (projected to increase to 2.4 percent by 2020) and some of that LNG is imported from relatively unstable countries. U.S. DOE, EIA. 2001. *Annual Energy Outlook 2002.*

27. Tobin, J. October 2001. *Natural Gas Transportation – Infrastructure Issues and Operational Trends* (U.S. DOE, EIA, Natural Gas Division).

28. U.S. DOE, EIA. 1998. *Natural Gas 1998: Issues and Trends,* pp. 126-127. See also, Gas Research Institute. August 1998. *GRI Baseline Projection of U.S. Energy Supply and Demand 1999 Edition,* p. 44.

29. U.S. DOE, EIA. 2000. *U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves 1999 Annual Report.* DOE/EIA-0216(99), pp. 34-35.

30. For comparisons of natural gas production and prices under different scenarios of technological advancements, see U.S. DOE, EIA. 2001. *Annual Energy Outlook 2002,* p. 224, Table F-10.

31. U.S. EPA. Landfill Methane Outreach Program, available at http://www.epa.gov/lmop.

32. There currently is no worldwide market for natural gas due to delivery constraints (notwithstanding some shipments of LNG in a few regions) and thus North American natural gas production rates can significantly alter North American prices and consumption.

33. By comparison, integrated gas combined cycle (IGCC) technology lowers CO_2 per kWh by about 20 percent relative to pulverized coal.

34. This statistic is based on the following engineering calculation: Assume (A) 10 percent CO_2 reduction = 561 $MMTCO_2$; (B) the emissions per unit output of new combined cycle gas units are 0.8 lb. CO_2 / kWh; and (C) the emissions per unit output of coal units are 2.1 lbs. CO_2 / kWh.

35. See 42 U.S.C. §§ 8301 et seq.

36. See U.S. EPA, Office of Air and Radiation. March 1999. *Analysis of Emission Reduction Options for the Electric Power Industry* U.S. EPA; U.S. DOE. December, 2000. *Analysis of Strategies for Reducing Multiple Emissions from Power Plants: Sulfur Dioxide, Nitrogen Oxides and Carbon Dioxide.* Report # SR/OIAF/2000-05; U.S. DOE, EIA. 2001. *Analysis of Strategies for Reducing Multiple Emissions from Electric Power Plants: Sulfur Dioxide, Nitrogen Oxides, Carbon Dioxide, and Mercury and a Renewable Portfolio Standard.* Report # SR/OIAF/2001-003.

37. U.S. DOE. 2001. *Analysis of Strategies for Reducing Multiple Emissions from Electric Power Plants: Sulfur Dioxide, Nitrogen Oxides, Carbon Dioxide, and Mercury and a Renewable Portfolio Standard.* Report # SR/OIAF/2001-003, pp. 37-38.

38. A nuclear facility is "uprated" when the Nuclear Regulatory Commission (NRC) approves an amendment to its license authorizing the facility to increase its output of energy. NRC will authorize an uprating only when the facility owner demonstrates that the facility can increase its output while continuing to comply with environmental and safety safeguards.

39. The Price-Anderson Act provides nuclear plant owners indemnification for liability arising from nuclear accidents. See 42 U.S.C. §2210. Reauthorization is necessary only to cover new plants; existing plants are covered under current law.

40. There are proposals under consideration to build significant new hydroelectric projects in Canada. There is also some potential for increasing output at existing hydroelectric facilities and installing generating equipment at existing dams without hydropower capability.

41. U.S. DOE, EIA. 2001. *Annual Energy Outlook 2002,* p. 79.

42. Energy Policy Act of 2002, H.R. 4 (Engrossed Amendment as Agreed to by Senate), 107th Cong. §264.

43. See U.S. DOE, EIA. 2002. *Impacts of a 10 Percent Renewable Portfolio Standard,* SR/OIAF/2002-03, p. 13.

44. Dixon, Robert K., Deputy Assistant Secretary, Office of Power Technologies, U.S. DOE. 2001. "Wind Power: Increasing Energy Supply, Providing Rural Economic Development, and Protecting the Environment." Presented at an Environmental and Energy Study Institute briefing, Russell Senate Office Building, June 27, 2001.

45. U.S. DOE, EIA. 2001. *Annual Energy Review 2000,* Table 8.2.

46. U.S. DOE, EIA. 2001. *Annual Energy Outlook 2002,* Tables A8 and A17.

47. Clean Energy Blueprint (Union of Concerned Scientists, 2001), available at http://www.ucusa.org.

48. "Heat rate" is defined as the ratio of fuel input to electricity output (a measure of the efficiency of converting fuel into electricity) normally expressed in terms of Btu per kilowatt hour. A lower heat rate represents more efficient generation.

49. U.S. DOE, EIA. 2001. *Annual Energy Outlook 2002,* p.75.

50. See U.S. DOE. 1999. *Supporting Analysis for the Comprehensive Electricity Competition Act,* DOE/PO-0059, pp. 16-19; U.S. DOE, Office of Policy, and L. Goudarzi and B.F. Roberts, *Efficient Heat Rate Benchmarks for Coal-Fired Generating Units* (1998 Draft, Economic Sciences Corporation/OnLocation, Inc.), available at www.econsci.com.

51. Combined heat and power (CHP) is the production of electricity and useful thermal energy (steam, hot water, or chilled water) at the same location. CHP can produce significant efficiency gains, cost savings, and CO_2 emissions reductions compared with providing the same amount of energy and power using separate systems.

52. See http://www.buildinggreen.com/products.

53. Swisher, J. *Cleaner Energy, Greener Profits: Fuel Cells as Cost-Effective Distributed Energy Resources,* available at http://www.rmi.org.

54. EPRI. 2001. *The Western States Power Crisis: Imperatives and Opportunities.*

55. Cost assumptions: 60 percent combined cycle @3.5¢ kWh + 40 percent peaks @$200/kW, 20 percent annual capital cost. 60 percent of kW represent energy savings @ 1000 #CO2/MWH.

56. U.S. DOE, EIA. 2001. *Annual Energy Outlook 2002,* Tables A4 and A5.

57. For example, in 1999, President Clinton directed each federal agency to reduce the GHG emissions associated with facility energy use by 30 percent by 2010, compared to such emissions levels in 1990. See Executive Order No. 13, 123, 64 Fed. Reg. 30,851 (June 8, 1999).

58. Kubo, T., H. Sachs, and S. Nadel. 2001. Opportunities for New Appliance and Equipment Efficiency Standards. In *American Council for an Energy-Efficient Economy* Report #AO16, p. 5 (September 2001).

59. The Federal Energy Star™ program steers consumers to energy-efficient products by awarding a government "Energy Star" label to such products. To earn an Energy Star™ label, a product typically must be in the upper quartile of its product class in terms of energy efficiency.

60. Some service providers have offered to go even further, providing fuel (such as natural gas), new boilers, chillers, and water and electric services.

61. The Public Utility Regulatory Policies Act, for instance, requires state utility commissions to conduct a proceeding to consider adopting federal standards on ratemaking and other utility issues. See 16 U.S.C. §§2621-2627.

62. Combined heat and power is addressed in Section V in the discussion of electricity.

63. U.S. DOE, Office of Policy and International Affairs. 1996. *Policies and Measures for Reducing Energy-Related GHG Emissions: Lessons Learned From Recent Literature.* Technical Document DOE/PO-0047.

64. U.S. DOE, EIA. 2001. *Annual Energy Outlook 2002,* p. 66. The balance of the projected decline in energy intensity is due to structural shifts within the industrial sector.

65. American Forestry Association. 1998. *The U.S. Forest Products Industry and Climate Change,* p. xxii.

66. Engineering calculation derived from U.S. DOE and EPA. July 2000. *CO_2 Emissions from the Generation of Electric Power in the U.S.,* p. 2.

67. U.S. DOE, EIA. 2001. *Annual Energy Outlook 2002,* p. 97 (CO_2 emissions from the transportation sector are projected to increase at a rate of 1.9 percent).

68. National Research Council. 2002. *Effectiveness and Impact of Corporate Average Fuel Economy Standards,* p. 67, Tables 4-2 and 4-3.

69. Id., p. 20.

70. Id., pp. 63-4.

71. The "gas guzzler" tax is set forth in the Internal Revenue Code, at 26 U.S.C. §4064. Under this provision, sales of cars achieving less than 22.5 miles per gallon are subject to a sliding scale of tax charges, ranging from $1,000 for cars achieving 21.5 to 22.5 miles per gallon to $7,700 for cars achieving less than 12.5 miles per gallon. The effectiveness of the gas guzzler tax in spurring further improvements in fuel efficiency is limited. First, light-duty trucks are exempt from the tax. Second, the tax applies to relatively few cars; in 2000, only one percent of all cars sold achieved less than 21.4 miles per gallon. See National Research Council. 2002. *Effectiveness and Impact of Corporate Average Fuel Economy Standards,* p. 21.

72. The safety implications of changes in vehicle weight are complex. Making sport utility vehicles lighter, for example, could enhance overall safety. See id., pp. 69-77 and 117-124.

73. For a discussion of the "well-to-wheel" GHG implications of various transportation fuels, see General Motors Corporation, et al. April 2001. *Well-to-Wheel Energy Use and Greenhouse Gas Emissions of Advances in Fuel/Vehicle Systems.*

74. Dunn, S. 2001. *Hydrogen Futures: Toward a Sustainable Energy System.* Worldwatch Institute, pp. 47-48.

75. Id., p. 54.

76. Schaper, V. and P. Patterson. February 1998. *Factors That Affect VMT Growth.*

77. Vehicles that are constantly stopping and starting in response to traffic conditions are less efficient and therefore emit more tons of GHGs than vehicles that are maintaining constant speeds.

78. See U.S. Department of Transportation, Office of Technology Assessment. *Saving Energy in U.S. Transportation. 1994.* OTA-ETI-589, pp. 254-255. Truck-related energy use and emissions can be reduced by shifting certain kinds of freight onto trains, such as high-density commodities (e.g., coal and grain) that need to be transported long distances. One of the few identifiable market barriers to moving more such freight onto rails would be excessive delays at terminals. The OTA report notes: "Many terminals are located in urban areas, are too small for the volume of traffic, and are difficult for trucks to access. Infrastructure changes, such as truck-only access roads from highways to intermodal terminals, or relocating terminals outside of urban areas, could be considered."

79. National Research Council. 2002. *Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards,* available at http://www.nap.edu/books/0309076013/html/.

80. Interlaboratory Working Group. November 2000. *Scenarios for a Clean Energy Future.* ORNL/CON-476 and LBNL-44029.

notes

This report examines a number of "climate-friendly" energy policy options for the near term—that is, policies that would advance U.S. energy policy goals during the next few decades while contributing to efforts to curb global warming. The Pew Center on Global Climate Change was established by the Pew Charitable Trusts to bring a new cooperative approach and critical scientific, economic, and technological expertise to the global climate change debate. We intend to inform this debate through wide-ranging analyses that will add new facts and perspectives in four areas: policy (domestic and international), economics, environment, and solutions.

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