DOE/S-0124

Comprehensive National Energy Strategy

National Energy Policy Plan

Pursuant to Section 801
of the Department of Energy Organization Act

Washington, D.C.
April 1998

Advance Copy

Message from the Secretary of Energy

I am pleased to convey the Department's Comprehensive National Energy Strategy, pursuant to Section 801 of the Department of Energy Organization Act. This Strategy is the result of an interaction among the Department of Energy, other Federal agencies, and the public at large through the hearing and comment process.

There are compelling reasons for a new and comprehensive energy strategy at this time. First, energy plays a vital role in our economy — accounting for over 7 percent of our gross domestic product, or about $2,000 annually for every man, woman, and child in the United States. In addition, energy is big business. The global market for energy supply equipment alone in 1996 was over half a trillion dollars.

Second, our national security depends on affordable and abundant supplies of energy. Under every conceivable scenario projected by energy analysts, natural gas and oil will remain a central part of our Nation's energy future. As the world demand for oil grows, the United States does not want to rely on any particular region of the world for imported oil. Moreover, our own dependence on imported oil is expected to grow from 50 percent today to 60 percent by 2010.

Third, we recognize that the environmental effects from production and use of energy are significant. On a local level, we know that fossil fuel use is associated with regional haze and smog. On a global scale, many experts believe that human activities associated with energy production and use have significantly altered the composition of atmospheric gasses.

Lastly, the U.S. economy still has ample opportunity to make further progress in the way we supply and use energy. Good public policy demands that we use our vital energy resources as wisely as possible.

We are at a historic moment when we have the flexibility to develop our responses to the energy challenges we see. We are not facing an immediate crisis. Our economy is doing well. Energy supplies seem ample. The environment is steadily improving. Our Comprehensive National Energy Strategy is a forward-looking effort that seeks to address the major energy challenges facing the Nation and to provide the basis for guiding and directing future action. The Strategy is based on five common-sense goals:

- Improving the efficiency of our energy system — for example, by widely deploying new technologies to make more effective use of our energy resources.
- Ensuring against energy disruptions by reducing the threat of supply interruption and increasing the security and reliability of our energy infrastructure.
- Promoting energy production and use in ways that protect our health and environment.
- Expanding future energy choices through wise investments in basic science and new technologies.
- Cooperating internationally on energy issues to help develop the means to address global economic, security, and environmental concerns.

This Strategy is the beginning of what I believe is a journey toward energy security, economic expansion, and protection of our environment. We have constructed this Strategy so the American people can track and measure our progress as we develop and implement steps to achieve our goals.

I believe you will find this new energy strategy innovative and in the best interests of the American people. I welcome your support.

Federico F. Peña
Secretary of Energy

Contents

Foreword

When the Department of Energy was created in 1977, the law required that a "National Energy Policy Plan" be regularly submitted to Congress. The President, the Department, the Congress, and the American people have all found this regular planning process useful, not only when energy prices have skyrocketed, as was the case when the first policy plan was due in 1979, but also in times like today, when energy supplies are abundant and affordable. Although there appears to be no energy crisis now, serious energy issues remain to be addressed to ensure that the Nation's current and future energy requirements can be met in a way that continues to grow the economy while improving protection of the environment and the health and safety of the American people.

This Comprehensive National Energy Strategy sets forth a set of five common sense goals for national energy policy [see box on next page]. These goals are further elaborated by a series of objectives and strategies to illustrate how these goals will be achieved. Taken together, the goals, objectives, and strategies form a blueprint for the specific programs, projects, initiatives, investments, and other actions that will be developed and undertaken by the Federal Government, with significant emphasis on the importance of the scientific and technological advancements that will allow implementation of this Comprehensive National Energy Strategy. Moreover, the statutory requirement of regular submissions of national energy policy plans ensures that this framework can be modified to reflect evolving conditions, such as better knowledge of our surroundings, changes in energy markets, and advances in technology. This Strategy, then, should be thought of as a living document.

Finally, this plan benefited from the comments and suggestions of numerous individuals and organizations, both inside and outside of government. The *Summary of Public Comments,* located at the end of this document, describes the public participation process and summarizes the comments that were received.

The Strategy at a Glance

Goal I. Improve the efficiency of the energy system — making more productive use of energy resources to enhance overall economic performance while protecting the environment and advancing national security.

Objective 1. Support competitive and efficient electric systems.
Enact electric utility restructuring legislation, develop advanced coal/gas powerplants, improve existing nuclear powerplants

Objective 2. Significantly increase energy efficiency in the transportation, industrial, and buildings sectors by 2010.
Develop more efficient transportation, industrial, and building technologies

Objective 3. Increase the efficiency of Federal energy use.
Adopt new/innovative energy-efficient and renewable technologies

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Goal II. Ensure against energy disruptions — protecting our economy from external threat of interrupted supplies or infrastructure failure.

Objective 1. Reduce the vulnerability of the U.S. economy to disruptions in oil supply.
Stabilize domestic production, maintain readiness of Strategic Petroleum Reserve, diversify import sources, reduce consumption

Objective 2. Ensure energy system reliability, flexibility, and emergency response capability.
Ensure reliable electricity/gas supply, refining and emergency response

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Goal III. Promote energy production and use in ways that respect health and environmental values — improving our health and local, regional, and global environmental quality.

Objective 1. Increase domestic energy production in an environmentally responsible manner.
Increase domestic gas production, recover oil with less environmental impact, develop renewable technologies, maintain viable nuclear option

Objective 2. Accelerate the development and market adoption of environmentally friendly technologies
Increase near-term deployment, expand voluntary efforts, design domestic greenhouse gas trading program, work with developing countries, design international trading/credit system

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Goal IV. Expand future energy choices — pursuing continued progress in science and technology to provide future generations with a robust portfolio of clean and reasonably priced energy sources.

Objective 1. Maintain a strong national knowledge base as the foundation for informed energy decisions, new energy systems, and enabling technologies of the future.
Pursue basic research, including research on carbon/climate; support energy science infrastructure

Objective 2. Develop technologies that expand long-term energy options
Develop long-term options, such as fusion, hydrogen-based systems, and methane hydrates, that can have major impacts

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Goal V. Cooperate internationally on global issues — developing the means to address global economic, security, and environmental concerns.

Objective 1. Promote development of open, competitive international energy markets, and facilitate the adoption of clean, safe, and efficient energy systems.
Encourage adoption of favorable legal/policy framework in other countries, promote clean/efficient energy systems and science/ technology collaboration

Objective 2. Promote foreign regional stability by reducing energy-related environmental risks in areas of U.S. security interest
Prioritize concerns and develop cost-effective solutions

Comprehensive National Energy Strategy

Energy — the Economy's Lifeblood

Americans share a desire for a high quality of life, characterized by good health, prosperity, security, and a clean environment. Government seeks to create conditions where these shared dreams have the greatest chance of being realized. Good energy policy can help us achieve each of these facets of the American dream.

Energy is the lifeblood of modern economies. It powers our factories, heats and cools our homes, and moves people and goods — all with the flick of a switch or the turn of an ignition key. The lifestyle U.S. citizens enjoy, the envy of much of the world, was built in large measure on reliable, affordable energy supplies.

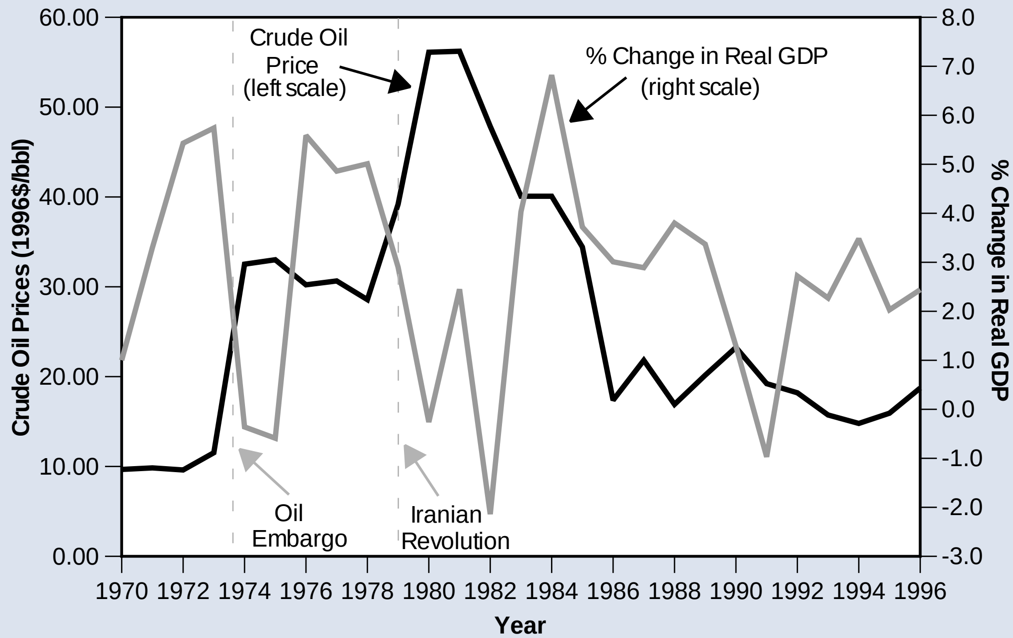
Energy is a global commodity. The price and availability of energy resources in one region can have global implications. Complacency about energy availability was shaken during the economic recessions that followed the two oil shocks experienced in the 1970s. The 1973 oil embargo and the 1978 Iranian Revolution showed how events thousands of miles away and largely outside U.S. control can disrupt our daily lives through impacts on energy markets and our national economy. In general, rising energy prices have tended to be associated with the onset of subpar economic performance [Fig. 1]. More recently, Operation Desert Shield/Desert Storm in 1991 provided a vivid reminder that energy security cannot be taken for granted.

The 1970s also witnessed broad recognition of the environmental consequences of energy use, such as urban smog and acid rain. New laws were enacted to counter the pollution from energy production and use. These were effective in lowering emissions and improving health, yielding substantial benefits that far exceed the incurred costs. This period also saw the dawning realization that greenhouse gas emissions from fossil fuel use could have global environmental implications.

During the late 1970s, it became apparent that the decades-old regulation of many energy prices was counterproductive and that the Nation should pursue market-oriented approaches to energy supply and use wherever possible. A consensus developed that competitive markets should be the cornerstone of a successful energy policy, but also that markets alone cannot be relied upon to achieve all of society's economic, environmental, and security goals because these societal benefits often are overlooked by the private sector.

The role of government in energy is now focused on the important tasks of improving the operation of competitive markets and addressing the market's inherent limits. This combined approach allows markets to be the key determinants of supply and demand, while government supplements market

Figure 1
Relationship of world oil prices and U.S. gross domestic product (GDP), 1970–1996



Source: Energy Information Administration, *Annual Energy Review 1996*, Table 1.6 (GDP values originally published by U.S. Department of Commerce).

International events outside our control have caused sharp increases in energy prices, which in turn have been followed by slowdowns in the U.S. economy.

forces through policies that bolster energy security and provide for a cleaner environment.

In this context, the Federal Government focuses on augmenting energy security by maintaining the Strategic Petroleum Reserve, coordinating emergency responses with our allies in the International Energy Agency, promoting increased domestic oil and gas production and use of alternative fuels, and maintaining military preparedness. The Federal Government also seeks to encourage favorable conditions in energy-producing regions of the world to facilitate access of all oil and gas resources to global energy markets. The Government reduces negative environmental effects by regulating pollution, limiting access to environmentally sensitive public lands and waters, and setting standards for energy use in consultation with the private sector. And the Government ensures the flow of new and cleaner energy technologies by funding energy research, development, and demonstration, often in concert with the private sector. Ultimately, the continued development of new technologies that provide diverse energy sources, improve the efficiency of end-use, and reduce the negative environmental effects of energy production and use is the key to maintaining our high quality of life.

Each day, most Americans depend on the benefits of energy, without always being aware of the role it plays in sustaining the quality of our lives. But this is not the case for many low-income households. While an average American family spends less than 5 percent of its income on household energy, poor families spend more, about 15 percent of income on home energy needs. This disparity is especially important during periods of energy price volatility. If cold weather and low heating fuel supplies cause heating fuel costs to spike, more affluent households can afford the increased cost. However, being cold is a possible, or even likely, outcome in low-income households without government action. That is why the Federal Government provides funds to the States during such situations to help low-income families afford basic energy purchases and why it provides funds to weatherize homes to reduce the burden of high energy costs on low-income families.

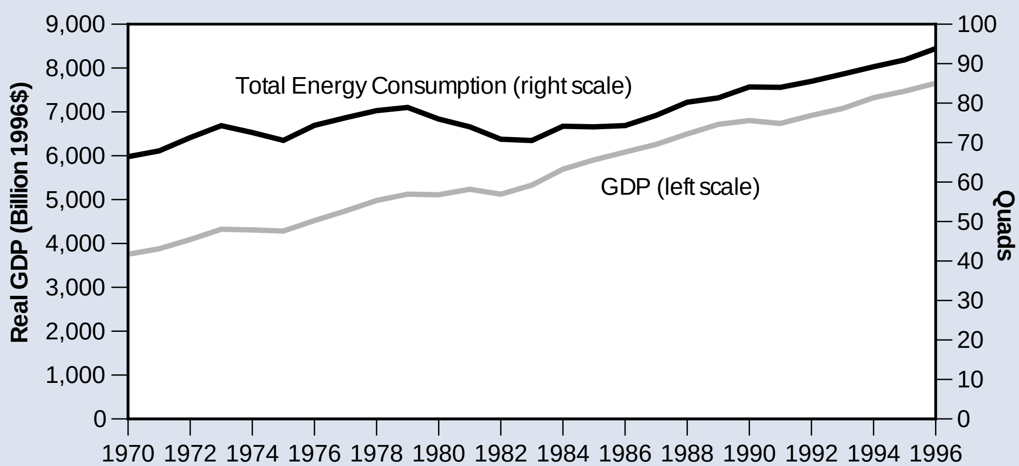
The policy of establishing a relatively circumscribed role for the Federal Government has proven adaptable to changing economic, energy, and environmental circumstances. For example, by the late 1970s and early 1980s, succeeding Administrations allowed the price of oil products to rise as world oil prices increased. This policy encouraged consumers to reduce oil consumption and gave producers incentives to boost production, both here and around the world. From 1975 to 1985, U.S. energy consumption relative to the level of economic activity decreased by about 25 percent; during 1985 alone, Americans saved more than $100 billion (in 1996 dollars) in energy costs thanks to the technological improvements that occurred during this 10-year period. These market adjustments ultimately helped erode the Organization of Petroleum Exporting Countries' (OPEC) monopoly power in oil markets and paved the way for today's lower world oil prices.

The U.S. Energy Landscape

Given the central role of energy in our economy, it is no surprise that U.S. energy consumption has grown with gross domestic product (GDP). From 1970 to 1996, total U.S. primary energy consumption rose by almost 50 percent, from about 66.4 quadrillion Btu (quads) to about 94 quads.[1] In the same time period, GDP more than doubled [Fig. 2]. This energy and GDP relationship reflects improvements in the use of energy in this country as a result of technical progress and changes in the composition of the U.S. economy.

[1]A quad (which is short for 1 quadrillion British thermal units, or Btu) is a convenient, common unit for measuring large amounts of energy derived from different sources or used in different applications. A quad is approximately equal to the heat content in 8 billion gallons of gasoline. The electricity component of end-use energy consumption is accounted for in terms of "primary" energy (the heat content of the fuel burned at the powerplant), not the electrical energy finally "delivered" to the customer.

Figure 2
Energy consumption and GDP, 1970–1996



Source: Energy Information Administration, *Annual Energy Review 1996*, Table 1.6 (GDP values originally published by U.S. Department of Commerce).

While U.S. energy consumption increased by almost 50 percent in the past 25 years, our gross domestic product more than doubled — a clear indication that we are using energy more efficiently.

Energy Consumption

Energy is consumed in the four basic demand sectors of our economy: transportation, industry, residential, and commercial [Fig. 3]. In addition to energy used directly by these sectors, large amounts of energy are used to produce electricity.

Transportation accounts for about 26 percent of our Nation's energy use.[2] The transportation sector accounts for about two-thirds of all petroleum use in the United States.

Industry accounts for about 37 percent of U.S. energy consumption. Industry relies on a mix of fuels to produce a myriad of products and services. Petroleum and natural gas continue to be the major industrial fuels, together accounting for roughly 70 percent of direct consumption. Much of the petroleum consumption in the industrial sector is used as a raw material or feedstock.

The *residential* sector accounts for about 21 percent of total primary energy consumption. About 50 percent of all primary energy consumption in the residential sector is used for heating rooms and water; air-conditioning accounts for about 8 percent of consumption; and major appliances (refrigerators, freezers, stovetops, ovens, washers, and dryers) are responsible for about 17 percent of residential consumption.

The *commercial* sector accounts for about 16 percent of total primary energy consumption. The diversity of building types found in the commercial sector and the variety of functions they perform create a broad range of energy needs.

Energy Supply

America's energy resources are extensive and diverse. Coal, oil, natural gas, and uranium are abundant, and a variety of renewable resources are available in large untapped quantities. The United States produces almost twice as much energy as any other nation, and nearly as much as Russia and China combined. Although our Nation uses most of this energy domestically, it exports considerable amounts of coal, refined petroleum products, and enriched uranium.

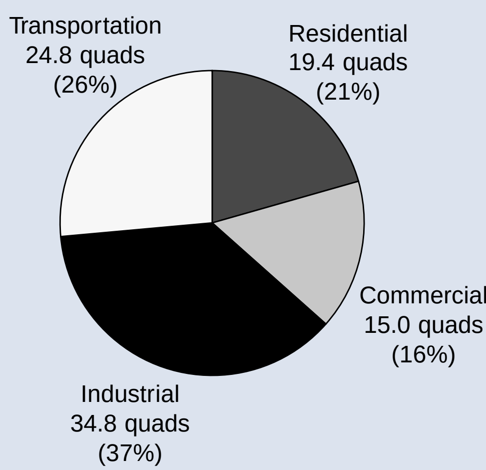
Domestic *oil* production accounts for about 22 percent of U.S. energy production, down from its share of 36 percent in the early 1970s [Fig. 4].

Natural gas accounts for about 27 percent of U.S. energy production. Although natural gas is produced in 33 States, Texas and its neighboring States, combined with the Federal offshore areas of the Gulf of Mexico, account for more than three-fourths of U.S. production.

Coal is the Nation's most abundant fossil fuel resource and accounts for about 31 percent of U.S. energy production. U.S. recoverable reserves of coal are greater than in any other nation, and more than twice those of China, the world's leading coal producer. Every year, the United States produces more than a billion tons of coal and exports roughly one-tenth of this production to a

[2]All statistics on current energy consumption and production are based on Energy Information Administration data for 1996.

Figure 3
Total U.S. energy consumption, by end-use sector, 1996 (total: 94 quads)



Note: Includes electricity generation, transmission, and distribution losses.

Source: Energy Information Administration, *Annual Energy Outlook 1998*, Table A2.

About three-fourths of the energy consumed in the United States is used in buildings and industry.

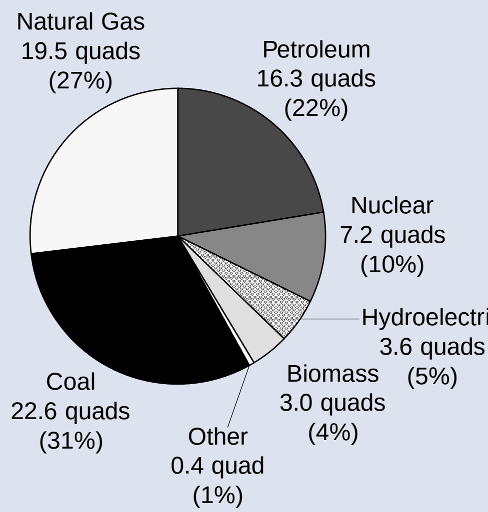
variety of markets. It uses almost 90 percent of the remainder to generate electricity.

Nuclear energy is the second largest source of U.S. electricity, after coal, producing more than 20 percent of our electricity.

Renewable energy includes hydropower, biomass (primarily wood and waste), geothermal, wind, and solar resources. These sources currently provide almost 10 percent of U.S. primary energy production. Although more than half of the U.S. renewable energy produced is used to generate electricity, it is also used for transportation fuels (such as ethanol), and for heating industrial processes (such as wood waste in the paper industry), buildings, and water. Renewable sources of electricity are dominated by conventional hydroelectric power, which provides 80 percent of all renewable electricity and 10 percent of total generation.

Electricity generation represents the conversion of energy from a primary source (fossil fuel, uranium, or renewable forms) into a clean, easily transported, and flexible secondary energy source with innumerable uses. U.S. electricity generation has grown almost every year during the past four decades. The United States is the world's largest producer of electricity, generating more than all of western Europe and Japan combined. More than half of all electricity is generated by burning coal; about one-fifth is derived from nuclear powerplants; renewable resources — primarily hydropower — provide about one-eighth; and the remainder is fueled by natural gas (about 9 percent) and oil (about 2 to 3 percent).

Figure 4
U.S. energy production, by fuel, 1996 (total: 72.6 quads)



Source: Energy Information Administration, *Annual Energy Review 1996*, Table 1.2.

Fossil fuels account for 80 percent of the energy produced in the United States (and 85 percent of the energy we consume).

A Changing Energy World

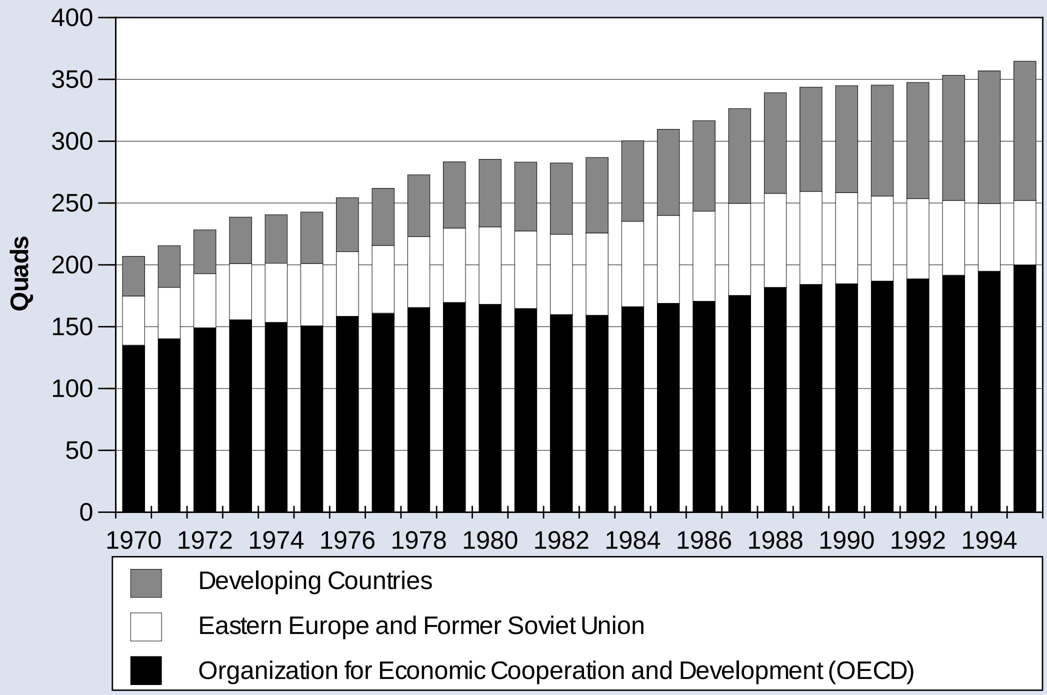
Growing populations and rising living standards, economies in transition to market-based systems, and increasing globalization of energy markets demand greater flexibility and creativity in government economic, environmental, foreign, and national security policies. Energy policies, too, must be reevaluated in the wake of the experiences of the 1990s. Three preeminent challenges emerge: how to maintain energy security in global energy markets; how to successfully harness competition in electricity markets; and how to respond to the threat of climate change.

Global Economic Transformation and Energy Security

The end of the Cold War unleashed market forces in one country after another, and many countries are in the process of transforming cumbersome, government-run energy sectors into private enterprise. Indeed, most of the global energy economy is now directed by market forces, as opposed to government fiat. At the same time, economic policies in the developing world have led to double-digit growth rates, significant increases in energy demand, and substantial inflows of private capital to finance expanding energy sectors. As a result, world energy use has grown and its composition has shifted [Fig. 5].

Projections of brisk growth in world oil demand substantially change the energy security outlook. In oil production, geology

Figure 5
World primary energy use, 1970–1995



Source: Energy Information Administration, *International Energy Annual 1996*, Table E1, and unpublished data.

Although OECD countries still account for more than half of world energy consumption, energy use in developing countries increased by 250 percent during the past 25 years, far outpacing the growth rate elsewhere.

is destiny. Roughly two-thirds of the world's proved oil reserves lie in the Persian Gulf region. Even with development of the resources in the Caspian region, rapid growth in world oil demand will likely be met primarily through growth in Persian Gulf oil exports [Fig. 6]. Excessive reliance on a single geographic area to satisfy increased world demand for oil creates the potential for oil-importing nations to be vulnerable to supply disruptions and price volatility. This risk can be minimized by coordinating policies with our allies in the International Energy Agency and by maintaining or enhancing our Strategic Petroleum Reserve.

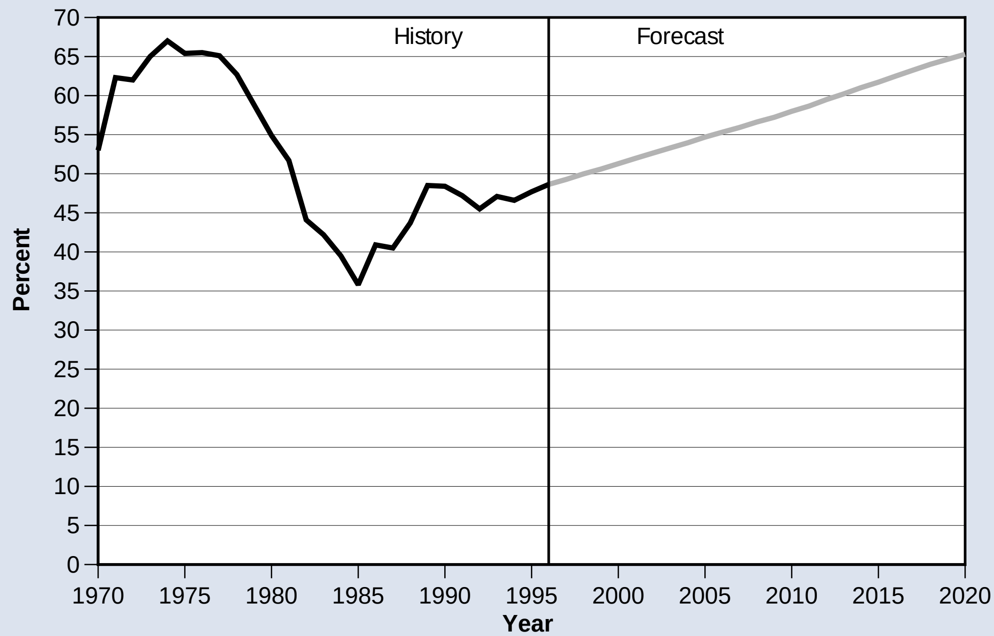
Competition in the U.S. Electricity Market

Closer to home, the success of deregulation in the oil and natural gas industries, along with the consumer benefits flowing from deregulation in other sectors once dominated by regulated monopolies, has prompted consideration of deregulating major portions of the Nation's electric power industry. Federal legislation enacted in the late 1970s and early 1990s has opened the wholesale power-generation sector of this industry to competition, and several States are in the process of implementing competition in retail markets. While a few States with relatively high electricity rates have led the way in aggressively pursuing competition, most States have just begun to examine prospects for competition to lower prices [Fig. 7].

International Response to Climate Change

The 1990s have seen the global climate change debate evolve from an issue discussed largely among scientists to one that engages the collective attention of governments around the world. In December 1997,

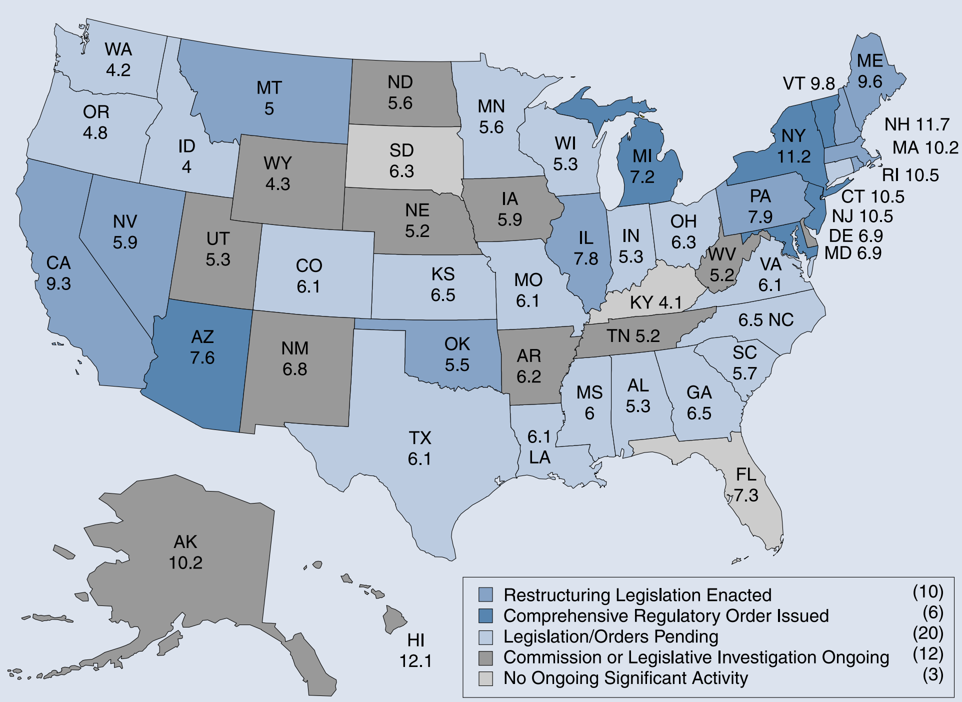
Figure 6
Persian Gulf share of world's oil exports, 1970–2020



Source: Energy Information Administration, *Annual Energy Outlook 1998,* Figure 28.

According to Energy Information Administration projections, oil exporters in the Persian Gulf are on a path to recapturing their historically high share of the world oil market.

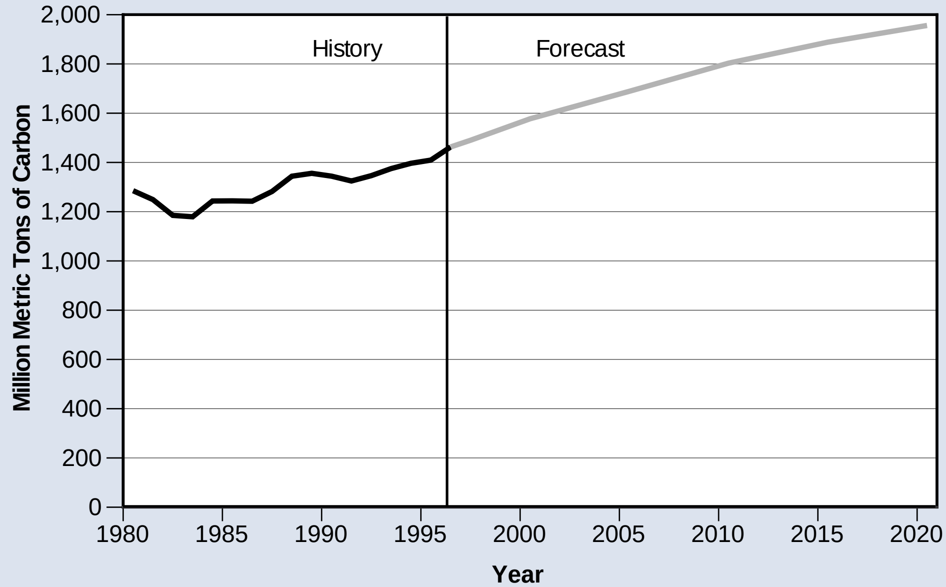
Figure 7
Electric power industry restructuring activities, showing current State average electricity rates (cents per kilowatthour)



Note: Information current as of April 1998.
Source: Energy Information Administration and Energetics, Inc.

Most States are actively pursuing changes that will bring greater competition to the electric power industry — and lower electricity prices to consumers.

Figure 8
U.S. energy-related carbon emissions, 1980–2020



Sources: Historical values are from Energy Information Administration (EIA), *Annual Energy Review 1996*. Forecast values are from EIA, *Annual Energy Outlook 1998,* Table A19 (reference case projection).

Without serious efforts to change our patterns of energy production and use, U.S. emissions of greenhouse gases will continue on a steady upward climb.

the international community negotiated the Kyoto Protocol to the United Nations Framework Convention on Climate Change, which includes targets for developed countries for reducing greenhouse gas emissions. Given that more than 80 percent of human-made greenhouse gas emissions are energy related, and that energy consumption continues to increase, energy policy has a new and demanding role [Fig. 8].

The Kyoto Protocol calls for the United States to reduce its average annual emissions to 7 percent below 1990 levels over the period 2008–2012 (measured net of baseline adjustments for hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, and carbon sequestration). This target entails significant emissions reductions when compared with recent projections, though not all of the reductions will come from energy sectors. Thus, the Kyoto Protocol, if the United States Senate gives its advice and consent to ratification, may set our Nation on a very different course toward an important and challenging goal. Attaining this target while preserving U.S. industrial competitiveness will require a blend of market-oriented policies with structured government involvement. However, the United States will not ratify the Kyoto Protocol without meaningful participation by key developing countries in the global response to the threat of climate change. [See Appendix A for further details on the Kyoto Protocol.]

Energy Technology: The Essential Basis for Progress

Without energy technologies, a ton of coal, a barrel of oil, a cubic foot of natural gas, a ton of uranium ore, a stiff breeze, or the Sun's warmth cannot directly contribute to the prosperity of modern society. With the very best technologies, however, society can use energy resources efficiently and responsibly and with great economic and environmental gain.

While economic and security challenges continue to demand investment in a robust energy research and development (R&D) program, environmental challenges provide special impetus for increased focus on energy-related science and technology during the coming years. Energy use is the principal cause of local and regional air-quality problems, such as the emission of fine particulates and the creation of smog and acid precipitation from nitrogen and sulfur oxides. On a global scale, there is little doubt that human activities associated with energy production and use have, over the last few decades, significantly altered the composition of atmospheric gases. In particular, the concentration of carbon dioxide, a greenhouse gas, has increased by a third over preindustrial levels. Once released, carbon dioxide remains in the Earth's atmosphere for a century or more. The great majority of involved scientists agree that "business as usual" greenhouse gas emissions will lead to significant increases in average global temperature and associated climate changes, although the magnitude and distribution of the ecological and human consequences remain the subject of research and debate. Prudence clearly dictates that new technologies be developed to provide additional options to meet evolving environmental, economic, and security needs.

The imperative for embarking on a strong technology program now is reinforced by recognition of the long periods of time associated with significant change in our energy infrastructure. Research and development itself often takes one or two decades to yield technological breakthroughs. The life expectancy for major energy supply and end-use technologies also extends to many decades. Decisions made every day about energy production and use commit the Nation to a certain energy path for what can be a considerable period of time. To the extent that economically attractive, clean, and efficient technologies are chosen, both the economy and the environment benefit. Thus, a robust energy R&D program is needed to enable us to achieve a healthy and prosperous future.

Over the next 10 to 15 years, advances in energy efficiency offer the greatest opportunity for serving environmental, economic, and national security goals. The scale of potential gains is established by the magnitude of our Nation's total energy expenditures (about $500 billion per year) or of total manufacturing expenditures on energy (about $100 billion per year).

Renewable energy technologies, those that harness the enormous energy available in natural systems, can be expected to make major contributions to our Nation's energy portfolio in coming decades. They will help meet energy needs in transportation, commercial and residential buildings, and industry with limited environmental impact. The scale and timing of market penetration will depend on further technological progress and the evolving regulatory framework. In addition, the continued operation and optimization of existing nuclear powerplants through advanced technologies may be an important contributor to meeting greenhouse gas emission-reduction goals if issues such as nuclear waste disposal and nonproliferation are resolved satisfactorily. In the longer term, fusion energy could also contribute to stabilizing and reducing the atmospheric concentration of greenhouse gases.

Advances spawned through American innovation will range from improvements seen directly in our everyday lives — much more efficient light bulbs, cars, appliances — to new approaches for large baseload energy sources. The Nation must engage the talent in our universities and national laboratories to advance basic science and engineering research and to partner with the private sector to develop and deploy new technologies. This is a central component of a modern, forward-looking energy strategy.

Proposed National Energy Goals

The basic energy policy for the United States in recent years has been to rely on markets to allocate most resources with selective government intervention to ensure that certain highly valued societal needs — including the need for energy security, environmental quality, and energy research — are met. While this general market-based approach to meeting energy challenges has endured, the precise blend of market reliance and government action is subject to substantial debate. The debate stems from different perceptions of market shortcomings and risks, varying degrees of emphasis on specific policy goals, as well as disagreement over the best strategies to be used.

In the past 5 years, the Administration has pursued an energy policy that has provided substantial economic, environmental, and national security benefits for the American public. This policy, however, has been based on a legislative and regulatory framework last revised in the early 1990s. It is now time to take stock of our Nation's energy progress, identify the most substantial challenges that remain, calibrate energy policy goals to the new century, and propose long-term solutions.

In the context of pursuing a market-based energy policy, this Comprehensive National Energy Strategy proposes five specific goals for the Nation. These goals arise out of the shared desires of all Americans to improve the quality of life through higher living standards, economic security, and a clean environment. A common thread running through our national response to these goals is development and deployment of new technology, achieved through basic scientific and engineering advances. While these goals are not new to this Administration, they are linked with specific proposed strategies that reflect the evolving energy environment. The proposed goals are:

- **Improve the efficiency of the energy system** — making more productive use of energy resources in order to enhance overall economic performance while protecting the environment and advancing national security.
- **Ensure against energy disruptions** — protecting our economy from external threat of interrupted supplies or infrastructure failure.
- **Promote energy production and use in ways that respect health and environmental values** — improving our health and local, regional, and global environmental quality.
- **Expand future energy choices** — pursuing continued progress in science and technology to provide future generations with a robust portfolio of clean and reasonably priced energy sources.
- **Cooperate internationally on energy issues** — developing the means to identify, manage, and resolve global economic, security, and environmental concerns.

These goals are interrelated, with tension among some and opportunities for synergy among others. Nevertheless, pursued simultaneously through a comprehensive market-based energy strategy, the attainment of these goals will produce payoffs greater than the sum of their individual components. These goals form a durable framework against which future energy initiatives should be judged to see if they are consistent with the national interest.

The term "comprehensive" in Comprehensive National Energy Strategy does not mean that every program, initiative, and technology that can help meet our national energy goals is included within these pages. Rather, this document is intended to be a blueprint. The Strategy will be used to coordinate energy-related programs, throughout the Administration, that implement the overall energy strategy reflected in these pages. It will specifically be used in developing future budgets, evaluating future legislative initiatives, and managing the Administration's energy-related programs.

Goal I

Improve the efficiency of the energy system — making more productive use of energy resources to enhance overall economic performance while protecting the environment and advancing national security.

To compete successfully in world markets and to improve living standards, the United States must achieve more productive and efficient use of its energy resources, including its electricity infrastructure, its fossil fuel reserves, and its productive capacity for clean, alternative fuels. In addition, the Federal Government must find new ways to buy and use energy. Among other things, these actions also will help reduce reliance on imported oil from unstable regions of the world.

Objective 1. Support competitive and efficient electric systems.

Strategy 1. *Enact legislation to promote the establishment of a competitive electric system with improved environmental performance.* The Administration supports comprehensive legislation that will promote efficiency, increase use of renewable resources, reduce emissions, lower costs for consumers, and allow electricity suppliers to provide value-added services. The existing Federal regulatory framework impedes the evolution of the electric marketplace. It prohibits some desirable actions by regulators and corporate decisionmakers; it requires companies to take some actions that are uneconomic; and it fails to give clear, unambiguous guidance to Federal and State regulators concerning who has authority to do what in an industry that is undergoing significant change. The Administration's Comprehensive Electricity Competition Plan would correct these problems. This plan is summarized in the box on this page.

Strategy 2. *By 2010, demonstrate cost-effective power systems that achieve electrical generating efficiencies greater than 60 percent using coal (compared with an average of 35 percent today) and 70 percent using natural gas (compared with about 50 percent today). Total fuel efficiency will reach 85 percent in combined heat and power applications.* Expanded R&D can accelerate the availability of advanced turbine and fuel cell technologies, which can be combined to raise the efficiency of new gas-fueled powerplants to 70 percent. These technologies can also be combined with advanced coal technology, such as integrated

The Administration's Comprehensive Electricity Competition Plan

The Administration believes that Federal legislation is needed to accelerate and guide the transition of the U.S. electric industry towards greater reliance on competitive market forces. It has issued a Comprehensive Electricity Competition Plan that outlines detailed specifications for provisions that Congress should enact in a single, comprehensive electric bill. The Administration expects that its plan will result in substantial benefits for both the economy and the environment. These benefits include:

- Reduction in the Nation's electric bill by at least 10 percent (or $20 billion per year in current dollars).
- A significant down-payment toward reduction of greenhouse gas emissions, with a 25-million to 40-million metric ton reduction in carbon emissions projected in 2010.
- A substantial increase in the use of nonhydro renewable energy sources by 2010, more than doubling the level of use projected without the plan.

The plan would achieve these benefits by:

- Establishing clear Federal policy support for wholesale and retail competition in the industry.
- Maintaining flexibility for State and local governments to develop approaches to retail competition that reflect unique local conditions.
- Maximizing consumer benefits by providing mechanisms and authorities to ensure that real competition occurs, and by requiring uniform easy-to-understand labeling that will empower consumers to make informed choices.
- Supporting low-income assistance, energy efficiency, renewable energy, and other public benefits through a Public Benefits Fund (PBF) and a Renewable Portfolio Standard (RPS).
- Reducing emissions through competition, which encourages efficiency, green power, and innovative services, and through the PBF and RPS proposals.
- Strengthening electric system reliability while building on the industry's tradition of self-regulation by requiring key market participants (including Federal power systems) to join an organization that would establish and enforce reliability standards subject to the oversight of the Federal Energy Regulatory Commission.
- Clarifying key authorities for Federal and State agencies with respect to governance of the new electricity industry.
- Allowing existing public power facilities used in competitive electricity markets to retain tax-exempt financing.
- Providing trading authority for nitrogen oxide emissions to facilitate cost-effective, market-driven reductions of nitrogen oxides.

The plan removes barriers in existing Federal law that are impeding the transition to competition, already under way. The major provisions of law were crafted in 1935, when competition was not contemplated. Existing laws block economically desirable actions, fail to give adequate guidance to Federal and State regulatory authorities regarding their respective jurisdiction under competition, and fail to give clear policy guidance on many important new questions related to competitive electricity markets.

Cars of the Future

By 2010, you may be driving a car that gets 80 mpg, emits virtually no pollution, has the acceleration, driving range, safety, and other performance characteristics to equal the best of today's cars — and is still affordable.

Such dramatic progress will come from totally reinventing how vehicles are powered, and from the use of advanced lightweight materials and aerodynamic designs in the body and chassis. While the exact layout needs further research, the cars of the 21st century will likely have an electric motor to drive the wheels, with the electric power coming from new powerplants — two promising technologies are an advanced compression-ignition engine combined with batteries, and a space-age device known as a fuel cell.

The design that features an engine and batteries is furthest along. Such vehicles with dual power sources are called hybrid vehicles; the primary power comes from the engine, but the batteries provide extra power acceleration and store any extra electricity generated by the engine. These hybrids will get at least twice the fuel economy of today's cars and have the potential to produce lower emissions. Even higher efficiencies may come from making these hybrid vehicles of new materials, such as carbon fiber composites, that are lighter but stronger than those used today.

Fuel cells require more development but offer additional advantages. Technically, fuel cells are not really engines, since they convert a fuel such as hydrogen directly into electricity without burning it, and the electricity is used by electric motors to power the vehicle. Fuel cells are much more efficient than any engine. They can also use fuels other than hydrogen, converting them into hydrogen while giving off only small amounts of pollutants. With no moving parts, fuel cells are silent and potentially almost maintenance-free.

Both new approaches could be used for a wide range of vehicles — from trucks, buses, and commercial vehicles to passenger sedans and sport utility vehicles. And while lower fuel costs will benefit the owners, the broader national benefits could be even more important. With widespread use, both hybrids and fuel-cell vehicles would reduce urban air pollution and cut dependence on imported oil. Fuel-cell vehicles, for example, are expected to be 70 to 90 percent cleaner than today's cars. When they comprise just 10 percent of the U.S. vehicle fleet, they would reduce oil imports by 130 million barrels per year. Higher efficiencies also translate into lower emissions of carbon dioxide, reducing pressures on the global climate. Moreover, leadership in producing such vehicles, which are expected to be popular around the world, could prove a competitive advantage.

Although several auto companies in the United States and elsewhere have built prototypes of these new vehicles, they are not yet ready for commercial production and need further work. Fuel cells, in particular, must be made smaller, lighter, and less costly. But the pace of development is accelerating. Early in the 21st century, these new vehicles are likely to begin rolling off assembly lines and onto the highway.

combined cycle, to achieve efficiencies of more than 60 percent. Even higher thermal efficiencies — over 85 percent — are possible for manufacturing applications that require both process heat and electricity.

In the nearer future, to meet new air-quality standards for microscopic particulates (PM2.5), enhanced R&D will seek ways to reduce both primary particulate emissions and emissions of sulfur and nitrogen oxides that are precursors to secondary particulate formation in the air. Also included in this effort is development of technologies to meet new standards for ozone and pending standards for visibility and air toxics.

Strategy 3. *Improve the reliability and performance of the operating nuclear plants, which number more than 100, to help meet the Nation's future electrical power needs more efficiently.* U.S. nuclear powerplants should see improvements in operating capacity — as much as 10 percentage points in the next several years (from 76 percent to 86 percent) — with further technological developments. A performance improvement of this amount in the operating plants would offset as much as 10,000 megawatts of new electrical output capacity.

Objective 2. Significantly increase energy efficiency in the transportation, industrial, and buildings sectors by 2010.

Strategy 1. *Develop more efficient technologies for the transportation sector.* The U.S. transportation sector accounts for two-thirds of the Nation's annual oil consumption and depends on oil for 97 percent of its fuel. Current trends in energy demand, particularly for oil, can be significantly altered by developing enabling technology to support commercialization of a personal vehicle capable of three times the fuel efficiency of conventional vehicles by 2010; lighter, cleaner heavy-duty vehicle engines; advanced aircraft engines and airframes; and fuel cells for transportation use by 2005. To ensure that more fuel-efficient vehicles enter the marketplace, the President has proposed tax credits of $3,000 to $4,000 for consumers who purchase advanced-technology, highly fuel-efficient vehicles [see Appendix B]. Research to improve the energy efficiency of other modes of travel is also under way; for example, the Department of Transportation is developing fuel cells for use in marine powerplants. Ways to improve the operation of our transportation system are being developed to reduce traffic congestion on highways and at airports.

Lastly, demand for transportation energy can be fundamentally altered by developing communities that are less dependent on automobiles. Sustainable community development can offer residents a mix of transportation services that make walking, biking, and public transit viable alternatives to drive-alone travel. The Department of Transportation will work with local and State decisionmakers to develop the tools and resources required to encourage pedestrian- and transit-oriented development and the integration of a full range of transportation alternatives.

Strategy 2. *Develop more efficient technologies for the industrial sector.* Industry consumes more than one-third of the energy delivered in the United States. Developing and implementing technology roadmaps (detailed plans for research, development, and deployment of industrial technology) leading to a 25-percent reduction in expected energy consumption of the six most energy-intensive industries in the United States by 2010 is a key element for meeting this objective. These six industries are the forest and paper products, steel, aluminum, metal casting, glass, and chemicals industries, which account for more than half of all manufacturing energy use. Crosscutting technologies such as advanced turbine systems, combined heat and power systems, advanced materials, and sensors and controls will be part of this R&D effort to increase energy savings and industrial productivity. To accelerate their entry into the marketplace, the President has proposed a 10-percent investment tax credit for the pur-

A Tale of Two Houses

Imagine two conventional frame houses, both built onsite. Imagine they look the same and cost the same. One house, however, uses 50 percent less energy and is more comfortable to live in than the other, with no drafts or cold walls yet with better ventilation. The difference is better design, more insulation, better windows, and smaller but more efficient furnaces and air conditioning equipment — what is known in the industry as “best practices.” The more energy-efficient house is clearly a better deal for the home buyer, if requiring a more thoughtful effort on the part of the builder. Nationally, the payoff is even greater — reduced energy needs, less pollution, less waste of materials. Nearly 20 percent of U.S. energy consumption, after all, occurs in the home. Under a joint government-industry program, some 10,000 best-practice homes are to be built in the next few years.

But could houses become even more energy efficient, even more comfortable and convenient to live in? Might the house of the future cut energy use even further, to 25 percent of present levels or less? Building scientists and engineers think it’s possible.

To start with, the house of the future is likely to be designed and oriented on the lot to take full advantage of the Sun — for natural light, for heating, even for generating its own electricity with photovoltaic roof panels. Equally important, the house is likely to benefit from “mass customization” based on computer-aided design tools, so that it meets the needs and tastes of different buyers — who can even “walk through” the house on a computer screen or a virtual reality display before the design is final — yet is optimized as a complete system to make sure components work together and to save costs, energy, and materials.

The house of the future is also likely to be built at least partly in a factory, for better quality control and lower costs, and shipped as modules or large components to the site for quick assembly. Building materials are lighter, stronger, and more environmentally friendly. Paints, wall fabrics, and carpeting do not emit organic compounds.

Advanced high-efficiency lighting is integrated with natural light and appliances with heating and cooling systems. The house might not only generate much of its own electricity — either from photovoltaic roof panels or from fuel cells — but might also sell excess power to the electricity company. The warmth from waste hot water and from stale air flushed by the ventilation system is recaptured, and waste water itself from sinks and showers used for flushing toilets or irrigating the garden.

Sensors throughout the house monitor temperature, humidity, light, and perhaps the presence of people. Smart appliances and house control systems adjust to match the weather, occupancy patterns, or the instructions of their owners, turning on lights when people enter a room or preheating the oven or the jacuzzi in response to a telephone or e-mail signal.

Making all these aspects of the house of the future come together requires more research to reduce costs and efforts to link together the whole chain of suppliers and builders involved in the housing industry. But the technologies already exist, at least in preliminary form. In perhaps a decade or two, look for some radical improvements in what’s offered in new housing developments.

Self-Powered Buildings

Two decades from now, chances are that many office buildings, hospitals, shopping malls, and other commercial buildings will be self-powered, generating most of their own electricity and even selling excess power to the electric company. The technological revolution at the root of this transformation is the fuel cell.

These devices, first used in the space program, are now coming down to earth, with units of the size to power a commercial building already available. Because fuel cells generate electricity by converting natural gas or a similar fuel electrochemically, like a battery, they have no moving parts and are silent. In addition to electricity, they produce heat and hot water and thus could replace furnaces and water-heating equipment. And because they operate onsite, there are no high-voltage transmission losses. Consequently, fuel cells offer significant gains in energy efficiency and major reductions in pollution.

Fuel cells lend themselves to a vision of a distributed power generation system for the United States, one that could significantly reduce the need for new centralized power stations and long transmission lines. With fuel cells installed in or near commercial buildings and as neighborhood powerplants in residential areas, the electrical grid would serve mostly to help redistribute excess power to areas where it is needed.

Based on its experience with fuel cells, Southern California Gas Company says that these devices are especially useful in facilities like hotels and hospitals that require power and hot water at all hours of the day. The water discharged from fuel cells is extremely clean and needs no treatment before use. In one Hyatt facility, a fuel cell provided 20 percent of the hotel's peak electricity needs, 90 percent of its space heating, and some of its hot water.

Fuel cells are still relatively expensive. Improved designs and more automated production techniques will be needed to bring costs down by at least a factor of two before widespread use in buildings is likely. That may happen as soon as the middle of the next decade, technical experts say. Improvements are planned both in the reformer, which converts natural gas to hydrogen, and in the fuel cell itself, which combines hydrogen with oxygen from the air to generate power.

A crucial part of a fuel cell is the electrically conductive material, or electrolyte, in which the chemical process takes place. One current design uses a phosphoric acid electrolyte and achieves efficiencies of about 36 percent, but cells based on several other materials are under development and may achieve efficiencies as high as 50 percent. Overall efficiencies can reach 85 percent when the cell's heat output is also used.

With this potential for efficient, clean, distributed power generation, it is no wonder that fuel cells seem likely to transform the way buildings get their power in the 21st century. Some companies are already talking about units small enough to power individual houses or even cars (see *Cars of the Future* on page 12).

chase of combined heat and power systems [see Appendix B]. In addition, government-industry cooperation helps to save energy with the Motor Challenge program, Climate Wi$e program, and others. These efforts help ensure the use of best-practice technologies and provide a more receptive market for advanced energy-efficiency technologies.

Strategy 3. *Develop more efficient technologies in the buildings sector.* America's buildings, including heating and cooling equipment, lighting, and appliances, consume 37 quads of energy each year, accounting for 39 percent of the Nation's energy bill. By 2010, research, regulation, and technology transfer — in partnership with industry, the research community and State and local entities — can save 2 quads annually, partly through avoiding the need for 150 billion kilowatthours of electricity and partly through savings in natural gas. These partnerships can encourage innovation in building design and energy technologies and deployment of efficient technologies, with an emphasis on effectively integrating all elements of building energy use. In addition, building-sector partnerships can contribute to the development of more cost-effective national standards and improved test procedures for energy-consuming appliances and equipment. To spur the use of more energy-efficient technologies in the buildings sector, the President's proposed tax program includes a 20-percent credit (subject to a cap) for purchasing energy-efficient building equipment and a $2,000 credit for purchasing energy-efficient new homes [see Appendix B]. Also, government-industry cooperation helps consumers purchase energy-efficient appliances and equipment through labeling and the Energy Star program.

Objective 3. Increase the efficiency of Federal energy use.

Strategy 1. *Improve the efficiency of energy use in Federal buildings.* Executive Order 12902 calls for reducing energy use in Federal buildings by 30 percent by 2005, compared to 1985 levels. Since 1985, Federal energy consumption has declined by almost 24 percent. However, as the Nation's largest single energy user, the Federal Government still spends roughly $8 billion each year on the energy required to operate its facilities, vehicles, and industrial equipment. Federal leadership in developing the technical expertise, procurement practices, and financing mechanisms to improve the efficiency of Federal buildings contributes to national energy savings. The establishment of regional, streamlined energy savings performance contracts allows Federal agencies to improve energy efficiency through private-sector investment mechanisms under which initial installation costs are covered by future energy cost savings.

Strategy 2. *Provide Federal technical support and leadership in adopting energy-efficient and renewable technologies.* Procurement mechanisms that enhance Federal agencies' access to "lean, clean, and green" products can accelerate widespread adoption of newer technologies by providing demonstrations of enhanced performance.

Goal II

Ensure against energy disruptions — protecting our economy from external threat of interrupted supplies or infrastructure failure.

Enhancing the security of global and domestic energy markets is one of the best bulwarks against threats to our Nation's continued economic prosperity. Disruptions in world oil markets have contributed to several economic slowdowns since the early 1970s. Although we have made significant progress toward reducing our vulnerability, there are signs that this vulnerability could increase in the future. The Administration will continue a strong emphasis on emergency preparedness efforts, a renewed emphasis on the stabilization of domestic oil production, and an increased attention to the security of domestic energy systems and related parts of the Nation's critical infrastructure. Actions taken to improve the efficiency with which energy is used will help achieve this goal as well.

Objective 1. Reduce the vulnerability of the U.S. economy to disruptions in oil supply.

Strategy 1. *By 2005, stop the decline in domestic oil production.* By developing improved reservoir imaging technologies to locate oil in deeper and more complex reservoirs, advanced extraction technologies to boost recovery from mature reservoirs, and environmental technologies to reduce the cost of regulatory compliance, this effort will boost domestic production. Working with industry partners, the effort will develop improved delivery and storage technologies to help ensure a safe, reliable, and cost-effective supply of petroleum products. The Department of Energy will support environmentally responsible development of leased Federal lands for oil recovery. The Department and other Federal agencies will expand collaborative efforts with States to ensure that Administration energy, Federal land management, and environmental policies all adequately protect the environment, but also are consistent and avoid duplicative and unnecessary regulations.

Strategy 2. *Maintain readiness to address threats and disruptions to world oil supplies.* Working with Congress to maintain the existing Strategic Petroleum Reserve sites and inventory in drawdown-ready condition, together with making investments in drawdown capability, provides a credible deterrent to international oil disruptions and may mitigate economic impacts should such disruptions occur. Investments include completing, by fiscal year 2000, the Life Extension Program to extend the life of this equipment through 2025.

The Strategic Petroleum Reserve is part of a larger effort to coordinate responses to petroleum supply disruptions with U.S. allies through the International Energy Agency. The member countries, at the urging of the United States, have evolved a consensus

Scanning the Earth for Oil

Like doctors using CAT scans to look inside the brain, petroleum geologists use computers and seismic data to look deep within the Earth for likely pockets of oil or natural gas. And just as a three-dimensional (3–D) CAT scan image is assembled from many separate x rays, 3–D seismic images assembled from many seismic snapshots are now a standard tool in the oil industry — one that has made it possible to recover more of the oil in the ground.

Now a new seismic technique is creating a stir. Known as 4–D seismic, it allows petroleum geologists to track the movement of oil or gas over time within a reservoir. The new technique compares several different 3–D seismic surveys taken at different times to add a time dimension to the geologic portrait. Developed by a consortium of scientists at Columbia University and five other academic institutions with support from the oil industry and the Department of Energy, the powerful new method can even synthesize seismic data that are gathered with different methods or not perfectly matched.

When the method was applied to the largest oil field in the Gulf of Mexico, near Eugene Island, it showed the drainage of the field over time, except for one intriguing situation. The 4–D seismic picture showed an area within the reservoir where no depletion was occurring, despite recovery from nearby wells. Suspecting that the anomaly represented an untapped pocket of oil, the companies drilled a well into it and hit paydirt — an estimated 2 million barrels of additional oil.

The prospect of finding such overlooked pockets, especially in existing oil fields that already have production facilities in place, is "like winning the lottery," as one expert put it. Use of the 4–D technique is spreading rapidly, the number of oil fields employing it doubling every year. Moreover, experts expect this new seismic tool to increase the amount of U.S. oil and gas ultimately recoverable from the ground by as much as 7 to 10 percent — boosting domestic reserves.

Engineering advances also promise to boost the amount of oil ultimately produced from below. Directional drilling rigs propel the drill bit with a motor inside the pipe itself, deep underground; unlike conventional drill strings propelled from the top, directional drilling equipment can turn 90 degree angles or even drill horizontally. New sensors enable drills to reach a precise location in an oil field even several kilometers from the wellhead.

Even more futuristic is the equipment being developed to exploit the oil industry's last great frontier — sea-floor deposits of oil and gas that lie beneath more than a kilometer of ocean. To get at these deposits, the oil industry is developing remotely controlled robot submarines that operate on the sea floor to install and service wellhead production equipment and undersea pipelines hundreds of kilometers long.

Taken together, these new tools may help to prolong domestic oil and gas production for years to come, helping us to increase domestic oil production and reduce U.S. vulnerability to interruptions in imports of foreign oil.

agreement that the proper role of governments is to let free markets balance supply and demand for oil in an emergency, and that the governments should supplement supply early in emergencies from strategic reserves. Acting together, the nations of the IEA could inject 4 million to 5 million barrels per day of oil from their reserves into the market while other action is taken to address the cause of the disruption. Efforts should be made to expand IEA membership to broaden the scope of participation.

Strategy 3. *Diversify sources of oil available to world oil markets.* By working with industry to increase sources of oil available on the world market, the Department of Energy, together with other Federal agencies, can enhance U.S. energy security and global energy security at the same time. Working to open more sources of oil in other regions of the world can reduce the adverse economic impacts that might be brought on by a cut in supply in any one region.

Of particular importance to the expansion of world oil supply sources is the Administration's work in the Caspian and central Asian region, home to large, still-to-be-developed reserves of oil and gas. While the actual extent of Caspian region oil and gas reserves (excluding Russia and Iran) is not yet definitely known, most observers believe the region could hold oil reserves in the range of 100 billion to 200 billion barrels and gas reserves of 300 trillion to 600 trillion cubic feet. The Administration is working to encourage the countries of that region to adopt open, fair, and transparent investment regimes that will create a favorable climate for U.S. companies to participate directly in the development of the region's energy resources. The Administration is also working with the countries of the region to develop multiple transportation options for moving the region's oil production out into world markets.

Currently, more than half of U.S. petroleum imports come from sources within the Western Hemisphere, and the Administration is working to deepen energy cooperation in this area. The Secretary of Energy co-chairs, with his Venezuelan counterpart, a Summit of the America's "Regional Energy Cooperation" initiative that opens an important avenue of dialog on energy with our hemispheric neighbors.

Strategy 4. *By 2010, develop technology options to help reduce expected oil consumption by at least 1 million barrels per day.* The development of light-duty vehicles with higher fuel economy, new technologies to provide increased production of transportation fuels from biomass and natural gas, increased use of more efficient transportation systems, and improvements in the efficiency of oil use in industrial processes can all help limit the expected growth in oil demand, which otherwise would be supplied by increased oil imports.

Strategy 5. *Reduce petroleum use in Federal transportation.* Increasing the Federal and postal fleet of alternative-fuel (natural gas, electric, and biofuels) vehicles to 100,000 by 2005 will provide critical support for emerging technologies and spur fueling infrastructure investments for these fuels.

Objective 2. Ensure energy system reliability, flexibility, and emergency response capability.

Strategy 1. *Promote the reliability and flexibility of electricity generation, transmission, and distribution.* Highly reliable electricity supply systems are vital to our national security, the well-being of our economy, and the quality of life in an era marked by increasing technological sophistication. Reliability and competition in the electricity industry can be compatible, but this result will not be achieved automatically; it must be made a design requirement for the public and private officials responsible for the architecture of the new industry.

Accordingly, as part of the Administration's Comprehensive Electricity Competition Plan [see box on page 11], reliability standards would be established and enforced by industry subject to the oversight of the Federal Energy Regulatory Commission.

Strategy 2. *Promote the reliability and flexibility of domestic oil refining, transportation, and storage.* Flexible implementation of new air emission regulations, together with expanded R&D support for low-emission refinery technologies, can help lower the cost of full environmental compliance, thereby minimizing adverse impacts on the domestic refining industry. The Department of Energy will work with industry and government regulators to meet increasingly stringent emission regulations more cost-effectively, while meeting increased demands for lighter, high-value finished petroleum products. Specific research efforts will address the new ozone/PM 2.5 standards; process modifications or technology improvements in refineries to prevent the formations of pollutants; use of ceramic membranes to separate high-value hydrogen from low-value refinery gases to improve product quality; and biochemical processes to upgrade crude oil. Further, in cooperation with the President's Commission on Critical Infrastructure Protection (PCCIP) and other Federal agencies, the Department of Energy will determine the best approach to enhance the security of the domestic oil refining, transport, and storage infrastructure. The PCCIP effort represents the first coordinated, interagency effort to protect the Nation's critical infrastructure.

Strategy 3. *Promote the reliability and flexibility of natural gas transportation and storage.* This effort will reduce the costs and increase the deliverability of the Nation's storage and delivery system to meet the projected growth in natural gas demand. Working closely with industry, the effort will develop novel and advanced fracture simulation technologies and improved remediation treatments that will increase reservoir deliverability. R&D in improved gas-flow metering and energy-measurement technologies will provide real-time, automated monitoring of pipeline gas flow and energy content, maximizing system capacity and gas sales to customers. The effort will develop advanced storage technologies to meet the specific storage needs of new and growing industrial and power generation markets, specifically the short-term or hourly requirements of the power generation sector. Research in emission-detection technologies will lead to development of systems capable of covering larger areas more cost-effectively and with greater accuracy than current technologies. Lastly, the PCCIP effort will determine the best approach to enhance the security of the domestic natural gas production, transport, and storage infrastructure.

Goal III

Promote energy production and use in ways that respect health and environmental values — improving our health and local, regional, and global environmental quality.

Climate change and other environmental issues present difficult challenges for the energy sector. U.S. demand for energy, especially for clean and reasonably priced energy sources, is likely to grow over time. New Clean Air Act requirements will impose additional requirements and costs. Abiding by the Kyoto Protocol will require the United States to make significant changes in energy use to reduce greenhouse gas emissions. Substantial improvements in energy technology and flexible, market-oriented government policies will help grow the economy while meeting our environmental goals. [See Appendix A for a discussion of the Kyoto Protocol.]

Objective 1. Increase domestic energy production in an environmentally responsible manner.

Strategy 1. *Support policies to allow domestic natural gas supply to grow by as much as 6 trillion cubic feet by 2010.* About 60 percent of this growth will be used in electricity-generating systems. Natural gas technologies are the most economic fossil fuel-based technologies for new capacity in electricity generation. By developing improved reservoir-imaging technologies to locate natural gas in deeper and more complex reservoirs, developing the drilling technology needed to reach those reservoirs, researching advanced extraction techniques to boost recovery from mature reservoirs, and leading industry in developing technologies that can reduce the cost of environmental compliance, domestic natural gas production can be significantly boosted. The Department of Energy will support environmentally responsible development of leased Federal lands for natural gas recovery. Lastly, the Department and other Federal agencies will expand collaborative efforts with States to ensure that Administration energy, Federal land management, and environmental policies all adequately protect the environment, but also are consistent and avoid duplicative and unnecessary regulations.

Strategy 2. *Use advanced technologies to recover more oil from reservoirs without significant environmental degradation.* The development and use of advanced exploration and recovery technologies can result in more than 400 million barrels of additional cumulative oil production between now and 2005. Working closely with industry, this effort will foster the more widespread use by industry of "best management practices" for environmental protection. Advanced technologies will be developed to lower the cost of drilling and production waste management, detection and control of air emissions, treatment and disposal of produced water, and management of naturally occurring radioactive materials. Credible scientific and technical information will be developed to serve as the basis for regulatory and compliance strategies. The Department of Energy and other Federal agencies will expand collaborative efforts with States to ensure that the Administration's energy, Federal land, and environmental policies are consistent and to eliminate duplicative and unnecessary regulations.

Strategy 3. *Develop renewable electric energy technologies capable of economically doubling nonhydroelectric renewable generation capacity to a total of at least 25,000 megawatts by the year 2010, and maintain the viability of existing hydropower sources.* Expanded Federal R&D efforts in renewable energy sources would encourage renewable energy. Voluntary, cost-shared partnerships with the Nation's utilities, industries, States, and the public will advance development and deployment of clean, renewable energy technologies. Improvements in the efficiency and affordability of renewable energy sources (such as wind energy, photovoltaics, solar thermal, geothermal, and biomass) will make clean, cost-effective, and reliable energy options more attractive in a competitive market, while also adding to the diversity of the Nation's energy supply. Technologies such as electric energy storage can increase the applicability of these renewable energy sources. Extension of the wind and biomass tax credit, which is part of the President's proposed tax package, will promote further acceptance and use of these renewable technologies [see Appendix B]. In addition, the Administration's Comprehensive Electricity Competition Plan includes a requirement that a specified percentage of electricity sales be from non-hydropower renewable sources.

The development of advanced hydropower turbines to repower existing dams has the potential to avoid some of the environmental challenges posed by conventional hydropower plants and extend the life of existing hydropower plants to help preserve their contribution to U.S. energy production.

The installation of photovoltaics and solar water heating systems on rooftops also will contribute to this strategy. Photovoltaic systems, including those that are incorporated into roofing materials, supply electricity directly to homes and other buildings and offer a clean and renewable source of electricity for the Nation. Solar water and air heating systems are equally attractive renewable energy options. To ensure that rooftop solar systems gain more widespread use in the market, the President has proposed a 15-percent tax credit for the purchase of such equipment [see Appendix B]. The Federal Government will work in partnership with utilities, builders, solar equipment manufacturers, State agencies, cities, and financial institutions to help meet the President's goal of installing 1 million photovoltaic and solar water and air heating systems on the roofs of buildings and homes across the Nation by 2010. The Federal Government will take the lead by installing 20,000 solar rooftop systems on its own facilities by 2010.

Strategy 4. *Maintain a viable nuclear energy option.* Cooperation between the private and public sectors to avoid premature shutdown of viable existing nuclear powerplants and R&D into nuclear power technology improvements can reduce greenhouse gas and other emissions from the electricity-generating sector. Nuclear power is an essential element in the overall energy supply mix of the United States and the world. An important issue impeding its progress is the disposal of nuclear waste.

The Nuclear Waste Policy Act of 1982 (Public Law 97–425) established the Department of Energy's responsibility to provide for the permanent disposal of the Nation's high-level radioactive waste and spent nuclear fuel and directed that the owners and generators of these wastes bear the costs of their management and disposal. The current program focuses on completing the scientific and technical analyses of the Yucca Mountain site, and if it is determined to be suitable for a geologic repository, obtaining a license from the Nuclear Regulatory Commission.

Objective 2. Accelerate the development and market adoption of environmentally friendly technologies.

Strategy 1. *Increase efforts to deploy climate-friendly technologies in the near term.* The President's fiscal year 1999 budget includes a $6.3 billion, 5-year plan to stimulate the adoption of climate-friendly technologies through a combination of increased investments in research, development, and early deployment programs, plus tax incentives for climate-beneficial investments. [See Appendix B for a discussion of the President's proposal.] This will accelerate the diffusion and market adoption of new and existing technologies in ways that generate economic benefits while reducing greenhouse gases and other emissions.

Accelerated development of biomass liquid fuels technologies, along with new voluntary programs that foster rapid adoption of alternative-fuel vehicles, could displace 100 million barrels of oil per year by 2005 and reduce expected energy consumption in the industrial sector by as much as 2 percent by 2010. Liquid fuels produced from biomass crops and agricultural residues provide a clean, affordable alternative to oil consumption in the transportation sector.

Promoting the acquisition of newly developed alternative-fuel transportation technologies for government and private fleets, through efforts such as the Clean Cities program, encourages more widespread use of alternative fuels. Federal funding, leveraged by significant private investment, can create an infrastructure of corridors in which alternative-fuel vehicles can readily find refueling stations, spurring the use of alternative transportation fuels in key regions.

Biomass energy systems for electricity generation, such as systems for co-firing energy crops with coal or for gasifying energy crops, potentially provide a clean, renewable alternative energy source. Since bioenergy crops raised for biomass energy systems absorb carbon during growth, their use for transportation fuels or electricity generation can, in principle, yield little, if any, net carbon dioxide over their life cycle. Displacing conventional fuels with biomass fuels can thus substantially lower greenhouse gas emissions.

Strategy 2. *Initiate sectoral consultations with U.S. industry to promote expanded voluntary efforts to reduce greenhouse gas emissions.* The Administration will seek voluntary pledges from major energy-using industries to reduce greenhouse gas emissions, expanding on successful programs in the electric utility sector and other industries. The Administration will ensure that those who take early action will receive appropriate credit for their actions. In addition, this environmental leadership will be afforded public recognition to help establish an example for others to emulate.

Strategy 3. *Design a domestic greenhouse gas emission trading system that will help meet binding emission targets in the most cost-effective way.* Domestic emission targets likely will be met, in part, through a system of emission allowance trading that builds upon the successful experience in reducing emissions associated with acid rain. A greenhouse gas emission trading system, however, will be more complex and will require substantial analytical development for effective implementation. This development will be carried out by an interagency team with substantial input from the private sector.

Strategy 4. *Participate in discussions with developing countries regarding their commitments to reduce greenhouse gas emissions, primarily through climate-friendly technologies.* An international response to reduce greenhouse gas emissions will be most effective if it includes the participation of key developing countries whose emissions are large and rapidly growing. The President has stated that the Administration would make submission of the Kyoto Protocol for Senate advice and consent to ratification contingent on the meaningful participation of key developing countries.

The Administration is developing a diplomatic strategy to engage key developing countries in a dialog that is intended to lead to some of these countries taking on more meaningful climate-change commitments. The Administration expects to engage in bilateral and multilateral discussions through various forums leading up to the Fourth Conference of the Parties in Buenos Aires in November 1998. [See Appendix A for further information on the Kyoto Protocol.]

Strategy 5. *Promote international joint efforts to reduce greenhouse gas emissions.* The development of a viable international emission allowance trading system among developed countries and the expansion of efforts to allow firms in developed countries to engage in emission reductions in developing countries while receiving credits for these reductions are critical elements of a globally cost-effective response to climate change. The Kyoto agreement provides for a system of international trade in emission permits, but does not specify all the details of such a system. The provisions that remain to be specified include monitoring and reporting practices, methods of recordation and reporting of trades, and compliance matters.

Further specification is also needed on procedures for banking unused credits, for bringing additional Parties into the agreement, and for recognizing emission reductions before the start of the first budget period.

It is widely believed that international trading of greenhouse gas permits could bring a wide range of low-cost carbon reduction opportunities to U.S. industries and significantly reduce the cost of U.S. emission reductions.

Goal IV

Expand future energy choices — pursuing continued progress in science and technology to provide future generations with a robust portfolio of clean and reasonably priced energy sources.

The U.S. scientific enterprise is the largest and most successful in the world. Advances in science and technology are critical to achieving our Nation's economic, environmental, and security objectives. Because competitive markets tend to underinvest in critical research and development for long-term energy solutions, government R&D investments — often in collaboration with the private sector — are needed to help ensure a steady stream of innovation that benefits the Nation and the world with improved energy technologies.

Objective 1. Maintain a strong national knowledge base as the foundation for informed energy decisions, new energy systems, and enabling technologies of the future.

Strategy 1. *Develop science that supports decisionmaking on future energy options, including the requirements of new energy system concepts and their anticipated effects on human health and the physical environment.* Energy production and use can result in releases of chemicals, particles, radiation, and other substances into the environment. Improved understanding of energy-related pollution (its generation, transport, interaction, and transformation pathways), as well as development of validated scientific models and methods for analyzing and predicting the health and environmental consequences of alternative energy options, will assist the Federal Government and the private sector in making informed energy investment choices. In addition, computational and high-speed simulation tools are needed to analyze the performance of new energy systems and the effects of modifying existing energy systems. These tools will reduce the need for costly test and pilot-scale facilities.

Strategy 2. *Intensify basic research on global climate change and on long-term, innovative systems for carbon cycle management.* Research into new technologies to capture and sequester energy-related carbon emissions could greatly expand the portfolio of long-term technology options available to manage the relationship between energy use and greenhouse gas emissions.

Predicting and assessing the specific effects of greenhouse gas emissions and aerosols (small particles produced by fossil fuel combustion that reflect solar radiation) on climate will require improved understanding of the natural processes affecting climate and of the ways human activities alter these processes. Basic research on natural carbon sequestration will advance understanding of the flow of carbon between the atmosphere, biosphere, and oceans. Research in these topics will identify the natural cycles and

Storing Carbon Naturally

Concern that Earth's climate may be changing has focused attention on emissions of carbon dioxide and other greenhouse gases arising from human activities. But those emissions are only part of the story. Trees and other plants absorb carbon dioxide, soils sometimes emit it, and oceans do both. These flows, part of Earth's natural carbon cycle, are 10 times larger than industrial emissions. Could forests be managed in ways that enhance the storage of carbon, helping to offset human activities and hence to stabilize the climate?

Ten years ago, not enough was known about the dynamics of forests to answer such questions. But a flurry of research, and in particular new methods of making direct measurements of how much carbon dioxide forests capture from the atmosphere, has begun to provide some insights. And the Kyoto Protocol provides ample incentive to probe further, because it offers emission credits to countries that can either plant new forests or "sequester" additional carbon in existing forests.

Planting new forests to replace those cut seems straightforward. But which lands and what species of trees will capture and store away the most carbon? And which will offer the most additional benefits — as a source of commercial timber, as improved wildlife habitat or watershed protection, as recreational opportunity? Studies now under way, such as the hardwood seedlings planted on a plot of frequently flooded land by scientists from Louisiana Tech University, are seeking answers. In the Mississippi River Valley alone, there are more than 4 million acres that not long ago held bottom land forests, much of it now abandoned bean fields and other excess agricultural land.

Managing forests to maximize carbon storage is more complex. Planting quick-growing trees and harvesting them for lumber on short cycles, every 30 years or so, might seem like an obvious approach. The carbon in wood, after all, is often stored as lumber in buildings or as paper in libraries for decades. But when forests are cut, carbon stored in the soil as roots and other organic matter begins to decay, releasing large amounts of carbon dioxide. Might different management practices increase carbon sequestration? More research is needed, but recent studies show that even mature forests more than 200 years old are vigorously taking up carbon, suggesting that very long cycles may be better. Forestry management practices could make a big difference in how much carbon can be sequestered.

Still other approaches that might enhance carbon storage remain to be explored. Would fertilizing forests help? Or how about genetically engineering trees to store more carbon in the wood and less in the roots? Might additional research find ways to increase microbial production of humus in the soil and to protect it better from decomposition — which could enormously increase the storage of carbon in soils?

A changing climate itself could become a major factor. Longer growing seasons, more rain, and higher levels of carbon dioxide — a nutrient for trees — in the atmosphere could stimulate growth and carbon storage, at least in mid-latitude forests, for many decades. In high-latitude peat and permafrost forests, on the other hand, there is suggestive evidence that higher temperatures will unlock large stores of carbon in the soil, resulting in additional emissions to the atmosphere.

There is still much to do to fully understand Earth's natural carbon cycle. But because forests might help restore that cycle to balance by capturing a portion of the carbon released by human activities, as much as 30 percent in some estimates, developing such a strategy further seems a high priority for research.

human intervention opportunities that could lead to cost-effective approaches to sequestering carbon emissions. The underlying science will contribute to U.S. leadership in the development of new technologies.

Strategy 3. *Conduct basic research that provides the foundations for long-term energy-technology breakthroughs.* This strategy supports high-priority research in energy-related sciences while improving mechanisms that support multidisciplinary research.

We must develop and maintain a basic research investment portfolio that ensures a competitive U.S. position in those areas of the natural sciences and engineering that are relevant to energy resources, production, conversion, and efficiency and to the mitigation of the adverse impacts of energy production and use. These sciences include materials sciences, chemical sciences, nuclear sciences, energy biosciences, structural biological and environmental sciences, genomic sciences, computational and mathematical sciences, engineering sciences, geosciences, and fusion and fusion plasma sciences. Efforts will focus on developing this national investment portfolio with a fuller understanding of the diverse research contributions by government, academia, and industry. This will require expanding research partnerships to increase the leverage of our national science investments.

Strategy 4. *Support a strong energy science infrastructure.* To conduct energy research in the national interest, the Nation's scientists in government, industry, and academia must have access to modern, leading-edge research facilities, including major scientific user facilities and the Nation's laboratories.

We should maintain and operate premier national user facilities to serve researchers at universities, national laboratories, and industrial laboratories, thus enabling the acquisition of new knowledge. Improving access to these user facilities, both onsite and remotely, by all qualified researchers will foster research partnerships between the public and private sectors.

Integral to a strong energy science infrastructure is improved cooperation among government, academia, and industry to promote the energy, math, and science awareness that will enable advanced education opportunities and build institutional capacity for important research. Cooperative efforts will be undertaken to expand the range of scientific and technical materials to educators and students, improve general math and science awareness, and help cultivate the next generation of world-class U.S. scientists and engineers.

Objective 2. Develop technologies that expand long-term energy options.

Strategy 1. *Develop long-term energy technologies that increase energy options, improve overall economics, use resources more efficiently, and reduce adverse impacts of energy supply and use.* This includes the development of advanced renewable technologies, research into fusion and low-cost proliferation-resistant nuclear fission reactor technologies, assessing the development of large, unconventional sources of methane (such as methane hydrate), and development of technologies for the storage, distribution, and conversion of hydrogen.

Fusion energy has the potential to provide an economically and environmentally attractive long-term option. Understanding the physics of ignited, or self-heated, plasmas and developing the technologies essential for fusion energy are linked goals that are achievable through the cooperative efforts of the world community.

Goal V

Cooperate internationally on global issues — developing the means to address global economic, security, and environmental concerns.

The energy market is now a global market. How effectively the United States interacts on an international basis will, to a large extent, determine how economically prosperous we remain domestically. Coopera-

Putting Superconductivity to Work

The discovery, in 1986, electrified physicists around the world: superconductivity at temperatures high enough that the phenomenon might become more than a laboratory curiosity. A decade later, explaining that phenomenon theoretically remains perhaps the preeminent unsolved problem of condensed matter physics.

Yet despite such unknowns, there has been remarkable progress toward practical applications. In 1997, industry manufactured more than 200 kilometers of superconducting wire; underground superconducting transmission lines for electric power, especially in urban areas, seem likely to be a commercial reality within a few years, with other energy-related uses close behind.

To reach this point has required the cooperation of university, government, and industrial scientists in a remarkable symbiosis of basic and applied research. High-temperature superconductors are ceramics, brittle materials that at first seemed impossible to form into wires at all. But a solution was found by packing superconducting powder in silver tubes and then processing the tube into wire. Since 1993, electrical devices have been built and tested using these “powder-in-tube” wires. More recently, researchers have found that thin films of high-temperature superconducting materials deposited on a metal strip were much more flexible — a discovery that opened up new approaches to making superconducting wire. Today, the powder-in-tube approach still dominates, but thin-film processes for making wires continue to evolve.

Even so, many prototype wires initially could not carry large currents, because of internal defects caused by disordered crystalline segments, or “grains,” within the material. But scientists with years of experience in metal processing, knowing that thin films often copy the internal patterns of the material they form on, suggested a way around the difficulty. They pointed out that rolling the underlying metal strip would align its “grains,” potentially creating an ideal template for the superconducting material — and so it turned out. Current densities improved.

The dialog between fundamental studies and practical development has continued. To understand complex superconducting materials better, scientists have studied their structure, seeking clues to their properties. That required collecting data with neutron beams, far more sensitive than x rays when probing light elements, such as the oxygen that is a critical constituent of these still mysterious new materials. It also required exploring how these materials behave in strong magnetic fields — since such fields can stop superconducting behavior. Insights from this research feeds development of improved wire manufacturing processes and industry teams working on applications for superconducting wire — transmission lines, large motors, transformers, energy storage devices with superconducting bearings. The payoff is expected to be substantial — prototypes are being developed of virtually loss-free transmission lines and high-capacity underground cables, more efficient electric motors that are half the size of conventional units, and devices that could store large amounts of electric power relatively cheaply.

There still are more problems to solve before a full range of superconducting technologies can be commercialized. More powerful research tools are being developed by Department of Energy laboratories — a more intense neutron beam at Oak Ridge National Laboratory, equipment that can generate very strong magnetic fields at Los Alamos National Laboratory. Industry teams are gearing up to make even larger quantities of superconducting wire. But the electric power industry has begun to assert that, early in the 21st century, superconductivity will emerge from the laboratory and add to the Nation’s energy options.

tion with foreign governments on energy regulations and laws, promotion and deployment of clean and efficient energy systems worldwide, and international science and technology cooperation aimed at maximizing benefits from Federal R&D funds will be important in determining how well we succeed in achieving our energy, economic, and environmental goals and objectives. The responsible transfer of energy technologies will also play an important role in international cooperative activities. International cooperation and collaboration will also be needed to address global environmental issues such as climate change.

Objective 1. Promote development of open, competitive international energy markets, and facilitate the adoption of clean, safe, and efficient energy systems.

Strategy 1. *Cooperate with foreign governments and international institutions to develop energy-sector laws, policies, and regulatory processes for setting standards and enforcing regulations.* This strategy emphasizes the development and implementation of appropriate policies and regulations through active and sustained participation in multilateral international and regional forums, and through constructive bilateral engagement with key countries. The United States is currently an active participant in the International Energy Agency, the International Atomic Energy Agency, the Nuclear Energy Agency, Asia Pacific Economic Cooperation (APEC), the Summit of the Americas, the G–8 Summit, and other multilateral groups. In addition, new regional forums with important energy programs (such as the Southeast Europe Cooperation Initiative) are emerging that offer new opportunities for leadership.

Working with our neighbors in Mexico and Canada, the Administration hopes to develop cooperative agreements among regulatory bodies to promote a North American natural gas and electricity system that is reliable, nondiscriminatory, and responsive to the marketplace. In the case of natural gas, free trade exists between Canada and the United States, and most regulatory differences have been resolved. Mexico is committed to creating an open-market system, but some obstacles still exist. In the case of electricity, all three countries are considering and making changes in their respective electric power sectors.

Strategy 2. *Promote deployment of clean and efficient energy systems.* By promoting the export of clean, energy-efficient, and cost-effective technologies through partnerships with energy industries, trade associations, and multilateral agencies, the Federal Government can help private industry identify hundreds of millions of dollars in market opportunities each year. International demand for electricity is expected to grow substantially in coming decades, with high demand for distributed non-grid-connected renewable energy applications. By gaining a substantial share of international markets, U.S. industries can reduce the costs of clean energy technologies.

Strategy 3. *Promote international science and technology collaboration to avoid duplication and maximize the national benefits of Federal R&D efforts.* International cooperation is, and will continue to be, a vital part of our Nation's science and technology programs. It is essential to our ability to participate in, for example, large-scale experiments and to advance the goals of our science and energy programs.

Participation in international collaborations allows the United States to develop and promote clean, safe, and efficient energy technologies, remain a leader in basic energy research, and promote U.S. national security objectives. There are many ongoing collaborations in science and energy-related fields. These include the Russian-American Fuel Cell Consortium; the International Thermonuclear Experimental Reactor Project with the European Union, Japan, and the Russian Federation; the Large Hadron Collider program collaboration with the European Physics Laboratory (CERN); and the Next Generation Internet (NGI) project, which will connect thousands of teams of researchers spread across the world. NGI is especially critical for international collaborations, where large, complex multidisciplinary problems require transfer of massive amounts of data in reasonable periods of time.

Objective 2. Promote foreign regional stability by reducing energy-related environmental risks in areas of U.S. security interest.

Strategy 1. *Promote foreign capacity building and solutions to environmental security concerns, integrating the capabilities of the Department of Energy and other agencies, foreign governments, the private sector, and nongovernmental organizations.* Identifying, assessing, and prioritizing environmental security concerns in selected world regions of importance to the United States will help point to cost-effective solutions to potential threats to U.S. national security interests. Environmental threats that cross national boundaries around the world can have a profound impact on the national security interests of the United States. Recognition of this reality has enlarged the focus of U.S. foreign policy to embrace international environmental issues, and has spurred new initiatives to prevent and remediate environmental degradation.

The Federal Government expects to address environmental security issues in partnership with the private sector and other donor governments, as well as with foreign, host governments. Areas of likely progress include the safe handling and disposition of nuclear materials, short- and long-term environmental management, energy resource development, demand-side management and efficiency, and modeling and assessments.

A Shared Commitment

A broad consensus on overarching energy policy goals does not ensure achievement of better energy and environmental outcomes. The vast array of participants in energy markets — the private sector, nations and their government agencies, public and private research facilities, advocacy groups, and individual citizens — have differing and perhaps changing perspectives on their roles and actions, even if they agree on the broad goals. Even if the entire choir has the same songbook, harmony will not result if everyone is singing from a different page. A fundamental challenge facing the United States is to harmonize these potentially discordant interests into making shared contributions to meeting the shared objectives.

The goals of the Comprehensive National Energy Strategy require a shared commitment if they are to be achieved. The various Federal agencies need to cooperate and coordinate activities in pursuit of these goals, with involvement at all levels and by making use of the unparalleled resources of the national laboratories. Similarly, the several branches of government must share in the belief that pursuit of these goals is a priority when resource commitments are being made. The commitment must extend beyond government to the private sector, which will be engaged through public-private partnerships, based on the recognition that meeting these goals is in the long-term interest of everyone involved. The nonprofit sector, especially universities, also must make a commitment to pursue these goals in order to mobilize the unique resources contained in these institutions. Communities also must share in the commitment, for the benefits of meeting these goals extend far beyond any single business or individual. Finally, countries must share in the commitment, for many of the benefits are global in nature, and the resources and knowledge base to address these goals generally are not concentrated solely in the United States. These shared commitments will maximize the probability of being successful without devoting unreasonable amounts of resources to this effort. If success is achieved, we will leave future generations of Americans a more livable country and a thriving energy sector with a wide variety of affordable and safe energy alternatives.