

ENERGY INDUSTRY STUDY REPORT

1996

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KJC Operating, Boron, CA
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ABSTRACT

The working group recommended the following policies and measures for the U.S. government: (1) provide incentives to lower petroleum consumption in order to reduce environmental degradation and lessen the vulnerability of the economy to oil price increases; (2) delegate authority to draw upon the Strategic Petroleum Reserve (SPR) to a level below that of the president; (3) develop a coherent long-range strategy for carrying out the deregulation of the electric power industry; and (4) set priorities for investment in advanced technology that will contribute the most to the overall aims of national energy policy.

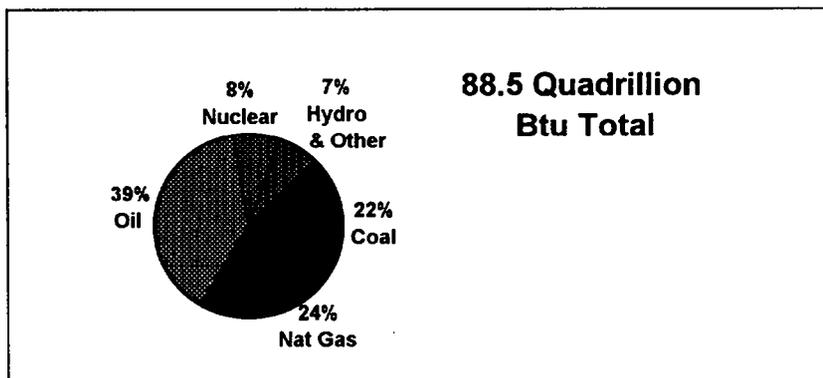
INTRODUCTION

Secure access to clean, abundant, and inexpensive energy is a fundamental requirement for an expanding and competitive economy. In the past 20 years, U.S. energy consumption has risen by more than 25 percent. And although the economy is becoming less energy intensive, that is, the amount of energy used to produce a dollar's worth of gross domestic product (GDP) is declining, energy production and distribution costs still represent about 8 percent of U.S. GDP. Energy imports are a major component of the U.S. international balance of trade, accounting for 10 percent of total imports.

Given the relationship between affordable energy and economic growth, sound energy policy is clearly an essential element of a broad national security strategy. The purpose of our study was to explore the role of the government in improving the productivity of the energy industry in environmentally sound ways and contributing to long-term economic growth, thereby enhancing U.S. national power. Our report frequently refers to the administration's *Sustainable Energy Strategy*, the July 1995 National Energy Policy Plan pursuant to Section 801 of the Department of Energy Organization Act. Using that strategy as a starting point, we have recommended the changes that we feel best serve the overall aims of U.S. policy. The group's strategic aims were:

1. To sustain economic growth, improve industrial productivity, and improve living standards. Energy policy should encourage the development of secure and economical sources.
2. To protect the environment. Energy production always involves some environmental impact. Therefore, energy policy should promote better ways of meeting energy needs with fewer harmful effects on the environment.
3. To set appropriate priorities for the use of limited research and development (R&D) funds that establish a proper balance between basic and applied research. Energy policy should continue to advance the state of the art while ensuring adequate funding for research that is likely to produce clean, abundant, and affordable energy technologies within a reasonable time horizon.
4. To streamline regulations and make the government more efficient and responsive. When possible, energy policy should make use of market forces, rather than government regulation, to control undesirburden of needless regulation and administration.

Figure 1. U.S. Energy Consumption by Source, 1994



In the past 25 years, disruptions in oil supplies have caused price shocks severe enough to plunge the U.S. economy into recession on three occasions. Although most experts agree that oil price shocks such as those

that occurred in the 1970s and 1980s are less likely today, the United States depends more than ever on oil for its primary energy requirements (see Figure 1). The transportation sector accounts for 67 percent of the United States's annual oil consumption; cars and trucks alone account for half of the annual consumption. Therefore, any policy that seriously seeks to reduce oil consumption must somehow address the demand for gasoline and diesel fuel. Reducing petroleum consumption through increased efficiency or the use of environmentally friendlier substitutes would reduce environmental degradation.

The Strategic Petroleum Reserve (SPR) was not used as effectively as it could have been during the Gulf War crisis. Although a formal U.S. and international process was in place to respond to crises in world oil markets, those mechanisms became encumbered by the political process. In hindsight, it would have been better to remove the formal implementation process from the political arena.

Demand for electricity constitutes a little more than a third of the overall energy use in the United States. In the past two decades, electricity requirements have increased by about 3 percent per year, but this growth in demand has already slowed and is expected to slow even more by 2010, averaging slightly more than 1 percent per year (*Sustainable Energy Strategy*, 1995, 41). The current movement toward deregulation of the electric power industry is consistent with the long-range goal of keeping energy costs down, but a major problem with deregulation is the lack of a comprehensive government strategy for carrying out deregulation. At present, the administration has not announced how it intends to resolve the issue of stranded costs equitably. The uncertainty of the future regulatory environment caused by this leadership void has prompted the various utilities to delay recapitalization plans.

In recent years the Department of Energy (DOE) budget for both applied and basic research has been reduced. Those budget reductions have resulted in some de facto energy policies that should be reexamined. The average expected cost-benefit time horizon, which has grown too long in recent years, should be shortened.

THE PETROLEUM INDUSTRY

The Petroleum Industry Defined and Current Conditions

The United States consumes more than 25 percent of the world's oil production. The U.S. domestic oil industry is very mature, and production has been on the decline for years. Today, proven U.S. oil reserves represent only about 2 percent of world's total, which has led to increased overseas exploration. U.S. production will continue to decline until around 2005, when a slight increase is expected as a result of emerging three-dimensional seismic analysis and horizontal drilling technologies jointly developed by the DOE and the oil industry, and the increased development of deep-water offshore oil wells in the Gulf of Mexico. Another largely unexplored area is the Arctic National Wildlife Refuge in Alaska, but current federal law prohibits production in that area.

Challenges

The two overriding U.S. national security concerns associated with the petroleum industry are the vulnerability of the U.S. economy to oil price shocks and long-term price increases, and the environmental impact associated with fossil fuel energy sources. Because nearly 40 percent of the United States's primary energy is supplied by petroleum and because much of the world's oil is produced in the volatile Persian Gulf region, price stability is a major concern.

The central environmental issue concerns how extensive governmental environmental controls should be and how they should be implemented. The petroleum industry is subject to government regulation in the extraction, processing, transportation, and use of petroleum products. Clearly, in all these endeavors, environmental risks exist. The question becomes how to work more effectively with industry, create incentives for responsible behaviors, and protect the environment while promoting affordable and secure energy sources. A particularly contentious environmental issue is global climate change. Many, but not all, scientists believe that burning fossil fuels results in irreversible and detrimental climate changes. If that is indeed the case, then limitations on fossil fuel consumption--on a global level--must be agreed upon.

Outlook

U.S. petroleum production is declining while world oil consumption is rapidly rising. That increased demand will be supplied primarily by production from the Organization of Petroleum Exporting Countries (OPEC). Most of OPEC's production will come from the Persian Gulf region, where two-thirds of the world's oil reserves are found. While there will always be some non-OPEC countries with significant amounts of oil for export (e.g., the United Kingdom, Norway, Colombia, Vietnam, Yemen), OPEC's share of world oil production is expected to increase in the next 20 years.

Motor gasoline, distillates (which include diesel fuel and heating oil), jet fuel, and residual fuel (mainly used by industry as a boiler fuel) make up 80 percent of all refinery production in the United States. Of the petroleum products used in the United States, transportation fuels account for nearly two-thirds.

Domestic refinery production has steadily increased over the last dozen years while reserve refining capacity has declined. Passage of the Clean Air Act Amendments of 1990 forced the closure of a number of small and inefficient refineries that were no longer economically viable as a result of the associated compliance costs. While refining capacity has declined, refined product consumption has risen, substantially increasing the utilization rates of U.S. refineries. However, a significant secondary processing capacity brought on line in the last few years allows further processing into more valuable products, such as motor gasoline. Another result of recent environmental regulations is the substantial increase in the number of required refined products. U.S. refiners must produce different types of gasoline, from reformulated to oxygenated, depending on the season and the region of the country in which the gasoline is consumed. This requirement has tested the limits of the flexibility inherent in the U.S. refining industry.

Government Goals and Role

To reduce the sensitivity of the U.S. economy to oil price shocks and long-term price increases, to provide incentives for investment in advanced technology, and to reduce the environmental impacts associated with the burning of fossil fuels, we advocate the following measures.

In addition to the current fuel efficiency regulations, we recommend gradually increasing the federal gasoline tax by 25-50 cents over the next five years. Those tax increases should be offset by reductions in other taxes, such as the federal income tax base rate, thus minimizing the economic costs of implementation. The gasoline tax is a very efficient way to cost out the externality of vehicle air pollution. Ideally, the market leverage provided by the gas tax would result in a fleet of more efficient vehicles and a reduction in vehicle miles traveled; neither of those objectives is obtained through the use of fuel efficiency standards. Nonetheless, if an increase in the federal gasoline tax proves to be politically nonviable, then the mandated fuel efficiency requirements should be revised upward and a gas-guzzler tax should be considered.

The group supports the removal of all remaining tariffs and advocates an open and free international oil market. We do not recommend using unilateral oil embargoes as an economic weapon. Also, since the U.S. SPR is the nation's best strategic hedge against oil supply disruptions, we advocate maintaining its current levels. Recent decisions to sell part of the SPR are shortsighted. The group also concluded that the SPR was not used as effectively as it could have been during the Gulf War. To preserve the integrity of the decision-making process, that is, to ensure that domestic politics do not overcome the formal process of evaluating world oil markets in a time of crisis, the group recommends that the authority to access the SPR be delegated to a level below that of the president. Finally, the group recommends additional scientific research on global climate change in order to determine the appropriate role of the government relative to that concern.

THE ELECTRIC INDUSTRY

The Electric Industry Defined and Current Conditions

Industrial companies, not utilities, once supplied more than half of the United States' electricity. Over the past half century, however, the primary suppliers were regulated utilities exercising monopoly power. Buyers could not search out alternative suppliers, and potential alternative suppliers had no means of delivering their product. The electric utilities also enjoyed monopsony power in purchasing electricity from nonutility producers. Perceived as a natural monopoly dominated by large, vertically integrated companies, the industry became one of the most heavily regulated in the United States at both the federal and state levels. Other countries either followed suit or assumed direct control through parastatal companies.

The traditional structure of the industry is related to the formidable barriers to entry. Base-load power plants and transmission and distribution systems are expensive. Once a firm had laid down those systems for its service area, investment costs for competing networks were prohibitive. State public utility commissions used established cost-based pricing methods to fix rates, encouraging utilities to emphasize reliability and expansion of service over cost. Public commissions used the rate structure to cover social costs such as extending service to uneconomical areas and subsidizing renewable energy demonstration projects. On the whole, utilities have been reasonably profitable. Return on equity has been consistently above 11 percent and was over 12 percent in 1994.

Today, the industry is on the verge of a massive change: deregulation. Federal and state regulators, who may struggle among themselves to determine their own roles as well as what regulation may still be required, will watch over the emerging marketplace of utility winners and losers. As the industry faces deregulation, it finds itself with 21 percent overcapacity and slowing demands for electricity. During the 1960s, the ratio of electricity demand to GDP growth was nearly 2:1. This ratio fell to 1.5:1 in the 1970s and nearly 1:1 in the 1980s. The Energy Information Administration (EIA) projects that this ratio will fall to 0.5:1 during 1993-

2010, mainly as a result of improved energy efficiency (EIA, "Annual Energy Outlook 1996," January 1996, Tables A8 and A20.).

Challenges

Technology, economics, and political and social goals are interacting to force change on the electricity industry. The foundations for these changes are in the 1978 Public Utility Regulatory Policies Act (PURPA) and the Energy Policy Act of 1992 (EPACT). EPACT specifically eases rigid government controls, creating a new category of power producers, exempt wholesale generators (EWGs). Utilities can be required to provide EWGs with point-to-point access to transmission systems, thereby unbundling generation, transmission, and distribution functions. The logical extension of this deregulation trend is the Electricity Competition Act of 1996, now awaiting congressional action, which provides for retail wheeling-- opening competition to buyers and sellers to make transactions over an open, nationwide power grid.

The strategic issues arising from deregulation are complicated. In the near term, the most fundamental questions for government policymakers are how much of the industry can be deregulated, whether deregulation includes transmission and distribution systems, what constitutes reasonable compensation for utilities' stranded costs in a deregulated market, and, as retail wheeling becomes a reality, whether utilities and their shareholders are entitled to compensation for major capital investments, such as nuclear power plants. These capital investments were frequently predicated on investment strategies mandated by local utility commissions and regulated but guaranteed rates of return. Likewise, the federal government required nuclear-powered utilities to contribute to developing the Yucca Mountain high-level nuclear waste storage facility in return for its completion not later than 1998, when 26 civilian nuclear sites will exhaust their on-site storage capacity. Yet 2010 is the DOE's current projected date for opening Yucca Mountain.

In the long term, as the industry focuses on the most efficient way to produce power in a competitive market, fuel sources must remain diverse enough for national security. The market must also manage the national power grid by providing for secondary services such as variable voltage

support, generation, and load matching and accounting for transmission losses, spinning reserves, and black startups.

Outlook

The electricity industry will be able to meet projected demand both in the short term (1-5 years) and long term (5-20 years). But the deregulated industry of the next 20 years is likely to be considerably turbulent. Real prices will come down, overseas investment will rise, and environmental concerns may suffer absent corrective measures.

Government Goals and Role

Experience with the deregulation of other industries and the early reaction of utilities to shed unnecessary costs confirms that open competition is more efficient than central planning in producing reliable, cost-efficient services. While the administration plans to assess the impact of deregulation before reforming PURPA, the working group felt that those reforms should be accelerated. In areas where open markets are unable to satisfy basic requirements, more flexible regulations should be adopted.

The electrical transmission and distribution system should remain a regulated monopoly to preclude many of the issues associated with stranded benefits and mitigate some of the problems associated with utility compensation and power-grid management. The role of the government in the future should be to monitor the performance of the new market, including watching the deregulated industry for anticompetitive behavior, such as "cream skimming," and tracking providers of generation and distribution in all regions to ensure the maintenance and management of the nation's power-grid system. As deregulation proceeds, the federal government should also ensure that former public utilities and their shareholders receive adequate compensation for their real stranded costs as a result of investment actions directed by local utility commissions. Finally, given the near-term nuclear waste storage and disposal problems and the increasing possibility of early retirement of some uneconomical nuclear power facilities, the federal government must immediately either open the Yucca Mountain high-level waste facility or find alternatives.

The federal government should develop a coherent long-range strategy for the deregulation of the electric power industry. Regulated monopolies are antithetical to market economies, are a drain on the private sector, and result in artificially high prices, weaker market incentives, restricted output, and less innovation. Competition, even imperfect competition, is preferable. Government policy must provide for careful monitoring of the deregulation of the industry and the maintenance of the nation's energy security.

THE COAL INDUSTRY

The Coal Industry Defined and Current Conditions

Coal continues to be one of the United States's most important energy sources, providing nearly 60 percent of the nation's electrical power. In addition, the coal industry directly contributes more than \$21 billion to the economy each year, and its total contribution, through its impact on other business sectors such as the transportation industry, is over \$132 billion annually. The coal industry employs about 136,000 people, directly affects another 1.4 million jobs, and contributes an estimated \$4.5 billion annually to the positive side of U.S. balance-of-trade payments. Coal exports are growing and hold promise for the future. U.S. coal producers ship more than 80 million tons of their products per year to approximately 40 different countries, including the major markets of Japan, Canada, Italy, the Netherlands, and Belgium.

Coal is in plentiful supply within U.S. borders. Proven U.S. recoverable coal reserves are the greatest of any single nation and represent about 23 percent of the world total. At present rates of recovery and use, U.S. coal reserves are expected to last more than 250 years.

The coal industry has a broad base of suppliers. There were 59 major coal producers doing business in the U.S. at the beginning of 1994, 8 of which were controlled by foreign firms. Production concentration ratios are low relative to those of most other major industries, with the top four producers accounting for around 22 percent. The increased demand for low-sulfur coal caused by the Clean Air Act and the lower production costs inherent in large surface mines in the West have contributed to a

decline in the number of inefficient and high-sulfur producing coal mines in the industry (from 6,000 in 1980 to about 2,300 in 1994).

Since the 1970s, U.S. coal production has grown substantially, and the coal industry has significantly improved productivity. Current annual production is approximately 1 billion tons--an increase of 90 percent since 1970. Coal mine productivity has also risen sharply, more than doubling since 1980. This growth and improved efficiency is due mainly to the introduction of modern technology into virtually all phases of mining. The most visible effects of modern technology are a significantly reduced but highly efficient work force, resulting in a steady decline in coal prices. From 1982 to 1994, prices fell from \$27 to \$19 per ton. In addition to increased productivity, mines today are also much safer than in the past as a result of sophisticated mining and safety technology (roof-bolting techniques in particular), improved training techniques, and compliance with safety and health laws.

Challenges

The principal challenge to the coal industry in the 21st century will be coping with environmental concerns. The industry will need to find less expensive technologies to reduce acid rain emissions in order to comply with the Clean Air Act amendments, or it will face a continuing decline in its share of the deregulated electricity market. If new regulations regarding greenhouse gas emissions are enacted, all fossil fuels, including coal, will be affected.

Outlook

Today coal accounts for approximately 22 percent of the U.S. total energy consumption and is expected to hold that share through at least 2010. Estimates are that demand in the industrial market will rise by 0.6 percent per year through 2015. More exports are expected as developing economies expand and require more steam coal to generate electricity. Overall production is expected to rise to an estimated 1.24 billion tons in the year 2015 while the real price of coal declines by 0.3 percent annually over the same period. The number of coal mines is projected to decline further as the industry continues to consolidate into fewer, larger firms.

Government Goals and Role

In terms of U.S. strategic energy goals, coal's impact on water quality, clean air, and land reclamation presents environmental risks rather than economic or security concerns. Specifically, the U.S. government's goals concerning coal should be to prevent damage to ground and surface waters, to reduce harmful air pollutants, and to return mined land to a condition at least as good as the original. The Clean Air Act, the Clean Water Act, and the Surface Mining Control and Reclamation Act all reflect intensive government scrutiny and regulation of the coal industry. In concert with its role of helping develop technology to ensure clean and affordable energy, the government spent \$2.58 billion on clean-coal technology demonstrations from 1988 to 1995. These demonstrations initially focused on emission control systems but in later years have focused on highly efficient, environmentally superior advanced power systems. Given the anticipated increased use of coal as an energy source in a deregulated electricity industry and the potential for early retirement of nuclear power facilities, developing more affordable clean-coal technology becomes increasingly important. Current government spending on clean-coal R&D does not reflect this trend. We believe this should be corrected.

THE NATURAL GAS INDUSTRY

The Natural Gas Industry Defined and Current Conditions

The current estimate of proven world gas reserves is nearly 5,000 trillion cubic feet (TCF), with approximately 40 percent of the known reserves located in the former Soviet Union (FSU). Eastern Europe, the FSU, and the Middle East account for approximately 70 percent of the total. Proven domestic natural gas reserves in 1994 were about 164,000 billion cubic feet (BCF), a decline from 197,000 BCF in 1984. Domestic reserves exist principally in five areas: Texas (22 percent), the Gulf of Mexico (17 percent), New Mexico (19 percent), Oklahoma (8 percent), and Wyoming (7 percent). Mature economies such as the United States, Canada, western European nations, and Japan are the principal natural gas consumers.

Developing nations often possess substantial natural gas reserves but lack the necessary infrastructure for distribution and consumption.

Domestic natural gas production in 1994 reached its highest level since 1981. Three-dimensional seismic analysis linked with computer-driven visualization, geochemical analysis, horizontal drilling, and other new technologies have greatly enhanced exploration efforts. Shell Oil is planning a Gulf of Mexico platform in an impressive 5,400 feet of water. Notwithstanding these efforts, the United States is a net importer of natural gas.

The Federal Energy Regulatory Commission (FERC) unbundled suppliers and pipeline companies with the issuance of Order 436 in 1985 and Order 636 in 1993. Increased competition for gas sales, an expanding resale market in the transportation sector, and new services have emerged as companies have entered new markets. Companies have sought to strengthen their positions through consolidations, diversification into unregulated energy markets, and strategic alliances to capitalize on opportunities not available to individual companies.

The domestic natural gas pipeline network is mature and efficient. Increased demand since 1990 has propelled a 14 percent increase in pipeline capacity largely due to development of new Canadian supplies and increased demand in Western and Northeastern markets. An anticipated increase in the use of natural gas in the electric power generation market is also driving new construction. Storage capacity in the United States, now is approximately 8,000 BCF distributed among 375 storage sites, has increased by 10 percent since 1990 as customers seek greater efficiency and supply reliability. The development of planned storage sites will increase capacity another 9 percent by 2000. Although natural gas can be transported by specially designed tankers when in a liquefied state (liquefied natural gas, LNG), the costs associated with LNG processing and transport have led to the selection of pipelines as the preferred means of natural gas transport in the U.S.

The natural gas consumption of utilities and nonutility power generators is rapidly increasing. Utilities favor natural gas as a cycling or peak power source, relying on other sources, such as coal or nuclear fission reactors,

for base-load power. The primary domestic use is for heating, so natural gas consumption is highly weather sensitive. The increased efficiency of home heating systems, however, has somewhat mitigated the growth in the demand for natural gas for heating and cooling.

Natural gas market prices have fallen over the last decade. Because gas prices exhibit great volatility, the futures market is used to manage price risk. Natural gas trading on the New York Mercantile Exchange is averaging over 36,000 contracts per day in 1996. By comparison, daily oil contracts are averaging around 102,000.

Challenges

The costs and environmental impacts of other electricity-producing fuels, such as coal and nuclear fission, have made natural gas the fuel of choice for future generating capacity. Gas is cleaner than coal, but most existing coal-fired plants are more economical to operate. The use of advanced technology shows promise in finding new reserves to replace depleted ones. For example, improved exploration and deep-water production technologies could aid in the discovery and development of offshore fields and reduce the cost of natural gas.

The government and the natural gas industry are exploring the use of natural gas as a substitute for gasoline in the automotive industry. Although some ventures have been successful, the shortage of distribution stations and the limited amount of natural gas a vehicle can carry are significant barriers to widespread market entry. If those barriers are overcome, it is likely that more government and individual users will convert to natural gas. The EIA projects an increase in the use of natural gas-fueled vehicles by 2010, primarily in government fleets.

New gas pipelines will have to be constructed to support the projected growth in demand for natural gas through 2000. Consumption is expected to increase to 22 TCF, with the major growth requirements focusing on electricity generation. Several of the companies we consulted predicted growth of around 35 percent by 2010. Although pipeline accidents are relatively few, initiatives by the Department of Transportation and

Congress have worked to ensure that this method of transportation remains safe.

Outlook

The drilling market is expected to grow at an average annual rate of 3.9 percent over the period 1993-2010. While technological advances can reduce the cost of production, high local distribution center costs will hurt the market. Energy use in the industrial sector is projected to increase by 18 percent by 2015, driven largely by distribution costs. The use of natural gas as a fuel for electricity production is expected to increase in the near term.

Government Goals and Role

In general, past legislation and policy initiatives have attempted to expand natural gas markets, while regulatory reform has focused on creating a more efficient and competitive market. Market reform has centered on restructuring interstate pipeline companies and their relationships with producers, local distribution companies, and end users. Of particular note, FERC Order 936 (1985) provided third-party access to pipelines, the Clean Air Act Amendments of 1990 set new air-quality standards, and FERC Order 636 "unbundled" pipeline services.

The DOE, which has the primary responsibility for managing the federal government's promotion of natural gas, received a natural gas budget appropriation for FY 1996 of \$267.5 million, a 28 percent increase over the prior year. A Natural Gas Coordinating Committee was recently established to ensure a single strategic focus for all federal programs involving natural gas. Federal goals regarding natural gas are to (1) foster development of advanced technologies, (2) encourage its use in new and existing markets, (3) remove regulatory impediments to its use, and (4) maximize its environmental benefits.

The federal government assumes a number of roles to accomplish its stated goals. It will provide direct and indirect support to explore specific applications such as advanced gas turbine systems, fuel cells, natural gas vehicles, building applications, and cleaner industrial systems. Current

research programs involve three-dimensional seismology, horizontal drilling techniques, improved fracture detection, and less intrusive drilling methods. By the end of FY 1995, some 16,700 natural gas vehicles were in federal service, about 20 percent of the nationwide inventory. Furthermore, tax incentives have been established for state, local, and individual purchases of these vehicles. Federal research money has funded the development of new gas turbine and combined-cycle power systems to encourage the expanded use of natural gas for cycle and peak electricity generation.

Programs are now in place to promote the recovery of gas reserves in environmentally sensitive areas. Royalty rate reductions may encourage exploitation of marginal onshore wells, and current research is seeking a better understanding of atmospheric emissions and ways to reduce methane losses from producing wells.

THE RENEWABLE ENERGY SOURCE INDUSTRY

The Renewable Energy Source Industry Defined and Current Conditions

Renewable energy sources (other than hydroelectric power) constituted only 3.5 percent (3.2 quadrillion Btu) of the total energy consumption in the United States in 1994. Although the contribution is minor on a national basis, renewable energy sources have very significant local effects and potential. Just as the use of renewable sources is expected to grow annually at a rate of about 1.5 percent, energy demand is projected to rise at about the same rate. Accordingly, the share of primary energy contributed by renewable sources is not expected to change by 2015.

Challenges

Renewable energy sources provide both unique advantages and associated challenges. In general, although renewables are attractive sources of energy because they are relatively clean, all have significant barriers to market entry that make them unattractive from an economic standpoint. For example, wind and solar sources are intermittent, so it is virtually impossible to match availability to periods of demand. Compared to fossil

fuels, renewables are diffuse energy sources and require greater capital investment in equipment to "capture" the energy, often over considerable acreage. Frequently the investment in renewable technologies is up-front, making financing of projects nearly impossible absent government funding. The utilization potential of several sources (e.g., wind, geothermal, solar, and hydroelectric) is also very localized or geographic in nature.

Outlook

The growth potential for renewables varies regionally. For the most part, development has been in niches where particular local or regional conditions are economic. Renewable energy systems are typically small-to medium-scale projects tailored to meet specific local needs. The potential of some renewables and their supporting technology as export products is a noted advantage. In particular, photovoltaics are globally marketed where power grids are not established; off-grid usage in remote areas (e.g., vacation homes, highway emergency call boxes) has a domestic market as well. The key factor that has prevented more rapid expansion of renewable energy sources to meet the nation's energy needs is the cost of efficiently producing usable energy from them, which can be as high as 10 times the cost of production by traditional means. The low price of fossil fuels has limited the economic incentive for turning to alternative sources, particularly in light of the high up-front capital costs associated with manufacturing and plant construction.

CONCLUSIONS

Investment in Advanced Technology

The classic debate over the merits of applied versus basic research relates to the market value and time horizon factors associated with each. Applied research is generally more market oriented and directed toward near-term results, while basic research generally involves longer-term efforts that do not necessarily produce market-oriented products. In recent years the DOE budget for both has been reduced, but applied research has been cut much more than basic research. Of the applied research efforts that remain, many are still oriented toward very long-range goals. Also, the

pressures of competition resulting from deregulation and the need to protect the short-term interests of corporate investors have forced the energy industries to respond by rapidly downsizing, consolidating, and reducing R&D expenditures, and nearly all of the private investment in energy-related R&D that has been eliminated is in the applied research category. The question for the government is how best to balance the advancement of state-of-the-art technology with adequate investment to support the intermediate- and short-range strategic objectives of national energy policy.

After examining the DOE's investment priorities as they related to the attainment of the working group's stated strategic aims, we concluded that the government's investments in energy-related R&D over the past two decades have not been as effective as they might have been in reducing U.S. dependence on petroleum or providing affordable means of reducing the adverse environmental impact of energy production. The group concluded that the current energy research budget is too heavily weighted toward extremely long-range projects with questionable potential for large-scale and affordable implementation. For example, research on fusion energy, a technology whose commercial application is still decades in the future, consumes 15 percent of the energy R&D budget (\$368 million in FY 1995). At the same time, funding for some extremely promising projects is currently inadequate. For example, only \$1.6 million (less than one-tenth of 1 percent of the FY 1996 energy budget) was earmarked for research on reductions in transportation demand. And clean-coal technologies and nuclear fission are currently receiving only about 8 percent and 4 percent of the R&D budget, respectively. The final report of the Energy Secretary's in-depth study of R&D, completed in June of 1995, was notably short on specific recommendations for setting priorities for projects.

The working group concluded that a wholesale reexamination of the DOE's R&D budget priorities is in order. The average expected cost-benefit time horizon, which has grown too long in recent years, should be shortened. The DOE should evaluate the role of potentially high-return R&D efforts in such areas as clean-coal technology, standardized advanced light-water nuclear reactor designs, and transportation demand reduction. Potential candidates for reduction (because of extended cost-

benefit time horizons) would include segments of renewable energy (such as wind and solar thermal power), fusion energy, and basic energy sciences. In summary, the DOE should reformulate and set priorities in a comprehensive, synergistic R&D plan that balances the goals of applied and basic research by evaluating the cost-benefit time horizon of each.

Sound Energy Policy

The study group concluded that the United States requires secure access to clean, abundant, and affordable energy sources. The government should institute policies to achieve the following overall aims of sound energy policy: (1) to encourage and sustain economic growth, improve industrial productivity, and improve living standards; (2) to protect the environment; (3) to use limited financial resources wisely; and (4) to make the government more efficient and responsive.

After examining the Sustainable Energy Strategy, the group felt that additional measures were necessary in four areas. First, the current strategy does not adequately address the United States's increasing vulnerability to oil price increases and the damage to the environment caused by increasing petroleum consumption. Second, the strategy fails to identify a time-phased plan for the deregulation of the electric power industry. In addition, the strategy generously funds research projects that do not substantively contribute to the stated aims of the strategy and hence wastes limited resources. Finally, procedures for accessing the SPR during a time of crisis should be freed from the political process by a formal delegation of authority to a lower level.

Our policy recommendations do not offer a panacea, but the group concluded that they would serve the overall aims of sound national energy policy. Implementing the recommendations in this report will contribute to the nation's security and prosperity, which, in turn, will enable the United States to continue to execute its vital global leadership role.

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